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(54) **Ion pump and vacuum pumping unit using the same**

Ionenpumpe und Vakuumpumpanlage dafür

Pompe ionique et unité de pompage à vide utilisant celle-ci

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(73) Proprietor: **EBARA CORPORATION**

Ohta-ku, Tokyo (JP)

(72) Inventors:

- **Nagai, Kazutoshi**
Nerima-ku, Tokyo (JP)

- **Satake, Tohru**

Yamato-shi, Kanagawa-ken (JP)

- **Hayashi, Hideaki**

Yokohama-shi, Kanagawa-ken (JP)

- **Yasui, Takanari**

Sendai-shi, Miyagi-ken (JP)

(74) Representative: **Wagner, Karl H., Dipl.-Ing. et al**

WAGNER & GEYER

Patentanwälte

Gewürzmühlstrasse 5

80538 München (DE)

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Description

[0001] The present invention relates to an exhaust apparatus and a vacuum pumping unit including the exhaust apparatus, which are specifically adapted for discharging a gas in a vacuum vessel to produce an ultra-high vacuum in the semiconductor process or the like.

[0002] Fig. 10 conceptionally illustrates a prior art vacuum equipment including the high vacuum pump, wherein a vacuum chamber 1 is connected to a vacuum pump 2 through an exhaust pipe 3. The vacuum pump 2, which comprises, for example, a turbo molecular pump, an oil diffusion pump, an ion pump and the like and, exhausts only the gas molecules which fly into the exhaust pipe 3 from the vacuum chamber 1.

[0003] However, in the above-constructed vacuum equipment, when a turbo molecular pump is used to exhaust a gas with a low compression ratio such as hydrogen, helium or the like, gas molecules may diffuse back to a high vacuum side i.e. to the vacuum chamber 1 and, thus causes a decrease in vacuum level.

[0004] In the case of an oil diffusion pump, the gas molecules, which were once exhausted by the pump, may flow back into the vacuum chamber and further, the vapor of pumping oil heated also diffuses back. Thus vacuum level decreases.

[0005] In the case of the ion pump, gas molecules absorbed into a titanium wall of the pump are desorbed and flow back into the vacuum chamber, thus reducing a vacuum level.

[0006] In the prior art, no effective means were available against the back diffusion of gas molecules with a low compression ratio or desorbed gas molecules from the vacuum pump. Nevertheless, oil vapor of the oil diffusion pump may be prevented only by providing a cold trap with liquid nitrogen, however, complete prevention for any counterflow has been substantially difficult.

[0007] The present invention has been carried out in view of the circumstances, and its object is to provide an exhaust apparatus capable of obtaining a high degree of vacuum by exhausting gas molecules in the vacuum chamber through ionization and acceleration of the gas molecules.

[0008] Then, another object of the present invention is to provide a vacuum pumping unit for an exhaust apparatus which is combined with an auxiliary pump set on a back pressure side for the pumping unit. The vacuum pumping unit is capable of producing a high degree of vacuum by ionization and acceleration of the gas molecules in a vacuum chamber toward the auxiliary pump, and also by ionization and acceleration of gas molecules which flow back from the auxiliary pump toward the auxiliary pump.

[0009] To achieve the above described objects, an exhaust apparatus according to a first aspect of the present invention comprises: a vessel; means provided in said vessel for ionizing gases in said vessel; and means provided in said vessel for accelerating said ion-

ized gases to discharge said gases out of said vessel.

[0010] An exhaust apparatus according to a second aspect of the present invention comprises: a cathode; an electron accelerating grid surrounding the cathode; an outer electrode surrounding the electron accelerating grid; an ion accelerating grid intersecting the axis of the outer electrode and installed apart from the outer electrode; a vessel for accommodating the grids and the electrodes; a magnet disposed outside of the vessel for generating a magnetic field almost parallel to the axis of said outer electrode; a high voltage power supply for applying a high voltage between said cathode and said electron accelerating grid; a DC power supply for applying a voltage between said electron accelerating grid and said outer electrode; and a DC power supply for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive.

Regarding the prior art further attention is drawn to US-A-2,578,009 which discloses an electronic high vacuum apparatus. In an exhaust line intermediate an evacuable device and a pump an enlarged section or glass chamber is provided which contains an ionisation system or "trap" for facilitating the removal of gas molecules which remain in the evacuable device after it has been "rough pumped". This chamber contains a source of electrons which, in the instant case, comprises a tungsten coil or wire (but which may take the form of a non-thermionic emitter) and, about the emitter as an axis, a grid and an anode are arranged in cylindrical symmetry. The anode is a non-perforate cylinder of a diameter of approximately that of the inner diameter of the glass chamber and may in fact comprise an adherent metallic coat or film applied to the inner surface thereof. The ends of the concentric grid and anode cylinders which lie adjacent to the inlet or "top" of the chamber are connected by an annular metal screen and hence are adapted to be maintained at the same potential, though they may be separated, electrically, if desired. The other ends of the grid and anode cylinders are closed by a similar metal screen, but this lower screen is separated electrically from the grid and anode, and hence from the upper screen as by two annular inserts of insulating material so that a difference in potential may be established between the upper and lower screen ends of the trap. The only other element of the trap is a magnet coil, which is disposed on the exterior of the glass chamber and supplies magnetic flux for influencing the trajectories of the electrons within the trap. It is apparent that the direction of the lines of force of the magnetic field from the coil is substantially parallel to the axis of the cathode.

[0011] Attention is also drawn to GB-A-684 710 which discloses an improved high vacuum pump containing an apparatused electrode arranged across a tube at right angles to the tube axis, a mesh, or grid-like electrode similarly arranged across the tube near the outlet end thereof, and an electron-emissive cathode adjacent to or constituted by said mesh or grid-like electrode, said

apparatured electrode being adapted to be maintained at a positive potential with respect to said mesh or grid-like electrode into the cathode so that, in operation, electrons emitted by the cathode are drawn into the space between said apparatured and said mesh or grid-like electrodes, and gas molecules ionized by electrons in said space are accelerated towards and through the mesh grid-like electrode towards the outlet end of the tube.

[0012] EP-A-0 469 631 (a document according to Article 54(3) Epc) describes an exhaust apparatus comprising a thermionic emission source, an electron accelerating grid surrounding the thermionic emission source, an outer electrode surrounding the electron accelerating grid, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel for containing said thermionic emission source, said electron accelerating grid, said outer electrode, and said ion accelerating grid therein, a magnet disposed outside of the vessel to generate a magnetic field almost parallel to the axis of said outer electrode, a power supply for heating said thermionic emission source, a first DC power supply for applying a voltage between said electron accelerating grid, said outer electrode and said thermionic emission source, a second DC power supply for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive.

[0013] According to the present invention an exhaust apparatus as set forth in claims 1, 2, 6 and claim 16 is provided. Preferred embodiments of the invention are disclosed in the dependent claims.

[0014] An exhaust apparatus according to a third aspect of the present invention comprises: a cold cathode; a cylindrical electron accelerating grid surrounding the cold cathode; an outer electrode surrounding the electron accelerating grid; an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode; a vessel for accommodating the grids and the electrodes; a magnet disposed outside of the vessel for generating a magnetic field almost parallel to the axis of said outer electrode; a high voltage power supply for applying a high voltage between said cold cathode and said electron accelerating grid; a DC power supply for applying a voltage between said electron accelerating grid and said outer electrode; and a DC power supply for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive.

[0015] An exhaust apparatus according to a fourth aspect of the present invention comprises: a cold cathode; an outer electrode surrounding the cold cathode; an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode; a vessel for accommodating the grid and the electrodes; a magnet disposed outside of the vessel for generating a magnetic field almost parallel to the axis of said outer electrode; a high voltage power supply for applying a

high voltage between said cold cathode and said outer electrode; and a DC power supply for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive.

