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(54) **REDUCING THE INFLUENCE OF THERMAL EXPANSION OF CONNECTOR PINS ON A SUBSTRATE IN A VACUUM PUMP**

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CPC ..... **F01D 25/24** (2013.01); **F04B 37/08** (2013.01); **F04B 37/14** (2013.01); **F04D 19/042** (2013.01);  
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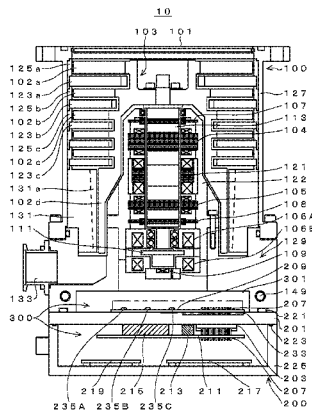
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(57) **ABSTRACT**  
A vacuum pump including a pump main unit and a control unit is disclosed. The control unit includes a substrate having electronic elements mounted thereon and terminal pins soldered to the substrate at a first end edge of the substrate. The substrate is mounted to a plate via an attachment near a second end edge opposing the first end edge and the plate is mounted to the pump main unit. The terminal pins extend through the plate. Upon linear thermal expansion of the terminal pins, by reason of the location of the terminal pins near the first end edge and the attachment near the second end edge, stresses in the soldered pin connections are reduced. A molding material having a Shore hardness of less  
(Continued)



than 50, is molded around the electronic elements on the substrate in one embodiment.

**12 Claims, 7 Drawing Sheets**

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*F01D 11/00* (2006.01)  
*F01D 25/24* (2006.01)  
*F04B 37/08* (2006.01)  
*F04B 37/14* (2006.01)  
*F04D 19/04* (2006.01)  
*F04D 29/64* (2006.01)  
*F04D 25/06* (2006.01)  
*H05K 3/00* (2006.01)  
*H05K 1/14* (2006.01)
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(2013.01); *H05K 3/0058* (2013.01); *H05K*

*1/144* (2013.01); *H05K 2201/068* (2013.01);  
*H05K 2201/10189* (2013.01); *H05K*  
*2201/10409* (2013.01)

- (58) **Field of Classification Search**  
USPC ..... 415/175, 182.1; 417/42, 44.1, 423.4;  
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See application file for complete search history.

