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D E C I S I O N
of 2 May 2002

Case Number: T 0679/01 - 3.4.2

Application Number: 93305514.7

Publication Number: 0587281

IPC: G01N 27/447

Language of the proceedings: EN

Title of invention:
Capillary electrophoresis detection

Applicant:
Beckman Coulter, Inc.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56, 84, 123

Keyword:
"Novelty, inventive step - second auxiliary requuest (yes)"

Decisions cited:
-

Catchword:
-

Case Number: T 0679/01 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 2 May 2002

Appellant: Beckman Coulter, Inc.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 19 January 2001 refusing European patent application No. 93 305 514.7 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: B. J. Schachenmann
Members: A. G. M. Maaswinkel
M. A. Rayner

Summary of Facts and Submissions

I. European patent application No. 93 305 514.7 (publication No. 0 587 281) was refused by the decision of the examining division, dispatched on 19 January 2001.

The reason for the refusal was that claim 1 according to applicant's single request then on file offended against Article 84 EPC and that the subject-matter of this claim lacked novelty having regard to the teaching of document:

D1: EP-A-0 421 595.

II. The applicant lodged an appeal against this decision. The notice of appeal was received on 19 March 2001, the prescribed fee being paid on the same day. The statement setting out the grounds of appeal including a new set of claims, was received on 26 May 2001.

III. In a communication in annex to summons to attend oral proceedings the board expressed its doubts with respect to the formal requirements of the claims (Article 84 EPC) with reference to a textbook T2 which had already been cited in the examination procedure. Furthermore the board pointed out that for the discussion of substantive matters in addition to document D1, the document D2 cited in the European Search Report should also be considered:

D2: EP-A-0 443 320

T2: Encyclopedia of Applied Physics, 1995, volume 12, page 435ff, Keyword "Optics, Geometrical" (postpublished).

IV. Oral proceedings were held on 2 May 2002 during which the appellant submitted three new requests and requested that the decision under appeal be set aside and that a patent be granted on the basis of the following documents:

main request:
claim 1 of the main request with the description and the dependent claims to be adapted;

first auxiliary request:
claim 1 of the first auxiliary request with the description and the dependent claims to be adapted;

second auxiliary request:
claims 1 to 13; description pages 1 to 5, 5a, 6 to 45; and drawings sheets 1/12 to 12/12.

V. The independent claim 1 of the main request reads as follows:

"A capillary electrophoresis system comprising a fibre optic input, a fibre optic output and a capillary tube (100), the capillary tube (100) having a bore (101), an inner surface (103) defining the bore, an outer surface (104) and a wall thickness (105) of the tube defined between the surfaces, the bore having a width and being for transporting fluid, a coating (110) disposed around the outer surface, an input window (108) and an output window (109) formed by selective removal of the coating, the input window and output window being spaced apart, each of the input window and the output window having a window width and which define an optical pathway through the capillary tube, *characterised in that* the fibre optic input and fibre optic output are aligned with the optical pathway through the capillary tube, and wherein the window width of the input window is not greater than the bore width such that optical radiation is directed substantially through a volume defined by the inner surface (103) of the capillary tube bore (101) and wherein the Numerical Aperture of the fibre optic input and of the fibre optic output and the Lagrange Invariant of the capillary tube are chosen so as to maximise the amount of light transmitted from the fibre optic input through the volume and to maximise the amount of light transmitted from the volume to the fibre optic output, the Lagrange Invariant being defined by the relation $H=Yn_1u_0$ wherein Y is substantially half the window widths, n_1 is the refractive index of the tube and u_0 is the angle between the optical pathway or axis and the line from an interface of the windows through the center of the capillary tube."

The independent claim 1 of the first auxiliary request is identical to claim 1 of the main request with the additional feature at the beginning of its characterising portion "(*characterised in that*) the input window is located radially opposite the output window".

