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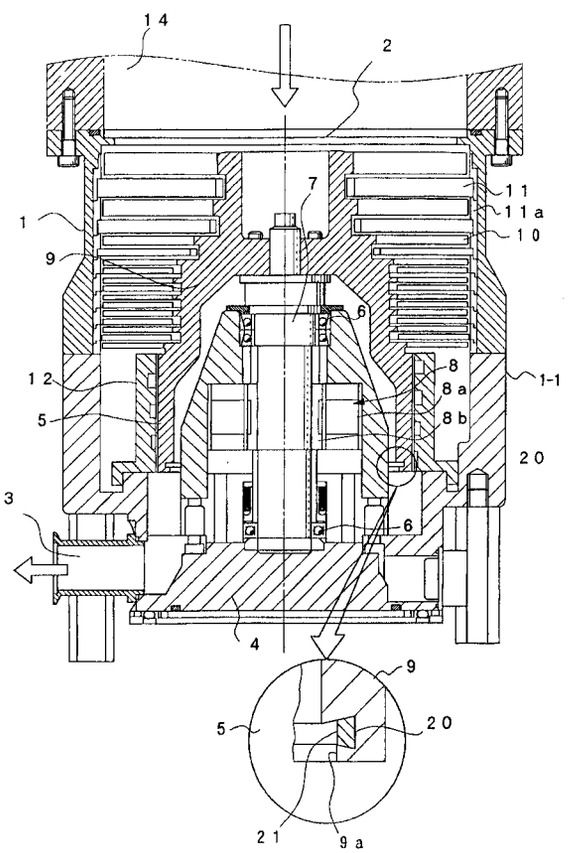
(54) Vacuum pump

(57) The present invention provides a vacuum pump having a small possibility of causing a damage of a rotor (9), excellent in working efficiency of the balancing of the rotor, and capable of keeping the balance during a long period of time. A ring shape groove (20) is formed at a lower portion side internal surface of a rotor along the circumferential direction of the rotor. A weight (21) for catching the balance of the rotor is fitted in and attached to the ring shape groove. Accordingly, there is no change of the section and no notch in the circumferential direction of the outer circumference of the rotor so that the stress concentration or the like is not caused and the maximum stress of the rotor is reduced, whereby the damage of the rotor is not easily caused.

FIG. 1



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Description

[0001] The present invention relates to a vacuum pump used for a semiconductor manufacturing apparatus, and particularly, to a structure for catching eccentric balance of a rotor thereof.

[0002] A vacuum pump such as a turbo molecular pump is employed as means for exhausting gas in a chamber in such a step that processes are performed in a process chamber (hereinafter, referred to as "chamber") of high vacuum, such as a dry etching step of semiconductor manufacturing process or a CVD process.

[0003] Fig. 5 shows a conventional basic structure of this kind of vacuum pump. A pump case 1 of a vacuum pump shown in Fig. 5 is provided with a gas inlet port 2 at the upper surface and an exhaust pipe that serves as an exhaust port 3 at one side portion of the lower portion, is formed in a cylindrical-shape and is attached to a base 1-1.

[0004] The bottom portion of the base 1-1 is covered with an end plate 4, and a stator column 5 is provided so as to be erected at the center portion of an internal bottom surface thereof.

[0005] A rotor shaft 7 is rotatably bored through an upper ball bearing 6 and a lower ball bearing 6 at the center of the stator column 5.

[0006] A driving motor 8 is arranged inside the stator column 5. The driving motor 8 has a structure in which a stator element 8a is disposed inside the stator column 5 and a rotator element 8b is disposed on the rotor shaft 8, and it is structured such that the rotor shaft 7 is rotated about the shaft.

[0007] A rotor 9, which covers the outer circumference of the stator column 5 and is formed in a section-shape, is connected to the upper portion protrusion end from the stator column 5 of the rotor shaft 7.

[0008] A plurality of rotor blades 10 and a plurality of stator blades 11, which are processed and formed in a blade-shape, are alternately disposed along the rotation center shaft of the rotor 9 between the upper portion side outer circumferential surface of the rotor 9 and the upper portion side inner wall of the pump case 1.

[0009] The rotor blades 10 are integrally disposed with the rotor 9, to thereby be integrally provided with the upper portion side outer circumferential surface of the rotor 9. Further, the rotor blades 10 can be integrally rotated with the rotor 9. However, the stator blades 11 are positioned and arranged between the upper stage and the lower stage of the rotor blades 10, 10 through a spacer 11a positioned at the upper portion side inner wall of the pump case 1. Further, the stator blades 11 are attached and fixed to the inner wall side of the pump case 1.

[0010] A fixed screw stator 12 is arranged at the position opposing the lower portion side outer circumferential surface of the rotor 9. The screw stator 12 is formed in a cylindrical-shape so that the entire shape thereof surrounds the lower portion side outer circumferential surface of the rotor 9, and integrally attached and fixed to the base 1-1. Note that a thread groove is formed inside the screw stator 12, that is, at the surface side opposing the rotor 9.

[0011] The vacuum pump shown in Fig. 5 is employed as means for exhausting gas in the chamber 14 as described above. However, in this used state, the vacuum pump shown in Fig. 5 is attached and fixed to the lower surface side opening portion of the chamber 14.

