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Datasheet for the decision of 8 March 2010

Case Number: T 1531/07 - 3.4.02

Application Number: 04750912.0

Publication Number: 1618423

IPC: G02B 13/06

Language of the proceedings: EN

Title of invention:
Compact wide-field-of-view imaging optical system

Applicant:
RAYTHEON COMPANY

Opponent:
-

Headword:
-

Relevant legal provisions:
-

Relevant legal provisions (EPC 1973):
EPC Art. 54(1), 56

Keyword:
"Novelty and inventive step (yes - after amendment)"

Decisions cited:
-

Catchword:
-

Case Number: T 1531/07 **-** 3.4.02

D E C I S I O N
of the Technical Board of Appeal 3.4.02
of 8 March 2010

Appellant: RAYTHEON COMPANY
870 Winter Street
Waltham MA 02451-1449 (US)

Representative: Jackson, Richard Eric
Carpmaels & Ransford
43, Bloomsbury Square
London WC1A 2RA (GB)

Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 26 March 2007 refusing European application No. 04750912.0 pursuant to Article 97(1) EPC 1973.**

Composition of the Board:

Chairman: A. G. Klein
Members: F. J. Narganes-Quijano
B. Müller

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal against the decision of the examining division refusing European patent application No. 04750912.0 based on the International application No. PCT/US2004/013242 (published with the International publication No. WO 2004/099841).

II. In the decision under appeal the examining division held by reference to previous communications that the subject-matter of claim 1 then on file directed to an imaging optical system contained added subject-matter (Article 123(2) EPC 1973), was not clear (Article 84 EPC 1973), and was anticipated (Articles 52(1) and 54 EPC 1973) or at lest rendered obvious (Article 56 EPC 1973) by the disclosure of the following documents:

D1 : US-A-5251063
D2 : US-A-3944337
D3 : US-B1-6292293
D6 : "Optics", E. Hecht, 2nd ed., Addison-Wesley Publishing Company (US), 1974; pages 211 to 214.

III. With the statement setting out the grounds of appeal the appellant submitted an amended set of claims, contested the examining division's view on the issue of the patentability of the claimed invention, and requested oral proceedings on an auxiliary basis.

IV. In a communication annexed to the summons to attend oral proceedings the Board introduced the following document:

D7 : "Higher order aplanatism", G. Schultz; Optics Communications, Vol. 41, No. 5 (1982); pages 315 to 319,

and expressed its preliminary opinion on the appellant's case.

V. In reply to the summons to oral proceedings the appellant filed by letter dated 15.01.2010 a new set of amended claims 1 to 5 and amended description pages 1 to 9 and requested setting aside of the decision under appeal and the grant of a patent on the basis of the amended application documents together with the drawing sheets on file.

After consideration of the amendments made to the application documents according to the request of the appellant, the Board cancelled the oral proceedings.

VI. Claim 1 amended according to the present request of the appellant reads as follows:

"A method of producing an imaging optical system having an optical axis (90) comprising:

providing a refractive optical group consisting only of a first lens (70) and a second lens (76) by:

positioning the first lens (70) on the optical axis (90), the first lens (70) having an aspheric first-lens front surface (72) and an aspheric first-lens back surface (74), and

positioning the second lens (76) on the optical axis (90) adjacent to the first lens (70), the second lens (76) having an aspheric second-lens front surface (78) and an aspheric second-lens back surface (80);

arranging the refractive optical group so that the imaging optical system has a substantially planar image surface (84) within specified tolerances lying on the optical axis (90), wherein the refractive optical group forms an image at the image surface (84), and:

designing the first lens (70) and the second lens (76) by applying, on a point-by-point basis across the entire field of view, the relation:

$$\varphi_t = \varphi_1 + \varphi_2 - (d\varphi_1\varphi_2)$$

wherein φ_t is the total local optical power of the refractive optical group, φ_1 is the local optical power of the first lens (70), φ_2 is the local optical power of the second lens (76), and d is the local spacing between a point on the first lens (70) and a point on the second lens (76), by selecting φ_t on a point-by-point basis across the entire field of view to produce the planar image surface within specified tolerances."

The present request also includes dependent claims 2 to 5 all referring back to claim 1.

