

ELECTROMAGNETIC ACTUATOR

The present invention relates to electromagnetic actuators of the type having a flat armature positioned to move in a magnetic gap, and more particularly to such actuators wherein the armature comprises a conductive pattern formed on a sheet of insulating material.

Compact low-cost electromechanical actuators such as DC motors are employed in a wide variety of consumer products from toys to tape recorders and cameras. In many such applications, to take best advantage of available space in the apparatus, a thin, flat actuator is desirable since the thin, flat spaces are more readily available than bulky, cubic or prismatic volumes. To this end, it is known to employ an electromagnetic actuator having a thin, flat armature which resides for movement in a magnetic gap. DE-A-3003462 shows an electromagnetic actuator of the type having a flat permanent magnet, a plate of ferromagnetic material spaced from the magnet to form a magnetic gap, and a flat armature comprising a flat conductive coil carried by a sheet of insulating material, mounted in the magnetic gap for movement in response to a current applied to the coil.

In cameras having other automatic features such as automatic focus control, it is desirable to employ a similar actuator to control the movement of another camera element, such as a lens element. Although such actuators are relatively compact, the use of a plurality of actuators to control a number of functions in the camera has the drawback that the weight and size of the camera control mechanism increases in proportion to the number of actuators

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employed. It is desirable to control a number of functions with electromagnetic actuators while minimising the weight and size of the actuators employed.

In accordance with the present invention there is provided an electromagnetic actuator having a flat permanent magnet and a first plate of ferromagnetic material spaced from the magnet to form a first magnetic gap, a first flat armature, comprising a flat conductive coil carried by a sheet of insulating material, mounted in the first magnetic gap for movement in response to a current applied to its conductive coil, a second plate of ferromagnetic material substantially parallel to said first plate, and spaced from the opposite side of the magnet as said first plate to form a second magnetic gap, and a second flat armature, comprising a flat conductive coil carried by a sheet of insulating material, mounted for movement in said second magnetic gap in response to a current in its conductive coil.

In accordance with the present invention there is also provided a photographic camera comprising a shutter and a movable lens element coupled to an electromagnetic actuator as set out in the immediately preceding paragraph to control exposure and focus respectively.

The present invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is an exploded perspective view of an electromagnetic actuator according to the present invention utilised in focus and exposure control apparatus;

FIGS. 2 and 3 are plan views of the assembled electromagnetic actuator shown in FIG. 1, viewed from the shutter side, showing the shutter fully closed and fully open respectively;

5 FIG. 4 is a top view of the assembled electromagnetic actuator shown in FIG. 1; and

10 FIG. 5 is a schematic diagram showing a photographic camera of the instant folding type having an electromagnetic actuator according to the present invention.

There is shown in Fig. 1 an electromagnetic actuator comprising a housing formed by mild steel top and bottom ferromagnetic plates 12 and 14 respectively. Sandwiched between the top and bottom plates 12 and 14 are a pair of relatively thin, flat generally keystone shaped permanent magnets 16 and 18. Each magnet 16, 18 comprises two segments magnetised in a direction generally perpendicular to the plane of the magnet and in generally opposite directions to each other. The magnets 16 and 18 are spaced from the top and bottom plates 12 and 14 by thin spacers 20 of nonmagnetic material to form magnetic gaps on both sides of permanent magnets 16 and 18. A central support member 22 formed of nonmagnetic material such as a plastics material, is located between magnets 16 and 18. Both top and bottom plates 12 and 14 and support member 22 define central apertures 12a, 14a and 22a respectively. Located in the magnetic gap formed between bottom plate 14 and magnets 18 and 16, is a first armature generally designated 24, comprising a conductive coil 26 printed on a coil support sheet 28 of flexible insulating material. Armature 24 is supported by a rigid hub 30 comprising an annular portion 32 and a cylindrical portion 34 around a central

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aperture 36. Extending from the backside of annular portion 32, are five equally spaced lugs 38. The lugs 38 extend through five holes 40 in coil support sheet 28. Rigid hub 30 is adhesively bonded to coil support sheet 28. Cylindrical portion 34 of rigid hub 30 is received in aperture 22a of central support member 22 to support armature 24 for rotation about its central aperture. Lugs 38 extend through five slots 42 in bottom plate 14.

Five shutter blades 44 (only one of which is shown) are pivotally mounted on pins (not shown) carried on the backside of plate 14. The pins extend through holes 45 in shutter blades 44. Lugs 38 extend through holes 46 in shutter blades 44 to drive the shutter when armature 24 rotates in the magnetic gap.

A cover plate 48 having a central aperture 50 and peripheral apertures 52 and 54 for receiving lugs 38 and the mounting pins for the shutter blades 44 is spaced from bottom plate 14 by washers 56 to retain the shutter blades 44 in place.

The armature 24 is normally urged in a counterclockwise direction, as seen in FIG. 2, by a pair of cantilever springs 58 and 60 (see FIG. 1). The cantilever springs 58 and 60 are each hooked on one end and attached by their hooks to support member 22 about posts (not shown) extending from support member 22. The other ends of springs 58 and 60 are received in holes 62 and 64 in the cylindrical portion 34 of hub 30. When a current is applied by camera control circuitry to coil 26 of armature 24, the armature 24 is caused to rotate in the direction of arrows A in FIG. 3, thereby opening the shutter.

