

A SHUTTER MECHANISM

This invention relates to shutter mechanisms.

A program shutter in which sectors are opened and
5 closed by means of a stepping motor is arranged such
that, in response to the operation of a release button,
driving pulses, having a predetermined period, are input
to the stepping motor so as to cause it to rotate
forwardly thereby gradually opening the sectors. When
10 the motor has rotated through a given number of steps
corresponding to a particular exposure time, the phase
of the driving pulses is switched to reverse the
direction of rotation of the stepping motor so as to
close the sectors, thus terminating the exposure.

15 A program shutter of the type described above
suffers from the following problems. When the shutter
is in a stationary state, a sector opening and closing
member is biased to a reference position by means of a
spring, in order to prevent erroneous operation.
20 Accordingly, when opening the sectors, the bias of the
spring is applied to the stepping motor. In addition, a
change of aperture diameter with respect to the elapsed
time in the process of opening the sectors is non-
uniform due to the inertia of components or the
25 clearance therebetween. For this reason, the described

program shutter is incapable of effecting precise exposure control.

The present invention seeks to provide a shutter mechanism which is so designed that it is possible to
5 make uniform the change in the aperture diameter defined by the sectors when opening.

According to the present invention there is provided a shutter mechanism comprising: sectors defining a lens aperture during an exposure operation;
10 a reversible stepping motor for opening and closing said sectors; and a control section including arithmetic circuit means for calculating an exposure corresponding to brightness of a subject to be photographed, counting means for determining the number of steps through which
15 said stepping motor should be rotated in accordance with the calculated amount of exposure, pulse circuit means for outputting pulses having a pre-determined period for driving said sectors in correspondence with the number of steps determined by said counting means, a time
20 circuit for setting ON/OFF periods in said period of the

pulses output from said pulse circuit means on the basis of the data obtained from said arithmetic circuit means; and driving circuit means for selectively rotating said stepping motor forwards and backwards in response to the
5 pulses output from said pulse circuit means.

Preferably said arithmetic circuit means includes a brightness detecting circuit for detecting the brightness of an object to be photographed. Said arithmetic circuit means may include memory means
10 ~~[includes memory means]~~ for storing stepping motor driving data corresponding to a plurality of brightnesses, and a counter circuit for counting the output of the brightness detecting circuit and providing an output to the memory means.

15 The pulse circuit means, in one embodiment, includes a first pulse generating circuit for generating pulses for driving the stepping motor in one direction and a second pulse generating circuit for generating pulses for driving the stepping motor in the reverse
20 direction.

The pulse circuit means preferably is arranged to produce pulses with differing ON periods. Thus the first pulse generating circuit may be arranged to produce pulses with increasing ON periods. The second
25 pulse generating circuit may be arranged to produce

pulses with decreasing ON periods.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

Figure 1, consisting of Figures 1(a) and 1(b),
5 shows front and sectional views of one embodiment of a shutter mechanism according to the present invention;

Figure 2, consisting of Figures 2(a) and 2(b),
shows front and sectional views of a stepping motor of the shutter mechanism of Figure 1;

10 Figure 3 is a block diagram of a controller of a shutter mechanism according to the present invention;
and

Figure 4 is a timing chart illustrating the operation of the controller of Figure 3.

15 Figure 1 shows one embodiment of a program shutter or shutter mechanism to which the present invention may be applied. The shutter mechanism has a base plate 1 with a lens positioning plate 2 secured thereto. A sector chamber 3 is defined between the base plate 1 and
20 the lens positioning plate 2. Two sectors 4 are disposed in the sector chamber 3 for pivotable movement about respective pins 5, the sectors 4 pivoting symmetrically to determine a lens aperture. A sector driving lever 6 is supported on the base plate 1 for
25 pivotal movement about a shaft 7. The lever 6 is

engaged via a grooved portion 6a formed at one end thereof with a pin 9a of a sector driving wheel 9 which is pivotally mounted on the shaft 7. The lever 6 is also engaged with the sectors 4 through a sector pin 10 which is built in a side thereof which is closer to the base plate 1. The sector driving wheel 9 is pivotally supported by the shaft 7 in such a manner that it is, when in a stationary state, held at a reference position by means of stopper portions 9b formed on the outer periphery thereof and a spring 8 which biases the wheel 9 so as to turn counterclockwise. The sector driving wheel 9 is connected at a toothed portion 9c formed at one end thereof to a driving shaft 13a of a stepping motor 12 through a gear train.

