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Bezeichnung der Erfindung:
Title of invention:
Titre de l'invention : A structure for vibration isolation in an apparatus with a vacuum system

Klassifikation / Classification / Classement : H01J 37/02

ENTSCHEIDUNG / DECISION

vom / of / du 30 January 1990

Anmelder / Applicant / Demandeur :

Patentinhaber / Proprietor of the patent / Titulaire du brevet : Fujitsu Limited

Einsprechender / Opponent / Opposant : 01. Wild Leitz GmbH
02. Leybold AG

Stichwort / Headword / Référence :

EPÜ / EPC / CBE Article 56

Schlagwort / Keyword / Mot clé : "Inventive step (yes);
Inherent functional feature not available to the public"

Leitsatz / Headnote / Sommaire

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Case Number : T 49/87 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 30 January 1990

Appellant : (Opponent 02)
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Decision under appeal : Interlocutory decision of the Opposition Division of the European Patent Office dated 5 December 1986 concerning maintenance of European patent No. 0 019 426 in amended form.

Composition of the Board :

Chairman : H. Reich
Members : C. Black
H. Beyer
G. Paterson
F. Benussi

Summary of Facts and Submissions

I. European patent No. 0 019 426 was granted on the basis of European patent application No. 80 301 515.5.

II. The Opponents "Ernst Leitz Wetzlar GmbH" and "Leybold-Heraeus GmbH" whose rights as an Opponent have been transferred to the companies "Wild Leitz GmbH" (OI) and "Leybold Aktiengesellschaft" (OII) respectively during the pending proceedings, separately filed notices of opposition against this patent on the grounds mentioned in Article 100(a) EPC

in view of the prior art, which can be derived from the European Search Report documents:

D1: GB-A-828 656;
D2: US-A-3 514 600;
D3: US-A-3 586 855;
D4: US-A-3 772 510; and
D5: DE-B-1 514 659;

in view of a prior public use of the scanning electron microscope "Leitz-AMR 1600 T", the technical features of which were evidenced by documents:

D6: piece list No. 301-297.000 (Gr/GrV);
D7: technical drawing No. 301-297.212 (Z1);
D8: technical drawing No. PM 006 160-X; and
D9: the deposition of the witness Dr. Gerhard Schlüter as stated in the minutes of his hearing dated 3 June 1986;

and in view of the document:

D10: catalogue No. HV200, Teil 5, with the title: "Turbo-Molekularpumpen und Zubehör" of the company "Leybold-Heraeus GmbH", printed in May 1977.

III. The Opposition Division, in an interlocutory decision within the meaning of Article 106(3) EPC maintained the patent in amended form on the basis of the documents specified in the communication pursuant to Rule 58(4) EPC dated 11 June 1986.

IV. The Opponent "Leybold AG" lodged an appeal against this decision, complementing his arguments in a further letter. The further party, Opponent "Wild Leitz GmbH", did not file any observations for preparing oral proceedings.

V. Oral proceedings were held, at the end of which the Appellant "Leybold AG" and the further party "Wild Leitz GmbH" both requested that the decision under appeal be set aside and that the patent be revoked.

The Respondent (Patentee) requested that the appeal be dismissed and that the patent be maintained on the basis of the following documents:

Claim 1: handed over during the oral proceedings dated 30 January 1990

Claims 2-9: received 10 July 1986 with letter dated 8 July 1986;

Description: column 1, line 1 to column 6, line 19, received 10 July 1986 with letter dated 8 July 1989;

Drawings: sheets 1 to 6 according to EP-B-0 019 426.

VI. Claim 1 reads as follows:

"1. An apparatus comprising a vacuum system, the vacuum system including a vacuum chamber for containing main instruments of the apparatus and an exhaust device adapted to exhaust air from said vacuum chamber, the exhaust device including a vacuum pump connected with the vacuum chamber through a bellows, the apparatus comprising a structure for vibration insulation including said bellows and adapted for preventing the transmission of the vibration of said exhaust device to a main section of the apparatus, an exhaust tube being connected with said bellows, said vacuum pump being attached to said exhaust tube, and said bellows, exhaust tube and vacuum pump being arranged in the form of a pendulum in which the bellows is used as a fulcrum, characterised in that said vacuum pump is a cryopump with a reciprocating moving piston, the length of the pendulum is such that the pendulum frequency is smaller than the frequency of vibration of said cryopump produced by the reciprocation of the piston so that the pendulum system cannot follow this vibration."

Claims 2-9 are referred back to Claim 1.

