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D E C I S I O N
of 29 July 1998

Case Number: T 0132/95 - 3.4.2

Application Number: 87906265.1

Publication Number: 0325601

IPC: G01F 1/84

Language of the proceedings: EN

Title of invention:
Improved drive means for oscillating flow tubes of parallel path coriolis mass flow rate meter

Patentee:
Micro Motion Incorporated

Opponent:
01: Endress + Hauser Flowtec AG
02: Krohne Messtechnik Massametron GmbH & Co. KG

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - ex post facto analysis"

Decisions cited:
-

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0132/95 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 29 July 1998

Appellant: (Opponent 01)	Endress + Hauser Flowtec AG Kägenstrasse 7 4153 Reinach BL1 (CH)
Representative:	Morstadt, Volker, Dipl.-Ing. Endress + Hauser Zentrale Patentabteilung Postfach 2222 79574 Weil am Rhein (DE)
Other party: (Opponent 02)	Krohne Messtechnik Massametron GmbH & Co. KG Friedhofstrasse 30 72124 Pliezhausen (DE)
Representative:	Gesthuysen, Hans Dieter, Dipl.-Ing. Patentanwälte Gesthuysen, von Rohr, Weidener, Häckel Postfach 10 13 54 45013 Essen (DE)
Respondent: (Proprietor of the patent)	Micro Motion Incorporated 7070 Winchester Circle Boulder Colorado 80301 (US)
Representative:	Heunemann, Dieter, Dr. Vossius & Partner Postfach 86 07 67 81634 München (DE)

Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 29 November 1994 rejecting the opposition filed against European patent No. 0 325 601 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: E. Turrini
Members: S. V. Steinbrener
M. Lewenton

Summary of Facts and Submissions

I. The appellant (opponent 01) lodged an appeal against the decision of the Opposition Division to reject both oppositions against European patent No. 0 325 601.

The oppositions had been filed against the patent as a whole, referring to Article 100(a) and (b) EPC respectively, since the subject matter of the patent in suit allegedly lacked an inventive step, and the subject matter of dependent claims 3, 6 and 7 was insufficiently disclosed. The patent proprietor requested that both notices of opposition be rejected as inadmissible according to Rule 56(1) EPC.

In its decision *inter alia* taking account of the following documents (using the numbering of the Opposition Division):

D3: US-A-4 491 025

D7: US-A-4 322 257

D8: S. Cedighian: "Die magnetischen Werkstoffe", VDI-Verlag GmbH, Düsseldorf 1975, pages 26, 27 and 76 to 79; and

D11: US-A-3 803 522,

the Opposition Division held that the oppositions were admissible, but not well-founded since the grounds for opposition referred to by the opponents did not prejudice the maintenance of the patent.

In the statement of grounds of appeal, the appellant cited the following further documents in order to support its objection of lack of inventive step:

D13: Micro Motion Model D Mass Flow Meters Instruction Manual, June 1985, Micro Motion, Inc, Boulder, Colorado, and

D14: US-A-4 559 833,

the former document being an earlier edition of the instruction manual referred to in the contested patent (see page 2, lines 10 to 12).

II. Oral proceedings were appointed at the respective auxiliary requests of the appellant and the respondent (patent proprietor). In the communication of 27 May 1998 pursuant to Article 11(2) of the Rules of Procedure of the Boards of Appeal, the Board starting from document D3 as the closest prior art formulated a series of issues on which the assessment of inventive step at the scheduled oral proceedings should in substance focus.

In a reply to said communication dated 29 June 1998, the respondent requested on an auxiliary basis to maintain the patent in restricted form combining the features of claim 1 as granted with the additional features of either one or more of the dependent claims 2 to 7 as granted. Furthermore, the respondent reserved the right to incorporate any further features disclosed elsewhere in the description if this deemed necessary in view of any further submissions of the appellant.

