

"MOTOR-DRIVEN BLADE DEVICE, E.G. FOR A CAMERA"

The present invention relates to a motor-driven blade device, e.g. for a camera.

It is known to employ a motor to move the shutter blades of a camera instead of using springs therefor.

5 Such a motor-driven shutter is disclosed, for example, in Japanese Laid-Open Patent Specifications Nos. 150829/1982 and 57327/1985.

10 In the construction disclosed in the former Japanese Patent Specification, the shutter blades have a rectilinear sliding motion and, therefore, at least two support portions are needed to limit the rectilinear sliding motion of the shutter blades. Since a large frictional resistance is produced, the shutter blades are unable to respond quickly to the rotation of the motor. Hence, it is difficult to control the operation of the
15 shutter blades accurately.

20 In the construction disclosed in the latter Japanese Patent Specification, the shutter blades are driven near their axes of rotation and so the efficiency of operation is high. However, a rattle which is produced because of clearances between components is augmented by the portions of the shutter blades which control the exposure. The shutter blades cannot quickly respond to the rotation of the motor because of the augmented

rattle and the moment of inertia, in the same way as in the first-mentioned construction. Consequently, it is difficult to control the operation of the shutter blades accurately.

5 In particular, where shutter blades which also act as a diaphragm are driven by a motor and when the subjects being photographed are bright, exposure errors are greatly increased. A special device is needed for cameras using a photosensitive material having a narrow latitude.

10 In the construction disclosed in the former Japanese Patent Specification, the shutter blades have a rectilinear sliding movement and so each component must be disposed non-uniformly around the shutter aperture. As a result, the lens system of the camera cannot be arranged in the usual way.

15 According, therefore, to the present invention, there is provided a motor-driven blade device for controlling the size of an aperture comprising a motor which can be rotated both clockwise and counter-clockwise; a drive gear which is driven by the motor and which is disposed on one side
20 of an aperture; at least one fixed shaft which is disposed on the opposite side of the aperture; and a plurality of blades each of which is rotatably mounted on a said fixed shaft for clockwise and counter-clockwise rotation about the latter to control the size of the aperture; each of the blades being
25 driven, directly or indirectly, by the drive gear.

Such a motor-driven blade device may be made inexpensive and small, and may have excellent responsiveness.

Preferably the motor is an electric motor which is arranged to be driven clockwise and counter-clockwise in accordance with a control signal from an electronic circuit.

At least one of the blades may have teeth which are in mesh with the teeth of the drive gear.

Furthermore, at least one of the blades may have a drive connection with the said one blade. In this case, the drive connection may comprise a lever which is rotatably mounted on the fixed shaft of the said one blade and which has a pin and slot connection with each of the blades.

There may be at least one further gear which is driven by the drive gear, at least one said blade having teeth which are in mesh with the teeth of the or a further gear.

In another arrangement, each of the blades is driven from the drive gear by way of a drive transmission comprising a plurality of parts, adjusting means being provided for relatively adjusting said parts so as to adjust the phase relationship between the motor and the blades. In this case, the said parts may comprise a driving lever having teeth in mesh with the teeth of the drive gear, the driving lever being mounted on one of a plurality of fixed shafts so as to be rotatable in opposite angular directions, and a transmission lever mounted on the last-mentioned fixed shaft so as to be

rotatable in opposite angular directions, the transmission lever acting to transmit rotary motion from the driving lever to the blades.

5 There may be an optical sensor which detects movement of a blade, the optical sensor being arranged to produce an output signal which controls the operation of the electronic circuit. The electronic circuit may be arranged to use the said output signal to find the time at which blade operation starts, or to check whether the said operation is
10 proceeding satisfactorily, or for a counting operation.

 There may be a switch which is opened and closed in dependence upon the rotation of the drive gear or of means driven thereby, the switch controlling the operation of the electronic circuit. Thus the switch may be actuated by
15 an idle gear which is in mesh with the drive gear, the idle gear having a larger diameter and a larger number of teeth than the drive gear.