VII. The arguments of the appellant in support of its request can be summarised as follows:

In the claimed invention the algebraic equation is not used as in document D6. In document D6 the lenses are spherical and the algebraic equation involves the gross focal lengths of spherical lenses and the distances measured from principal planes (Figure 6.1), and not the local optical powers of aspheric lenses on a point-by-point basis and the local spacing between a point on the first lens and a point on the second lens as in the claimed invention (Figure 3). None of the documents cited by the examining division suggests that in the case of aspheric lenses it is not sufficient to model them on a gross basis as it is the case in the algebraic equation of document D6 and they must be modelled on a point-by-point basis, or that the distances between principal planes in the equation could be substituted with the distance from surface point to surface point.

Therefore, document D6 presents a spherical lens analysis and the values in the equation are not local values as in the claimed invention, but gross values of spherical lenses, and there is no evidence that the equation of document D6 has any applicability to the design of aspheric lens systems. The principle behind the invention is that the use of two aspheric surfaces on each lens defined using the equation of claim 1 allows the spacing of two adjacent lenses to be varied from field point to field point, resulting in a compact lens system with a wide field of view.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

The application documents have been amended in response to the grounds given by the examining division for the refusal of the application (point II above) and also in response to the observations made by the Board in its communication and relating to issues such as novelty and sufficiency of disclosure. As a result of the amendments, the invention is now directed to the production of an imaging optical system constituted by two lenses and the amendments overcome, among others, the objections raised by the examining division under Articles 84 and 123(2) EPC 1973. In particular,

- claim 1 is based on the imaging optical system defined in claims 12 and 13 as published together with the disclosure in paragraph [0029] *et seq.* of the description as published relating to the design and production of the imaging optical system and the features disclosed on page 3, lines 19 to 24, page 7, lines 8 to 11, page 7, line 25 to page 8, line 2, and page 8, lines 23 to 30 of the description as published, and

- the features of dependent claims 2 to 5 are respectively based on claims 14, 15, 16 and 19 together with the disclosure on page 6, lines 25 to 30 of the application as published.

The description has been thoroughly revised and brought into line with the invention as now claimed (Article 84 EPC 1973, second sentence, and Rules 27(1)(b) and (c) EPC 1973).

3. *Novelty*

3.1 Document D7 discloses a method of producing an imaging optical system consisting of two lenses and designed so that the image surface formed by the optical system for large pupils is, within a predetermined order of approximation, substantially planar (see abstract together with section 3 and page 315, first column, last paragraph). According to the disclosure of the document, the planarity condition of the image surface is achieved to a predetermined high order of approximation by endowing the two lenses with aspheric surfaces designed by successively applying on a point-by-point basis across the entire field of view an algorithm involving the power series expansion of the wave aberration for finite angular apertures (Figure 2 together with sections 2 and 3, first paragraph of section 4, and last paragraph of section 5 on page 319).

The claimed method of producing an imaging optical system consisting of two lenses and forming, within a predetermined tolerance, a substantially planar image also involves endowing the two lenses with aspheric surfaces designed by applying on a point-by-point basis a mathematical algorithm across the entire field of view. However, while in document D7 this algorithm involves the power series expansion of the wave aberration, in the claimed method the algorithm is given by the following algebraic relation:

$$\varphi_t = \varphi_1 + \varphi_2 - (d\varphi_1\varphi_2)$$

where φ_1 and φ_2 are the local optical powers of the first and the second lenses, respectively, d is the spacing between two corresponding points on the first and the second lenses, and φ_t is the total local optical power of the two lenses, the value φ_t being selected on a point-by-point basis while the relation is applied across the entire field of view so that the image surface is planar within specified tolerances.

3.2 Documents D1, D2 and D3 disclose optical systems comprising lenses with aspheric surfaces (D1, abstract and column 11, lines 47 to 52, D2, abstract and the examples, and D3, column 3, line 43 ***et seq.***), and none of the documents addresses the design and production of an optical system as claimed. In particular, none of the documents discloses the design of aspheric lens surfaces on the basis of the algebraic expression specified in the claimed method.

