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G02B 27/10 (2006.01) G03B 21/62 (2014.01)  
G02B 27/30 (2006.01) G03H 1/02 (2006.01)

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(54) Title: STRUCTURE AND MANUFACTURING METHOD OF HOLOGRAPHIC OPTICAL ELEMENTS

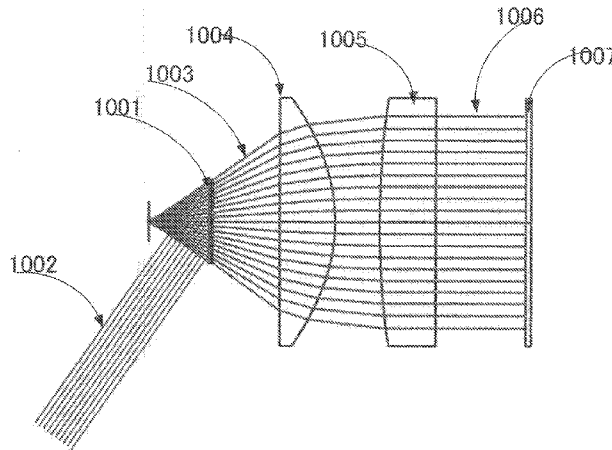


Fig-10

(57) Abstract: Manufacturing methods are disclosed to produce a seamless hologram using a free-from-lens enabling arbitrary adjustment of diffraction angle and also a thick hologram made of transparent inorganic materials and heat and IV resistant is disclosed.



GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,  
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,  
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,  
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,  
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,  
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,  
KM, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- *of inventorship (Rule 4.17(iv))*

**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))*
- *with information concerning one or more priority claims considered void (Rule 26bis.2(d))*

**(88) Date of publication of the international search report:**

31 October 2019 (31.10.2019)

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/14388

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G02B 27/09, G02B 27/10, G02B 27/30, G03B 21/14, G03B 21/62, G03H 1/02 (2019.01)  
 CPC - G02B 27/0955, G02B 27/10, G02B 27/30, G02B 3/02, G02B 5/32, G03B 21/142, G03B 21/62,  
 G03H 1/024, G02B 2003/0093, G03H 2001/0439, G03H 2260/12, G02B 27/0103,  
 G02B 2027/010

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)

See Search History Document

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

See Search History Document

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

See Search History Document

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category*     | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No. |
|---------------|---|-----------------------|
| X<br>---<br>A | US 2008/0186547 A1 (SHIMIZU et al.) 07 August 2008 (07.08.2008), title; Fig. 1, 6A, 7A; para [0003], [0016], [0043], [0044], [0054], [0063], [0067], [0069], [0107] | 1-3<br>-----<br>4     |
| A             | US 2016/0357094 A1 (ISHII) 08 December 2016 (08.12.2016), abstract; para [0007], [0078], [0099]; claim 8, 9   | 1-4                   |
| A             | US 2013/0083003 A1 (PEREZ et al.) 04 April 2013 (04.04.2013), para [0086], [0130]   | 1-4                   |
| A             | US 2012/0235885 A1 (MILLER et al.) 20 September 2012 (20.09.2012), para [0150], [0154], [0174]-[0176], [0240]   | 1-4                   |
| A             | US 5,547,786 A (BRANDSTETTER et al.) 29 November 2001 (29.11.2001), entire document   | 1-4                   |
| A             | US 2012/0008482 A1 (BABLUMYAN et al.) 12 January 2012 (12.01.2012), entire document   | 1-4                   |
| A             | US 2001/0046072 A1 (TAKADA) 29 November 2001 (29.11.2001), entire document  | 1-4                   |
| A             | US 2015/0277125 A1 (SONY CORPORATION) 01 October 2015 (01.10.2015), entire document   | 1-4                   |
| A             | US 2017/0163937 (MCNELLEY et al.) 08 June 2017 (08.06.2017), entire document  | 1-4                   |
| A             | US 2015/0260994 A1 (SONY CORPORATION) 17 September 2015 (17.09.2015), entire document   | 1-4                   |
| A             | US 5,850,300 A (KATHMAN et al.) 15 December 1998 (15.12.1998), entire document  | 1-4                   |

 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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

06 August 2019

Date of mailing of the international search report

03 SEP 2019

Name and mailing address of the ISA/US

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/14388

**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:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-4, drawn to a see-through display.

Group II: Claims 5, drawn to a manufacturing method.

Group III: Claims 6-9, drawn to a see-through display.

-- see extra 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 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.:  
1-4

- 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.

Continuation of Box No. III -- Observations where unity of invention is lacking

The inventions listed in the above-mentioned groups 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 includes the special technical feature of at least one of the coherent beams is focused on the photopolymer, not included in the other groups.

Group II includes the special technical feature of recording beams coincides with said tilt angle of the micro stripe in the hologram, not included in the other groups.

Group III includes the special technical feature of a periodical structure and diffract incident light whose incident angle and wavelength and a pitch of the periodical structure meet Bragg's law, not included in the other groups.

**Common Technical Features:**

The only technical features shared by Groups I-III that would otherwise unify the groups, are a lens, a combiner and a hologram and an image. However, these shared technical features do not represent a contribution over prior art, because the shared technical features are disclosed by US 2012/0235885 A1 to Miller et al. (hereinafter Miller).

The only technical features shared by Groups I and II that would otherwise unify the groups are beams and a free-form lens,

The only technical feature shared by Groups II and III that would otherwise unify the groups is a display device.

Miller discloses a free-form lens (para [0150]: two surface freeform waveguide), a combiner (para [0174]-[0176], a hologram (para [0176]), an image (para [0150]), beams (para [0171]: optical beams) and a display device (para [0150], [0173]).

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

Therefore, Groups I-III lack unity under PCT Rule 13.

Note: The claims include numerous instances where antecedent basis is lacking. For purposes of this determination the relevant antecedent basis is inferred as best understood by the claims presented.