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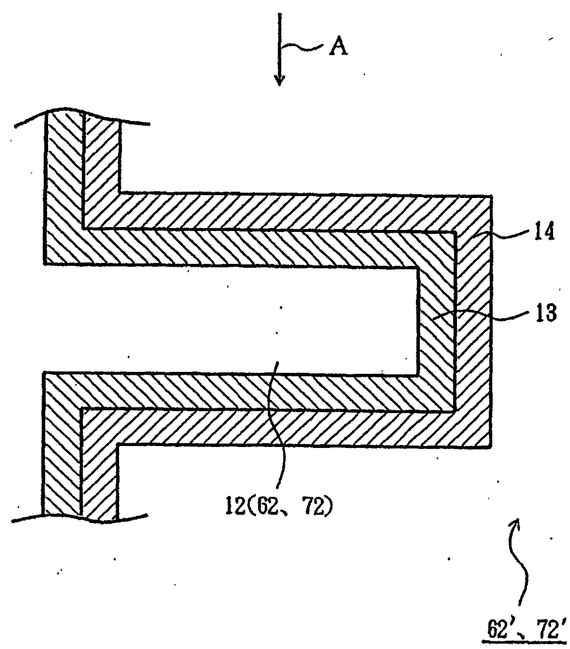
(54) **VACUUM PUMP DEVICE**

(57) Disclosed is a vacuum pump device, such as a turbo-molecular pump, wherein heat is prevented from being transmitted from the surface of members in the pump device, for example, the surface of the blades of rotor wings or stator wings, to the interior of the blades.

A first layer 13 consisting of a low-thermal-conductivity film is formed on blades 12 of rotor wings 62 or of stator wings 72 of a turbo-molecular pump device 1, which are exposed to pump compression heat, heat from a heater, etc., and then a second layer 14 consisting of a high-thermal-conductivity film is formed on the surface of the first layer 13. This double-layered coating prevents heat transmission from the second layer 14 to the blades 12. As a result, the surface of the blades 12 of the rotor wings 62 or of the stator wings 72 is not cooled, and semiconductor product which would otherwise adhere to or accumulate on the wing surface is smoothly sublimated.

FIG.2



EP 1 156 223 A1

Description

TECHNICAL FIELD

[0001] This invention relates to a vacuum pump device and, more specifically, to a mechanical vacuum pump, such as a turbo-molecular pump or a drag pump.

BACKGROUND ART

[0002] Recently, a CVD device, an etching device, etc. have come into wide use as semiconductor manufacturing devices. When manufacturing semiconductors by these devices, a vacuum pump device is used to create a high-vacuum atmosphere in the chamber of a CVD device or the like.

[0003] Among the various types of vacuum pump devices, a non-contact-rotation-type turbo-molecular pump device magnetically levitating a rotor is used, discharging process gas, such as SiH4, PH3, B2H6, and ASH3, from the chamber of a CVD device or the like.

[0004] As is known in the art, the process gas is changed from a gas to a solid when the temperature is lowered to a level of approximately 50°C to 60°C, and the resultant product adheres to or accumulates on the inner wall of the turbo-molecular pump device, the members forming the flow passage for the process gas, etc. When the operation is continued in this state for a long period of time, the amount of accumulated substance on the members forming the flow passage for the process gas, such as rotor wings and stator wings provided in the turbo-molecular pump, increases, which sometimes makes it impossible for the operation of the turbo-molecular pump device to be smoothly conducted.

[0005] To prevent adhesion of the semiconductor product to the members forming the flow passage for the process gas, such as the rotor wings and stator wings of the turbo-molecular pump, it is necessary to maintain the temperature of the rotor wings, stator wings, etc. at a level higher than the sublimation temperature (solidification temperature) of the semiconductor product.

[0006] For this purpose, the following methods have conventionally been adopted.

(1) To raise the surface temperature of the rotor wings, stator wings, etc., a heating portion is provided, raising the temperature of the portions where the semiconductor product would be allowed to adhere to or accumulate on the rotor wings, stator wings, etc.

(2) A gas in the turbo-molecular pump, such as process gas, locally heats the stator side of the flow passage shown in the drawing by means of the heating portion.

[0007] The above conventional methods, however, involve the following problems.

[0008] In the method (1), an increase in the temperature of the rotor wings, stator wings, etc. of the turbo-molecular pump, which is a high-speed rotating device, causes the blades forming these wings to be exposed for a long period of time to the compression heat of the pump and the heat from the heating portion, so that there is the possibility of generation of creep or the like in the blade material. Thus, a temperature rise beyond a permitted temperature for the rotor wings, stator blades, etc. is not allowed. To prevent the temperature limit from being exceeded, it is necessary to provide a highly accurate control function.

