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(54) Title: SHAPE MEMORY ALLOY ACTUATION APPARATUS

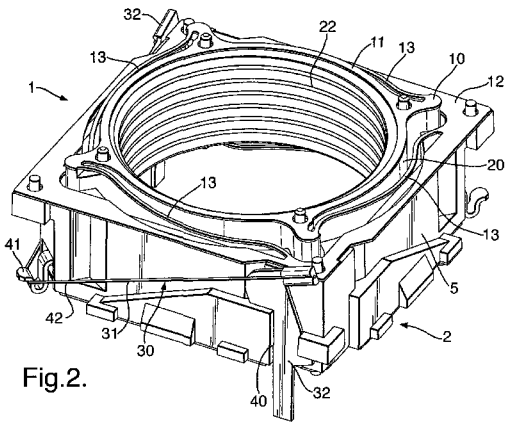

Fig.2.

(57) Abstract: A miniature camera lens actuation apparatus comprises a support structure, a camera lens element supported on the support structure by a suspension system; and an SMA actuator connected between the support structure and the movable element to drive movement of the camera lens element. The control circuit may include a drive circuit and a sensor circuit which have separate electrical connections to the SMA actuator to reduce the impact of the resistance of the electrical connections on the sensing. The control circuit may vary the drive signal in response to a temperature signal indicative of the ambient temperature. An endstop limits movement to prevent extension of the SMA actuator in its unheated state beyond a maximum length which is at or below the length corresponding the local maximum resistance of the resistance-length curve. Control of position is effected using resistance of the SMA actuator as a measure of position. The control employs a "ratcheting" method to prevent a failure condition and an initial calibration step to derive a range of target resistance values. In manufacture, the position of a lens holder is adjusted relative to a carrier to provide focussing on the image sensor of an image of an object at a distance in the range from infinity to the hyperfocal distance when the SMA actuator is heated to a predetermined temperature greater than ambient temperature.

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ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. F03G7/06 G03B3/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documenlation searched (classification system followed by classification symbols)
F03G G03B. A61B

Documentation searched other 1han minimum documenlation 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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 977 886 A (TAKEHANA SAKAE [JP] ET AL) 18 December 1990 (1990-12-18) columns 4-14; figure 19	1-10, 67-77
A	US 2006/109570 Al (OHTSUKA KATSUMI [OP] ET AL) 25 May 2006 (2006-05-25) page 1	1-10, 67-77
A	US 2002/001467 Al (TANAKA YOSHIHARU [JP] ET AL) 3 January 2002 (2002-01-03) paragraphs [0128] - [0130], [0155] - [0186]	1-10, 67-77
A	WO 2005/026539 A (NANOMUSCLE INC [US]; SZILAGYI ANDREI [US]; MACGREGOR RODERICK [US]; EV) 24 March 2005 (2005-03-24) paragraphs [0003], [0004], [0033]	1-10, 67-77

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[X] Further documents are listed in the continuation of Box C. [X] Sea 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 document but published on or afterthe 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 rot in conflict with the application but cited to understand the principle or iheory 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	Date of mailing of the international search report
9 May 2008	24/09/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rückeri , Ralph

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2008/000478

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 574 958 B1 (MACGREGOR RODERICK [US]) 10 June 2003 (2003-06-10) columns 1-4; figure 2 columns 15-16	1-10, 67-77

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2008/000478

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 allsearchable 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 reportcovers only those claims for which fees were paid, specifically claims Nos.

4. [X] 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.:

1-10, 67-77

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: 1-10,67-77

Calibration of a SMA camera lens actuator using maximum and minimum resistance values of the SMA as reference values.

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2. claims: 11-24,67-77

Detection of minimum resistance of a SMA actuator as reference position including immediate cooling after the detection.

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3. claims: 25-33

SMA actuator comprising an endstop at the maximum length side.

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4. claims: 34-49,67-77

SMA actuator using the resistance of the SMA as position feedback and using the minimum resistance value as start position.

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5. claims: 50-55,67-77

SMA actuator using the resistance of the SMA as position feedback and using the maximum resistance value as start position, wherein the direction of proportionality of current and resistance is monitored.

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6. claims: 56-66

Assembly of a camera including a SMA actuator for moving a camera lens, wherein the position of the camera lens is mechanically adjusted, while the SMA is held at a predetermined (reference) temperature.

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7. claims: 78-88

SMA actuator comprising electrical connections to drive the SMA and separate electrical connections to monitor resistance of the SMA for providing a feedback signal.

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8. claims: 89-91

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

SMA as camera lens actuator controlled by drive signals, wherein one of the signals is dependent on ambient temperature.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2008/000478

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4977886 A	18-12-1990	NONE	
US 2006109570 A1	25-05-2006	WO 2006054535 A1	26-05-2006
US 2002001467 A1	03-01-2002	NONE	
WO 2005026539 A	24-03-2005	EP 1676030 A2	05-07-2006
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