

Description

This invention relates to a method of controlling an electromechanical actuator in a camera in accordance with the output of a digital computer, which actuator is of the type including an electromechanical transducer having a movable element providing a mechanical output which varies as a function of a variable electrical input, which method includes the steps of creating an electrical control signal including a series of current pulses having a frequency above the cut-off frequency in the frequency-response curve of the electromechanical transducer, varying the control signal in accordance with the desired mechanical output, the varying of the control signal including varying the duty cycle of the series of pulses in accordance with the output of the digital computer, and applying the control signal to the electromechanical transducer. It also relates to an electromechanical actuator readily controlled by such a method.

The latest direction in photographic camera control is toward the use of a small digital computer, called a microprocessor, to control all camera functions. The microprocessor accepts digital inputs from a variety of transducers in the camera, such as scene light measuring apparatus, camera mechanism position indicators, automatic range finders, and the switch or button that is actuated by the photographer to initiate an exposure. The microprocessor responds to these inputs to produce control signals for various parts of the camera, such as lens focus, aperture size, shutter operation, mirror movement, and film advance. The control signals, as produced by the microprocessor, are in a digital format; thus necessitating the step of digital-to-analog conversion when an analog output transducer is employed.

It is the object of the invention to provide a method of controlling an electromechanical actuator in a camera from the output of a digital computer with a minimum of complex digital-to-analog conversion apparatus.

This object is accomplished by biasing the movable element towards a rest position, by varying the duty cycle in accordance with the desired extent of displacement of the variable element, and by controlling the number of the pulses in the series to control the duration of the displacement.

With this method, conversion from digital electrical output to mechanical analog output is accomplished without the usual complex digital to analog conversion equipment. Essentially, the conversion is made by the actuator itself.

The US—A—4 104 656 depicts control means for a diaphragm of a single reflex camera, whereby the aperture of an electromagnetically operated diaphragm is set by a pot-shaped electromagnet. The coil of the electromagnet is supplied with current by an electronic circuit which responds to light falling on a photo-electric converter and transmits the current in a rapid series

of pulses to the coil of the magnet which operates the diaphragm.

Many known electromechanical actuators can be controlled by this method. Examples of one type of actuator particularly adapted to control by this method are shown in DE—A—30 03 462 and DE—A—29 42 636 in which the actuator is an electromagnetic aperture which also may function as a shutter. The actuator includes an armature having a substantially planar conductor coil, means for mounting the armature for rotational movement in the plane of the coil, means for producing a magnetic field generally perpendicular to the coil and resilient means for urging the armature toward an initial position. With such a structure, a series of current pulses can be applied to the coil above the cut-off frequency of the actuator and the duty cycle varied in accordance with the digital output of a computer. The armature will then rotate as a function of the average current to control aperture size in the camera.

In the above devices, resilient means and mounting means are separate structures thereby adding a certain amount of complexity to the system. Further, because electrical power is limited in cameras, it is important that friction associated with an electrically powered actuator be limited.

The US—A—3 572 906 shows a flexible hinge for controlling a diaphragm, whereby the two movable parts of the diaphragm, which form the aperture, are secured to flexed spring members.

It is the object of the invention to provide a camera having an actuator controllable by the above method and generally of the type just described, but which has a low friction mount and is less complex than such prior actuators.

This object is accomplished by a flexure hinge which accomplishes the functions of the mounting means and the resilient means in an actuator of the type described.

In the preferred embodiment of the invention, the flexure hinge is a λ -hinge having a virtual pivot about which the armature rotates.

The invention will be described with reference to the drawings, wherein:

FIG. 1 is a schematic diagram of an electromechanical actuator according to the present invention;

FIG. 2 is a schematic diagram similar to FIG. 1, showing the actuator in operation;

FIG. 3 is an exploded perspective view of another embodiment of the actuator according to the present invention;

FIG. 4 is a top view of the actuator shown in FIG. 3 with magnets removed to reveal the orientation of coils;

FIG. 5 is a top view similar to FIG. 4, showing the actuator in operation;

FIG. 6 is a partially schematic cross section, taken along line 6—6 in FIG. 4, of the actuator according to the presently preferred embodiment of the invention, illustrating the magnetic field in relation to the coils;

FIG. 7 is a partially schematic cross section, taken along line 7—7 in FIG. 5, similar to FIG. 6, showing the actuator in operation;

FIGS. 8a—c are graphs illustrating a series of current pulses created in carrying out the invention;

FIGS. 8x—z are graphs showing an actuator response to the pulses shown in FIGS. 8a—c, respectively;

FIG. 9 is a graph showing another pulse series used for driving an actuator in carrying out an embodiment of the invention; and

FIG. 10 is a schematic diagram of an electrical circuit for producing a control signal in carrying out the invention.