VII. In support of his request the Appellant "Leybold AG" argued essentially as follows:

(a) Prior public used scanning electron microscope "Leitz AMR 1600 T" evidenced by documents D6 to D9 makes use of all features of Claim 1 of the patent in suit in an apparatus with a turbo-molecular pump. In this prior art device, the turbo-molecular pump is suspended at the apparatus to be protected against vibrations via a damping bellows so that the pump may move in pendulum fashion.

The suspended turbo-molecular pump, rotating normally at a speed of 4.10^4 rpm, gives rise to a horizontal pendulum vibration of this frequency. A simple calculation shows that a pendulum has a characteristic frequency of 0.7 Hz at 50 cm length, of 1.6 Hz at 10 cm length, of 5 Hz at 1 cm length and of 16 Hz at 1 mm length. These frequency values demonstrate that the prior art meets the claimed frequency condition.

(b) When analysing the operation of microscope "Leitz AMR 1600 T", a skilled person easily becomes aware that the length of the known pendulum is such that the pendulum frequency is smaller than the frequency of vibration of the pump. Applying the known effects of this frequency condition in an apparatus with a cryopump is obvious to a skilled person.

VIII. The party "Wild Leitz GmbH" argued as follows:

(a) Conventional vacuum systems use pumps which are directly fixed to the vacuum chambers. The essential features of Claim 1 of the patent in suit are a freely hanging pump without any support and insulated from the vacuum chamber via a bellows. These features, however, are also realised in the object of the prior public use as can be seen in particular from document D7.

(b) The pendulum length is composed of a part of the bellows, the exhaust tube and the pump part between its opening and its centre of gravity. Also in a cryopump, the distance between the pump opening and the centre of gravity of the pump has a certain

length so that it may well be that in the replacement of the turbo-molecular pump by a cryopump the claimed frequency condition is automatically met.

(c) In the event that after the pump exchange there is still a disturbing vibration transfer to the vacuum chamber and the instruments therein, the only parameter which can be changed is the length of the freely hanging pump system. The physical model of the bellows-attached pump being a leaf spring, a lowering of the characteristic frequency of the spring by an increase of its length is generally known.

IX. The above arguments were contested by the Respondent (Patentee) who made essentially the following submissions:

(a) It was agreed that the technical features evidenced by documents D6 to D9 form part of the state of the art according to Article 54(2) EPC. However, the Opponents produced no evidence that the prior art teaches to decouple a vibration of a freely hanging pump which is attached to a vacuum chamber via a bellows, by regarding the pump-bellows-system as a pendulum, and by increasing the pendulum length in order to shift the characteristic frequency of the pendulum out of resonance with the pump vibration frequency to be decoupled.

(b) The decoupling of the 10^4Hz vibrations of a turbo-molecular pump needs different technical considerations from the insulation of the 2 Hz piston caused vibration of a cryopump. If a replacement of the turbo-molecular pump in the microscope according to document D7 by a cryopump results in complying with the frequency condition claimed in Claim 1, such a result would be entirely coincidental.

(c) In conventional insulating of vacuum pump vibrations only the resonant frequency of the elastic system between apparatus and pump is considered and adjusted by an appropriate choice of the bellows material and thickness, or by the provision of additional bellows or damping material around the bellows.

Reasons for the decision

1. The appeal is admissible.

2.1 There is no formal objection under Articles 123(2) or 123(3) EPC to the current version of the claims, specification and drawings. In particular, present Claim 1 comprises the subject-matter of as well Claims 1 and 2 of the published patent specification which is identical with that of originally filed Claims 1 and 2, as characteristics disclosed in the original description page 5, lines 2 to 28.

2.2 The Board is convinced that a skilled person is able to derive implicitly from the wording of Claim 1 that according to the invention only the cryopump vibration component in direction of the freely swinging centre of gravity of the pendulum - i.e. in mainly horizontal direction - is effectively insulated from the vacuum chamber, and that the frequency of this vibration component is determined by the reciprocation rate of the cryopump piston. Hence it follows that Claim 1 satisfies Article 84 EPC.

3. **Novelty**

3.1 None of the documents relied on in the pending proceedings describes an apparatus with a vacuum system - in particular not a vacuum system according to the first part

of Claim 1, i.e. essentially comprising a vacuum pump attached to an exhaust tube which is connected to a bellows, through which the pump exhausts air from a vacuum chamber housing instruments, and which bellows is used as a fulcrum of a pendulum system formed of bellows, exhaust tube and pump - wherein the vacuum pump is a cryopump.

