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(54) Fan motor suspension

(57) A suspension system (100) for a fan (10). The suspension system (100) has at least one damping member (20; 22) interposed between a housing (16) housing an impeller (15) of the fan (10), and at least one housing and supporting member (12, 13) housing and supporting an electric motor (11). And the suspension system (100) is characterized in that the damping member (20; 22) is located at a distance (r) according to the following equation:

$$r = \sqrt{\frac{J}{M}}$$

0 where (M) is the "suspended mass" defined by the combined masses of the electric motor (11), the housing and supporting member (12, 13), a drive shaft (14), and the impeller (15); and (J) is the moment of inertia of the "suspended mass" with respect to a longitudinal axis (a) of symmetry of the drive shaft (14).

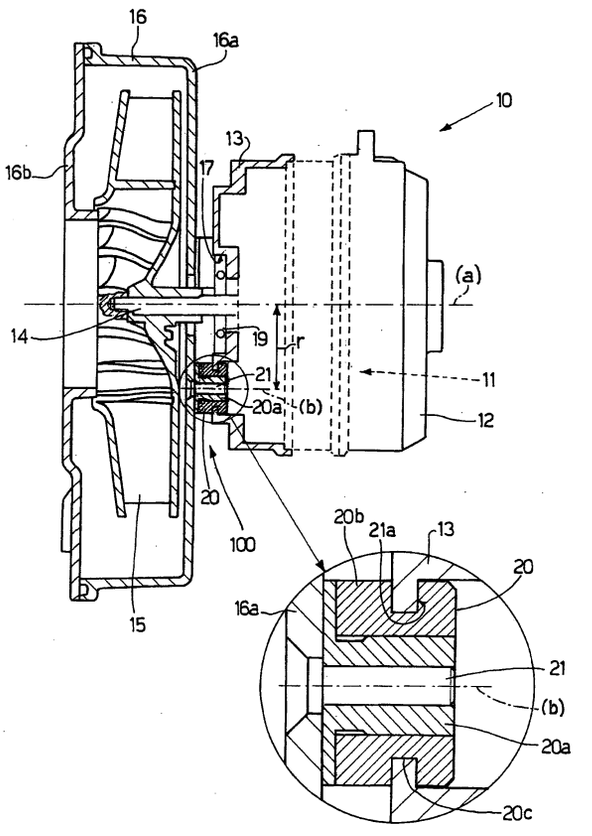

Fig.1

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Description

[0001] The present invention relates to a fan suspension system for reducing vibration on the supporting frame induced by rotation of the electric motor shaft and the masses, e.g. the fan impeller, connected to it.

[0002] As is known, the way in which an electric motor is connected to the supporting frame plays an important part in reducing noise and vibration induced by dynamic unbalancing forces generated by rotation of the motor shaft and the masses connected to it. In fact, severe unbalancing forces may be generated when the motor is used to power a fan impeller.

[0003] Severe vibration may be generated in particular when the electric motor shaft rotates at high speed.

[0004] Such is the case, for example, of impellers powered by electric brushless motors whose speed is independent of mains frequency. Without the mains frequency limitation, in fact, the designer can opt for high operating speed to reduce the size of the impeller, since the increase in the tangential speed of the impeller increases the energy of the output gas, e.g. combustion air.

[0005] At high rotation speeds of the motor shaft, therefore, severe vibration is transmitted to the frame, and produces high noise levels.

[0006] In applications involving fan motors, various solutions are adopted to isolate the motor and induced vibration from rotation of the motor shaft and the masses connected to it.

[0007] One of these is described in DE 197 21 365, which employs three members made of rubber or elastomeric material, located 120° apart, and equidistant from the rotation axis of the motor.

[0008] In DE 197 21 365, however, no mention is made of the distance required between the electric motor shaft axis and the three rubber members to achieve the best vibration damping effect.

[0009] It is therefore an object of the present invention to provide an innovative suspension system employing one or more elastic members (metal springs or rubber pads) located symmetrically with respect to the rotation axis, and the radial position of which with respect to the rotation axis has a particular value, as specified in detail later on.

[0010] According to the present invention, therefore, there is provided an innovative suspension system for an electric motor applied to a fan, as claimed in Claim 1.

