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D E C I S I O N
of 21 January 1999

Case Number: T 0782/96 - 3.4.2

Application Number: 87906264.4

Publication Number: 0333713

IPC: G01N 9/00

Language of the proceedings: EN

Title of invention:

Apparatus and methods for measuring the density of an unknown fluid using a coriolis meter

Patentee:

Micro Motion Incorporated

Opponent:

Endress + Hauser Flowtec AG
Krohne MeBtechnik GmbH & Co. KG

Headword:

-

Relevant legal provisions:

EPC Art. 54, 56, 102(2)

Keyword:

"Novelty (yes)"

"Inventive step (yes)"

Decisions cited:

-

Catchword:

-



Case Number: T 0782/96 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 21 January 1999

Appellant:
(Opponent 01)

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Respondent:
(Proprietor of the patent)

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Decision under appeal:

Decision of the Opposition Division of the
European Patent Office posted 2 July 1996
rejecting the opposition filed against European
patent No. 0 333 713 pursuant to Article 102(2)
EPC.

Composition of the Board:

Chairman: E. Turrini
Members: M. Chomentowski
M. Lewenton

Summary of Facts and Submissions

I. The respondent is proprietor of European patent No. 0 333 713, which was granted with 16 claims on the basis of European patent application No. 87 906 264.4 citing inter alia D2b: US-A-4 491 009 as relevant prior art.

The only two independent claims of the patent read as follows:

"1. A method of calibrating and using a metering system which measures the density of a process fluid using a Coriolis meter having at least one flow tube which is driven to resonantly oscillate in a substantially sinusoidal manner about a bending axis while a fluid flows through said flow tube, said method comprising the steps of:

selecting a first or second one of two known calibration fluids or a process fluid as a selected fluid for use in determining a corresponding first, second or third value of a factor therefor;

determining the value of the factor for said selected fluid, said factor value determining step comprising the steps of:

measuring a value of the period at which the flow tube resonantly vibrates while said selected fluid flows through the tube to yield a measured period value;

measuring a value of the temperature of said flow tube while said selected fluid flows therethrough;

determining, in response to said measured temperature value and to a constant having a value appropriate to the material from which said flow tube is fabricated, a temperature coefficient value for said selected fluid; and

calculating the value of the factor for said selected fluid as being a square of the value of the measured tube period for said selected fluid multiplied by said temperature coefficient value;

obtaining first and second known density values, wherein said each of said known density values substantially equals the density of a corresponding one of said two known fluids as the corresponding one fluid successively flows through the flow tube, and wherein the first and second known calibration fluids do not have to be at the same temperature while flowing through the flow tube; and

calculating the density of the process fluid as said first known density value additively combined with a difference between said first and second known density values multiplied by a function of the first, second and third values for said factor."

"8. A metering system which measures the density of a process fluid using a Coriolis meter, having at least one flow tube (130) which is driven to resonantly oscillate in a substantially sinusoidal manner about a bending axis while a fluid flows through said flow tube, said system comprises:

means (110) arranged to direct a first or second one of two known calibration fluids or a process fluid as a selected fluid for use in determining a corresponding first, second or third value of a factor therefor, the first and second known calibration fluids not having to be at the same temperature while flowing through the flow tube;

means (190) for measuring a value of the temperature of said flow tube while said selected fluid flows therethrough;

means (160, 170) to sense vibrations of said tube; processing means (20) arranged to determine the value of the factor for said selected fluid by:

measuring a value of the period at which the flow tube resonantly vibrates while said selected fluid flows through the tube, to yield a measured period value;

determining, in response to said measured temperature value and to a constant having a value appropriate to the material from which said flow tube is fabricated, a temperature coefficient value for said selected fluid; and

calculating the value of the factor for said selected fluid as being a square of the value of the measured tube period for said selected fluid multiplied by said temperature coefficient value; said processing means also being arranged to obtain first and second known density values, wherein said each of said known density values substantially equals the density of a corresponding one of said two known fluids as the corresponding one fluid successively flows through the

flow tube, and to calculate the density of the process fluid from said first known density value additively combined with a difference between said first and second known density values multiplied by a function of the first, second and third values of said factor."

- II. An opposition was filed by opponent I on the grounds of lack of novelty or inventive step having regard to, inter alia, D2b, D8: Mesures, Régulation et automatismes, oct. 1984, pages 43 to 47, and D11: 7830/7840/7841 Liquid Density Transducers, Solartron Transducers, Solartron-Schlumberger, Farnborough, GB, 1984.

