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(54) **Turbomolecular pump**

(57) A turbomolecular pump is provided in which the structure of a stator blade (20) is improved for cooling rotor blades (2), thereby achieving a higher thermal conduction efficiency. The arrangement provides contact surfaces of the stator blades (20) and stator blade spacers (22) to be engaged/crushed upon assembling the pump.

FIG.1A

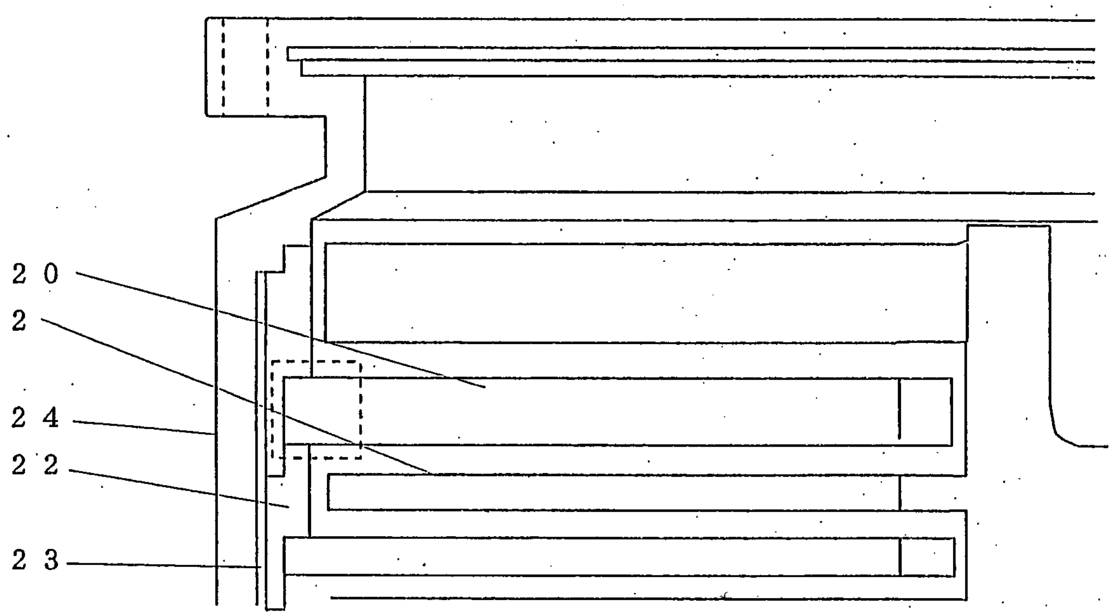

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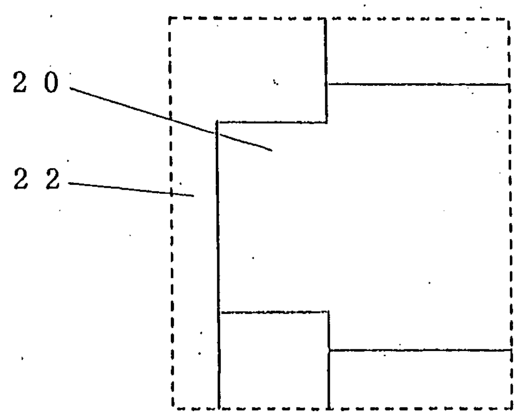
FIG.1B



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a turbomolecular pump used as a vacuum apparatus such in semiconductor manufacturing equipment.

2. Description of the Related Art

[0002] A turbomolecular pump is used as, for example, a vacuum apparatus for exhausting gas within a chamber in a semiconductor manufacturing equipment, and is adapted to suck/discharge a process gas supplied into the chamber therein/therefrom for a semiconductor fabricating process.

[0003] Fig. 4 is a structural view showing an entire turbomolecular pump. In Fig. 4, a rotor blade 2 is rotated by a motor 3 while being floated by a magnetic bearing 4.

[0004] A plurality of stator blades 20 are provided with slight gaps between the blades of the rotor blade 2. The stator blades 20 are supported while the outer circumeferential ends of the stator blades 20 are engagingly inserted between a plurality of stator blade spacers 22 stacked stepwise.