[0012] The operation of the above vacuum pump will be described. In the vacuum pump, an auxiliary pump (not shown) connected to the gas exhaust port 3 is operated to cause the inside of the chamber 14 to enter the vacuum state of some degrees. Thereafter, the driving motor 8 is operated to rotate the rotor 9 and the rotor blades 10 at high speed integrated with the rotor shaft 7.

[0013] Thus, the rotor blade 10 of the uppermost stage rotating at high speed imparts downward momentum to gas molecules entered from the gas inlet port 2. The gas molecule including the downward momentum is guided to the stator blade 11 and sent into the side of the rotor blade 10 of the next lower stage. The above momentum impartment to a gas molecule and the sending operation are repeated in a lot of stages. As a result, the gas molecule of the side of the gas inlet port 2 is sequentially moved to the inside of the screw stator 12 of the lower portion side of the rotor 9. The exhausting operation of the gas molecule is caused due to interaction between the rotating rotor blades 10 and the fixed stator blades 11.

[0014] The gas molecule, which has reached the screw stator 12 of the lower portion side of the rotor 9 through the above described gas molecule exhausting operation, is compressed by interaction between the rotating rotor 9 and the thread groove formed inside the screw stator 12, and is moved to the side of the gas exhaust port 3, and then is exhausted to the exterior through the auxiliary pump (not shown) from the gas exhaust port 3.

[0015] Incidentally, it is understood that in the vacuum pump having the above described structure, it is capable of catching balance thereof while a rotation body composed of a rotor 9 and rotor blades 10 rotates at high speed in the pump assembling and manufacturing steps. Such methods for catching the balance include: 1) a method for partially cutting the outside or the inside of the rotor 9 with a drill or a router; and 2) a method for adding a weight to the outside or the inside of the rotor 9 with an adhesive or the like.

[0016] However, in the above cut method D, the cutting is performed and thereafter a hole is formed in a balancing structure. Therefore, the stress due to centrifugal force of the rotor 9 concentrates on the hole portion, and the maximum stress of the rotor 9 rises. Consequently, damage of the rotor 9 easily occurs.

[0017] In particular, the conventional vacuum pump shown in Fig. 5 is designed such that the described above balancing of the rotor 9 is conducted at two po-

sitions of the upper portion and the lower portion of the rotor 9. However, the lower portion side of the rotor 9 has a larger diameter and larger centrifugal force than the upper portion side of the rotor 9, resulting in having a high possibility that damage of the rotor 9 is caused due to the hole, cut for catching the balance at the lower portion side of the rotor 9, in the balancing structure of the cut method shown in the above 1).

[0018] When a weight is added to the outside of the rotor 9 with an adhesive or the like, there is a defect in which the weights falls by centrifugal force, resulting in making it impossible to obtain the rotor 9 capable of catching the balance during a long period of time, in the balancing structure of an addition method shown in the above 2). Further, when the weight is added to the inside of the rotor 9 with an adhesive or the like, it takes a lot of time to perform solidification thereof. Therefore, there is a problem in that a lead time of the pump assembling and manufacturing steps is extended. In this case, there can be considered a method of applying an ultraviolet curing type adhesive. However, in the method, it is necessary that the inside of the rotor 9 is irradiated with ultraviolet rays, resulting in degrading the working efficiency of the weight attachment.

[0019] The present invention is made for solving the above described problems and an object of the present invention is to provide a vacuum pump having a small possibility of causing damage of a rotor, excellent in working efficiency of the balancing of the rotor, and capable of keeping the balance during a long period of time.

[0020] To attain the above described object, according to the present invention, it is characterized by comprising: a pump case forming an inlet port at an upper surface; a cylinder-type rotor provided rotatably in the pump case; rotor blades provided integrally with the outer circumferential surface of the rotor; stator blades positioned and arranged between the rotor blades or at the outside thereof; a driving motor for rotating the rotor; and a ring shape groove formed at the internal surface of the lower portion side of the rotor along the circumferential direction thereof, in which a weight for catching the balance of the rotor is fit and attached.

[0021] According to the present invention, there is no change of the section and no notch in the circumferential direction of the outer circumference of the rotor so that the stress concentration or the like is not caused and the maximum stress of the rotor is reduced. Also, the balancing structure of the rotor is different from the conventional structure of attaching the weight which is conducted only with an adhesive . It is structured such that this kind of weight is fit in and attached to the ring shape groove of the rotor, thereby preventing the weight from easily falling off from the rotor, being capable of keeping the balance of the rotor during a long period of time, and being excellent in working efficiency of the balancing of the rotor.

[0022] The present invention is characterized in that the ring shape groove forms a dovetail groove in which the weight is press fit. According to such a structure, the weight that is fitted in and attached to the dovetail groove is subjected to prevention of slip out by a reverse taper action with respect to the slip out direction thereof, thereby being capable of holding the weight at the attachment position more securely.