[0011] The present invention may be used to advantage in a fan associated with a combustion unit, in which reducing vibration, and therefore noise, is particularly important.

[0012] A number of non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a fan (partly in section) to which a first embodiment of the present invention is applied;

Figure 2 shows a plan view of the Figure 1 fan;

Figure 3 shows a cross section of a portion of the Figure 1 and 2 fan;

Figure 4 shows a fan (partly in section) to which a second embodiment of the present invention is applied;

Figure 5 shows a plan view of the Figure 4 fan;

Figure 6 shows a cross section of a portion of the Figure 4 and 5 fan;

Figures 7a and 7b show graphs of vibration as a function of the speed of the electric motor.

[0013] With reference to Figures 1 to 3, number 10 indicates a fan to which is applied a first embodiment of a suspension system 100 for an electric motor 11 enclosed in a casing 12 supported by a partly sectioned "cup-shaped" member 13 (Figure 1).

[0014] The innovative system 100 will be described in detail later on.

[0015] In known manner, electric motor 11 rotates a drive shaft 14, which is fitted with an impeller 15 enclosed in a housing 16 having a scroll.

[0016] More specifically, housing 16 comprises a first "cup-shaped" portion 16a, and a second portion 16b in the form of a cover; and the two portions 16a, 16b are fixed to each other by conventional means (not described) to enclose impeller 15.

[0017] As shown in Figure 1, member 13 houses, inside a seat 17, a bearing 19 supporting drive shaft 14.

[0018] In the first embodiment of the present invention shown in Figure 1, the whole (so-called "suspended mass") defined by electric motor 11, casing 12, "cup-shaped" member 13, drive shaft 14, and impeller 15, is substantially symmetrical with respect to a longitudinal axis of symmetry (a) of drive shaft 14.

[0019] As shown in Figures 1 to 3, three elastic members 20, spaced 120° apart, are screwed to the outer end of first "cup-shaped" portion 16a.

[0020] The three elastic members 20 are made of rubber or any elastomeric material, and each surrounds a pin 20a screwed to the outer end of first portion 16a by a respective screw 21 (Figure 3).

[0021] More specifically, each elastic member 20 comprises a substantially cylindrical main body 20b, in which is formed a circumferential groove 20c.

[0022] In actual use (Figure 1), each elastic member 20 is inserted inside a corresponding seat 21a formed in "cup-shaped" member 13; and circumferential groove 20c engages the walls of respective seat 21a to elastically secure housing 16 with respect to "cup-shaped" member 13 as required.

[0023] Testing and theoretical calculations show a marked attenuation of vibration with a distance (r), between the longitudinal axis (a) of symmetry of drive shaft 14 and a longitudinal axis (b) of symmetry of each elastic member 20, according to the following equation:

$$r = \sqrt{\frac{J}{M}}$$

where J is the moment of inertia of the "suspended mass" with respect to axis (a), and M is the "suspended mass" itself.

[0024] As stated, the term "suspended mass" in the present context is intended to mean the whole defined by electric motor 11, casing 12, "cup-shaped" member 13, drive shaft 14, and impeller 15, and which is substantially symmetrical with respect to the longitudinal axis (a) of drive shaft 14.

[0025] Tests have also shown that, even if the "suspended mass" is not perfectly symmetrical with respect to axis (a), the teachings of the present invention still provide for good results in terms of balance.

[0026] In other words, system 100 according to the present invention comprises at least one damping member 20 interposed between housing 16 housing impeller 15, and member 13 housing and supporting electric motor 11.

[0027] Suspension system 100 is characterized by damping member 20 being located at a distance (r) with respect to a longitudinal axis (a) according to the following equation:

$$r = \sqrt{\frac{J}{M}}$$

where M is the "suspended mass" defined by the combined masses of electric motor 11, casing 12, member 13, drive shaft 14, and impeller 15; and J is the moment of inertia of the "suspended mass" with respect to a longitudinal axis (a) of symmetry of drive shaft 14.

[0028] The results of system 100 according to the present invention compared with those of a conventional system are shown in Figures 7a and 7b.

