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| ✓ Description : paged 1 to paged 10 |    |
| ✓ Claim(s) : paged 1 to paged 12    |    |
| ✓ Drawing(s) : paged 7 to paged 7   |    |
| ✓ Abstract : paged 1 to paged 1     |    |
| DATE OF RECEIPT .....               |    |

# APPARATUS FOR DETECTING AN INITIAL POSITION OF A MOVABLE LENS IN A LENS BARREL OF A CAMERA

## BACKGROUND OF THE INVENTION

### 5 1. Field of the Invention

This invention relates to an apparatus for detecting an initial position of a movable lens in a lens barrel of an inner focusing type for use in optical systems such as cameras.

### 10 2. Description of the Background

Conventionally, there have been proposed cameras, e.g., a video camera, which utilize a zoom lens barrel of an inner focusing type. In the inner focusing zoom lens barrel, lenses such as a master lens for  
15 focusing, a variator lens for zooming and the like are movable along an optical axis of the lens barrel. In the lens barrel, a position of the master lens is relatively determined depending upon a position of the variator lens. Accordingly, it is essential to  
20 determine a reference position (origin) of the master lens for accurate positioning control. Namely, an initial position of the master lens must be determined as the reference position. For the purpose of fulfilling such requirement, there has been proposed an apparatus  
25 for detecting an initial position of the master lens, which includes a photo-interrupter used as a sensor means for detecting the initial position, as disclosed in Japanese Utility Model laid-open appln. No. 2-13216. FIGS. 12 to 14 are directed to the apparatus thus  
30 proposed. Referring to FIG. 12, an inner focusing lens barrel 1 has a cylindrical housing 2 which is provided, on front and rear portions thereof, with a focusing lens 3 and a charge coupled device (CCD) 7, respectively. Now, assuming the focusing lens 3 is the front of the  
35 lens barrel 1, mounted behind the focusing lens 3 are guide shafts 4a, 4a both of which extend axially.

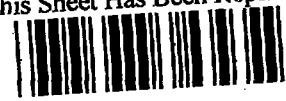




parallel to the optical axis of the lens barrel, and in front of the CCD 7 are disposed guide shafts 4b, 4b which also extend parallel to the optical axis. On the guide shafts 4a, 4a is supported a lens holder 6  
5 retaining a variator lens 5 for zooming. The lens holder 6 is reciprocally moved on the guide shafts 4a, 4a by manual operation along an optical axis C of the lens barrel 1. On the guide shafts 4b, 4b is supported a lens holder 9 retaining a master lens 8 for focusing.  
10 The lens holder 9 is reciprocally moved on the guide shafts 4b, 4b along the optical axis C by means of a motor M or the like.

The lens barrel housing 2 is also provided with an apparatus 50 for detecting an initial position  
15 of the master lens 8. As illustrated in FIG. 13, the apparatus 50 consists of an intercept plate 51 and a photo-interrupter 52 having a light-emitting element 53 and a photo-detecting element 54. The intercept plate 51 is secured to a lower portion of an outer periphery  
20 of the lens holder 9. The photo-interrupter 52 is secured at a rear portion of a lower inner-periphery of the housing 2 so as to face the plate 51 upon reciprocating movement of the lens holder 9. The  
25 elements 53 and 54 are disposed opposite each other in a direction perpendicular to the optical axis C. When the lens holder 9 moves reciprocally and the plate 51 fixed thereon moves to pass between the elements 53 and 54, the plate 51 intercepts light emitted from the element  
30 53. In response to the interception of the emitted light, the photo-detecting element 54 generates an output signal so that an initial position of the master lens 8 is determined on the basis of a position of the lens holder 9.

Recently, since high miniaturization of video  
35 cameras has been sought, it is necessary to effect highly accurate positioning of movable lenses in the



lens barrel. If lens positioning error exceeds approximately  $10\mu\text{m}$ , incorrect focusing or the like occurs. However, the photo-interrupter 52 of the aforementioned apparatus 50 has an output voltage  
5 characteristic varying in response to change in environmental temperature, as shown in FIG. 14. This characteristic causes deterioration of lens positioning accuracy. Moreover, the photo-interrupter 52 is not  
10 suitable for miniature cameras due to its large size and further, due to its high manufacturing cost.