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FIG. 1

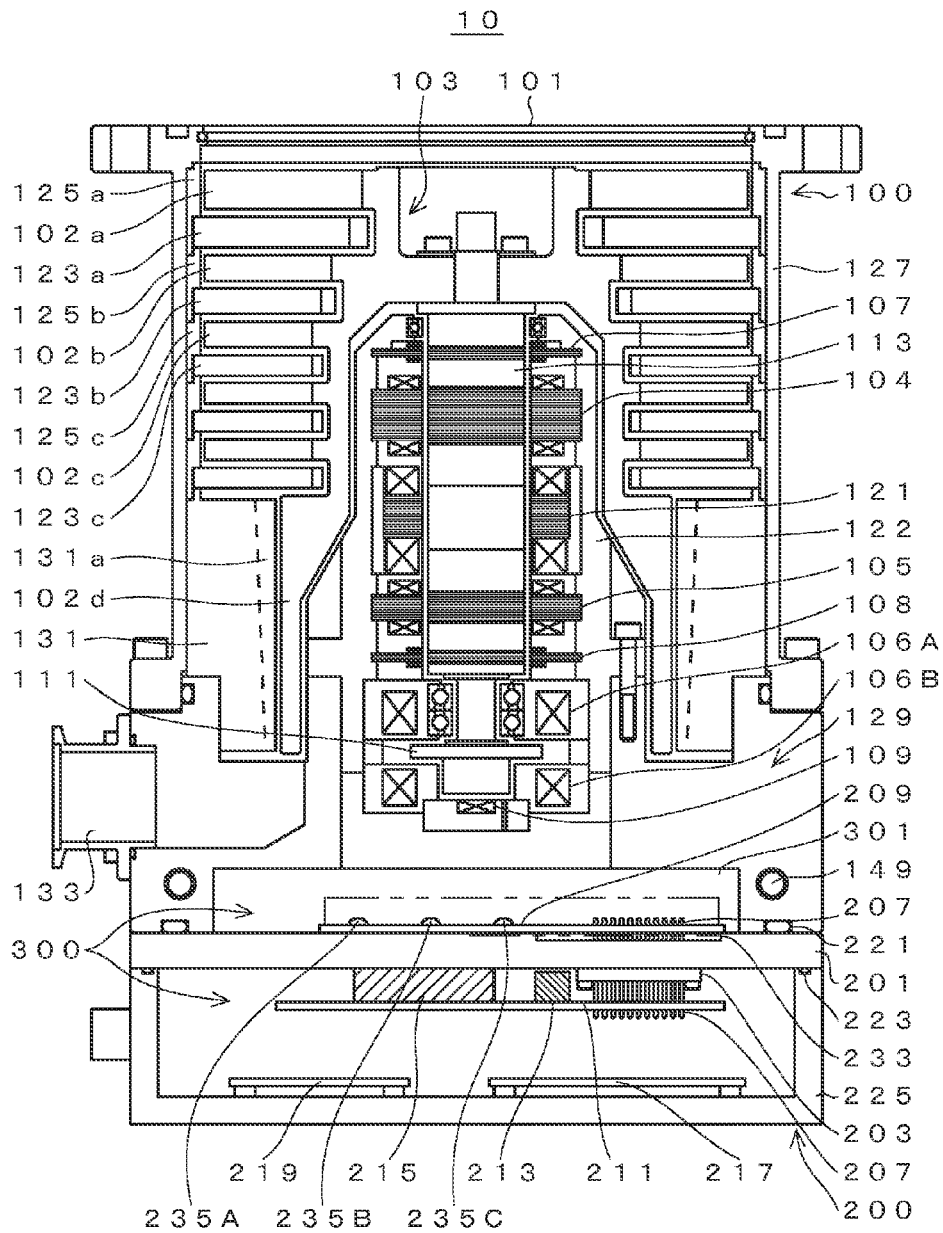


FIG. 2

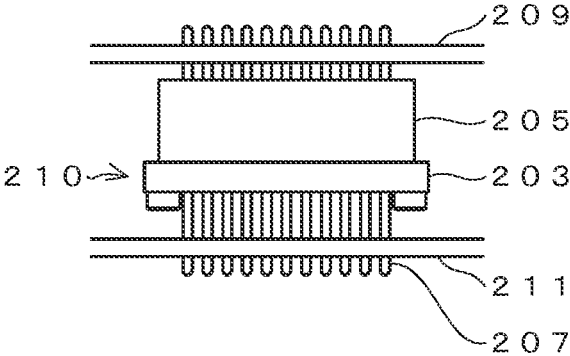


FIG. 3

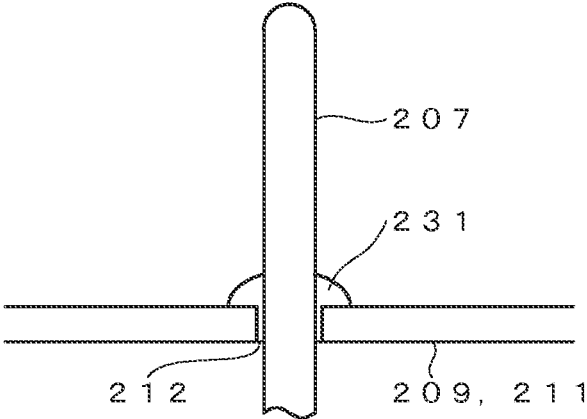


FIG. 4

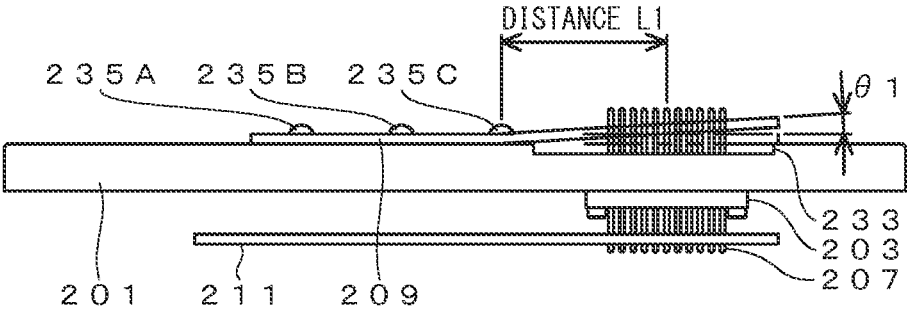


FIG. 5

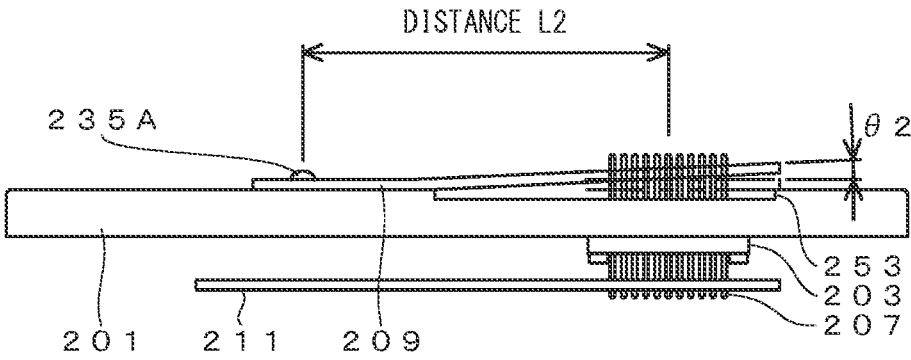


FIG. 6

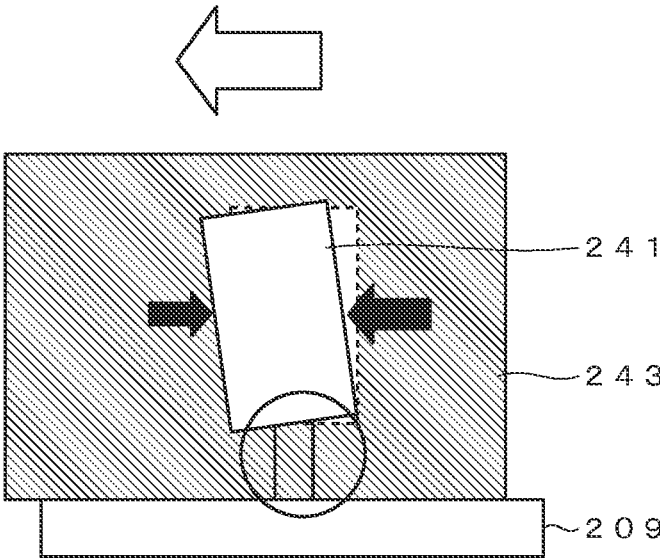
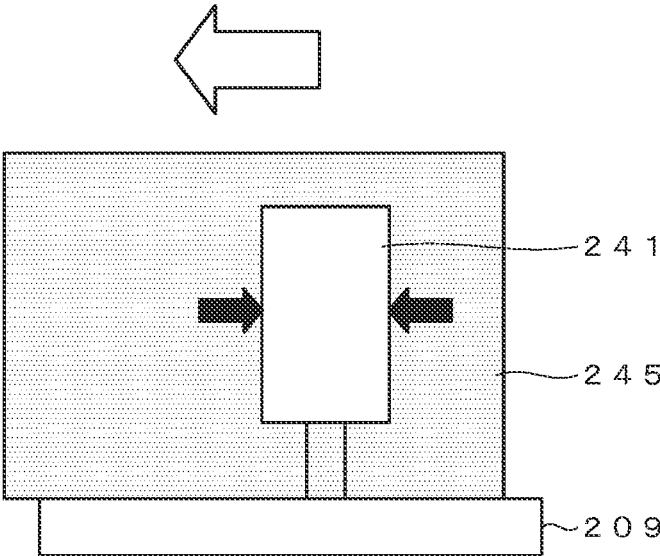




FIG. 7



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## REDUCING THE INFLUENCE OF THERMAL EXPANSION OF CONNECTOR PINS ON A SUBSTRATE IN A VACUUM PUMP

### TECHNICAL FIELD

The present invention relates to a vacuum pump, and particularly relates to a vacuum pump reducing the influence of thermal expansion of connector pins to prevent cracks in soldered parts while preventing damage to electronic elements.

### BACKGROUND ART

As a result of the recent development of electronics, there is a rapid increase in the demand for semiconductor devices such as memories and integrated circuits.

Such a semiconductor device is manufactured by doping impurities into a highly pure semiconductor substrate to impart electrical properties thereto, and forming a minute circuit on the semiconductor substrate by etching, for example.

Such operations must be performed in a chamber in a high-vacuum state to avoid the influence of dust or the like in the air. A vacuum pump is generally used to evacuate the chamber. In particular, a turbo-molecular pump, which is a kind of vacuum pump, is widely used since it involves little residual gas and is easy to maintain.

When manufacturing a semiconductor, these are many steps for making various process gases act on a semiconductor substrate, and the turbo-molecular pump is used not only to create a vacuum in a chamber, but also to discharge these process gases from the chamber.