[0016] An exhaust apparatus according to a fifth aspect of the present invention comprises: an outer electrode, a grid electrode intersecting an axis of the outer electrode and installed apart from the outer electrode; a vessel for accommodating said outer electrode and said grid electrode; a magnet provided outside of the vessel for generating a magnetic field almost parallel to the axis of said outer electrode; and a DC power supply for applying a high voltage between said outer electrode and said grid electrode so as to get said grid electrode negative.

[0017] An exhaust apparatus according to a sixth aspect of the present invention comprises: a first grid electrode; a second grid electrode installed opposite to the first grid electrode; a vessel for accommodating the first and second grid electrodes; a magnet provided outside of the vessel for applying a magnetic field intersecting said first and second grid electrodes; and a DC power supply for applying a high voltage between said first and second grid electrodes so as to get the second grid electrode negative.

[0018] An exhaust apparatus according to a seventh aspect of the present invention comprises: a first grid electrode; a second grid electrode installed opposite to the first grid electrode; a vessel for accommodating the two electrodes; coils or electrodes disposed outside of the vessel and connected to a high frequency power supply; and a DC power supply for applying a voltage between said first and second grid electrodes so as to get the second grid electrode negative.

[0019] A vacuum pumping unit of the present invention is constituted by combining an optionally selected vacuum pump with the high vacuum device according to one of the aspects of the present invention described above.

[0020] With an exhaust apparatus of the present invention, a high vacuum is achieved since the gas molecules within the vacuum vessel are ionized and accelerated. With a vacuum pumping unit of the present invention, the gas molecules diffused back or desorbed from the vacuum pump may be ionized and accelerated to be returned to the vacuum pump, and at the same time the gas molecules in the vacuum vessel may be ionized and accelerated to be actively fed into the vacuum pump. Thus the discharge efficiency should be improved to achieve a high degree of vacuum in the vacuum vessel.

[0021] The above and other objects, features and advantages of the present invention will become more apparent from the following description when taken in conjunction with the drawings in which preferred embodiments of the present invention are shown by way of illustrative examples.

Fig. 1 is a view showing a first embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention;

Fig. 2 is a view showing a second embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention;

Fig. 3 is a view showing a third embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention;

Fig. 4 is a view showing a fourth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention;

Fig. 5 is a view showing a fifth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention;

Fig. 6 is a view showing a sixth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention;

Fig. 7 is a view showing a seventh embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention;

Fig. 8 is a view showing an eighth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention;

Fig. 9 is a view showing a ninth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention; and

Fig. 10 is a view showing a conventional evacuating method.

[0022] High vacuum devices according to the present invention and vacuum pumping units including the high vacuum devices will now be described with reference to Fig. 1 through Fig. 9.

[0023] Fig. 1 shows a first embodiment of the present invention in which numeral 50 denotes an exhaust apparatus of the present invention and numeral 100 denotes a vacuum pumping unit also of the present invention including the high vacuum device 50. Said vacuum pumping unit 100 is constituted by combining the high vacuum device 50 and a vacuum pump 31 provided on the back pressure side of the high vacuum device 50. The vacuum pump 31 may be a turbo-molecular pump, an oil pump or an ion pump.

[0024] Said high vacuum device 50 includes a vessel 25 for connecting the vacuum pump 31 and a vacuum vessel 32 to be evacuated. A rod-like cold cathode 21 is disposed at the center of the vessel 25, and an electron accelerating grid 22 is installed so as to surround

the cold cathode 21. Further, a cylindrical electrode 23 forming an outer electrode is installed so as to surround the electron accelerating grid 22. An ion accelerating flat grid 24 is disposed so as to intersect the axis of the cylindrical electrode 23 and is installed apart from the cylindrical electrode 23.

[0025] On the other hand, an electromagnet 26 is disposed outside of the vessel 25 so as to produce a DC magnetic field almost parallel to the axis of the cylindrical electrode 23. Further, three DC power supplies 28, 29, 30 are provided outside of the vessel 25 so that the output of each of the DC power supplies are applied to each components 21, 22, 23, 24 through vacuum tight terminals provided at a portion of the vessel 25. The DC high voltage power supply 29 applies a high DC voltage between the cold cathode 21 and the electron accelerating grid 22. The ion accelerating DC power supply 30 applies a voltage between the cylindrical electrode 23 and the ion accelerating grid 24 so as to get the ion accelerating grid 24 negative. Further, the DC power supply 28 applies a voltage between the electron accelerating grid 22 and the cylindrical electrode 23 so as to get the cylindrical electrode 23 negative, and thereby the electrons are decelerated in the space.

[0026] The DC high voltage power supply 29 generates a discharge in gases between the cold cathode 21 and the electron accelerating grid 22. Electrons generated in the discharge are accelerated toward the electron accelerating grid 22 and obtain sufficient energy to pass the electron accelerating grid 22. Since a magnetic field perpendicular to the direction of electron's movement is applied between the electron accelerating grid 22 and the cylindrical electrode 23, the electrons are caused to move toward the cylindrical electrode 23 while moving in a circular path in the plane perpendicular to the axis of the cylindrical electrode 23. Under the circular movement of the electrons, the electrons' path toward the cylindrical electrode 23 is greatly lengthened, whereby they collide with a lot of gas molecules and a large amount of ions are generated. The generated ions are accelerated toward the ion accelerating grid 24 and pass through the grid 24 to be captured by the vacuum pump 31 for exhaustion.

[0027] It should be noted that, high speed electrons have a relatively smaller cross section of collision with the gas molecules which lowers ionization efficiency for gases. In the present invention, however, since an electric field for decelerating electrons is applied by the DC power supply 28 between the electron accelerating grid 22 and the cylindrical electrode 23, the electrons are gradually decelerated between the components 22, 23, the cross section with the gas molecules increases and ionization occurs effectively. Further, while it is difficult to generate discharge between the cold cathode 21 and the electron accelerating grid 22 when the gas pressure is lowered, discharge may be continued under the presence of the magnetic field created by the electromagnet 26 and pumping effect is maintained even when the gas

pressure in the vessel 25 is lowered.

[0028] Further, in the case where the DC power supply 28 is removed to bring the cylindrical electrode 23 and the electron accelerating grid 22 to the same potential, those electrons which have passed the electron accelerating grid 22 by obtaining a large kinetic energy lose their speed and are reversed when they have reached the cylindrical electrode 23. They are started to be accelerated again toward the electrode accelerating grid 22, repeating collision with gas molecules to generate ions.

[0029] In this way, gas in the vacuum vessel 32 and the molecules which are diffused back or desorbed from the vacuum pump 31, which become the cause of the reduction in the degree of vacuum, are ionized and accelerated by the high vacuum device according to the present invention to be returned again to the vacuum pump 31. Thus a high degree of vacuum may be achieved. Further, if only the vacuum pump 31 is used, only those gas molecules having entered the exhaust hole are exhausted. However, since the high vacuum device of the present invention is jointly used to actively ionize and to accelerate the gas molecules to feed them into the vacuum pump 31, the discharging efficiency is improved and a high degree of vacuum is achieved.

[0030] It should be noted that, the power supply 28 may also be variable so that the potential at the cylindrical electrode 23 is adjusted to the best point for the discharging efficiency of the pump. In this way, a high degree of vacuum may be achieved.

[0031] A second embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention will now be described with reference to Fig. 2. In Fig. 2, those components having the same effects and functions as those components in Fig. 1 are denoted by the same reference numerals and description thereof will be omitted.

[0032] A rod-like cold cathode 21 is disposed at the center of the vessel 25, and a cylindrical electrode 23 forming the outer electrode surround the cold cathode 21. Further, an ion accelerating grid 24 is disposed so as to intersect the axis of the cylindrical electrode 23 and installed apart from the cylindrical electrode 23.

[0033] Further, an electromagnet 26 is disposed outside of the vessel 25. The electromagnet 26 is arranged to produce a DC magnetic field almost parallel to the axis of the cylindrical electrode 23.