[0009] The method (2) has, in addition to the problem of the above method (1), a problem in that the temperature on the rotor wing side does not increase unless a gas such as process gas flows into the pump to cause heat transmission from the heating portion to the rotor wings of the pump. Further, if a gas such as process gas is caused to flow into the pump to achieve a rise in temperature, it is necessary to control the gas flow rate while detecting the temperature of the pump rotor wings.

[0010] However, this control imposes limitation on the gas exhaust amount, which is disadvantageous for a vacuum pump, which is designed to exhaust gas to achieve a high degree of vacuum.

[0011] To solve the above problems, the present invention aims at preventing heat from being transmitted (dissipated) to the blades of members in a vacuum pump device and at preventing semiconductor product from adhering to and accumulating on the surface of members in the vacuum pump device.

DISCLOSURE OF THE INVENTION

[0012] To achieve the above object, there is provided, in accordance with the present invention as claimed in Claim 1, a vacuum pump device, wherein there is formed, on a member in the vacuum pump device, a double-layered coating comprising a first layer consisting of a low-thermal-conductivity film and a second layer formed on the first layer and consisting of a high-thermal-conductivity film.

[0013] In accordance with the present invention as claimed in Claim 2 of the present invention, the above object is achieved by a vacuum pump device according to Claim 1, wherein the vacuum pump is a turbo-molecular pump comprising a rotor main body rotated by a motor, rotor wings arranged and secured in a plurality of stages in the rotating axis direction of the rotor main body and provided with a plurality of radial rotor blades inclined by a predetermined angle with respect to the rotating axis of the rotor main body, and stator wings arranged and secured in a plurality of stages between the rotor wings and provided with a plurality of radial stator blades inclined by a predetermined angle with respect to the rotating axis of the rotor main body, and wherein said double-layered coating is provided on at least either the rotor wings or the stator wings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a diagram showing the general construction of a turbo-molecular pump device to which an embodiment of the present invention is applied;
Fig. 2 is a vertical sectional view showing a coating structure according to an embodiment of the present invention applied to a rotor wing or a stator wing of the turbo-molecular pump of the present invention;
Fig. 3 is a sectional view of a turbo-molecular pump in which the embodiment of the present invention is applied to the rotor wing side of the turbo-molecular pump; and
Fig. 4 is a sectional view of a turbo-molecular pump in which the embodiment of the present invention is applied to the stator wing side of the turbo-molecular pump.

BEST MODE FOR CARRYING OUT THE INVENTION

[0015] A preferred embodiment of the present invention will now be described in detail with reference to Figs. 1 through 4.

(1) Outline of the Embodiment

[0016] A vacuum pump device, for example, a turbo-molecular pump 1, is connected to a semiconductor manufacturing device and operated. During the operation, a process gas is sucked in by the turbo-molecular pump 1, and the atmosphere in the pump 1 including the process gas is compressed, thereby generating compression heat inside the pump. At the same time, as stated above, heat (hereinafter referred to as "heater heat") is generated in the pump due to a heating portion (not shown) provided for the rotor wings 62 or the stator wings 72 of the turbo-molecular pump 1 and a heating portion (not shown) provided on the threaded spacer portion 80 side of the in-pump gas flow passage. As a result, the temperature of the process gas to be discharged is markedly raised in the pump discharge flow passage.

[0017] Adouble-layered coating comprising a first layer 13 consisting of a low-thermal-conductivity film and a second layer 14 formed on the first layer 13 and consisting of a high-thermal-conductivity film, is formed on blades 12 of the rotor wings 62 or the stator wings 72 of the pump which receive the compression heat or the heater heat (hereinafter referred to as "compression heat, etc."). Due to the insulating effect of the first layer 13, no heat is transmitted (dissipated) from the second layer 14, which is the outermost layer directly receiving heat, to the blades 12, so that it is possible to maintain high temperature. As a result, the second layer 14 is not cooled, and the semiconductor product which would otherwise adhere to or accumulate on the blades 12, etc. is smoothly sublimated. Further, it is possible to prevent the blades 12 from being damaged by the heat.

(2) Detailed Description of the Embodiment

[0018] Fig. 1 is a diagram showing the general construction of a turbo-molecular pump 1 according to an embodiment to which the present invention is applicable.

[0019] The turbo-molecular pump 1 is installed, for example, in a semiconductor manufacturing device, and serves to exhaust process gas 100 from the chamber. In this example, a flange 11 is formed at the upper end of a casing 10 formed as a cylinder, and the pump is connected to the semiconductor manufacturing device (not shown) by bolts or the like.

