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H04Q 11/00 (2006.01) *G02B 6/12* (2006.01)
G02B 27/01 (2006.01) *G02B 6/122* (2006.01)
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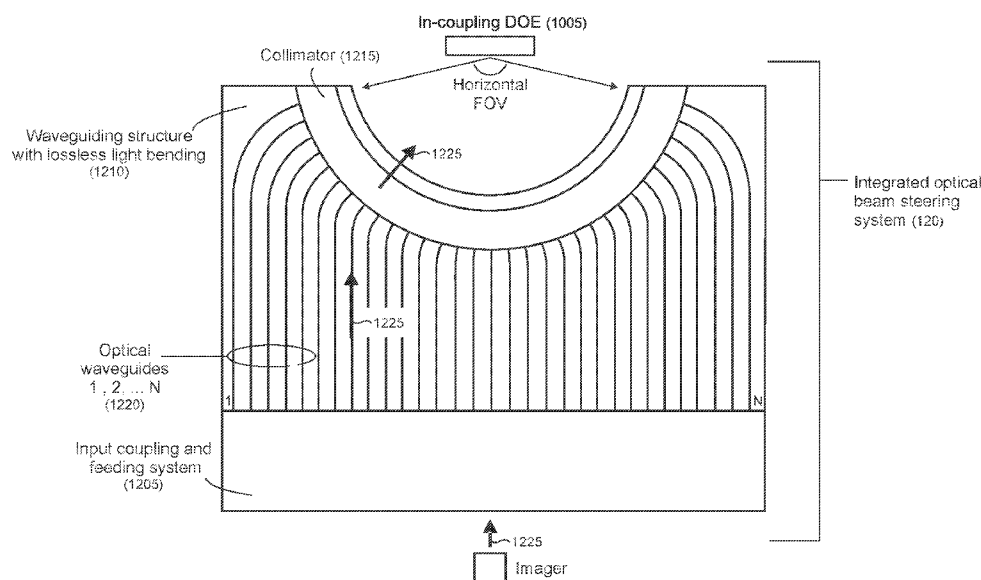
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(54) Title: INTEGRATED OPTICAL BEAM STEERING SYSTEM

FIG 12



(57) Abstract: An integrated optical beam steering system is configured in three stages to provide beam steering for image light from an imager (e.g., laser, light emitting diode, or other light source) to downstream elements in a display system such as an exit pupil expander (EPE) in a mixed-reality computing device. The first stage includes a multi-level cascaded array of optical switches that are configurable to spatially route image light over a first dimension of a two-dimensional (2D) field of view (FOV) of the display system. The second waveguiding stage transfers the image light along preformed waveguides to a collimator in the third stage which is configured to collimate the image light along the first dimension of the FOV (e.g., horizontal). The waveguiding and collimating stages may be implemented using lightweight photonic crystal nanostructures.

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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International application No
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A. CLASSIFICATION OF SUBJECT MATTER		
INV.	H04J14/02 G02F1/31	H04Q11/00 G02B6/12
	G02B27/01 G02B6/122	G02B6/35 G02F1/313
		G02F1/21 G02F1/225
ADD.		
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) G02B G02F H04J H04Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/289652 A1 (RICKMAN ANDREW GEORGE [GB]) 5 October 2017 (2017-10-05)	1-6
Y	paragraph [0083] - paragraph [0087] paragraph [0114] - paragraph [0116] figures 1,12,13	7,8
X	US 2016/025930 A1 (HASEGAWA JUNICHI [JP] ET AL) 28 January 2016 (2016-01-28) paragraph [0032] - paragraph [0045] figures 3,4a	1-6
	----- -/--	
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* 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 1 October 2019		Date of mailing of the international search report 17/10/2019
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer von Hentig, Roger

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International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	L H Frandsen ET AL: "Broadband photonic crystal waveguide 60° bend obtained utilizing topology optimizationTwo Dimensional Semiconductor-Based Photonic Crystal Slab Waveguides for Ultra-Fast Optical Signal Processing Devices", Opt. Express, vol. 12, no. 24 29 November 2004 (2004-11-29), pages 2059-2062, XP055600147, Retrieved from the Internet: URL:https://www.osapublishing.org/DirectPDFAccess/F3FF5F96-FE8E-2B84-ABD8B7B34754956D_81901/oe-12-24-5916.pdf [retrieved on 2019-06-27] figure 3 Chapter 3: Simulation and experimental results	7,8
X	----- HSIEH CHIH-HUNG ET AL: "Fabrication and characterization of thin-film nanostructured Luneburg lens", 2013 INTERNATIONAL CONFERENCE ON OPTICAL MEMS AND NANOPHOTONICS (OMN), IEEE, 18 August 2013 (2013-08-18), pages 35-36, XP032524847, ISSN: 2160-5033, DOI: 10.1109/OMN.2013.6659046 ISBN: 978-1-4577-1511-2 [retrieved on 2013-11-08] abstract Section: I. Introduction figures 1,2	9-14
X	----- PAVEL N DYACHENKO ET AL: "Graded photonic quasicrystals", OPTICS LETTERS, OPTICAL SOCIETY OF AMERICA, US, vol. 37, no. 12, 15 June 2012 (2012-06-15), pages 2178-2180, XP001576239, ISSN: 0146-9592, DOI: 10.1364/OL.37.002178 [retrieved on 2012-06-04] abstract page 2178, left-hand column, paragraph 1 - page 2179, left-hand column, paragraph 2 figure 1 ----- -/--	9-12

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/024160

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LIU WEI ET AL: "Luneburg and flat lens based on graded photonic crystal", OPTICS COMMUNICATIONS, vol. 364, 6 December 2015 (2015-12-06), pages 225-232, XP029362335, ISSN: 0030-4018, DOI: 10.1016/J.OPTCOM.2015.11.058 Section: Introduction Section: Design of Luneburg Lens figures 1,3,4 -----	9-12,14
X	TAKAHASHI S ET AL: "Design and fabrication of dielectric nanostructured Luneburg lens in optical frequencies", OPTICAL MEMS AND NANOPHOTONICS (OPT MEMS), 2010 INTERNATIONAL CONFERENCE ON, IEEE, PISCATAWAY, NJ, USA, 9 August 2010 (2010-08-09), pages 179-180, XP031838370, ISBN: 978-1-4244-8926-8 page 179 - page 180, right-hand column, paragraph 2 figures 1,2 -----	9-12,14
X	HANHONG GAO ET AL: "Design of thin-film photonic metamaterial Luneburg lens using analytical approach", ARXIV.ORG, CORNELL UNIVERSITY LIBRARY, 201 OLIN LIBRARY CORNELL UNIVERSITY ITHACA, NY 14853, 17 November 2011 (2011-11-17), XP080539974, page 3 - page 4 figures 1,2,6,8 -----	9-12,14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/024160

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:

see additional sheet

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 an 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.:

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-8

refer to an optical routing system

2. claims: 9-14

refer to an optical collimator

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2019/024160

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017289652 A1	05-10-2017	CN 108370279 A	03-08-2018
		EP 3357180 A1	08-08-2018
		US 2017289652 A1	05-10-2017
		WO 2017055848 A1	06-04-2017

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