The invention deals with both a method of controlling an electromechanical actuator and an actuator particularly suited for control by the method. However, the method can be used to control other actuators and the actuator can be controlled by other methods. For convenience of description, the actuator will be described first and illustrated in FIGS. 1—7 as controlled only by the application of electrical current. The method according to the invention will be described with respect to FIGS. 8—10.

As shown schematically in FIG. 1, a planar actuator according to the present invention, includes an armature generally designated 20, having a planar coil 22 carried by a coil support member 24. The coil support member 24 is preferably formed from a sheet of insulating material. The coil can be formed on the coil support member 24 by photofabrication techniques. The coil support member 24 is mounted for movement about a flexure hinge 26. Flexure hinge 26 is a λ -hinge. In essence, a λ -hinge is a hinge having two resilient non-parallel legs. In this application, the legs converge, giving the hinge a virtual pivot point 28 at a point where the extension of the legs of the λ -hinge intersect. Flexure hinge 26 may be formed by an extension of the coil support member, if the coil support member is made of a suitably stiff material, or may be formed separately and attached to the armature. The flexure hinge provides a low friction mounting and a resilient restoring force to return the armature to an initial position after each operation. Thus, it performs the functions of both a resilient means and a mounting means while adding very little friction to the device.

Planar coil 22 has first and second legs 30 and 32 generally perpendicular to the direction of movement of the coil about pivot point 28. A first magnetic field B_1 , generally perpendicular to the plane of the coil 22 and indicated by the arrow heads as pointing out of the drawing in FIG. 1, lies in the vicinity of the first leg 30. A second magnetic field B_2 generally anti-parallel to the first magnetic field and indicated by arrow tails as pointing into the paper in FIG. 1, lies in the vicinity of the second leg, 32. Planar coil 22 is electrically connected to a control circuit 34, shown schematically as a battery 36 and a switch 38. When switch 38 is open, the actuator is inactive. Current for coil

22 supplied by battery 36 is carried along the legs of flexure hinge 26 either by flexible conductors formed on or bonded to the flexure hinge or, preferably, the flexure hinge itself is conductive and serves as the current conductor.

An aperture blade 40 carried on an end of the coil support member opposite from coil 22, forms a tapered aperture 42 for progressively uncovering a fixed aperture 44 in a camera mechanism plate 46. Preferably, the coil support member material is opaque and aperture blade 40 is integrally formed therefrom.

The operation of the actuator will now be described with reference to FIG. 2. When switch 38 is closed, current from battery 36 is caused to flow in planar coil 22. A current i_1 flows in the direction indicated in FIG. 2 in leg 30 of planar coil 22, and a current i_2 of equal magnitude flows in the opposite direction in leg 32 of coil 22, as shown in FIG. 2. As a result of the current i_1 flowing in magnetic field B_1 , a force F_1 is generated on the first leg 30 of planar coil 22 in a direction tending to pivot the actuator around virtual pivot point 28. A force F_2 , generally in the same direction as the force F_1 , is generated by current i_2 in magnetic field B_2 . The currents in other portions of the coil likewise generate forces on the coil, however the major components of these forces are perpendicular to the direction of movement of the coil and therefore are negligible for considering the performance of the actuator. The forces F_1 and F_2 act together to rotate armature 20 around virtual pivot point 28 in the direction of arrow A to displace the aperture blade 40 with respect to the fixed aperture 44 and therefore uncover the fixed aperture as shown in FIG. 2. By controlling the amount of current in coil 22, and hence the amount of movement of the aperture blade, the apparatus may be used to control aperture size in a camera, or it may be used as a shutter to control exposure time, or both.

When current ceases to flow in planar coil 22, flexure hinge 26 returns the actuator to its original position as shown in FIG. 1. For faster operation, the current may be momentarily reversed in coil 22 by providing suitable current switching means in control circuit 34 to provide an extra return force on the armature. The flexure hinge is a relatively low friction mounting thereby making the actuator even more efficient.

Preferably, the mass of the armature and the mass of the shutter blade are selected to be balanced about pivot point 28 so that the actuator is not subject to forces due to gravity or linear acceleration.

