BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

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File No.: T 0388/91 - 3.4.1

Application No.: 86 903 486.8

Publication No.: 0 262 129

Classification: H01J 37/05

Title of invention: A device for providing an energy filtered charged particle image

D E C I S I O N
of 12 October 1993

Applicant: Kratos Analytical Limited

Proprietor of the patent:

Opponent:

Headword:

EPC: Art. 84

Keyword: "Clarity, (yes)" - "Functional features in a claim justified and supported by the description"

Headnote
Catchwords

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0388/91 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 12 October 1993

Appellant: Kratos Analytical Limited
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Decision under appeal: **Decision of the Examining Division 047 of the European Patent Office dated 20 December 1990 refusing European patent application No. 86 903 486.9 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G.D. Paterson
Members: R.K. Shukla
H.J. Reich

Summary of Facts and Submissions

I. European patent application No. 86 903 486.8 relates to a method and device for providing an energy filtered charged particle image, and was refused by a decision of the Examining Division on the ground of lack of clarity pursuant to Article 84 EPC.

II. Independent Claims 1, 4 and 11 which were considered in the decision as contravening Article 84 EPC had the following wording:

Claim 1

"A method of providing an energy filtered charged particle image comprising applying a crossed electrostatic and magnetic field to a beam of imaging charged particles to cause deflection thereof from an initial path of travel, reflecting the deflected beam in said field to effect charged particle energy filtering thereof, providing an output beam of energy filtered imaging charged particles from said reflecting travelling in a path displaced from said initial path, characterised by providing a non-uniform electrostatic field of the said crossed field, between spaced electrodes (P, P_1, W), and adjusting the difference of potential between the spaced electrodes (P, P_1, W) so as to provide predetermined electrostatic force field components acting transverse to the direction of the applied magnetic field, the magnitude of which components varies with transverse distance in the electrostatic field, whereby to control motion of the particles in the crossed field and correct for distortion of the electron image in said output beam."

Claim 4

" A device for providing an energy filtered charged particle image comprising an entrance aperture (3) for an input beam (I_1) of imaging particles, means for forming a crossed electrostatic and magnetic field to deflect said input beam (I_1) from an initial path of travel, means (4,5) for reflecting the deflected beam to effect particle energy filtering thereof and provide an output beam (I_M) of energy filtered imaging particles travelling in a path displaced from said initial path characterised by first electrode means (P) of the electrostatic field, second electrode means (P_1,W,S) of the electrostatic field spaced from said first electrode means (P), and means for holding the second electrode means (P_1,W,S) at a potential negative with respect to the first potential so as to provide predetermined electrostatic field components acting transverse to the direction of the applied magnetic field, the magnitude of which components varies with transverse distance in the electrostatic field, whereby to control motion of the particles in that crossed field and correct for distortion of the electron image in said output beam."

Claim 11

" A device for providing a band-pass energy filtered charged particle image comprising an inlet aperture (3), an outlet aperture (9), means (4,5,6,7,8) between the inlet and the outlet apertures for energy filtering of an input beam (I_1) of imaging particles directed through the inlet aperture (3) to provide an output beam of band-pass energy filtered imaging charged particles directed through the outlet aperture, first and second crossed electrostatic and magnetic fields between the inlet and outlet aperture, said first field effecting deflection upon the input beam (I_1) to provide an

intermediate beam travelling along a path displaced from the path of said input beam (I_1), said second field effecting a deflection of said intermediate beam (I_M) opposite to the first mentioned deflection to provide said output beam (I_2) travelling along a path corresponding to a restoration of the path of said input beam to said inlet aperture, said electrostatic fields of the first and second crossed fields being provided by means of spaced electrodes (P, P_1, W), one of which in each crossed field is held at a negative potential with respect to the other to produce a non-uniform electrostatic field between the electrodes so as to provide predetermined electrostatic force field components acting transverse to the direction of the applied magnetic field, the magnitude of which components varies with transverse distance in the electrostatic field, whereby to control motion of the particles in the crossed field and correct for distortion of the electron image in said output beam."

III. The reasons given by the Examining Division in the decision for the finding of lack of clarity can be summarised as follows:

(i) The wording of Claim 1 merely defines the nature of the "predetermined electrostatic force field components", and that of the variation of their magnitudes, in terms of the result to be achieved, and does not specify the essential condition, as disclosed in the description (see page 13, lines 2 to 8), for correcting image distortion, namely that in the electric field the electric potential is a parabolic function of y.

(ii) Claim 1 is also not clear since it fails to specify that the applied magnetic field is directed parallel to the axis of the incident beam as in Figures 1 and 2 of the application, whereby a crossed field arrangement, in which both the electric and magnetic fields are aligned normal to the beam direction, imparting a transverse displacement to the charged particles in the beam is not excluded from the wording of the claim.