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Returning now to FIG. 1, a second armature 66 identical to armature 24 is located in the second magnetic gap formed by top plate 12 and magnets 18 and 16. The second armature 66 likewise comprises a
5 conductive coil 68 printed on a coil support sheet 70 of flexible insulating material and is supported by a rigid hub 72 having five lugs 74 extending therefrom. Similarly, slots 76 are provided in top plate 12 for the passage of lugs
10 74. Cantilever springs 78 and 80 mounted on posts 82 and 84 respectively of the support member 22 urge armature 66 in a clockwise direction as seen in FIG. 1. A cam ring 86 located on the outside of top plate 12 has five slots 88 for receiving the five
15 lugs 74 of armature 66 and three cam surfaces 90 equally spaced around the periphery of the cam ring 86. A movable lens holder 92 having three radial cam follower extensions 94 is received in cam ring 86 with cam follower extensions 94 resting on cam
20 surfaces 90. A stationary lens housing 96 covers cam ring 86 and lens holder 92 and defines slots 98 which cooperate with cam follower extensions 94 to restrict rotational movement of lens holder 92. A flat washer spring 100 is located in the lens housing 96 to urge
25 the lens holder 92 into contact with cam ring 86.

Normally, when no current is flowing in coil 68 of armature 66, cantilever springs 78 and 80 urge armature 66 in a clockwise direction, as seen in FIG. 1, and cam follower extensions 94 of lens ring 92 rest
30 on the lower portions of cam surfaces 90 of cam ring 86, placing lens 93 at its infinity focus position. When a current is applied to coil 68 of armature 66, the armature 66 rotates in a counterclockwise direction, as viewed in FIG. 1, thereby rotating cam ring 86 in a

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counterclockwise direction. Since lens holder 92 is constrained by lens housing 96 from rotating, the cam for lower extensions 94 ride up the cam surfaces 90 of cam ring 86, thereby moving lens 93 toward a near focus position and compressing spring 100. When current is removed from armature 66, cantilever springs 78 and 80 return the armature 66 to its initial position, thereby returning lens 93 to infinity focus.

Referring now to FIG. 5, the use of an electromagnetic actuator according to the present invention to control exposure and focus in a folding instant camera is illustrated. The camera generally designated 102 includes a camera body 104 defining an aperture for viewfinder optics 106 and having a folding cover door 108 hinged to the front of the camera body 104. A lens board 110 is carried by the distal end of cover door 108. The lens board 110 comprises the electromagnetic actuator for controlling exposure and focus as shown in FIG. 1. A bellows 111 connected between the camera body 104 and the cover door 108 forms a light tight housing for the optical path of the camera 102.

The camera 102 is powered by batteries 114 which supply power to a film drive motor 116 which drives pressure rollers 118 in a known manner. The batteries 114 also supply power to a camera control circuit including a microcomputer 120. A light sensitive circuit 122 measures scene light and supplies scene light information to microcomputer 120 in a known manner. A distance measuring circuit 124 measures the distance to the photographic object and supplies distance information to microcomputer 120.

When the camera user actuates a release button 126, the microcomputer 120 calculates the desired exposure and lens position based on the inputs from

light-sensitive circuit 122 and distance measuring circuit 124 according to a program stored in a memory in the microcomputer 120, and signals current drivers 128 and 130 connected to the respective armatures in the electromagnetic actuator to control the exposure and the focus of the camera via flexible control leads 132.

The use of the electromagnetic actuator eliminates the need for active mechanical coupling between the lens board 110 and the camera body 104, thereby facilitating the design of a compact folding camera.

The present invention has been described above with reference to an exposure and focus control mechanism in a photographic camera. It is emphasised, however, that it could also be employed to perform other functions in a camera, or in other apparatus requiring electromechanical actuators.



Claims

- 1 An electromagnetic actuator having a flat permanent magnet and a first plate of ferromagnetic material spaced from the magnet to form a first magnetic gap, a first flat armature, comprising a flat conductive coil carried by a sheet of insulating material, mounted in the first magnetic gap for movement in response to a current applied to its conductive coil, a second plate of ferromagnetic material substantially parallel to said first plate, and spaced from the opposite side of the magnet as said first plate to form a second magnetic gap, and a second flat armature, comprising a flat conductive coil carried by a sheet of insulating material, mounted for movement in said second magnetic gap in response to a current in its conductive coil.
- 2 An electromagnetic actuator according to claim 1 wherein said first and second armatures are mounted for pivotal movement about a common axis, each armature having an aperture centred on said common axis.
- 3 An electromagnetic actuator according to claim 1 or 2 further comprising means for urging said first and second armatures toward respective rest positions.
- 4 An electromagnetic actuator according to claim 1, 2 or 3 wherein said first armature is coupled to a shutter to control exposure and said second armature is coupled to a movable lens element to control focus in a photographic camera.



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- 5 An electromagnetic actuator according to claim 4 wherein said armatures are each supported by a respective hub member, said hub members having a plurality of lugs extending therefrom, said lugs of the hub member supporting said first armature being coupled to the blades of an iris-type shutter, and said lugs of the hub member supporting said second armature being coupled to a cam for driving said movable lens element.
- 10 6 An electromagnetic actuator according to claim 1 substantially as hereinbefore described with reference to, and as shown in, Figs 1 to 4 of the accompanying drawings.
- 15 7 A photographic camera comprising a shutter and a movable lens element coupled to an electromagnetic actuator according to any one of the preceding claims to control exposure and focus respectively.
- 20 8 A photographic camera according to claim 7 substantially as hereinbefore described with reference to, and as shown in, Fig 5 of the accompanying drawings.
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