[0034] A DC high voltage power supply 29 for discharge applies a DC high voltage between the cold cathode 21 and the cylindrical electrode 23. The ion accelerating DC power supply 30 applies a voltage between the cylindrical electrode 23 and the ion accelerating grid 24 so as to get the ion accelerating grid 24 negative.

[0035] Operation will now be described of the high vacuum device constructed as described above and of the vacuum pumping unit including the high vacuum device.

[0036] The DC high voltage power supply 29 makes a discharge between the cold cathode 21 and the cylindrical electrode 23. Electrons generated by the discharge are accelerated toward the cylindrical electrode 23. Since a magnetic field is applied by the electromagnet 26 orthogonally to the electron's movement in the space between the cold cathode 21 and the cylindrical electrode 23, the electrons move toward the cylindrical electrode 23 in circular paths within a plane perpendicular to the central axis of the cylindrical electrode 23. Under the circular movement, the electrons' path toward the cylindrical electrode 23 is greatly lengthened and they collide with a lot of gas molecules to generate a large amount of ions. The generated ions are accelerated toward the ion accelerating grid 24 and captured by the vacuum pump 31.

[0037] A third embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention will now be described with reference to Fig. 3. In Fig. 3, those components having the same effects and functions as those components in Fig. 1 are denoted by the same reference numerals and description thereof will be omitted.

[0038] In the vessel 25, a flat plate-like grid electrode 24 is installed apart from the cylindrical electrode 41. Further, an electromagnet 26 is disposed outside of the vessel 25 in a similar arrangement as in the embodiment shown in Fig. 1.

[0039] A DC high voltage power supply 42 applies potential between the cylindrical electrode 41 and the grid electrode 24 so as to get the grid electrode 24 negative.

[0040] Operation will now be described of the high vacuum device constructed as described above and of the vacuum pumping unit including the high vacuum device. A discharge occurs between the cylindrical electrode 41 and the grid electrode 24 by the DC high voltage power supply 42 to generate a great amount of ions. The ions are accelerated toward the grid electrode 24 and pass through the grid electrode 24 to be captured by the vacuum pump 31. The electromagnet 26 has the effect of lengthening orbit of the electrons so that discharge is continued to maintain the pumping effect even when the gas pressure in the vessel 25 is lowered and the degree of vacuum increases.

[0041] A fourth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention will now be described with reference to Fig. 4. In Fig. 4, those components having the same effects and functions as those components in Fig. 1 are denoted by the same reference numerals and description thereof will be omitted.

[0042] In the vessel 25, a cylindrical electrode 41 is disposed in a similar arrangement as in the embodiment of Fig. 3, and a grid electrode 24 is installed apart from the cylindrical electrode 41. A high frequency power supply 43 and a DC power supply 44 apply their output between the cylindrical electrode 41 and the grid elec-

trode 24. The DC power supply 44 is connected so as to get the grid electrode 24 negative. The operation of the present embodiment is as follows.

[0043] A discharge occurs between the cylindrical electrode 41 and the grid electrode 24 by the high frequency power supply 43 to generate a large amount of ions. These ions are accelerated by the DC power supply 44 toward the grid electrode 24 and pass through the grid electrode 24 to be captured by the vacuum pump 31. The electromagnet 26 has the effect of lengthening the orbit of the electrons so that discharge is continued to maintain the pumping effect even when the gas pressure in the vessel 25 is lowered and the degree of vacuum increases.

[0044] Fig. 5 shows a fifth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention. In this figure, those components having the same effects and functions as those components in Fig. 1 are denoted by the same reference numerals and description thereof will be omitted.

[0045] In the vessel 25, a grid electrode 51 and a grid electrode 24 are installed opposite to each other. A DC high voltage power supply 42 is connected between the two grid electrodes 51, 24 so as to get the grid electrode 24 negative. The operation of the present embodiment is as follows.

[0046] A discharge occurs between the grid electrode 51 and the grid electrode 24 by the high voltage DC power supply 42 to generate a large amount of ions. The ions are accelerated toward the grid electrode 24 and pass through the grid electrode 24 to be captured by the vacuum pump 31. The electromagnet 26 has the effect of lengthening the orbit of the electrons so that the discharge is continued to maintain the pumping effect even when the gas pressure in the vessel 25 is lowered and the degree of vacuum increases.

[0047] Fig. 6 shows a sixth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention. In this figure, those components having the same effects and functions as those components in Fig. 1 are denoted by the same reference numerals and description thereof will be omitted.

[0048] In the vessel 25, a grid electrode 51 and a grid electrode 24 are installed opposite to each other. A high frequency power supply 43 and a DC high voltage power supply 44 are connected between the two grid electrodes 51, 24. The DC power supply 44 is connected so as to get the grid electrode 24 negative. The operation of the present embodiment is as follows.

[0049] A discharge occurs between the grid electrode 51 and the grid electrode 24 by the high frequency power supply 43 to generate a large amount of ions. The ions are accelerated by the DC power supply 44 toward the grid electrode 24 and pass through the grid electrode 24 to be captured by the vacuum pump 31. The electromagnet 26 has the effect of lengthening the orbit of the

electrons so that discharge is continued to maintain the pumping effect even when the gas pressure in the vessel 25 is lowered and the degree of vacuum increases.

[0050] In the embodiments shown in from Fig. 1 to Fig. 6, ions are produced by the collision between the gas molecules and the electrons generated through cold cathode discharge. As another method for gas ionization, a heat filament may be disposed in the vicinity of the cold cathode 21 of the first and second embodiments (see Fig. 1, Fig. 2), or installed between the grid electrode 24 and the cylindrical electrode 41 of the third and fourth embodiments (see Fig. 3, Fig. 4) or between the grid electrode 24 and the grid electrode 51 of the fifth and sixth embodiments (see Fig. 5, Fig. 6). When the filament is heated to emit thermoelectrons, the electrons trigger discharge so as to start the high vacuum device.

[0051] Fig. 7 shows a seventh embodiment of the present invention in which numeral 50 denotes an exhaust apparatus of the present invention and numeral 100 denotes a vacuum pumping unit also of the present invention using the high vacuum device 50. Said vacuum pumping unit 100 is constituted by combining the high vacuum device 50 and a vacuum pump 31 provided on the back pressure side of the high vacuum device 50.

[0052] Said high vacuum device 50 includes a vessel 25 for connecting the vacuum pump 31 and a vacuum vessel 32 to be evacuated. The vessel 25 is cylindrical or rectangular in cross section and is made of a glass or ceramic. In the vessel 25, a flat plate-like ion collecting or attracting grid 24 and a flat plate-like grid electrode 51 are installed opposite to each other.

[0053] A DC power supply 30 is connected so as to get the ion collecting grid 24 negative with respect to the grid electrode 51. Further, a coil 21A is installed outside of the vessel 25 so as to surround the vessel 25. A high frequency power supply 43 is connected to the coil 21A.

[0054] The vacuum pump 31 may be a turbo-molecular pump, an oil pump or an ion pump.

[0055] Operation will now be described of the high vacuum apparatus constructed as described above and of a vacuum pumping unit using such high vacuum apparatus.

[0056] A high frequency current flows through the coil 21A by the high frequency power supply 43, and discharge occurs between the grid electrode 51 and the ion collecting grid 24 by the inductive coupling phenomenon which generates a large amount of ions. A pumping effect is achieved such that the ions are accelerated toward the ion collecting grid 24 by the DC power supply 30 and pass through it to be captured by the vacuum pump 31.

[0057] It should be noted that the output of the power supply 30 is transmitted to the components 24 and 51 through vacuum tight terminals provided at a portion of the vessel 25.

[0058] In this way, gas molecules in the vacuum vessel 32 are ionized and accelerated by the high vacuum device of the invention to be actively fed to the vacuum

pump 31 and at the same time the molecules which are diffused back or desorbed from the vacuum pump 31. Thus a high degree of vacuum may be achieved.