A pin 11 is adapted to engage with either one or the other of the stopper portions 9b of the sector driving wheel 9 thereby to limit the range of angular rotation of the sector driving wheel 9.

Referring next to Figure 2, which shows one embodiment of the stepping motor 12, the stepping motor has a quadripole rotor 13 which is made of permanent magnets and which is rotatably mounted between upper and lower plates 14, 15 with one end of a rotor shaft 13a projecting from the lower plate 15, so that the sector driving wheel 9 of the shutter mechanism is driven

through a pinion 16 which is secured to the projecting end of the rotor shaft 13a. U-shaped stators 17,18 each made of magnetic material each have two leg portions. Each of the stators 17,18 has an exciting coil L_1 , L_2 wound on one leg portion thereof, and each stator has two magnetic pole portions 17a,17b, or 18a,18b provided at the distal ends of the legs in such a manner that the two magnetic pole portions are in 90° relation to each other with respect to the central axis of the rotor 13.

The stators 17,18 are positioned by means of guide pins 19 so that one magnetic pole portion 17b of the stator 17 and one magnetic pole portion 18b of the stator 18 are in 45° relation to each other with respect to the central axis of the rotor 13. Thus, the stepping motor 12 is arranged so that the rotor 13 can be rotated both forwards and backwards in 90° steps.

Figure 3 illustrates a controller of a shutter mechanism according to the present invention. The controller has a frequency divider 22 which frequency divides a signal from a reference pulse oscillator 21 having a crystal oscillator to generate a clock signal CK1 for digitising photometric data, stepping motor driving clock signals CK2,CK3 and an interpolation clock signal CK4. A brightness detecting circuit 23 makes comparison by means of a comparator 23d between a

charging voltage from a capacitor 23b which is charged with a constant current through a transistor 23a which is turned ON/OFF by a switch 24 actuated in response to the operation of a release button (not shown) and a
5 terminal voltage of a logarithmic compression diode 23c which is connected in series to a light-receiving element 25 such as a cds or the like. When the switch 24 is actuated, the brightness detecting circuit 23 opens a gate 23e to output the clock signal CK1 to a
10 counter circuit 26. Also when the output of the comparator 23d is inverted, the gate 23e is opened to output the clock signal CK1 to the counter circuit 26, and when the output of the comparator 23d is inverted, the gate 23e is closed to suspend the output of the
15 clock signal CK1, thereby outputting a digitised subject brightness.

The counter circuit 26 is cleared in response to the operation of the switch 24 and, at the same time, activated to count the subject brightness data output
20 from the brightness detecting circuit 23 and output the contents thereof. An exposure data memory circuit 27 stores stepping motor driving data corresponding to various subject brightnesses. The memory circuit 27 is arranged such that it is possible to access data
25 regarding the given number of steps through which the

stepping motor should be rotated and interpolation data for correcting an exposure error resulting from the given number of steps in accordance with the contents of the counter 26. The memory circuit 27 further stores
5 data used to determine ON/OFF periods in the driving pulse period for each step. This data is read out by a time circuit 37 when ON/OFF periods are set for drive circuits 36. A forward driving pulse generating circuit 28 generates, on the basis of the stepping motor driving
10 clock signal CK2, pulses $P_1 \dots P_n$ whereby the stepping motor can be driven forwards against the load of the position control spring 8 (Figure 1) of the shutter mechanism. The forward driving pulse generating circuit 28 is suspended to output the pulses in response to the
15 inversion of the output of a forward/reverse switching circuit 32.

