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(54) **COMPRESSOR**

VERDICHTER

COMPRESSEUR

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a compressor to be used in, for example, air conditioners, refrigerators and the like.

### BACKGROUND ART

**[0002]** Conventionally, there has been provided a compressor which has a closed container, a compression element placed within the closed container, and a motor placed within the closed container and acting to drive the compression element via a shaft, and in which an integral structure part is formed by integrally assembling the compression element and a rotor of the motor via the shaft (see JP 3586145 B). The document US 5,087,170 represents the closest prior art to the subject-matter of the invention and discloses a rotary compressor having the features of the preamble of claim 1.

**[0003]** The document US2006/0171835 discloses another example of a rotary compressor according to the background art.

### SUMMARY OF INVENTION

#### TECHNICAL PROBLEM

**[0004]** However, with the conventional compressor shown above, there is a likelihood that the integral structure part of the compression element and the rotor may have a natural frequency five times the number of rotations of the compressor under its operation. With the natural frequency of the integral structure part equal to five times the number of rotations of the compressor under its operation, large noise and vibrations would occur during the operation of the compressor as a problem.

**[0005]** Accordingly, an object of the present invention is to provide a compressor enabled to prevent large noise and vibrations during the operation of the compressor.

#### SOLUTION TO PROBLEM

**[0006]** In order to achieve the above object of the invention there is provided a compressor having the features of claim 1. According to the compressor of the invention, since the natural frequency of the integral structure part of the compression element and the rotor is larger than five times the maximum number of rotations of the compressor under its operation, large noise and vibrations during the operation of the compressor can be prevented within a range of the number of rotations of the compressor under its operation.

**[0007]** According to the compressor of the invention, since the bearing provided in the compression element to support the shaft is inserted into the large-diameter portion of the rotor core of the rotor, the integral structure

part of the compression element and the rotor can be reduced in axial size, allowing a reduction in variations and an improvement in rigidity to be achieved, so that the natural frequency can be increased more reliably.

Thus, large noise and vibrations during the operation can be reduced and moreover the cost can be reduced.

**[0008]** In one embodiment, a refrigerant in the closed container is carbon dioxide.

**[0009]** According to the compressor of the embodiment, since the refrigerant in the closed container is carbon dioxide, which is a refrigerant having large refrigerating capacity per unit volume, downsizing of the cylinder chamber of the compression element causes the diameter of the shaft as well as the diameter of the bearing to be narrowed, resulting in lowered rigidity and making it difficult to increase the natural frequency. Therefore, the arrangement that the bearing is inserted into the large-diameter portion of the rotor core is particularly effective for increasing the natural frequency of the compressor using a refrigerant of large refrigerating capacity.

### ADVANTAGEOUS EFFECTS OF INVENTION

**[0010]** According to the compressor of the invention, since the natural frequency of the integral structure part of the compression element and the rotor is larger than five times the maximum number of rotations of the compressor under its operation, large noise and vibrations during the operation of the compressor can be prevented within a range of the number of rotations of the compressor under its operation.

### BRIEF DESCRIPTION OF DRAWINGS

**[0011]**

Fig. 1 is a longitudinal sectional view showing an embodiment of the compressor of the invention;  
Fig. 2 is a plan view of a main part of the compressor;  
and  
Fig. 3 is a graph showing a relationship between the natural frequency of the integral structure part of the compression element and the rotor and the sound level of the compressor.

### DESCRIPTION OF EMBODIMENTS

**[0012]** Hereinbelow, the present invention will be described in detail by way of embodiment thereof illustrated in the accompanying drawings.

**[0013]** Fig. 1 shows a longitudinal sectional view according to an embodiment of the compressor of the invention. The compressor includes a closed container 1, a compression element 2 placed within the closed container 1, and a motor 3 placed within the closed container 1 and acting to drive the compression element 2 via a shaft 12.

**[0014]** This compressor is a so-called vertical high-

pressure dome type rotary compressor, in which the compression element 2 is placed below and the motor 3 is placed above within the closed container 1. The compression element 2 is driven by a rotor 6 of the motor 3 via the shaft 12. An electric terminal 140 to be electrically connected to the motor 3 is attached to the closed container 1.

