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G2A

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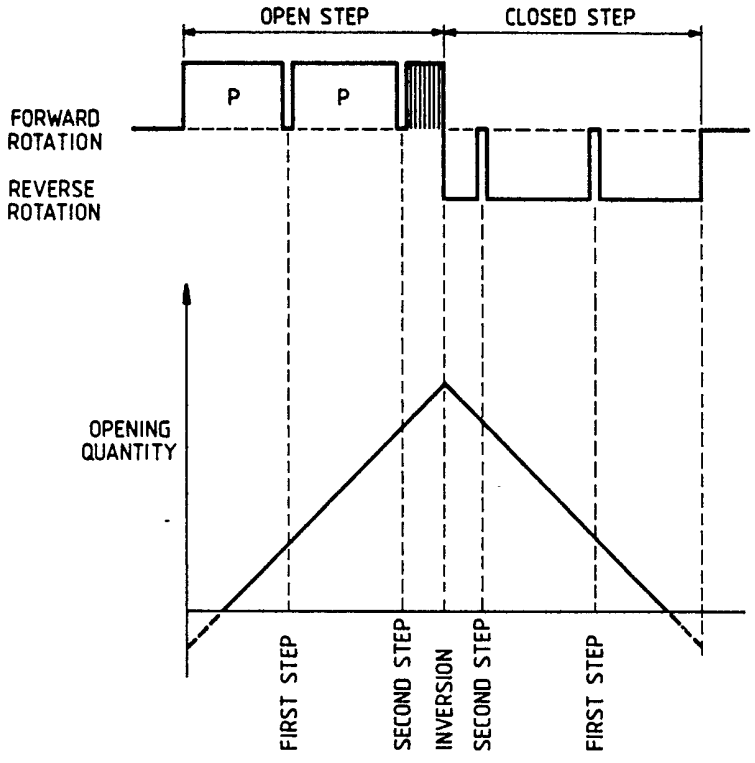
(54) Stepper motor drive for programme shutter

(57) A control circuit supplies pulses to a reversible motor which controls the operation of a programme shutter in accordance with stored exposure information, errors in the operating mechanism being compensated for by stored interpolation data and a second pulse counter which is counted down before the stepper motor is rotated in the reverse direction.

Fig. 4.



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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

Fig. 1(a)

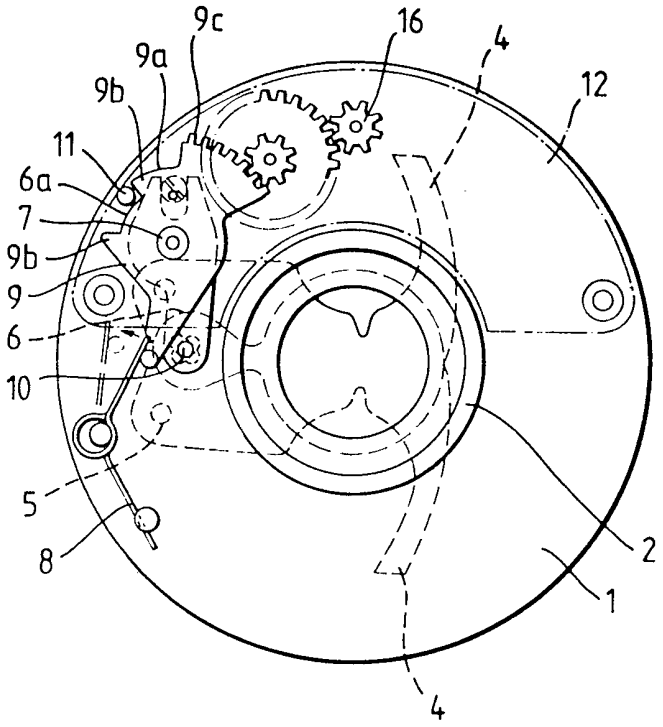


Fig. 1(b)

