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Datasheet for the decision of 13 June 2019

Case Number: T 0669/15 - 3.4.02

Application Number: 12178625.5

Publication Number: 2672242

IPC: G01J3/18, G01J3/28, G01J3/02, G01N21/35

Language of the proceedings: EN

Title of invention:
Compact spectrometer for remote hydrocarbon detection

Applicant:
Raytheon Company

Relevant legal provisions:
EPC Art. 54, 56, 83, 84

Keyword:
Clarity (yes, amended claims)
Sufficiency of disclosure (yes)
Novelty and inventive step (yes)

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Case Number: T 0669/15 - 3.4.02

D E C I S I O N
of Technical Board of Appeal 3.4.02
of 13 June 2019

Appellant: (Applicant)	Raytheon Company 870 Winter Street Waltham, MA 02451 (US)
Representative:	HGF Limited 4th Floor Merchant Exchange 17-19 Whitworth Street West Manchester M1 5WG (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 24 November 2014 refusing European patent application No. 12178625.5 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	R. Bekkering
Members:	F. J. Narganes-Quijano
	T. Karamanli

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal against the decision of the examining division refusing European patent application No. 12178625.5.

II. During the first-instance proceedings reference was made to the following documents:

D1: US 6 104 488 A
D2: US 7 382 498 B1
D3: US 2009 0257622 A1.

In its decision the examining division held in respect of the sole request then on file that

- claims 1, 5 to 7, 12 and 13 were not clear (Article 84 EPC),
- the subject-matter of claim 1 was not new in view of document D1 (Article 54(1) EPC), and
- the subject-matter of independent claim 12 did not involve an inventive step in view of documents D1 and D3 (Article 56 EPC).

In an *obiter dictum* of its decision, the examining division expressed doubts as to whether the claimed invention was sufficiently disclosed within the meaning of Article 83 EPC.

III. With its statement setting out the grounds of appeal, the appellant submitted claims according to a main request and an auxiliary request and requested that the decision under appeal be set aside and a patent be granted on the basis of the claims of the main request or the auxiliary request.

IV. In reply to the observations made by the board in a communication annexed to summons to oral proceedings, the appellant filed by letter dated 1 April 2019, among other documents, amended claims 1 to 14 of a new main request to replace those of the main request then on file and amended description pages 5 to 9 and 16 according to the main request.

In reply to a telephone consultation with the rapporteur of the board, the appellant filed by letter dated 10 April 2019, among other documents, amended description pages 1 to 3 and 3a according to the main request.

In reply to a subsequent telephone consultation, the appellant, by letter dated 11 April 2019, formulated a main and an auxiliary request for grant, the main request being based on the following application documents:

- Claims: Nos. 1 to 14 of the main request filed by letter dated 1 April 2019.
- Description: Pages 1 to 3 and 3a of the main request filed by letter dated 10 April 2019, pages 4 and 10 to 15 of the application as originally filed, and pages 5 to 9 and 16 of the main request filed by letter dated 1 April 2019.
- Drawings: Sheets 1/10 to 10/10 of the application as originally filed.

V. In view of the main request submitted by the appellant, the oral proceedings were cancelled.

VI. Independent claims 1 and 12 of the main request read as follows:

"1. A multi-band imaging spectrometer comprising:

an objective optical system (320);

an optical spectrometer sub-system (330) including a blazed diffraction grating (460), the optical spectrometer sub-system (330) configured to receive and collimate an input beam (450) from the objective optical system (320) to provide a collimated beam at the diffraction grating (460), wherein the diffraction grating (460) is configured to disperse the collimated beam into at least two spectral bands offset in a spectral dimension using a corresponding different diffraction order of the diffraction grating (460) for each spectral band, the spectral bands being separated in the spectral dimension;

a single entrance slit (420) positioned between the objective optical system (320) and the optical spectrometer sub-system (330) and configured to direct the input beam (450) from the objective optical system (320) to the optical spectrometer sub-system (330), the single entrance slit providing spatial co-registration of the at least two spectral bands offset in the spectral dimension; and

a single focal plane array (340, 500, 610, 630, 635) optically coupled to the diffraction grating (460) and configured to simultaneously receive the at least two offset spectral bands and to produce an image at the single focal plane array (340, 500, 610, 630, 635) from the at least two spectral bands with the offset in the spectral dimension."