Another embodiment of the actuator according to the invention, employed in a combination aperture-shutter, is shown in exploded perspective in FIG. 3. The actuator includes two pivoting armatures, with two planar coils on each armature. The actuator is supported on a mechanism plate 100 which forms a fixed aperture 102. The mechanism plate, made from mild steel, is covered with a layer of electrically insulating porcelain enamel and carries stand-off posts 104. Four

conductive mounting pads 106, 108, 110 and 112, are formed on the surface of the enamel by the process of screening the pattern on the enamel using a paint containing a powdered metal, and firing the paint to sinter the powdered metal. Conductive mounting pads 106 and 112 are connected to electrical contacts, and pads 108 and 110 are electrically connected by a conductor strip 114. A first armature generally designated 116 includes an aperture blade 118 defining a tapered aperture 120 for progressively uncovering fixed aperture 102, and two coil support portions 122 and 124. Two spiral coils 126 and 128 are formed on the coil support portions 122 and 124 respectively. The armature is formed from thin polyethylene terephthalate film loaded with 1 micron size particles of carbon to render the film opaque. The armature is about 7 cm long and about 2.5 cm wide at its widest point. The spiral coils are formed on the surface of the armature by standard photofabrication techniques. A thin layer of conductive metal such as copper is deposited on the surface of the armature material, and the coil pattern is formed using photolithography in the relatively thin layer of metal. The pattern of thin metal is then built up to the desired thickness by further plating onto the thin metal pattern.

The armature is supported for pivotal movement about a flexure hinge 130 comprising a pair of leaf springs 132 and 134 formed from a beryllium sheet. The flexure hinge has a virtual pivot at the point where the projection of the leaf springs intersect. Leaf spring 132 has tabs 136 and 138 projecting at right angles from the spring on each end. Tab 138 is bent around the edge of the armature and is soldered to a mounting pad formed at the end of the coil on the armature. Detail A in FIG. 3 illustrates this method of attaching the leaf spring to the armature. Similarly, leaf spring 134 defines tabs 140 and 142 at each end, tab 142 being attached to the armature. Coil 128 starts where leaf spring 132 is connected to the armature and proceeds on the top surface of the armature, as viewed in FIG. 3, proceeding counterclockwise in an inward spiral and into a through-hole 144 in the center of the coil from whence it emerges to the other side of the armature to continue in a counterclockwise spiral out from the center as shown in dotted lines in FIG. 3. The conductor pattern proceeds across the underside of the armature to the other coil support portion 122 counterclockwise in an inward spiral around support portion 122 to a center through-hole 146 and back up to the top surface of the armature. The conductor then forms an outward spiral on the top surface of conductor support 122 ending at the mounting pad for flexure spring 134 where tab 142 makes electrical contact with the coil. As shown in FIG. 3, coil 126 has two legs 143 and 145 arranged generally radially of the virtual pivot point defined by flexure hinge 130, i.e. generally perpendicular to the direction of movement of the armature. Likewise, coil 128 has two legs 147 and 149 arranged generally radially of the virtual pivot defined by the flexure hinge 130. Tabs 136 and

140 on the other ends of the flexure leaf springs are soldered to mounting pads 112 and 110, respectively. A second armature, generally designated 116' is identical to the first armature 116 except that it has been turned over on its back. The parts of armature 116' are numbered similarly to the parts of armature 116 with primes (''). Tabs 136' and 140' of leaf springs 132' and 134', respectively, are soldered to mounting pads 108 and 106, respectively.

A permanent ceramic magnet 148, approximately 3 mm thick, produces the magnetic fields in the vicinity of coils 128 and 128'. The magnet 148 is magnetized in a direction perpendicular to its top and bottom surfaces (as viewed in FIG. 3). One-half of magnet 148 (designated 148a) is magnetized with the north magnetic pole on the top and the south magnetic pole on the bottom, and the other half (designated 148b) is magnetized with the south magnetic pole on the top and the north magnetic pole on the bottom. A second permanent ceramic magnet 150, similar to magnet 148, produces the magnetic fields in the vicinity of coils 126 and 126'. The magnets 148 and 150 are cemented to the underside of a holder 152 made from mild steel. Holder 152 defines an aperture 154 for mounting a taking lens 156. Magnet holder 152 has four tabs 158, for receiving stand-off posts 104 to suspend the magnets over the coils of the armatures and form a gap between the magnets and the mechanism plate 100 in which the armatures 116 and 116' reside.