III. Oral proceedings took place on 29 July 1998 in the absence of the remaining party (opponent 02) who did not actively take part in the present appeal proceedings.

During the oral proceedings, the respondent was informed by the Board that its unspecified auxiliary requests were considered inadmissible. The respondent then declared these requests to be purely precautionary in the sense that their filing might be intended in concretised form should the situation arise. At the end of the oral proceedings, the decision of the Board was pronounced.

IV. The appellant requested that the decision under appeal be set aside and that the European patent No. 0 325 601 be revoked.

V. The respondent requested that the appeal be dismissed and that the patent be maintained.

VI. The wording of claim 1 as granted reads as follows:

"1. A parallel path Coriolis mass flow rate meter for measuring the mass flow rate of a fluid, comprising:

a housing member (12) including an inlet manifold and an outlet manifold, two substantially parallel continuous flow tubes (20, 22) said flow tubes having adjacent ends fixedly mounted in a fluid tight manner to said inlet manifold and said outlet manifold so that fluid entering into said inlet manifold flows in parallel fashion through said flow tubes and exists therefrom into said outlet manifold;

each of said flow tubes having an oscillation axis (W, W') about which axes said flow tubes can be oscillated like tines of a tuning fork, and each of said flow tubes having a torsion axis (T, T') about which axes said flow tubes move due to the Coriolis forces generated by the flow of said fluid through said flow tubes when oscillated;

said flow tubes each having essentially equal moments of inertia and essentially equal spring constants about said oscillation axes and essentially equal moments of inertia and essentially equal spring constants about said torsion axes, and said tubes having a resonant frequency of oscillation about said torsion axes which is different from both the resonant frequency of oscillation about said oscillation axes and harmonics thereof;

a pair of sensor means (36, 38) for sensing the movement of said flow tubes about said oscillation and torsion axes, each said sensor means producing an output signal representative of the actual movement of said flow tubes;

time difference measuring means (44) for determining the time difference between said output signals with said time difference being indicative of the mass flow rate of the fluid passing through said flow tubes;

drive means for oscillating said flow tubes about said oscillation axes and comprising permanent magnet and keeper assembly (46, 48) mounted about one of said flow tubes and coil means (58) mounted about the other of said flow tubes, said permanent magnet and keeper assembly interfitting with said coil means; and drive circuit means adapted to be connected to said coil to oscillate said flow tubes at said resonant frequency about said oscillation axes, said drive circuit generating a periodic wave of predetermined frequency, and said drive circuit and the resistance of said coil providing a drive current in the range from about 50 mA to about 250 mA, said drive means comprising

said permanent magnet (46) comprising a rare earth magnet of samarium cobalt iron or of neodymium iron and having an annular configuration,

a cup-shaped keeper member (48) concentrically disposed with respect to and about said annular magnet forming an annular-conformed spacing of predetermined dimensions between said permanent magnet and said keeper member, and said permanent magnet and said keeper member affixed to one of said flow tubes proximate its midpoint with said annular conformed spacing facing said other flow tube; and

said coil means (48) comprising electrically conducting insulated wire having a predetermined number of turns wound in an annular configuration, said coil means sized to interfit into said annular-conformed spacing formed between said permanent magnet and said keeper, said coil means affixed to the other of said flow tubes proximate its midpoint to interfit within a portion of said annular confirmed spacing, and said coil means having such turns and dimensions that its inductance is from about 320 microhenries to about nine millihenries."

Claims 2 to 7 as granted are appended to claim 1.

