

"PROGRAM SHUTTER"

The present invention relates to program shutters for use in cameras.

5 A program shutter comprising a shutter mechanism operable by a stepper motor driven by pulses from a pulse-generating circuit operates as follows. When a shutter-release button is depressed, pulses of a certain frequency are applied to the stepper motor to rotate it forward, gradually to open the sectors. When the motor has rotated through an angle corresponding to a predetermined light exposure value, the phase
10 of the pulses is reversed. The motor is then rotated backward to close the sectors, thus obtaining an appropriate exposure.

A shutter constructed as described above has some drawbacks. In particular, when the shutter is at rest, the members that open and close the sectors are held in their home
15 positions by spring means to prevent the occurrence of a malfunction. Therefore, when the sectors are being opened, the motor is loaded by the spring means. Also, during the opening of the sectors, the opening does not change uniformly with time because of either the inertia of movement of movable
20 components or fit tolerances of various components. This has made it impossible accurately to control the exposure.

In view of the foregoing problems, it is a main object of the present invention to provide a program shutter, the movement of whose sectors can be varied, while the shutter is being opened, to vary the rate of opening, ⁱⁿ particular, to achieve a substantially uniform variation of shutter opening with time.

According to the invention, therefore, a program shutter for use in a camera comprises a shutter mechanism operable by a stepper motor driven by pulses from a pulse-generating circuit, the pulse widths being individually variable to control the rate of variation of the shutter opening.

Preferably, the pulse width variation is such as to achieve a substantially uniform variation of shutter opening with time.

In one embodiment of the invention, a program shutter includes a shutter mechanism comprising sectors forming a lens aperture and a stepper motor that can rotate forward or backward to open or close the sectors, the pulse width of each pulse applied to the motor to drive it being determined according to the operating characteristic of the shutter mechanism, in order that the opening changes uniformly with time.

From another aspect, the invention includes a program shutter for use in a camera, comprising a shutter mechanism having sectors for forming a lens opening during an exposure operation and a stepper motor that is stepped forward or backward

to open or close the sectors; and a control portion having arithmetic means for calculating the exposure corresponding to the luminance of a subject, counter means for delivering the number of steps through which the motor should be
5 rotated according to the calculated exposure, pulse-generating means for producing pulses having individual pulse widths conforming to the operating characteristic of the shutter mechanism according to the number of steps delivered from the counter means, and driver means for rotating the motor
10 forward or backward according to the pulses from the pulse-generating means.

How the invention can be carried into effect is hereinafter particularly described with reference to the accompanying drawings, in which:-

15 Figure 1A is a front elevation of a shutter mechanism for use in a program shutter according to the invention,

Figure 1B is a cross-sectional view of the mechanism shown in Figure 1A;

20 Figure 2A is a front elevation of a stepper motor for use in the shutter mechanism shown in Figures 1A and 1B;

Figure 2B is a cross-sectional view of the motor shown in Figure 2A;

25 Figure 3 is a block diagram of an apparatus for controlling the shutter mechanism shown in Figures 1A and 1B; and

Figure 4 is a diagram illustrating the operation of the apparatus shown in Figure 3.

A shutter mechanism according to the present invention (Figures 1A and 1B) has a mount 1 on which a base plate 2 is mounted, the plate 2 acting to hold a lens in position. A sector chamber 3 is formed between the mount 1 and the base plate 2. Two sectors 4 for defining the aperture of the lens are pivotally mounted on pins 5, so as to be rotatable symmetrically within the chamber 3. A lever 6 is pivotally mounted on a shaft 7 that extends from the mount 1. A sector pin 10 on one end of the lever 6 engages with the sectors 4, so that pivotal movement of the lever rotates the sectors in opposite directions. The lever 6 is bifurcated at its other end to form a groove 6a. A wheel 9 is rotatably mounted about the shaft 7 and has a pin 9a which engages within the groove 6a of the lever 6. The periphery of the wheel 9 has a recess between two angular stop portions 9b, between which is located a pin 11 on the mount 1. The wheel 9 is biased counterclockwise by a spring 8 so that the pin 11 engages one angle-setting portion 9b in a home position. A portion of the periphery of the wheel 9 has teeth 9c which are connected via a gear train 16a with pinion 16 on a shaft 13a for driving by a stepper motor 12. The pin 11 limits clockwise rotation of the wheel 9 by engagement with the other angle-setting portion 9b.