(iii) Claim 1 also does not specify, as it should, that the magnetic field is uniform in the z-direction.

(iv) Claim 1 specifies that electrostatic force field components act "transverse to" the direction of the magnetic field, and that their magnitudes vary with "transverse distance in the electrostatic field". The expression "transverse to" the magnetic field defines a plane (i.e. xy-plane), whereas it appears from the examples given in the description that the electrostatic field components act only in a **specified** direction, and that their magnitudes vary with distance **along that direction** (i.e. y-direction).

IV. The Applicant filed an appeal against the above decision, and filed a new set of Claims 1 to 16 and amended pages of the description with the Statement of Grounds of Appeal. A letter from the inventor, Professor David Turner, commenting upon the technical features of the invention regarded as essential in the decision under appeal was also filed with the Statement of the Grounds.

The new independent Claims 1, 5 and 12 corresponding to the earlier Claims 1, 4 and 11 respectively, were amended to meet the objection under paragraph III-(ii) above and included a statement to the effect that the direction of the magnetic field was arranged along the direction of the incident beam.

V. The Appellant presented essentially the following arguments in support of the clarity in the wording of the new independent Claims 1, 5 and 12 mentioned above:

(a) According to the "Guidelines for Examination in the European Patent Office", C-III, 4.7, the rule against claiming an invention by reference to a result is a general rule and is not to be adhered to in all cases. According to the Guidelines claiming by reference to a result is permissible if the "result is one which can be directly and positively verified by test or procedures adequately specified in the description and involving nothing more than trial and error". This test is entirely satisfied in the present case. Moreover, the functional relationship which is considered to be an essential technical feature of the invention by the Examining Division (see item III (i)) relates to an idealised form of field which is not realisable in practice. A definition of the invention in terms of this feature as suggested by the Examining Division during the prosecution of the application would unjustifiably limit the scope of Claim 1.

(b) With regard to the objection that the magnetic field is not specified as uniform in Claim 1 (see item III (iii)), this is not an essential condition for correcting image distortion. The uniform fields on page 17, lines 28 to 29 refers to

a simplified calculation method to demonstrate the feasibility of the invention, and in the description on page 17, lines 19 to 21 there is a specific disclosure that some variation in the magnetic field is permissible, provided that it is a slow variation to avoid adiabatic breakdown.

(c) The wording of Claim 1 stating that the electrostatic force field components act "transverse to" the direction of the magnetic field, and that their magnitudes vary with "transverse distance in the electrostatic field" (see item III(iv)) clearly defines without any indefiniteness an essential aspect of the invention since the drift motion of charged particles transverse to the magnetic field axis is only influenced by the components of electric field which are transverse to the magnetic field axis.

VI. In its communication pursuant to Article 110(2) EPC, the Board took the view that although the Appellant's arguments as set out in paragraphs (b) and (c) were accepted, in the application in suit the non-uniform electrostatic field was applied with a view to correcting only the non-uniform shear in the particle beam image, and there was no teaching to correct any other type of image distortion, such as the smear of the image, by the application of a non-uniform electrostatic field. Claim 1 was therefore considered to be unduly broad and not supported by the description (Article 84 EPC).

An objection of lack of clarity was raised against the wording "whereby to control **motion** of the particles in the cross field" in Claim 1. In this connection the Board considered that according to the description of the invention, the electrostatic field controlled the

drift velocity of the particles with a view to correcting non-uniform image shear, and that the claim did not bring out this inter-relationship between the non-uniform electrostatic field, control of the drift velocity and the non-uniform image shear.

VII. In response to the above communication, the Appellant filed new claims and description, and requested the grant of the patent on the basis of the following:

Description: pages 2, 3 and 8 to 26 of the published application,
page 7 of the published application amended as requested by the Appellant during a consultation by telephone on 15 September 1993,
pages 1a and 5 filed on 24 August 1990,
pages 1 and 6 filed on 23 April 1991, and
pages 4 and 6a filed on 25 May 1993;

Claims: 1 to 16 as on pages 27, 29 and 32 filed on 25 May 1993 and pages 28, 30, 31 and 33 filed on 23 April 1991, Claim 12 on page 32 amended further as requested by the Appellant during a consultation by telephone on 15 September 1993;

Drawings: sheets 1/8 to 8/8 of the published application, Figure 2 having been amended according to the Applicant's request dated 23 August 1990.