[0059] A eighth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention will now be described with reference to Fig. 8. In Fig. 8, those components having the same effects and functions as those components in Fig. 7 are denoted by the same reference numerals and description thereof will be omitted.

[0060] A pair of plate-like electrodes 22A are provided outside of the vessel 25 in contact with the outer wall of the vessel 25 opposite to each other. And a high frequency power supply 43 is connected to the pair of plate-like electrodes 22A. For the other portions, the construction is the same as the construction in Fig. 7. Operation of the present embodiment is as follows.

[0061] A high frequency voltage is applied to the electrodes 22A by the high frequency power supply 43. Discharge by the capacitive coupling phenomenon between the grid electrode 51 and the ion collecting grid 24 makes a large amount of ions. Thus, in a similar manner as in the case of Fig. 7, a pumping effect is achieved such that the ions are accelerated toward the ion collecting grid 24 by the DC power supply 30 and pass through it to be captured by the vacuum pump 31.

[0062] Fig. 9 shows a ninth embodiment of the high vacuum device and the vacuum pumping unit including the high vacuum device according to the present invention. In this figure, those components having the same effects and functions as those components in Fig. 7 are denoted by the same reference numerals and description thereof will be omitted.

[0063] The present embodiment is constructed by adding a heat filament to the seventh embodiment (see Fig. 7). That is, a heat filament 26 is disposed in the vicinity of the grid electrode 51 and a heating power supply 27 is connected to the heat filament 26.

[0064] In the seventh and eighth embodiments (see Fig. 7, Fig. 8), ions are produced by bombardment of the electrons generated in discharge that is induced by inductive coupling of a high frequency magnetic field or capacitive coupling of a high frequency electric field. If however an attempt is made to start these high vacuum devices in the condition where the pressure is low, there occurs a problem that the discharge is difficult to be generated. To avoid this, a heat filament 26A is provided between the ion collecting grid 24 and the grid electrode 51, and is heated by a power supply 27 to emit thermoelectrons. These electrons trigger discharge.

[0065] As is apparent from the foregoing description, according to an exhaust apparatus of the present invention, a high vacuum may be achieved in a vacuum vessel by ionizing and accelerating the gas molecules within the vacuum vessel for discharge. Further, according to a vacuum pumping unit of the present invention, those gas molecules diffused back or desorbed from the vac-

uum pump may be ionized and accelerated to be returned to the vacuum pump. At the same time the gas molecules in the vacuum vessel may be ionized and accelerated so that they are actively fed into the vacuum pump. Thus the discharge efficiency may be improved to achieve a high degree of vacuum in the vacuum vessel. Furthermore, in the case of using an oil diffusion pump as the vacuum pump, there is no need for jointly using a cold trap by means of liquid nitrogen. A reduction in costs may thus be achieved and, because of the fact that problems associated with supplying liquid nitrogen are eliminated, prolonged operation will be possible.

15 Claims

1. An exhaust apparatus (50) comprising: an outer electrode (41); an ion accelerating grid (24) crossing the axis of the outer electrode and installed apart from the outer electrode (41); a vessel (25) for accommodating said outer electrode (41) and said ion accelerating grid (24); a magnet (26) provided outside of the vessel (25) for generating a magnetic field almost parallel to the axis of said outer electrode (41); and a high voltage DC power supply (42) connected between said outer electrode and said ion accelerating grid (24) so as to get said outer electrode positive (41) and to generate a discharge between said outer cylindrical electrode (41) and said ion accelerating grid (24).
2. An exhaust apparatus (50) comprising: a cold cathode (21); an outer electrode (23) surrounding said cold cathode (21); an ion accelerating grid (24) crossing the axis of the outer electrode (23) and installed apart from the outer electrode (23); a vessel (25) for accommodating the grid (24) and the electrodes; a magnet (26) disposed outside of the vessel (25) for generating a magnetic field almost parallel to the axis of said outer electrode (23); a high voltage power supply (29) connected between said cold cathode (21) and said outer electrode (23); a DC power supply (30) connected between said outer electrode (23) and said ion accelerating grid (24) so as to get said outer electrode (23) positive; and wherein said high voltage power supply (29) generates a discharge between said cold cathode (21) and said outer electrode (23).
3. An exhaust apparatus (50) of claim 2, wherein the cold cathode (21) is a rod-like cold cathode.
4. An exhaust apparatus (50) of claim 2 or 3, wherein the cold cathode is disposed at the center of the vessel (25).
5. An exhaust apparatus (50) of one of claims 2-4, wherein the outer electrode (23) surrounds the cold

cathode.

6. An exhaust apparatus (50) comprising: a cathode (21); an electron accelerating grid (22) surrounding the cathode (21); an outer electrode (23) surrounding the electron accelerating grid (22); an ion accelerating grid (24) intersecting the axis of the outer electrode (23) and installed apart from the outer electrode (23); a vessel (25) for accommodating the grids (22,24) and the electrodes; a magnet (26) disposed outside of the vessel (25) for generating a magnetic field almost parallel to the axis of said outer electrode (23); a high voltage power supply (29) for applying a high voltage between said cathode (21) and said electron accelerating grid (22); a DC power supply (28) for applying a voltage between said electron accelerating grid (22) and said outer electrode (23); a DC power supply (30) for applying a voltage between said outer electrode (23) and said ion accelerating grid (24) so as to get said outer electrode (23) positive; and wherein said high voltage power supply (29) generates a discharge between the cathode (21) and the electron accelerating grid (22).
7. An exhaust apparatus (50) of claim 6, wherein the DC power supply (28) connected between said electron accelerating grid (22) and said outer electrode (23) is removed to equalize potentials at said electron accelerating grid (22) and said outer electrode (23).
8. An exhaust apparatus (50) of claim 6, wherein the DC power supply (28) for applying a voltage between said electron accelerating grid (22) and said outer electrode (23) generates a variable output.
9. An exhaust apparatus (50) of any of claims 6-8, wherein said cathode (21) is a cold cathode.
10. An exhaust apparatus (50) of any of the preceding claims, wherein a high frequency power supply (43) is overlaid upon the DC power supply (30,42,44) provided between said outer electrode and said ion accelerating grid (24).
11. An exhaust apparatus (50) of any of the preceding claims, wherein the outer electrode (23,41) is a cylindrical electrode.
12. An exhaust apparatus (50) of any of the preceding claims, wherein the ion accelerating grid (24) is disposed so that it orthogonally crosses the axis of the outer electrode (23,41).
13. An exhaust apparatus (50) of any of the preceding claims, wherein the ion accelerating grid (24) is a plate-like grid.

14. An exhaust apparatus (50) of any of the preceding claims, wherein the vessel (25) forms a structure which serves as an exhaust hole of a vessel (32) to be evacuated by the high vacuum device or a structure which is in communication with the exhaust hole of the vacuum vessel (32).
15. An exhaust apparatus of any of the preceding claims, wherein a heat filament for emitting thermoelectrons is disposed between the ion accelerating grid (24) and the outer electrode (41).
16. An exhaust apparatus (50) comprising: a first grid electrode (24); a second grid electrode (51) installed opposite to the first grid electrode; a vessel (25) for accommodating the first and second grid electrodes; a magnet (26) provided outside of the vessel for applying a magnetic field in a crossing direction with respect to said first and second grid electrodes; and a DC power supply (44) for applying a high voltage between said first and second grid electrodes so as to get the second grid electrode negative, and to generate a discharge between said first and second grid electrodes (24,51).
17. An exhaust apparatus of claim 16, wherein a high frequency power supply (43) is overlaid upon the DC power supply provided between said first and second grid electrodes.
18. An exhaust apparatus of claim 16, wherein the first and second grid electrodes (24,51) are plate-like electrodes.
19. An exhaust apparatus of claim 16, wherein the vessel (25) forms a structure which serves as an exhaust hole of a vessel (32) to be evacuated by the high vacuum device or a structure which is in communication with the exhaust hole of the vacuum vessel.
20. An exhaust apparatus of claim 16, wherein a heat filament (26A) for emitting thermoelectrons is disposed between the first grid electrode and the second grid electrode.
21. A vacuum pumping unit comprising: an optionally selected vacuum pump; and an exhaust apparatus of any one of the preceding claims.
22. A high vacuum pumping unit comprising: a vacuum pump optionally selected; and an exhaust apparatus as claimed in any one of claims 1 to 20 provided between said vacuum pump and a vessel to be evacuated.