[0029] Figure 7a shows vibration, along the Y axis, with respect to the speed of drive shaft 14, along the X axis; and the comparison was made between a fan 10 in accordance with the present invention and fitted with suspension system 100 described, and the same fan fitted with a prior-art suspension system. In the case of Figure 7a, the vibration detecting device (not shown) was placed on casing 12 of electric motor 11.

[0030] Similarly, Figure 7b shows vibration (along the Y axis) with respect to the speed of drive shaft 14, but, in this case, with the detecting device on housing 16.

[0031] As shown in Figure 7b, after a given speed value (4630 rpm, to be exact), the solution proposed in the present invention brings about a fall in vibration.

[0032] In the second embodiment in Figures 4 to 6, the three members 20 proposed in the first solution (Figures 1 to 3) are replaced with a single toroidal member 22, also made of rubber or any elastomeric material.

[0033] In this case, too, toroidal member 22 is inserted inside a seat 23 formed in "cup-shaped" member 13, and, as shown in Figure 6, is fixed to first portion 16a by three screws 24.

[0034] In this case, too, the best damping effect has been found to be achieved with a distance (r) according to the following equation:

$$r = \sqrt{\frac{J}{M}}$$

where J and M are as specified in the first embodiment in Figures 1 to 3.

Claims

1. A suspension system (100) for a fan (10), the suspension system (100) comprising at least one damping member (20; 22) interposed between a housing (16) housing an impeller (15) of said fan (10), and at least one housing and supporting member (12, 13) housing and supporting an electric motor (11); the suspension system (100) being **characterized in that** said at least one damping member (20; 22) is located at a distance (r) according to the following equation:

$$r = \sqrt{\frac{J}{M}}$$

where (M) is the "suspended mass" substantially defined by the combined masses of said electric motor (11), said housing and supporting member (12, 13), a drive shaft (14), and said impeller (15); and (J) is the moment of inertia of said "suspended mass" with respect to a longitudinal axis (a) of symmetry of said drive shaft (14).

2. A system (100) as claimed in Claim 1, wherein said "suspended mass" is substantially symmetrical with respect to said axis (a).

3. A system (100) as claimed in any one of the foregoing Claims, wherein said at least one damping member (20) is substantially cylindrical.

4. A system (100) as claimed in claim 1 or 2, wherein said at least one damping member (22) is a toroidal member.

5. A system (100) as claimed in any one of the foregoing Claims, wherein said at least one damping member (20; 22) is fixed to said housing (16).

6. A system (100) as claimed in Claim 5, wherein said at least one damping member (20; 22) is housed

inside a respect seat (21a; 23) formed in a member (13) integral with said electric motor (11).

7. A system (100) as claimed in any one of the foregoing Claims, wherein said electric motor (11) is a brushless electric motor.

8. A combustion unit, **characterized by** comprising at least one fan (10) equipped with a suspension system (100) as claimed in any one of the foregoing Claims.

