

Internal distribution code:

- (A) [] Publication in OJ
(B) [] To Chairmen and Members
(C) [X] To Chairmen
(D) [] No distribution

D E C I S I O N
of 10 April 2002

Case Number: T 0059/98 - 3.4.1

Application Number: 91710020.8

Publication Number: 0459939

IPC: G01P 15/125

Language of the proceedings: EN

Title of invention:

Capacitive acceleration sensor with free diaphragm

Patentee:

COPAL COMPANY LIMITED

Opponent:

Mannesmann VDO AG

Headword:

-

Relevant legal provisions:

EPC Art. 100(a), 52(1), 56, 102(3)

Keyword:

"Second auxiliary request - inventive step - (yes) after amendment"

"Maintenance - in amended form"

Decisions cited:

-

Catchword:

-



Case Number: T 0059/98 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 10 April 2002

Appellant:
(Opponent)

Mannesmann VDO AG
Rüsselsheimer Strasse 22
D-60326 Frankfurt (DE)

Representative:

Zmyj, Erwin, Dipl.-Ing., Dipl.-Wirtsch.-Ing.
Rosenheimer Strasse 52/II
D-81669 München (DE)

Respondent:
(Proprietor of the patent)

COPAL COMPANY LIMITED
2-16-20, Shimura
Itabashi-ku
Tokyo 174 (JP)

Representative:

Patentanwälte Wenzel & Kalkoff
Postfach 24 48
D-58414 Witten (DE)

Decision under appeal:

**Decision of the Opposition Division of the
European Patent Office posted 22 December 1997
rejecting the opposition filed against European
patent No. 0 459 939 pursuant to Article 102(2)
EPC.**

Composition of the Board:

Chairman: G. Davies
Members: G. Assi
R. Q. Bekkering

Summary of Facts and Submissions

- I. The opponent (appellant) lodged an appeal, received on 14 January 1998, against the decision of the opposition division, dispatched on 22 December 1997, rejecting the opposition against the European patent No. 0 459 939 (application number 91 710 020.8). The fee for appeal was paid on the same day. The statement setting out the grounds of appeal was received on 20 April 1998.
- II. Opposition had been filed against the patent as a whole and was based on Article 100(a) EPC, in particular on the grounds that the subject-matter of the patent was not patentable within the terms of Articles 52(1) and 56 EPC.

In the decision under appeal, the opposition division held that the grounds of opposition did not prejudice the maintenance of the patent as granted, having regard *inter alia* to the following documents:

(D1) US-A-4 435 737 and

(D6) US-A-3 559 492.

In the attacked decision (see page 5, point 9.4), the opposition division also considered the prior art sensor shown in Figure 24 of the patent in suit and disclosed in the following document cited in the description of the patent in suit (see column 1, line 23):

(D8) US-A-4 694 687.

III. During the appeal proceedings, the following further documents have been considered:

(D2) DE-C-2 523 446,

(D3) US-A-2 767 973,

(D4) US-A-2 643 869,

(D5) DE-A-2 936 607 and

(D7) US-A-4 399 705.

IV. Oral proceedings were held on 10 April 2002.

V. The appellant requested that the decision under appeal be set aside and that the patent be revoked.

The respondent (patent proprietor) requested that the patent be maintained on the basis of the following documents:

Main request:

Claims: No. 1 to 11 of the granted patent,

Description: columns 1 to 27 of the granted patent,

Drawings: Sheets 1/19-19/19 of the granted patent,

First auxiliary request:

Claims: No. 1 filed at the oral proceedings on
10 April 2002,
No. 2 to 11 of the granted patent,

Description: columns 1, 2, 5 to 27 of the granted patent,
columns 3, 4 filed at the oral proceedings on 10 April 2002,

Drawings: Sheets 1/19-19/19 of the granted patent.

Second auxiliary request:

Claims: Nos. 1, 2, 3 filed at the oral proceedings on 10 April 2002,

Description: columns 1, 2, 2a, 3, 3a, 3b, 4 to 12 filed at the oral proceedings on 10 April 2002,

Drawings: Figures 1 to 5, 6A, 6B, 7 filed at the oral proceedings on 10 April 2002.