Patentansprüche

1. Abfuhrvorrichtung (50) die folgendes aufweist:
Eine Außenelektrode (41); ein Ionenbeschleunigungsgitter (24), welches die Achse der Außenelektrode (41) schneidet und getrennt von der Außenelektrode (41) eingebaut ist; ein Gefäß (25) zur Unterbringung der Außenelektrode (41) und des Ionenbeschleunigungsgitters (24); ein Magnet (26) vorgesehen außerhalb des Gefäßes (25) zur Erzeugung eines Magnetfeldes nahezu parallel zur Achse der Außenelektrode (41); und eine Gleichstromhochspannungsleistungsversorgung (42) verbunden zwischen Außenelektrode und Ionenbeschleunigungsgitter (24), um so die Außenelektrode (41) positiv zu machen und eine Entladung zwischen der zylindrischen Außenelektrode (41) und dem Ionenbeschleunigungsgitter (24) zu erzeugen.

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2. Abfuhrvorrichtung (50) wobei folgendes vorgesehen ist:
Eine Kaltkathode (21), eine die Kaltkathode (21) umgebende Außenelektrode (23); ein Ionenbeschleunigungsgitter (24), welches die Achse der Außenelektrode (23) kreuzt und weg von der Außenelektrode (23) eingebaut ist; ein Gefäß (25) zur Unterbringung des Gitters (24) und der Elektroden; ein Magnet (26) angeordnet außerhalb des Gefäßes (25) zur Erzeugung eines Magnetfeldes fast parallel zur Achse der Außenelektrode (23); eine Hochspannungsleistungsversorgung (29) verbunden zwischen Kaltkathode (21) und Außenelektrode (23); eine Gleichstromleistungsversorgung (30) geschaltet zwischen die erwähnte Außenelektrode (23) und das Ionenbeschleunigungsgitter (24), um so die Außenelektrode (23) positiv zu machen; und wobei die Hochspannungsleistungsversorgung (29) eine Entladung zwischen der Kaltkathode (21) und der Außenelektrode (23) erzeugt.

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3. Abfuhrvorrichtung (50) nach Anspruch 2, wobei die Kaltkathode (21) eine stabartige Kaltkathode ist.

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4. Abfuhrvorrichtung (50) nach Anspruch 2 oder 3, wobei die Kaltkathode in der Mitte des Gefäßes (25) angeordnet ist.

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5. Abfuhrvorrichtung (50) nach einem der Ansprüche 2 bis 4, wobei die Außenelektrode (23) die Kaltkathode umgibt.

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6. Abfuhrvorrichtung (50), die folgendes aufweist: eine Kathode (21); ein die Kathode (21) umgebendes Elektronenbeschleunigungsgitter (22); eine Außenelektrode (23), die das Elektronenbeschleunigungsgitter (22) umgibt; ein die Achse der Außenelektrode (23) schneidendes Ionenbeschleunigungsgitter (24) und zwar eingebaut weg von der Außenelektrode (23); ein Gefäß (25) zur Unterbringung der Gitter (22, 24) und Elektroden; einen Magneten (26) angeordnet außerhalb des Gefäßes (25) zur Erzeugung eines Magnetfeldes fast parallel zur Achse der Außenelektrode (23); eine Hochspannungsleistungsversorgung (29) zum Anlegen einer Hochspannung zwischen der Kathode (21) und dem Elektronenbeschleunigungsgitter (22); eine Gleichstromleistungsversorgung (28) zum Anlegen einer Spannung zwischen dem Elektronenbeschleunigungsgitter (22) und der Außenelektrode (23); eine Gleichstromleistungsversorgung (30) zum Anlegen einer Spannung zwischen der Außenelektrode (23) und dem Ionenbeschleunigungsgitter (24), um so die Außenelektrode (23) positiv zu machen; und wobei die Hochspannungsleistungsversorgung (29) eine Entladung zwischen der Kathode (21) und dem Elektronenbeschleunigungsgitter (22) erzeugt.

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7. Abfuhrvorrichtung (50) nach Anspruch 6, wobei die zwischen Elektronenbeschleunigungsgitter (22) und Außenelektrode (23) geschaltete Gleichstromleistungsversorgung (28) zum Ausgleichen der Potentiale an dem Elektronenbeschleunigungsgitter (22) und der Außenelektrode (23) entfernt ist.

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8. Abfuhrvorrichtung (50) nach Anspruch 6, wobei die Gleichstromleistungsversorgung (28) zum Anlegen einer Spannung zwischen dem Elektronenbeschleunigungsgitter (22) und der Außenelektrode (23) eine variable Ausgangsgröße erzeugt.

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9. Abfuhrvorrichtung (50) nach einem der Ansprüche 6 bis 8, wobei die Kathode (21) eine Kaltkathode ist.

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10. Abfuhrvorrichtung (50) nach einem der vorherigen Ansprüche, wobei eine Hochfrequenzleistungsversorgung (43) der Gleichstromleistungsversorgung (30, 42, 44) vorgesehen zwischen der Außenelektrode in dem Ionenbeschleunigungsgitter (24) überlagert ist.

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11. Abfuhrvorrichtung (50) nach einem der vorherigen Ansprüche, wobei die Außenelektrode (23, 41) eine zylindrische Elektrode ist.

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12. Abfuhrvorrichtung (50) nach einem der vorherigen Ansprüche, wobei das Ionenbeschleunigungsgitter (24) derart angeordnet ist, daß es die Achse der Außenelektrode (23, 41) senkrecht schneidet.

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13. Abfuhrvorrichtung (50) nach einem der vorherigen Ansprüche, wobei das Ionenbeschleunigungsgitter (24) ein plattenartiges Gitter ist.

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14. Abfuhrvorrichtung (50) nach einem der vorherigen Ansprüche, wobei das Gefäß (25) eine Struktur bil-

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det, die als ein Auslaßloch eines zu evakuierenden Gefäßes (32) dient und zwar durch die Hochvakuumvorrichtung oder eine Struktur, die in Verbindung steht mit dem Auslaßloch des Vakuumgefäßes (32).

15. Abfuhrvorrichtung (50) nach einem der vorherigen Ansprüche, wobei ein Heizfaden zur Emission von Thermoelektronen zwischen dem Ionenbeschleunigungsgitter (24) und der Außenelektrode (41) angeordnet ist.

16. Abfuhrvorrichtung (50) die folgendes aufweist: eine erste Gitterelektrode (24); eine zweite Gitterelektrode (51) eingebaut entgegengesetzt zur ersten Gitterelektrode; ein Gefäß (25) zur Unterbringung der ersten und zweiten Gitterelektroden; ein Magnet (26) vorgesehen außerhalb des Gefäßes zum Anlegen eines Magnetfeldes in einer Kreuzungs- oder Schneidrichtung bezüglich der ersten und zweiten Gitterelektroden; und eine Gleichstromleistungsversorgung (44) zum Anlegen einer Hochspannung zwischen den ersten und zweiten Gitterelektroden derart, daß die zweite Gitterelektrode negativ gemacht wird, und zum Erzeugen einer Entladung zwischen den ersten und zweiten Gitterelektroden (24, 51).