**[0015]** The compression element 2 sucks in a refrigerant gas from an accumulator (not shown) through a suction pipe 11. The refrigerant gas can be obtained by controlling unshown condenser, expansion mechanism and evaporator that constitute an air conditioner as an example of a refrigeration system in combination with the compressor. This refrigerant is, for example, carbon dioxide, HC, HFC such as R410A, HCFC such as R22.

**[0016]** In this compressor, a compressed high-temperature, high-pressure refrigerant gas is discharged from the compression element 2 to fill the closed container 1 therewith, while the refrigerant gas is passed through a gap between a stator 5 and the rotor 6 of the motor 3 to cool the motor 3. The refrigerant gas is thereafter discharged outside from a discharge pipe 13 provided on the upper side of the motor 3.

**[0017]** An oil reservoir 9 in which lubricating oil is accumulated is formed in lower portion of a high-pressure region within the closed container 1. This lubricating oil passes from the oil reservoir 9 via an oil passage (not shown) provided in the shaft 12 to move to bearing or other sliding contact portions of the compression element 2 and the motor 3, lubricating the sliding contact portions. This lubricating oil is, for example, polyalkylene glycol (polyethylene glycol or polypropylene glycol etc.) oil, ether oil, ester oil, or mineral oil.

**[0018]** The compression element 2 includes a cylinder 21 fitted to an inner surface of the closed container 1, and an upper-side end plate member 50 and a lower-side end plate member 60 fitted to upper and lower opening ends of the cylinder 21, respectively. A cylinder chamber 22 is defined by the cylinder 21, the upper-side end plate member 50 and the lower-side end plate member 60.

**[0019]** The upper-side end plate member 50 has a disc-shaped body portion 51, and a boss portion 52 provided upwardly at a center of the body portion 51. The shaft 12 is inserted into the body portion 51 and the boss portion 52.

**[0020]** In the body portion 51 is provided a discharge hole 51a communicating with the cylinder chamber 22. A discharge valve 31 is mounted on the body portion 51 so as to be positioned on one side of the body portion 51 opposite to the side on which the cylinder 21 is provided. This discharge valve 31 is, for example, a reed valve which opens and closes the discharge hole 51a.

**[0021]** A cup-type muffler cover 40 is mounted on the body portion 51 on its one side opposite to the cylinder 21 so as to cover the discharge valve 31. The muffler cover 40 is fixed to the body portion 51 by a fixing member 35 (e.g., bolt). The boss portion 52 is inserted into the

muffler cover 40.

**[0022]** The muffler cover 40 and the upper-side end plate member 50 define a muffler chamber 42. The muffler chamber 42 and the cylinder chamber 22 are communicated with each other via the discharge hole 51a.

**[0023]** The muffler cover 40 has a hole portion 43. By the hole portion 43, the muffler chamber 42 and an outer side of the muffler cover 40 are communicated with each other.

**[0024]** The lower-side end plate member 60 has a disc-shaped body portion 61, and a boss portion 62 provided downwardly at a center of the body portion 61. The shaft 12 is inserted into the body portion 61 and the boss portion 62.

**[0025]** In short, one end portion of the shaft 12 is supported by the upper-side end plate member 50 and the lower-side end plate member 60. That is, the upper-side end plate member 50 and the lower-side end plate member 60 constitute a bearing 7, and the shaft 12 is cantilevered by the bearing 7. One end portion (on the support end side) of the shaft 12 intrudes into the cylinder chamber 22.

**[0026]** On the support end side of the shaft 12, an eccentric pin 26 is provided so as to be positioned within the cylinder chamber 22 of the compression element 2. The eccentric pin 26 is fitted to a roller 27. The roller 27 is placed revolvable in the cylinder chamber 22 so that compression action is exerted by revolving motion of the roller 27.

**[0027]** Referring to compression action of the cylinder chamber 22, as shown in Fig. 2, the cylinder chamber 22 is internally partitioned by a blade 28 integrally provided with the roller 27. That is, in a chamber on the right side of the blade 28, the suction pipe 11 is opened in the inner surface of the cylinder chamber 22 to form a suction chamber (low-pressure chamber) 22a. In a chamber on the left side of the blade 28, the discharge hole 51a (shown in Fig. 1) is opened in the inner surface of the cylinder chamber 22 to form a discharge chamber (high-pressure chamber) 22b.