FIG. 4 is a top view of the actuator with the magnet holder 152 and magnets 148 and 150 removed to reveal the positions of the armatures at rest, with aperture 102 covered by blades 118 and 118'. FIG. 6 is a cross section of the actuator taken along line 6-6 in FIG. 6 showing the lines of magnetic flux generated by magnet 148 in the vicinity of coils 128 and 128'. As shown in FIG. 6, leg 147 of coil 128 and leg 149' of coil 128' lie in a magnetic field B_2 directed upward from the mechanism plate 100 to magnet 148. Leg 149 of coil 128 and leg 147' of coil 128' lie in a magnetic field B_1 pointing down from the permanent magnet toward the mechanism plate 100. FIG. 6 shows how the mild steel mechanism plate 100 and the mild steel magnet holder 152 provide flux return paths for the magnetic field produced by magnet 148.

The operation of the actuator will now be described with reference first to FIG. 4. When the positive terminal of an electrical power supply is connected to the terminal adjacent mounting pad 112 and the negative terminal of the power supply is connected to the terminal adjacent mounting pad 106, current flows counterclockwise in coils 128 and 126, and clockwise in coils 128' and 126'. The forces generated on the coils due to the currents flowing in the magnetic fields produced by permanent magnets 148 and 150 (not shown in FIG. 4), cause armature 116 to pivot in a counterclockwise direction, and armature 116' to pivot in a clockwise direction thereby moving blades 118 and 118' to uncover aperture 102, as shown in

FIG. 5. FIG. 7 is a cross section through coils 128 and 128', taken along lines 7—7 in FIG. 5, showing the forces generated on the active legs of the coils when current flows as described above. The directions of current flow are indicated by arrow heads and tails, the head indicating current flowing into the page as viewed in FIG. 7, and the tails indicating current flowing out of the page.

Current flowing in a direction out of the page in leg 147' of coil 128' in the downwardly directed magnetic field B_1 generates a force F_1' directed to the left as viewed in FIG. 7. Current flowing in a direction into the page in leg 149' of coil 128' in the upwardly directed magnetic field B_2 generates a force F_2' likewise directed to the left. Similarly, the forces F_1 and F_2 generated in legs 147 and 149 of coil 128 are both directed to the right.

Since the forces on the armatures 116 and 116' of the actuator are proportional to the current flowing in the coils, the position of the actuator, and hence the extent to which fixed aperture 102 is uncovered by blades 118 and 118', can be controlled by controlling the current supplied to the actuator.

Thus far, the actuator has been shown to be actuated merely by application of current. The actual position reached by the actuator upon application of current can be controlled by many well known methods, for example, by varying the position of a stop, using a feedback system with a variable aperture over a photocell or carefully controlling the amount of current applied. Controlling the amount of current applied is a superior approach in many applications because mechanical structures necessary with other methods can be eliminated.

If the actuator is to be controlled in accordance with a digital computer conversion of the computer output from digital to analog would ordinarily be necessary. According to the invention, this conversion is accomplished with a minimum of additional structure by applying to the actuator a series of current pulses above the cutoff frequency of the actuator and varying the duty cycle of the series of pulses in accordance with the output of the digital computer.

Although this method is usable with actuators other than the ones described above, it has the additional advantage with such an actuator of reducing position error caused by static friction. The current pulses constitute a small dither signal, which, when applied to the actuator, breaks any static friction. Thus, in its preferred form, the frequency of the pulses in the control signal is chosen to be somewhat above the cutoff frequency in the frequency vs. response curve of the actuator, but not so far above the cutoff frequency that the system does not respond to the frequency, since the armature must vibrate enough to break the static friction.

The cutoff frequency is the point in the frequency vs. response curve of the actuator, where the response is down about 3 db from the DC response. Preferably, the frequency of the pulses is chosen to be at a point about 26 db down from

the DC response, or about four times the natural frequency of the actuator. The use of pulsed current to drive the actuator makes the actuator compatible with direct digital control and has the added advantage that inexpensive drive circuits may be employed. The average current to the actuator and hence the final position achieved by the actuator is controlled by varying the duty cycle of the series of pulses, for example, by varying either the duration of each pulse of a fixed frequency pulse train or by varying the repetition frequency of a pulse of fixed duration (as long as the pulse repetition frequency remains above the cutoff frequency of the actuator). The actuator is operated in a slightly underdamped condition so that there is a slight overshoot of, and then a settling into the final position. Slight underdamping allows a moderately fast opening time and relatively quick settling into the desired final position. The damping is determined partially by the back EMF in the coils in the magnetic field, and mostly by the dynamic friction of the actuator. The dynamic friction is controlled by raising or lowering the magnet holder over the armatures.

