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(12) **United States Patent**  
**Dror et al.**

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(54) **MINIATURE TELEPHOTO LENS ASSEMBLY**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.  
  
This patent is subject to a terminal disclaimer.

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US 2016/0291293 A1 Oct. 6, 2016

**Related U.S. Application Data**

(63) Continuation of application No. 14/932,319, filed on Nov. 4, 2015, now Pat. No. 9,402,032, which is a (Continued)

(51) **Int. Cl.**

- G02B 13/18** (2006.01)
- G02B 9/62** (2006.01)
- G02B 13/00** (2006.01)
- G02B 9/60** (2006.01)
- H04N 5/225** (2006.01)
- H04N 5/232** (2006.01)
- H04N 9/04** (2006.01)
- H04N 9/097** (2006.01)
- G02B 13/02** (2006.01)
- G02B 1/04** (2006.01)
- G02B 27/00** (2006.01)

(Continued)

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CPC ..... **G02B 13/0045** (2013.01); **G02B 1/041**

(2013.01); **G02B 9/60** (2013.01); **G02B 13/009** (2013.01); **G02B 13/02** (2013.01); **G02B 27/0025** (2013.01); **G02B 27/646** (2013.01); **H04N 5/2254** (2013.01); **H04N 5/2257** (2013.01); **H04N 5/2258** (2013.01); **H04N 5/23296** (2013.01); **H04N 9/045** (2013.01); **H04N 9/097** (2013.01); **G02B 5/005** (2013.01); **G02B 9/12** (2013.01); **G02B 9/62** (2013.01); **G02B 9/64** (2013.01); **G02B 13/00** (2013.01); **G02B 13/004** (2013.01); **G02B 13/18** (2013.01); **H04N 2101/00** (2013.01); **Y10T 29/4913** (2015.01)

(58) **Field of Classification Search**

CPC ..... **G02B 13/0045**; **G02B 9/62**; **G02B 9/60**; **G02B 13/18**; **G02B 13/004**; **G02B 9/64**; **G02B 5/005**; **G02B 13/00**; **G02B 9/12**  
USPC ..... **359/713**, **714**, **715-717**, **739**, **740**, **359/745-748**, **754-795**  
See application file for complete search history.

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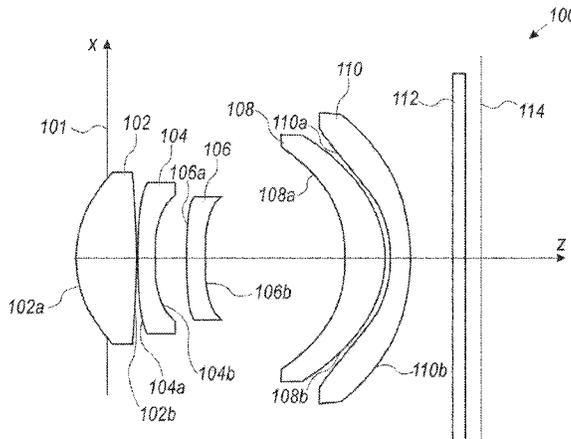
*Primary Examiner* — Evelyn A Lester

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Patent Agents Ltd.; Menachem Nathan

(57) **ABSTRACT**

An optical lens assembly includes five lens elements and provides a TTL/EFL<1.0. In an embodiment, the focal length of the first lens element  $f_1 < TTL/2$ , an air gap between first and second lens elements is smaller than half the second lens element thickness, an air gap between the third and fourth lens elements is greater than  $TTL/5$  and an air gap between the fourth and fifth lens elements is smaller than about 1.5 times the fifth lens element thickness. All lens elements may be aspheric.

**19 Claims, 6 Drawing Sheets**



**Related U.S. Application Data**

continuation of application No. 14/367,924, filed as application No. PCT/IB2014/062465 on Jun. 20, 2014, now abandoned.

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(51) **Int. Cl.**

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<i>G02B 5/00</i>	(2006.01)
<i>G02B 9/64</i>	(2006.01)
<i>G02B 9/12</i>	(2006.01)
<i>H04N 101/00</i>	(2006.01)