**[0028]** Semicolumnar-shaped bushes 25, 25 are set in close contact with both surfaces of the blade 28 to provide a seal. Lubrication with the lubricating oil is implemented between the blade 28 and the bushes 25, 25.

**[0029]** Then, as the eccentric pin 26 eccentrically rotates along with the shaft 12, the roller 27 fitted to the eccentric pin 26 revolves while the outer circumferential surface of the roller 27 keeps in contact with the inner circumferential surface of the cylinder chamber 22.

**[0030]** As the roller 27 revolves in the cylinder chamber 22, the blade 28 moves back and forth while both side faces of the blade 28 are held by the bushes 25, 25. Then, the low-pressure refrigerant gas is sucked from the suction pipe 11 into the suction chamber 22a and compressed into a high pressure in the discharge chamber 22b, so that a high-pressure refrigerant gas is discharged from the discharge hole 51a (shown in Fig. 1).

**[0031]** Thereafter, as shown in Fig. 1, the refrigerant

gas discharged from the discharge hole 51a is discharged via the muffler chamber 42 outward of the muffler cover 40.

**[0032]** As shown in Fig. 1, the motor 3 has the rotor 6, and the stator 5 placed radially outside of the rotor 6 with an air gap interposed therebetween. That is, the motor 3 is an inner rotor type motor.

**[0033]** The stator 5 has a stator core 510, insulators 530 placed to face both axial end faces, respectively, of the stator core 510, and a coil 520 wound around the stator core 510 and the insulators 530 in common.

**[0034]** The stator core 510, made of a plurality of multilayered steel plates, is fitted into the closed container 1 by shrinkage fit or the like. The stator core 510 has an annular portion (not shown), and a plurality of teeth portions (not shown) protruding radially inwardly from an inner circumferential surface of the annular portion and arrayed circumferentially at equal intervals. The coil 520 is wound around the individual teeth portions and not wound over the plurality of teeth portions, i.e., provided in so-called concentrated winding.

**[0035]** The rotor 6 has a rotor core 610, and magnets (not shown) embedded in the rotor core 610. The rotor core 610 is cylindrical shaped and formed of, for example, multilayered electromagnetic steel plates. Each of the magnets is, for example, a rare-earth flat permanent magnet, and a plurality of the magnets are arrayed at center angles of equal intervals in the circumferential direction of the rotor core 610.

**[0036]** Inside the rotor core 610 are provided a small-diameter portion 610a in upper part and a large-diameter portion 610b in lower part. An inner diameter of the small-diameter portion 610a is smaller than an inner diameter of the large-diameter portion 610b. The shaft 12 is fixed to the small-diameter portion 610a. The bearing 7 that is provided in the compression element 2 to support the shaft 12 is inserted into the large-diameter portion 610b.

**[0037]** That is, an upper end portion of the boss portion 52 of the upper-side end plate member 50 is inserted into the large-diameter portion 610b of the rotor core 610. The inner diameter of the large-diameter portion 610b of the rotor core 610 is formed larger than an outer diameter of the boss portion 52, and a lower end of the rotor core 610 is positioned lower than the upper end of the boss portion 52.

**[0038]** An integral structure part 8 is formed by integrally assembling the compression element 2 and the rotor 6 via the shaft 12. The integral structure part 8 has a natural frequency which is larger than five times the maximum number of rotations of the compressor under its operation.

**[0039]** Fig. 3 shows a relationship between the natural frequency of the integral structure part 8 of the compression element 2 and the rotor 6 and the sound level of the compressor. The horizontal axis represents the natural frequency (Hz) of the integral structure part 8, and the vertical axis represents 5n sound (dB). The pole number of the motor is four, and the operating number of rotations

of the compressor is  $86\text{s}^{-1}$ .

**[0040]** As apparent from Fig. 3, the 5n sound level comes to a maximum when the natural frequency of the integral structure part 8 is 430 Hz. That is, the 5n sound level of the compressor is the largest when the natural frequency of the integral structure part 8 is 430 Hz, which is five times the operating number of rotations of  $86\text{s}^{-1}$  of the compressor.

**[0041]** According to the compressor of this constitution, since the natural frequency of the integral structure part 8 is larger than five times the maximum number of rotations of the compressor under its operation, large noise and vibrations during the operation of the compressor can be prevented within a range of the number of rotations of the compressor under its operation.