VI. The wording of Claim 1 of the main request reads as follows:

"1. *An acceleration sensor comprising:*

- *a first stationary substrate (1) having a first central junction pad (18u) and a first peripheral stationary electrode (17u) of an annular shape surrounding the first central junction pad (18u);*
- *a second stationary substrate (2) having a second central junction pad (32m) and a second peripheral stationary electrode (30l) of an annular shape which surrounds the second central junction pad (32m) and which is opposed to the first peripheral stationary electrode (17u) with a given spacing;*
- *an electrically conductive diaphragm (3) having a*

- central segment (26) fixed in the spacing through the pair of first and second central junction pads (18u, 32m), and a peripheral segment (25m) of annular shape surrounding around and extending resiliently from [read "from"] the central segment (26) to undergo a displacement in the spacing relative to the first and second peripheral stationary electrodes (17u, 301) in response to an external acceleration force, the electrically conductive diaphragm (3) being comprised of a thin segmented plate having a leaf spring piece (27) connecting the peripheral segment (25m) to the central segment (26) in free-end support;*
- *a pair of spacers (8, 9) composed of thin metal plates having an identical shape, and being disposed between respective ones of the first and second central junction pads (18u, 32m) and the central segment (26) of the diaphragm (3) to sandwich the same (3) such as to provide an electrical path from the peripheral segment (25m) to either of the first and second central junction pads (18u, 32m), and*
 - *a coupling member (13) for securing a superposed structure of the diaphragm (3), the pair of spacers (8, 9) and the pair of first and second stationary substrates (1, 2) with each other, said coupling member passing centrally through said superimposed structure."*

Claims 2 to 11 of the main request are dependent.

The wording of Claim 1 of the first auxiliary request is identical to that of Claim 1 of the main request with the mention of the expression "of planar shape"

between "..., the electrically conductive diaphragm (3) being comprised of a thin segmented plate" and "having a leaf spring piece (27) ...".

Claims 2 to 11 of the first auxiliary request are dependent.

The wording of Claim 1 of the second auxiliary request is identical to that of Claim 1 of the main request with the mention of the following further feature at the end of the claim:

"..., wherein at least one (17u) of the stationary electrodes (17u, 301) is composed of an electro-conductive pattern comprising a main section (171u) having a fixed area dimension and a variable section consisting of a plurality of divided sections (172u) which can be cut selectively from the main section (171u)."

Claims 2 and 3 of the second auxiliary request are dependent.

VII. The appellant submitted that the closest state of the art was represented by D1 or, alternatively, D8.

Considering Claim 1 of the main request, should it be drafted in a two-part form with regard to D1, the characterising portion would only include the features concerning the "diaphragm" consisting of a thin plate having a leaf spring piece connecting the peripheral segment to the central segment in free-end support, the "pair of spacers" composed of thin metal plates, and the "coupling member" passing centrally through the

superposed structure of the accelerometer. These features represented technical measures within the scope of the customary practice followed by persons skilled in the art. In particular, it was obvious to replace the thin diaphragm portion 18 of the accelerometer known from D1 with the claimed leaf spring piece 27, both solutions being equivalent (see D4, Figures 3 and 4) and ensuring a flexible free-end connection of the peripheral segment to the central segment of the diaphragm. The claimed use of a pair of spacers was an obvious alternative to the central thick portion 16 of the accelerometer shown in D1, both solutions providing a gap between the diaphragm and the stationary electrodes. The claimed central coupling member also represented an obvious alternative to the central fixation of the superposed structure of the accelerometer according to D1. In this respect, attention was drawn to D7, Figure 1.

Having regard to D8, the only difference between the subject-matter of Claim 1 of the main request and the disclosure of Figure 3 of this document concerned the central coupling member, the provision of which could, however, not be considered as involving an inventive step.

As to Claim 1 of the first auxiliary request, the use of the adjective "*planar*" simply implied that the claimed diaphragm was not curved. The diaphragms of the accelerometers according to D1 or D8 were also "*planar*", so that the amendment made could not add anything inventive. Moreover, the amendment gave the impression that the surface of the diaphragm was continuous although a slit pattern was present.