[0005] An outer casing 24 is fixed to the circumferences of the stator blade spacers 22 at slight gaps 23. The bottom of the outer casing 24 is fixed with a gap to a base portion incorporating the motor 3 and the magnetic bearing 4 therein.

[0006] In the turbomolecular pump having such an arrangement, a gas molecule sucked from an intake port 1 is knocked downwardly by the rotation of blades of the rotor blade 2 to be fed in an axial direction, and then exhausted from an exhaust port 11.

[0007] In recent years, a large amount of process gasses tend to be supplied into the chamber for a semiconductor fabricating process. As a result, an intake port and an exhaust port are required to have a higher pressure-allowance when the turbomolecular pump is operated so as to be able to effectively exhaust the gas.

[0008] However, higher allowable pressure leads to the increased number of gas molecules impinging upon the rotor blades per unit time, resulting in an elevated temperature of the rotor blades due to heat generation upon this impingement.

[0009] A use of the rotor blades at more than an allowable temperature causes deterioration of the material or failure of the pump. Consequently, the allowable pressure must be limited within a range such that the rotor blades may be used at lower than the allowable temperature thereof. Besides, this temperature elevation of the rotor blades may be caused by the heat generation at an electromagnet used for the motor or the magnetic bearing.

[0010] A turbomolecular pump is equipped generally with a gas-cooling or water-cooling unit to prevent the high temperature of the rotor blades resulting from the above-mentioned reasons.

[0011] Such a problem may further occur as follows. When an active gas is sucked through a turbomolecular pump, and the temperature within the pump is not higher than a sublimated temperature of the active gas, a reaction product may solidify and adher to the inside of the pump. This results in no gap between the rotor blades and the stator blades and brings them into contact therewith.

[0012] In order to avoid generation of this reaction product, such a measure has been taken that a heater is fixedly wound around the pump so that the temperature within the pump may not be lower than a predetermined temperature.

[0013] Referring to Figs. 5A and 5B, illustrated is one example of the measure. As shown in these figures, a heater 8 is fixedly wound around a base portion 10, and the base portion 10 is equipped with a water-cooling pipe 12 to prevent the heater 8 from elevating the temperature of the rotor blades.

[0014] Fig. 5A is a longitudinal sectional view schematically showing a part of the turbomolecular pump equipped with the heater 8 and the water-cooling pipe 12; and Fig. 5B is a sectional view taken along the line A-A of Fig. 5A.

[0015] The heater 8 is ON/OFF-controlled, and an electromagnetic valve 14 for determining flow rate of the water-cooling pipe 12 is also ON/OFF-controlled so that a temperature at a temperature sensor 16 built-in the base portion 10 may be the temperature set by a temperature control circuit 18.

[0016] These controls can prevent a reaction product within the pump from being solidified and adhered thereto, although the allowable pressures at the intake port and the exhaust port are still restrictive.

[0017] The conventional controls as just described for the heater 8 and the electromagnetic valve 14 of the water-cooling pipe 12 is based on values detected by the temperature sensor 16, and the temperature of the rotor blades may exceed the allowable temperature in fact.

[0018] In order to prevent this, such experiments have been conducted that the respective temperatures are checked and temperatures to be controlled are set based on the obtained values. The pump is constructed by plural components, and the assembling accuracy is different from pump to pump.

[0019] A different assembling extent for these components affects the thermal conduction efficiency between the components. The resultant temperature may be different from pump to pump.

[0020] Therefore, an improvement of the thermal conduction efficiency within the pump is required to ensure a temperature control, without any influence by the assembling accuracy.

SUMMARY OF THE INVENTION

[0021] The present invention has been made in view of these conventional problems, and therefore has an object of the present invention to provide an improved turbomolecular pump in which an improvement of the thermal conduction efficiency within the pump allows heat generated at the rotor blades to effectively escape, thereby improving pressure-allowance at the intake port and the exhaust port.