**[0042]** Conversely, if the natural frequency of the integral structure part 8 is set to five times the maximum number of rotations, large noise occurs at the maximum number of rotations. Also, if the natural frequency of the integral structure part 8 is set smaller than five times the maximum number of rotations, e.g., set to four times the maximum number of rotations, indeed large noise can be prevented at the maximum number of rotations, but large noise occurs at a number of rotations that is four fifths of the maximum number of rotations.

**[0043]** Now a theory of setting the natural frequency of the integral structure part 8 larger than five times the maximum number of rotations of the compressor under its operation is described. It is known theoretically that modulation components generated between fundamental vibration-exciting force components and 1N components due to vibrational rotations of the rotor, i.e., the vibration-exciting force corresponding to a product of multiplying the number of rotations by (pole number  $\pm 1$ ) increases. As motors commonly used for compressors in many cases have a pole number of four, vibration-exciting force corresponding to a product of multiplying the number of rotations by (pole number  $\pm 1$ ), i.e. by three or five, increases. Accordingly, setting the natural frequency of the integral structure part 8 larger than five times the maximum number of rotations eliminates the likelihood of coincidence between the natural frequency and a frequency three or five times the number of rotations within a range of number of rotations of the compressor under its operation, so that large noise and variations during the operation can be prevented.

**[0044]** Also, since the bearing 7 is inserted into the large-diameter portion 610b of the rotor core 610, the integral structure part 8 can be reduced in axial size, allowing a reduction in variations and an improvement in rigidity to be achieved, so that the natural frequency can be increased more reliably. Thus, large noise and vibrations during the operation can be reduced and moreover the cost can be reduced.

**[0045]** Furthermore, since the refrigerant in the closed container 1 is carbon dioxide, which is a refrigerant having large refrigerating capacity per unit volume, downsizing of the cylinder chamber 22 of the compression ele-

ment 2 causes the diameter of the shaft 12 as well as the diameter of the bearing 7 to be narrowed, resulting in lowered rigidity and making it difficult to increase the natural frequency. Therefore, the arrangement that the bearing 7 is inserted into the large-diameter portion 610b of the rotor core 610 is particularly effective for increasing the natural frequency of the compressor using a refrigerant of large refrigerating capacity.

[0046] Moreover, as the coil 520 is provided in concentrated winding, which involves larger and concentrated electromagnetic force applied to one teeth portion, the increasing ratio of vibration-exciting force due to changes in the air gap between the stator 5 and the rotor 6 becomes larger than that of distributed winding. However, since the natural frequency of the integral structure part 8 is set larger than five times the maximum number of rotations of the compressor under its operation, a large noise and vibrations during the operation can be prevented particularly effectively.

[0047] The magnets of the rotor 6 are rare-earth magnets, and the rare-earth magnets are large in residual magnetic flux density and coercive force in comparison to ferrite magnets so as to allow necessary magnetic flux quantity and demagnetization yield strength to be obtained even if the area and thickness of magnets are reduced, contributing to downsizing of the rotor 6. For instance, with the magnets each formed into a thin, flat plate shape, it becomes possible to gain a wide space ranging from the small-diameter portion 610a of the rotor core 610, to which the shaft 12 is fixed, to the magnets, so that the large-diameter portion 610b can be provided.

[0048] The present invention is not limited to the above-described embodiment. For example, the motor 3 may also be implemented by an outer rotor type motor. The compression element 2 may also be a rotary type one in which its roller and blade are provided independent of each other. The compression element 2 may further be a scroll type or reciprocating type one other than the rotary type. The compression element 2 may yet further be a two-cylinder type one having two cylinder chambers. It is also allowable that the compression element 2 is provided above and the motor 3 is provided below.

## Claims

1. A compressor having a closed container (1), a compression element (2) placed within the closed container (1), and a motor (3) which is placed within the closed container (1) and which drives the compression element (2) via a shaft (12), where an integral structure part (8) is formed by integrally assembling the compression element (2) and a rotor (6) of the motor (3) via the shaft (12), wherein the integral structure part has a natural frequency larger than five times a maximum number of rotations of the compressor under its operation, **characterised in that**, a coil (520) of a stator (5) of the motor (3) is

provided in concentrated winding, a small-diameter portion (610a) and a large-diameter portion (610b) are provided inside a cylindrical-shaped rotor core (610) of the rotor (6), the shaft (12) is fixed to the small-diameter portion (610a), a bearing (7) provided in the compression element (2) to support the shaft (12) is inserted into the large-diameter portion (610b), with the shaft (12) cantilevered by the bearing (7).