The aforementioned stepper motor 12 (Figures 2A and 2B) includes a rotor 13 having four poles, the rotor being made of a permanent magnet. The shaft 13a is rotatably mounted in

an upper plate 14 and a lower plate 15 and one end of the shaft 13a of the rotor protrudes. The pinion 16 mounted on the shaft 13a drives the sector-driving wheel 9 of the shutter mechanism. Mounted between the upper and lower plates 14 and 15 on guide pins 19 are two U-shaped stators 17 and 18, each having two legs, and made of a magnetic material. An exciting coil L_1 is wound around one leg of the stator 17 and a coil L_2 around one leg of the stator 18 respectively. The legs of the stators 17 and 18 have poles 17a, 17b and 18a, 18b, respectively, at their front ends. The poles 17a and 17b are angularly displaced from each other by an angle α preferably 90° , about the rotor 13 and the poles 18a and 18b by the same angle. The stators 17 and 18 are held in position by guide pins 19 in such a way that an angle β preferably 45° , is formed between the poles 17b and 18b about the rotor 13. The rotor 13 can be rotated either forward or backward in steps of 90° , multiples of 90° and sub-multiples of 90° .

The operation of the shutter mechanism is controlled by apparatus (Figure 3) which has a clock pulse generator 21 equipped with a crystal oscillator. A frequency divider circuit 22 receives the clock pulses from the pulse generator 21 and produces clock pulses CK_1 , CK_2 , CK_3 , CK_4 , of frequencies which are integral submultiples of the input frequency. The clock pulses CK_1 are used to convert data obtained by photometry

value into digital form. The clock pulses CK_2 and CK_3 are employed to step the motor. The clock pulses CK_4 are used for interpolating purposes. A luminance detector circuit 23 comprises a transistor 23a, a capacitor 23b, a diode 23c, a comparator 24d and an AND gate 24e. The transistor 23a is turned on or off by a switch 24 that interlocks with the shutter-release button (not shown). The capacitor 23b is charged with a constant current from the transistor 23a. The comparator 24d compares the voltage developed across the capacitor 23b with the voltage produced across the diode 23c that is connected in series with a luminance detector 25 made from CdS or the like. The diode 23c is used for logarithmic compression. When the switch 24 is closed, the AND gate 24e is enabled to permit the clock pulses CK_1 to be supplied to a counter circuit 26. When the output signal from the comparator 24d is inverted the gate 24e is inhibited so that the clock pulses CK_1 may no longer be fed to the counter circuit 26. Thus, the luminance detector 23 is designed to digitize data regarding the luminance of the subject.

When the switch 24 is closed, the counter circuit 26 is cleared and, at the same time, begins to count the output signal from the luminance detector circuit 23. The total count of the counter circuit 26 is fed to a

memory 27 in which data corresponding to various values of luminance of the subject is stored to drive the stepper motor 12. Data on the number of steps through which the stepper motor is to be rotated and interpolation data used to correct the error of the exposure caused by this step number can be accessed, depending on the total count in the counter circuit 26. The memory 27 also stores data used to determine the pulse width of each pulse applied to the stepper motor. This kind of data is read out immediately before the stepper motor makes the next step movement, according to either the output from a first presettable down counter 31a or the output from a second presettable down counter 31b of a rotational direction-switching counter circuit 31.

A forward pulse generator circuit 28 receives the clock pulses CK_2 and produces pulses $P_1, \dots, P_n$ to rotate the stepper motor forward against the action of the spring 8 (Figure 1) of the shutter mechanism. A backward pulse generator circuit 29 receives the clock pulses CK_3 and produces pulses $Q_1, \dots, Q_n$ to rotate the stepper motor backward. The pulses P and Q are supplied, respectively, to the inputs of two AND gates 30a and 30b of a pulse selection circuit 30. The outputs of the AND gates 30a and 30b are supplied to an OR gate 30c.

A pulse switching circuit 32 receives the output of the counter circuit 31, latches it and controls the pulse selection circuit 30 accordingly by an output signal which

is applied directly to a second input to the AND gate 30a and via an inverter to a second input to the AND gate 30b. When the motor is to turn forward, the pulse selection circuit 30 delivers pulses P. When the motor is to rotate backward, the circuit 30 delivers pulses Q.

The first presettable down counter 31a of the rotational direction-switching counter circuit 31 comprises flip-flops F_1 to F_3 connected together in cascade, and the second down counter 31b comprises flip-flops F_4 to F_6 , also connected together in cascade. When the stepper motor is to be started forward or backward, the number of steps to be moved is loaded into the first counter 31a from the memory 27. Outputs from the flip-flops F_1 , F_2 and F_3 are taken to an OR gate G_2 whose output is taken to an AND gate G_1 which is thus enabled whenever a count exists in the circuit 31a, other than zero. The output of OR gate G_2 is also inverted and taken as one input to an AND gate G_3 and to an NAND gate G_5 . Then, the counter is decremented whenever one pulse P or Q is applied to it from the output of the circuit 30 through the AND gate G_7 until the total count reaches zero. Then, no output signal is produced from the OR gate G_2 , but an output signal is produced for the AND gate G_3 and NAND gate G_5 . When the motor commences rotating forwardly, data concerning the amount of interpolation is loaded into the second counter 31b from the memory 27. Outputs from the flip-flops F_4 , F_5 and F_6 are taken to an NOR gate G_4 whose output is taken to the pulse-