A reverse driving pulse generating circuit 29 outputs pulses $Q_1 \dots Q_n$ for driving the stepping motor backwards on the basis of the stepping motor driving
20 clock signal CK3 from the time when the output of the forward/reverse switching circuit 32 is inverted.

A pulse switching circuit 30 consists of AND gates 30a, 30b and an OR gate 30c which connects together these AND gates. The AND gate 30a is supplied at one input
25 thereof with the pulses P from the pulse generating

circuit 28 and at the other input with a signal output from the forward/reverse switching circuit 32, and the AND gate 30b is supplied at one input thereof with the pulses Q from the pulse generating circuit 29 and at the other input with a signal obtained by inverting the signal from the forward/reverse switching circuit 32. When the stepping motor is rotated forwards, the pulse switching circuit 30 outputs the pulses P, whereas, when the motor is reversed, the pulse switching circuit 30 outputs the pulses Q.

A rotation mode switching counter 31 consists of a first presettable down counter 31a composed of flip-flops F_1 to F_3 cascade-connected to each other and a second presettable down counter 31b composed of cascade-connected flip-flops F_4 to F_6 . The first counter 31a is preset with a given number of steps delivered from the exposure data memory circuit 27 when the forward rotation of the pulse motor is started and when the motor is reversed. The counter 31a is decremented by one in response to each pulse P or Q, and when the counter reaches zero, the counter 31a outputs a signal from an output gate G_2 . On the other hand, the counter 31b is preset with interpolation data delivered from the exposure data memory circuit 27 when the forward rotation of the pulse motor is started. The counter 31b

is decremented by one in response to each pulse of the interpolation clock signal CK4 from the time when the count of the first counter 31a reaches zero, and when the count of the second counter 31b reaches zero it outputs a signal from an output gate G₄. It should be noted that data used to determine the width of each of the pulses P and Q is transferred from the exposure data memory circuit 27 to either the forward driving pulse generating circuit 28 or the reverse driving pulse generating circuit 29 in response to the output of the counter 31a or 31b immediately before the generation of the pulse.

The forward/reverse switching circuit 32 latches a signal output from the rotation mode switching counter circuit 31, activates the pulse switching circuit 30 to switch over the output pulses from the pulses P to the pulses Q and, at the same time, switches over the pulse movement direction determined in a stepping motor driving circuit 33. The stepping motor driving circuit 33 is a so-called ring counter in which a terminal from which a signal is output is shifted to another terminal which is adjacent to it every time a pulse signal is input thereto. The stepping motor driving circuit 33 is supplied with pulses from the pulse switching circuit 30 and activated in response to a signal output from the

forward/reverse switching circuit 32 to switch over the direction of movement of pulses so as to rotate the stepping motor forwards or backwards.

A second switch 34 resets both the rotation mode switching counter 31 and the forward/reverse switching circuit 32 in response to operation of the release button. A set signal generating circuit 35 sets the pulse generation circuits 28,29 in response to the operation of the switch 34. The drive circuits 36 respectively amplify signals output from the output terminals Q_1 to Q_4 of the stepping motor driving circuit 33 and feed the amplified signals to the exciting coils L_1, L_2 of the stepping motor 12. The time circuit 37 sets ON/OFF periods for each of the drive circuits 36 on the basis of the data concerning ON/OFF periods in the driving pulse period for each step which is stored in the memory circuit 27.

The operation of the controller of Figure 3 will now be described with reference to a timing chart shown in Figure 4.

A power supply switch (not shown) is turned ON, and the release button provided on a camera body is then pressed as far as a first position. In consequence, the first switch 24 is turned ON, and the subject brightness detecting circuit 23 is thus activated to output a

number of pulses of the clock signal CK1 corresponding to the brightness of the subject to be photographed, the brightness data thus obtained being stored in the counter 26. The exposure data memory circuit 27
5 outputs, on the basis of the brightness data delivered from the counter 26, information related to the number of steps of rotation of the stepping motor necessary to achieve the required exposure and an interpolation quantity for compensating for the rotation of the
10 stepping motor effected on the basis of the number of steps, to the first and second down counters 31a, 31b, respectively, in the rotation mode switching counter circuit 31 to preset these down counters, thereby setting exposure data corresponding to the detected
15 brightness of the subject to be photographed.

