



US008731390B2

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

(10) **Patent No.:** **US 8,731,390 B2**
(45) **Date of Patent:** **May 20, 2014**

(54) **ELECTROMAGNETIC ACTUATORS FOR DIGITAL CAMERAS**

(71) Applicant: **Corephotonics Ltd.**, Tel-Aviv (IL)

(72) Inventors: **Ephraim Goldenberg**, Ashdod (IL); **Gal Shabtay**, Tel-Aviv (IL); **Eliezer Mendlovic**, Tel Aviv (IL); **Eran Kali**, Jerusalem (IL)

(73) Assignee: **Corephotonics Ltd.**, Tel Aviv (IL)

(*) 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.: **13/983,304**

(22) PCT Filed: **Jan. 7, 2013**

(86) PCT No.: **PCT/IB2013/050130**

§ 371 (c)(1),
(2), (4) Date: **Aug. 2, 2013**

(87) PCT Pub. No.: **WO2013/105012**

PCT Pub. Date: **Jul. 18, 2013**

(65) **Prior Publication Data**

US 2014/0063331 A1 Mar. 6, 2014

Related U.S. Application Data

(60) Provisional application No. 61/585,795, filed on Jan. 12, 2012.

(51) **Int. Cl.**
G03B 3/10 (2006.01)

(52) **U.S. Cl.**
USPC **396/133; 335/219; 335/220; 359/824**

(58) **Field of Classification Search**

CPC G03B 3/10; G02B 7/09
USPC 396/133; 335/219, 220
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,291,958 A * 9/1981 Frank et al. 396/133
(Continued)

FOREIGN PATENT DOCUMENTS

JP S54 104826 8/1979
JP 2005 284212 10/2005

OTHER PUBLICATIONS

PCT/IB2013/050130 Search Report of the international search authority, Jun. 2013.

Primary Examiner — W B Perkey

(74) *Attorney, Agent, or Firm* — Nathan & Associates Patent Agents Ltd.; Menachem Nathan

(57) **ABSTRACT**

Electromagnetic actuators for digital cameras, in particular miniature cell-phone and tablet cameras, include an electro-magnet with a first elongated ferromagnetic member surrounded coaxially in part by a conductive coil along a first longitudinal axis, and a elongated second ferromagnetic member with a second longitudinal axis. The first and second ferromagnetic members have respective first and second operative surfaces and are aligned such that their longitudinal axes are parallel and such that respective operative surfaces overlap each other across a gap. The two members are mechanically coupled to respective frames. A frame hinge connects the frames and enables a relative tilt motion between the ferromagnetic members when current passes through the coil. The tilt motion is convertible into a linear displacement along an optical axis of an optical element coupled to the actuator. Two actuators can be combined into an assembly capable of providing double-axis tilt.

27 Claims, 12 Drawing Sheets