This turbo-molecular pump consists of a pump main unit and a control device for controlling the pump main unit. As a method for simplifying wiring between substrates by reducing the number of pins of connector plugs for connecting the pump main unit and the control device, Patent Literature 1 suggests that a control substrate for a motor and a magnetic bearing should be arranged on the vacuum side.

### CITATION LIST

#### Patent Literature

[Patent Literature 1] Japanese Unexamined Patent Pub. No., 2007-508492

### SUMMARY OF INVENTION

#### Technical Problem

In the case of Patent Literature 1, a cable is used to connect a substrate having electronic elements thereon to a connector. In order to further simplify the wiring, it is desirable to connect the substrate directly to the connector through soldering, without using the cable.

However, when connecting the substrate directly to the connector through soldering, heat is easily accumulated in the pump main unit since the inside thereof is in a vacuum state and it is difficult to release heat through conduction. Accordingly, connector pins linearly expand greatly with the accumulated heat, which leads to possible cracks in solder connection parts.

Further, it is required to prevent the electronic elements mounted on the substrate from damage due to the linear expansion of the connector pins.

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The present invention has been made in view of these conventional problems, and an object thereof is to provide a vacuum pump reducing the influence of thermal expansion of connector pins to prevent cracks in soldered parts while preventing damage to electronic elements.