[0023] The present invention is characterized in that the internal surface of the rotor, from the lower portion opening end of the rotor to the ring shape groove, is cut to provide a cut out portion formed thereby. According to this structure, the rotor internal diameter of the ring shape groove lower portion side is enlarged due to the cut out portion. Therefore, when the balance of the rotor is caught in the pump assembling and manufacturing steps, a finger is directly put inside this rotor, and thus the weight for catching the balance can be fit in and attached to the ring shape groove while the rotor remains set in an inspection device for catching the balance. In this concern, the working efficiency in the balancing of the rotor becomes more excellent.

[0024] The present invention is characterized in that the plurality of ring shape grooves are provided in a vertical direction of the rotor. According to the structure, one large ring shape groove can be divided into a plurality of small ring shape grooves and arranged. Therefore, the weight is attached to and fit in more positions as compared with the case of forming one large ring shape groove. As a result, the number of weights having the same weight is increased, thereby being capable of adapting to the large imbalance.

[0025] The present invention is characterized in that when the weight is accommodated in a box body provided with leaf spring members on both sides thereof, and the body box including the weight is inserted and set in the ring shape groove, the leaf spring members of the body box cause an elasticity return and are pressed by the inner walls of the ring shape groove to be in contact therewith, whereby the weight together with the box body is fitted in and attached to the ring shape groove.

[0026] The present invention is characterized in that the leaf spring member is folded into a U-shape, a holder including pinching pieces is used, which are constituted by further folding back externally the both sides of the folded end and the weight is fixed integrally to the inner side bottom portion formed in a U-shape of the holder, and that when the holder including the weight is inserted and set in the ring shape groove, the pinching pieces of the holder cause an elasticity return to be pressed by the inner walls of the ring shape groove to be in contact therewith, whereby the weight together with the holder is fitted in and attached to the ring shape groove.

[0027] Embodiments of the present invention will now be described by way of further example only and with reference to the accompanying drawings, in which:-

Fig. 1 is a sectional view of a vacuum pump showing

an embodiment of the present invention.

Figs. 2A, 2B and 2C are diagrams showing another structural example of a weight which is fitted in and attached to a ring shape groove of the vacuum pump shown in Fig. 1: Fig. 2A is a perspective view of a box body having leaf spring members, in which the weight is accommodated; Fig. 2B is an explanatory view showing a state just before the attachment of the box body to the ring shape groove; and Fig . 2C is an explanatory view showing a state after the attachment of the box body to the ring shape groove.

Fig. 3 is a diagram showing still another structural example of the weight which is fitted in and attached to the ring shape groove of the vacuum pump shown in Fig. 1.

Fig. 4 is a sectional view of a vacuum pump showing another embodiment according to the present invention.

Fig. 5 is a sectional view of a vacuum pump of the conventional example.

[0028] An embodiment of a vacuum pump according to the present invention will be described below in detail with reference to the attached drawings. Incidentally, the basic structure of a vacuum pump is the same as that of the conventional example. Therefore, the same symbols will be used to designate the same components and the specific explanation will be omitted.

[0029] In the vacuum pump shown in Fig. 1, a ring shape groove 20 is formed at the lower portion side internal surface of the rotor 9 along the circumferential direction of the rotor. The ring shape groove 20 forms a dovetail groove as shown in a partial enlarged view of Fig. 1 and is formed a little above from the lower portion opening end of the rotor 9.

[0030] A weight 21 is fitted in and attached to the ring shape groove 20, which is used for catching the balance during a high speed rotation of the rotor 9 in the pump assembling and manufacturing steps.

[0031] Thus, the present invention adapts the structure in which the ring shape groove 20 is formed in the lower portion side internal surface of the rotor 9 and the weight 21 is fitted in and attached to the ring shape groove 20, to thereby balance the rotor 9.

[0032] According to the balancing structure of the above described present embodiment, there is no change of the section and no notch in the circumferential direction of the outer circumference of the rotor 9, so that the stress concentration or the like is not caused and the maximum stress of the rotor 9 is reduced, whereby the damage of the rotor 9 is not easily caused.

[0033] The materials applicable to the weight 21 include lead, copper, aluminum, solder material, or a high polymer elastic body mixing metal powder and the like such as a viton rubber (fluorocarbon rubber) mixed with SUS (stainless steel) powder, etc. which is consisted of hyperbaric materials, the shape of which easily causes a plastic deformation due to the appliance of pressure.

[0034] In the structure in which the weight 21 is fitted in and attached to the ring shape groove 20, a press fitting structure may be used, in which the weight 21 is directly press fit in the ring shape groove 20 as shown in the partial enlarged view of Fig. 1. However, there can be adopted the structure in which a box body 50 provided with leaf spring members 50a, 50a at both sides thereof is employed to fit the weight in the ring shape groove 20 to be attached thereto as shown in Fig. 2. In this structure, it is assumed that the weight 21 is accommodated in the box body 50 so as to be integrated therewith. When the box body 50 including such weight 21 is fitted in and attached to the ring shape groove 20, it is sufficiently achieved if the leaf spring members 50a, 50a are pressed from the surfaces of the both sides of the box body 50 to hold the box body 50 and then the box body 50 is inserted into the ring shape groove 20 to be set in this state. When such insertion and set is performed, the leaf spring members 50a, 50a of the box body 50 causes the elasticity return in the ring shape groove 20, and are pressed by the inner walls of the ring shape groove 20 to be in contact therewith. As a result, the weight 21 integrated with the box body 50 is fitted in and attached to the ring shape groove 20. Incidentally, stainless steel is applicable to the material of the box body 50. Also, in the structure of the box body 50 and the weight 21 at the inside thereof, there can be adopted the structure in which the box body 50 is made of stainless steel and the inside of the box body 50 made of stainless steel is filled with stainless steel powder and an epoxy resin to achieve solidification thereof.