 In one embodiment, a first blade has external teeth in mesh with the drive gear and a second blade has inner
20 teeth in mesh with the drive gear.

 The arrangement is preferably such that the difference between the distance of the said inner teeth from the centre of the shutter aperture and the distance of the external teeth from the said centre is such as to make the change
25 in the area of the aperture formed by the first-mentioned

blade at the said centre substantially equal to the change in the area of the aperture formed by the second blade at the said centre.

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

Figure 1 is a plan view of a stepper motor forming part of a first embodiment of a motor-driven shutter for a camera;

Figure 2 is a plan view of another part of the said first embodiment showing shutter blades in a closed position in which
10 they occlude a shutter aperture;

Figure 3 is a view similar to Figure 2, but showing a part of a second embodiment;

Figure 4 is a view similar to Figure 3 but showing a part of a third embodiment;

15 Figure 5 is a view similar to Figure 1, but illustrating part of a fourth embodiment;

Figure 6 is a view similar to Figure 2, but illustrating another part of the fourth embodiment;

20 Figure 7 is a cross-sectional view taken on the line VII - VII of Figure 6;

Figure 8 is a view similar to Figure 6 but illustrating a part of a fifth embodiment;

Figure 9 is a cross-sectional view taken on the line IX - IX of Figure 8;

25 Figure 10 is a plan view of a part of a sixth embodiment; and

Figure 11 is a plan view of a part of a seventh embodiment.

Terms such as "clockwise" and "counter-clockwise", as used in the description below, are to be understood to refer to directions as seen in the accompanying drawings.

Referring to Figure 1, an electrical stepper motor M, which can be rotated either forwardly or reversely according to a control signal from a known electronic circuit (not shown), comprises a rotor R, two stators SA, SB and coils LA, LB fitted over the stators SA and SB, respectively. The rotor R is rotatably mounted on a shaft 1, and consists of a permanent magnet which is radially polarized so as to have a plurality of poles. The stators SA and SB have poles which are disposed opposite to the magnetic poles of the rotor R. The coils LA, LB are connected to the said known control circuit (not shown).

The stators SA and SB are rigidly fixed to a base plate 8 of the motor M by shafts SA₁ and SB₁ respectively. The positions of the magnetic poles opposite to the rotor R are restricted by pins SA₂ and SB₂ respectively.

A shutter opening OA is formed in the centre of the base plate 8 of the motor M. The shaft 1 on which the rotor R is mounted extends downwardly through the base plate. A gear 2, which is driven by the motor M, is mounted on the front end of the shaft 1 so as to be a press fit thereon. The base plate

8 is of circular shape and extends concentrically around the shutter opening OA.

A shutter mount 3, shown in Figure 2, is mounted on the rear surface of the base plate 8 of the motor M. Shutter blades 4 and 5 are disposed between the shutter mount 3 and the base plate 8. Working regions in which the blades 4, 5 can move are formed.

The shutter blade 4 is rotatably mounted on a fixed shaft 4a and comprises an edge portion 4b and a groove or slot 4c. The shutter blade 5 is rotatably mounted on a fixed shaft 5a and comprises an edge portion 5b, a groove or slot 5c and teeth 5d in mesh with the teeth of the gear 2. The edge portions 4b and 5b cooperate to define an aperture. The shafts 4a and 5a are disposed on the opposite side of the shutter opening OA from the gear 2.

An opening lever 6 is secured to the rear surface of the shutter mount 3 so as to be rotatable about the fixed shaft 5a. A pin 6a extends upwardly from the lever 6, and is fitted in the slots 4c and 5c. Another pin 6b extends further upwardly towards the side of the motor M, protrudes upwardly of the base plate 8 of the motor M, and is in contact with a switch contact SW.

The switch contact SW is in contact with a contact pin SP to form a pair of switches which are connected to the control circuit (not shown but described later).

