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Datasheet for the decision of 15 October 2007

Case Number: T 0305/06 - 3.4.02

Application Number: 95943701.3

Publication Number: 0852020

IPC: G02B 23/00

Language of the proceedings: EN

Title of invention:
Integrated optical system for endoscopes and the like

Applicant:
HOOGLAND, Jan

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (yes)"

Decisions cited:
-

Catchword:
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Case Number: T 0305/06 **-** 3.4.02

D E C I S I O N
of the Technical Board of Appeal 3.4.02
of 15 October 2007

Appellant: HOOGLAND, Jan
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 16 August 2005 refusing European application No. 95943701.3 pursuant to Article 97(1) EPC.**

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 to refuse European patent application No. 95943701.3 (based on International application No. PCT/US95/15911 published with the International Publication No. WO 96/18125).

In the decision under appeal the examining division held that the subject-matter of claim 1 then on file did not involve an inventive step (Articles 52(1) and 56 EPC) in view of the disclosure of document

D1 : EP-A-0558278

and the general common knowledge in the art as illustrated by documents

D2 : Modern optical engineering: the design of optical systems, W. J. Smith, 2nd ed., McGraw-Hill, 1990; pages 151 to 154, 239 to 241 and 335

D3 : US-A-4784118.

II. With the statement setting out the grounds of appeal the appellant submitted an amended set of claims and requested that the decision under appeal be set aside and that a patent be granted.

III. In response to a telephone consultation with the rapporteur, the appellant filed with its letter dated 26.09.2007 an amended set of claims 1 to 14 and amended page 1 of the description replacing the corresponding application documents.

IV. Claim 1 amended according to the appellant's request reads as follows:

" An endoscopic optical system extending along an optical axis comprising:

at least three spaced-apart groups of optical elements-disposed serially along the optical axis for the transfer of an image from an input focal plane (0) through said at least three spaced-apart groups to an output focal plane (8-12; 16; 20), said three groups being displaced from focal planes (F) and pupil planes (P) in the endoscopic optical system, each of said at least three groups being of positive optical power and having at least one element, each element in each of said three groups being of uniform refractive index and having surfaces (2-19) defined by a respective radii of curvature R and curvature, C, and

an external entrance pupil at an entrance pupil plane (1) which is displaced from the three groups of optical elements and is positioned between the input focal plane and the nearest one of said three groups; characterized in that

said external entrance pupil comprises an aperture that comprises a protective glass or plastic cover; and

the aberration correction and optical power are distributed over said three spaced apart groups of optical elements such that said optical elements in said spaced apart groups have reduced curvature, the sum of the absolute values of the curvatures, C, as represented by $\Sigma \left|1/R\right|$, where $C = 1/R$, for all of said elements in said at least three groups being less than 1.5 mm^{-1}, the wavefront aberration being between 0.48 and 0.10 waves and the color aberrations being between

0.8 and 0.03 waves when the field is between 60 and 80 degrees."

Claims 2 to 14 are all dependent claims referring back to claim 1.

V. The arguments of the appellant in support of its requests can be summarised as follows:

Conventional endoscope designers faced with the problem of obtaining a sensible compromise between optical imaging quality and manufacturing costs and/or complexity have addressed this problem by conceptualizing the complete endoscope optical system as consisting of four basic and separate optical functions, namely an objective, a field lens at an image plane, an image transfer lens at a pupil plane, and a focusing lens. The optical system design is thus broken up into parts with single and clearly defined functions which the designer has considerable experience in designing so as to provide well corrected images. Light and information transfer capacity of the endoscope is also maximum when the optical power is concentrated at the image and the pupil planes. However, no one previously recognized a problem with the otherwise high level of optical correction provided by the systems previously being designed using the traditional approach.

In addition, using surfaces having reduced curvature is not synonymous with reduced optical aberration. First, increased curvature is needed for colour correction, dispersion of opposite sign in different materials forming curved surfaces causes refraction in different

directions that is used to counteract chromatic aberration, and the curvature is employed in providing such chromatic correction. Second, curvature is used to correct other aberrations as well; the correction of astigmatism, field curvature as well as chromatic aberrations is conventionally accomplished using short radii of curvature. Thus, to say that one skilled in the art will necessarily reduce curvature to reduce aberrations is not correct.