After the completion of the above-described setting, the release button is pressed as far as the second position. In consequence, the switch 34 is turned ON, and both the rotation mode switching counter
20 31 and the forward/reverse switching circuit 32 are thus reset and, at the same time, both the forward driving pulse generating circuit 28 and the reverse driving pulse generating circuit 29 are activated to generate pulses P and Q, respectively. The pulse switching
25 circuit 30 selects the pulses P and outputs them to the

first down counter 31a in the rotation mode switching counter 31 and to the stepping motor driving circuit 33. At the same time, the time circuit 37 sets data delivered from the memory circuit 27 on the basis of the
5 the subject brightness data output from the brightness detecting circuit 23 and also sets ON/OFF periods for the drive circuits 36. Every time one pulse P is input, energising time data for compensating for the effects of the load of the spring 8 (Figure 1), the inertia of the
10 shutter mechanism, backlash attributable to the fit clearance, etc. is output from the memory circuit 27 to the time circuit 37, and the stepping motor 12 is thus rotated one step forwardly, causing the sectors 4 to open with a relationship such as that shown by the solid
15 line in Figure 4(a). At the same time, the first down counter 31a is decremented by one.

More specifically, in the prior art the stepping motor is driven with pulses P whereby energisation is continued throughout one period as shown by the chain
20 line in Figure 4(b) and therefore hunting occurs due to the inertia of components of the shutter mechanism and the fit clearance therebetween as shown by the chain line in Figure 4(a), resulting in non-uniform change of the aperture diameter with respect to the elapsed time.
25 In the present invention, however, the memory circuit 27

designates ON/OFF periods set previously in conformity with the above-described factors as shown by the solid line in Figure 4(b). Accordingly, the sectors 4 are activated with a relationship such as that shown by the solid line in Figure 4(a).

In other words, pulses P_3 , P_5 , P_6 and P_8 are set with relatively long ON periods for the purpose of correcting the non-uniform aperture diameter shown by the chain line in Figure 4(a) into a uniform aperture diameter shown by the solid line, so that the sectors 4 are moved rapidly in the direction of arrow A. On the other hand, pulses P_2 , P_4 , P_7 and P_{10} are set with relatively short ON periods for the purpose of similarly correcting the non-uniform aperture diameter shown by the chain line in Figure 4(a) into a uniform aperture diameter shown by the solid line, so that the sectors 4 are moved gently in the direction of arrow B.

In this way, the operation proceeds, and when the pulse P_n , the number n of which is coincident with the number of pulses which has been preset in the first down counter 31a, is input, the interpolation clock signal CK4 is input to the second counter 31b and the gate G_3 with the stepping motor kept rotating towards the final step.

When the last pulse of the clock signal CK4,

determined by the number preset in the second counter 31b, is input, the forward/reverse switching circuit 32 is inverted so as to instruct the pulse switching circuit 30 to output pulses Q. At the same time, the forward/reverse switching circuit 32 switches the stepping motor driving circuit 33 to the reverse drive position. In consequence, the pulses Q from the pulse switching circuit 30 are input to the driving circuit 33, and the stepping motor is caused to rotate in the reverse direction, so that the sectors 4 are pivoted reversely in synchronism with the pulses Q by the cooperation of the stepping motor and the counterclockwise turning force stored in the position control spring 8. Thus, the sectors 4 are closed. In the case of the pulses Q also, ON periods are designated by the time circuit 37 so that operation characteristics are compensated for on the basis of the output from the memory circuit 27 in the same way as in the case of the forward rotation. When the count of the first counter 31a reaches zero again, the sectors 4 return to the previous positions to close the optical path.