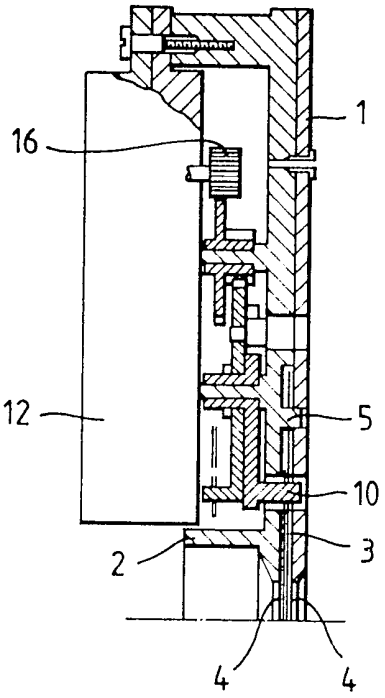


Fig.2(a)

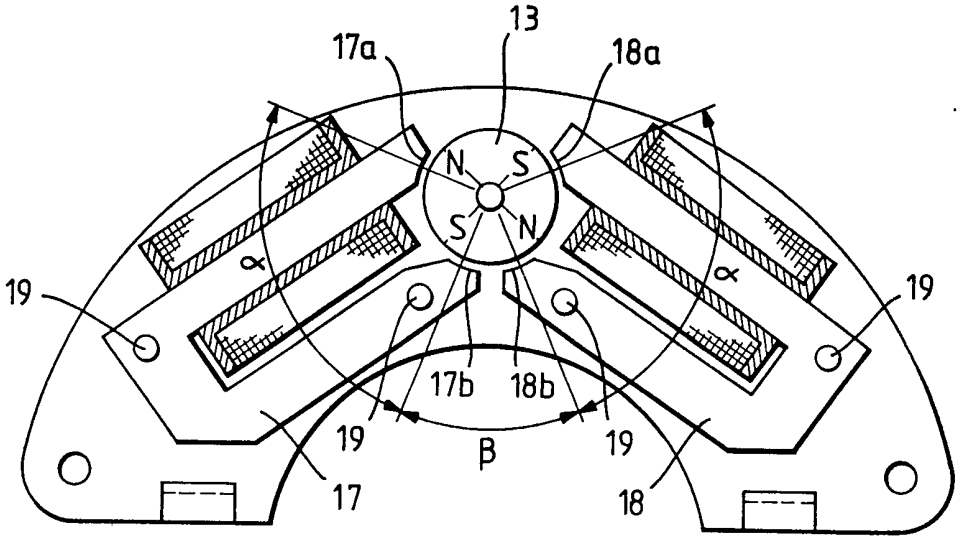