[0022] In order to attain the foregoing object, according to the present invention, a turbomolecular pump comprises:

blades of a rotor blade being rotated by a motor;
stator blades confronting the rotor blades with slight gaps;
stator blade spacers each supporting one end of each of the stator blades and being stacked stepwise in a floating direction of the rotor blades;
an outer casing being fixed to the stator blade spacers with a space in a radial direction; and
a base portion being fixed to the outer casing with a gap and incorporating the motor therein,

wherein the stator blades and the stator blade spacers are engaged so that the contacting surfaces thereof are crushed, whereby thermal conductivity can be enhanced.

[0023] Further, according to the present invention, an annular member made of a material having high thermal conductivity is provided to at least one of the gaps formed between the stator blades and the stator blade spacers.

[0024] Still further, according to the present invention, an annular member made of a material having high thermal conductivity is provided to the gap formed between the outer casing and the base portion.

[0025] Furthermore, according to the present invention, each stator blade spacer is made of a material having higher thermal conductivity than that of the outer casing, and when a temperature of the rotor blade reaches a predetermined temperature or more, the stator blade spacers and the outer casing are brought into contact with each other.

[0026] Embodiments of the present invention will now be described by way of further example only and with reference to the accompanying drawings, in which:-

Figs. 1A and 1B are views according to a first embodiment of the present invention;
Figs. 2A and 2B are views according to a second embodiment of the present invention;
Figs. 3A and 3B are views according to a third embodiment of the present invention;
Fig. 4 is a sectional view showing a turbomolecular pump; and
Figs. 5A and 5B show an appearance of a turbomolecular pump equipped with a heater and a water-cooling pipe.

DETAINED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0027] Preferred embodiments of the present invention will now be described with reference to the drawings.

[0028] Figs. 1A and 1B are partially enlarged views according to a first embodiment of the present invention.

[0029] Fig. 1B is an enlarged view showing a portion enclosed by a broken line in Fig. 1A.

[0030] In Fig. 1B, stator blades 20 and stator blade spacers 22 are engaged with each other so that the contacting surfaces thereof are crushed. The stator blades 20 and the stator blade spacers 22 are generally made of aluminum alloy in consideration with their thermal conductivity or workability, and gaps formed therebetween are designed in size and managed in tolerance so as to be substantially zero upon assembly.

[0031] However, a plurality of stator blades 20 and a plurality of stator blade spacers 22 are stacked, so that gaps of a set value or more will be inevitably generated therebetween.

[0032] In order to prevent the lowering of the thermal conductivity between the stator blades 20 and the stator blade spacers 22 due to the gaps therebetween, the respective components are designed so that the contacting surfaces of the stator blades 20 and the stator blade spacers 22 are engaged/crushed with each other. When the total height is obtained by this engagement/crush of the contacting surfaces between the stator blades 20 and the stator blade spacers 22, the contact property therebetween may be enhanced, resulting in an improvement of the thermal conductivity. This allows heat received at the stator blades 20 through heat radiation from the blades of the rotor blade 2 to effectively escape via the stator blade spacers 22.

[0033] Now, Figs. 2A and 2B are partially enlarged views according to a second embodiment of the present invention.

[0034] Fig. 2B is an enlarged view showing a portion enclosed by a broken line in Fig. 2A.

[0035] In Fig. 2B, a ring-like annular member 30 is sandwiched between the stator blades 20 and the stator blade spacers 22. The foregoing first embodiment of the present invention takes a structure in which the contact property of the respective stator blades 20 and stator blade spacers 22 are improved by the engagement/crush of the contacting surfaces therebetween. On the other hand, the second embodiment of the present invention has a structure in which the annular member 30 is engaged/crushed.

[0036] The annular member 30 is made of a material having a high thermal conductivity, such as aluminum alloy, so that an enhanced contact property may be attained. As a result, the heat received at the stator blades

20 through heat radiation from the blades of the rotor blade 2 is allowed to effectively escape via the stator blade spacers 22.

[0037] The annular member 30 can be selected from several kinds of annular members having different thicknesses, any of which is suitable for the gap.

[0038] According to this process, unlike the first embodiment, there is no need for presetting the dimensions of the respective stator blades 20 and the stator blade spacers 22 with taking the engagement/crush thereof into account, thereby eliminating design change for the components.

