(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 561 384 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **93104358.2**

(51) Int. Cl.5: **F04B 39/00**

(22) Date of filing: **17.03.93**

(30) Priority: **18.03.92 IT PN920011 U**

(43) Date of publication of application: **22.09.93 Bulletin 93/38**

(84) Designated Contracting States: **AT DE ES FR GB IT**

(71) Applicant: **Zanussi Elettromeccanica S.p.A.**
Via Giardini Cattaneo 3
I-33170 Pordenone-C.P. 147(IT)

(72) Inventor: **Bucciarelli, Maurizio**
Via Pasiano di Sotto 18/C
I-33087 Pasiano, Pordenone(IT)
Inventor: **Pol, Lanfranco**
Viale Cadore 21/F
I-32014 Ponte nelle Alpi, Belluno(IT)

(74) Representative: **Patentanwälte Grünecker, Kinkeldey, Stockmair & Partner**
Maximilianstrasse 58
D-80538 München (DE)

(54) Hermetically encased compressor with spring suspension.

(57) A hermetically encased compressor comprising a casing (6) enclosing a motor-compressor unit (7, 8) supported therein by prop members (12) comprising, from the bottom of said casing upwards, a first cylindrical section (13) having a major diameter and a second cylindrical section (14) having a smaller diameter terminating in a frustoconical end portion (15) and being inserted into the lower end of a cylindrical spring (11) secured to the base of said motor-compressor unit. The relative dimensions of the various components are calculated with a view to reducing the noise generated by the suspension assembly during transient phases of the compressor. In particular, the laterral surface of the frustoconical portion (15) of each prop member is inclined at an agnle of 11° relative to the axis of the respective prop member.

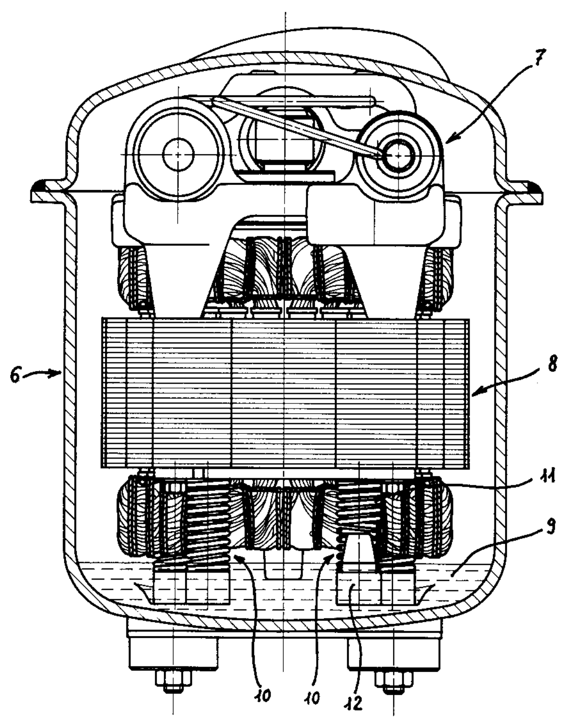

Fig. 2

EP 0 561 384 A1

The present invention relates to a hermetically encased compressor, particularly for domestic refrigerating appliances, of the type comprising a volumetric motor-compressor unit supported within a hermetically sealed casing by means of a spring suspension system.

As known for instance from the description of DE-A-3 006 316, it is general practice, with a view to reducing the noise produced by the compressor, to provide a spring suspension systemwith at least three points of support situated substantially in a horizontal plane below the center of gravity of the motor-compressor unit. More specifically, the points of support are usually distributed about the periphery of the base of the motor-compressor unit and have each attached thereto the upper end of a cylindrical spring the opposite (lower) end of which takes support on an associated vertical prop member resting on the bottom of the casing of the compressor and preferably made of steel. With a view to minimizing the vibratory and acoustic effects of the pulsive forces generated during operation of the motor-compressor unit, the connection of the suspension springs to the supporting prop members is of particular importance. Generally each prop member has an upwards projecting portion of a reduced diameter, including a first cylindrical section and a second narrower portion, and projecting partially into the associated spring when the latter is in the relaxed state. The narrower upper end portion of the support prop member is usually of frustoconical shape, with its lateral surface inclined at an angle of about 6° with respect to the vertical axis of the prop member and the spring, the latter being usually made of steel wire having a diameter of about 1.6 mm.

