US009411135B2

(12) **United States Patent**
Jojiki

(10) **Patent No.: US 9,411,135 B2**
(45) **Date of Patent: Aug. 9, 2016**

(54) **IMAGING OPTICAL SYSTEM**

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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.

(21) Appl. No.: **14/830,141**

(22) Filed: **Aug. 19, 2015**

(65) **Prior Publication Data**

US 2016/0170179 A1 Jun. 16, 2016

(30) **Foreign Application Priority Data**

Dec. 11, 2014 (JP) 2014-250831

(51) **Int. Cl.**
G02B 9/60 (2006.01)
G02B 13/00 (2006.01)
G02B 27/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 13/0045*** (2013.01); ***G02B 9/60*** (2013.01); ***G02B 27/0075*** (2013.01)

(58) **Field of Classification Search**
CPC G02B 13/0045; G02B 13/18; G02B 9/60
USPC 359/713, 714, 740, 763, 770
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,976,525 A * 12/1990 Matsumura G02B 13/18 359/649
5,673,136 A * 9/1997 Inoue G02B 26/12 359/205.1
2004/0136085 A1* 7/2004 Huang G02B 15/00 359/676
2013/0100541 A1 4/2013 Huang et al.

FOREIGN PATENT DOCUMENTS

JP 2008-008960 A 1/2008
JP 2013-047753 A 3/2013
JP 2013-092774 A 5/2013

* cited by examiner

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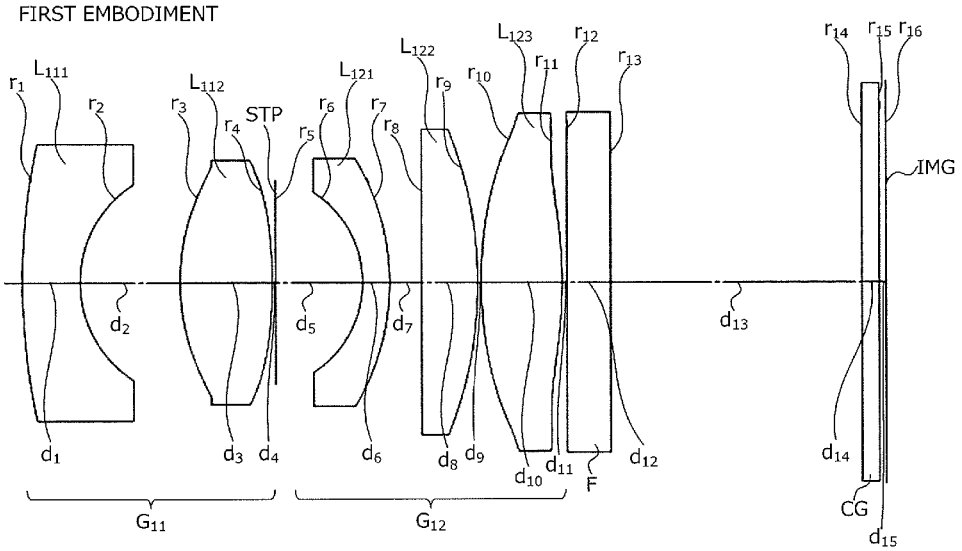
(57) **ABSTRACT**

An imaging optical system includes sequentially from an object side a front group configured to include a positive lens disposed at a position nearest a diaphragm; the diaphragm; and a rear group configured to include a negative lens disposed at a position nearest the diaphragm. The imaging optical system satisfies a conditional expression (1) $0.27 \leq |\theta 3/\theta 2| \leq 1.80$, where θ3 represents temperature-dependent variation of relative refractive index for d-line of the negative lens and θ2 represents temperature-dependent variation of relative refractive index for d-line of the positive lens.

4 Claims, 12 Drawing Sheets