2. The compressor as claimed in Claim 1, wherein a refrigerant in the closed container (1) is carbon dioxide.

## Patentansprüche

1. Kompressor mit einem geschlossenen Behälter (1), einem Verdichterelement (2), das innerhalb des geschlossenen Behälters (1) angeordnet ist, und einem Motor (3), der innerhalb des geschlossenen Behälters (1) angeordnet ist und der das Verdichterelement (2) mittels einer Welle (12) antreibt, wobei ein integrales Strukturteil (8) gebildet ist, indem das Verdichterelement (2) und ein Rotor (6) des Motors (3) über die Welle (12) integral aufgebaut sind, wobei das integrale Strukturteil eine Eigenfrequenz aufweist, die größer als das fünffache einer Maximaldrehzahl des Kompressors im Betrieb ist, **dadurch gekennzeichnet, dass** eine Spule (520) eines Stators (5) des Motors (3) in Form einer konzentrierten Wicklung vorgesehen ist, innerhalb eines zylindrischen Rotorkerns (610) des Rotors (6) ein Abschnitt mit kleinem Durchmesser (610a) und ein Abschnitt mit großem Durchmesser (610b) vorgesehen sind, wobei die Welle (12) an dem Abschnitt mit kleinem Durchmesser (610a) fixiert ist, ein Lager (7), das in dem Verdichterelement (2) zum Abstützen der Welle (12) vorgesehen ist, in den Abschnitt mit großem Durchmesser (610b) eingesetzt ist, wobei die Welle (12) von dem Lager (7) freitragend gehalten ist.
2. Kompressor nach Anspruch 1, **dadurch gekennzeichnet, dass** ein Kühlmittel in dem geschlossenen Behälter (1) Kohlendioxid ist.

## Revendications

1. Compresseur ayant un carter fermé (1), un élément de compression (2) placé à l'intérieur du carter fermé (1), et un moteur (3) qui est placé à l'intérieur du carter fermé (1) et qui entraîne l'élément de compression (2) par le biais d'un arbre (12), dans lequel une partie de structure intégrale (8) est formée par

l'assemblage intégral de l'élément de compression (2) et d'un rotor (6) du moteur (3) par le biais de l'arbre (12), dans lequel la partie de structure intégrale a une fréquence naturelle supérieure à cinq fois un nombre maximum de rotations du compresseur dans le cadre de son fonctionnement, **carac-**  
**térisé en ce que**

une bobine (520) d'un stator (5) du moteur (3) est mise en oeuvre selon un enroulement concentré, une partie de petit diamètre (610a) et une partie de grand diamètre (610b) sont mises en oeuvre à l'intérieur d'un noyau de rotor de forme cylindrique (610) du rotor (6), l'arbre (12) est fixé sur la partie de petit diamètre (610a), un palier (7) mis en oeuvre dans l'élément de compression (2) pour supporter l'arbre (12) est inséré dans la partie de grand diamètre (610b), avec l'arbre (12) mis en porte-à-faux par le palier (7).