VIII. Independent Claims 1, 5 and 12 under consideration have the following wording:

Claim 1

"A method of providing an energy filtered charged particle image comprising applying a crossed electrostatic and magnetic field to a beam of imaging charged particles to cause deflection thereof from an initial path of travel, reflecting the deflected beam in said field to effect charged particle energy filtering thereof, providing an output beam of energy filtered imaging charged particles from said reflecting travelling in a path displaced from said initial path, characterised by arranging for the direction of the magnetic field to correspond to the direction of the incident beam and supplying a non-uniform electrostatic field of the crossed field to provide predetermined electrostatic force field components transverse to the direction of the applied magnetic field, the magnitude of which components varies with transverse distance in the electrostatic field, so as to control the drift velocity of the particles in the cross field and correct for non-uniform shear of the particle beam image in said output beam."

Claim 5

" A device for providing an energy filtered charged particle image comprising an entrance aperture (3) for an input beam (I_1) of imaging particles, means for forming a crossed electrostatic and magnetic field to deflect said input beam (I_1) from an initial path of travel, means (4,5) for reflecting the deflected beam to effect particle energy filtering thereof and provide an output beam (I_M) of energy filtered imaging particles travelling in a path displaced from said initial path

characterised in that the magnetic field direction is along the direction of the incident beam, first electrode means (P) of the electrostatic field, second electrode means (P_1,W) of the electrostatic field spaced from said electrode means (P), and means (P_1,W,S) for introducing non-uniformity to the electrostatic field between said first and second electrode means so as to provide predetermined electrostatic field components acting transverse to the direction of the applied magnetic field, the magnitude of which components varies with transverse distance in the electrostatic field, so as to control the drift velocity of the particles in that crossed field and correct for non-uniform shear of the particle image in said output beam."

Claim 12

" A device for providing a band-pass energy filtered charged particle image comprising an inlet aperture (3), an outlet aperture (9), means (4,5,6,7,8) between the inlet and the outlet apertures for energy filtering of an input beam (I_1) of imaging particles directed through the inlet aperture (3) to provide an output beam of band-pass energy filtered imaging charged particles directed through the outlet aperture, first and second crossed electrostatic and magnetic fields between the inlet and outlet aperture, said first field effecting deflection upon the input beam (I_1) to provide an intermediate beam travelling along a path displaced from the path of said input beam (I_1), said second field effecting a deflection of said intermediate beam (I_M) opposite to the first mentioned deflection to provide said output beam (I_2) travelling along a path corresponding to a restoration of the path of said input beam to said inlet aperture, characterised in that the magnetic field direction is along the direction of the incident beam, and means (P,P_1,W,S) for supplying a non-

uniform electrostatic field of said cross field to provide predetermined electrostatic force field components acing transverse to the direction of the applied magnetic field, the magnitude of which components varies with transverse distance in the electrostatic field, so as to control the drift velocity of the particles in the crossed field and correct for non-uniform shear of the particle image in said output beam."

Reasons for the Decision

1. *Amendments*

Claim 1 is based on the subject-matters of original Claims 1 and 2 and is further amended in relation to the original claim essentially in that it states (i) that the direction of the magnetic field is arranged to correspond to the direction of the incident beam and (ii) that the magnitude of the electrostatic force field components varies with transverse distance, so as to control **drift velocity** of the particles and correct for **non-uniform shear of the particle** beam image.

Similarly independent Claims 5 and 12 have been amended to include essentially the features (i) and (ii). The description has been amended for consistency with the wording of the amended claims.

In the specific example of the invention described on page 8, the magnetic field B is arranged to be parallel to the direction of the incident beam (I_1) of electrons (see also Figures 1 and 2). References to page 4, lines 18 to 24, page 10, lines 8 to 11 and page 20, lines 12 to 14 of the description as filed make it clear

that it is the drift velocity of the electrons which is controlled by the application of a non-uniform electrostatic field so as to correct the non-uniform shear of the image.

Amended Claim 1, and also Claims 5 and 12 and the new pages of the description, thus do not go beyond the content of the application as filed and meet the requirement of Article 123(2) EPC.

2. *Clarity of the claims (Article 84 EPC)*

The only issue which remains to be considered in the present appeal is therefore the question of clarity of the independent claims.

2.1 It is the established jurisprudence of the Boards of Appeal that in appropriate cases it is permissible to define technical features in a claim using functional terminology, that is, in terms of a result to be achieved, if from an objective viewpoint, such features cannot otherwise be defined more precisely without unduly restricting the scope of the invention, and if these features provide instructions which are sufficiently clear to the skilled person to reduce them to practice without undue burden, if necessary with a reasonable number of experiments (T 68/85 OJ EPO 1987, 228; T 139/85, EPOR 1987, 229).

Applying the above principles in the present case, it needs to be considered whether the disclosure of the invention justifies a broad definition of the invention in functional terms and whether there is adequate support in the description for such a definition.