3.2 The prior public use of scanning electron microscope "Leitz-AMR 1600 T" according to documents D6-D9 discloses an apparatus as defined in the precharacterising part of Claim 1, having a turbo-molecular pump as a vacuum pump; see in particular document D7, no. 1 of the piece list. Turbo-molecular pumps are also used in the devices known from document D2 (see column 3 lines 59 and 60) and from document D10 (see the title).

3.3 In the apparatus known from document D1 an oil diffusion pump (10) exhausts air from the vacuum chamber (6) via a tube system (7, 9) which is axially movable in gasket rings (13, 14, 17).

3.4 Document D4 describes the vibration insulating suspension of an electron microscope (60), via inclined mounting brackets (64) which extend outside the vacuum chamber of the microscope. The end of each bracket is respectively fastened to a bellows (40) which forms part of the walls of a separate container communicating through valves (20, 24) with a separate reservoir (22) and a roughing pump (26). The type of the fine pump and its connection to the vacuum chamber of the microscope is not specified in document D4. In particular, it is not recognisable from Fig. 4 whether the fine pump is part of the suspended microscope.

3.5 Neither do documents D3 and D5 specify the type of vacuum pump or its connection to the respective vacuum chamber. Bellows (17) of document D3 forms a flexible suction way, which allows to adjust the position of the top portion (3) of an electron microscope to differently sized specimen chambers. Bellows (28) of document D5 represents a sealed feed tube of a coolant container (20).

3.6 For the reasons given above, the subject-matter of Claim 1 is considered novel (Article 54(2) EPC).

4. Inventive step

4.1 In the Board's opinion, the prior use of the scanning electron microscope "Leitz-AMR 1600 T" as evidenced in particular by documents D6-D9, represents the prior art which comes closest to the invention. It covers all features defined in the precharacterising part of Claim 1. Starting from this art, the objective problem underlying the invention is to adapt the vibration insulation of this known exhaust device to the special needs of a cryopump with a low frequency vibration of about 2-3 Hz in horizontal direction, caused by the reciprocating motion of its piston; see the description of the patent under appeal, column 1, lines 24-26; column 2, lines 6-12; and column 3, lines 62-65.

The Board regards exclusively the insulation of the horizontal component of the cryopump vibration to be comprised in the objective technical problem. The pendulum inertia gets only effective with regard to forces acting on the pendulum tangentially to the path of its centre of gravity and having frequencies lower than the pendulum frequency (resonance decoupling). The vertical component

of the cryopump vibrations is insulated from the vacuum chamber by the axial flexibility of the bellows (see the specification of the patent under appeal, column 4, lines 28-34).

4.2 The Appellant is followed in his view according to point VIIb above, insofar as it has to be regarded as obvious to a skilled person to replace turbo-molecular pump 1 of document D7 by a generally known cryopump. However, in addition to the wording "said vacuum pump is a cryopump with a reciprocating moving piston" the characterising part of Claim 1 contains the following dimensioning rule:

"the length of the pendulum is such that the pendulum frequency is smaller than the frequency of vibration of said cryopump produced by the reciprocation of the piston so that the pendulum system cannot follow this vibration."

This dimensioning rule in Claim 1 is not limited to the condition, that the pendulum frequency shall be smaller than the frequency of the disturbing vibration. In the Board's view it teaches the skilled person rather to reduce the pendulum frequency until the pendulum system: "bellows-exhaust tube - cryopump" follows no longer the reciprocating movement of the pump piston.

4.3.1 Therefore, considering the question of inventive step it remains to be examined whether the prior art gives a person skilled in the art a hint to dimension the distance between the fulcrum of the bellows and centre of gravity of a cryopump so that the resulting excitation of the vacuum chamber movement by the pump piston can be neglected with regard to the requirements of the instruments.

4.3.2 The dimensioning rule of the pendulum length claimed in Claim 1 is defined in form of a functional feature. In answering the question whether a functional feature forms part of the prior art, it has to be decided what was "made available" to the public and not what may have been "inherently" contained in the object which was made available to the public by earlier written description or prior use (see points VIIa and VIIIb); see the decision of the Enlarged Board of Appeal G 6/88, dated 11 December 1989 (to be published), point 8.1, paragraph 2.

4.4 As far as the known vacuum systems with a freely suspended pump are concerned, neither from the submitted evidence describing the technical properties of prior used scanning electron microscope "Leitz-AMR 1600 T" (documents D6 to D9) nor from document D10, in the Board's opinion, is a skilled person able to derive any advice that the pendulum frequency of the pendulum system formed by the bellows-suspended pump has to be put into relation with the frequency of a disturbing pump vibration, or that the local position of the centre of gravity of the pump should be varied, if the insulation of horizontal pump vibrations is unsatisfactory.