17. Abfuhrvorrichtung (50) nach Anspruch 16, wobei eine Hochfrequenzleistungsversorgung (43) der Gleichstromleistungsversorgung vorgesehen zwischen den ersten und zweiten Gitterelektroden überlagert ist.

18. Abfuhrvorrichtung (50) nach Anspruch 16, wobei die ersten und zweiten Gitterelektroden (24, 51) plattenartige Elektroden sind.

19. Abfuhrvorrichtung (50) nach Anspruch 16, wobei das Gefäß (25) eine Struktur bildet, die als ein Auslaßloch eines Gefäßes (32) dient, welches durch die Hochvakuumvorrichtung evakuiert wird, oder durch eine Struktur, die in Verbindung steht mit dem Auslaßloch des Vakuumgefäßes.

20. Abfuhrvorrichtung (50) nach Anspruch 16, wobei ein Heizfaden (26a) zur Emission von Thermoelektronen zwischen der ersten Gitterelektrode und der zweiten Gitterelektrode angeordnet ist.

21. Eine Vakuumpumpeneinheit die folgendes aufweist:
eine wahlweise ausgewählte Vakuumpumpe; und
eine Abfuhrvorrichtung (50) nach einem der vorherigen Ansprüche.

22. Hochvakuumpumpeinheit die folgendes aufweist:
eine wahlweise ausgewählte Vakuumpumpe; und
eine Abfuhrvorrichtung (50) nach einem der An-

sprüche 1 bis 20 vorgesehen zwischen der Vakuumpumpe und einem zu evakuierenden Gefäß.

5 Revendications

1. Appareil d'évacuation (50) comprenant: une électrode extérieure (41); une grille (24) accélératrice d'ions croisant l'axe de l'électrode extérieure et disposée séparément de l'électrode extérieure (41); un récipient (25) destiné à contenir ladite électrode extérieure (41) et ladite grille (24) accélératrice d'ions; un aimant (26) disposé à l'extérieur du récipient (25) pour générer un champ magnétique presque parallèle à l'axe de ladite électrode extérieure (41); et une source d'alimentation (42) en courant continu haute tension connectée entre ladite électrode extérieure et ladite grille (24) accélératrice d'ions, de manière à rendre positive ladite électrode extérieure (41) et à générer une décharge entre ladite électrode extérieure (41) et ladite grille (24) accélératrice d'ions.

2. Appareil d'évacuation (50) comprenant: une cathode froide (21); une électrode extérieure (23) entourant ladite cathode froide (21); une grille (24) accélératrice d'ions croisant l'axe de l'électrode extérieure (23) et disposée séparément de l'électrode extérieure (23); un récipient (25) destiné à contenir la grille (24) et les électrodes; un aimant (26) disposé à l'extérieur du récipient (25) pour générer un champ magnétique presque parallèle à l'axe de ladite électrode extérieure (23); une source d'alimentation (29) haute tension connectée entre ladite cathode froide (21) et ladite électrode extérieure (23); une source d'alimentation en courant continu (30) connectée entre ladite électrode extérieure (23) et ladite grille (24) accélératrice d'ions, de manière à rendre positive ladite électrode extérieure (23); et dans lequel ladite source d'alimentation (29) haute tension génère une décharge entre ladite cathode froide (21) et ladite électrode extérieure (23).

3. Appareil d'évacuation (50) selon la revendication 2, dans lequel la cathode froide (21) est une cathode froide en forme de tige.

4. Appareil d'évacuation (50) selon la revendication 2 ou 3, dans lequel la cathode froide est disposée au centre du récipient (25).

5. Appareil d'évacuation (50) selon l'une des revendications 2-4, dans lequel l'électrode extérieure (23) entoure la cathode froide.

6. Appareil d'évacuation (50) comprenant: une cathode (21); une grille (22) accélératrice d'électrons entourant la cathode (21); une électrode extérieure

- (23) entourant la grille (22) accélératrice d'électrons ; une grille (24) accélératrice d'ions coupant l'axe de l'électrode extérieure (23) et disposée séparément de l'électrode extérieure (23) ; un récipient (25) destiné à contenir les grilles (22, 24) et les électrodes ; un aimant (26) disposé à l'extérieur du récipient (25) pour générer un champ magnétique presque parallèle à l'axe de ladite électrode extérieure (23) ; une source d'alimentation (29) haute tension pour appliquer une haute tension entre ladite cathode (21) et ladite grille (22) accélératrice d'électrons ; une source d'alimentation (28) en courant continu pour appliquer une tension entre ladite grille (22) accélératrice d'électrons et ladite électrode extérieure (23) ; une source d'alimentation (30) en courant continu pour appliquer une tension entre ladite électrode extérieure (23) et ladite grille (24) accélératrice d'ions, de manière à rendre positive ladite électrode extérieure (23) ; et dans lequel ladite source d'alimentation (29) haute tension génère une décharge entre la cathode (21) et la grille (22) accélératrice d'électrons.
7. Appareil d'évacuation (50) selon la revendication 6, dans lequel la source d'alimentation (28) en courant continu connectée entre ladite grille (22) accélératrice d'électrons et ladite électrode extérieure (23) est supprimée pour rendre égaux les potentiels au niveau de ladite grille (22) accélératrice d'électrons et de ladite électrode extérieure (23).
8. Appareil d'évacuation (50) selon la revendication 6, dans lequel la source d'alimentation (28) en courant continu pour appliquer une tension entre ladite grille (22) accélératrice d'électrons et ladite électrode extérieure (23), génère une sortie variable.
9. Appareil d'évacuation (50) selon l'une quelconque des revendications 6-8, dans lequel ladite cathode (21) est une cathode froide.
10. Appareil d'évacuation (50) selon l'une quelconque des revendications précédentes, dans lequel une source d'alimentation (43) haute fréquence est disposée sur la source d'alimentation (30, 42, 44) en courant continu disposée entre ladite électrode extérieure et ladite grille (24) accélératrice d'ions.
11. Appareil d'évacuation (50) selon l'une quelconque des revendications précédentes, dans lequel l'électrode extérieure (23, 41) est une électrode cylindrique.
12. Appareil d'évacuation (50) selon l'une quelconque des revendications précédentes, dans lequel la grille (24) accélératrice d'ions est disposée de telle sorte qu'elle croise orthogonalement l'axe de l'électrode extérieure (23, 41).
13. Appareil d'évacuation (50) selon l'une quelconque des revendications précédentes, dans lequel la grille (24) accélératrice d'ions est une grille en forme de plaque.
14. Appareil d'évacuation (50) selon l'une quelconque des revendications précédentes, dans lequel le récipient (25) forme une structure qui sert de trou d'évacuation d'un récipient (32) dans lequel on doit faire le vide par le dispositif à vide poussé, ou une structure qui est en communication avec le trou d'évacuation du récipient sous vide (32).
15. Appareil d'évacuation selon l'une quelconque des revendications précédentes, dans lequel un filament incandescent pour émettre des thermoélectrons est disposé entre la grille (24) accélératrice d'ions et l'électrode extérieure (41).
16. Appareil d'évacuation (50) comprenant : une première électrode (24) de grille ; une deuxième électrode (51) de grille disposée à l'opposé de la première électrode de grille ; un récipient (25) destiné à contenir les première et deuxième électrodes de grille ; un aimant (26) disposé à l'extérieur du récipient pour appliquer un champ magnétique dans une direction transversale par rapport auxdites première et deuxième électrodes de grille ; et une source d'alimentation (44) en courant continu pour appliquer une haute tension entre lesdites première et deuxième électrodes de grille, de manière à rendre négative la deuxième électrode de grille, et à générer une décharge entre lesdites première et deuxième électrodes (24, 51) de grille.
17. Appareil d'évacuation selon la revendication 16, dans lequel une source d'alimentation (43) haute fréquence est disposée sur la source d'alimentation en courant continu disposée entre lesdites première et deuxième électrodes de grille.
18. Appareil d'évacuation selon la revendication 16, dans lequel les première et deuxième électrodes (24, 51) de grille sont des électrodes en forme de plaque.
19. Appareil d'évacuation selon la revendication 16, dans lequel le récipient (25) forme une structure qui sert de trou d'évacuation d'un récipient (32) dans lequel on doit faire le vide par le dispositif à vide poussé, ou une structure qui est en communication avec le trou d'évacuation du récipient sous vide.
20. Appareil d'évacuation selon la revendication 16, dans lequel un filament incandescent (26A) pour émettre des thermoélectrons est disposé entre la première électrode de grille et la deuxième électrode de grille.