3.3 Document D6 is an excerpt from a textbook on general optics and discloses in equation (6.8) on page 214 the algebraic expression specified in present claim 1. This equation is however disclosed in the context of an optical system comprising two lenses having spherical surfaces and, in addition, the document is silent as to the design and production of optical systems consisting of two lenses having aspheric surfaces.

3.4 The remaining documents on file are less relevant, and the Board concludes that the subject-matter of claim 1 and that of dependent claims 2 to 5 is novel over the prior art on file (Article 54(1) EPC 1973).

4. *Inventive step*

4.1 The closest state of the art is represented by the method of designing and producing an aplanatic imaging optical system constituted by two lenses having aspheric surfaces disclosed in document D7, from which the claimed method differs in that the design of the lens surfaces is based on the claimed algebraic expression instead of the power series expansion of the wave aberration as already concluded in point 3.1 above.

4.2 As regards the technical problem solved by the claimed invention, the board notes that the claimed method would also result in an optical system constituted by two lenses each having aspheric surfaces and forming, in a wide field of view and within a predetermined tolerance, a planar image surface as it is the case in document D7 and that, in addition, the appellant has not identified any technical advantage or improvement achieved by the distinguishing feature identified above over the method known from document D7.

Accordingly, the distinguishing feature of the claimed subject-matter identified above solves the technical problem of providing an alternative to the method of production of an imaging optical system disclosed in document D7.

4.3 As held by the examining division during the first-instance proceedings by reference to document D6 (page 214, equation (6.8)), the algebraic relation underlying the claimed design algorithm is known in the general field of optics as an algebraic expression relating the total optical power of an optical system constituted by two lenses and the optical powers of the individual lenses. However, it has to be noted in this context that the known algebraic relation results from a linear approximation obtained assuming lenses with spherical surfaces and also assuming small imaging apertures with paraxial rays, i.e. imaging rays close to the optical axis (document D6, page 211, first paragraph). Thus, the applicability of the known algebraic relation is generally confined to spherical lenses and to the paraxial region of the optical system in which, by virtue of the relation, the image is substantially planar only in the paraxial region of the image field close to the optical axis and, contrary to the view expressed by the examining division during the first-instance proceedings, the relation is not straightforwardly applicable to non-spherical lenses and outside the paraxial region of the optical system.

Furthermore, none of the documents on file discloses or suggests the application of the known paraxial relation to non-spherical lenses in the non-paraxial region, let alone replacing the design method followed in document D7 and based on an algorithm involving the power series expansion of the wave aberration for finite angular apertures - and therefore valid in the paraxial region as well as in the non-paraxial region - by a design method in which a purely paraxial approach is applied in the non-paraxial region across a broad field of view.

In addition, even assuming that the skilled person would have considered the application of the claimed algebraic relation to the non-paraxial region of the optical system in order to solve the problem formulated above, he would then have been confronted with the subsequent problem of the application of a relation involving spherical lens surfaces along different non-paraxial directions and with different optical parameters, and there is no teaching in the available prior art that would have suggested subsequently solving this problem by assuming aspheric lens surfaces and imposing the mathematical constraints involved in such an approach on a point-by-point basis in a wide field of view only within specified tolerances as claimed.

4.4 Documents D1, D2 and D3 are silent as to the use of the algebraic expression specified in the claim in the design of optical systems, let alone in the design of optical systems operating in the non-paraxial region.

The remaining documents on file are less relevant.

4.5 The Board concludes that the subject-matter of claim 1, as well as that of dependent claims 2 to 5, is not rendered obvious by the available prior art (Article 56 EPC 1973).

5. The Board is also satisfied that the application documents amended according to the present request and the invention to which they relate meet the remaining requirements of the EPC within the meaning of Article 97(1) EPC. The Board therefore concludes that the decision under appeal is to be set aside and a patent be granted on the basis of the application documents amended according to the present request of the appellant (Article 97(1) EPC together with Article 111(1) EPC 1973).

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent in the following version:
   - claims 1 to 5 filed with the letter dated 15.01.2010,
   - description pages 1 to 9 filed with the letter dated 15.01.2010, and
   - drawing sheets 1/4 to 4/4 of the application as published.

The Registrar: The Chairman:

M. Kiehl A. G. Klein