As known, the vibratory stresses to which the anchoring system of the suspension units is subjected during the transient phases of starting and stopping the operation of the compressor may be interpreted as the impulsive response (i. e. the product of the resultant of the excitation of the system by the inherent mode of vibration of the structure) on the part of a system constituted by a spring having one end simply supported (with finite impedance) on the associated prop member and its other end fixedly secured to the motor-compressor unit. The dampening effect of the system is determined by the dampening properties of the spring plus the dampening component resulting from friction between the surface of the prop member and the windings of the spring when these two components are in mutual contact.

In the case of a known compressor of the type described above, the dampened noise produced by a suspension during the transient at the time of stopping the operation of the compressor (this being generally the transient generating the strongest noise), has a typical profile as represented in fig. 1 of the drawings. In particular, the noise thus produced is represented by a curve in which for a period T there occurs a succession of peaks of logarithmically decreasing amplitude, with a maximum peak amplitude P. With the suitable scale transformations, this function, measured experimentally, may be taken as the representation of a displacement, an acceleration, or a sonar pressure. In any case, the noise generated by the suspension system in a compressor of the known type is undesirably strong, with a peak amplitude P corresponding to about 47 to 49 dB and a duration T of between 1.5 and 1.8 seconds.

It is therefor a desirable object of the present invention to provide a hermetically encased compressor with a spring suspension system of simple and reliable construction and capable of substantially dampening the noise emitted during operation of the compressor, particularly during the transient periods on starting and stopping the operation of the compressor.

According to the invention, this object is attained in a hermetically encased compressor including a spring suspension system incorporating the characteristics of the appended claims.

The characteristics and advantages of the invention will become more clearly evident from the following description, given by way of example with reference to the accompanying drawings, wherein:

- fig. 2 shows a diagrammatic sectional view of a hermetically encased compressor according to the invention,
- figs. 3 and 4 show lateral views of two components of the compressor of fig. 2 according to a preferred embodiment of the invention, and
- fig. 5 shows a graph representing the noise produced during a stop-operation transient of the hermetically encased compressor according to the invention.

With reference to fig. 2, the hermetically encased compressor shown is substantially of the same type as the known compressor used for measuring the noise represented in fig. 1. It is mainly composed of a hermetically sealed casing 6 enclosing a volumetric compressor 7 adapted to be driven by an electric motor 8. As per se known, the motor-compressor unit 7, 8 takes support on the bottom of casing 6, containing a liquid lubricant bath 9, by the intermediary of a suspension system comprising at least three (preferably four) suspension units generally indicated at 10 and evenly distributed about the base of the motor-compressor unit 7, 8 below the center of gravity thereof. With additional reference to figs. 3 and 4, each suspension unit 10 comprises a cylindrical spring 11 made of steel and having its upper end fixedly secured to the base of the motor-compressor unit in a per se known and therefore not shown manner. The lower end of each spring 11 (considered under rest conditions as in figs 2 and 4) is partially slipped in a force-fit onto an associated prop member 12 preferably made of steel and mounted in vertical position on the base of casing 6. More specifically, each prop member 12 comprises a lower first cylindrical section 13 of a major diameter and an upper second cylindrical section 14 having a smaller diameter and terminating in a frustoconical end portion 15. The second cylindrical section 14 including its frustoconical end portion 15 are normally received within the associated spring 11, the lower end of which takes support on the shoulder defining the upper end of the first cylindrical section 13 of the prop member.

Each spring 11 is preferably made of a steel wire having a diameter of about 1.5 mm, the spring having an inner diameter of about 10.9 mm, an axial length (in the relaxed state) of about 28.5 mm, and a constant pitch between windings of about 2 mm.