In order to overcome such disadvantages in the conventional detection apparatus 50 using a photo-interrupter, there has been proposed an apparatus using a Hall element. Referring to FIGS. 9 to 11, an  
15 apparatus 40 for detecting an initial position of a master lens 8 includes a rectangular magnet 41 and a Hall element 42. The magnet 41 consists of north- and south-polar magnet halves 41a and 41b which extend outwardly from a lower outer-periphery of the lens  
20 holder 9 and are attached together such that their mating faces extend in a longitudinal direction of the lens holder 9. The Hall element 42 is secured to a lower inner-periphery of the barrel housing 2 so as to face the north-polar magnet half 41a upon rearward  
25 movement of the lens holder 9. The Hall element 42 detects magnetic flux generated from the magnet 41 and produces an output signal on the basis of an amount of the detected magnetic flux. On the basis of the produced output signal, an initial position of the lens  
30 holder 9, i.e., the master lens 8 mounting the magnet 41 is determined. The Hall element 42 has output voltage characteristic as shown in FIG. 10, in which vertical and longitudinal axes indicate the output voltage (V) and distance (D) between the magnet 41 and the Hall  
35 element 42, respectively. In FIG. 10,  $1/2 V_0$  indicating half an amount of a peak voltage  $V_0$  is detected by a

circuit (not shown) connected to the Hall element 42.

However, the output voltage characteristic of the Hall element 42 varies in response to change in environmental temperature, as shown in FIG. 11.

5 Accordingly, an initial position of the lens 8, which is detected upon generation of the initially determined voltage  $1/2 V_0$ , also varies from  $\ell_0$  to  $\ell_0'$  or  $\ell_0''$  according to temperature change so that accuracy in positioning of the lens 8 is deteriorated and thereby  
10 focusing error is caused in the camera.

#### SUMMARY OF THE INVENTION

It is an object of the present invention to eliminate the aforementioned disadvantages and to provide an improved apparatus for detecting an initial  
15 position of a movable lens in a lens barrel of a camera.

In order to accomplish this object, there is provided an apparatus for detecting an initial position of a movable lens in a lens barrel in which a lens holder retaining the lens is reciprocally movable  
20 parallel with an optical axis of the lens. The apparatus includes magnet means which has north and south polarities and is alternatively secured to either an outer periphery of the lens holder or an inner periphery of the lens barrel. Magnet flux detecting  
25 means is also secured to whichever of the outer periphery of the lens holder or the inner periphery of the lens barrel, to which the magnet means is not secured, such that the detecting means faces a boundary between the magnet halves of the magnet means. The  
30 detecting means detects magnetic flux density of the magnet means and develops an output voltage based on the detected magnetic flux density. The initial position of the lens is determined as a point where the output voltage indicates zero or a value of approximately zero.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

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FIG. 1 is a perspective view of an apparatus for detecting an initial position of a movable lens, according to one embodiment of the present invention;

FIG. 2 is an enlarged perspective view of a first magnet which may be used in the apparatus of FIG. 1;

FIG. 3 is a diagram showing output voltage characteristics of a Hall element used in the apparatus of FIG. 1;

FIG. 4 is a diagram showing the output voltage characteristics of the Hall element varied according to change in environmental temperature;

FIG. 5 is an enlarged perspective view of a second magnet which may be embodied in the apparatus of FIG. 1;

FIG. 6 is an enlarged perspective view of a third magnet which may be embodied in the apparatus of FIG. 1;

FIG. 7 is an enlarged perspective view of a fourth magnet which may be embodied in the apparatus of FIG. 1;

FIG. 8 is a schematic plan view of an apparatus for detecting an initial position of a movable lens, according to another embodiment of the present invention;

FIG. 9 is a perspective view of a conventional apparatus for detecting an initial position of a movable lens, in which a Hall element is used;

FIG. 10 is a diagram showing output voltage characteristics of the Hall element of FIG. 9;

FIG. 11 is a diagram showing output voltage characteristics of the Hall element of FIG. 9, as varied according to change in environmental temperature;

FIG. 12 is a sectional view of a conventional lens barrel;

FIG. 13 is a perspective view of a

conventional apparatus for detecting an initial position of a movable lens, in which a photo-interrupter is used; and

5 FIG. 14 is a diagram showing output voltage characteristics of the photo-interrupter, as varied according to change in environmental temperature.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of an apparatus for detecting an initial position of a movable lens in a  
10 lens barrel, according to the present invention will now be described with reference to the accompanying drawings. The explanations made hereinbefore with regard to FIGS. 12-14 in which the conventional lens barrel is described, are incorporated for reference into  
15 the detailed description of the preferred embodiment of the invention wherein the same reference numerals will represent like parts of the assembly of the invention.