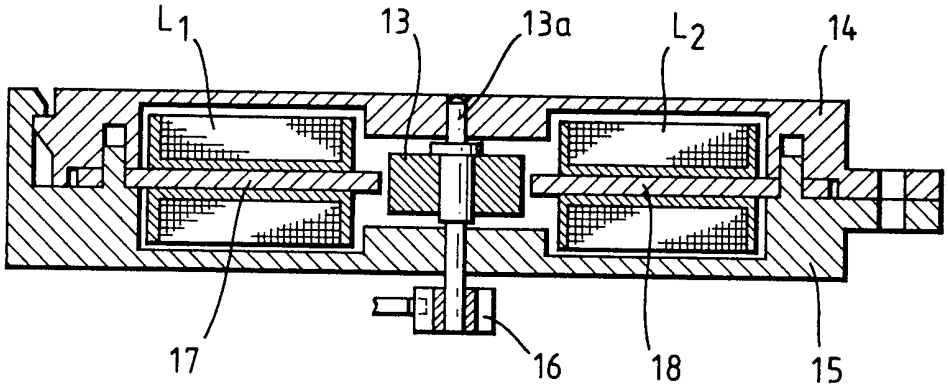
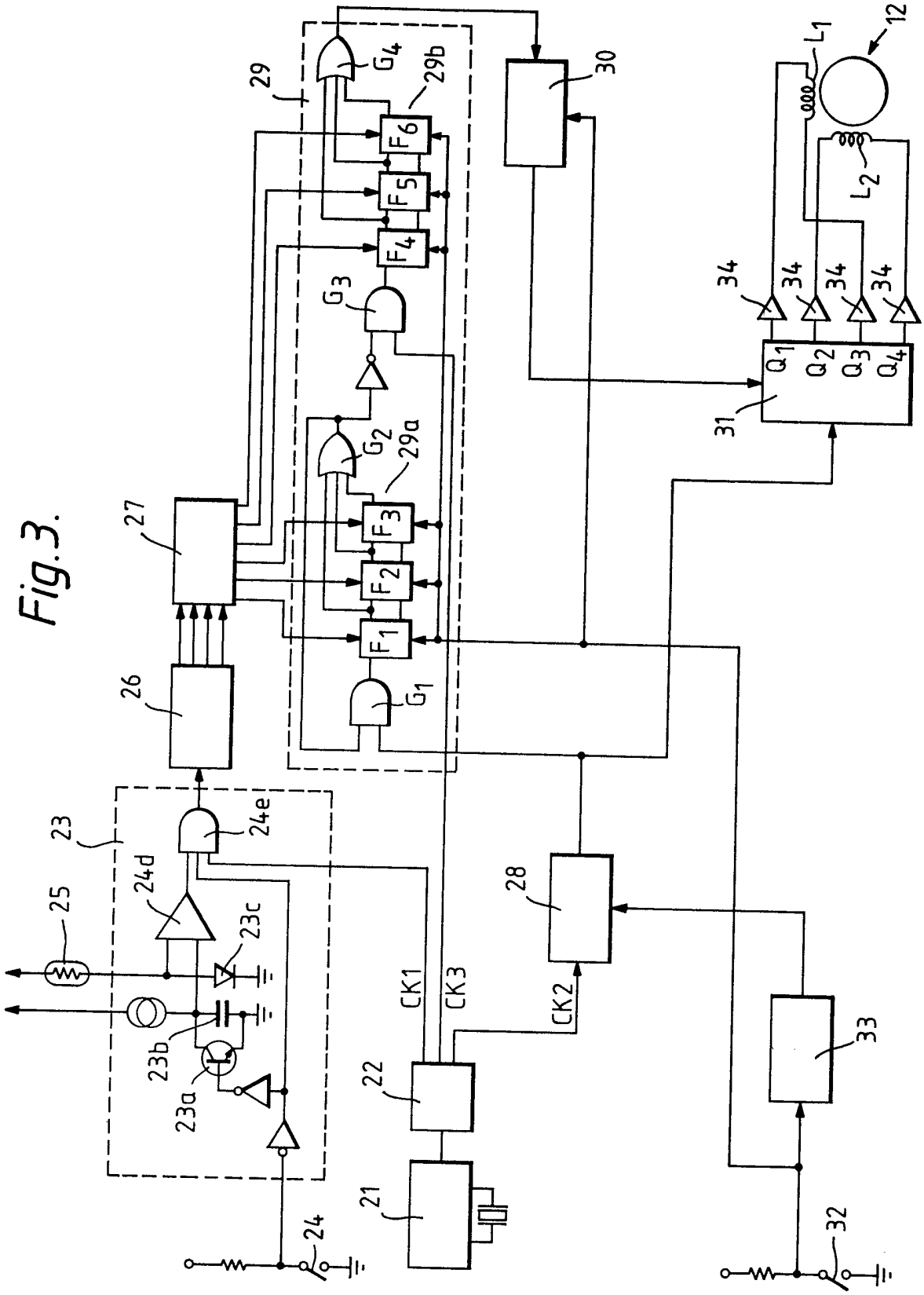