[0035] Further, as another structure in which the weight 21 is fitted in and attached to the ring shape groove 20, there can be adopted the structure in which a holder 60 having the shape as shown in Fig. 3 is employed. In the shape of the holder 60, a leaf spring member 60a is folded into a U-shape and the holder 60 has pinching pieces 60b, 60b that are obtained by further folding back externally the both folded ends. The weight 21 is integrally fixed to the inner side bottom portion formed in a U-shape of the holder 60 having such shape due to a caulking process, etc. When the holder 60 including the weight 21 is fitted in and attached to the ring shape groove 20, it is sufficiently achieved if the pinching pieces 60b, 60b are pressed from the surfaces of both sides of the holder 60 to hold the holder 60, and then the holder 60 is inserted into the ring shape groove 20 to be set in this state. When such insertion and set is performed, the pinching pieces 60b, 60b of the holder 60 causes the elasticity return in the ring shape groove 20, and are pressed by the inner wall of the ring shape groove 20 to be in contact therewith. As a result, the weight 21 together with the holder 60 is fitted in and attached to the ring shape groove 20.

[0036] According to the attached and fitted structure of the weight 21 using the box body 50 or the holder 60, the box body 50 or the holder 60 can be slightly moved

in the ring shape groove 20. Therefore, the setting position of the weight 21 in the ring shape groove 20 is finely adjustable with ease as compared with the structure in which the weight 21 is directly fixed to the inside of the ring shape groove 20 by press fitting, and the working efficiency of the balancing of the rotor 9 is excellent.

[0037] According to the attached and fitted structure of the weight 21 using the box body 50 or the holder 60, the setting position of the weight 21 is finely adjusted and thereafter the box body 50 or the holder 60 is adjunctively fixed with an adhesive. However, the fixation with an adhesive may be omitted, if not necessary. Further, even when the weight 21 is directly press fit to the ring shape groove, the weight 21 may be adjunctively fixed with an adhesive, if necessary. When an ultraviolet curing type adhesive is used as this kind of adhesive, the position of the rotor 9 is inclined in some cases so that an application portion of the adhesive is irradiated sufficiently with an ultraviolet rays. However, the weight 21 is fixed to the ring shape groove 20 by press fitting or through the box body 50 or the holder 60, thereby preventing the weight 21 from falling off, even in this case. Further, the position of the rotor 9 can be freely set at the time of irradiation of an ultraviolet rays. Therefore, the adhesive by which the weight 21 is adjunctively fixed has a satisfactory working efficiency in its solidification.

[0038] In the internal surface of the rotor 9, from the lower portion opening end of the rotor 9 to the ring shape groove 20, there is provided a cut out portion 9a, which is formed by cutting the above internal surface by a small area. The internal diameter of the rotor 9 of the lower portion side of the ring shape groove 20 is enlarged by the cut out portion 9a. Thus, there is adopted such a structure that the internal diameter of the rotor 9 of the lower portion side of the ring shape groove 20 is enlarged because the working efficiency is improved in the case where the weight 21 is fitted in and attached to the ring shape groove 20.

[0039] That is, when the balance of the rotor 9 is caught in the pump assembling and manufacturing steps, first, the rotor 9 is set in the inspection device. The rotor 9 is rotated at high speed on the inspection device, thereby specifying the eccentric load of the rotor 9 and the position thereof. Next, the weight 21 is fitted in and attached to the ring shape groove 20 on the basis of the data of the eccentric load or the position. In this case, the present embodiment adopts the structure in which the internal diameter of the rotor 9 of the lower portion side of the ring shape groove 20 is enlarged by the cut out portion 9a, so that a finger is directly put inside the rotor 9 to make it possible to fit the balancing weight 21 in the ring shape groove 20 to be attached while the rotor 9 remains set in the inspection device.

[0040] Therefore, according to the vacuum pump of the present embodiment, even when the operation in which the data of the eccentric load of the rotor 9 and the data of the position of the rotor 9 are obtained, and the press fitting operation of the weight 21, which is conducted on basis of the above data, are repeated several times in the pump assembling and manufacturing steps, it is not necessary to remove the rotor 9 from the inspection device every time. Thus, the balancing operation of the rotor 9 can be smoothly performed.

[0041] Note that, the described above embodiment makes a description as to the example where one ring shape groove 20 is provided in the lower portion side internal surface of the rotor 9. However, as this kind of ring shape groove 20, there may be provided two ring shape grooves composed of two stages or more ring shape grooves in a vertical direction of the rotor 9 as shown in Fig. 4. According to the structure including the ring shape groove 20 consisted of a plurality of stages, one large ring shape groove can be divided into a plurality of small ring shape grooves and arranged. Therefore, the number of the positions which the weight 21 is fitted in and attached to is increased as compared with the case where one large ring shape groove is formed. As a result, the number of the weights 21 having the same weight is increased, thereby being capable of adapting to the large imbalance.