[0020] A plurality of stator wings 72 are arranged inside the casing 10, and a plurality of rotor wings 62 are arranged between the stator wings 72. The rotor wings 62 are provided on the outer peripheral wall of a rotor 60, which is secured to a rotor shaft 18 consisting of a magnetic material by bolts 19 so that it may rotate with the rotor shaft 18.

[0021] The rotor 60 uses a so-called magnetic bearing. In the upper portion of the rotor shaft 18, there are arranged two pairs of radial electromagnets 21 opposed to each other with the rotor shaft 18 therebetween, the two pairs of radial electromagnets being arranged so as to be perpendicular to each other. Further, there are provided two pairs of radial sensors 22 which are adjacent to the radial electromagnets 21 and which are opposed to each other with the rotor shaft 18 therebetween.

[0022] Similarly, in the lower portion of the rotor shaft 18, there are arranged two pairs of radial electromagnets 24, and two pairs of radial sensors 26 adjacent to the radial electromagnets 24.

[0023] An exciting current is supplied to these radial electromagnets 20 and 24, whereby the rotor shaft 18 is magnetically levitated. This exciting current is controlled at the time of magnetic levitation in accordance with position detection signals from the radial sensors 22 and 26, whereby the rotor shaft 18 is held in a predetermined position in the radial direction.

[0024] Further, in the casing 10, a high-frequency motor 30 is arranged between the radial sensors 22 and the radial sensors 26. By supplying electricity to this high-frequency motor 30, the rotor shaft 18 and the rotor wings 62 secured thereto rotate.

[0025] A metal disc 31 formed of a magnetic material is secured to the lower portion of the rotor shaft 18, and there are provided a pair of axial electromagnets 32 and a pair of axial electromagnets 34, which are opposed to each other with the metal disc 31 therebetween. Further, an axial sensor 36 is arranged so as to be opposed to the cut end portion of the rotor shaft 18.

[0026] An exciting current for the axial electromagnets 32 and 34 is controlled in accordance with a position detection signal from the axial sensor 36, whereby the rotor shaft 18 is held in a predetermined position in the axial direction.

[0027] Further, in Fig. 1, there are arranged a threaded spacer portion 80 and thread grooves 81, which constitute a thread groove pump portion. The threaded spacer portion 80 is connected to spacers 71, and is arranged below the spacers 71 and the stator wings 72. The thickness of the threaded spacer portion 80 is such that its inner peripheral wall is close to the outer peripheral surface of the rotor main body 61, and a plurality of spiral thread grooves 81 are formed in the inner peripheral wall of the threaded spacer portion 80. The thread grooves 81 communicate with the space between the stator wings and the rotor wings, and the gas transferred and exhausted is introduced into the thread grooves 81.

[0028] While in this embodiment the thread grooves 81 are formed on the stator 70 side, it is also possible to form the thread grooves 81 in the outer peripheral surface of the rotor main body 61. It is also possible to form the thread grooves 81 in both the threaded spacer portion 80 and the outer peripheral surface of the rotor main body 61.

[0029] Fig. 2 is a sectional view, taken in the direction of the rotor rotating axis 90, of a rotor wing 62' or stator wing 72' obtained by forming a double-layered coating 13, 14 of the present invention on a rotor blade or stator blade 12 (rotor wing 62, stator wing 72) arranged in the turbo-molecular pump 1 of Fig. 1. In the drawing, the wing blade surface receives compression heat, etc., for example, from the direction of an arrow A.

[0030] As shown in Fig. 2, in this embodiment, a layer 13 having low thermal conductivity (hereinafter referred to as "low-thermal-conductivity layer 13") is first formed on the rotor blade or stator blade 12 (rotor wing 62, stator wing 72) formed of stainless steel, aluminum or the like, and then a layer 14 having high thermal conductivity (hereinafter referred to as "high-thermal-conductivity layer 14") is formed thereon.

[0031] Preferable examples of the material of the first, low-thermal-conductivity layer 13 include heat-insulating and/or heatproof ceramic materials (such as $ThO2$, $ZrO2$, $K2O\cdot nTiO2$, and $CaO\cdot SiO2$) and resins (such as teflon resins, acrylic resins, and epoxy resins). Further, it is also possible to use in the low-thermal-conductivity layer 13 a material having a large number of minute voids. It is also possible to form a layer composed of such a material having a large number of minute voids and one of the above-mentioned ceramic materials covering the same.

[0032] Using these materials, the layer 13 can be formed on the rotor blade or stator blade 12 (rotor wing 62, stator wing 72) preferably by enameling, melting, thermal spraying, electrostatic coating, electrodeposition, spraying, CVD or the like.