13
17a
18a
N
S
S
N
19
19
α
α
17b
18b
19
19
β
17
18

Fig.2(b)


L1
13
13a
L2
14
17
16
18
15


12
L1
L2
30
29
29b
29a
G4
G3
G2
G1
F6
F5
F4
F3
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F1
34
Q1
Q2
Q3
Q4
31
27
26
23
24e
24d
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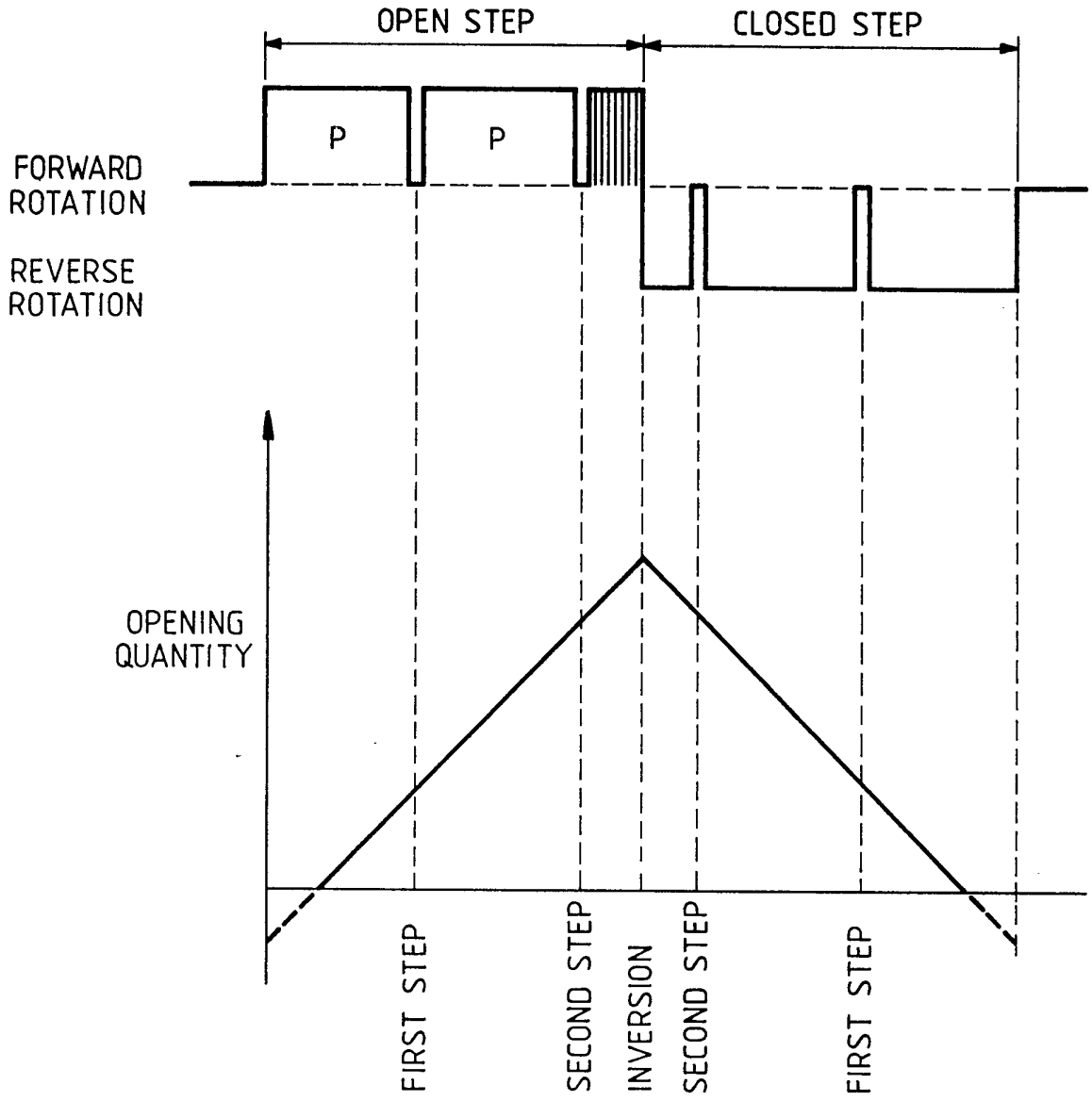
23c
23b
23a
CK1
CK3
CK2
28
22
21
33
24
32

Fig.3.

Fig. 4.


OPEN STEP
CLOSED STEP
P
P
FORWARD ROTATION
REVERSE ROTATION
OPENING QUANTITY
FIRST STEP
SECOND STEP
INVERSION
SECOND STEP
FIRST STEP

SPECIFICATION

Control circuit for program shutter

This invention relates to control circuits for program shutters.

A program shutter permits shutter sectors to be opened and closed by a stepper motor and is such that drive pulses having a fixed frequency are fed to the stepper motor upon initiation of a shutter release operation to rotate the stepper motor in one direction and gradually open the sectors. The phase of the drive pulses is switched when the stepper motor has rotated by a number of steps corresponding to a predetermined exposure to rotate the stepper motor in the opposite direction and close the sectors, thus achieving the predetermined exposure.

However, as the stepper motor used in a program shutter has a relatively low maximum rotational speed—at the most 500 to 1000 pulse/sec—the shortest time required for rotation by one step is limited, and in particular, there can be a relatively large error when the exposure time is relatively short. Moreover, "slippage" occurs between a drive signal and the predetermined exposure due to non-uniformity of shape of the sectors and play in a rotation transmission mechanism, etc. As a result, it is not possible to achieve acurately the desired predetermined exposure.