#### Solution to Problem

Accordingly, the present invention is characterized in including: a substrate on which electronic elements are mounted; a plurality of pins soldered to the substrate so that the pins are arranged near one end edge apart from the center of the substrate; a plate having the pins; and an attachment for attaching the substrate to the plate, in which the attachment is arranged near the other end edge apart from the center of the substrate.

The pins may be retained by the plate by being fixed while directly penetrating the plate, instead of by being inserted into the plate through the body of the terminal. When the pins are fixed while directly penetrating the plate, it is desirable that the parts where the pins are in contact with the plate are insulated depending on the material of the plate.

The pins are arranged near one end edge apart from the center of the substrate. A group of pins functions as a connector. An attachment such as a screw is arranged near the other end edge apart from the center of the substrate, the one end edge and the other end edge facing each other with the center of the substrate therebetween.

Since an attachment is arranged only on the other end side of the substrate and the one end side of the substrate is released from attachments, the bend angle of the substrate can be kept small even when the pins expand with heat, which makes it possible to reduce the stress applied on solder connection parts. Accordingly, the possibility of causing cracks in the solder connection parts is extremely small. Since deforming pressure of the substrate is reduced, influence on the electronic elements can be reduced correspondingly.

Further, the present invention is characterized in that a ratio of a distance from the center of the group of pins to the attachment to a distance from the center of the group of pins to the center of the substrate is 1.5 or greater.

Furthermore, the present invention is characterized in including: a substrate on which electronic elements are mounted; a plurality of pins soldered to the substrate so that the pins are arranged near one end edge apart from the center of the substrate; a plate having the pins; an attachment for attaching the substrate to the plate; and a molding material for molding the electronic elements on the substrate, in which the molding material has a Shore D hardness of less than 50.

The electronic element on the substrate is molded with a molding material such as resin. When the substrate bends, the molding material **243**, if having high hardness, is deformed corresponding to the deformation of the substrate. At this time, pressure of the molding material is applied to a fixing leg etc. of the electronic element. When the molding material has high hardness, the electronic element is possibly destroyed when reaction force of the electronic element is not great enough to resist the deforming pressure.

Accordingly, a molding material having a Shore D hardness of less than 50 is selected. Since the molding material flexibly follows the deformation of the substrate, load applied to the electronic element is reduced and reaction force of the electronic element can resist the deforming

pressure of the molding material. Therefore, the electronic element cannot be easily destroyed.

#### Advantageous Effects of Invention

As explained above, according to the present invention, since the attachment is arranged near the other end edge apart from the center of the substrate, the bend angle of the substrate can be kept small even when the pins expand with heat, which makes it possible to reduce the stress applied on solder connection parts. Accordingly, the possibility of causing cracks in the solder connection parts is extremely small. Since deforming pressure of the substrate is reduced, influence on the electronic elements can be reduced correspondingly.

#### BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 A block diagram according to an embodiment of the present invention;

FIG. 2 Terminal structure;

FIG. 3 A diagram showing a pin soldered to a substrate;

FIG. 4 A diagram showing a bend amount when a screw is arranged near the center of an AMB control substrate;

FIG. 5 A diagram showing a method for reducing a bend angle;

FIG. 6 A diagram showing an electronic element when a molding material having high hardness is used; and

FIG. 7 A diagram showing the electronic element when a molding material having low hardness is used.

#### DESCRIPTION OF EMBODIMENTS

Hereinafter, embodiments of the present invention will be explained. FIG. 1 shows a block diagram according to an embodiment of the present invention. In FIG. 1, a turbomolecular pump 10 consists of a pump main unit 100 and a control unit 200 integrated with each other while sandwiching an aluminum plate 201 therebetween.

The plate 201 functions both as the bottom face of the pump main unit 100 and the top face of the control unit 200. However, the plate 201 may be replaced with two plates.

The pump main unit 100 has an inlet port 101 formed at the upper end of an outer cylinder 127. Inside the outer cylinder 127, there is provided a rotor 103 having in its periphery a plurality of rotary blades 102a, 102b, 102c, . . . formed radially in a number of stages and constituting turbine blades for sucking and exhausting gas.

A rotor shaft 113 is mounted at the center of the rotor 103, and is levitated and supported in the air and controlled in position by a so-called 5-axis control magnetic bearing, for example.

Four upper radial electromagnets 104 are arranged in pairs in the X and Y axes which are perpendicular to each other and serve as the radial coordinate axes of the rotor shaft 113. An upper radial sensor 107 formed of four electromagnets is provided in close vicinity to and in correspondence with the upper radial electromagnets 104. The upper radial sensor 107 detects a radial displacement of the rotor 103 and transmits the detection result to a control device 300 (mentioned later.)

Based on the displacement signal from the upper radial sensor 107, the control device 300 controls the excitation of the upper radial electromagnets 104 through a compensation circuit having a PID adjusting function, thereby adjusting the upper radial position of the rotor shaft 113.