In particular, claim 1 has been amended so as to specify that the colour correction is between 0.8 and 0.03 waves. One skilled in the art, seeking to provide colour correction, would not be inclined, given the aforementioned conventional design and correction approaches, to provide reduced curvature as claimed.

Document D2 shows a periscope system (Figure 9.3) with separate optical entities and illustrates the background art referred to above. The correction of the corresponding aberrations requires relatively short radii. The design of document D2 likely suffers high aberration, increased curvature, or both because the lenses are situated at the intermediate image planes and the pupil planes. In contrast, according to the invention the lens is displaced from the stop locations and astigmatism is removed; consequently, optical surfaces of very short radii are not needed to correct astigmatism, spherical aberration is near minimum, and chromatic aberration is greatly reduced by the displacement of the elements from the image planes and the pupil planes. In addition, the distribution of correction aberration according to the invention surprisingly simplifies the optical system.

Reasons for the Decision

1. The appeal is admissible

2. *Formal requirements - Articles 123(2) and 84 EPC*

The Board is satisfied that the application documents as presently amended meet the formal requirements of the EPC, and in particular those set forth in Articles 84 and 123(2) EPC. More particularly, amended claim 1 is based on claims 10, 11, 22, 24 and 27, page 1, line 33 to page 2, line 3, and Table XII on page 15 of the application as published, dependent claims 2 to 14 are respectively based on claims 23, 25, 26, 23, 28, 30, 31, 32, 34, 35, 36, 37 and page 2, lines 11 and 12 of the application as published, and the description has been brought into conformity with the invention as claimed (Article 84 and Rule 27(1)(c) EPC) and also appropriately amended pursuant to Rule 27(1)(b) EPC.

The Board notes that in the decision under appeal, in addition to the reasons given for the refusal of the application, the examining division also expressed doubts as to the clarity of the subject-matter of claim 1 then on file (Article 84 EPC). Nonetheless, after consideration of the subject-matter of claim 1 amended according to the present request of the appellant, the Board considers that some of the clarity issues addressed by the examining division have been overcome by the amendments and that the remaining issues do not amount in the Board's view to valid objections under Article 84 EPC.

3. *Inventive step*

3.1 The Board concurs with the examining division in considering document D1 as representing the closest state of the art. This document discloses an assembly of the endoscopic type for a combustion chamber monitoring camera (Figure 1 and the corresponding description). The assembly comprises four spaced-apart lenses disposed along an optical axis for the transfer of the image from the combustion chamber constituting the input focal plane (plane 2) to the camera image plane (plane 5) constituting the output focal plane. The lenses are displaced from focal planes (planes 3 and 3' and column 2, line 31 to 33) and pupil planes (plane 1) and are of positive optical power (optical arrangement represented in Figure 1) and of a uniform refractive index. The assembly includes in addition an external entrance pupil (field stop 1, column 2, lines 38 to 49 and column 3, lines 2 to 4 and 17 to 20) displaced from the lenses and positioned between the input focal plane and the first of the lenses (Figure 1).

3.2 The subject-matter of claim 1 according to the present request of the appellant differs from the optical assembly disclosed in document D1 in that

a) the external entrance pupil comprises an aperture that comprises a protective glass or plastic cover,

b) the aberration correction and optical power are distributed over the lenses such that the lenses have reduced curvature and the sum of the absolute values of the curvatures $\Sigma \left|1/R\right|$ for all of the lenses is less than 1.5 mm^{-1}, and

c) for a field between 60 and 80 degrees

c-1) the wavefront aberration is between 0.48 and 0.10 waves and

c-2) the colour aberrations are between 0.8 and 0.03 waves.

