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Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

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16 April 2015

(54) Title: INFRARED REFRACTIVE OBJECTIVE LENS ASSEMBLY

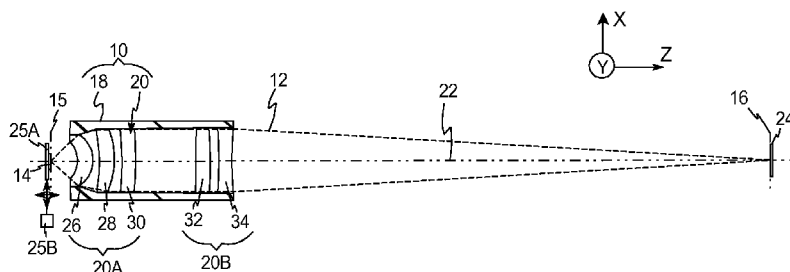


Fig. 1A

(57) Abstract: A mid-infrared objective lens assembly (10) includes a plurality of spaced apart, refractive lens elements (20) that op-
erate in the mid-infrared spectral range, the plurality of lens elements (20) including an aplanatic first lens element (26) that is
closest to an object (14) to be observed. The first lens element (26) has a forward surface (36) that faces the object (14) and a rear-
ward surface (38) that faces away from the object (14). The forward surface (36) can have a radius of curvature that is negative.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/33878

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G02B 21/02 (2015.01)

CPC - H04N 5/33; G02B 21/006; G02B 21/02; G02B 21/025

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8):G02B 21/02 (2015.01)

CPC:H04N 5/33; G02B 21/006; G02B 21/02; G02B 21/025

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

IPC(8):G02B 21/02 (2015.01)

CPC:H04N 5/33; G02B 21/006; G02B 21/02; G02B 21/025; USPC:359/210.1, 221.2,362,377,383

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Patbase, Google Patents, Google Scholar;

Search terms used: mid infrared, infrared, mir, multiple, plural, several, second, two, three, third, lens, aplanatic, index, refraction, germanium, zns, znse, zinc sulfide, zinc selenide, silicon, si, separation, spacing, distance, gap, radius, negative, positive, working distance, infinite con

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 2012/0223260 A1 (HANSEN et al.) 06 September 2012 (06.09.2012), para [0121], [0345], [0384]	1, 2 ----- 3-16
Y	US 5,920,432 A (SUENAGA et al.) 06 July 1999 (06.07.1999), col 3, ln 56-64	3, 4
Y	US 3,391,974 A (RIDE et al.) 09 July 1968 (09.07.1968), col 1, ln 66-col 2, ln 18	4
Y	WO 2009/109979 A2 (BENDER et al.) 11 September 2009 (11.09.2009), pg. 2, 13	5-9
Y	US 5,202,792 A (ROLLIN) 13 April 1993 (13.04.1993), col 4, ln 45-68; Tables 1, A	10, 15, 16
Y	US 6,069,744 A (KUSAKA et al.) 30 May 2000 (30.05.2000), col 3, ln 10-23; col 11, ln 5-25	14
Y	US 2013/0057751 A1 (OHTAKE et al.) 07 March 2013 (07.03.2013), para [0012], [0077], [0090]	11-13
Y	US 7,876,505 B1 (OLCZAK) 25 January 2011 (25.01.2011), col 4, ln 16-40; 57-64	11-13

☐ Further documents are listed in the continuation of Box C.


* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

27 January 2015 (27.01.2015)

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/33878

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Group I: claims 1-16: drawn to a mid-infrared objective lens assembly that gathers infrared light from an object positioned at an object plane and focuses the light onto an image plane comprising a plurality of spaced apart, refractive lens element, the lens element including an aplanatic first lens element that is closest to the object, the first lens having a forward surface that faces the object and a rearward surface that faces away from the object, wherein the forward surface has a radius of curvature that is negative.

Group II: claim 17: drawn to a mid-infrared refractive objective lens assembly that gathers infrared light from an object positioned at an object plane and focuses the light onto an image plane, the lens assembly having a RMS wavefront error of less than approximately 0.5 waves over a wavenumber range of approximately 5.5 micrometers in the mid-infrared spectral range and over a field of view between 100 micrometer up to 2 millimeters.

--please see continuation on extra page--

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-16

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/33878

Continuation of Box No. 3:

Group III: claims 18-20: drawn to an infrared objective lens assembly that gathers infrared light from an object positioned at an object plane and focuses the light onto an image plane, the assembly comprising a plurality of spaced apart refractive lens elements that operate in the mid-infrared spectral range, the lens elements designed and arranged so that a ratio of a magnification factor of the lens assembly to a numerical aperture of the lens assembly is less than thirty.

Group IV: claims 21-24: drawn to a mid-infrared objective lens assembly that gathers infrared light from an object positioned at an object plane and focuses the light onto an image plane, the lens assembly comprising a plurality of spaced apart refractive lens elements that operate in the mid-infrared spectral range, the lens elements including an aplanatic front lens element that is closest to the object, the front lens element having an optical axis, a forward surface that faces the object and a rearward surface that faces away from the object; the forward surface being spaced apart from the object a front separation distance along the optical axis; a mover assembly that moves at least one of the object and the front lens element to adjust the front separation distance; and a control system that control the mover assembly to adjust the separation distance to reduce RMS wavefront error.

The inventions listed as Groups I-IV do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special technical features:

Group I requires a first lens having a forward surface that faces the object and a rearward surface that faces away from the object, wherein the forward surface has a radius of curvature that is negative, not found in the other groups.

Group II requires a RMS wavefront error of less than approximately 0.5 waves over a wavenumber range of approximately 5.5 micrometers in the mid-infrared spectral range and over a field of view between 100 micrometers up to 2 millimeters, not found in the other groups.

Group III requires a plurality of spaced apart refractive lens elements that operate in the mid-infrared spectral range, the lens elements designed and arranged so that a ratio of a magnification factor of the lens assembly to a numerical aperture of the lens assembly is less than thirty, not found in the other groups.

Group IV requires a mover assembly that moves at least one of the object and the front lens element to adjust the front separation distance; and a control system that control the mover assembly to adjust the separation distance to reduce RMS wavefront error, not found in the other groups.

Shared Features:

The only technical features shared by Groups I-IV that would otherwise unify the groups are a mid-infrared, objective lens assembly that gathers light from an object and focuses the light onto an image plane, the objective lens assembly comprising: a plurality of spaced apart, refractive lens elements that operate in the mid-infrared spectral range, the plurality of lens elements including an aplanatic front lens element that is closest to the object, the front lens element having an optical axis, a forward surface that faces the object and a rearward surface that faces away from the object; the forward surface being spaced apart from the object a front separation distance along the optical axis.

However, these shared technical features do not represent a contribution over prior art, because the shared technical features are disclosed by US 2012/0223260 A1 to Hansen et al. (hereinafter 'Hansen') 06 September 2012 (06.09.2012), which discloses a mid-infrared (para [0384]), objective lens assembly (FIG 5) that gathers light from an object and focuses the light onto an image plane (para [0121]), the objective lens assembly comprising: a plurality of spaced apart, refractive lens elements (para [0121]; Fig 5, lens elements 503, 504, 505) that operate in the mid-infrared spectral range, the plurality of lens elements (503, 504, 505) including an aplanatic front lens element (503) that is closest to the object (501), the front lens element having an optical axis, a forward surface that faces the object and a rearward surface that faces away from the object; the forward surface being spaced apart from the object a front separation distance along the optical axis (see FIG 5).

As the shared technical features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups.

Groups I-IV therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.