An other opposition was filed by opponent II on the grounds of lack of inventive step having regard to, inter alia, D2b.

- III. The oppositions were rejected.

The opposition division took the following view:

The only cited document which came close to claim 1 was D2b; however, this document did not disclose the last step of claim 1, i.e. calculating the density of the process fluid on the basis of a formula with various parameters obtained by calibrating the system with known fluids. Moreover, other steps of claim 1, for instance taking into account a constant of the material from which the flow tube is fabricated, were not comprised in the known method. Therefore, the subject-matter of claim 1 was new.

The inventor of the claimed method had recognised the problems of temperature variations in the technique known from D2b, which already mentioned calibration, and developed a particular calibration method with a sequence of particular steps which did not result from

reading D2b. The particular method of claim 1 in which three factors, which were defined in a particular way, with reference to a particular constant and developed from temperature coefficient values and the square of the period, and used together as defined in the step of calculating the density in claim 1, could not immediately be extracted from D2b. It would require some inventive step to analyse the circuit of this prior art and arrive at the particular calculation as defined.

The further prior art documents, some of which, contrary to the claimed method, used stabilized temperature, were not considered as relevant.

Therefore, the subject-matter of claim 1 and the corresponding apparatus of claim 8 involved an inventive step.

IV. Opponent I lodged an appeal against this decision.

V. Oral proceedings, which had been requested auxiliarily by both parties, took place on 21 January 1999.

VI. The appellant (opponent I) submitted the following arguments in support of his request that the decision under appeal be set aside and the patent be revoked:

A method of using and calibrating a metering system which measures the density of a process fluid was known from D2b; in addition to the resonant angular velocity of oscillation and thus of the period at which the flow tube resonantly vibrates while a selected fluid flows through the flow tube, the temperature of this flow tube had also to be measured and the temperature dependent spring constant about the oscillation axis calculated. The equation for the density of a substance passing through a resonantly oscillating flow tube was,

in general, a relationship where the first term was the oscillating flow tube spring constant about the oscillation axis, which was a function of temperature multiplied by the square of the period of oscillation and thus of its frequency. Thus, in the known method, there were steps of

measuring a value of the period at which the flow tube resonantly vibrates while a selected fluid was flowing through the tube to yield a measured period value,

measuring with a thermometer a value of the temperature of said flow tube while said selected fluid was flowing therethrough,

determining, in response to said measured temperature value and to a constant having a value appropriate to the material from which said flow tube was fabricated, a temperature coefficient value for said selected fluid, and processing the signals and calculating the density of the process fluid, i.e. processing the signals from the coil sensing the vibrations of the tube and the temperature variable resistor sensing the temperature changes of the metering system, said calculation being done in a circuit taking into account said factor and providing a direct readout of the density ρ of the process fluid.

The method of D2b, in the calibrating steps, used two selected known calibration fluids, e.g. air and distilled water, at various temperatures. Moreover, in said method, the formula relating the constants of the flow tube to the square of the period of oscillation of the tube for providing the measured value of the density of the fluid flowing in the flow tube was the same as that shown in the patent in suit. This was also the case for the teaching of, inter alia, D8 and D11:

Therefore, no inventive activity was needed to replace in the method of D2b the analog computing and calculating circuitry by a digital microprocessor for effecting the calculations with the same formula.

VII. The respondent (patent proprietor) argued in substance as follows in support of his request to dismiss the appeal:

The subject-matter of claim 1 in dispute was first distinguished from the method known from D2b by the replacement of a circuitry of the analog type by a digital microprocessor. The analog circuitry, using in function of temperature scaling of circuit components such as resistors, had the drawbacks stressed in the patent in suit. In any case, there was no teaching in D2b for abandoning the analogous circuitry and passing to the digital technique.

Moreover, the method in dispute included further the feature that a constant having a value appropriate to the material from which said flow tube was fabricated was found, for instance in a table or in a memory, and used for determining, in response to a measured temperature value, a temperature coefficient value for said selected fluid. This provides the possibility of using the technique in a very simple way.

It was only by hindsight that the prior art, including also inter alia D8 and D11, could make the subject-matter of claim 1 obvious in view of the state of the art, and this is not permitted when assessing inventive step. Therefore, the subject-matter of claim 1 and that of claim 8 involved an inventive step.