4.4.1 The Board is satisfied that the technical teaching made available to the public by prior use of microscope "Leitz AMR 1600 T" is limited with regard to the functioning of the freely hanging pump to the following: The known bellows decouples the pump oscillation from the vacuum chamber and the known exhaust tube allows to attach the suction opening of the pump to other system components.

Also the other prior art documents - as shown below - do not make it obvious to a skilled person to mentally associate a freely hanging pump with a physical pendulum and to vary the pendulum length for resonance decoupling. Hence, the Board does not follow the Appellant's view in point VIIb above that a skilled person is able to recognise, in the distance of the centre of gravity of the known freely hanging pump from its fulcrum, the length of a pendulum which may be varied in order to decouple a mechanical vibration of the pendulum mass from the fulcrum of the pendulum.

The above reasoning also applies to the resulting object of an aggregation of the prior used microscope and a cryopump and its association with a leaf spring; see points VIIIb and VIIIc. The Board is furthermore convinced that the state of the art offers the skilled person - as stated in point IXc - a multitude of technical means for vibration insulation. Hence, contrary to the opinion of the party "Wild Leitz AG" mentioned in point VIIIc, there exists no one-way-situation, leading from the aggregated microscope and cryopump to the subject-matter of Claim 1.

4.4.2 Interpreting the functioning of the cushioning-body represented in Figure 5.15 of document D10, in combination with Figures 5.19 and 5.32, results in a device wherein the rotor axis of the turbo-molecular pump is parallel to the axis of symmetry of the bellows. Hence it follows that an unbalanced rotor movement in the pump of document D10 causes a circular pendulum vibration of the suspended pump with a horizontal component. These vibrations are insulated from the vacuum chamber by the resiliency-body of Figure 5.15 which, in addition to a bellows, contains rubber damping elements, see page 5.10, right column, lines 7-11. However, in order to take into account the

frequency of the disturbing vibration, document D10 (page 5.10, right column, lines 12-15) recommends the skilled person to optimise the damping by varying not the pendulum length but the prestress on the resiliency-body via threaded bolts.

4.5 In the apparatus known from document D2 the turbo-molecular pump 30 is not part of a pendulum system, but vacuum chamber and pump are both mounted on solid vibration-free concrete (column 4, lines 29-31). Within the exhaust system, vibration insulation is provided by a horizontally extending bellows (20) with shock attenuating spacing means (22) between the pleats (21) of the bellows.

4.6 The vibration isolating means of document D4 is an elastically deformable and individually sealed container with a partial pressure therein (see the abstract). The bellows (40) are part of the walls of the container, which is evacuated by a roughing pump (26). The residual pressure in the container determines its characteristic frequency, the lower value of which being limited by the spring rate of the bellows. As far as the isolation of the microscope (60) not only from vertical vibrations, but also from lateral and pendular vibrations is mentioned (column 5, lines 20-26), this is done by brackets (64), the axes of the vibration isolators being inclined at 45° from the vertical - whereas the axis of the bellows of the subject-matter of Claim 1 is vertical.

4.7 Document D1 teaches to use gaskets for vibration insulation; see page 2, lines 104-108. The bellows used in documents D3 and D5 are not vibration insulation means, but flexible conduits permitting displacement of different portions of the apparatus.

4.8 For the reasons set out in point 4.3.1 to 4.7, the Board is convinced that the technical information of the cited documents does not hint, neither alone nor in combination with each other, at the dimensioning rule of the pendulum length such as claimed in the characterising part of Claim 1. Hence, the Board finds that the subject-matter of Claim 1 involves an inventive step within the meaning of Article 56 EPC.

5. Hence it follows that Claim 1 is allowable.

6. Since granted Claims 3 to 10 relate to preferred embodiments of the apparatus according to Claim 1, their allowability follows from that Claim 1. They can, therefore, be maintained as Claims 2 to 9.

Order

For these reasons, it is decided that:

1. The appeal is dismissed.

2. The decision of the Opposition Division is set aside.

3. The patent is maintained on the basis of the following documents:

Claim 1: handed over during oral proceedings dated 30 January 1990

Claims 2-9: received 10 July 1986

Description: column 1 to column 6, line 19, received 10 July 1986

Drawings: sheets 1 to 6 according to EP-B-0 019 426.

The Registrar: The Chairman:

M. Beer H. Reich