[0033] Preferable examples of the material of the second, high-thermal conductivity layer 14 include metals, such as aluminum and copper. It is necessary that the melting point of these materials should be higher than the temperature of the gas in the turbo-molecular pump 1. It is desirable to employ a ductile material for the second layer 14, which is under the influence of the change in temperature due to the pump compression heat in the turbo-molecular pump 1 and is subject to thermal-expansion/thermal-contraction.

[0034] Preferable examples of the method for forming the second layer 14 by using these materials include surface treatment processings, such as electroless plating, electroplating, vacuum evaporation, and ion plating.

[0035] The thickness of each layer is preferably 10 μm to 5 mm and, more preferably, 50 μm to 100 μm.

[0036] However, to prevent as much as possible the transmission of heat to the blade 12 (62, 72), it is desirable that the first, low-thermal-conductivity layer 13 be relatively thick. On the other hand, it is only necessary for the second layer 14 to be thick enough to maintain the requisite heat capacity to maintain the temperature at which the semiconductor product due to the process gas is sublimated. Generally speaking, the thicker the coating, the greater the inner stress, whichmeans the coating is more subject to swell and separation. Thus, it is desirable for the coating to be relatively thin.

[0037] To further prevent heat transmission to the blade 12 (62, 72), it is possible to adopt a multi-layer structure consisting of more than two layers. It is to be noted in this case that the outermost layer, which directly receives heat, should be a high-thermal-conductivity layer.

[0038] Fig. 3 shows a first embodiment in which the double-layered coating of the present invention is formed on the rotor-wing-side wall surface of the turbo-molecular pump of Fig. 1. The shaded areas in Fig. 3 are the portions where the double-layered coating is formed.

[0039] When the turbo-molecular pump 1 is in operation, the rotor 61 rotates at high speed, and the blades 12 of the rotor wings 62 and of the stator wings 72 receive the process gas, which is at high temperature due to the compression heat, etc., from the direction of the intake port, indicated by the arrow A of Fig. 2. At this time, the second, outermost layers 14 of the blades 62 reach high temperature as a result of receiving the compression heat, etc.

[0040] In this embodiment, however, the first layers 13 have low thermal conductivity, so that the compression heat, etc. are not transmitted, or not easily transmitted, to the rotor blades 12 of the rotor wings 62', on which the double-layered coating of the present invention is formed. Thus, the rotor blades 12 of the rotor wings 62', on which the double-layered coating of the present invention is formed, are free from adverse effects such as creep.

[0041] In particular, adhesion or accumulation of semiconductor product at the distal ends 200 of the rotor blades 12 makes the rotor blades liable to contact with other members or throws the entire wings out of balance during the high-speed rotation of the rotor 60. Thus, it is most desirable to provide the double-layered coating of the present invention. When this eliminates adhesion or accumulation of semiconductor product, there is no need to provide an ABS (Automatic Balancing System) circuit, which has conventionally been provided as needed.

[0042] Further, it is to be noted, in particular, that, in the turbo-molecular pump 1, the inter-blade distance is relatively small in the downstream-side region of the interior of the pump 1, which means the above-mentioned problem due to the adhesion of semiconductor product is likely to occur in this region. To eliminate this problem, the coating of the present invention may be selectively formed on the downstream-side wing blades. Further, it is also possible to provide the coating on the inner wall 250 in the lower portion of the rotor on the downstream side of the pump 1.

[0043] Fig. 4 shows an embodiment in which the double-layered coating of the present invention is formed on the stator-wing-side wall surface and the exhaust-port wall surface of the turbo-molecular pump 1 of Fig. 1. The shaded areas are the portions where the coating is provided. As for the coating on the stator wings 72, it is substantially the same as the coating on the rotor-wing-blades 62 of Fig. 3 described above.

[0044] In this embodiment, the coating of the present invention is also formed on the surface 251 of a member opposed to the inner wall of the rotor 60 on the downstream side of the pump 1, the thread groove spacer portion constituting the thread groove pump portion, the wall 300 of the thread groove, the inner wall of the exhaust port 350, etc.

[0045] While in Figs. 3 and 4 (The components and the device are the same as those of Fig. 1) the coating is formed on the entire rotor wing 60 or the entire stator wing 72, etc., it is also possible for the coating to cover only a part of these wings. Further, it is also possible for the coating to be formed entirely or partially on both the rotor wing 60 and the stator wing 72. Furthermore, as shown in Fig. 4, it is also possible to selectively form the coating on portions other than the wings, such as the wall surface 350 of the exhaust port.