VIII. Opponent II has not filed an appeal and has reacted neither to the interventions of the appellant or of the respondent and, although duly summoned to the oral proceedings as a party as of right pursuant to Article 107 EPC, was not present at said proceedings.

Reasons for the Decision

1. The appeal is admissible.
2. *Novelty*

The subject-matter of claim 1 is new in the sense of Article 54 EPC, and this, in particular during the oral proceedings, has not been contested by the appellant either.

3. *Inventive step*

- 3.1 With reference also to point VI of this decision, the appellant has argued as follows:

A method of **using** a metering system which **measures the density of a process fluid** is known from D2b (see the whole document and, in particular, claim 6); this method uses a Coriolis mass flow meter having at least one flow tube which is driven to resonantly oscillate in a substantially sinusoidal manner about a bending axis while a fluid flows through said flow tube. In the known method, in addition to the resonant angular velocity of oscillation and thus of the period at which the flow tube resonantly vibrates while a selected fluid flows through the flow tube, the temperature of this flow tube must also be measured and the temperature dependent spring constant about the oscillation axis calculated (see column 2, lines 31 to

46). The equation for the density of a substance passing through a resonantly oscillating flow tube is, in general, a relationship where the first term is the oscillating flow tube spring constant about the oscillation axis, which is a function of temperature multiplied by the square of the period of oscillation (see column 2, lines 47 to 56).

Thus, in the known method, there are steps of

- measuring (see column 4, lines 51 to 68) a value of the period at which the flow tube (12) resonantly vibrates while a selected fluid flows through the tube to yield a measured period value;
- measuring (column 5, lines 48 to 58; see also claim 6) with a thermometer (24) a value of the temperature of said flow tube while said selected fluid flows therethrough;
- determining (see column 4, lines 21 to 68; column 5, line 58 to column 6, line 14), in response to said measured temperature value and to a constant having a value appropriate to the material from which said flow tube is fabricated, a temperature coefficient value for said selected fluid; and
- processing the signals and calculating (see column 4, line 58 to column 5, line 6) the density of the process fluid, i.e. processing the signals from the coil (22) sensing the vibrations of the tube (12) and the temperature variable resistor (24) sensing the temperature changes of the metering system, said calculation being done in a circuit taking into account said factor and providing a direct readout (V_p) of the density ρ of the process fluid.

It is to be noted that the known method (see column 6, line 46 to column 7, line 10) can include steps of a method of **calibrating the metering system**, said method of calibrating comprising the same steps as the method of measuring, but with respect to other fluids, i.e., with **two selected known calibration fluids**, e.g. air and distilled water, for use in determining a corresponding first and second value of a factor therefor, this being done **at various temperatures** (see column 6, lines 49 to 54 and Table I), whereby the first and second known calibration fluids do not have to be at the same temperature while flowing through the flow tube.

It is further to be noted that the formula relating the constants of the flow tube to the square of the period of oscillation of the tube for providing the measured value of the density of the fluid flowing in the flow tube, which equation is shown in the patent in suit (see in particular page 15, line 7, equation 12), was also known in the art of Coriolis mass flowmeters or directly derivable therefrom, in particular from the same D2b (see column 5, line 38 to column 6, line 20).

It is to be noted additionally that claim 1 does not specify the type of the circuit and consequently the type of the calculation for measuring the density.

Thus, even by taking into account the embodiment of the patent in suit showing the use of digital techniques, in particular the use of a microprocessor, this would then be the only distinguishing feature and the skilled person, at the priority date of the patent in suit, knowing that a calculation is necessary and being aware of the overall application of computers, would evidently use a computer, thereby arriving in an obvious way at the method of claim 1 in dispute.

3.2 Indeed, it is derivable from various parts of D2b (see column 2, lines 42 to 46, column 5, lines 1 to 6) that calculations are performed according to specific equations relating the density of a substance to the periods of oscillation of the oscillating tube of a Coriolis mass flow meter and to the temperature thereof.