As far as Claim 1 of the second auxiliary request was concerned, the added feature concerning the adjustment of the area of one of the stationary electrodes could be derived from D5.

VIII. The respondent submitted that the closest state of the art was represented by D1 which disclosed an acceleration sensor having a superposed structure with central fixation and comprising a "*first stationary substrate*" with a first peripheral annular electrode, a "*second stationary substrate*" with a second peripheral annular electrode, and an "*electrically conductive diaphragm*" having a central segment and a peripheral annular segment extending resiliently from the central segment to undergo a displacement in the spacing between the first and second peripheral stationary electrodes in response to an external acceleration force. The known accelerometer had significant disadvantages, in particular high manufacturing precision and care in view of the dimensions, the materials and the technology used.

The object underlying the present invention was to provide a capacitive accelerator characterised by a high measuring precision and a simple manufacturing process, in particular an easy assembling and re-assembling. This object was achieved by the combination of the features of Claim 1 of the main request relating to the "*diaphragm*" made of a thin plate having a leaf spring piece connecting the peripheral segment to the central segment in free-end support, the "*pair of spacers*" consisting of thin metal plates providing an electrical path from the peripheral segment of the diaphragm to either of the first and second central junction pads, and the "*coupling member*" passing

centrally through the superposed structure including the diaphragm, the pair of spacers, the first and second stationary substrates. The combination of these features offered the significant advantages over D1 that the diaphragm could be easily manufactured, the sensitivity of the accelerometer could be changed in a simple manner and the accelerometer could be assembled and repaired without difficulty. Document D1 concerned an accelerometer with structural similarities to that claimed but manufactured using a semiconductor microcircuit technology based on etching and coating. The skilled person had no reason for or hint at departing from this teaching. A combination of D1 with the other documents cited would not be justified because D2, D3, D4 and D8 dealt with accelerometers having a different structure, namely with a diaphragm fixed at the outer periphery and deforming under thermal stress; D6 and D7 concerned a completely different design concept.

As to Claim 1 of the first auxiliary request, the adjective "*planar*" implied that the claimed diaphragm was not curved and had a uniform thickness. Thus, the amendment made further distinguished the claimed diaphragm from that according to D1, for which different thicknesses of the portions 16, 18, 20 were essential.

With regard to Claim 1 of the second auxiliary request, D5 did not teach the adjustment of the area of one of the stationary electrodes of a capacitive accelerometer so as to compensate for an imbalance.

In summary, the combination of the teaching of D1 with that of the other documents cited reflected an *ex post*

facto analysis.

Reasons for the Decision

1. The appeal is admissible.
2. *Respondent's main request*
 - 2.1 Document D1, which is considered to represent the most relevant state of the art, discloses an acceleration sensor comprising the following features (see Figures 1 and 2):
 - a first stationary substrate 12 having a first central junction pad (see column 3, lines 37 to 41) and a first peripheral stationary electrode 22 of annular shape surrounding the first central junction pad,
 - a second stationary substrate 12 having a second central junction pad and a second peripheral stationary electrode 22 of annular shape, which surrounds the second central junction pad and is opposed to the first peripheral stationary electrode with a given spacing,
 - an electrically conductive diaphragm 14 having a central segment 16 fixed between the first and second central junction pads, a thin intermediate segment 18 and a peripheral segment 20 of annular shape, the intermediate segment resiliently connecting the peripheral segment to the central segment in free-end support so that the peripheral segment undergoes a displacement in the spacing

between the first and second peripheral stationary electrodes in response to an external acceleration force (see column 5, lines 2 to 5),

- the first stationary substrate, the diaphragm and the second stationary substrate forming a superposed structure and being centrally bonded together by electrostatic or anodic bonding (see column 4, lines 13 to 16) or soldering techniques (see column 4, lines 43 to 45) or other equivalent process producing high strength joints and precise positioning and spacing (see column 5, lines 22 to 26).