VII. The appellant's argumentation in support of its requests may be summarised as follows:

Although documents D3 and D13 originating from the respondent are closely related since the latter must be considered as a technical realisation of the concept described in the former, it is believed that document D13 constitutes the most relevant document with respect to the subject-matter of claim 1 as granted. In this prior art, there is disclosed a mechanical construction of the mass flow rate meter identical to that of the contested patent when taking account of properties which cannot be considered to be "hidden inherent" properties (compare Figure 2 of D13 to Figure 1 of the patent). In particular, whereas the features of claim 1 concerning a symmetrical design of the flow tubes, which are not explicitly mentioned in D13, must be taken as a matter of course (these features are in any case disclosed in document D3), the claimed drive current range is derivable from said document by a mere comparison of what has been set out in the claim with the prior art. Such an approach cannot be disqualified as being based on hindsight. Moreover, there is a clear reference in the contested patent that the drive circuits described in document D13 are suitable for driving the claimed drive means which confirms the similarity of the respective drive current ranges.

As the claimed magnetic materials are conventional (see documents D7 and D8), the alleged invention boils down to the drive means design which is of loudspeaker type. However, a direct link between loudspeaker technology and vibration drivers for Coriolis mass flow rate meters has been established by document D14. The respondent's attempt of proving a discrepancy between the embodiments of Figures 1, 3 and 6 of said document must fail since a skilled person would consider the driver "plates" in Figures 3 and 6 to be only a schematic representation of what has been more explicitly disclosed in Figure 1 and associated text conclusively referring to loudspeaker driver design. Moreover, the same term ("linear electromagnetic driver") is used in D14 for all drive means. Therefore, provision of a drive means of the moving coil type on parallel flow tubes would appear logical from D14.

Having regard to the claimed inductance range, the driver should be more or less of the same diameter as the oscillating flow tubes (see e.g. Figure 1 of document D3 in this respect, which seems to be drawn to scale). The coil inductances can then be obtained from D13 by reverse engineering. Furthermore, in order to achieve the necessary drive power, strong magnets are required, such hard magnetic materials existing on the market.

Thus, documents D3 and D13 show the respondent's own state of the art according to which mass flow rate meters have been built before the priority date of the patent in suit, and from which the relevant parameter ranges can be derived in a straightforward way, taking account of pre-existing safety standards. Since loudspeaker drivers are referred to in document D14, and details of loudspeaker design, as e.g. the existence of an air gap and the requirement of drive linearity, are conventional (see document D11), the claimed solutions are at a skilled persons disposal. Minor variations, as e.g. whether the air gap is formed inside or outside the magnet, may be decided by the expert in accordance with circumstances.

Finally, it has to be emphasised that the moving coil design as such is basically asymmetric as can also be seen from Figure 2 of the contested patent. A detrimental influence of such a dissymmetry of the drive means on the measuring results has neither been described in the patent nor would it be apparent to a skilled person.

VIII. The respondent argued as follows:

In an assessment of inventive step which is the only issue at the present proceedings, document D3 should be selected as closest starting point since it stresses the importance of symmetry with respect to vibration physics in parallel path Coriolis mass flow rate meters. Although the meter described in D13 looks quite similar, said document is silent on the vibrational properties. As no prior use objection was raised by the appellant (although the meter of D13 could have been easily retrieved on the market), it may be assumed that the meter of D13 differs from the contested patent in this respect. Furthermore, the drive means of D13 does not correspond to that claimed in the patent, and even if the present patent refers to the drive circuits of D13, this only means that circuits of the type disclosed in D13 may be used, but does not suggest any ranges of operational parameters.

The requirement of vibrational symmetry, which is clearly apparent from claim 1 as granted, has consequences for the overall construction of the meter, and in particular for the driver design. The patent proposes a specific design of the drive means, which serves the purpose of vibrational symmetry in an advantageous way and differs fundamentally from loudspeaker drivers. In loudspeaker drivers, a highly linear transmission of the electromagnetic signal to the membrane is intended, which causes a highly asymmetrical construction consisting of a heavy stator part and an extremely light, movable membrane part. Examples of this type can be seen from document D11. If such a loudspeaker design were applied to a Coriolis mass flow rate meter, precise measuring results would not be obtained.

The claimed construction is simple and efficient, and preserves the symmetry as much as possible. Moreover, by reducing the strength of the drive current and thus the generation of heat, operation in dangerous environments becomes feasible.