Claim 1 of the second auxiliary request reads as follows:

"A capillary electrophoresis system comprising a fibre optic input, a fibre optic output and a capillary tube (100), the capillary tube (100) having a bore (101), an inner surface (103) defining the bore, an outer surface (104) and a wall thickness (105) of the tube defined between the surfaces, the bore having a width and being for transporting fluid, a coating (110) disposed around the outer surface, an input window (108) and an output window (109) formed by selective removal of the coating, the input window and output window being spaced apart, each of the input window and the output window having a window width and which define an optical pathway through the capillary tube, *characterised in that* the input window is located radially opposite the output window, the fibre optic input and fibre optic output are aligned with the optical pathway through the capillary tube, and wherein the respective width of each of the windows is not greater than the bore width such that optical radiation is directed substantially through a volume defined by the inner surface (103) of the capillary tube bore (101) and wherein the Numerical Aperture of the fibre optic input and of the fibre optic output and the Lagrange Invariant of the capillary tube are chosen so as to maximise the amount of light transmitted from the fibre optic input through the volume and to maximise the amount of light transmitted from the volume to the fibre optic output, the Lagrange Invariant being defined by the relation $H=Yn_1u_0$ wherein Y is substantially half the window widths, n_1 is the refractive index of the tube and u_0 is the angle between the optical pathway or axis and the line from an interface of the windows through the center of the capillary tube."

Claims 2 to 13 of this request are dependent claims.

VI. The appellant's arguments may be summarised as follows:

In order to overcome the objection under Article 84 EPC claim 1 according to all requests has been amended to define an electrophoresis system by now including fibre optic input and output and the optical pathway through the capillary tube. Furthermore the objection against the expression "Lagrange Invariant" has been overcome by including in the claim the definition of this expression from the description. The amendments are supported by the original disclosure, thereby also meeting the conditions of Article 123(2) EPC.

With respect to the issue of patentability of claim 1 according to the main request, the essential feature is that the size of the input window is not greater than the bore width of the capillary tube, which ensures that optical radiation from the fibre input is directed substantially through the bore of the tube along a pathway defined by the input and output windows. Thereby the amount of scattered light in the outer part of the capillary tube is minimised. Furthermore by using the relation between the Numerical Aperture of the fibre input, fibre output and the Lagrange Invariant in the design of the optical system a resultant increase in the system efficiency is ensured. The output window of the capillary tube is not further detailed in the claim, such details not being an essential feature of the invention, there being different ways to design the collector side of the system for handling the output radiation.

Document D1 represents the closest prior art for novelty. This document discloses an integrated temperature control/alignment system for a capillary electrophoresis apparatus. According to the main embodiment shown in Figures 1 to 5, the capillary tube is fixed by two mounting plates 28 having grooves 36. Although the capillary tube includes detection "windows" obtained by selective removal of the polymer coating of the tube, these windows do not define the optical pathway, which is defined by a detection slit 38 in the upper mounting plate and a detection hole 40 in the lower mounting plate. The windows in the capillary tube are aligned with the pathway through the slit and hole. A further difference between the claimed electrophoresis system and the apparatus disclosed in Figures 1 to 5 of document D1 is that rather than a fibre optic input a UV radiation source is used. Therefore the system is inherently optically inefficient. The second embodiment in Figures 12 to 15 of document D1 shows an optical fibre *bundle* which couples light through a capillary tube and into an optical output fibre. This embodiment therefore relates to a system different to that of the claimed system implying that the fine coupling constraints defined in claim 1 cannot be met.

When starting from the disclosure in D1 for assessing the question of inventive step, the technical problem to be solved is that of improving the efficiency and the accuracy of a capillary electrophoresis system. The solution is achieved by ensuring that the light is coupled from a light source only through the bore of the capillary tube and at the same time maximising the amount of light by selecting the Numerical Apertures of the fibres with respect to the Lagrange Invariant of the tube. Since the limiting aperture in the apparatus according to document D1 is not the input window in the capillary tube and, hence, the optical pathway is not defined by the windows and the relevance of choosing the Numerical Apertures of the fibres with the Lagrange

Invariant of the capillary tube for maximising the amount of light from the input fibre to the output fibre is neither taught nor suggested, the solution defined in claim 1 of the main request involves an inventive step.