"12. A method for remote hydrocarbon gas detection using an imaging spectrometer comprising:

directing an input light beam through a single entrance slit (420);

collimating the input light beam to provide a collimated beam (450);

spectrally dispersing the collimated beam into at least two spectral bands offset in a spectral dimension, using a corresponding different diffraction order of a blazed diffraction grating (460) for each spectral band, the spectral bands being separated in the spectral dimension;

directing the at least two spectral bands simultaneously to an imaging detector (340, 500, 610, 630, 635), the single entrance slit providing spatial co-registration of the at least two spectral bands offset in the spectral dimension; and

imaging the at least two spectral bands with the offset in the spectral dimension at the imaging detector (340, 500, 610, 630, 635)."

The claims of the main request also include dependent claims 2 to 11 and dependent claims 13 and 14 referring back to independent claims 1 and 12, respectively.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request - Amendments*

Claim 1 of the main request is based on claim 1 and dependent claim 14 as originally filed, together with the passages on page 2, lines 15 to 21, page 5, lines 25 to 31, and page 7, lines 7 to 9 of the description as originally filed.

Independent claim 12 of the main request is based on independent claim 12 and dependent claim 14 as originally filed, together with claim 1 as originally filed and the passages on page 4, lines 19 to 21, page 5, lines 25 to 31, and page 7, lines 7 to 9 of the description as originally filed.

Dependent claims 2 to 11, 13 and 14 of the main request are respectively based on dependent claims 2 to 11, on dependent claim 13 together with the passage on page 2, lines 22 to 25, and on dependent claim 15 of the application as originally filed.

The amendments made to the description relate to the adaption of its content to the invention as defined in the present claims (Rule 42(1)(c) EPC) and to the acknowledgement of the pertinent state of the art (document D1) in the introductory part of the description (Rule 42(1)(b) EPC).

The board concludes that the application documents amended according to the present main request of the appellant comply with the requirements of Article 123(2) EPC.

3. *Main request - Clarity*

3.1 In its decision the examining division held that the expression "spectral bands" in the claims then on file was vague because any wavelength range could be construed as comprising two sub-ranges constituting two spectral bands as claimed, and that the features of independent claims 1 and 12 relating to the spectral bands being "offset" or "separated in the spectral dimension" were also unclear because any spectral band could be subdivided in spectrally offset sub-bands.

This objection of lack of clarity, however, is not found persuasive by the board. The claims then on file, as well as independent claims 1 and 12 of the present main request, do not simply refer to spectral bands of an input light beam, but to a diffraction grating configured to disperse the collimated input light beam into at least two spectral bands using a corresponding different diffraction order of the diffraction grating for each spectral band. Therefore, the skilled person would not understand the at least two spectral bands referred to in the claims as consisting of any of the spectral sub-bands into which a broader spectral band can conceptually be divided, but as consisting of at least two of the distinct spectral bands diffractively dispersed, and therefore spatially separated, by a corresponding one of the diffraction orders of the diffraction grating.

In addition, independent claims 1 and 12 of the present main request specify that the at least two spectral bands are "separated in the spectral dimension", and these claims have been amended to specify that the at least two offset spectral bands are "offset in a spectral dimension". The skilled person would therefore understand that the at least two spectral bands spatially dispersed by the diffraction grating are not only spectrally offset with respect to each other (for instance, in the sense that the central wavelength of each of the spectral bands is offset with respect to the central wavelength of the remaining spectral bands), but also that they are separated in the spectral dimension (see Fig. 7 to 10 and the corresponding description), thus excluding that the at least two spectral bands substantially overlap each other in a part of the spectrum.