The second cylindrical section 14 of each prop member 12 correspondingly has a diameter of about 10.9 mm, while its axial length, inclusive of its frustoconical end portion 15, is about 13 mm, that is to say, fractionally shorter than half the axial length of the spring 11. In particular, and according to an important aspect of the invention, the lateral surface of the frustoconical end portion 15 has an inclination of about 10° to 12°, preferably 11°, relative to the axis 16 of the respective prop member 12. In addition, the frustoconical end portion 15 preferably has a blunt end and an axial length of about 9.5 mm.

With the values as set forth above, and in particular thanks to the inclination of the lateral surface of the frustoconical end portion 15, it has been found and also experimentally verified that in the hermetically encased compressor with a spring suspension system according to the invention, the supporting prop members 12 interact to a surprisingly limited degree with the associated springs 11 over the major part of their vibration range, so that the emission of transient noise during start and stop operations of the compressor is substantially dampened. As a matter of fact, and as shown by way of example in fig. 5, the noise produced at the location of each suspension unit 10 of the compressor according to the invention in a compressor stop transient period comprises a series of oscillations which is of substantially limited duration and displays substantially low peak values. In particular, it has been verified in the course of more than two thousand trial operations, that the duration T of the oscillations depicted in fig. 5 is only about 1 sec, with a peak value P of about 34 dB. It will be recognized that these values are drastically reduced relative to corresponding values obtained with corresponding compressors of conventional construction.

According to the invention, this surprising result of acoustic optimization has been obtained in the first place by ensuring the maximum attrition dampening of the oscillations of the springs 11, and at the same time by minimizing the number of possible impacts between the components which would act to transmit the oscillation energy of the springs.

The hermetically encased compressor as described may of course undergo any suitable modifications within the purview of the invention.

Claims

1. A hermetically encased compressor comprising a hermetically sealed casing in which a volumetric motor-compressor unit is supported by spring suspension units each comprising a support prop member extending vertically from the bottom of said casing, with a first cylindrical section of a major diameter and a second cylindrical section having a smaller diameter and terminating in a frustoconical end portion, said second cylindrical section being axially inserted in a force fit into the lower end of a cylindrical spring having one end axially abutting said first cylindrical section and its other, upper end secured to the base of said motor-compresor unit, characterized in that said frustoconical end portion (15) of each prop member (12) has a lateral surface inclined at 10° to 12°, preferably 11°, relative to the axis (16) of said prop member (12).

2. A hermetically encased compressor according to claim 1, characterized in that in each said prop member (12), said second cylindrical section (14),inclusive of its frustoconical end portion (15), has an axial length of about 13 mm, the axial length of said frustoconical end portion being about 9.5 mm.

3. A hermetically encased compressor according to claim 1 or 2, characterized in that each of said springs (11) is made of a steel wire having a diameter of about 1.5 mm and being wound in windings which in the relaxed state have a pitch of about 2 mm and an inner diameter of about 10.9 mm.