With reference to claim 1 of the first auxiliary request, the additional feature of this claim that the input window is located radially opposite the output window further defines the inventive concept that the capillary tube itself defines the optical pathway through the capillary tube. It is noted that document D1 is silent concerning the position of the output window with respect to the input window.

Claim 1 of the second auxiliary request includes the feature that both the input window and output window have widths not greater than the bore width of the capillary tube. This defines even further the optical pathway through the capillary tube.

VII. At the end of the oral proceedings, the board gave its decision.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 Article 123(2) EPC

With respect to claim 1 as originally filed claim 1 of the main request has been amended to include in the optical system the fibre optic input and fibre optic output; a requirement for the size of the input window; and choosing the Numerical Apertures of the fibres and the Lagrange Invariant of the tube within the particular meaning of the patent application. The fibre optic input and output are described in Section 6 [*sic*] on pages 28 to 31 of the original application. The discussion of the concept of "Lagrange Invariant" is presented in Section 6 [*sic*], pages 26 to 28 of the original application. The concept of matching the Numerical Apertures with the Lagrange Invariant is contained in Section 7, pages 31 to 36 of the patent application. The feature of claim 1 according to the main request that the window width of the input window is not greater than the bore width is disclosed on page 22, second paragraph and the corresponding Figures (*e.g. Figures 1, 3a, 3c*).

The further feature of claim 1 according to the first auxiliary request that the input window is located radially opposite the output window finds its support in original claim 35.

The additional feature of claim 1 according to the second auxiliary request that the respective width of each of the windows is not greater than the bore width is disclosed on page 24, first and second paragraphs.

The board is satisfied that the amendments in the dependent claims equally find their support in the application as originally filed.

Therefore the claims of all requests meet the requirements of Article 123(2) EPC.

2.2 Article 84 EPC

In the opinion of the board, the claims of the all requests fulfil the requirements of Article 84 EPC. The former objection against the expression "Lagrange Invariant" which had been found objectionable because of use throughout the patent application with a different meaning to that commonly accepted in the field of optics (*as, for instance, documented in the textbook T2, page 442, Section 3.3.6*), has been overcome by explicitly including in the claim the definition used by the applicant. In the remainder of this decision the board therefore will also understand the expression "Lagrange Invariant" according to the definition of the applicant concerning the relation between the window widths and the angle formed by the optical axis and the marginal ray through the tube aperture for a tube having a refractive index n_1.

3. *Substantive matters (Article 52 EPC)*

3.1 Novelty

3.1.1 Document D1 discloses an integrated temperature control/alignment system for a capillary electrophoretic apparatus. In the embodiment shown in Figure 14 the apparatus comprises a fibre optic input (*two 100µm diameter optical fibres 86a*), a fibre optic output (*600µm fibre 86c*) and a capillary tube 12' (*Figure 12*). Capillary tubes are shown in Figure 2 of document D1 and have a bore having a width ("*I.D.*"), an inner and outer surface, a coating (*polyimide, column 10, line 2*) and input and output windows (*13', 13"*) formed by selective removal of the coating (*column 10, lines 9 to 14*). According to column 10, lines 33 to 35, the two detection windows define the irradiated volume within the capillary column and thereby the electrophoretic detection zone and hence the windows define the optical pathway through the capillary tube. Therefore document D1 discloses an electrophoretic apparatus with the features of the preamble of claim 1 (*all requests*).

3.1.2 The features of the characterising portion of claim 1 of the main request are related to the optical arrangement between the fibres and the detection zone (*alignment of the fibres; and selection of the Numerical Apertures of the fibres having regard to the Lagrange Invariant of the tube*); and to the selection of the window width of the input window of the capillary tube. No *explicit* disclosure of these features is found in document D1.

Document D2 discloses a capillary electrophoresis detection apparatus and technique. The apparatus disclosed in D2 does not comprise optical fibres, nor is the capillary tube used in this apparatus of the coated type with windows formed by selective removal of the coating.

The subject-matter of claim 1 (*all requests*) is therefore novel over the prior art capillary electrophoresis apparatuses disclosed in documents D1 and D2.