[0039] Further, although not shown, by sandwiching an annular member made of a material having a high thermal conductivity between a clearance formed between the outer casing 24 and the base portion, as in the second embodiment, it is possible to enhance the contact property between both components and to improve the thermal conductivity.

[0040] Now, Figs. 3A and 3B show partially enlarged views according to a third embodiment of the present invention.

[0041] Referring to Fig. 3A, a gap 23 formed between the stator spacer 22 and an outer casing 24 is dimensioned based on a difference in thermal expansion in a radial direction at a predetermined temperature (calculated by an inverse operation from an allowable temperature of the blades of the rotor blade 2).

[0042] The stator blade spacers 22 are made of aluminum, for example, while the outer casing 24 is made of stainless steel, for example.

[0043] Aluminum has a thermal expansion of approximately 2.6×10^{-5} (1°C), whereas stainless steel, 1.1×10^{-5} (1°C).

[0044] The respective temperatures are obtained as follows based on experimental values when the turbomolecular pump is operated: when a temperature of the rotor blade is 120°C, the stator blade spacer 22 is at 110°C (t), and the outer casing 24 is at 90°C (t).

[0045] Now, assuming the outer diameter of the stator blade spacer 22 (ϕa) = inner diameter of the outer casing 24 (ϕA) = ϕ 230, and that a room temperature is 20°C, a difference between these in thermal expansion is calculated. An amount of thermal expansion of the stator blade spacer 22 is ($\cdot \phi$a) = $\times \phi 230 \times 2.6 \times 10^{-5} \times$ (110-20) = 1.69 (mm), thus, $\times \phi$a' - $\times \phi$a = 0.169, and therefore ϕa' = ($\times \phi$a + 1.69) / = 230.54 (mm) (1) can be obtained.

[0046] An amount of thermal expansion of the outer casing 24 is ($\cdot \phi$a) = $\times \phi 230 \times 1.1 \times 10^{-5} \times$ (90-20) = 0.556 (mm), and therefore ϕA' = ($\times$ 230 + 0.556) / = 230.18 (mm) (2) can be obtained.

[0047] From the calculation, (1) - (2) = 0.36 (mm) can be found. Accordingly, when the gap 23 is 0.18 (mm) or less (the gap 23 is a dimension at one side, and is thus 0.36/2), the stator blade spacers 22 and the outer casing 24 are brought into contact with each other. Fig. 3B shows a state the stator blade spacers 22 and the outer casing 24 are brought into contact with each other. This contact may improve a thermal conductive effect, and increases even more the heat radiation through the outer casing 24 than the conventional one.

[0048] As described above, according to the present invention, such an arrangement is taken in which the stator blades and the stator blade spacers are engaged/crushed with each other, with the result that the improved thermal conductivity facilitates a cooling operation thereof. Therefore, the rotor blade can be effective cooled. As a result, the life of the rotor blade can be elongated, and reliability of the rotor blade can be improved.

[0049] Further, according to the present invention, an annular member may be arranged at the respective gaps formed between the stator blades and the stator blade spacers. As a result, the respective amounts of the heat radiation can be increased between the stator blades and the stator blade spacers through the thermal conduction.

[0050] Still further, according to the present invention, an annular member may be arranged at a gap formed between the outer casing and the base portion. As a result, an amount of the heat radiation can be increased between the outer casing and the base portion through the thermal conduction.

[0051] Furthermore, according to the present invention, a gap may be formed between the stator blade spacers and the outer casing and is determined based on a difference in thermal expansion so as to be close to each other. Therefore, the stator blade spacers and the outer casing can be closely brought into contact with each other at a predetermined temperature, thereby allowing heat to be more effectively radiated than the conventional one.

[0052] The aforegoing description has been given by way of example only and it will be appreciated by a person skilled in the art that modifications can be made without departing from the scope of the present invention.