In the preferred embodiment of the invention, the pulse duration is modulated to control the aperture size, and the number of pulses applied to the actuator controls the shutter time. FIGS. 8a—c illustrate a series of pulse trains of the type used to control the actuator in the preferred embodiment of the invention. The pulse repetition frequency and pulse amplitude of each pulse train is the same, but the duty cycle increases progressively from FIG. 8a to FIG. 8c. FIGS. 8x—z depict the actuator response to the pulse trains illustrated in FIGS. 8a—c respectively, in terms of the percent of the fixed aperture that is uncovered versus time. The series of dotted lines in FIGS. 8x—z indicate the effects on total shutter open time of progressively longer pulse trains.

To reliably establish a zero position both before and after each actuation, a stream of leader and trailer pulses of both positive and negative polarity and fifty percent duty cycle are supplied to the actuator at the beginning and end of each actuation. FIG. 9 illustrates a full current profile showing the fifty percent duty cycle leader pulses, the aperture/shutter control pulses, and the fifty percent duty cycle trailer pulses. The leader and trailer pulses essentially "shake" the actuator to overcome static friction both before and after each actuation.

The method according to the invention can be carried out by a control system comprising a microprocessor that receives scene parameter inputs such as scene brightness and is programmed to produce the appropriate pulse train for driving the actuator in response to the scene parameter inputs.

FIG. 10 is a schematic of the control system for carrying out the preferred embodiment of the invention. The control system comprises a microprocessor 200, a reference oscillator or clock 202, a light controlled oscillator 204, an output driver

206, a power supply 208, and an actuator switch 210. The light controlled oscillator 204 includes a photosensitive element such as photodiode 212, a logarithmic feedback diode 214, an operational amplifier 216, and a voltage controlled oscillator 218. The photodiode, operational amplifier, and feedback diode in combination, are responsive to scene light to produce a voltage proportional to the log of the intensity of the scene light. The voltage is applied to the voltage controlled oscillator to produce a pulse train having a repetition frequency proportional to the log of the intensity of scene light.

In operation, when switch 210 is closed by the operator of the camera, power is supplied from power supply 208 to the rest of the control circuit. The reference oscillator 202 starts to produce clock pulses used to time the operations of the microprocessor, the microprocessor 200 is initialized, and the light controlled oscillator 204 starts producing the pulse train having a frequency proportional to the log of scene light. The microprocessor 200 is programmed to sample the output of the light controlled oscillator 204 for a predetermined time interval, counting the number of pulses received during the time interval. The final count is proportional to the log of the scene brightness. The microprocessor employs a table lookup using the pulse count as an address to retrieve the required pulse duration and total number of pulses to produce the proper aperture and shutter time for the given scene brightness. The microprocessor then constructs the pulse train from the information retrieved from the table, adds the leader and trailer pulses, and applies the pulse train to driver 206. Driver 206 buffers the pulse train from the microprocessor and applies the pulse train to the actuator. The control system is easily adapted for total program control, shutter preferred, or aperture preferred operation. If shutter or aperture preferred operation are employed, in addition to measuring the scene light, the microprocessor retrieves desired aperture or shutter settings from manually set inputs indicated in phantom by boxes 220 and 222 in FIG. 10. The microprocessor then uses the manually input aperture or shutter preference to compute or retrieve from a table lookup the proper actuator pulse control train. The microprocessor is easily programmed to override any manual input that would result in improper exposure.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the scope of the appending claims. For example, precisely the same method can be used to drive an auto focus actuator setting the position of a lens in response to a distance determination made in the microprocessor.

Claims

1. A method of controlling an electro-

mechanical actuator in a camera in accordance with the output of a digital computer, which actuator is of the type including an electromechanical transducer having a movable element (20) providing a mechanical output which varies as a function of a variable electrical input, which method includes the steps of creating an electrical control signal including a series of current pulses having a frequency above the cut-off frequency in the frequency-response curve of the electromechanical transducer, varying the control signal in accordance with the desired mechanical output, the varying of the control signal including varying the duty cycle of the series of pulses in accordance with the output of the digital computer, and applying the control signal to the electromechanical transducer, characterized by biasing the movable element (20) towards a rest position, by varying the duty cycle in accordance with the desired extent of displacement of the movable element (20) and by controlling the number of pulses in the series to control the duration of the displacement.