Therefore, the subject-matter of Claim 1 of the main request differs from the acceleration sensor known from D1 in the following features:

- (i) a leaf spring piece in the intermediate segment of the diaphragm,
- (ii) a pair of spacers consisting of thin metal plates, having an identical shape and being disposed between the central segment of the diaphragm and the first and second central junction pads, respectively, to sandwich the diaphragm so as to provide an electrical path from the peripheral segment to either of the first and second central junction pads,
- (iii) a coupling member passing centrally through the superposed structure so as to secure it.

2.2 In the letter of 3 September 1998 (see pages 6 and 7), the respondent states that the features (i), (ii) and

(iii), in combination with the remaining features of the claim, represent the solution to the technical problem to provide a capacitive acceleration sensor which allows a precise detection of acceleration and can be easily assembled and re-assembled. Moreover, in the patent in suit (see column 2, line 58, to column 3, line 4), the need for a high sensitivity is also mentioned. Considering the limits of the sensor known from D1 resulting from the relatively rigid diaphragm used (see the patent in suit, column 2, lines 46 to 51) and the microcircuit technology used for its manufacture (see D1, column 2, lines 3 to 7), the Board agrees with this definition of the problem as far as sensitivity and manufacture are concerned. On the other hand, the statement in the patent in suit (see column 2, lines 49a to 51) on the measuring precision of the known sensor is not convincing because, according to D1 (see column 2, lines 37 to 40), acceleration is measured while compensating for temperature and stray capacitance, this speaking for precision of the measure.

- 2.3 Whereas the feature (i) provides for a better flexibility of the diaphragm and thus a higher sensitivity of the acceleration sensor, the features (ii) and (iii), in particular the latter one, enable a simple assembling and re-assembling of the device. The features, however, are not so functionally linked together that a synergistic effect results from their combination. Indeed, the flexibility of the diaphragm due to the presence of a leaf spring piece, *i.e.* a plurality of circumferential slits according to the disclosure of Figures 2, 10 and 17 of the granted patent, is not related to the effect resulting from feature (iii) that the sensor can be easily assembled.

The provision of a gap between the peripheral segment of the diaphragm and the first and second stationary electrodes, respectively, by means of suitable spacers (feature (ii)) is not linked to the resiliency of the connection of the peripheral segment to the central segment of the diaphragm (feature (i)). The fact that, according to feature (iii), the elements of the sensor are fixed together by a central coupling element has no effect on the flexibility of the diaphragm (feature (i)) or the electrical path relying on the presence of the spacers (feature (ii)). In summary, the effect achieved by one of the features (i), (ii) and (iii) is not dependent on that of the others. The lack of a functional relationship entails that, while assessing inventive step, each of the features (i), (ii) and (iii) can be considered *per se*.

- 2.4 At the oral proceedings, the appellant stated that the acceleration sensor according to Claim 1 lacks inventive step having regard to the disclosure of D1 and the technical knowledge of the skilled person, for which evidence has been produced in the form of documents D4 and D7.
- 2.5 The flexibility of the claimed diaphragm is obtained by the provision of a leaf spring piece 27 (feature (i)), whereas, according to D1, it results from the presence of the thin intermediate segment 18. The skilled person knows that the flexibility of a disk-shaped diaphragm can be influenced in different ways, for example by using different materials and/or changing the diameter of the diaphragm and/or changing its thickness and/or using various types of cut-out portions (slits) in the diaphragm. Evidence for this technical knowledge is given by document D4 relating to an acceleration sensor

provided with a spring member 28 forming part of an acceleration-responsive system (see Figures 2, 3 and 4, column 5, lines 50 to 59, column 6, lines 57 to 75). Thus, the skilled person, if he considers the sensitivity of the sensor of D1 to be insufficient because the diaphragm is relatively rigid, knows how the flexibility of this pick-up element can be varied and improved. This means that, in the light of this knowledge, the claimed solution of providing a leaf spring piece in the diaphragm, *i.e.* a plurality of suitable slits according to the description of the patent in suit, is an obvious alternative to that known from D1 of reducing the thickness of the diaphragm in its intermediate segment 18.