[0042] In the described above embodiment, the example using the ring shape groove 20 formed in the dovetail groove shape has been described. However, the ring shape groove 20 is also capable of employing the ones that have the rectangular section.

[0043] In the described above embodiment, the description has been made for the example where the present invention is applied to a turbo molecular pump. However, the present invention is also applicable to the other pumps with use of rotation such as a drag pump or the like. Further, a magnetic bearing, an air bearing, or the like may be used in addition to a ball bearing as a bearing of the rotor shaft 7.

[0044] As described above, according to the present invention, there is adopted the structure in which a ring shape groove is formed along a circumferential direction of the lower portion side internal surface of a rotor, and a weight for catching the balance of the rotor is fit in and attached to the ring shape groove. Therefore, the stress increased shape is not formed in the rotor unlike in the conventional method where an area of the rotor is cut away in order to balancing of the rotor through the processing. Further, the stress concentration is not caused due to the shape, either. Therefore, the maximum stress of the rotor is reduced and the damage of the rotor can be effectively avoided. Still further, the balancing structure of the rotor is different from the conventional structure in which the weight is attached only by an adhesive. The present invention is structured such that this kind of weight is fit in and attached to the ring shape groove of the rotor. Therefore, the weight is not easily fallen off from the rotor and the balance of the rotor can be kept during a long period of time. Also, the working efficiency of the balancing of the rotor is excel-

lent.

[0045] 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 pump comprising:

a pump case (1) forming an inlet port (2) at an upper surface;
a rotor (9) provided rotatably in the pump case;
rotor blades (10) provided integrally with an outer circumferential surface of the rotor;
stator blades (11) positioned and arranged between the rotor blades or at the outside thereof;
a driving motor (8) for rotating the rotor; and
a ring shape groove (20) formed at an internal surface of a lower portion side of the rotor.

2. A pump according to claim 1, the pump further comprising a weight (21) is fitted in and attached to the ring shape groove.

3. A pump according to claim 1 or 2, wherein the ring shape groove forms a dovetail groove.

4. A pump according to claim 3, wherein the weight is press fitted to the dovetail groove.

5. A pump according to any one of claims 1 to 4, wherein the internal surface of the rotor, from a lower portion opening end of the rotor to the ring shape groove, is cut to provide a cut out portion formed thereby.

6. A pump according to any one of claims 1 to 5, wherein the plurality of ring shape grooves are provided in a vertical direction of the rotor.

7. A pump according to any one of claims 1 to 6, wherein when the weight is accommodated in a box body (50;24) provided with leaf spring members on both sides thereof, and the body box including the weight is inserted and set in the ring shape groove, the leaf spring members of the body box cause an elasticity return and are pressed by the inner walls of the ring shape groove to be in contact therewith, whereby the weight together with the box body is fitted in and attached to the ring shape groove.

8. A pump according to any one of claims 2 to 6, wherein a leaf spring member (60) is folded into a U-shape, a holder including pinching pieces is used, which are constituted by further folding back externally the both sides of the folded end, and the weight is fixed integrally to the inner side bottom portion formed in a U-shape of the holder, and

that when the holder including the weight is inserted and set in the ring shape groove, the pinching pieces of the holder cause an elasticity return to be pressed by the inner walls of the ring shape groove to be in contact therewith, whereby the weight together with the holder is fitted in and attached to the ring shape groove.