The rotor shaft 113 is formed of a material having a high magnetic permeability (e.g., iron), and is attracted by the magnetic force of the upper radial electromagnets 104. Such adjustment is performed independently in the X- and Y-axis directions.

Further, lower radial electromagnets 105 and a lower radial sensor 108 are arranged similarly to the upper radial electromagnets 104 and the upper radial sensor 107 to adjust the lower radial position of the rotor shaft 113 similarly to the upper radial position thereof.

Further, axial electromagnets 106A and 106B are arranged with a metal disc 111 vertically sandwiched therebetween, the metal disc 111 having a circular plate-like shape and arranged at the bottom of the rotor shaft 113. The metal disc 111 is formed of a material having a high magnetic permeability, such as iron. An axial sensor 109 is arranged to detect an axial displacement of the rotor shaft 113, and its axial displacement signal is transmitted to the control device 300.

The axial electromagnets 106A and 106B are excitation-controlled based on this axial displacement signal through a compensation circuit having a PID adjusting function in the control device 300. The axial electromagnet 106A and the axial electromagnet 106B attract the metal disc 111 upward and downward respectively by their magnetic force.

In this way, the control device 300 appropriately adjusts the magnetic force exerted on the metal disc 111 by the axial electromagnets 106A and 106B to magnetically levitate the rotor shaft 113 in the axial direction while supporting it in space in a non-contact state.

A motor 121 has a plurality of magnetic poles circumferentially arranged around the rotor shaft 113. Each magnetic pole is controlled by the control device 300 to rotate and drive the rotor shaft 113 through the electromagnetic force acting between the rotor shaft 113 and the magnetic pole.

A plurality of stationary blades 123a, 123b, 123c, . . . are arranged apart from the rotary blades 102a, 102b, 102c, . . . with small gaps therebetween. The rotary blades 102a, 102b, 102c, . . . are inclined by a predetermined angle from a plane perpendicular to the axis of the rotor shaft 113 in order to transfer the molecules of exhaust gas downward through collision.

Similarly, the stationary blades 123 are inclined by a predetermined angle from a plane perpendicular to the axis of the rotor shaft 113, and arranged alternately with the rotary blades 102 so as to extend toward the inner side of the outer cylinder 127.

One ends of the stationary blades 123 are supported while being fitted into the spaces between a plurality of stationary blade spacers 125a, 125b, 125c, . . . stacked together.

The stationary blade spacers 125 are ring-like members which are formed of, e.g., aluminum, iron, stainless steel, copper, or an alloy containing some of these metals.

The outer cylinder 127 is fixed on the outer periphery of the stationary blade spacers 125 with a small gap therebetween. A base portion 129 is arranged at the bottom of the outer cylinder 127, and a threaded spacer 131 is arranged between the lower end of the stationary blade spacers 125 and the base portion 129. An exhaust port 133 is formed under the threaded spacer 131 in the base portion 129, and communicates with the exterior.

The threaded spacer 131 is a cylindrical member formed of aluminum, copper, stainless steel, iron, or an alloy containing some of these metals, and has a plurality of spiral thread grooves 131a in its inner peripheral surface.

The direction of the spiral of the thread grooves **131a** is determined so that the molecules of the exhaust gas moving in the rotational direction of the rotor **103** are transferred toward the exhaust port **133**.

At the lowest end of the rotary blades **102a**, **102b**, **102c**, . . . of the rotor **103**, a rotary blade **102d** extends vertically downward. The outer peripheral surface of this rotary blade **102d** is cylindrical, and extends toward the inner peripheral surface of the threaded spacer **131** so as to be close to the inner peripheral surface of the threaded spacer **131** with a predetermined gap therebetween.

The base portion **129** is a disc-like member constituting the base portion of the turbo-molecular pump **10**, and is generally formed of a metal such as iron, aluminum, and stainless steel.

Further, the base portion **129** physically retains the turbo-molecular pump **10** while functioning as a heat conduction path. Thus, it is desirable that the base portion **129** is formed of a metal having rigidity and high heat conductivity, such as iron, aluminum, and copper.

In this configuration, when the rotor shaft **113** is driven by the motor **121** and rotates with the rotary blades **102**, exhaust gas from the chamber is sucked in through the inlet port **101** by the action of the rotary blades **102** and the stationary blades **123**.

The exhaust gas sucked in through the inlet port **101** flows between the rotary blades **102** and the stationary blades **123** to be transferred to the base portion **129**. At this time, the temperature of the rotary blades **102** increases due to frictional heat generated when the exhaust gas comes into contact with or collides with the rotary blades **102**, and conductive heat and radiation heat generated from the motor **121**, for example. This heat is transmitted to the stationary blades **123** through radiation or conduction by gas molecules of the exhaust gas etc.