switching circuit 32. CK_4 pulses from circuit 22 are taken to the other input of the AND gate G_3 . After the total count of the counter 31a reaches zero, the AND gate G_3 is opened and the counter 31b is decremented by each interpolating clock pulse CK_4 until the total count in counter 31b reaches zero, after which an output signal is delivered from the NOR gate G_4 . The output from the circuit 32 is taken also to the other input of NAND gate G_5 . When the content of counter 31a is zero and there is an output from circuit 32, the output of NAND gate G_5 goes down and closes the AND gate 30b to stop the passage of pulses through circuit 30. At other times AND gate 30b is enabled and thus controlled by the inverted output of circuit 32. The data used to determine the pulse width of the pulses P_1 to P_n and Q_1 to Q_n is supplied to the pulse generator circuit 28 or 29 from the memory 27 in response to the contents of the counter 31a or 31b immediately before the generation of each pulse width.

When the desired number of pulses P and the desired number of pulses CK_4 have occurred, the pulse-switching circuit 32 latches the output signal from the counter circuit 31 and operates the pulse selection circuit 30 so that the output from it may be switched from the pulses P to the pulses Q. At the same time, the switching circuit 32 changes the direction in which pulses are moved in a motor driver circuit 33 consisting of a ring counter. Whenever one pulse is applied to the ring counter, the terminal at which an output signal appears shifts to the neighbouring terminal. The pulses from the switching circuit 30 are supplied to the driver circuit 33, which switches the direction

of movement of pulses according to the output signal from the switching circuit 32 to rotate the stepper motor forward or backward.

5 When the release button is depressed, a second switch 34 is closed to reset the flip-flops of the counters of the rotational direction-switching circuit 31 and the pulse-switching circuit 32. Also, when the switch 34 is closed, a start signal generator circuit 35 produces an output signal for setting the pulse generator circuits 28 and 29 into
10 operation. Signals appearing at the output terminals R_1 to R_4 of the motor driver circuit 33 are amplified by driver circuits 36, respectively, before application to the exciting coils L_1 and L_2 of the stepper motor.

15 The operation of the apparatus constructed as described above is next described by referring to the timing diagram of Figure 4. First, the power switch (not shown) is turned on. Then, the release button on the body of the camera is depressed to a first position to close the first switch
20 24. This operates the luminance detector circuit 23 to pass a number of clock pulses CK_1 , which corresponds to the luminance of the subject. Thus, data about the luminance is loaded into the counter 26. The number of steps determined so as to accommodate the exposure according to the luminance

data from the counter 26 and the amount of interpolation for correcting such a step movement are derived from storage in the memory 27 and placed into the first down counter 31a and the second down counter 31b, respectively, of the circuit 31. In this way, the data regarding the exposure corresponding to the luminance of the subject is loaded into the down counters.

Subsequently, the release button is depressed to a second position to close the switch 34, resetting the counters of the circuit 31 and the pulse-switching circuit 32. Concurrently, the pulse generator circuits 28 and 29 are operated by the start signal from circuit 35 to produce pulses P and Q. The pulse selection circuit 30 selects the pulses P as the signal supplied to the first counter 31a of the switching counter 31 and also to the motor driver circuit 33, because the output from circuit 32 is such as to enable AND gate 30a and disable AND gate 30b. The stepper motor 12 rotates one step forward against the action of the spring 8 (Figure 1) whenever a pulse P is applied to it, in order to open the sectors 4. At this time, data about pulse width for compensating for the inertia of the shutter mechanism and for correcting the play attributed to fit tolerances is transmitted from the memory 27 to the pulse generator circuit 28. During this process, the first down

counter 31a is decremented with each input pulse.

As the sectors 4 are moved, an opening is revealed therebetween to define an aperture for the camera lens.

It is desirable to achieve an opening which varies

5 substantially uniformly with time, as shown in solid lines in the upper part of Figure 4. The operating characteristics of the shutter mechanism due to inertia and fit tolerances may be such as to produce non-uniform variation of opening with time, as illustrated in broken lines in the upper part
10 of Figure 4, when, as in conventional apparatus, the stepper motor is driven by pulses P of constant frequency as indicated by the broken lines in the middle part of Figure 4. According to an example of the present invention, the pulse width of each pulse P is set as indicated by the solid lines in
15 the lower part of Figure 4, according to the operating characteristic of the shutter mechanism, in order to achieve a substantially uniform variation of opening with time.

Data about the pulses is stored in the memory 27.