[0046] The above-described embodiment is applicable not only to the turbo-molecular pump 1, but also to other mechanical vacuum pumps in general, such as a drag pump. The above embodiments provide the following advantages.

(1) Upon receiving compression heat, etc., the second layer 14, which is a high-thermal-conductivity coating formed on the surface of the rotor wing 62' or the stator wing 72' provided with the double-layered coating of the present invention, undergoes an increase in temperature. However, the first layer 13, which is between the blade 12 and the second layer 14 and which is a low-thermal-conductivity coating, does not allow heat transmission to the blade 12, or makes it difficult for heat to be transmitted thereto. Thus, the blade 12 does not undergo thermal deformation, creep, etc., thereby achieving an improvement in durability with respect to heat of the rotor wing 62' or the stator wing 72' which is provided with the double-layered coating of the present invention. Further, the second layer 14 of the surface coating of the rotor wing 62' or the stator wing 72' is not cooled, so that the sublimation of the semiconductor product, which would otherwise adhere to or accumulate on the wing surface, is smoothly effected.

(2) Since the heat transmission between the second, high-thermal-conductivity layer 14 and the blade 12 is restrained by the first, low-thermal-conductivity layer 13, it is possible to cool the wing blades without lowering the temperature of the second layer 14.

(3) Further, if the temperature of the heat for sublimating the semiconductor product which would accumulate on the wing surface is not lower than the resistance temperature of the blades 12, it is possible to apply to the wing surface heat which is at a temperature not lower than the resistance heat of the material forming the blade 12 due to the insulating effect of the first layer 13. As a result, there is no need to perform strict control on the temperature in the turbo-molecular pump 1 for sublimating the semiconductor product which would adhere to the surface of the rotor wing 62' or the stator wing 72' provided with the double-layered coating of the present invention. That is, it is possible to set the surface temperature of the blades, etc. relatively high, without being restricted by the permissible temperature of the blades 12 (62, 72) as in the prior art. Further, the sublimation of the semiconductor product which would otherwise adhere to the rotor wing 62' or the stator wing 72' is promoted.

(4) It is possible to make it impossible or difficult for heat to be transmitted to surfaces other than the surface of the rotor wing 62' or the stator wing 72' provided with the double-layered coating of the present invention, such as the inner walls 250 and 350 of the turbo-molecular pump 1, which are exposed to high-temperature process gas. Thus, in these portions also, the blades are free from the influence of heat, allowing smooth sublimation of semiconductor product which would otherwise adhere to or accumulate on these portions. Thus, the number of times that the interior of the turbo-molecular pump 1 is cleaned is reduced, thereby reducing maintenance cost.

INDUSTRIAL APPLICABILITY

[0047] As described above, in the vacuum pump device of the present invention, it is possible to prevent compression heat, etc. from being transmitted from the high-thermal-conductivity layer to the blades which are members in the vacuum pump device, whereby the compression heat, etc. does not adversely affect the blades by, for example, reducing the material strength thereof. Further, the semiconductor product due to the process gas is smoothly sublimated.

Claims

1. A vacuum pump device, wherein there is formed on a member in the vacuum pump device a double-layered coating comprising a first layer (13) consisting of a low-thermal-conductivity film and a second layer (14) formed on the first layer and consisting of a high-thermal-conductivity film.

2. A vacuum pump device according to Claim 1, wherein the vacuum pump device is a turbo-molecular pump device comprising a rotor main body (61) rotated by a motor, rotor wings (62) arranged and secured in a plurality of stages in the rotating axis direction of the rotor main body (61) and provided with a plurality of radial rotor blades inclined by a predetermined angle with respect to the rotating axis of the rotor main body (61), and stator wings (72) arranged and secured in a plurality of stages between the rotor wings (62) and provided with a plurality of radial stator blades inclined by a predetermined angle with respect to the rotating axis of the rotor main body (61), and wherein said double-layered coating is provided on at least one of the rotor wings (62), the stator wings (72), and an exhaust flow passage.