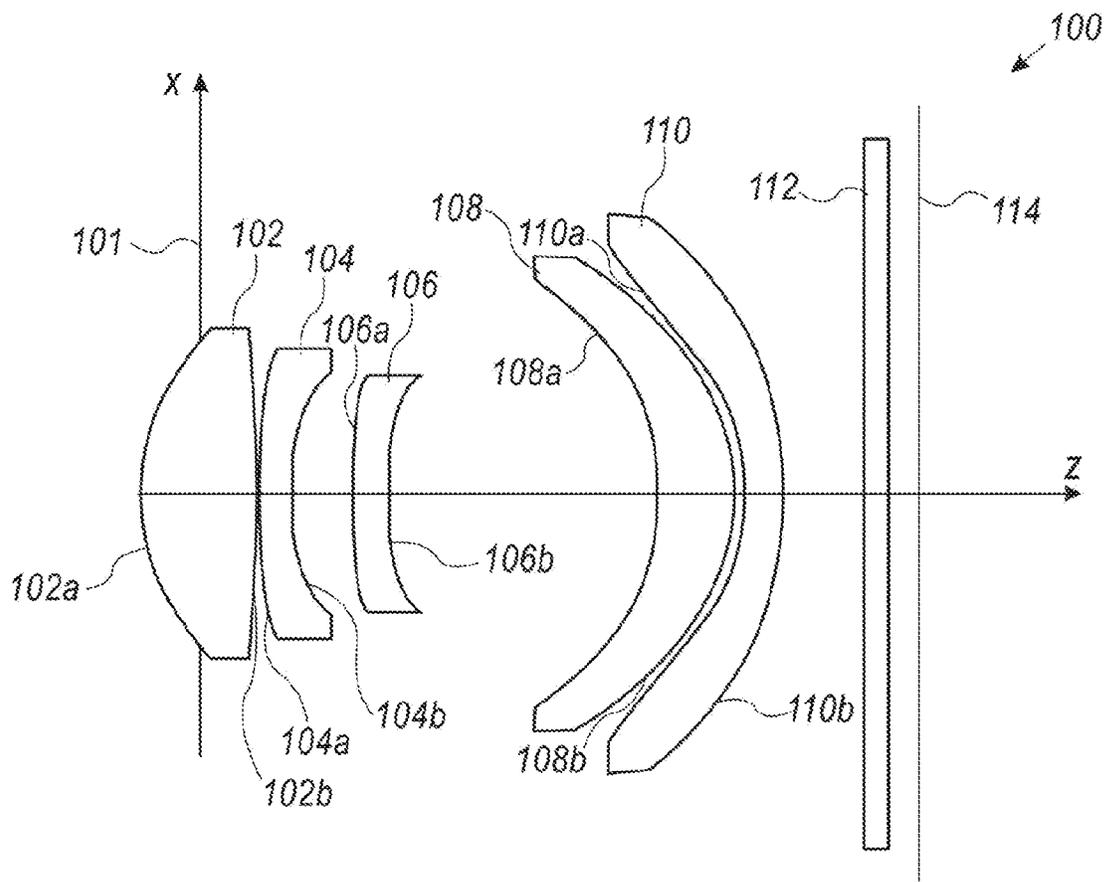
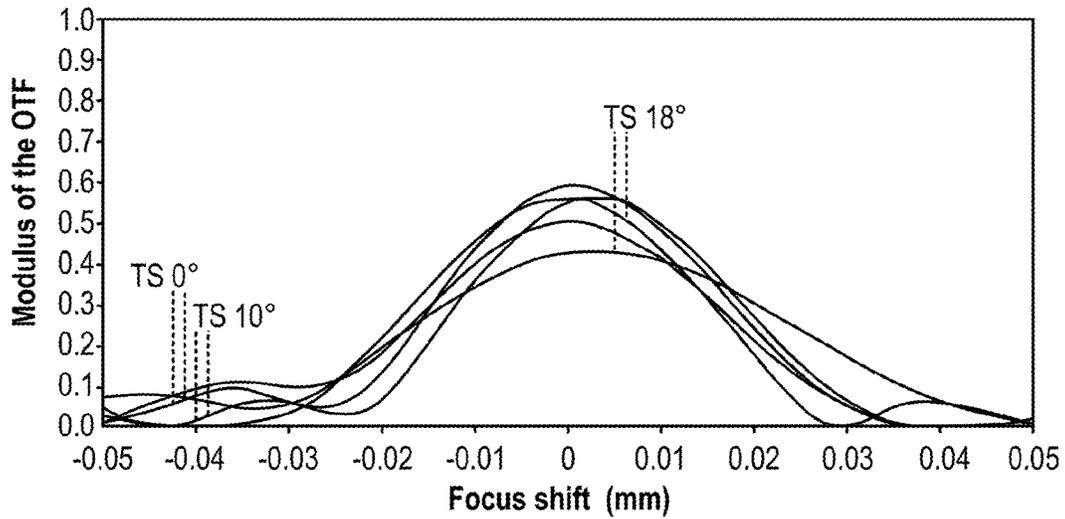