3.2 Inventive step - main request.

3.2.1 According to the appellant, the differences between the capillary electrophoretic system defined in claim 1 and the apparatus known from document D1 solve the technical problem of improving the efficiency and the accuracy of the capillary electrophoresis system. The board shares this view.

This technical problem of improving the efficiency and accuracy of an existing optical measurement system is a basic aim underlying any optical design and engineering, therefore in the present case the formulation of the technical problem itself cannot involve an inventive step.

3.2.2 With respect to the solution of this problem defined in claim 1 of the main request, according to Section 3.1.2 the novel features of the characterising portion of this claim relate to:-

(i) the optical arrangement between the fibres and the detection zone; and

(ii) selecting the window width of the input window of the capillary tube.

Whereas the optical arrangement (i) addresses the problem of increasing the optical efficiency (*throughput*) of the optical system, the selection (ii) of the size of the input window follows the aim of ensuring that the input beam entering the capillary tube does not propagate through the outer part of the tube, which would deteriorate the signal to noise ratio in the output signal.

3.2.3 Having regard to the embodiment shown in Figures 12 to 15 in document D1 in which the optical system comprises input and output fibres, the following is observed:-

With respect to the optical arrangement between the fibres and the detection zone (feature i), according to the embodiment of Figure 14, as disclosed in column 19, line 53 to column 20, line 13, the two optical input fibres 86a are "polished and press-fitted into a teflon tube 110 mounted in the first mounting block member 28'". Furthermore the 600μm optical fibre 86c "is press-fitted into the second mounting block member 29'". This fibre "optically couples radiation exiting the capillary column 12' into the sample cell fiber optics 84". Therefore it must be concluded that, although not disclosed *expressis verbis*, in the apparatus of this embodiment "the fibre optic input and fibre optic output are aligned with the optical pathway through the capillary tube". Moreover, concerning the selection of the Numerical Apertures of the fibre input and output and the Lagrange Invariant as defined in the present claim so as to maximise the amount of transmitted light, document D1 discloses that the input fibre comprises two 100μm optical fibres (*column 19, line 47*) which are used in order to improve the signal to noise ratio (*column 20, lines 4 to 5*). Document D1 continues "*For this preferred embodiment, a capillary window 13' having an axial length of about 240 micrometers is formed in the capillary column 12'*" (*column 20, lines 5 to 8*). According to the board's understanding of this embodiment, the two 100μm diameter input fibres are arranged to form a light cone of 200μm height and 100μm width at the output of the fibre bundle, which substantially fits the height of the aperture of 240μm. With respect to the *width* of the input window of the capillary tube document D1 is silent. Differing from the presently claimed system, the limiting aperture in the apparatus is formed by a thin (*about 2.5μm thick, see column 21, line 33*) stainless steel mounting member 125, interposed between the plate 28' and the port 126. Since, according to document D1, column 12, lines 46 to 49, the width of the aperture in the first embodiment should be "*in the range approximately equal or less than the I.D. of the capillary column 12*" it must be assumed that the width of the aperture in the second embodiment is selected in a similar way (*which size may differ depending on the particular capillary tube, because, according to column 21, lines 42 to 44, the tube's I.D. is selectively variable, depending on the particular application*). This requirement of ensuring that the light exactly goes through the liquid filled part of the capillary tube by selecting the width of the input slit, appears to be well known in the field of capillary tube electrophoresis, as is also documented in document D2, column 10, lines 15 to 18. Therefore, in summary, in this embodiment in document D1 the shape of the output beam of the input fibre bundle is selected to substantially fit with the input aperture (*its width being defined by the input slit width 125b, which is selected by the I.D. of the particular tube used; its height being fitted to the size of the window in the capillary tube*). As to the output fibre, this has an aperture of 600µm, which is larger than the I.D. and even than the O.D. of the fibre (357µm, see column 21, line 42).

3.2.4 Therefore, in the board's assessment of document D1, in the embodiment of Figures 12 to 15 the selection and the optical arrangement of the fibres has been chosen so as to optimise the optical throughput of the detection system and the teaching underlying this optimisation reflects the one defined in feature (i) of claim 1 of the main request.