Although the present invention is primarily directed to any novel integer or step, or combination of integers or steps, herein disclosed and/or as shown in the accompanying drawings, nevertheless, according to one particular aspect of the present invention to which, however, the invention is in no way restricted, there is provided a control circuit for a program shutter having sectors forming a lens aperture and a stepper motor rotatable in forward and reverse directions for opening and closing the sectors, the control circuit comprising: motor control data storing means for receiving step drive number data and interpolation data corresponding to a predetermined exposure; pulse generator means for generating drive pulses and clock pulses; first counter means for presetting the step drive number data before opening of the sectors and arranged to be counted down on receipt of drive pulses from the pulse generator means to rotate the stepper motor in the forward direction to open the sectors; second counter means for presetting the interpolation data before the count in the first counter means reaches zero and arranged to be counted down on receipt of clock pulses from the pulse generator means; inversion drive means for detecting when the count in the second counter means reaches zero to rotate the stepper motor in the reverse direction; and motor drive means for driving the stepper motor by drive pulses from the pulse generator means.

Preferably the control circuit includes an object luminance detection circuit for producing the step drive number data consisting of a number of clock pulses corresponding to the predetermined exposure.

The motor drive means may be ring counter.

The inversion drive means in the preferred embodiment is connected to latch a signal from the second counter means to cause the motor drive means to determine the direction of rotation of the stepper motor.

According to a further non-restrictive aspect of the present invention there is provided a program shutter having a control circuit according to the present invention.

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

Figures 1a and 1b are elevational and sectional views respectively of a program shutter for use with a conventional control circuit according to the present invention;

Figures 2a and 2b are elevational and sectional views respectively of a preferred embodiment of a stepper motor of the program shutter of Figures 1a and 1b;

Figure 3 is a circuit diagram of an embodiment of a control circuit according to the present invention for the program shutter of Figure 1; and

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

Figures 1a and 1b illustrate a program shutter for use with a control circuit according to the present invention. A base plate 1 has a guide plate 2 thereon for positioning a lens (not shown). A sector chamber 3 is defined between the base plate 1 and the guide plate 2. Two sectors 4, symmetrically arranged to determine a lens aperture, are rotatably mounted on a pin 5 in the sector chamber 3. A sector drive lever 6 is rotatably supported by a shaft 7 fitted to the base plate 1, and is engaged, through a recessed portion 6a, with a pin 9a of a sector driving wheel 9 rotatably mounted on the shaft 7. The sector drive lever 6 is also engaged with sectors 4 by a sector pin 10 fitted to the base plate. The sector driving wheel 9 is rotatably supported by the shaft 7 so as to be located in a rest position defined by stopper portions 9b formed on the outer circumference of the sector driving wheel and a spring 8 which urges the sector driving wheel 9 to rotate in the counter-clockwise direction to the rest position. The sector driving wheel 9 is connected by an arcuate toothed portion 9c formed at one end thereof to a drive shaft 13a of a stepper motor 12. A pin 11 engages with the stopper portions 9a of the sector driving wheel 9 to restrict the range of rotation.

Figures 2a and 2b show a preferred embodiment of the stepper motor 12 which has

a permanent magnetic quadripole rotor 13. The rotor 13 is such that one end of a rotor shaft 13a projects through an upper plate 14 and a lower plate 15, and the sector driving wheel 9 is driven by a pinion 16 mounted to the shaft 13a. Stators 17,18 are each formed of U-shaped magnetic material and have two leg portions. One leg portion of each stator is surrounded by exciting coils L_1, L_2. Magnetic pole portions 17a, 17b,18a,18b are formed at respective free ends of each stator in a position at an angle α of 90° to the rotor. The stators 17,18 are arranged, in plan, in an inverted V-shape and are positioned by guide pins 19 so that the magnetic pole portions 17b,18b may be positioned at an angle β of 45° to the axis of the rotor 13. The rotor 13 can be rotated in forward and reverse directions in steps of 90°.