3.2 In its decision the examining division also objected that independent claims 1 and 12 then on file merely defined the spectral band separation as a desired result, without specifying the structural features required for achieving this result.

Independent claims 1 and 12 then on file already required the use of a diffraction grating for carrying out the claimed spectral band separation, and independent claims 1 and 12 of the present main request have been amended to further require that the diffraction grating is of the blazed type. The spectral diffraction characteristics of a blazed diffraction grating as claimed render possible the dispersion of the incident light beam into spectral bands offset in the spectral dimension and separated in the spectral dimension as claimed (see point 4 below, third paragraph). Therefore, the examining division's objection has been overcome by way of amendment.

3.3 In view of the above considerations, and also of other amendments made to the claims, the board is of the opinion that the claims of the present main request are clear and supported by the description within the meaning of Article 84 EPC.

4. *Main request - Sufficiency of disclosure*

In an *obiter dictum* of its decision, the examining division expressed the view that the application did not provide a single complete example of the invention, and that there was no teaching disclosed in the application on how to select and to arrange the optical components in order to reproduce the invention and thus

the disclosure in the application was not sufficient within the meaning of Article 83 EPC.

The application discloses with reference to Fig. 4 an imaging optical arrangement to be used as the foreoptics of the imaging spectrometer system disclosed with reference to Fig. 3. Furthermore, the application discloses with reference to Figs. 5A and 5B to Figs. 10A and 10B different band slit and focal plane array configurations according to the invention.

In addition, the description discloses explicit examples of dispersion of an input light beam into two or three offset spectral bands separated in the spectral dimension using a corresponding one of the different diffraction orders of a blazed diffraction grating (Tables 1 to 9 together with the corresponding description). The description does not provide details on the blazed diffraction grating, and in particular on the design parameters of the grating (grating period, blaze angle, shape of the grating periods, etc.) determining the diffraction characteristics and therefore the diffraction efficiency and shape of the dispersed spectral bands (diffraction efficiency at the central wavelength, width of the bands, etc.). However, the description specifies that the design should obtain, among other results, separation of the spectral bands in the spectral dimension (paragraph bridging pages 10 and 11), and the skilled person would see in this passage an instruction to appropriately select the different design parameters of the blazed diffraction grating so that the claimed spectral band separation is achieved. The board is of the opinion that the skilled person in the technical field under consideration would be able, without undue burden and on the basis of the common general knowledge relating to blazed diffraction

gratings, to select the appropriate design parameters of the blazed diffraction grating required to obtain the claimed spectral band separation.

The board therefore concludes that the claimed invention is sufficiently disclosed within the meaning of Article 83 EPC.

5. *Main request - Claim 1 - Novelty*

5.1 Document D1 discloses a multi-band imaging spectrometer (abstract, and Fig. 3 together with the corresponding description) comprising

- an objective (foreoptics 305 in Fig. 3);
- an optical spectrometer sub-system (collimator 307 and camera mirror 303 in Fig. 3) including a diffraction grating (grating 302 in Fig. 3) of the blazed type (abstract, second sentence, and column 3, lines 18 to 35) and configured to receive and collimate an input beam from the objective to provide a collimated beam at the blazed diffraction grating (see Fig. 3), the blazed diffraction grating being configured to disperse the collimated beam into at least two spectral bands offset in a spectral dimension using a corresponding one of the diffraction orders of the diffraction grating for each spectral band (column 3, lines 18 to 35);
- a single entrance slit (slit aperture 306 in Fig. 3) positioned between the objective and the spectrometer sub-system and configured to direct the input beam from the objective to the optical spectrometer sub-system, the entrance slit providing spatial co-registration of the at least two spectral bands (Fig. 3, together with column 3, lines 12 to 14); and

- a single focal plane array of the dual- or multi-band type (FPA or focal plane array 304 in Fig. 3, together with claim 1 and column 3, lines 47 to 54) optically coupled to the diffraction grating and configured to simultaneously receive the at least two spectral bands and to produce an image at the single focal plane array from the at least two spectral bands (column 1, lines 61 to 64, column 2, lines 14 to 32, column 2, line 53 to column 3, line 12, and Figs. 4a to 4c together with the corresponding description).