2. The method according to claim 1, wherein the duty cycle of the series of pulses is varied by varying the duration of the pulses of said series.

3. The method according to claim 1 or 2, wherein the step of creating a series of pulses is preceded by the step of creating a series of alternating polarity pulses of equal magnitude and applying said series of alternating polarity pulses to said actuator.

4. A camera having an electromechanical actuator controlled in accordance with the output of a digital computer (200), which actuator is of the type including an electromechanical transducer having a movable element (20) providing a mechanical output which varies as a function of a variable electrical input, the camera including means (202) for creating an electrical control signal including a series of current pulses having a frequency above the cut-off frequency in the frequency-response curve of the electromechanical transducer, means (200) for varying the control signal in accordance with the desired mechanical output and including varying the duty cycle of the series of pulses in accordance with the output of the digital computer, and means (206) for applying the control signal to the electromechanical transducer, characterized by resilient biasing means (26) biasing the movable element (29) towards a rest position, means (200) for varying the duty cycle in accordance with the desired extent of displacement of the variable element, and means (200) for controlling the duration of the series to control the duration of the displacement.

5. A camera according to claim 4, characterized in that said electromechanical transducer comprises an armature (20) having a substantially planar coil (22),

means (26) for mounting the armature (20) for rotational movement in the plane of said coil (22),

means (148, 150) for producing a magnetic field generally perpendicular to said coil (22), and

206, a power supply 208, and an actuator switch 210. The light controlled oscillator 204 includes a photosensitive element such as photodiode 212, a logarithmic feedback diode 214, an operational amplifier 216, and a voltage controlled oscillator 218. The photodiode, operational amplifier, and feedback diode in combination, are responsive to scene light to produce a voltage proportional to the log of the intensity of the scene light. The voltage is applied to the voltage controlled oscillator to produce a pulse train having a repetition frequency proportional to the log of the intensity of scene light.

In operation, when switch 210 is closed by the operator of the camera, power is supplied from power supply 208 to the rest of the control circuit. The reference oscillator 202 starts to produce clock pulses used to time the operations of the microprocessor, the microprocessor 200 is initialized, and the light controlled oscillator 204 starts producing the pulse train having a frequency proportional to the log of scene light. The microprocessor 200 is programmed to sample the output of the light controlled oscillator 204 for a predetermined time interval, counting the number of pulses received during the time interval. The final count is proportional to the log of the scene brightness. The microprocessor employs a table lookup using the pulse count as an address to retrieve the required pulse duration and total number of pulses to produce the proper aperture and shutter time for the given scene brightness. The microprocessor then constructs the pulse train from the information retrieved from the table, adds the leader and trailer pulses, and applies the pulse train to driver 206. Driver 206 buffers the pulse train from the microprocessor and applies the pulse train to the actuator. The control system is easily adapted for total program control, shutter preferred, or aperture preferred operation. If shutter or aperture preferred operation are employed, in addition to measuring the scene light, the microprocessor retrieves desired aperture or shutter settings from manually set inputs indicated in phantom by boxes 220 and 222 in FIG. 10. The microprocessor then uses the manually input aperture or shutter preference to compute or retrieve from a table lookup the proper actuator pulse control train. The microprocessor is easily programmed to override any manual input that would result in improper exposure.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the scope of the appending claims. For example, precisely the same method can be used to drive an auto focus actuator setting the position of a lens in response to a distance determination made in the microprocessor.

Claims

1. A method of controlling an electro-

mechanical actuator in a camera in accordance with the output of a digital computer, which actuator is of the type including an electromechanical transducer having a movable element (20) providing a mechanical output which varies as a function of a variable electrical input, which method includes the steps of creating an electrical control signal including a series of current pulses having a frequency above the cut-off frequency in the frequency-response curve of the electromechanical transducer, varying the control signal in accordance with the desired mechanical output, the varying of the control signal including varying the duty cycle of the series of pulses in accordance with the output of the digital computer, and applying the control signal to the electromechanical transducer, characterized by biasing the movable element (20) towards a rest position, by varying the duty cycle in accordance with the desired extent of displacement of the movable element (20) and by controlling the number of pulses in the series to control the duration of the displacement.

2. The method according to claim 1, wherein the duty cycle of the series of pulses is varied by varying the duration of the pulses of said series.