Claims

1. A turbomolecular pump, comprising:

blades (2) of a rotor blade being rotated by a motor;

stator blades (20) confronting the rotor blades with slight gaps therebetween;

stator blade spacers (22) each supporting one end of a respective one of the stator blades and being stacked stepwise in a floating direction of the rotator blades;

an outer casing (24) being fixed to the stator blade spacers with a space in a radial direction; and

a base portion being fixed to the outer casing with a gap and incorporating the motor therein;

wherein the stator blades and the stator blade spacers are engaged so that the contacting surfaces thereof are crushed, thereby enhancing thermal conductivity.

2. A turbomolecular pump as claimed in claim 1, wherein an annular member (30) made of a material having high thermal conductivity is provided to at least one of the gaps formed between the stator blades and the stator blade spacers.

3. A turbomolecular pump as claimed in claim 1 or 2, wherein an annular member made of a material having high thermal conductivity is provided in the gap formed between the outer casing and the base portion.

4. A turbomolecular pump as claimed in claim 1, 2 or 3, wherein the stator blade spacers are made of a material having higher thermal conductivity than that of the outer casing, and

wherein when the temperature of the rotor blades reach a predetermined temperature or more, the stator blade spacers and the outer casing are brought into contact with each other.

FIG.1A

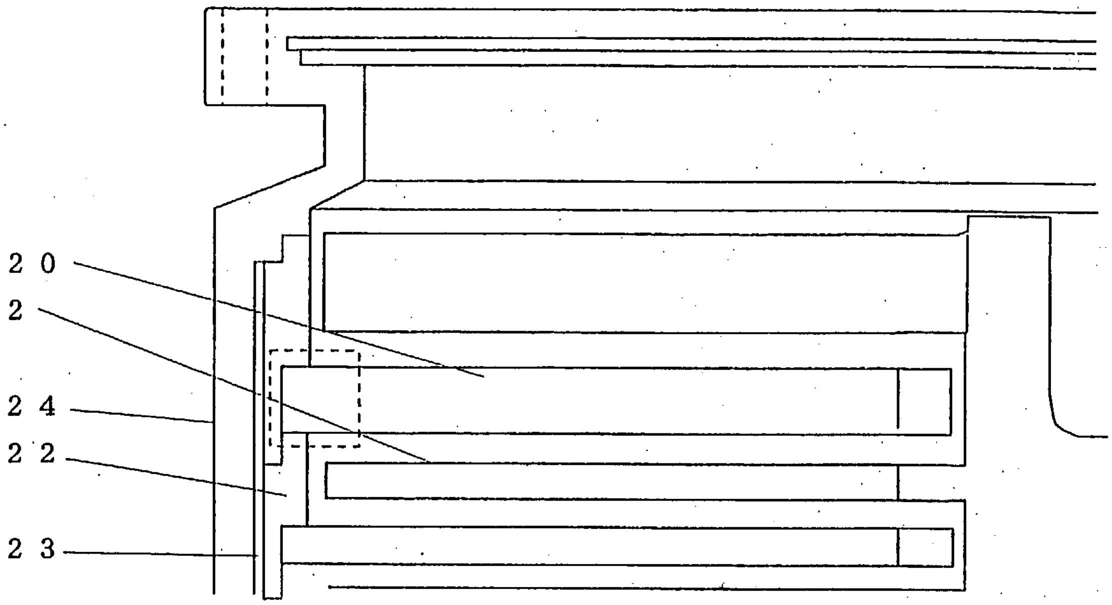


FIG.1B

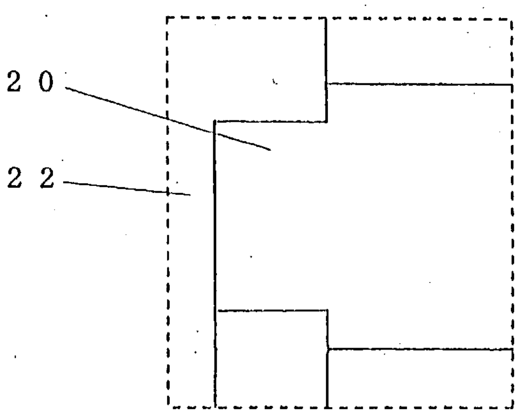


FIG.2A

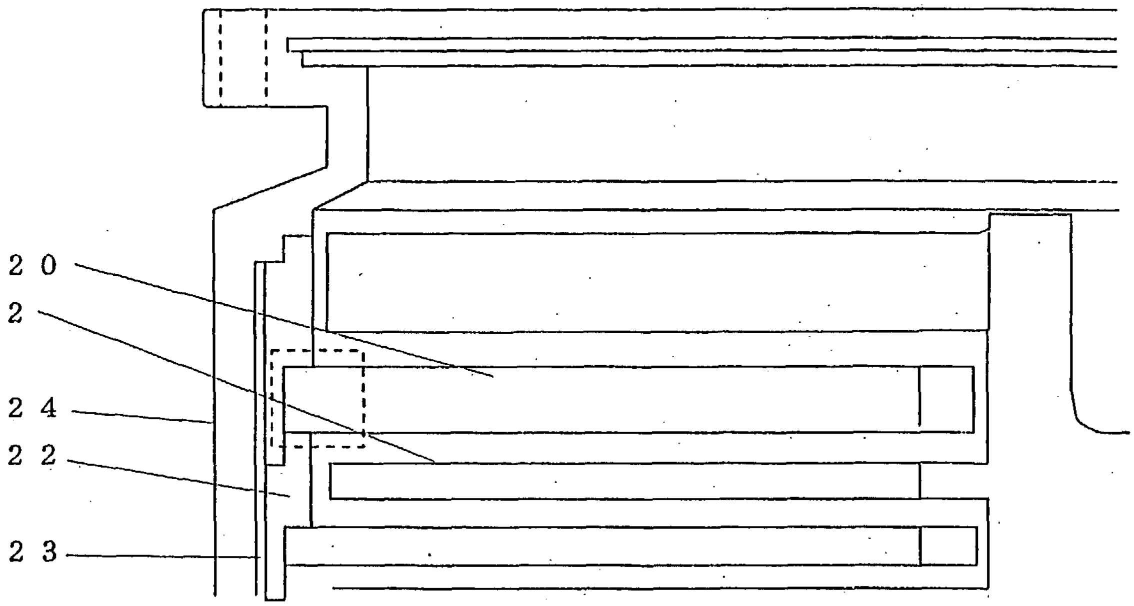


FIG.2B

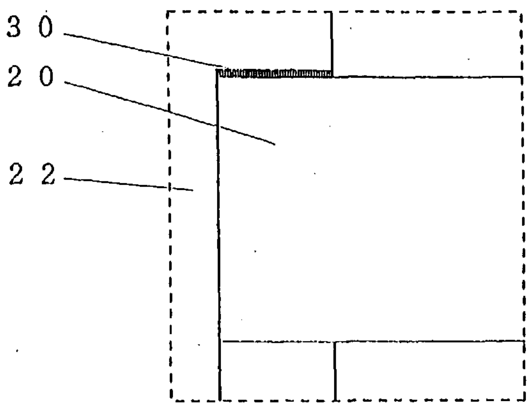


FIG.3A

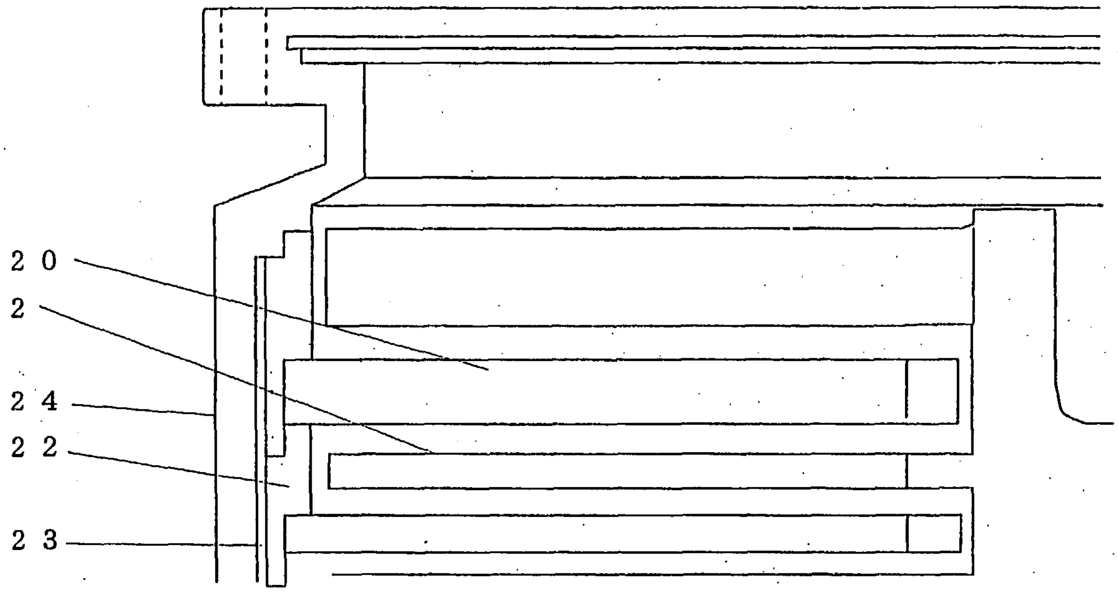


FIG.3B

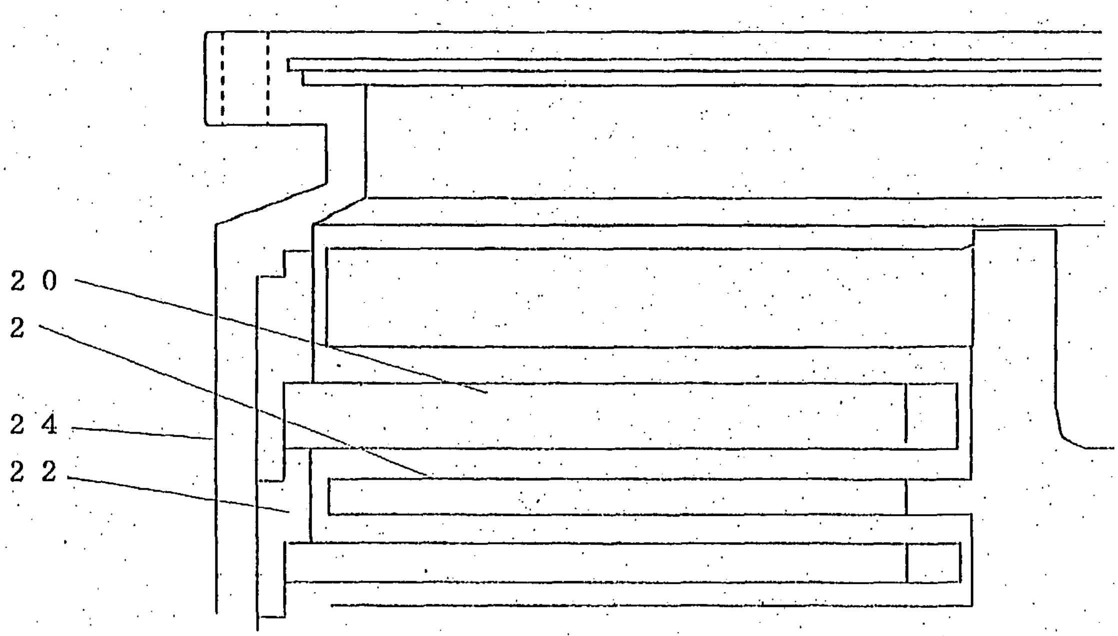


FIG.4

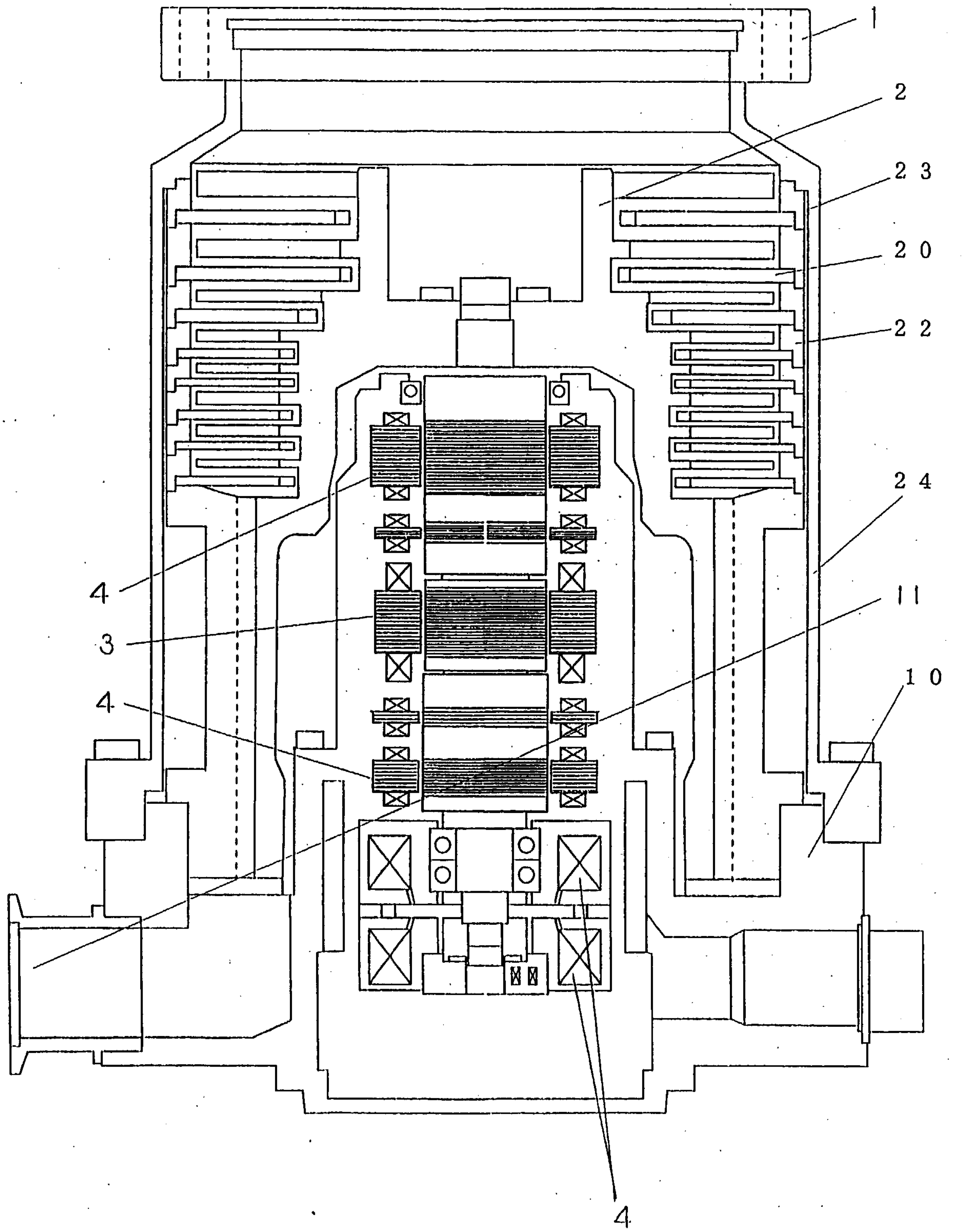


FIG.5A

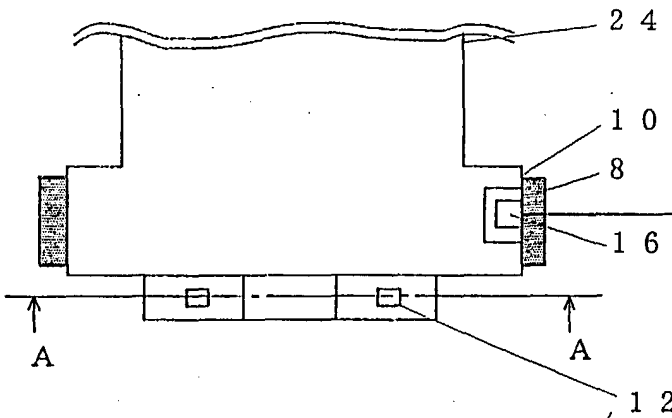


FIG.5B