The manner in which the structure described above operates

is now described. The known control circuit (not shown) operates to deliver signals of two phases for energizing the two coils LA and LB with two polarities. Then, the stators SA and SB are excited to rotate the rotor R counter-clockwise.

5 The shutter blade 5, whose teeth are in mesh with the gear 2, rotates clockwise about the shaft 5a. At this time, the pin 6a is actuated by the wall defining the slot 5c to rotate the opening lever 6 also clockwise. As the pin 6a moves the wall defining the slot 4c in the shutter blade 4, the shutter

10 blade 4 is rotated counter-clockwise about the shaft 4a.

As the rotor R continues to rotate counter-clockwise, the shutter opening is gradually opened by the edge portions 4b and 5b of the shutter blades 4 and 5 to control the exposure according to the combination of the aperture and the exposure

15 time. When the desired value is reached, the known control circuit delivers signals to the coils LA and LB, for reversing the rotor R. Then the rotor R is immediately reversed. Subsequently, the gear 2 rotates the shutter blade 5 counter-clockwise about the shaft 5a and the blade 5 cooperates

20 with the blade 4 to close the shutter opening OA.

When the opening lever 6 turns clockwise, the pin 6b actuates the switch contact SW to cause the control circuit to start calculating the exposure value.

Figure 3 is a view similar to Figure 2 but showing

25 a second embodiment which employs a simplified device

for driving the shutter blades which does not require the opening lever 6 used in the first embodiment. Note that like components are indicated by like reference numerals in both Figures 2 and 3. In Figure 3, a gear 7 which is in mesh with the gear 2 is rotatably mounted on a shaft 7a firmly fixed in the shutter mount 3. The gear 7 is also in mesh with teeth 4d formed on the shutter blade 4.

When the rotor R rotates counter-clockwise, the gear 2 rotates the shutter blade 5 via the teeth 5d in the same way as in Figure 2. At the same time, the gear 7 is turned clockwise. Therefore, the shutter blade 4 whose teeth 4d are in mesh with the teeth of the gear 7 is rotated counter-clockwise. Thus the exposure of the shutter is controlled.

The switch contact SW shown in Figure 1 may be designed to be actuated by the shutter blades 4, 5, or by the gears 2, 7, or the like in a manner not illustrated but similar to the example shown in Figure 2.

Figure 4 is a view similar to Figure 3 but showing a third embodiment which employs a larger gear 2a formed substantially integrally with the gear 2. This gives a larger degree of freedom to the arrangement of the shafts 1 and 7a. The gear 2a is in mesh with the gear 7b. This structure operates in the same way as the structure shown in Figure 3 and so the operation is not described in detail herein.

In the above embodiments, the motor M is a stepper motor. However, an ultrasonic motor or other motor which can be rotated either forwardly or reversely according to the control signal from an electronic circuit may also be used.

5 As will be appreciated, in the embodiments described above, each of the shutter blades 4, 5 is driven, directly or indirectly, by the gear 2 and are driven at the positions which are as remote as possible from the axes of rotation of the blades. The effects of the rattle produced by the clearances between engaging parts, and the effects of the moment of inertia, are therefore reduced, the responsiveness of the device is improved, and the exposure can be accurately controlled.

10 Since the axes of rotation of the blades and the positions of the gears are on opposite sides of the shutter aperture, the lens system can be arranged in the usual way.

15 The shutter can be of circular shape for use in a camera provided with a lens shutter which varies the focal distance of the lens.

20 In particular, if the shutter is circular in shape, the clearance between the lens assembly and fixed portions can be appropriately filled with parts which can be machined most efficiently. Also a circularly shaped shutter is easy to make and reduces the cost of fabrication.

25 In the above embodiments, the shutter blades also act as a diaphragm but the invention is also applicable to a device which controls only the aperture.

In the embodiments described above, the phase relationship between the motor and the blades may differ among different manufactured shutters because of the backlash of the engaging gears included in the transmission system which transmits rotary motion from the motor-driven gear to the blades, and because of the accumulation of clearances between interfitting portions of the device. As a result, the amount by which the two blades overlap prior to actuation of the device may not be maintained constant. Also, the diameter of the aperture may not be kept constant while the shutter is being opened. In particular there may be serious problems when a bright subject is being photographed and the aperture to be controlled is small.