3.2.5 With respect to the second feature, pertaining to selecting the window width of the input window of the capillary tube, a difference with respect to the embodiment of Figures 12 to 15 of document D1 is provided because according to the teaching of document D1 the restricting aperture in the detection system is formed by the mounting member 125 having the aperture slit 125b. It is observed that in this particular embodiment this mounting member is a very thin plate (*thickness approximately 2.5µm*) which includes a capillary mounting groove 125a. This member is disposed in a platelet 28' which also includes a support groove 120 for the capillary column and which is dimensioned "*for snugly mounting the respective ends of a given capillary column*" (column 21, lines 24 to 26). Therefore the arrangement of the member 125 and the capillary tube in this embodiment is such that the member's slit 125b abuts against the capillary tube input window.

In the apparatus according to claim 1 of the main request the limiting aperture width is directly defined by the width of the coating removed from the tube, whereas in the apparatus according to document D1 this width is uncritical, and the coating may be even removed to form a 360 degree peripheral band (*column 10, lines 19 to 21*), the limiting aperture in this case being formed by the slit 125b of the platelet 125 abutting against the input window of the tube. Replacing the arrangement of document D1 by directly defining the limiting input aperture by the coating removed from the capillary tube, amounts, in the opinion of the board, to a routine measure for the skilled person in this field, since the arrangements are optically equivalent, the only difference being in the mechanical construction. The skilled person would, however, be aware that both the solution of document D1 and that of claim 1 have intrinsic advantages and disadvantages. The solution in document D1 requires an additional component and is therefore mechanically less simple than the device claimed, but may offer advantages resulting from a slit machined in a stainless steel platelet having a more precise shape and being totally opaque for all radiation not passing through the slit, which opacity may not exist to the same extent for a slit obtained by removing the coating of the tube. Furthermore, document D1 already discloses that a slit with a defined aperture height is formed in the outer surface of the capillary tube (*column 20, lines 6 to 8*). Therefore the skilled person would be aware of this alternative and would simply apply this alternative solution according to his preference.

3.2.6 Thus it is concluded that the subject-matter of claim 1 according to the main request does not involve an inventive step.

3.3 Inventive step - first auxiliary request.

Claim 1 of this request contains the additional feature that the input window is located radially opposite the output window. This feature is known from document D1, see column 10, lines 10 to 14 ("*first and second detection windows 13, 13, spaced approximately 180 degrees from one another*"), and also the embodiment of Figure 14, wherein ports 126 are defined, implying that the detection windows of the capillary tube would be arranged on the optical axis defined by these ports as well. Therefore claim 1 of the first auxiliary request does not define patentable subject-matter.

3.4 Inventive step - second auxiliary request.

3.4.1 Claim 1 of this request contains the further condition that in addition to the width of the input window the width of the output window formed in the outer surface of the capillary tube is also not greater than the bore width of the tube. The provision of a second aperture at the capillary tube output further reduces stray radiation still passing through the outer part of the tube and improves the signal to noise ratio of the device. In neither of the embodiments of document D1 are such apertures provided at the output of the capillary tube (*in the embodiment of Figure 2, the detection hole 40 has a diameter in the "range of about 2 mm or less"; in the embodiment in Figures 12 to 15 the output fibre has a diameter of 600µm*). Therefore both embodiments of document D1 teach collecting all the light exiting the output window of the capillary tube. Since this window may even be in the shape of a 360 degrees peripheral band, it must be concluded that document D1 does not teach or suggest including a further limiting aperture at the output of the capillary tube, and even less limiting its width so as not to be greater than the bore width.

3.4.2 The only further document under consideration, document D2, also neither teaches or suggests the solution defined in claim 1 of the second auxiliary request.

3.4.3 Claims 2 to 13 of the second auxiliary request are dependent claims, and, hence, define patentable subject-matter by virtue of their dependence.

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 grant a patent in the following version:

   - claims 1 to 13

   - description pages 1 to 5, 5a, 6 to 45

   - drawings sheets 1/12 to 12/12,

   all as filed at the oral proceedings as second auxiliary request.

The Registrar: The Chairman:

P. Martorana B. Schachenmann