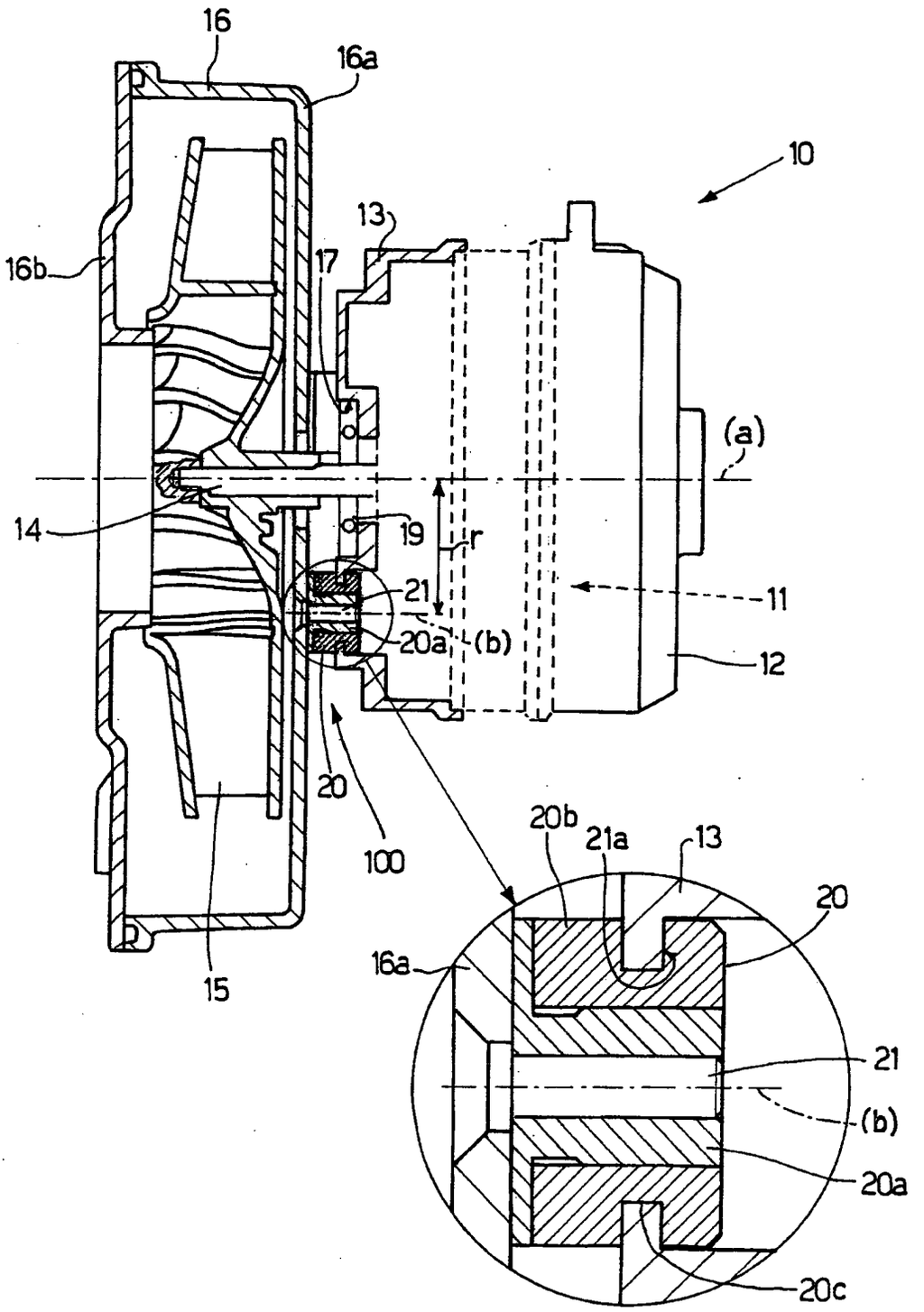

16
16a
10
13
16b
17
(a)
14
19
r
21
11
20a
(b)
12
20
100
20b
21a
13
20
16a
15
21
(b)
20a
20c