3.3 In its decision the examining division referred to

- fields of view of the order of 60 to 70° that are typically considered in endoscopes (document D3, column 2, lines 48 and 49),
- the Raleigh criterion commonly used for image resolution and allowing up to 0.25 waves of aberration (document D2, page 152, last sentence of the first paragraph, and page 335, chapter 11.4), and
- the general design principle of reducing the optical power and therefore the curvature of lenses in relay lens systems as illustrated by the design of an endoscope periscope in document D2, paragraph bridging pages 240 and 241.

In view of this general common knowledge, the examining division concluded that features b) and c-1) did not involve an inventive step on the grounds that the problem solved by these features, namely finding a compromise between optical imaging quality and manufacturing cost and/or complexity (page 1, lines 19 to 24 and page 5, lines 20 to 24 of the application), directed the skilled person to distribute the optical power over the lenses such as to minimize the sum of the absolute optical power and thus to design the lens surfaces as flat as possible in order to minimize and compensate for optical aberrations for fields of view of the order of 60 to 80° as claimed.

The subject-matter of claim 1 as presently amended, however, has been further restricted by the incorporation of features a) and c-2). In addition, even if the aforementioned line of argument of the examining division were to be followed, none of the documents considered by the examining division discloses or suggests further improving the compromise between optical imaging quality and manufacturing costs and/or complexity of the optical system by maintaining also the colour aberrations between 0.8 and 0.03 waves for a field between 60 and 80 degrees as required by feature c-2). In particular, document D1 is silent as to the image quality characteristics of the optical system, document D3 discloses the automatic correction for lateral chromatic aberration in a symmetrical rod lens relay arrangement and is silent as to any relationship of the chromatic aberration with the total amount of curvature of the lens surfaces (column 4, line 32 *ff*.), and document D2 discloses the Rayleigh's criterion for aberration allowances in imaging resolution (paragraph bridging pages 152 and 153, and page 335, central paragraphs) but is silent as to any criterion for colour aberration allowances in connection with the curvature of the lens surfaces of the optical system. Similar comments apply with regard to the remaining documents on file.

The Board accepts that, as maintained by the examining division, it belongs to the common general knowledge of a person skilled in the art to maintain the different imaging aberrations of an imaging optical system as low as possible and that the skilled person also knows that optical aberrations are mainly caused by the curvature of the optical surfaces. However, generally the

curvatures of the different lens surfaces of a multi-component optical system are primarily selected, not according to a predetermined degree of optical aberration correction, but rather according to the optical power and the optical layout of the system (document D2, page 240, second paragraph to page 241, first paragraph), and then adjusted to provide a predetermined degree of aberration correction as illustrated by the documents on file. In this context, and as submitted by the appellant, none of the documents discloses or suggests maintaining the sum of the absolute values of the curvatures of the lens surfaces of a multi-component optical system of the type disclosed in document D1 below the claimed low value 1.5 mm^{-1} in order to maintain simultaneously and specifically the wavefront and the colour aberrations within the claimed low wave number ranges, let alone the technical advantages achieved therewith, namely achieving a simplified endoscopic optical arrangement with good optical imaging quality (paragraph bridging pages 1 and 2, and page 5, lines 20 to 24 together with page 3, lines 25 and 26 of the application).

3.4 Having regard to the above, the Board concludes that the endoscopic optical system defined in claim 1 as presently amended involves an inventive step over the available prior art (Articles 52(1) and 56 EPC).

The same conclusion applies to dependent claims 2 to 14 by virtue of its dependence on claim 1.

4. The Board is also satisfied that the application documents as presently amended and the invention to

which they relate meet the remaining requirements of the EPC within the meaning of Article 97(2) EPC.

In view of the above conclusions and considerations, the Board 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 (Articles 97(2) and 111(1) EPC).

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 14 filed with the letter dated 26.09.2007,
   - description pages 2 to 17 as published, page 1 filed with the letter dated 26.09.2007 and page 1a filed with the letter dated 23.07.2003, and
   - drawing sheets 1/3 to 3/3 as published.

The Registrar: The Chairman:

M. Kiehl A. G. Klein