Referring to FIG. 1, numeral 10 represents an apparatus for detecting an initial position of a movable  
20 lens 8 which is disposed in a housing 2 of a lens barrel 1. The lens 8 is a master lens retained in a cylindrical lens holder 9 which is supported by guide shafts 4b, 4b so as to be reciprocally movable parallel to an optical axis C of the lens 8. The apparatus 10  
25 includes a rectangular magnet 11 and a Hall element 12. The magnet 11 consists of north- and south-polar magnet halves 11a and 11b which extend outwardly from a lower outer-periphery of the lens holder 9 and are attached together so as to be aligned in a longitudinal direction  
30 of the lens holder 9. The Hall element 12 is secured to a lower inner-periphery of the housing 2 so as to face a boundary 11c between the north- and south-polar magnet halves 11a and 11b according to reciprocating movement of the lens holder 9. For instance, after the lens holder  
35 9 is forced to the frontmost or rearmost position by manually, spring force or motor-drive, the magnet 11 on



the lens holder 9 moves toward the Hall element 12. Then, the Hall element 12 detects magnetic flux generated from the magnet 11 and develops an output voltage on the basis of an amount of the detected magnetic flux.

The output voltage characteristics of the Hall element 12 are shown in FIG. 3, in which vertical and horizontal axes respectively indicate the output voltage (V) and distance (D) between the magnet 11 and the Hall element 12. There are two peaks in the output voltage, one positive, one negative, in the vicinity of a point  $\phi_0$  where an output voltage line traverses the horizontal axis. At an intersecting point  $\phi_0$ , the Hall element 12 is just opposed to a boundary 11c between the magnet halves 11a and 11b. Accordingly, in a case where a position of the magnet 11 corresponding to the intersecting point  $\phi_0$  of FIG. 3 is determined as an initial position of the magnet 11, various positions of the magnet 11 are determined relative to the initial position. Therefore, an initial position of the master lens 8 is determined as well as an initial position of the lens holder 9 mounting the magnet 11. Consequently, by using the initial position of the master lens 8 as a reference, various positions of the lens holder 9 may be determined with high accuracy.

Further, the Hall element may be connected to a circuit which functions to vertically offset the horizontal axis D where the output voltage indicates zero, for instance, as shown in a dotted line of FIG. 3. Due to this vertical offset of the horizontal axis D, a point  $\phi_0'$  may be employed as the initial position of the master lens 8 instead of the point  $\phi_0$ .

Referring to FIG. 4, the Hall element 12 has output voltage characteristics varying in response to change in environmental temperature. In FIG. 4, as similar to FIG. 3, vertical and horizontal axes



respectively indicate the output voltage (V) and distance (D) between the magnet 11 and the Hall element 12. Further, a position of the lens holder 9 corresponding to the intersecting point  $\ell_0$  is determined as an initial position of the master lens 8. As shown in FIG. 4, separate output voltage lines traverse the horizontal axis at substantially the same point  $\ell_0$ , while the peaks of the output voltage are different in level. Therefore, the initial position of the master lens 8 is stably determined without influence of change in environmental temperature.

Since the Hall element 12 has a smaller size and a lower manufacturing cost than a photo-interrupter as conventionally used, the apparatus 10 may be considerably improved in view of size, cost and consumption of electric power.

Further to say, the magnet 11 utilized in the apparatus of the invention may be of cylindrical shape 21 or trapezoidal shape 21' as illustrated in FIGS. 5 and 6. Further, as illustrated in FIG. 7, a rectangular magnet 21" may be formed by alternately arranging magnet pieces having north- and south polarities and attaching them together.

Another preferred embodiment of an apparatus for detecting an initial position of a movable lens in a lens barrel will be described hereinafter with reference to FIG. 8. Referring to FIGS. 8 and 12, the apparatus 30 includes a rectangular bar-like magnet member 31 and a Hall element 32. The bar-like magnet member 31 is secured to a lower outer-periphery of the lens holder 9 while the Hall element 32 is mounted on a lower inner-periphery of the housing 2. In the proximity of the rear end portion, the bar-like magnet member 31 has at least a pair of north- and south-polar end magnets 31a and 31b. When the end magnets 31a and 31b on the bar-like magnet member 31 passes over the Hall element