The present application relates to a method and device for producing an energy filtered charged particle image, and addresses the problems of non-uniform (or non-linear) image shear encountered in an arrangement using uniform crossed electrostatic and magnetic fields (see page 3, line 13 to page 4, line 5). According to the general description of the invention (see page 4, line 19 to page 5, line 4 of the published application), the use of a **non-uniform** electrostatic field in the crossed field region results in the setting up of electrostatic field components acting transverse to the direction of the applied magnetic field, and whose magnitude varies with transverse distance. Further, according to the description, this variation allows the drift velocity in the direction orthogonal to these fields to be controlled at each transverse distance and a proper choice of the form of the non-uniform electrostatic field enables one to remove image shear over much of the image.

In the preferred embodiments of the invention, the Cartesian system of coordinate is employed, and the non-uniform electrostatic field is produced between electrostatic field plates P and P1 by providing slits in the negatively biased field plate P1 (see page 12, lines 23 to 28; page 13, lines 17 to page 14, line 21; Figures 2 and 3a, 3b) or by a series of spaced wires W arranged between two field plates, and all biased at a negative potential with respect to the plates (page 14, line 22 to page 16, line 8; Figures 3(c) and 3(d)). As is evident from Figure 7(b), it is possible to reduce the non-uniform shear of an image of a tungsten filament in a device according to Figure 2 by employing a non-uniform electrostatic field produced by field plates biased at potentials specified on page 23, line 18 to page 24, line 10.

An examination of the contours of the equipotential lines shown in Figures 3(a) to 3(d) reveals that it is not possible to define the form or nature of the non-uniform electrostatic field required to correct non-uniform shear of the image in terms of a mathematical function or equation. With regard to the statement on page 2, lines 2 to 12 that the necessary condition for shear correction is satisfied by an electrostatic field in which the potential is a parabolic function of y, represented by V(y), the Board accepts the submissions by the inventor, Professor Turner, that the above statement does not refer to an essential condition of the invention, but is a statement of the ideal form of field which if invariant in the z-direction would produce the desired result, and that such a field is not realisable in practice as it contravenes the Laplace relation governing the field components when only variations in x and y directions are allowed. The Board also notes that the above condition applies only to the Cartesian coordinate system, whereas it is clear from the description that the electrostatic fields required to correct for image shear can also be defined in the cylindrical coordinate system (see page 5, lines 20 to 26). In the Board's view, therefore, the nature or form of the non-uniform electrostatic field cannot be defined any more precisely than has been done in the independent claims under consideration. Moreover, a claim defining the non-uniform electrostatic field in terms of a parabolic potential function V(y) or $\bar{V}(y)$ would unjustifiably exclude from its scope other non-uniform electrostatic fields such as the one defined in a cylindrical coordinate system, and would not provide a fair scope of protection for the invention which has been made.

In the Board's view, the present definition of the non-uniform electrostatic field in functional terms is not excessively broad and is supported by the description, since it would be well within the competence of a person skilled in the art to extend the specific teaching of the embodiments of Figures 2 and 3 to other arrangements, such as the one involving shaped plates referred to on page 5, lines 2 to 3 of the published application to define the equipotentials required. Also by choosing appropriate width of the slots, and thereby the mean field curvature in the crossed field region, as in the embodiments of Figures 2 and 3, the skilled person would be in a position to correct the image shear by routine trials.

2.2 Moreover, in an arrangement where, for example, the non-uniform electrostatic field is defined *inter alia* by a shaped plate curved around the direction of the magnetic field, the electrostatic field components would not be confined along a **specific** direction transverse to the direction of the magnetic field, but would be along any direction in a plane transverse to the direction of the magnetic field. In the Board's view, therefore, the statements in the claim that the non-uniform electrostatic field provide predetermined electrostatic field components "transverse to the direction of the applied magnetic field", and" the magnitude of which components varies with transverse distance in the electrostatic field" are adequately supported by the description of the invention.

2.3 Similarly, according to the description on page 17, lines 19 to 21, a slow variation of the magnetic field along the z-axis is allowed provided that it avoids adiabatic breakdown, so that the Board agrees with the Appellant that an exact uniformity of the magnetic field

along the z-axis is not an essential condition of the invention. The present wording of the independent claims in this respect are therefore clear.

2.4 For the foregoing reasons, in the Board's judgment, independent Claims 1, 5 and 12 comply with the requirements of Article 84 EPC.

2.5 From the official communication dated 14 February 1989 pursuant to Article 96(2) EPC, it is evident that the first instance had found the application to meet the remaining requirements of the Convention, in particular those of Article 52(1) EPC.

Order

For the above reasons, it is decided that:

1. The decision of the first instance is set aside.

2. The case is remitted to the first instance with an order to grant the patent on the documents specified in paragraph VII above.

The Registrar: The Chairman:

M. Beer G.D. Paterson