FIG. 1A



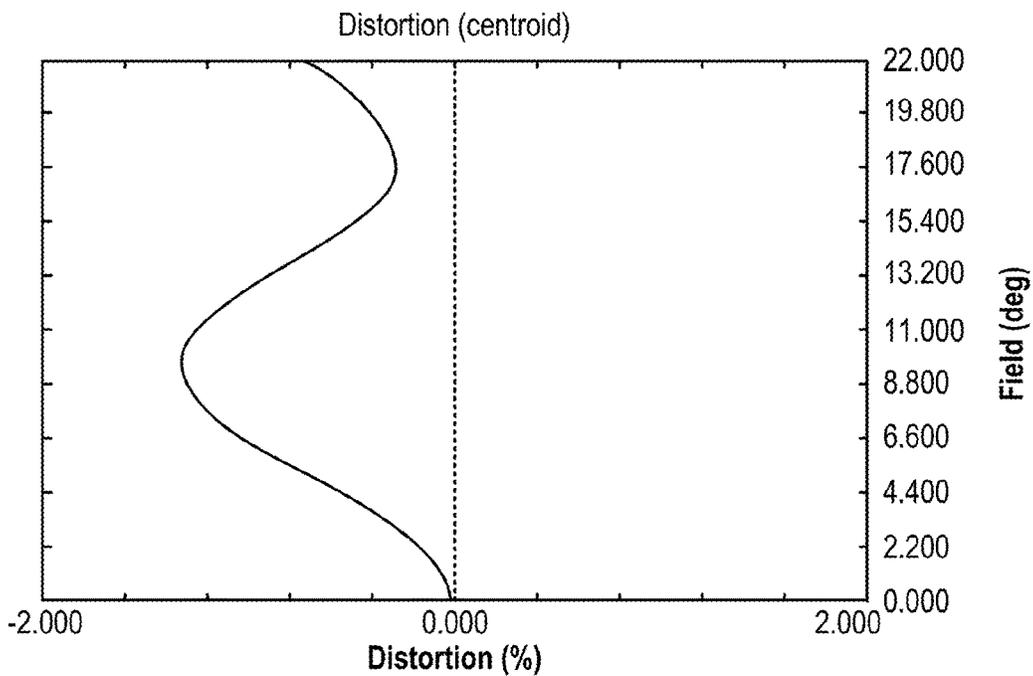
Polychromatic Diffraction Through Focus MTF

Angle 6/2/2013

Data for 0.4350 to 0.6560  $\mu\text{m}$ .

Spatial Frequency: 180.0000 cycles/mm.

FIG. 1B



30/06/2013

Maximum distortion = 1.3%

FIG. 1C

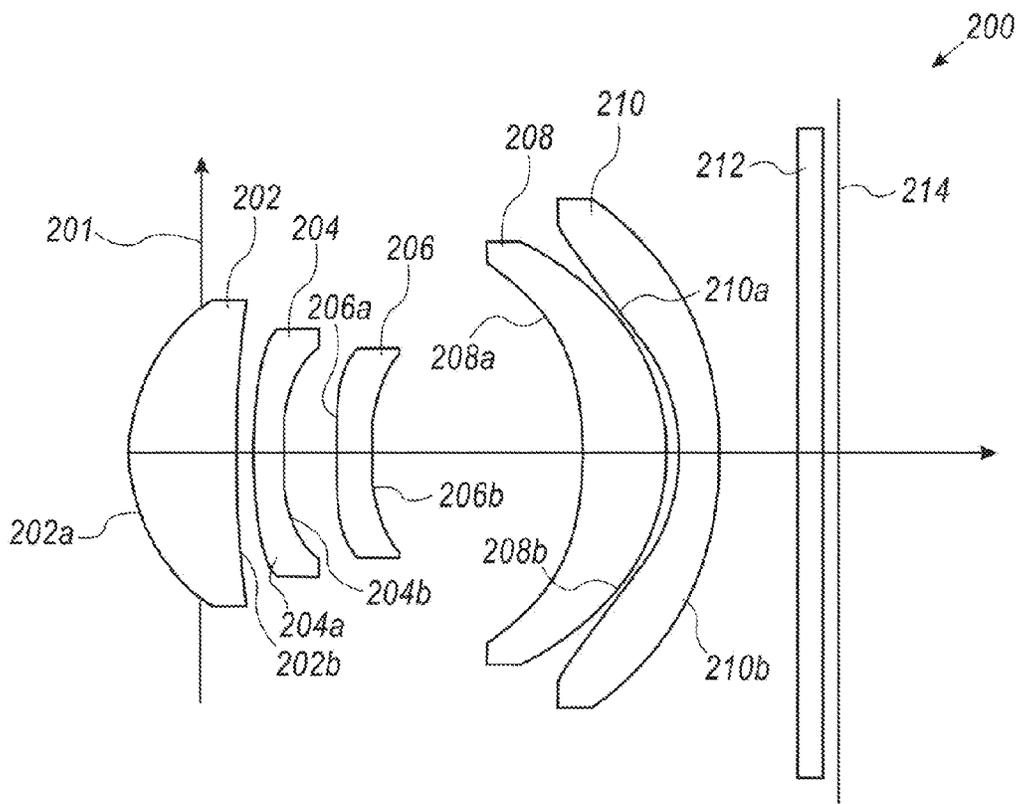


FIG. 2A

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