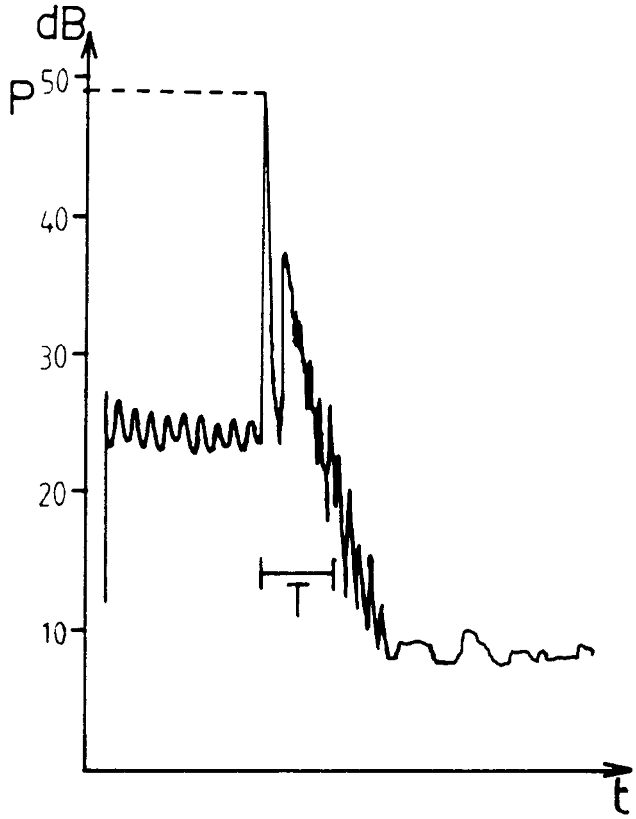

Fig. 1

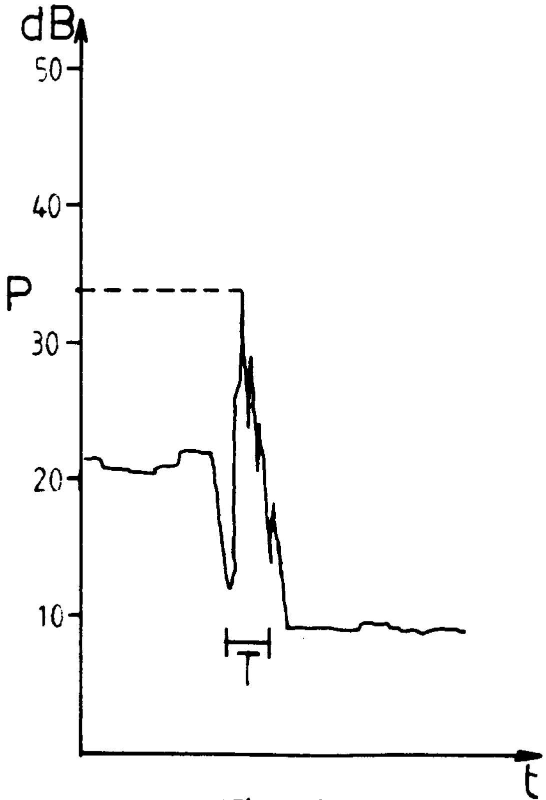

Fig. 5

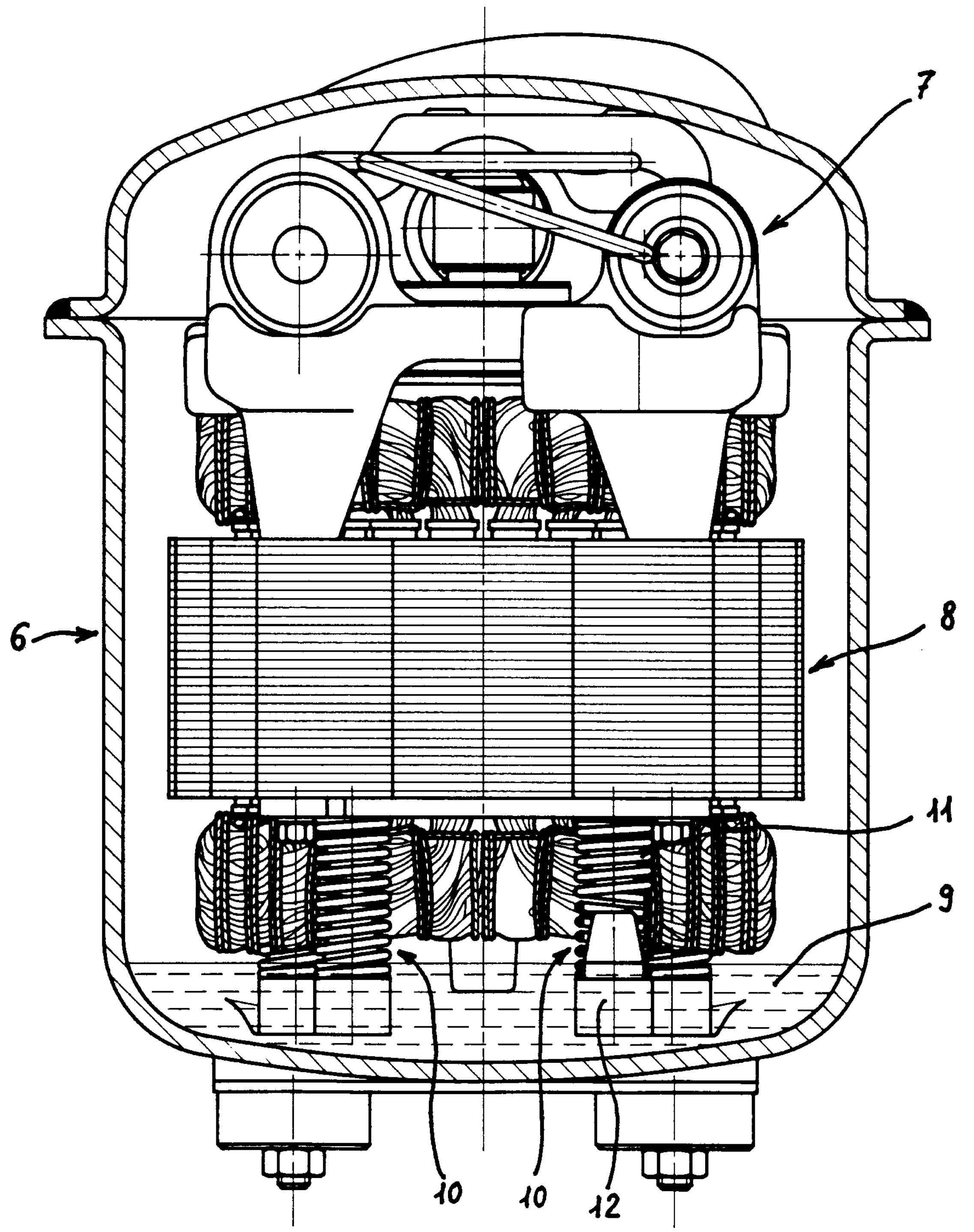

Fig. 2

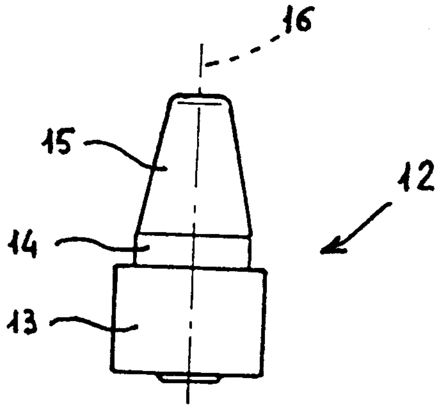

Fig. 3

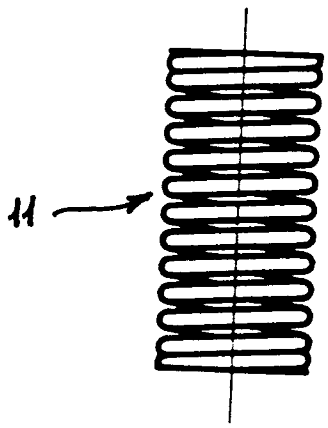

Fig. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93104358.2

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.5)
X	PATENT ABSTRACTS OF JAPAN, unexamined applications, M field, vol. 2, no. 5, January 13, 1978 THE PATENT OFFICE JAPANESE GOVERNMENT page 6386 M 77 * No. 52-115 412 (HITACHI) *	1,2	F 04 B 39/00
A	& JP-A-52-115 412 (HITACHI) --	3	
A	US - A - 4 431 383 (BOEHMLER) * Totality; especially fig., pos. # 17,18 * --	1-3	
A	GB - A - 1 573 649 (DANFOSS) * Totality * --	1-3	
D,A	DE - A - 3 006 316 (BOSCH) * Totality * ----	1-3	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F 04 B 35/00
F 04 B 39/00
F 25 B 1/00
F 25 B 31/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	25-05-1993	WERDECKER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document