3. The method according to claim 1 or 2, wherein the step of creating a series of pulses is preceded by the step of creating a series of alternating polarity pulses of equal magnitude and applying said series of alternating polarity pulses to said actuator.

4. A camera having an electromechanical actuator controlled in accordance with the output of a digital computer (200), which actuator is of the type including an electromechanical transducer having a movable element (20) providing a mechanical output which varies as a function of a variable electrical input, the camera including means (202) for creating an electrical control signal including a series of current pulses having a frequency above the cut-off frequency in the frequency-response curve of the electromechanical transducer, means (200) for varying the control signal in accordance with the desired mechanical output and including varying the duty cycle of the series of pulses in accordance with the output of the digital computer, and means (206) for applying the control signal to the electromechanical transducer, characterized by resilient biasing means (26) biasing the movable element (29) towards a rest position, means (200) for varying the duty cycle in accordance with the desired extent of displacement of the variable element, and means (200) for controlling the duration of the series to control the duration of the displacement.

5. A camera according to claim 4, characterized in that said electromechanical transducer comprises an armature (20) having a substantially planar coil (22),

means (26) for mounting the armature (20) for rotational movement in the plane of said coil (22),

means (148, 150) for producing a magnetic field generally perpendicular to said coil (22), and



resilient means (26) for urging said armature toward an initial position.

6. A camera according to claim 5, characterized in that said resilient means and said mounting means comprise a flexure hinge (26).

7. A camera according to claim 6, wherein the flexure hinge is a hinge (26) forming a virtual pivot point (29) within the armature (20).

Patentansprüche

1. Verfahren zum Steuern einer elektromechanischen Bestätigungseinrichtung in einer Kamera entsprechend dem Ausgangssignal eines Digitalrechners, wobei die Bestätigungseinrichtung einen elektromechanischen Wandler mit einem bewegbaren Element (20) umfaßt, das eine mechanische Wirkung erzeugt, die sich nach Maßgabe eines variablen elektrischen Eingangssignals ändert, und wobei nacheinander ein elektrisches Steuersignal erzeugt wird, das eine Reihe von Stromimpulsen umfaßt, deren Frequenz über der Grenzfrequenz der Frequenz-Ansprechkurve des elektromechanischen Wandlers liegt, das Steuersignal gemäß der gewünschten mechanischen Wirkung variiert und dabei das Tastverhältnis der Impulsreihe nach Maßgabe des Ausgangssignals des Digitalrechners verändert wird und wobei das Steuersignal dem elektromechanischen Wandler übermittelt wird, dadurch gekennzeichnet, daß das bewegbare Element (20) in eine Ruhestellung vorgespannt, das Tastverhältnis entsprechend dem gewünschten Maß der Auslenkung des bewegbaren Elements (20) geändert und die Zahl der Impulse in der Impulsreihe zum Steuern der Auslenkzeit gesteuert wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß das Tastverhältnis der Impulsreihe durch Änderung der Dauer der Impulse der Reihe variiert wird.

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der Erzeugung einer Impulsreihe die Erzeugung einer Reihe von Impulsen wechselnder Polarität und gleicher Größe vorausgeht und daß diese Reihe von Impulsen wechselnder Polarität der Betätigungseinrichtung zugeführt wird.

4. Kamera mit einer entsprechend dem Ausgangssignal eines Digitalrechners (200) gesteuerten elektromechanischen Betätigungseinrichtung, die einen elektromechanischen Wandler mit einem bewegbaren Element (20) umfaßt, das eine mechanische Wirkung erzeugt, die sich nach Maßgabe eines variablen elektrischen Eingangssignals ändert, wobei die Kamera Mittel (202) zum Erzeugen eines elektrischen Steuersignals enthält, das eine Reihe von Stromimpulsen umfaßt, deren Frequenz über der Grenzfrequenz der Frequenz-Ansprechkurve des elektromechanischen Wandlers liegt, Mittel (200) zum Variieren des Steuersignals gemäß der gewünschten mechanischen Wirkung unter gleichzeitiger Veränderung des Tastverhältnisses der Impulsreihe gemäß dem Ausgangssignal des Digitalrechners, und Mittel (206) zum Anlegen des Steuersignals

an den elektromechanischen Wandler, gekennzeichnet durch federelastische Vorspannmittel (26), die das bewegbare Element (29) in eine Ruhestellung vorspannen, Mittel (200) zum Ändern des Tastverhältnisses entsprechend dem gewünschten Maß an Auslenkung des bewegbaren Elements und die Dauer der Impulsreihe steuernde Mittel (200) zum Steuern der Auslenkzeit.