9. A pump as claimed in any one of the preceding claims in which said pump is a vacuum pump.

FIG. 1

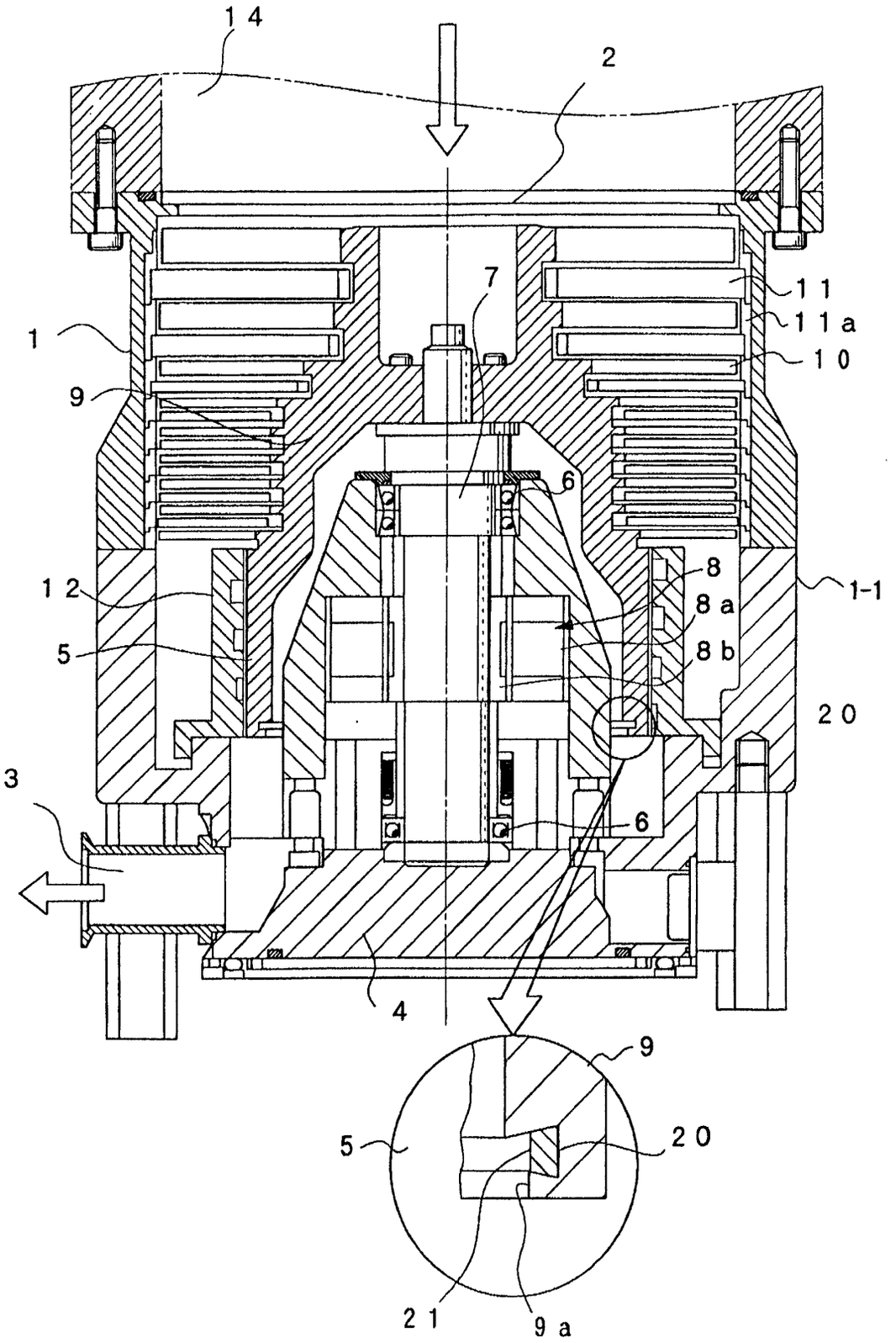


FIG. 2A

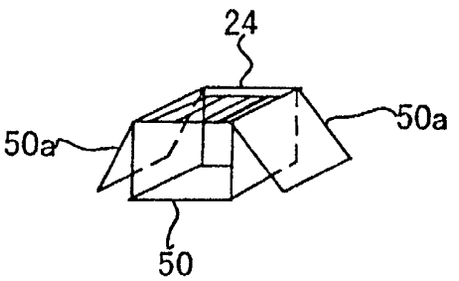


FIG. 2B

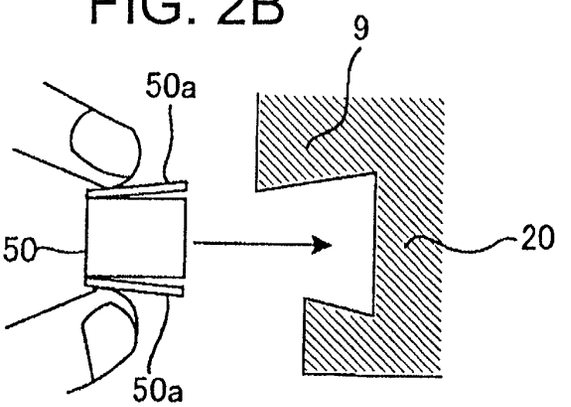


FIG. 2C

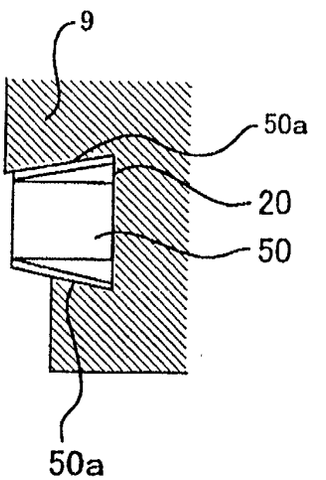


FIG. 3