2. Compresseur selon la revendication 1, dans lequel un réfrigérant dans le carter fermé (1) est du dioxyde de carbone.

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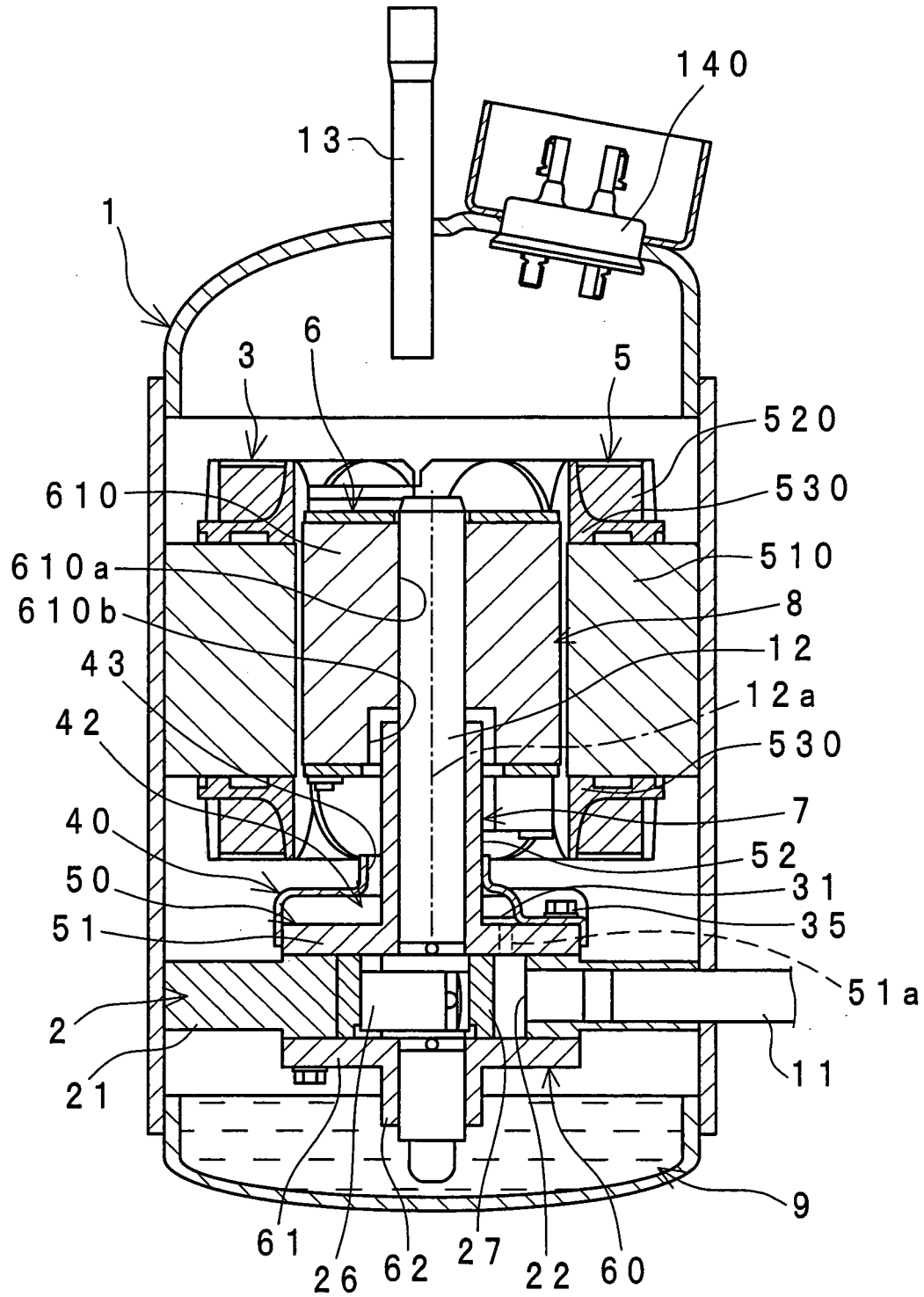
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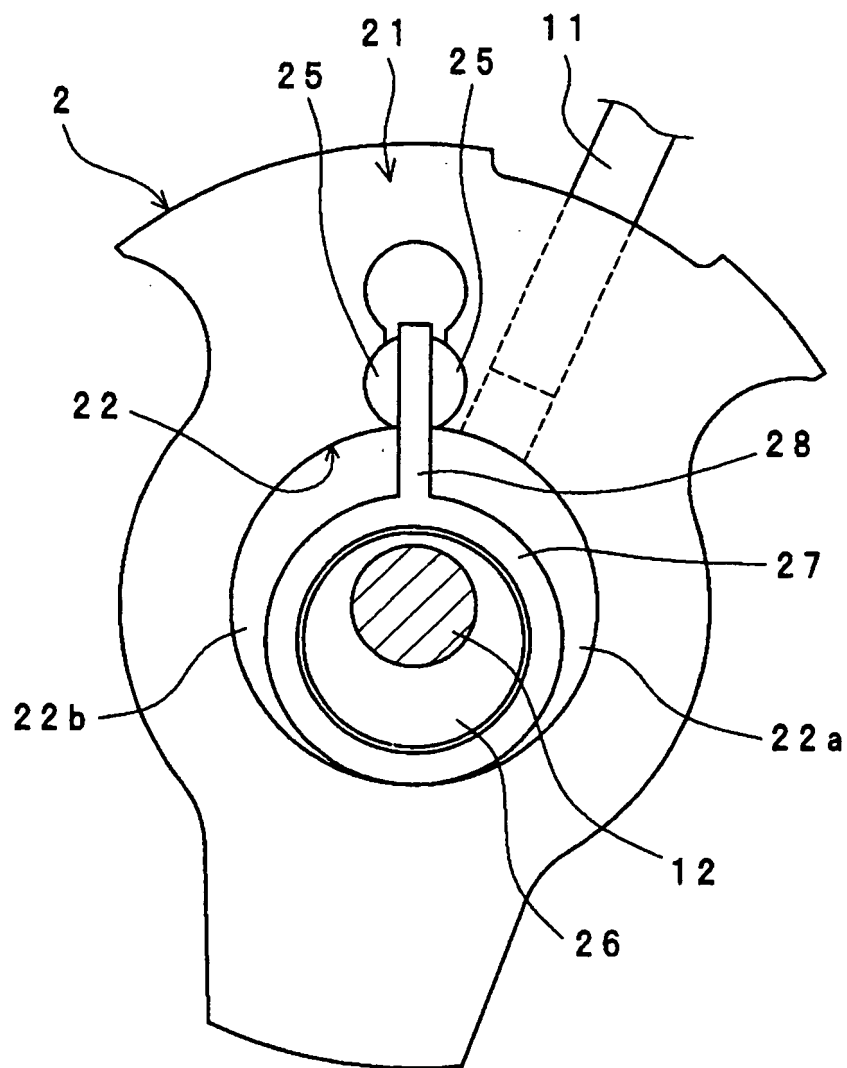