32 upon reciprocating movement of the lens holder 9, the Hall element 32 detects magnetic flux generated from the end magnets 31a and 31b and outputs a voltage depending upon change in the detected magnetic flux. At this  
5 time, a boundary 31c between the end magnets 31a and 31b is detected as a point where the output voltage from the Hall element 32 indicates zero or approximately zero. As similar to the first embodiment mentioned above, when the Hall element 32 detects the boundary 31c between the  
10 end magnets 31a and 31b, the corresponding position of the lens holder 9 is determined as an initial position of the lens 8. Moreover, the bar-like magnet member 31 extends forwardly into the front portion of the housing 2 where a lens holder 6 is reciprocally located. The  
15 bar-like magnet member 31 is also provided, at least in a part opposing to the lens holder 6 located in the front portion of the housing 2, with a plurality of north- and south-polar magnet pieces which are alternately arranged and attached together to form an  
20 integral body of the magnet member 31. In addition, a known MR (magnetoresistive elements) sensor 33 is secured to a front portion of the lower inner-periphery of the housing 2, in which the lens holder 6 retaining a variator lens 5, for example, is reciprocated. When the  
25 magnet member 31 moves toward the MR sensor 33 upon reciprocating movement of the lens holder 9, the MR sensor 33 detects output signals which are produced due to magnetic flux generated from the magnet pieces of the magnet member 31. Accordingly, a position of the  
30 variator lens 5 is also determined by detecting addresses or the like corresponding to respective positions of the magnet pieces by means of the MR sensor 33.

As is obvious from the aforementioned  
35 description of the preferred embodiments according to the invention, the apparatus of the invention includes a



magnetic flux detecting means and north- and south-polar magnets which are alternatively secured to a lens barrel or a lens holder such that the detecting means faces a boundary between north and south poles of the magnet means. In the apparatus, an initial position of a movable lens in a lens barrel is determined as a position of the lens where an amount of output voltage of the detecting means is approximately zero. As a result, the initial position is accurately determined without influence of change in temperature and/or change due to the lapse of time. In addition, the apparatus of the invention can be further miniaturized and manufacturing costs and power-consumption can be effectively reduced..

Although, in the apparatus according to the aforementioned embodiment of the present invention, a magnet means is secured to the lens holder movable within the lens barrel to which a magnetic flux detecting means is secured thereto, the opposite arrangement may alternatively be employed. Further, the detecting means of the invention is not limited to a Hall element. In addition, the apparatus of the invention may be applicable to a lens holder retaining a variator lens for zooming so that an initial position of the variator lens can be determined. The present invention has been described in terms of a video camera but it is noted that the disclosed invention may be further applied to a still camera or other electronic optical system.

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CLAIMS

1. An apparatus for detecting an initial position of a movable lens (8) in a lens barrel (1) in which a lens holder (9) retaining the lens (8) is reciprocally movable parallel with an optical axis (C) of the lens, characterized in that it comprises :

magnet means (11) having north and south polarities (11a,11b) and secured to an outer periphery of the lens holder (9); and

magnetic flux detecting means (12) secured to the inner periphery of the lens barrel (1) such that the detecting means (12) faces a boundary (11c) between the polarities (11a,11b) of said magnet means (11), said detecting means (12) detecting magnetic flux density of said magnet means (11) to output a voltage based on the detected magnetic flux density, said initial position of the lens (8) being determined as a point where said output voltage indicates zero or approximately zero.

2. The apparatus according to claim 1, wherein said magnet means (11) is secured to an inner periphery of the lens barrel (1), while said magnetic flux detecting means (12) is secured to the outer periphery of the lens holder (9).

3. The apparatus according to claim 1, wherein said lens (8) is a focusing lens for an electronic camera.

4. The apparatus according to claim 1, wherein said magnet means (11) is of rectangular shape.

5. The apparatus according to claim 1, wherein said magnet means (21) is of cylindrical shape.

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6. The apparatus according to claim 1, wherein said magnet means (21') is of trapezoidal shape.

05 7. The apparatus according to claim 1, wherein said magnet means (21") has at least two pairs of north and south polarities which are alternately arranged such that opposite polarities are adjacent to each other.

10 8. The apparatus according to claim 1, wherein said detecting means (12) is a Hall element.

15 9. The apparatus according to claim 3, wherein said magnet means (31) further has a plurality of north and south polarities which are alternately arranged and attached together to form an integral body of said magnet means, so that a position of a zoom lens is detected by a detecting means (33).

20 10. The apparatus according to claim 9, wherein said detecting means (33) is an MR (magnetoresistive elements) sensor.

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