2.6 According to all the embodiments described in the patent as granted, the diaphragm is a thin plate with uniform thickness (see Figures 1, 7 and 14). For this reason, a pair of thin metallic spacers are provided between the central segment of the diaphragm and the first and second central junction pads of the stationary substrates in order to have a gap between the peripheral segment of the diaphragm and the first and second stationary electrodes, respectively. Thus, interpreting Claim 1 in the light of the description, the solution of providing a pair of spacers lacks inventive step because it represents a foreseeable and logic consequence of the choice of a diaphragm with uniform thickness. Moreover, it is an obvious alternative to the solution shown in D1, which consists in that the thickness of the central segment 16 of the diaphragm is higher than that of the remaining part of the diaphragm, in particular the peripheral segment 20. As regards the material of the spacers, they are made of metal so as to establish an electrical path from the

peripheral segment of the diaphragm to either of the first and second central junction pads. Such a path is also provided in the sensor according to D1, in which the diaphragm is made of an electrically conductive semiconductor. The choice of metal for this aim is obvious.

- 2.7 The provision of a coupling member for centrally fixing the superposed elements of the acceleration sensor clearly represents a simplification while assembling the device as compared with the bonding techniques used in D1. In the decision under appeal (see page 4), the opposition division argues that *"screwing or nailing together of semiconducting wafers would appear to be a very exotic technique, given the small overall dimensions of the devices."* This statement is contested by the appellant who refers to document D7 concerning an acceleration sensor for detecting knocking signals in internal combustion engines.

The Board remarks that the sensor according to D7 (see Figure 1 and 3, column 2, lines 19 to 42) includes *inter alia* a superposed structure consisting of a thrust collar 4, a ceramic insulating washer 3, a piezoceramic element 1, another ceramic insulating washer 3 and a reaction mass 5, all these elements being provided with a central opening through which a mounting screw is guided to fix the acceleration sensor to a surface of the engine. Thus, even though D7 concerns a sensor different from that claimed, it gives evidence for the technical feasibility of a stack of ceramic elements fixed by a central coupling member. In view of the advantages of this system, in particular the easy assembling and re-assembling, the reliability of the fixation and the precise and simple centring of

the various elements, the skilled person would consider to use the feature (iii) for mounting the substrates and the diaphragm of the sensor according to D1, the more so as the materials used in D1 are from a structural point of view similar to those of the piezoelectric element and the washers of D7.

2.8 In conclusion, the subject-matter of Claim 1 of the main request results in an obvious way from the disclosure of document D1 to be considered together with the technical knowledge of the skilled person, for which evidence is given in documents D4 and D7.

2.9 Hence, the respondent's main request is not allowable.

3. *Respondent's first auxiliary request*

3.1 As compared to Claim 1 of the main request, Claim 1 of the first auxiliary request includes the further feature that the diaphragm consists of a thin segmented plate "*of planar shape*". This amendment does not render the claimed subject-matter inventive. Indeed, the adjective "*planar*" characterising the "*shape*" clearly indicates that the claimed diaphragm lies in a plane, i.e. it is not curved, just as the diaphragm of the sensor according to D1. The amendment is not equivalent to the expression "*of uniform thickness*" having a different technical meaning. In this respect, the thickness of the diaphragm is not defined in the patent in suit, apart from the Figures 1, 7 and 14 which, however, have a qualitative nature only. The Board, moreover, notes that the passage of the patent as granted cited by the respondent in support of the amendment, i.e. column 6, lines 3 and 4, refers to Figure 2 which, being a top view of the diaphragm (see

also column 3, lines 50 to 53) cannot give any information concerning the thickness.

3.2 Thus, the subject-matter of Claim 1 of the first auxiliary request lacks inventive step.

3.3 Therefore, the respondent's first auxiliary request is not allowable.

4. *Respondent's second auxiliary request*

4.1 With reference to Claim 1 of the main request, Claim 1 of the second auxiliary request includes the further feature concerning the adjustable area of at least one of the stationary electrodes. The added subject-matter is disclosed in Claim 2 of the patent as granted and Claims 4, 5 and Figure 6A of the application as filed. Moreover, it clearly limits the protection conferred by the patent as granted.

As regards the dependent claims, new Claim 2 corresponds to Claim 3 of the patent as granted and Claim 6 of the application as filed. The subject-matter of new Claim 3 is disclosed in the application as filed (see column 5, lines 31 to 33).