The stationary blade spacers **125** are connected together in the outer periphery and transmit, to the outer cylinder **127** and the threaded spacer **131**, heat received by the stationary blades **123** from the rotary blades **102**, frictional heat generated when the exhaust gas comes into contact with or collides with the stationary blades **123**, etc.

The exhaust gas transferred to the threaded spacer **131** is transmitted to the exhaust port **133** while being guided by the thread grooves **131a**.

Further, in order to prevent the gas sucked in through the inlet port **101** from entering an electrical component section formed of the motor **121**, the lower radial electromagnets **105**, the lower radial sensor **108**, the upper radial electromagnets **104**, the upper radial sensor **107**, etc., the electrical component section is covered with a stator column **122**, and the inside of this electrical component section is kept at a predetermined pressure by a purge gas.

Next, configuration of the control device **300** will be explained. Electronic elements constituting the control device **300** are stored separately in a bottom space **301** formed between the plate **201** and the base **129** of the pump main unit **100** and in the control unit **200**. The inside of the bottom space **301** is set at a vacuum atmosphere, and the inside of the control unit **200** is set at an air atmosphere.

A hole is arranged in a part of the plate **201**, and a body **205** of a terminal **210** as shown in FIG. 2 is fixed while penetrating this hole. The body **205** of the terminal **210** has a columnar shape and protrudes from the top face of a roughly-quadrangular bottom plate **203**, and many straight pins **207** are fixed while penetrating the body **205** and the roughly-quadrangular bottom plate **203**.

The pins **207** may be retained by the plate **201** by being fixed while directly penetrating the plate **201**, instead of by being inserted into the plate **201** through the body **205** of the terminal **210**. In this case, it is desirable that the parts where the pins **207** are in contact with the plate **201** are insulated depending on the material of the plate **201**.

The upper parts of the pins **207** are exposed upward from the plate **201** and penetrate pinholes **212** of an AMB control substrate **209**. As shown in FIG. 3, the upper parts of the pins **207** are soldered to the AMB control substrate **209** through the pinholes **212** of the AMB control substrate **209**. Accordingly, no cable is required between the substrate and the pins, differently from the conventional techniques. Electronic elements for controlling the magnetic bearing are mounted on the AMB control substrate **209**.

The pins **207** and the electronic elements on the AMB control substrate **209** are electrically connected through the soldered parts.

On the other hand, the lower parts of the pins **207** are exposed downward from the plate **201** and penetrate the pinholes **212** of an aerial connection substrate **211**. As shown in FIG. 3, the lower parts of the pins **207** are soldered to the aerial connection substrate **211** through the pinholes **212** of the aerial connection substrate **211**. Electronic elements for controlling the motor **121** are mounted mainly on the aerial connection substrate **211**. The pins **207** and the electronic elements on the aerial connection substrate **211** are electrically connected through the soldered parts.

An electrolytic capacitor **213** is arranged near the pins **207** on the aerial connection substrate **211** with its elements facing the plate **201**. A heat sink **215** is arranged between the aerial connection substrate **211** and the plate **201**. As a result, the AMB control substrate **209**, the plate **201**, and the aerial connection substrate **211** are integrated into one structure.

Some electronic elements which are not used for controlling the magnetic bearing and the motor are mounted on bottom control substrates **217** and **219**. However, instead of arranging the substrates depending strictly on the intended use, electronic elements excepting the electrolytic capacitor **213** may be arbitrarily mounted on the AMB control substrate **209** in the vacuum atmosphere.

In order to achieve drip-proof performance, an O-ring **221** is embedded between the plate **201** and the base **129** while surrounding the bottom space **301**, and an O-ring **223** is embedded between the plate **201** and a wall **225** forming the housing of the control unit **200**.

Further, a water-cooling pipe is arranged in the base portion **129** near the plate **201** (see a water-cooling pipe **149** in FIG. 1), which makes it possible to cool the plate **201** through the base portion **129**.

Next, operation of the control device **300** will be explained.

A substrate unit structure is formed by covering the opening of the casing of the pump main unit **100** with the plate **201** functioning also as the casing of the control unit **200**. The pins **207** of the terminal **210** fixed while penetrating the plate **201** are soldered directly to the AMB control substrate **209** and the aerial connection substrate **211** in order to integrate these components. Therefore, only one plate **201** is arranged between the pump main unit **100** and the control unit **200**.

By integrating the pump main unit **100** with the control unit **200**, the casing and sealing structures can be made simple, differently from the conventional techniques requiring each of the pump main unit **100** and the control unit **200** to have a casing and a sealing member.

Further, by cooling the plate **201** by the water-cooling pipe **149**, electronic components mounted respectively on the AMB control substrate **209** in the vacuum atmosphere and the aerial connection substrate **211** in the air atmosphere can be cooled simultaneously. Therefore, the cooling structure can be simplified.