Figure 3 illustrates an embodiment of a control circuit according to the present invention for the program shutter of Figure 1. The control circuit has a divider circuit 22 for stepping down an output signal having a predetermined frequency from a reference pulse generator 21 including a crystal resonator, to generate a clock signal CK1 for digitizing photometric data, a clock signal CK2 for driving the stepper motor 12 and a clock signal CK3 for interpolation. An object luminance detection circuit 23 is such that a terminal voltage of a capacitor 23b charged by a constant current through a transistor 23a, which is turned ON and OFF by a first switch 24 interlocked with a release button (not shown) of the program shutter, is compared withaterminal voltage of a logarithmic compression diode 23c connected in series with a light receiving element 25 such as a CdS cell by a comparator 24d. A gate 24e is opened upon operation of the first switch 24 to output the clock signal CK1 to a counter circuit 26. The gate 24e is closed upon inversion of the output of the comparator 24d to block the clock signal CK1. Thus the number of pulses of the clock signal CK1 passed by the gate 24e is a function of the brightness of an object to be photographed as determined by the light receiving element 25 i.e. the luminance detection circuit 23 outputs a digital object luminance signal.

The counter circuit 26 is cleared by the operation of the first switch 24, and simultaneously acts to count pulses of the clock signal CK1 produced by the luminance detection circuit 23 and stores a count which is a function of the object luminance signal. An exposure data memory circuit 27 storing stepper motor drivedataderived from the object luminance signal is permitted to access step number data for rotating the stepper motor and interpolation data for compensating an exposure error generated by the step number data and "slippage" between the drive signal and the exposure due to non-uniformity of shape of the sectors and play of rotation transmission mechanism according to the count in the counter circuit 26. A step drive pulse generator 28 receives the clock signal CK2 and generates constant frequency drive pulses P for driving the stepper motor in the forward direction upon operation of a second switch 32 by the release button so that the stepper motor drives the sectors stepwise. A rotation mode switching counter circuit 29 comprises a first presettable down counter 29a including flip-flops F_1 to F_3 connected in cascade with each other and a second presettable down counter 29b including flip-flops F_4 to F_6 connected in cascade with each other. The step number data from the exposure data memory circuit 27 is preset in the counter 29a at the start of forward and reverse rotation of the stepper motor, and outputsa signal from an output gate G_2 when the count therein reaches zero, the count being reduced by one for each pulse p received by a gate G_1 from the pulse generator 28. The interpolation data from the exposure data memory circuit 27 is set in the counter 29b at the start of forward rotation of the stepper motor, and a signal is outputted from an output gate G_4 when the counter reaches zero, the count being reduced by one for each pulse of the clock signal CK3 received starting from the time when the content of the first counter 29a has reached zero.

A forward/reverse switching circuit 30 serves to latch the signal from the rotation mode switching counter circuit 29 and to switch the stepper motordriver circuit 31 to cause it to determine the direction of rotation of the stepper motor. The stepper motor driver circuit 31 is a ring counter which permits a signal to appear sequentially at one of four output terminals Q_1, Q_2, Q_3, Q_4 "moving" from one terminal to the next adjacent terminal, each time a pulse is received from the pulse generator 29. In other words, the stepper motor driver circuit 31 receives a pulse signal from the forward/reverse switching circuit 30, and this determines the direction in which the drive pulses P from the pulse generator 28 drive the stepper motor.

The second switch 32 serves to reset the rotation mode switching counter circuit 29 and the forward/reverse switching circuit 30 upon operation of the release button. A set signal generating circuit 33 sets the pulse generator 29 upon operation of the switch 32. Drive circuits 34 serve to amplify signals from the output terminals Q_1 to Q_4 of the stepper motor driver circuit 31 and supply current to exciting coils L_1, L_2 of the stepper motor 12.

Operation of the control circuit of Figure 3 will now be described with reference to the timing chart shown in Figure 4. After turning ON a power switch (not shown), when the release button is depressed from an initial

position to a first position, the first switch 24 is turned OFF and the object luminance detection circuit 23 is energised to output the object luminance signal consisting of a number of pulses of the clock signal CK1 and corresponding to the object luminance. The object luminance signal is stored in the counter circuit 26. The exposure data memory circuit 27 outputs the step number data corresponding to a desired exposure and interpolation data for compensating for any exposure error to the counter 29a and the counter 29b respectively of the rotation mode switching counter circuit 29 in dependence upon luminance data from the counter circuit 26, and presets the step number data and the interpolation data, thereby setting exposure data corresponding to the object luminance.