Upon the completion of the above-described operation, the AND gate 30b is activated through the NAND gate G_4 in response to the output signal from the forward/reverse switching circuit 32 and the inverted

output signal from the OR gate G_2 , so that no reverse driving pulses are output from the OR gate 30c.

Accordingly, the motor 12 is suspended, and the release button returns to the previous position to open the switch 24, thus making ready for a subsequent operation of taking a picture.

Although in the foregoing description the ON periods are corrected such that the ON periods for the pulses P_3 , P_5 , P_6 and P_8 are increased while the ON periods for the pulses P_2 , P_4 , P_7 and P_{10} are reduced, the present invention is not necessarily limited thereto, and the direction in which correction is made, the extent to which a particular pulse is corrected, etc. may be decided on the basis of data set in the memory circuit 27 with experimental operation characteristics being taken into consideration.

Further, it is also possible to set constant ON/OFF periods for all the pulses, or increase or decrease the ON/OFF periods in conformity with the operation characteristics of each individual shutter mechanism.

Moreover, it is not always necessary to correct the pulses Q if the operation is established without making correction thereof.

As has been described above in relation to the

embodiment of the present invention, ON periods for predetermined pulses are corrected in conformity with the operation characteristics of the shutter mechanism, thereby making uniform the change of the aperture

5 diameter with respect to elapsed time in the process of opening the sectors and also permitting the sectors to operate smoothly. Accordingly, it is possible to effect high-precision exposure control with respect to the subject brightness. In addition, when a picture is
10 taken using flash, it is possible to synchronise the shutter with the flash bulb at an optimal aperture diameter corresponding to the subject distance. Thus, high-precision control can be effected.

Since the movement of the sectors is smooth, the
15 reliability in the exposure operation can be enhanced.

When the shutter is not in use, the supply of power to the drive circuit which has a relatively high rate of power consumption is cut off. Therefore, it is possible to suppress the consumption of battery power
20 and hence provide a small-sized camera which uses a small-sized battery.



CLAIMS

1. A shutter mechanism comprising: sectors defining a lens aperture during an exposure operation; a reversible
5 stepping motor for opening and closing said sectors; and
a control section including arithmetic circuit means for
calculating an exposure corresponding to brightness of a
subject to be photographed, counting means for
determining the number of steps through which said
10 stepping motor should be rotated in accordance with the
calculated amount of exposure, pulse circuit means for
outputting pulses having a predetermined period for
driving said sectors in correspondence with the number
of steps determined by said counting means, a time
15 circuit for setting ON/OFF periods in said period of the
pulses output from said pulse circuit means on the basis
of the data obtained from said arithmetic circuit means;
and driving circuit means for selectively rotating said
stepping motor forwards and backwards in response to the
20 pulses output from said pulse circuit means.

2. A shutter mechanism as claimed in claim 1 in which
said arithmetic circuit means includes a brightness
detecting circuit for detecting the brightness of an
object to be photographed.

25 3. A shutter mechanism as claimed in claim 2 in which



said arithmetic circuit means includes memory means for storing stepping motor driving data corresponding to a plurality of brightnesses, and a counter circuit for counting the output of the brightness detecting circuit
5 and providing an output to the memory means.

4. A shutter mechanism as claimed in any preceding claim in which the pulse circuit means includes a first pulse generating circuit for generating pulses for driving the stepping motor in one direction and a second
10 pulse generating circuit for generating pulses for driving the stepping motor in the reverse direction.

5. A shutter mechanism as claimed in any preceding claim in which the pulse circuit means is arranged to produce pulses with differing ON periods.

15 6. A shutter mechanism as claimed in claim 5 when dependent upon claim 4 in which the first pulse generating circuit is arranged to produce pulses with increasing ON periods.

7. A shutter mechanism as claimed in claim 5 when
20 dependent on claim 4 or claim 6 in which the second pulse generating circuit is arranged to produce pulses with decreasing ON periods.

8. A shutter mechanism substantially as herein described with reference to and as shown in the
25 accompanying drawings.