Fig.1

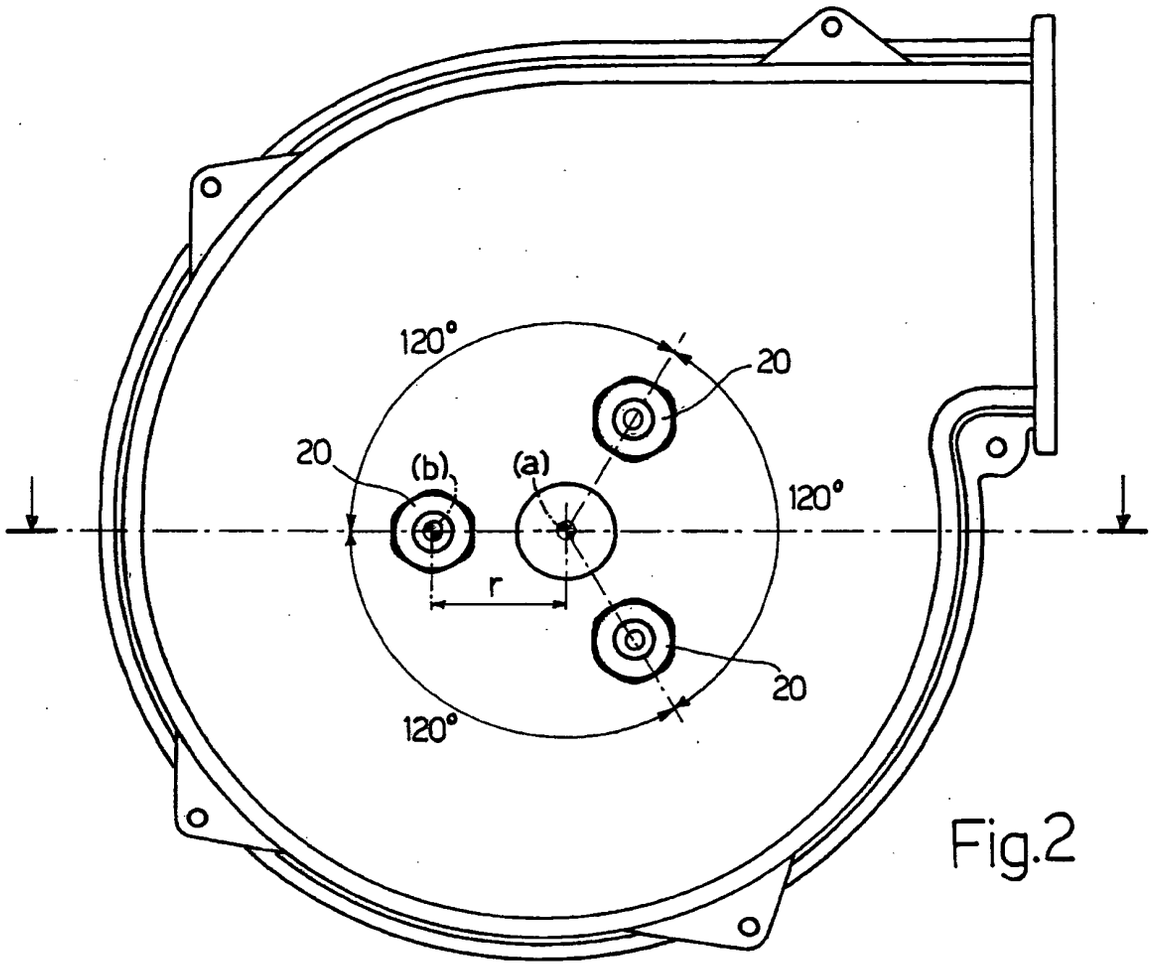


Fig.2

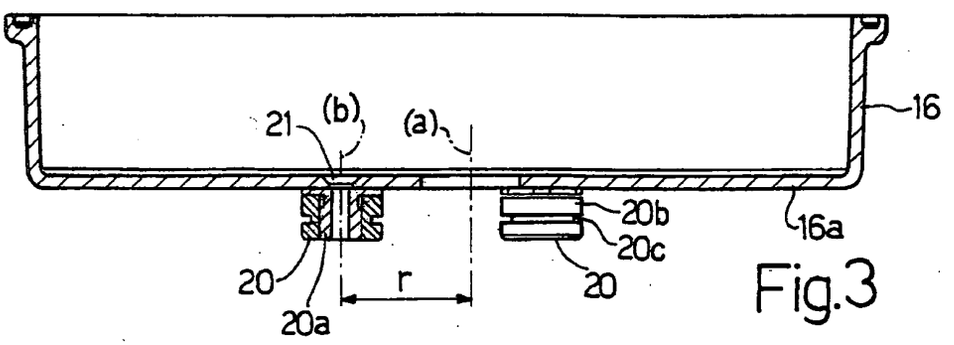


Fig.3

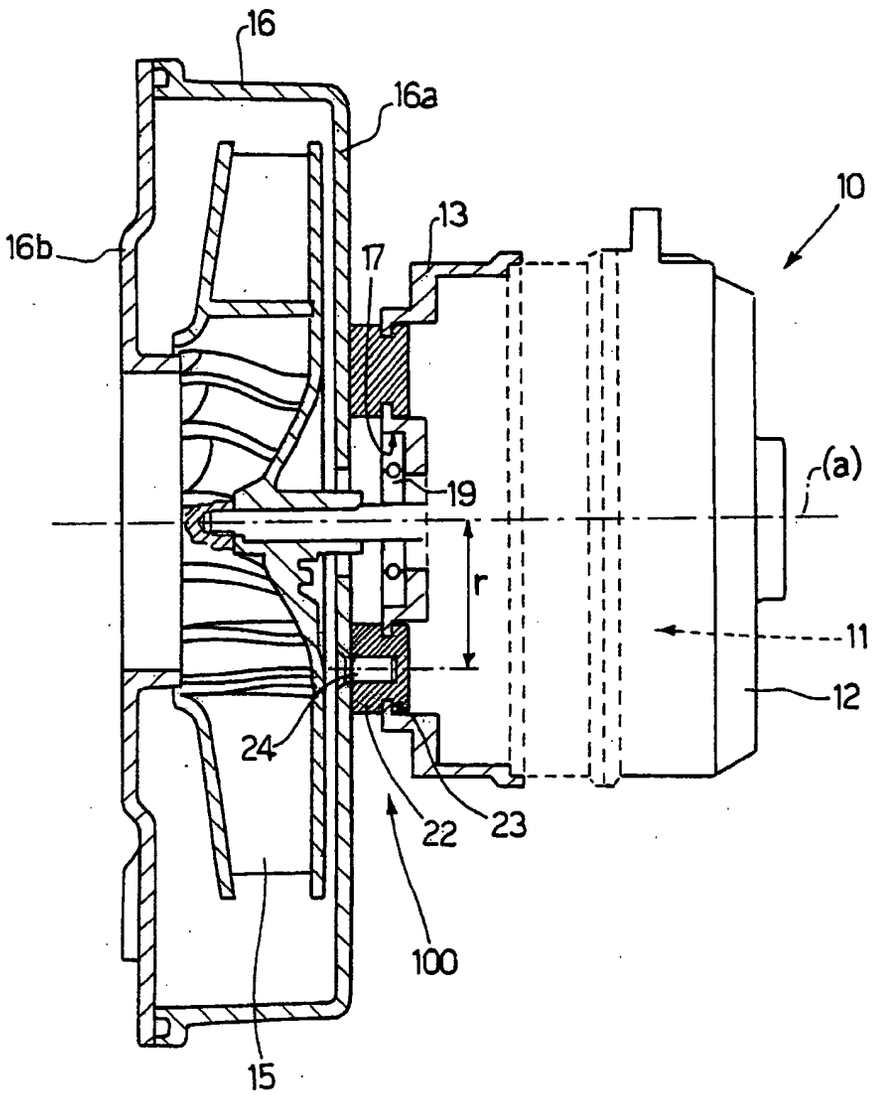


Fig.4

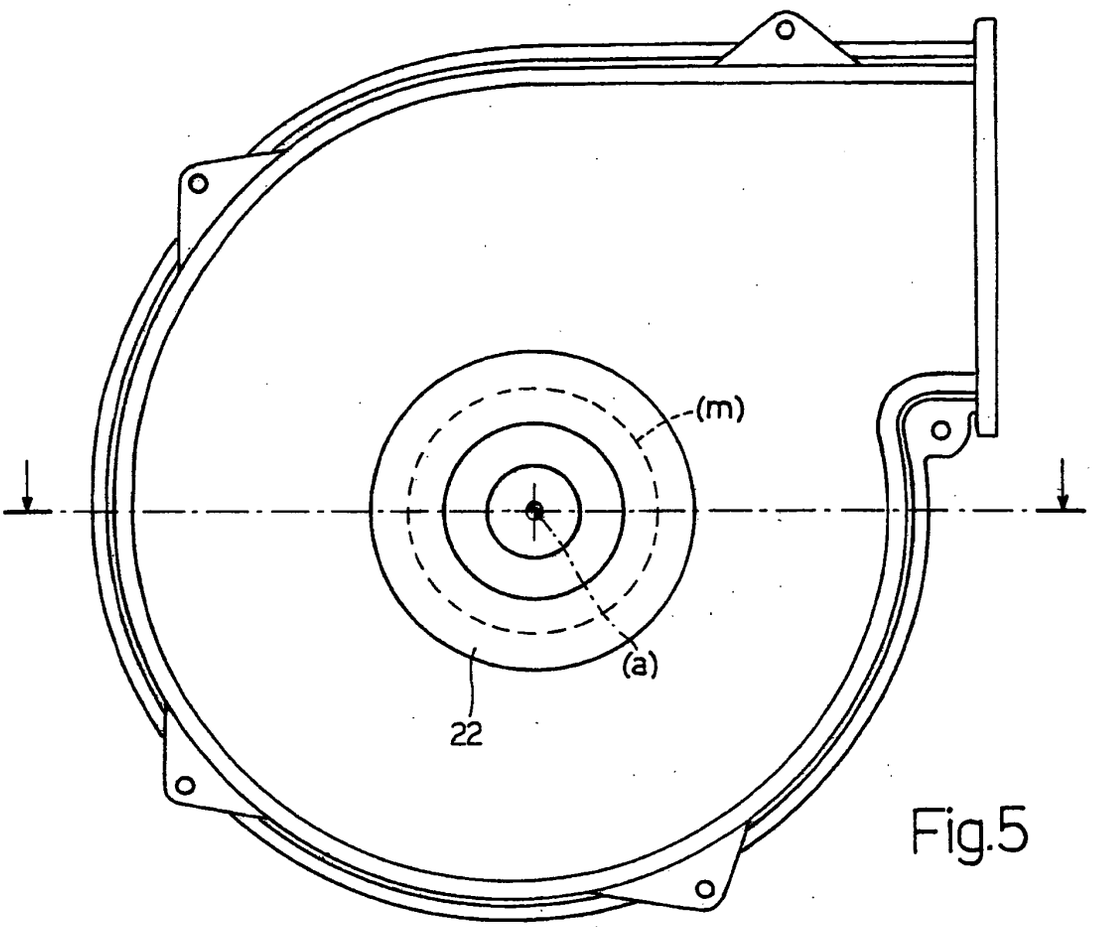


Fig.5

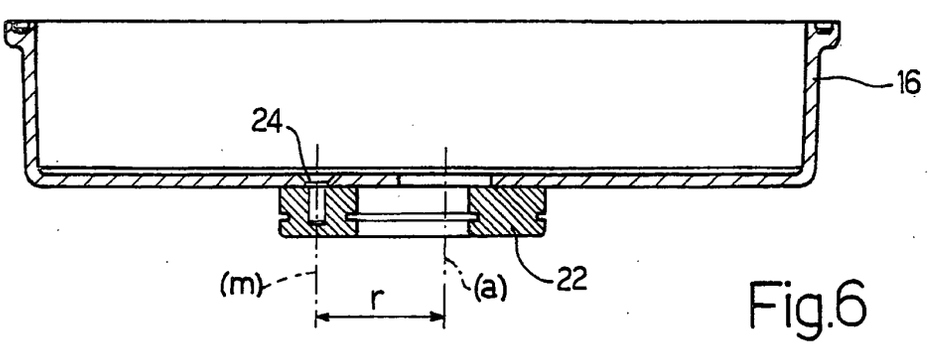


Fig.6

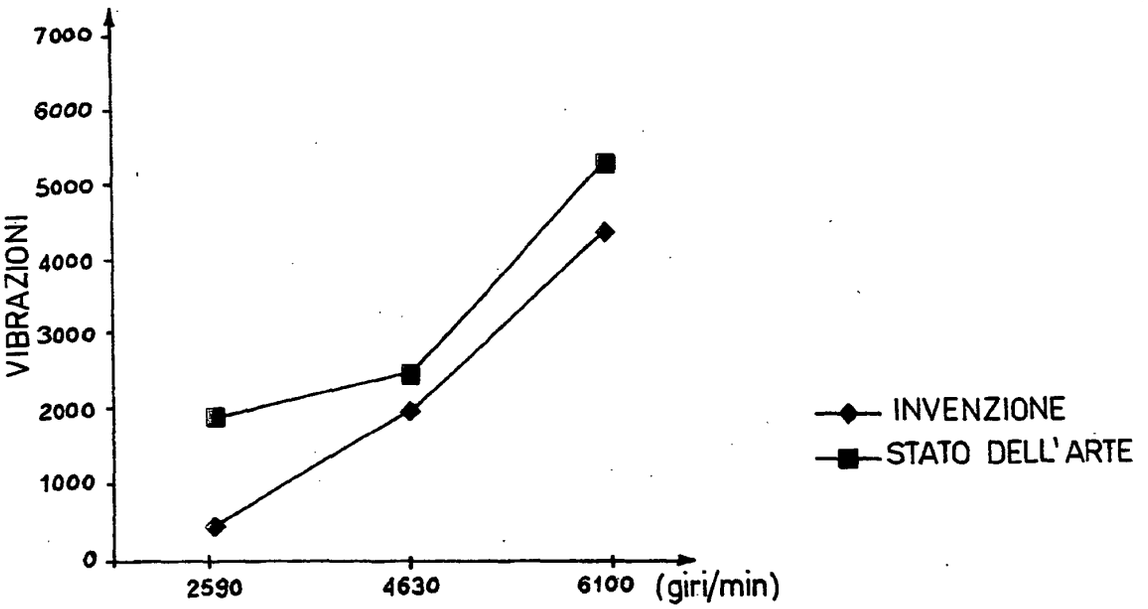
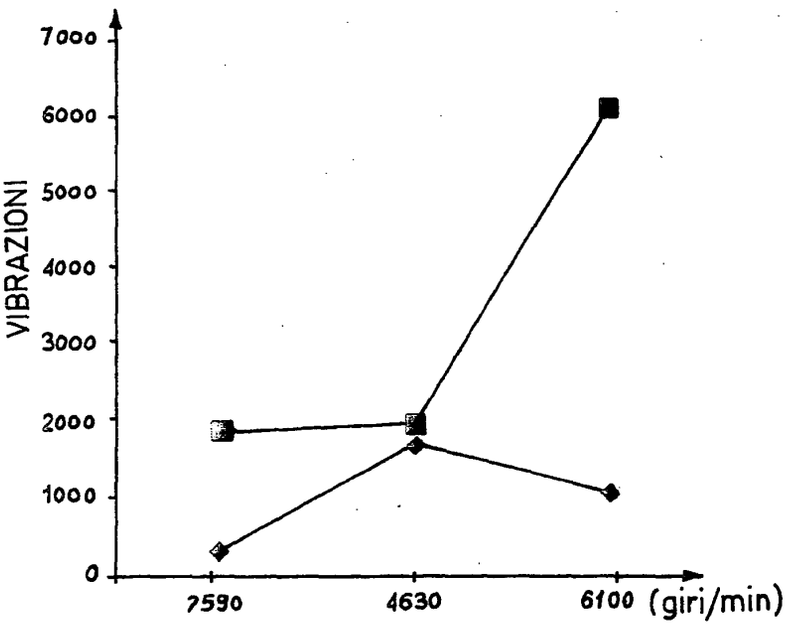

7000
6000
5000
4000
3000
2000
1000
0
VIBRAZIONI
2590
4630
6100
(giri/min)
INVENZIONE