The line of arguments put forward by the appellant is based on an ex-post-facto analysis. Document D14 refers to loudspeaker drivers in the context of an asymmetric mass flow rate meter having the above-mentioned massive stator part on a rigid support, and a movable coil part fixed to the single flow tube. This design corresponds to the driver of Figure 1 of D11. As can be seen from the remaining Figures of D14, different drive means, which apparently are not based on loudspeaker technology, are provided in the prior art for symmetrical flow tube arrangements. This fact is not surprising since loudspeaker drivers are not suitable for symmetric vibration measuring systems.

The claimed use of known hard magnetic materials does by no means attempt to monopolise the materials as such but adds to a low mass, high efficiency drive design which by its inherent compatibility with the symmetry requirement differs substantially from the loudspeaker drivers disclosed in D11: apart from being much more complex, those drivers are neither suitable nor intended for parallel path flow rate meters.

The claimed operational parameters must not be seen in an isolated manner as a mere result of meeting existing safety standards. Rather they are closely connected to the specific drive means design so that synergistic effects as to accuracy of measurement, high mass flow rate and applicability in hazardous environments should be acknowledged.

Reasons for the Decision

1. *Admissibility of appeal*

The present appeal is admissible.

2. *Patentability*

2.1 The only ground for opposition maintained by the appellant in the present appeal proceedings concerns lack of inventive step pursuant to Article 100(a) EPC.

The subject matter of claim 1 as granted is novel with respect to the available prior art as can be seen from the following assessment of inventive step.

2.2 Closest prior art

In the Board's opinion, the respondent's own document D3 comes closest to the subject matter of claim 1.

In particular, there is described in D3 (see Figure 1 and associated text and claim 1) a parallel path Coriolis mass flow rate meter comprising

- inlet and outlet manifolds 20, 26;

- two parallel continuous flow tubes 14, 14' fixedly mounted to said manifolds and having an oscillation axis W, W' (see D3, column 5, line 56 to column 6, line 12) and a torsion axis O, O' (see D3, column 8, second paragraph), the claimed vibrational properties of the flow tubes about said axes being disclosed in D3, column 5, lines 56 to 59, column 9, lines 30 to 40, column 8, lines 5 to 43 and claim 1, features (B)(v) and (B)(vi);

- a pair of sensor means 40, 42;

- time difference measuring means (see D3, column 7, line 35 to 63 and claim 1, feature (F));

- drive means 18 consisting of a magnet and a coil mounted on said respective flow tubes in proximity to their midpoints and interfitting with one another (see D3, column 6, lines 4 to 12); and

- drive circuit means to be connected to said coil (see D3, column 6, lines 4 to 12).

Therefore, the subject matter of claim 1 differs from this prior art mainly in that

(i) a drive current is provided in the range from about 50 mA to about 250 mA whereas in D3 the drive current range is not specified;

(ii) the magnet comprises a rare earth magnet of samarium cobalt iron or of neodymium iron and has an annular configuration whereas in D3 the magnet type is not indicated, and an annular configuration might only be concluded from the drawings; and

(iii) said drive means has a specific construction by comprising a cup-shaped keeper member forming an annular spacing around the magnet, and the coil interfitting with said annular spacing and having an inductance from about 320 µH to about 9 mH whereas such details of the drive means design are not mentioned in D3.