More specifically, in the example given, the pulse P_5
20 is shortened so that the pulse P_6 is delivered earlier in order that the opening may change uniformly with time as indicated by the solid line, instead of non-uniformly as indicated by the broken line in the upper part of Figure 4. The earlier

generation of the pulse P_6 moves the sectors 4 quickly so that the opening variation is changed in the direction indicated by the arrow A. Conversely, the pulse P_7 is lengthened to drive the sectors 4 slowly so that the opening variation is changed in the direction indicated by the arrow B. It will be appreciated that the pulse widths of the driving pulses may be varied in ways other than that of the example given in order to achieve a substantially uniform rate of change of the opening.

If the count of pulses loaded in the first counter 31a by memory 27 is n , then when the predetermined n -th pulse P_n is applied to the first down counter 31a, the AND gate G_3 is opened to permit interpolating clock pulses CK_4 to be supplied to the second counter 31b while the stepper motor is on its way to the final angular position. When the number of the applied clock pulses CK_4 reaches the number loaded in the second counter 31b, the switching circuit 32 is switched to the other state. Under this condition, the switching circuit 32 causes the pulse selection circuit 30 to deliver the pulse Q. At the same time, the direction of movement of pulses in the motor driver circuit 33 is switched to the other direction for reverse rotation. Then, the

pulse Q from the switching circuit 30 is applied to the driver circuit 33 to reverse the motor. The motor rotates the sectors in a stepwise fashion in the reverse direction in synchronism with the pulses Q with the aid of the resilient force stored on the spring 8. As a result, the sectors 4 are closed. The pulse width of each pulse Q is set according to the operating characteristic in response to the output signal from the counter 31b in the same manner as in the case of forward rotation. When the total count of the first counter 31a becomes again zero, the sectors 4 are returned to their original positions blocking the optical path.

Thereafter, the output signal from the switching circuit 32 and the inverted output signal from an OR gate G_2 are supplied to a NAND gate G_5 to disable the AND gate 30b. This prevents the OR gate 30c from delivering the pulses for stepping the motor backward. In this state, the motor 12 does not operate. The release button is returned to its original position. Then, the switch 24 is opened. Thus, preparations for the next photograph are made.

In the above example, the pulse widths of some pulses are altered in such a way that one pulse is produced earlier to move the sectors in the direction indicated by the arrow A

and that another pulse is produced later to shift the sectors in the direction indicated by the arrow B. The direction of correction, the pulses to be modified, and other factors which are stored in the memory 27 are experimentally determined, taking the operating characteristic of the shutter mechanism into account. Whilst similar pulse width modifications may be made to the pulses Q, it may not be necessary to make any compensation for the pulses Q, if the apparatus operates stably.

As described thus far, in the present embodiment of the invention, the pulse widths of some pulses are varied to compensate for the operating characteristic of the shutter mechanism, so that the opening of the sectors changes uniformly with time. Thus, the sectors operate smoothly.

This permits accurate control over the exposure corresponding to the luminance of the subject. Further, when a photograph is taken by flash photography, the shutter is released in synchronism with the flash at an appropriate opening corresponding to the distance, and accurate control is allowed. Furthermore, the reliability with which exposure operation is performed can be enhanced, because the sectors move smoothly.



C L A I M S

1. A program shutter for use in a camera, comprising
a shutter mechanism operable by a stepper motor driven by
pulses from a pulse-generating circuit, the pulse widths
being individually variable to control the rate of variation
5 of the shutter opening.
2. A program shutter as claimed in claim 1, in which the
pulse width variation is such as to achieve a substantially
uniform variation of shutter opening with time.
3. A program shutter as claimed in claim 1 or 2, in
10 which the number of pulses to be applied to the stepper motor
is determined according to a luminance detector.
4. A program shutter as claimed in claim 1, 2 or 3,
in which the pulse width variation is determined in accordance
with the number of pulses to be applied to the stepper motor.
- 15 5. A program shutter for use in a camera, substantially
as hereinbefore particularly described and shown in the
accompanying drawings.



6. A program shutter for use in a camera, comprising a shutter mechanism having sectors for forming a lens opening during an exposure operation and a stepper motor that is stepped forward or backward to open or close the sectors:
- 5 and a control portion having arithmetic means for calculating the exposure corresponding to the luminance of a subject, counter means for delivering the number of steps through which the motor should be rotated according to the calculated exposure, pulse-generating means for producing pulses having individual
- 10 pulse widths conforming to the operating characteristic of the shutter mechanism according to the number of steps delivered from the counter means, and driver means for rotating the motor forward or backward according to the pulses from the pulse-generating means.
- 15 7. A program shutter as claimed in claim 6, wherein the sectors are driven in such a way that the opening varies uniformly with time.
8. Any novel integer or step, or combination of integers or steps, hereinbefore described and/or shown in the
- 20 accompanying drawings irrespective of whether the present claim is within the scope of, or relates to the same or a different invention from that of, the preceding claims.
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