Thus, the claims have not been amended in such a way that they contain subject-matter which extends beyond the content of the application as filed (Article 123(2) EPC) or so as to extend the protection conferred (Article 123(3) EPC).

4.2 In Claim 1, the added feature solves the further technical problem concerning the need to balance the first and second capacitors of the acceleration sensor,

which are defined by the peripheral segment of the diaphragm and the first and the second peripheral stationary electrodes, respectively. Indeed, considering that each capacitance C1 and C2 *inter alia* depends on the surface S1, S2 of the stationary electrode and the distance d1, d2 between the diaphragm and the stationary electrode (see the patent in suit, column 8, lines 42 to 56), unequal distances d1 and d2 would cause an imbalance between C1 and C2, assuming that S1 and S2 are equal (see column 8, line 57, to column 9, line 9). If such an imbalance is present, the sensor does not have a stable neutral operating point (see column 11, line 52, to column 12, line 7).

- 4.3 The appellant submits that the acceleration sensor of Claim 1 lacks inventive step having regard to the combination of the teaching of document D1 with that of D5.

Document D5 concerns an adjustable electronic element. In particular, the Figure shows a capacitor having a first electrode on a substrate 1, a dielectric layer 2 and a second electrode composed of an electrically conductive pattern comprising a plurality of sections 4, 5, 6, 7 having different areas, these sections being connected to a common lead in 12 through a path 11. By interrupting the connection of the section 4 to the path 11 or the connections 8, 9, 10, it is possible to adjust the capacitance.

- 4.4 The Board notes that the problem related to the capacitance imbalance in the acceleration sensor is not recognised in D1, although this document concerns a capacitive acceleration sensor comprising two capacitors. Nor can the imbalance problem be recognised

in D5 because this document refers to a simple capacitor with adjustable capacitance.

Starting from the acceleration sensor known from D1, there is no reason to assume that this sensor is negatively affected by a capacitive imbalance. On the contrary, according to D1, column 5, lines 22 to 26, the process used for bonding the semiconductor diaphragm to the glass substrates ensures "*precise positioning and spacing*". This means that the sensor has an inner symmetry which results from the accurate assembling procedure. The solution of Claim 1 is based on a quite different approach. The sensor is assembled in a simple way (see features (ii) and (iii)) so that an asymmetry between the electrode gaps is not excluded. A high measurement precision is nevertheless obtained by introducing a further asymmetry between the stationary electrode areas, which is easy to be realised and compensates the measuring error due to imbalance. Thus, it may be argued that it is *per se* known to adjust a capacitance by varying the area of one of the electrodes of the capacitor (see D5). But this knowledge is not sufficient to render obvious the claimed solution which combines the advantages of an easy assembling and high measuring precision by not avoiding a first structural asymmetry which is then compensated by a second asymmetry deliberately introduced into the sensor. The presence of an inventive step is, furthermore, supported by the fact that other solutions are possible which would be completely different from that claimed, for instance compensating the imbalance with the electronic detecting circuit.

Therefore, the Board concludes that the appellant's

combination of documents D1 and D5 is based on an *ex post facto* analysis.

4.5 Hence, the subject-matter of Claim 1 of the second auxiliary request involves an inventive step. Claims 2 and 3, being dependent on Claim 1, also fulfil the requirement of inventive step.

4.6 The description according to the second auxiliary request has been adapted to the new Claim 1. The appellant has raised no objections against the amendments made.

4.7 The respondent's second auxiliary request is thus allowable.

5. In conclusion, taking into consideration the amendments according to the respondent's second auxiliary request, the Board considers that the patent as amended meets the requirements of the EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order to maintain the patent as amended in the following version according to the respondent's second auxiliary request:

Claims: 1, 2, 3 filed at the oral proceedings on

10 April 2002,

Description: columns 1, 2, 2a, 3, 3a, 3b, 4 to 12
filed at the oral proceedings on
10 April 2002,

Drawings: Figures 1 to 5, 6A, 6B, 7 filed at the
oral proceedings on 10 April 2002.

The Registrar:

The Chairman:

R. Schumacher

G. Davies