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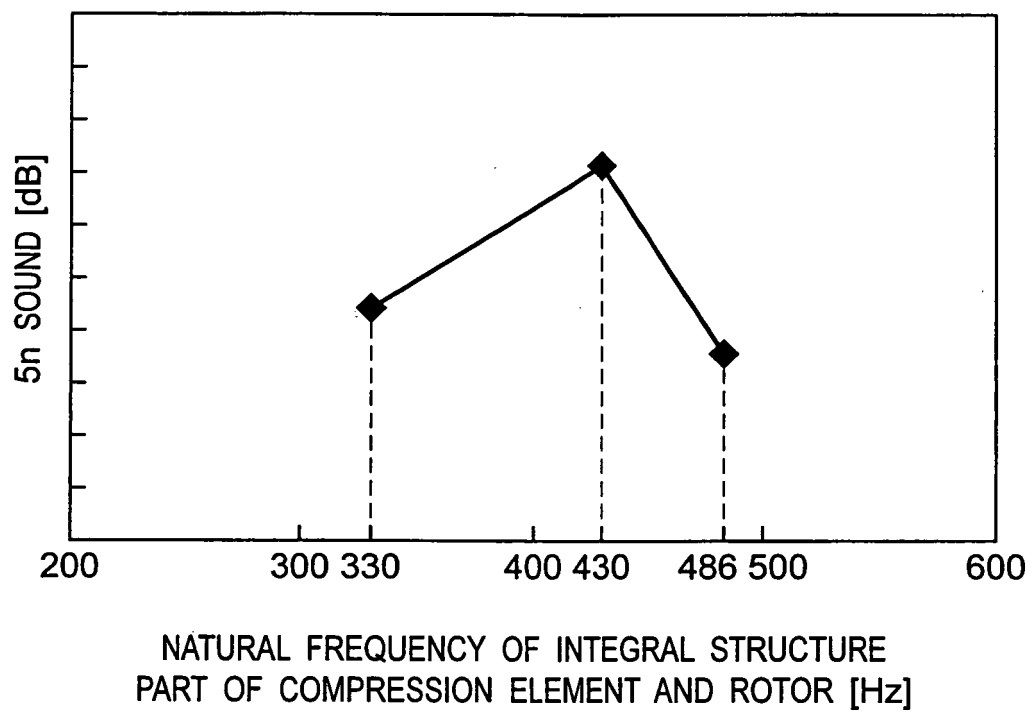
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Fig. 1



*Fig.2*



*Fig.3*

**REFERENCES CITED IN THE DESCRIPTION**

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