Similar state of the art is disclosed in document D13 (see in particular Figures 2 and 4 and associated text) originating from the respondent as well. Being apparently an instruction manual for mass flow meters sold on the market, it may relate to a concrete version of the more general concept described in document D3 as the appellant asserts. Although a housing member is clearly shown in Figure 2 of D13, which is not explicitly mentioned in D3, other features of claim 1, in particular those concerning the symmetric vibrational properties of the flow tubes are not disclosed in said document: even if there is a high degree of probability that those features are also present in D13, they cannot be derived in a direct and unambiguous way from this prior art, which is the well-established standard of proof applicable in the context of content of disclosure. However, as may be concluded from the foregoing, this fact does not induce the Board to follow the respondent's assertions of a fundamental difference between the claimed subject matter and the meter of D13 in this respect. On the other hand, at least differences (ii) and (iii) also exist with respect to D13 since the driver design is not specified in the prior art, and the appellant's estimations of the inductance values not explicitly disclosed in D13 can only prove that an inductance range similar to that set out in claim 1 **might plausibly** have been used in the prior art. In the Board's view, a similar argument holds good for the drive current range according to difference (i), even though in this case the situation admittedly seems to be more borderline having regard to direct and unambiguous derivability.

In consequence, contrary to the appellant's opinion the Board still considers document D3 to constitute the closest prior art. However, the question of whether one starts from D3 or D13 in the assessment of inventive step is not of crucial importance for the final decision reached (see item 2.4 below).

2.3 Technical problem and solution

The technical problem to be objectively solved by said differences (i) to (iii) may be seen in realising a high drive capability of the drive means without adding substantial additional mass to the flow rate meter or increasing the amount of resistivity and inductance of the drive coil, as has been specified at page 2, lines 44 to 49 of the patent in suit.

By selecting hard magnetic materials and by efficient utilisation of magnetic flux, a powerful and compact driver design is achieved, the moderate energy consumption of which allows an operation in hazardous environment.

In document D3, there is only a general reference to a drive mechanism of the magnet and coil type. When putting the teaching of D3 to practice, in the Board's view the above problem is obvious since a skilled person would realise the necessity of a drive means having sufficient drive power and a low mass for reasons of sensitivity to the small Coriolis force effects. Depending on the desired operating environment, a skilled person would also take account of existing safety standards with respect to stored energy in the drive coil.

2.4 Existence of inventive step

Although the claimed parameter ranges may not be disclosed in D13 in the strict interpretation of this concept according to constant practice of the Boards of Appeal, it appears to be plausible from said document that such ranges are not unusual in the prior art. As the appellant has pointed out in the statement of grounds of appeal, starting from the drive coil resistances given in D13 (see page 35, Table 8) and interpreting the drive circuit diagrams shown in Figures 6 and 43 of D13 with respect to applied voltages, drive current values may be calculated using Ohm's law for the various flow meter models of D13. Some of these current values, in particular the values for "Sensor Size 100", "150" and "300", then fall within the current range of claim 1. Similarly, coil inductances may be calculated for the given coil resistances with the aid of well-known formulae and further plausible assumptions on coil heights and wire diameters, these calculations again leading to inductance values within the claimed range, in particular for the above sensor sizes.

If such parameter ranges seem to be typical in the field of flow meter drivers, it would be obvious for a skilled person to make specific selections from the typical range in order to meet specific safety standards. Thus, the Board does not consider these features of differences (i) and (iii) to be inventive per se. This means that the additional features derivable from D13, which are not disclosed in D3, cannot support the existence of an inventive step.

Furthermore, it has not been contested in the present proceedings that the claimed magnetic materials (see difference (ii)) as such are well-known (see e.g. documents D7 and D8).

In the present case, these materials are used in a specific driver design consisting of an annular magnet, a cup-shaped keeper member concentrically disposed with respect to said magnet leaving an air gap in-between, and an annular coil sized to interfit into said air gap (see remaining features of differences (ii) and (iii)).