- 21.** Unité de pompage à vide comprenant : une pompe à vide sélectionnée de manière optionnelle ; et un appareil d'évacuation selon l'une quelconque des revendications précédentes.

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- 22.** Unité de pompage à vide poussé comprenant : une pompe à vide sélectionnée de manière optionnelle ; et un appareil d'évacuation selon l'une quelconque des revendications 1 à 20 disposé entre ladite pompe à vide et un récipient dans lequel on doit faire le vide.

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Fig. 1

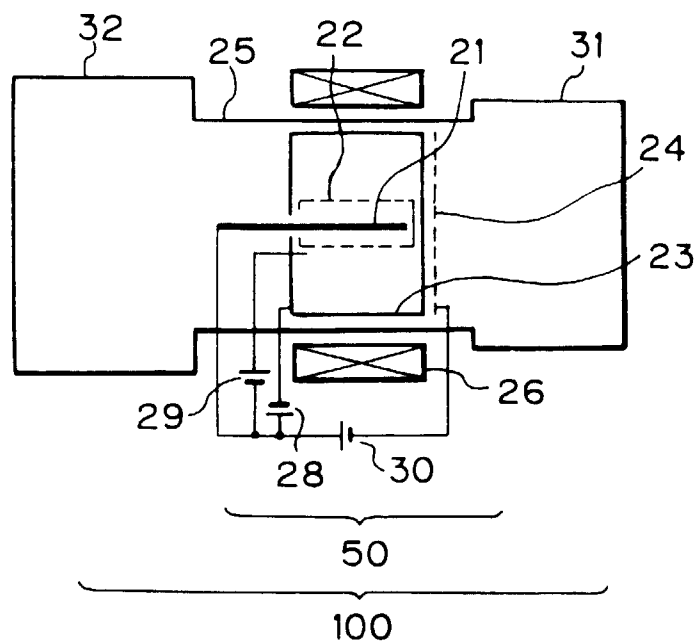


Fig. 2

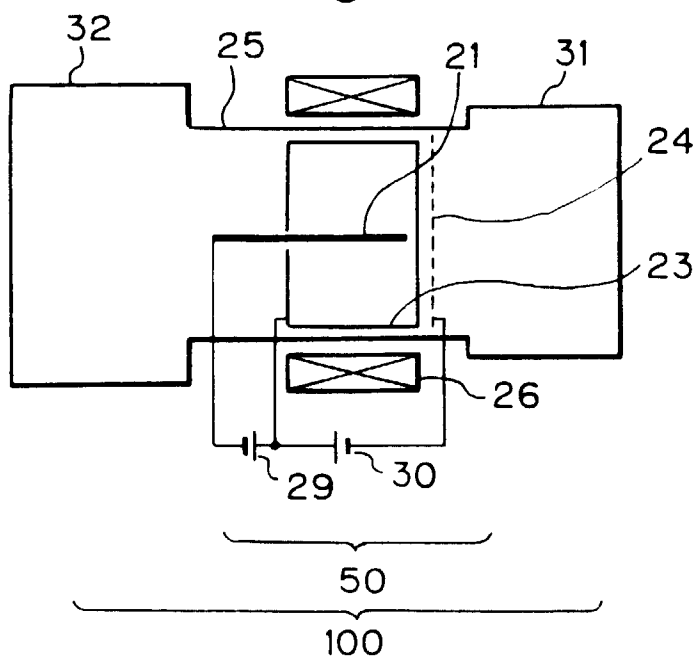


Fig. 3

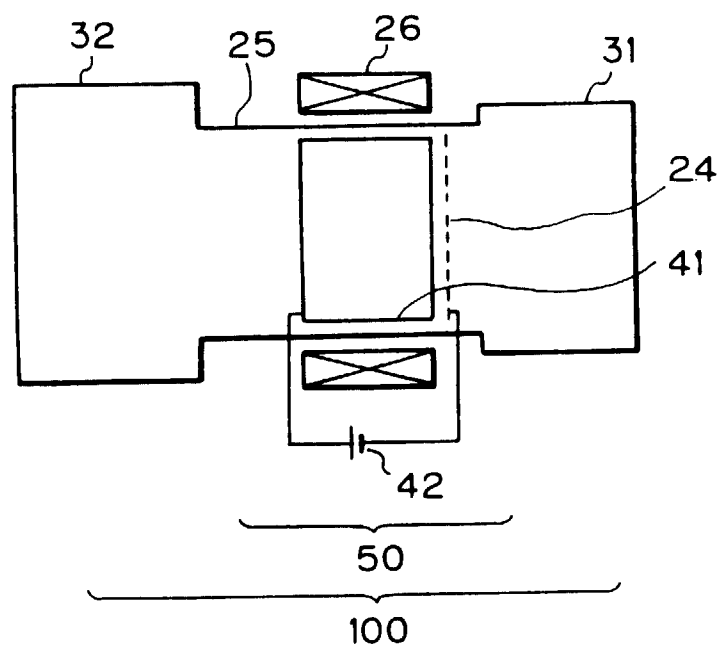


Fig. 4

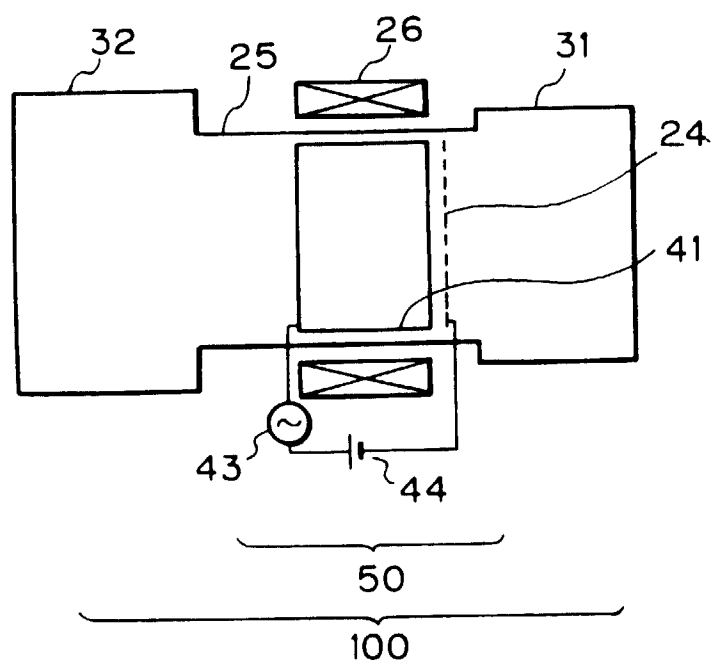


Fig. 5

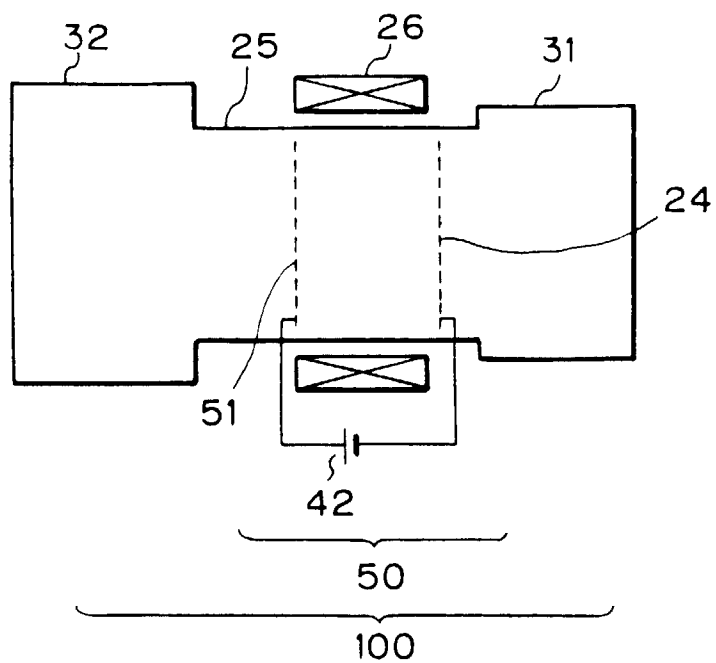


Fig. 6

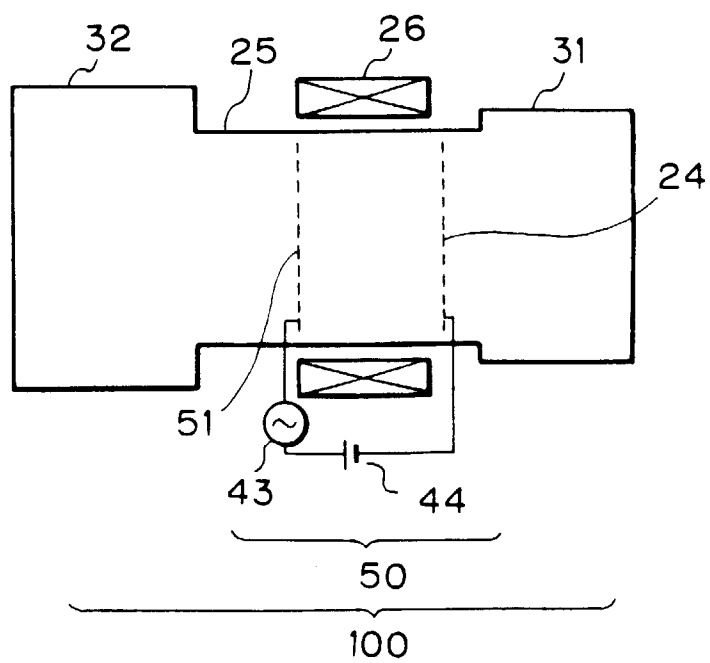


Fig. 7

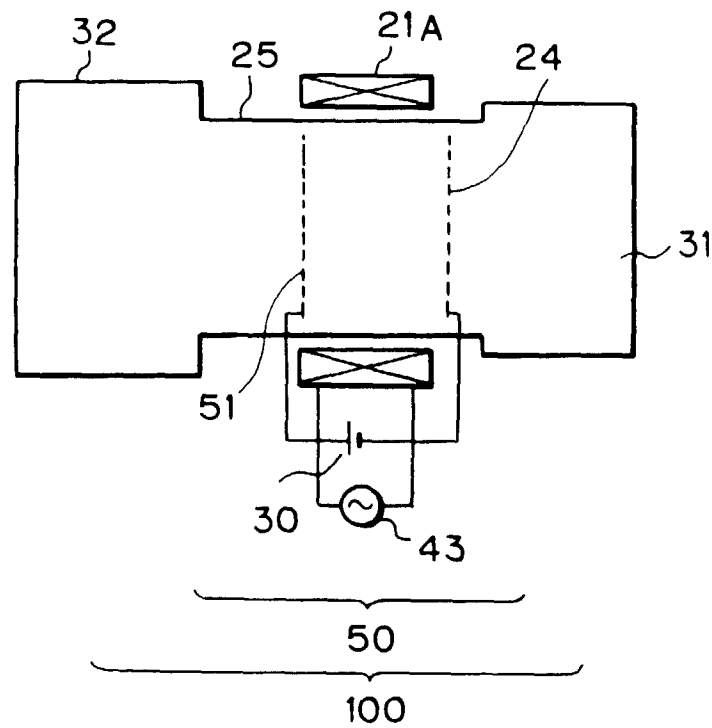


Fig. 8

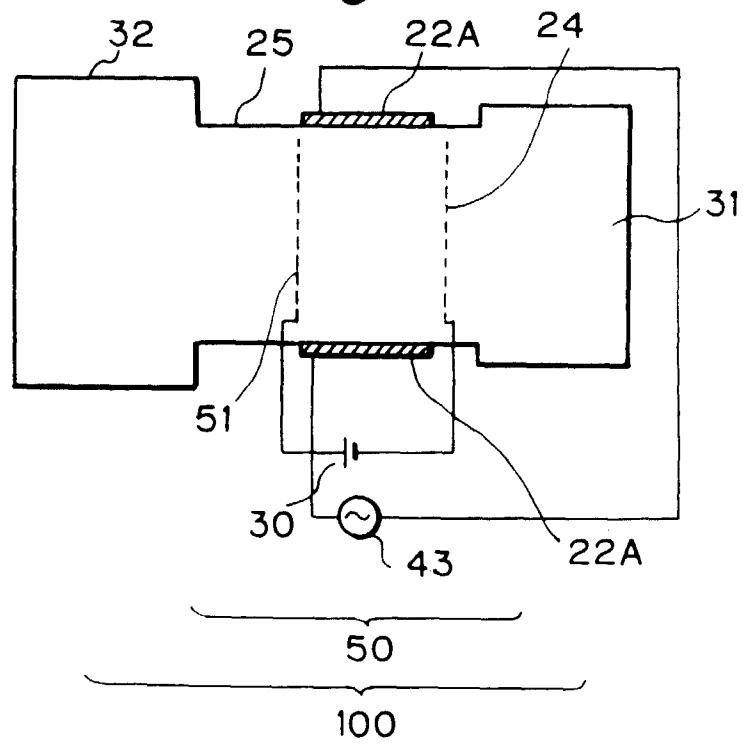


Fig. 9

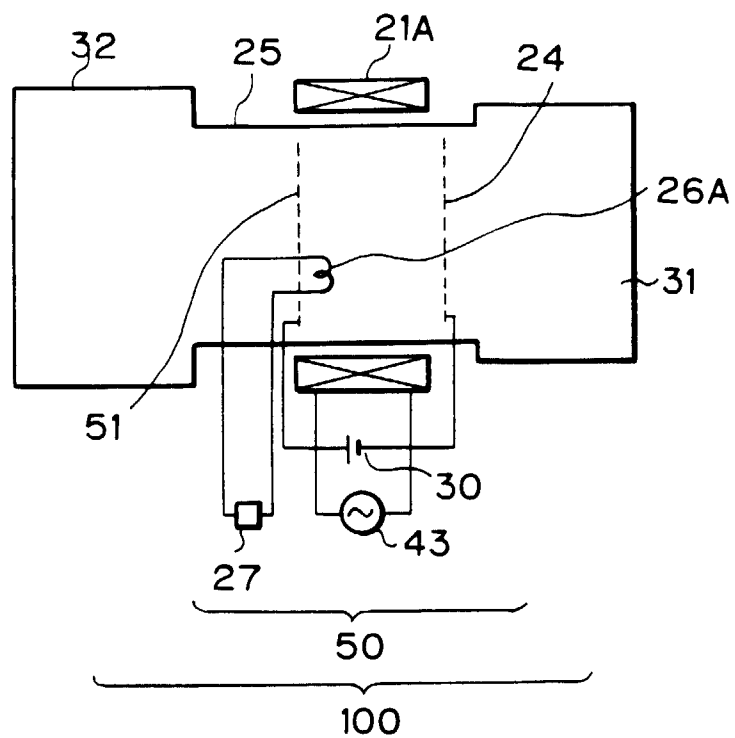


Fig. 10