The AMB control substrate **209** is arranged in the bottom space **301** set at the vacuum atmosphere, and electronic elements difficult to place in the vacuum atmosphere are arranged on the aerial connection substrate **211**. Since the AMB control substrate **209**, the plate **201**, and the aerial connection substrate **211** are integrated into one structure through the pins **207**, no extra wiring work is required for the substrates.

Since electronic elements for controlling the magnetic bearing are arranged in the bottom space **301** set at the vacuum atmosphere, there is no need to lead the lines of the electromagnets and sensors to the outside, which makes it possible to reduce the number of lines between the AMB control substrate **209** and the aerial connection substrate **211** and the number of pins **207** as much as possible.

FIG. 4 is a diagram showing the area including the AMB control substrate **209**, the plate **201**, and the aerial connection substrate **211**. A recess **233** is formed on the plate **201** around the upper parts of the pins **207**, corresponding to the shape of the AMB control substrate **209**. The AMB control substrate **209** is fixed to the plate **201** at several points by screws **235A**, **235B**, and **235C** serving as attachments.

In FIG. 4, the screws **235A**, **235B**, and **235C** are arranged only on the left of the pins **207**. The screw **235A** is arranged near the left edge of the AMB control substrate **209**, and the screw **235C** is arranged approximately at the center of the AMB control substrate **209**.

In the configuration of FIG. 4, there is a fear that the pins **207** linearly expands with the heat accumulated in the bottom space **301** and makes the AMB control substrate **209** suddenly bend by an angle  $\theta 1$  from the screw **235C** as a fulcrum. The bottom space **301** is heated quite easily since it is in the vacuum environment. In this case, the distance between the center of the group of pins **207** and the screw **235C** is defined as L1.

As shown in FIG. 5, the bend angle of the AMB control substrate **209** is reduced by omitting the screw **235B** and **235C** while keeping only the screw **235A**. Since no screw is arranged on the right of the screw **235A**, the AMB control substrate **209** is released toward the right.

In this case, the AMB control substrate **209** bends by an angle  $\theta 2$  from the screw **235A** as a fulcrum, but this bend angle is gradual, which means that the possibility of causing cracks in the solder connection parts is extremely small. Here, the distance between the center of the group of pins **207** and the screw **235A** is defined as L2. Both in FIG. 4 and FIG. 5, the pins **207** linearly expand with the heat accumulated in the bottom space **301**, similarly. Therefore, the relationship as shown in Formula 1 is established.

$$L1 \times \tan \theta 1 = L2 \times \tan \theta 2 \quad [\text{Formula 1}]$$

Here, a bend reduction  $\alpha$  is defined as  $\theta 1/\theta 2$ . When the angle  $\theta$  is tiny, the bend reduction  $\alpha$  can be expressed as in Formula 2.

$$\alpha = \frac{\theta 1}{\theta 2} = \frac{L2}{L1} \quad [\text{Formula 2}]$$

The bend reduction  $\alpha$  is effective when it is 1.5 or greater. It is more desirable that the bend reduction  $\alpha$  is 1.7 or greater, and still more desirably, 2 or greater.

A recess **253** is expanded to the left beyond the left edge of the recess **233**, to have a larger area than the recess **233**.

By making the recess **253** broader, the AMB control substrate **209** bends smoothly since the AMB control substrate **209** can be prevented from adhering to the plate **201** due to any deposit etc.

Next, influence of the bend on the electronic elements mounted on the AMB control substrate **209** will be discussed.

As shown in FIG. 6, an electronic element **241** on the AMB control substrate **209** is molded with a molding material **243** such as resin. As stated above, when the AMB control substrate **209** bends, the molding material **243**, if having high hardness (e.g., as when using Araldite **2012** (trade name) produced by Huntsman), is largely deformed corresponding to the deformation of the substrate. At this time, great deforming pressure of the molding material is applied to a fixing leg etc. of the electronic element **241**, as shown with a thick arrow in the drawing. When the molding material **243** has high hardness, the electronic element **241** is possibly destroyed when reaction force of the electronic element **241** is not great enough to resist the deforming pressure.

Accordingly, as shown in FIG. 7, a molding material **245** having low hardness (e.g., DELO-DUOPDX CR804 (trade name) having a Shore D hardness of 43) is selected. It is desirable that the molding material **245** has a Shore D hardness of less than 50.

In this case, since load applied to the electronic element **241** is reduced as shown with a thick arrow in the drawing, reaction force of the electronic element **241** can resist the deforming pressure of the molding material **245**. Therefore, the electronic element **241** cannot be easily destroyed.