Late-filed document D14 which is relevant to the present case, refers to a linear electromagnetic driver for mass flow rate meters being "of the moving coil type, similar to loudspeaker drivers, or of the solenoid type with a movable magnetic core" (see D14, column 4, lines 5 to 7). However, this reference is given in the context of the first embodiment only (see Figure 1 of D14) where a rather massive "stator" (presumably the magnet) is fixed to a rigid support, and a less massive "movable armature" (presumably the coil) is fixed to the single flow tube. In case of more symmetrical flow tube arrangements, i.e. a single flow tube together with a "bucking beam" having the same dynamo-elastic properties (see Figures 3 to 5 of D14) or two identical parallel flow tubes (see Figures 6 to 8 of D14), apparently a different electromagnetic driver design is provided in D14, said driver having two "reactive parts" of more or less identical form and size, albeit not described in detail. The Board is not convinced by the appellant's counterarguments assuming a schematic representation of an otherwise identical design since both the drawings and the associated text of D14 consistently relate to a different, clearly more symmetrical and less massive driver configuration. The importance of symmetry for driving parallel flow tube configurations is also apparent from document D3 (see in particular column 4, lines 7 to 39).

Moreover, document D14 seems to confirm the general fact that loudspeaker drivers are basically massive and asymmetric, having a heavy magnet and a light movable coil for linear signal transmission. In the Board's view, it therefore seems doubtful whether in view of the present problem a skilled person would follow the advice given in D14 for highly asymmetric conditions, where the single flow tube is only charged by the low mass of the moving coil, and make use of heavy "loudspeaker drivers" for a symmetric parallel flow tube configuration for which D14 points in a different direction.

However, even if it were assumed that the normal skilled person followed the teaching of D14 for an asymmetric flow tube construction in the case of a symmetric parallel flow tube system as described in D3, the Board does not consider the claimed solution to be obvious. In such a case, the skilled person - apart from the problem of added mass - might be aware of a preferably symmetrical design from documents D14 and D3. In a direct approach, the average practitioner would then apply the stator/moving coil concept of D14 in a lightweight version as "symmetrised" as possible to the parallel flow tubes of D3, with the result of an annular magnet on one flow tube, said magnet surrounding a coil (and presumably some compensation mass) fixed to the other flow tube. In consequence, it must be assumed that at least the problem of sufficient drive power would remain unsolved.

Therefore, in a further step the skilled person would have to look for some more efficient driver design of the type under consideration in the field of loudspeaker technology and may eventually end up with document D11. Although the different drivers disclosed in D11 (see Figures 1 to 3 and associated text, Figure 3 coming closest to the claimed driver structure) may be even more efficient with respect to utilisation of flux, the design of the magnet part is more complex and, by the magnetizable endplates and pole pieces and non-magnetizable plates, more massive than the solution according to the patent in suit so that it would not easily comply with the requirements of low additional mass and symmetrical layout of the drive means. Thus, in order to arrive at the driver configuration set out in claim 1 of the patent in suit, a skilled person would have to further modify the efficient drive means of D11 with a view of mass reduction and design symmetry, keeping in mind the drive power requirement. There is no indication in this respect in document D11 dealing with a general improvement of the efficiency of permanent magnet assemblies for use in loudspeakers and force motors (see D11, column 1, lines 3 to 13).

Therefore, in view of the available prior art, the claimed invention could only be reached by surmounting a series of barriers in a well-defined sequence of steps which are guided by the knowledge of the invention. The Board considers this to be a classical hindsight situation.

The Board would like to add that although the parameter ranges and the magnetic materials as such are conventional, a synergetic effect may be seen in the contribution of the latter to a powerful low mass magnet allowing the use of conventional drive coils operable with a safe stored energy content (see also page 2, lines 23 to 43 of the contested patent in this context).

The subject matter of claim 1 as granted thus involves the inventive step required by Article 56 EPC, and claim 1 is allowable for this reason.

2.5 Dependent claims

The dependent claims relate to preferred embodiments of the invention according to claim 1 and are not open to objection under Article 100(b) EPC. Such an objection raised in the opposition proceedings has not been pursued in the present appeal proceedings.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS * BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE * CHAMBRES DE RECOURS DE L'OFFICE EUROPÉEN DES BREVETS

E. Görgmaier E. Turrini