However, for the following reasons, the appellant's arguments cannot convince the Board:

In the patent in suit (see page 2, lines 36 to 47; see also page 7, lines 25 to 34), it is pointed out, with respect to an instrument known from D2b, that the density of an unknown fluid flowing through an oscillating flow tube is proportional to the square of the period at which the tube resonates; in said known instrument, an analogue circuit computes density through use of two serially connected integrators; a reference voltage is applied to the first integrator; inasmuch as the spring constant of each flow tube varies with temperature and thereby changes the resonant frequency, the reference voltage is appropriately **compensated** for temperature variations of the tube; both operators operate for a period of time equivalent to the square of the resonant period; in this manner, the output signal generated by the **analog circuit** provides a product of a temperature dependent function and the square of the value of the resonant period; with appropriate **scaling** of the reference voltage, the output **analog** signal provides a direct readout of the density measurement (in specific gravity units) of the unknown fluid that flows through the flow tube.

According further to the patent in suit (see page 2, line 48 to page 3, line 8; see also page 3, line 46 to page 4, line 7; page 17, line 56 to page 18, line 7), it is pointed out that, because of the analog circuitry used in the instrument known from D2b, there are various drawbacks, some of them associated with the costs of adequate analog circuit components for arriving at a needed precision of the measurements or for easily converting measurements units for specific applications.

Therefore, it is derivable from the whole content of the patent in suit that the method in dispute is not of the type which uses electronic circuitry such as that of the metering system of D2b, in particular the circuit part including the adjustable resistors R7 and R5 for scaling the circuit, i.e. **analog circuitry**.

Thus, when interpreting the extent of protection conferred by claim 1, i.e. by using also the description and the drawings, as indicated in Article 69 EPC and the Protocol on the Interpretation of Article 69 of the Convention, the skilled reader will be made aware that claim 1 in dispute does not cover a method such as the one known from D2b, but is distinguished therefrom not only because of the use of a microprocessor in place of some analog calculation appliance, but also because of the use of digital calculation in place of "scaling" components, for instance resistors, of the circuitry of said analog measuring circuit.

- 3.3 Moreover, as convincingly argued by the respondent, the method known from D2b does not take into account or derive, for instance from a memory, any constant having a value appropriate to the material from which the flow tube is fabricated, and this is a further feature distinguishing the method of the patent in suit (see in

particular page 11, lines 35 to 39; page 12, lines 8 to 13 and 17 to 49) from the method of D2b, wherein the direct readout of accurate density measurements of substances flowing through the flowing tubes is obtained by scaling by means of resistors the output voltage of a measuring circuit including inter alia temperature sensors, frequency sensors and integrators. Thus, there is no step of determining, in response to said measured temperature value and to a constant having a value appropriate to the material from which said flow tube is fabricated, a temperature coefficient value for said selected fluid.

3.4 The further arguments of the appellant concerning other prior art documents are not considered as relevant either. For instance, in the method known from D8 (see page 44, the part "L'étalonnage en température"; see also page 45, the part "Un calculateur pour les corrections"), calibration for each of the measured fluids is effected by implementing a computer; however, this is not done with two fluids of known densities and thereafter determining a value of a coefficient or factor for a fluid to be measured, but it is done for the specific fluid being measured, at different temperatures, thus resulting in a method which differs from the method in dispute. The method known from D11 (see in particular page 7, part "Calibration considerations") indeed is also for calibration; however, it uses three known fluids (air, kerosene and Freon) (out of 5 liquids) and, contrary to the feature stressed in claim 1 in dispute and in the whole patent in suit (see for instance page 3, lines 28 to 45), it is done at stabilized temperature, this resulting in a lengthy measurement.

The other prior art documents are even less relevant.

Moreover, as convincingly argued by the respondent, it is only by hindsight that a combination of all these prior art documents can lead to the specific method of claim 1 in dispute, and this is not admissible when assessing inventive step.

3.5 Therefore, having regard to the state of the art, the subject-matter of claim 1 in dispute is not obvious to a person skilled in the art and thus involves an inventive step in the sense of Article 56 EPC.

4. Consequently, claim 1 in dispute is allowable in the sense of Article 52(1) EPC and, since claim 8 in dispute only recites the same technique in apparatus terms, this also applies thereto, so that the grounds of opposition do not prejudice the maintenance of the patent unamended (Article 102(2) EPC).

Order

For these reasons it is decided that:

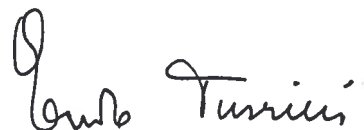
The appeal is dismissed.

The Registrar:



P. Martorana

The Chairman:



E. Turrini