#### REFERENCE SIGNS LIST

- 10**: Turbo-molecular pump
- 100**: Pump main unit
- 102**: Rotary blades
- 104**: Upper radial electromagnets
- 105**: Lower radial electromagnets
- 106A, B**: Axial electromagnets
- 107**: Upper radial sensor
- 108**: Lower radial sensor
- 109**: Axial sensor
- 111**: Metal disc
- 113**: Rotor shaft
- 121**: Motor
- 122**: Stator column
- 123**: Stationary blades
- 125**: Stationary blade spacers
- 127**: Outer cylinder
- 129**: Base portion
- 131**: Spacer
- 133**: Exhaust port
- 149**: Water-cooling pipe
- 200**: Control unit
- 201**: Plate
- 203**: Roughly-quadrangular bottom plate
- 205**: Body
- 207**: Pins
- 209**: AMB control substrate
- 210**: Terminal
- 211**: Aerial connection substrate

- 212: Pinholes
- 213: Electrolytic capacitor
- 215: Heat sink
- 221, 223: O-rings
- 233, 253: Recesses
- 235A, 235B, 235C: Screws
- 241: Electronic element
- 243, 245: Molding material
- 300: Control device
- 301: Bottom space

The invention claimed is:

1. A vacuum pump comprising:

a pump main unit having a rotor and sucking a gas by rotation of the rotor; and

a control unit configured to control rotation of the rotor; 15  
the control unit further comprising:

a substrate on which electronic elements are mounted;

a plurality of straight pins soldered to the substrate so that the plurality of straight pins are arranged near a first end edge apart from a center of the substrate; 20

a plate having the plurality of straight pins; and an attachment attaching the substrate to the plate,

wherein the attachment is arranged near a second end edge apart from the center of the substrate.

2. The vacuum pump of claim 1, wherein a ratio of a distance from a center of a group of the plurality of straight pins to the attachment to a distance from the center of the group of the plurality of straight pins to the center of the substrate is 1.5 or greater.

3. The vacuum pump of claim 1 wherein the pump main unit includes magnetic bearings and the electronic elements are configured to control the magnetic bearings within the pump main unit to support the rotor. 30

4. The vacuum pump of claim 1 wherein the electronic elements are configured to control the rotation of the rotor within the pump main unit. 35

5. The vacuum pump of claim 1 wherein the control unit is configured to control the rotation of the rotor to create a vacuum atmosphere in an area within the pump main unit and wherein the substrate is disposed within the area within the pump main unit having the vacuum atmosphere. 40

6. The vacuum pump of claim 1 wherein the pump main unit has an inlet port and an exhaust port, the control unit is configured to produce rotation of the rotor to suck the gas into the pump main unit through the inlet port and to exhaust the gas from the pump main unit through the exhaust port, the electronic elements are configured to control at least one aspect of an operation of the pump main unit, and the plurality of straight pins are electrically coupled to the electronic elements. 45

7. A vacuum pump comprising:

a pump main unit having a rotor and sucking a gas by rotation of the rotor; and

a control unit configured to control rotation of the rotor; 50  
the control unit further comprising:

a substrate on which electronic elements are mounted;

a plurality of pins soldered to the substrate so that the plurality of pins are arranged near an end edge apart from a center of the substrate; 55

a plate having the plurality of pins;

an attachment attaching the substrate to the plate; and a molding material for molding the electronic elements on the substrate,

5 wherein the molding material has a Shore D hardness of less than 50.

8. The vacuum pump of claim 7 wherein the pump main unit includes magnetic bearings and the electronic elements are configured to control the magnetic bearings within the pump main unit to support the rotor. 10

9. The vacuum pump of claim 7 wherein the electronic elements are configured to control the rotation of the rotor within the pump main unit.

10. The vacuum pump of claim 7 wherein the control unit is configured to control the rotation of the rotor to create a vacuum atmosphere in an area within the pump main unit and wherein the substrate is disposed within the area within the pump main unit having the vacuum atmosphere.

11. The vacuum pump of claim 7 wherein the pump main unit has an inlet port and an exhaust port, the control unit is configured to produce rotation of the rotor to suck the gas into the pump main unit from the inlet port and to exhaust the gas from the pump main unit through the exhaust port, the electronic elements are configured to control at least one aspect of an operation of the pump main unit, and the plurality of pins are electrically coupled to the electronic elements. 25

12. A vacuum pump comprising:

a pump main unit having a rotor; and

a control unit configured to produce rotation of the rotor within the pump main unit to create an area having a vacuum atmosphere within the pump main unit; and

a plate mounted to the pump main unit and at least partially defining the area having the vacuum atmosphere; 30

the control unit further comprising:

a substrate disposed within the area having the vacuum atmosphere and having electronic elements mounted thereon for controlling at least one aspect of the operation of the pump main unit, wherein the substrate includes a center and first and second opposed end edges; 35

a plurality of straight pins extending through the plate, soldered to the substrate and in electrical communication with the electronic elements, the plurality of straight pins being disposed near the first end edge and spaced from the center of the substrate; and

an attachment for attaching the substrate to the plate, wherein a first end of the substrate adjacent the first end edge having the straight pins soldered thereto is not affixed to the plate so as to permit flexing of the first end of the substrate in response to linear expansion of the plurality of straight pins and wherein a second end of the substrate adjacent the second end edge is fixedly mounted to the plate via the attachment. 50

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