5.1.1 In its decision the examining division held that the at least two spectral bands of document D1, in addition to being offset in a spectral dimension as mentioned above, were also separated in the spectral dimension as required by claim 1.

In its statement setting out the grounds of appeal, the appellant contested the examining division's view in this respect, and referred to the passages in column 2, lines 30 to 32, of document D1 according to which the disclosed spectrometer "allows two overlapping grating orders (spectra) to fall onto the dualband focal plane array" and these orders "are separated by the dualband capability of the focal plane array".

In the board's opinion the feature "overlapping grating orders" referred to by the appellant and disclosed in column 2, lines 30 and 31, of document D1 (see also the similar formulations in the first sentence of the abstract, in column 3, lines 9 to 11, and in the first paragraph of claims 1 and 2) is ambiguous, and therefore by itself alone not conclusive for the present purposes, because it can in principle be construed - as submitted by the appellant - as referring to grating orders that overlap each other in

the spectral dimension, but also as referring to grating orders that do not necessarily overlap each other in the spectral dimension but are projected and focused spatially overlapped on each other on the focal plane array. Therefore, the mentioned feature requires interpretation in the context of document D1.

5.1.2 The board first notes that document D1 focuses on the diffraction efficiency of the blazed diffraction grating at and around the central wavelength of each of the spectral bands, i.e. at and around the blaze wavelength λ_{blaze} and at and around entire fractions thereof (λ_{blaze}/n, with n = 2, 3, etc.) (column 2, lines 33 to 35, and column 3, lines 28 to 33; see also second sentence of the abstract). The document, however, is silent as to the specific degree of diffraction efficiency over the whole wavelength range of each of the spectral bands, and therefore silent as to the lower and the higher values of the wavelength ranges (ranges between λ_1/n and λ_2/n, with n = 1, 2, etc., respectively centred around the wavelength λ_{blaze}/n and referred to in column 3, lines 19 to 35) of each of the spectral bands dispersed by the diffraction grating.

In addition, document D1 refers to the detection of the spectral bands in the dual or multi-band single focal plane array in a respective detection wavelength range for each of the spectral bands projected superposed on each other on the array, and the corresponding detection wavelength ranges do not overlap with each other in the spectral dimension (see for instance column 3, lines 50 to 54, and claim 4). These detection wavelength ranges are, however, determined by the specific cut-off wavelengths of the dual- or multi-band single focal plane array, these cut-off wavelengths defining the spectral response of the imaging pixels of

the single focal plane array to allow discriminating between the superposed spectral bands in the detection of the spectral bands by the dual- or multi-band focal plane array (Fig. 2 and column 2, lines 31 and 32). In addition, there is no direct and unambiguous disclosure that the wavelength range of each of the spectral bands dispersed by the diffraction grating is identical to or falls within a respective one of the detection wavelength ranges of the dual- or multi-band single focal plane array. It follows that the disclosure of document D1 does not exclude that - as submitted by the appellant - the spectral bands dispersed by the blazed diffraction grating overlap - at least to a predetermined extent - each other in the spectral dimension.

As a consequence, there is no direct and unambiguous disclosure in document D1 that the spectral bands dispersed by the blazed diffraction grating and offset in the spectral dimension are, in addition, separated in the spectral dimension as required by the claimed subject-matter.

5.1.3 In view of these considerations, the subject-matter of claim 1 is new over the disclosure of document D1 by virtue of the feature relating to the offset spectral bands being separated in the spectral dimension.