5. Kamera nach Anspruch 4, dadurch gekennzeichnet, daß der elektromechanische Wandler einen Anker (20) mit einer im wesentlichen planen Spule (22),

Mittel (26), mit denen der Anker (20) in der Ebene der Spule (22) drehbar gelagert ist,

Mittel (148, 150) zur Erzeugung eines allgemein senkrecht zu der Spule (22) verlaufenden Magnetfeldes sowie

federelastische Mittel (26) aufweist, mit denen der Anker in eine Ausgangsstellung gedrückt wird.

6. Kamera nach Anspruch 5, dadurch gekennzeichnet, daß die federelastischen Mittel und die Lagermittel ein flexibles Gelenk (26) aufweisen.

7. Kamera nach Anspruch 6, worin das flexible Gelenk als Gelenk (26) ausgebildet ist, das innerhalb des Ankers (20) wie ein Drehpunkt (29) wirkt.

Revendications

1. Procédé pour commander un activateur électromécanique dans un appareil de prise de vues en fonction des données de sortie d'un ordinateur digital, cet activateur étant d'un type comprenant un transducteur électromécanique équipé d'un élément mobile (20) produisant un effet mécanique variant en fonction d'une donnée d'entrée électrique variable, ce procédé qui comprend les étapes pour créer un signal de commande électrique qui comprend un train d'impulsions de courant présentant une fréquence supérieure à la fréquence de coupure dans la courbe de réponse en fréquence du transducteur électromécanique, pour faire varier le signal de commande en fonction de l'effet mécanique désiré, la variation du signal de commande comprenant la variation de la configuration normale du train d'impulsions en fonction de la donnée de sortie de l'ordinateur digital, et pour envoyer le signal de commande au transducteur électromécanique, étant caractérisé par la sollicitation de l'élément mobile (20) en direction d'une position de repos, par la variation de la configuration normale en fonction de l'amplitude désirée du déplacement de l'élément mobile (20) et par la commande du nombre des impulsions du train pour commander la durée du déplacement.

2. Procédé conforme à la revendication 1, où la configuration normale du train d'impulsions varie par changement de la durée des impulsions de ce train.

3. Procédé conforme à la revendication 1 ou 2, où l'étape pour créer un train d'impulsions est précédée par une étape pour créer un train d'impulsions de polarité alternée et d'amplitude égale



et pour envoyer ce train d'impulsions de polarité alternée à cet activateur.

4. Appareil de prise de vues muni d'un activateur électromécanique qui est commandé en fonction de la donnée de sortie d'un ordinateur digital (200), et qui est d'un type comprenant un transducteur électromécanique équipé d'un élément mobile (20) produisant un effet mécanique variant en fonction d'une donnée d'entrée électrique variable, cet appareil qui comprend des moyens (202) pour créer un signal de commande électrique qui comprend un train d'impulsions de courant présentant une fréquence supérieure à la fréquence de coupure dans la courbe de réponse en fréquence du transducteur électromécanique, des moyens (200) pour faire varier le signal de commande en fonction de l'effet mécanique désiré et pour changer la configuration normale du train d'impulsions en fonction de la sortie de l'ordinateur digital, et des moyens (206) pour envoyer le signal de commande au transducteur électromécanique, étant caractérisé par des moyens de sollicitation élastique (26) sollicitant l'élément mobile (29) en direction d'une position

de repos, des moyens (200) pour faire varier la configuration normale en fonction de l'amplitude désirée du déplacement de l'élément variable, et des moyens (200) pour commander la durée du train pour commander la durée du déplacement.

5. Appareil conforme à la revendication 4, caractérisé en ce que le transducteur électromécanique comprend une armature (20) possédant une bobine plate (22),

des moyens (26) pour monter l'armature (20) de manière à ce qu'elle puisse basculer dans le plan de cette bobine (22),

des moyens (148, 150) pour créer un champ magnétique perpendiculaire à cette bobine (22), et

des moyens élastiques (26) pour entraîner cette armature en direction d'une position initiale.

6. Appareil conforme à la revendication 5, caractérisé en ce que ces moyens élastiques et ces moyens de montage comprennent une charnière flexible (26).

7. Appareil conforme à la revendication 6, où la charnière flexible est une charnière (26) formant un pivot virtuel (29) dans l'armature (20).



* C L M S *