Upon completion of setting of the exposure data, when the release button is depressed to a second position, the second switch 32 is turned ON to reset the rotation mode switching counter circuit 29 and the forward/reverse switching circuit 30, and simultaneously the pulse generator 28 is energised to generate the drive pulses p which are fed to the counter 29a of the rotation mode switching counter circuit 29 and the stepper motor driver circuit 31. The stepper motor 12 is rotated in the forward direction by one step each time one of the drive pulses P is received. Accordingly, the sectors 4 start to open, and simultaneously the first counter 29a is counted down. When the number of drive pulses P applied to the stepper motor is equal to the step number data stored in the counter 29a, the clock signal CK3 is passed from the divider circuit 22 to the counter 29b by the gate G_3 when the stepper motor is executing its final step of rotation in the forward direction. At this time in order to compensate for slippage between the drive signal and the exposure due to non-uniformity in sector shape and play in the rotation transmitting mechanism, the clock signal CK3 is fed to the counter 29b through the gate G_4 and the interpolation data stored in the counter 29b is counted down to zero. The output of the forward/reverse switching circuit 30 is then inverted and switches the stepper motor driver circuit 31 to cause the drive pulses P to drive the stepper motor to rotate step wise in the reverse direction. As a result the stepper motor is forcibly driven and rotated synchronously with the drive pulses P in the reverse direction to close the sectors 4. When the content in the counter 29a reaches zero again, the sectors 4 are returned to their original position having effected precise exposure wherein errors due to non-uniformity and sector shape and play in the rotation transmitting mechanism has been compensated. The release button is then released to return to its original position, and the power switch is turned OFF so that the control circuit is ready for the taking of the next photograph.

The control circuit according to the present invention and described above is such that the step number data and interpolation data corresponding to a desired exposure are initially stored and the sectors are stepwise driven by the drive pulses according to the step number data. When a time corresponding to the interpolation data has elapsed from the time when the final step drive pulse is produced, the stepper motor is reversibly rotated. Accordingly, the exposure may be finely controlled according to the object luminance, and additionally exposure error due to peculiarities of the shutter mechanism and instrument error may be precisely corrected by a relatively simple operation.

CLAIMS

1. A control circuit for a program shutter having sectors forming a lens aperture and a stepper motor rotatable in forward and reverse directions for opening and closing the sectors, the control circuit comprising: motor control data storing means for receiving step drive number data and interpolation data corresponding to a predetermined exposure; pulse generator means for generating drive pulses and clock pulses; first counter means for presetting the step drive number data before opening of the sectors and arranged to be counted down on receipt of drive pulses from the pulse generator means to rotate the stepper motor in the forward direction to open the sectors; second counter means for presetting the interpolation data before the count in the first counter means reaches zero and arranged to be counted down on receipt of clock pulses from the pulse generator means; inversion drive means for detecting when the count in the second counter means reaches zero to rotate the stepper motor in the reverse direction; and motor drive means for driving the stepper motor by drive pulses from the pulse generator means.

2. A control circuit as claimed in claim 1 including an object luminance detection circuit for producing the step drive number data consisting of a number of clock pulses corresponding to the predetermined exposure.

3. A control circuit as claimed in claim 1 or 2 in which the motor drive means is a ring counter.

4. A control circuit as claimed in any preceding claim in which the inversion drive means is connected to latch a signal from the second counter means to cause the motor drive means to determine the direction of rotation of the stepper motor.

5. A control circuit for a program shutter substantially as herein described with reference to and as shown in Figures 3 and 4 of the accompanying drawings.

6. A program shutter having a control circuit as claimed in any preceding claim.

7. In a program shutter including sectors forming a lens aperture and a forwardly/reversely rotatable step motor for opening and closing said sectors, a control circuit for said program shutter comprising a control unit comprising a motor control data storing means for receiving a step drive number and an interpolation quantity corresponding to an exposure quantity as a data and storing the exposure quantity in an address, a pulse generator means for generating a step drive pulse and a clock pulse, a first counter means for presetting the step drive number before opening of said sectors and before inversion of said step motor and adapted to be counted down by the step drive pulse from said pulse generator means, a second counter means for presetting the interpolation data before count-up of said first counter means and adapated to be counted down by the clock pulse, an inversion drive means for detecting a timing when said second counter means is counted up and reversely rotating said motor, and a motor drive means for driving said motor by the pulse from said pulse generator means.

8. Any novel integer or step, or combination of integers or steps, hereinbefore described and/or as shown in the 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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