5.2 The remaining documents on file are less pertinent than document D1. In particular,

- document D2 discloses a spectrometer for imaging a scene in two different wavelength bands (column 1, lines 6 to 9), and in which an input beam from the scene is spectrally separated by a beam-splitter into two spectral components which are then dispersed by a respective diffraction grating (abstract, and Fig. 1

and 4 together with the corresponding description, in particular column 5, lines 12 to 50, and lines 60 to 63), and

- document D3 discloses the remote sensing of gaseous materials through multi-spectral analysis (abstract and paragraph [0001]),

and none of these documents disclose in particular the use of a blazed diffraction grating for the spectral dispersion of an input beam into spectral bands offset and separated in the spectral dimension.

5.3 Therefore, the multi-band imaging spectrometer defined in claim 1 of the main request is new over the documents of the prior art on file (Articles 52(1) and 54 EPC).

6. *Main request - Claim 1 - Inventive step*

6.1 Document D1 represents the closest state of the art.

The claimed spectrometer differs from the spectrometer disclosed in document D1 in the distinguishing feature identified in point 5.1.3 above. The fact that the spectral bands dispersed by the blazed diffraction grating are not only offset in the spectral dimension, but also separated in the spectral dimension, allows for an improved spectral selection of the spectral bands in the multi-band imaging spectrometer and, consequently, for an improved discrimination between the spectral bands being detected at the single focal plane array, thus simplifying and improving the spectral detection and analysis of the input beam.

Document D1 focuses on the selection of the blaze of the diffraction grating to achieve a high diffraction efficiency at and around the central wavelength of the

spectral bands dispersed by the grating (abstract, second sentence, column 2, lines 33 to 35, and column 3, lines 22 to 32), and also on the selection of specific values of the cut-off wavelengths of the dual- or multi-band single focal plane array for the appropriate detection of the different spectral bands (column 2, lines 57 to 61, and column 3, lines 2 to 7, and lines 50 to 59). However, there is no suggestion in document D1 to operate the blazed diffraction grating in such a way that the spectral bands do not substantially overlap with each other, i.e. that they are separated in the spectral dimension as claimed. In particular, in the introductory part of document D1 relating to the background of the invention it is mentioned that the diffraction efficiency of a blazed diffraction grating "is high over only an approximate 'octave' range of wavelengths near the 'blaze' wavelength", but the document is silent as to the possibility of specifically designing the blazed diffraction grating in order to achieve predetermined values of the diffraction efficiency over the ranges of wavelengths of the corresponding spectral bands such that the spectral bands are separated from each other in the spectral dimension.

The remaining documents on file are less relevant. In particular, neither document D2 nor document D3 relate to the spectral characteristics of the spectral bands dispersed by a blazed diffraction grating (see point 5.2 above).

6.2 Therefore, the multi-band imaging spectrometer defined in claim 1 of the main request involves an inventive step over the documents of the prior art on file (Article 56 EPC).

7. *Main request - Claims 2 to 14 - Novelty and inventive step*

Independent claim 12 is directed to a method for remote hydrocarbon gas detection using an imaging spectrometer, and the steps of the method are essentially in one-to-one correspondence with the functional features of the multi-band imaging spectrometer defined in claim 1. Therefore, the method of independent claim 12 is also new and involves an inventive step over the documents of the prior art on file (Articles 52(1), 54 and 56 EPC).

The same conclusion applies to dependent claims 2 to 11 and dependent claims 13 and 14 by virtue of the reference in these claims to independent claims 1 and 12, respectively.

8. The board concludes that the present main request of the appellant is allowable.

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: Nos. 1 to 14 of the main request filed by letter dated 1 April 2019.

- Description: Pages 1 to 3 and 3a of the main request filed by letter dated 10 April 2019, pages 4

and 10 to 15 of the application as originally filed, and pages 5 to 9 and 16 of the main request filed by letter dated 1 April 2019.

- Drawings: Sheets 1/10 to 10/10 of the application as originally filed.

The Registrar: The Chairman:

M. Kiehl R. Bekkering

Decision electronically authenticated