FIG.1

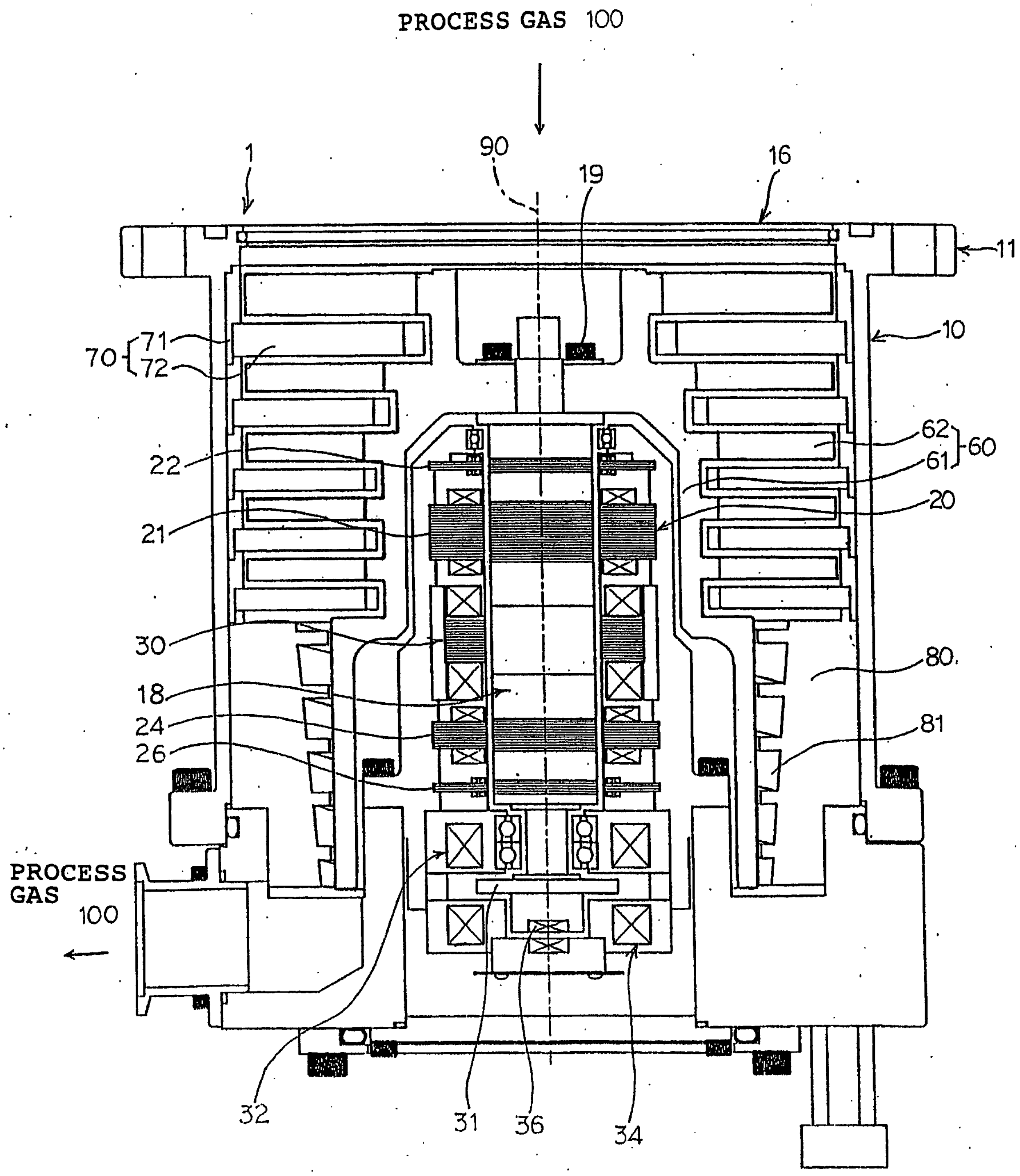

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FIG.2

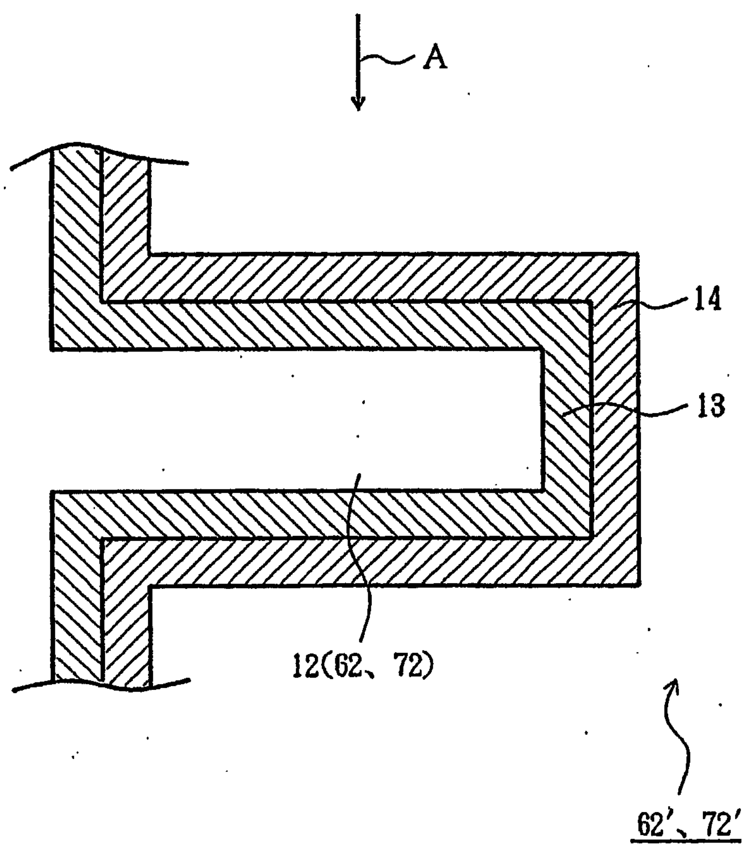

FIG.3

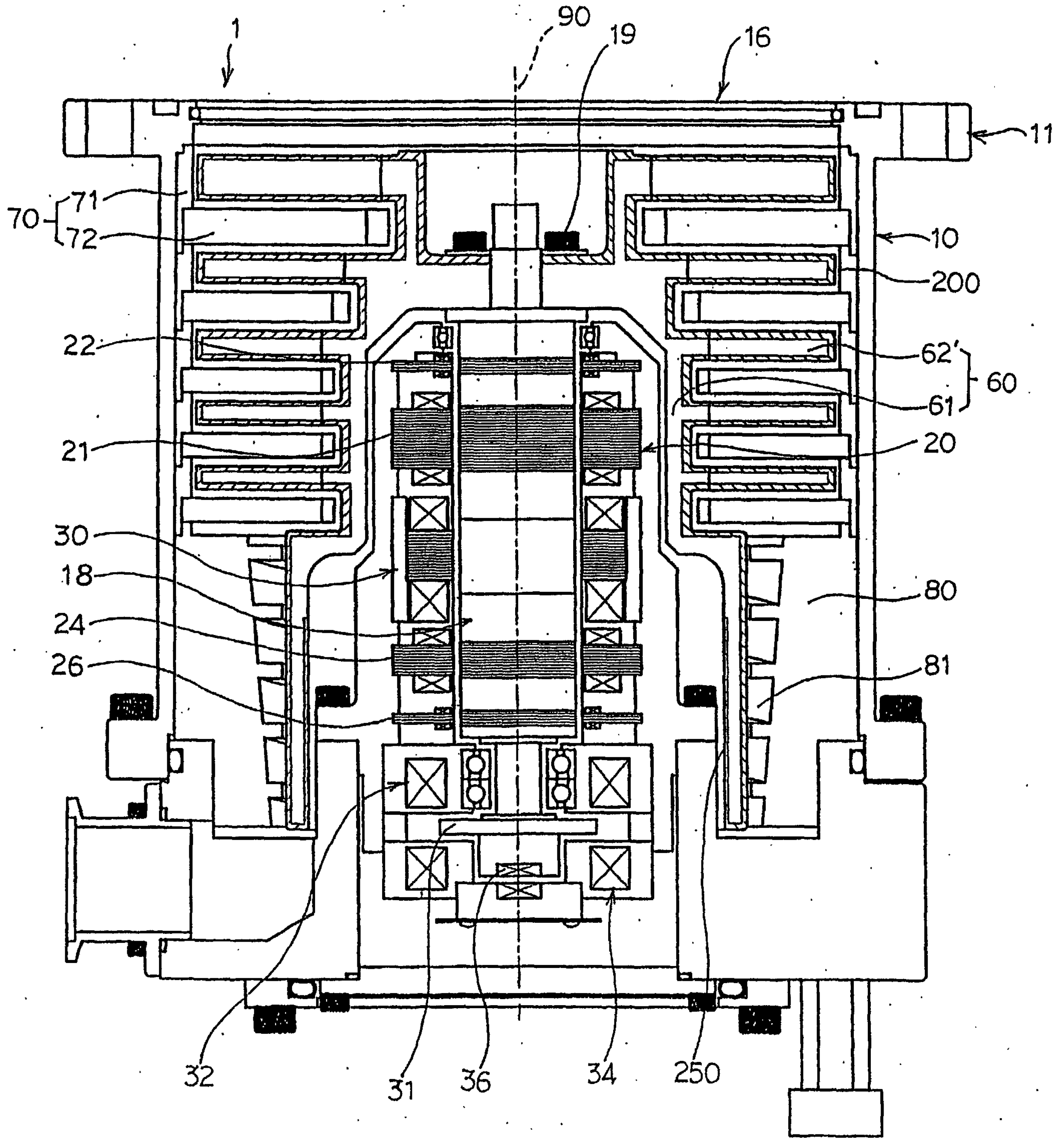
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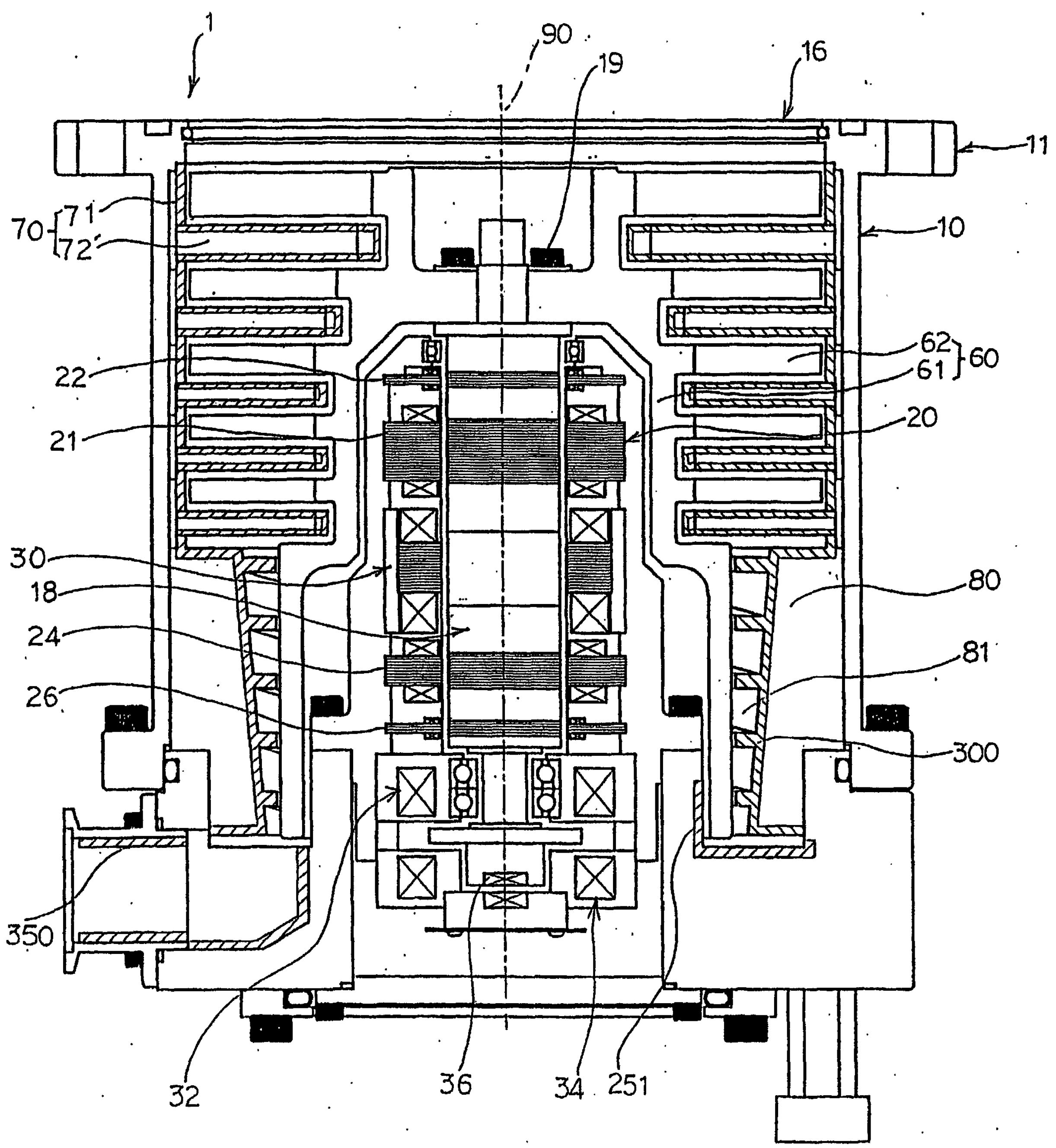
FIG.4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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/00429

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 F04D19/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^7 F04D19/04

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

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2000
Kokai Jitsuyo Shinan Koho	1971-2000	Jitsuyo Shinan Toroku Koho	1996-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 1-305197, A (Daikin Ind. Ltd.), 08 December, 1989 (08.12.89), Full text, Figs. 1-6 (Family: none)	1-2
Y	JP, 63-230989, A (Hitachi, Ltd.), 27 September, 1988 (27.09.88), Full text, Fig. 1 (Family: none)	2

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
26 April, 2000 (26.04.00)	16 May, 2000 (16.05.00)

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