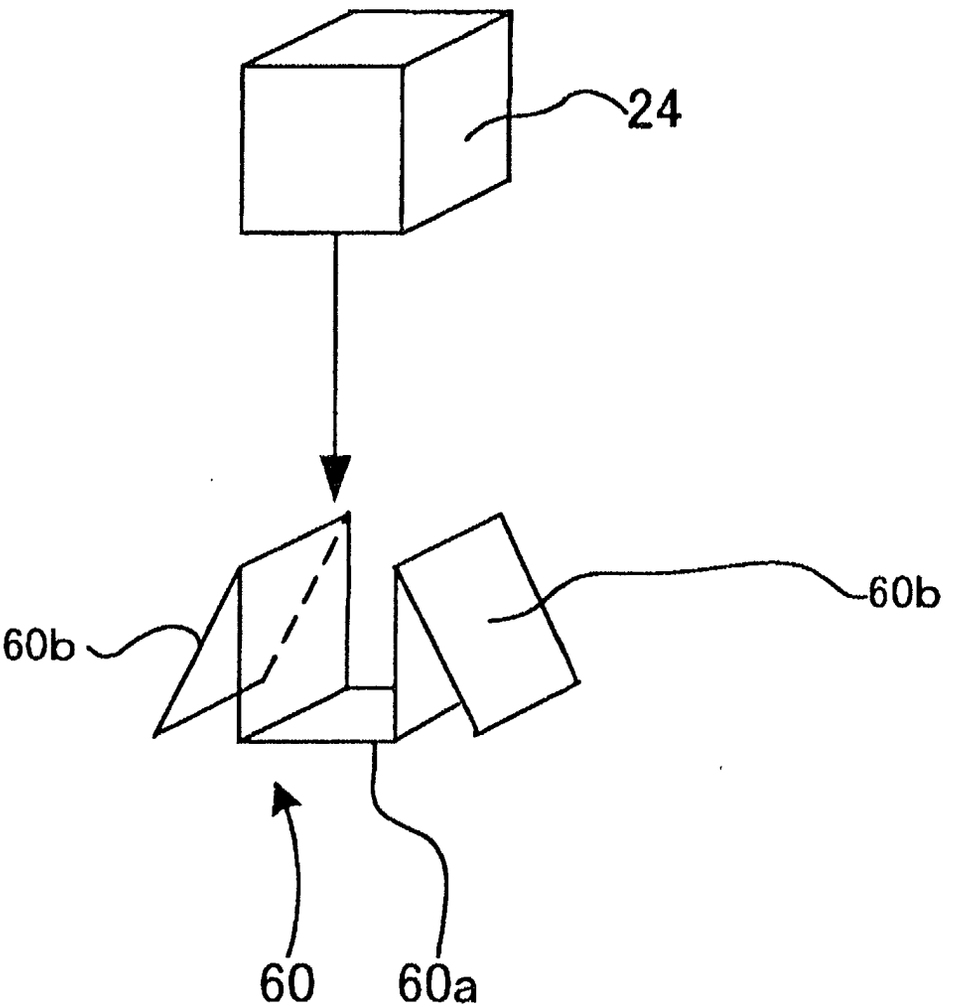


FIG. 4

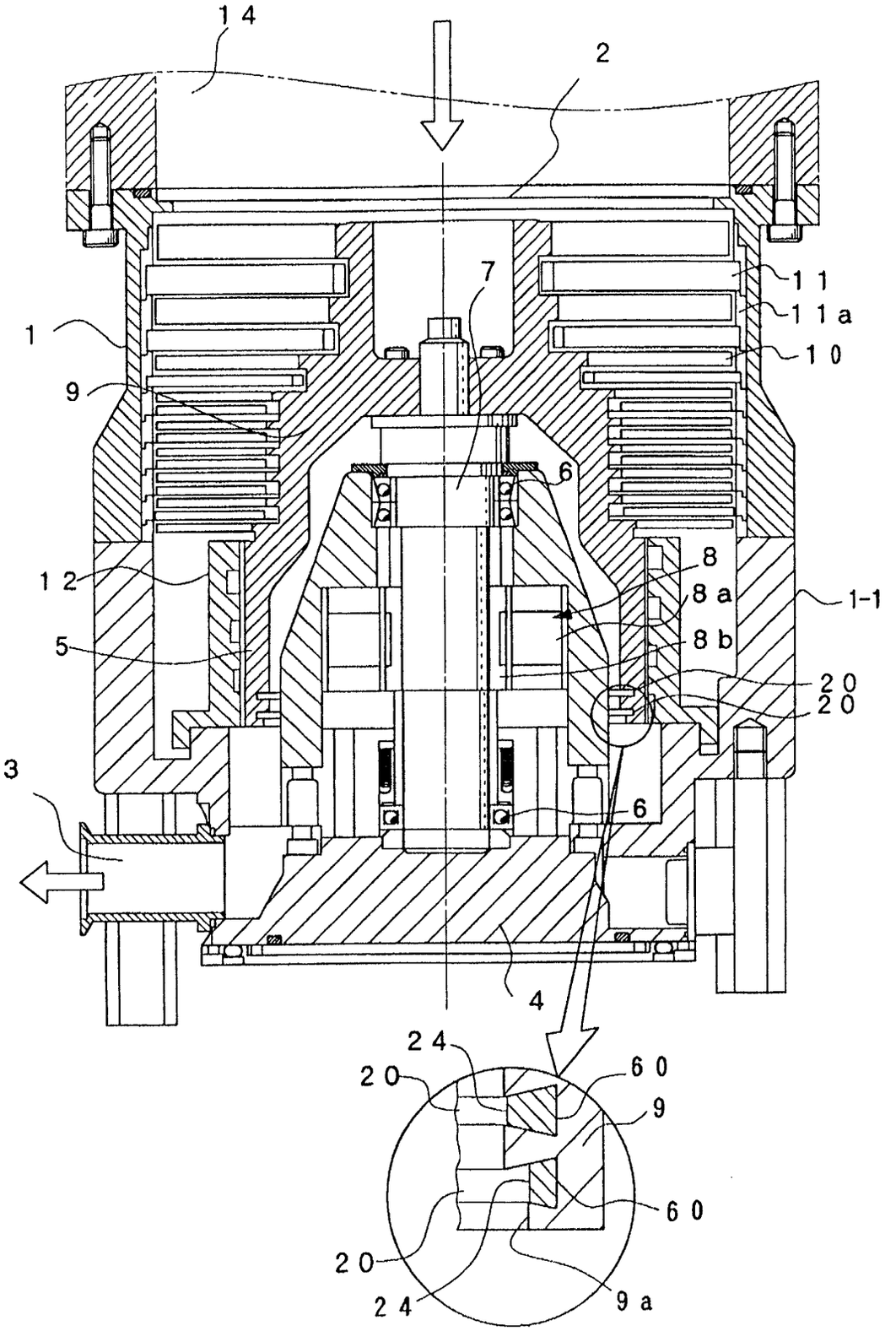
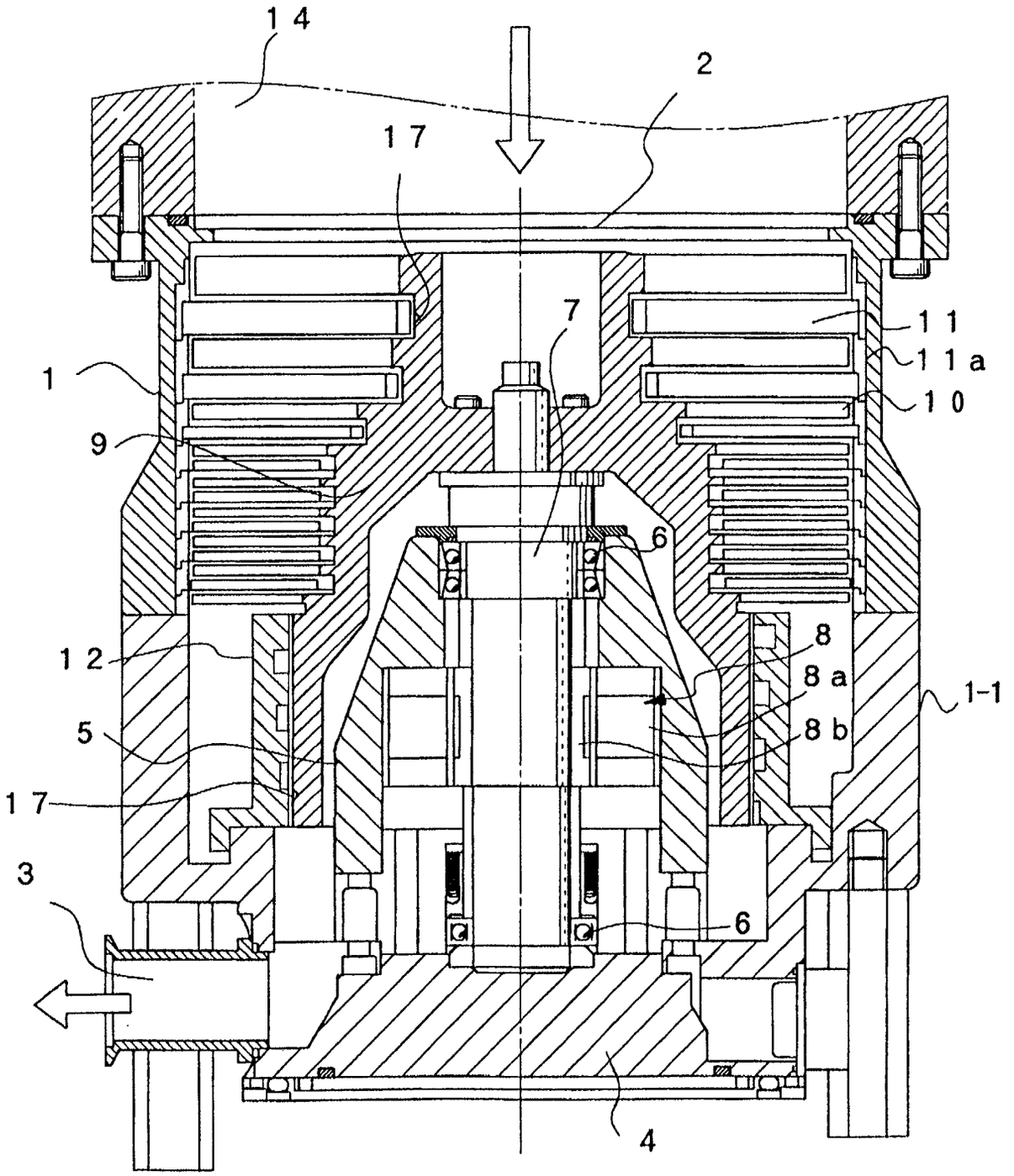


FIG. 5



Prior Art

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 25 2919

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 536 148 A (NISHIUCHI AKIRA ET AL) 16 July 1996 (1996-07-16) * column 4, line 16 - line 32; figure 4 *	1,2,6,9	F04D19/04 F04D29/66
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F04D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	5 September 2002	Fistas, N

CATEGORY OF CITED DOCUMENTS

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