STATO DELL'ARTE

Fig.7a


7000
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VIBRAZIONI
2590
4630
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(giri/min)

Fig.7b

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EUROPEAN SEARCH REPORT

Application Number
EP 04 42 5136

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)
A	DE 202 06 862 U (EBM WERKE GMBH & CO KG) 4 September 2003 (2003-09-04) * page 6, paragraph 6 - page 7, paragraph 1 * * page 7, paragraph 3 * * page 8, paragraph 4 * * figures 1,5,6 * ---	1	F04D29/66
A	US 5 030 068 A (JACOBS PAUL G ET AL) 9 July 1991 (1991-07-09) * column 5, line 7-49 * * column 6, line 45 - line 56 * * figures 3,6-9 * ---	1	
A	US 6 278 209 B1 (KNOEPFEL GERD ET AL) 21 August 2001 (2001-08-21) * column 3, line 66 - column 4, line 38 * * figure 3 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			F04D F01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	20 July 2004	Giorgini, G

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 20206862 U	04-09-2003	DE 20206862 U1	04-09-2003
US 5030068 A	09-07-1991	NONE	
US 6278209 B1	21-08-2001	DE 19813984 A1	30-09-1999
		WO 9950082 A1	07-10-1999
		EP 0986489 A1	22-03-2000
		JP 2002500860 T	08-01-2002

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