In Figures 5-7 there is therefore shown a fourth embodiment of the present invention.

Referring to Figure 5, a stepper motor M_1 comprises a rotor 41, two stators 44, 45 having poles 44a, 44b and 45a, 45b, respectively, opposite to the magnetic poles of the rotor 41, and coils 47 and 48 extending over the stators 44 and 45, respectively. The rotor 41 is secured to a shaft 42 so as to be rotatable therewith. The rotor 41 consists of a permanent magnet which is circumferentially polarized so as to have a plurality of magnetic poles which are spaced from each other. The coils 47 and 48 are connected to a known control circuit (not shown).

The stators 44 and 45 are rigidly fixed to a base plate 10 of the motor M_1 by means of mounting shafts 11 and 12, respectively. The positions of the magnetic poles 44a, 44b, 45a, 45b of the stators 44 and 45 which are located opposite to the magnetic poles of the rotor 41 are restricted by pins 14-17 respectively. The base plate 10 of the motor M_1 is of a circular shape. A circular shutter aperture 20 is formed in the centre of the base plate 10. The shaft 42 holding the rotor 41 extends through the base plate 10 to the rear side of the plate. A gear 21 is secured to the front end of the shaft 42 so as to be rotatable therewith.

Referring to Figure 6, a shutter mount 23 is spaced a given distance from the rear surface of the base plate 10 of the stepper motor M_1 . A driving lever 24, shutter blades 26 and 27 are disposed between the base plate 10 and the mount 23 and arranged in this order from the side of the base plate 10. Regions in which the blades 26 and 27 can move are formed around them. Figure 6 is a front elevation of the blade-actuating device as viewed from the rear side of the base plate 10, and in which the base plate 10 of the motor M_1 is omitted.

The shutter blade 27 is rotatably mounted on a fixed shaft 31 which is located substantially on the opposite side of the shutter opening 20 from the gear 21. The blade 27 has an edge portion 27a and a groove or slot 27b in which an operating pin 34 is fitted. The shutter blade 26 is also rotatably mounted on a

fixed shaft 32 that is located substantially on the opposite side of the shutter aperture 20 from the gear 21. The blade 26 is provided with an edge portion 26a which cooperates with the edge portion 27a to form an aperture. The blade 26 further includes an operating groove or slot 26b in which the operating pin 34 is fitted.

One end of the driving lever 24 is rotatably mounted on the fixed shaft 31. The lever 24 is similar in shape to the shutter blade 27. The other end of the lever 24 has teeth 24a which are always in mesh with the gear 21. A transmission lever 30 is mounted between the driving lever 24 and the shutter blade 26 in such a way that its intermediate portion is rotatably mounted on the fixed shaft 31. The operating pin 34 which engages in the operating slots 26b and 27b extends upright from one end of the transmission lever 30. As shown in Figure 7, an adjusting pin (adjusting means) 35 has a reduced portion 35a incompletely crimped against the other end of the lever 30. The adjusting pin 35 further includes an enlarged portion 35b fitted in an adjusting groove 24b formed in the driving lever 24.

The operation of the fourth embodiment is now described. The known control circuit (not shown) operates to deliver signals of two phases for energizing the two coils 47 and 48 with two polarities. Then, the stators 44 and 45 are excited to rotate the rotor 41 in a counter-clockwise direction. The

gear 21 rotates the driving lever 24, by meshing with the teeth 24a thereof, about the fixed shaft 31 in a clockwise direction. At this time, the wall defining the adjusting slot 24b drives the adjusting pin 35 to rotate the transmission lever 30 in the same direction. Therefore, the wall defining the operating slot 26b in the shutter blade 26 is driven by the operating pin 34 so that the blade 26 turns in a counter-clockwise direction about the fixed shaft 32 to open the shutter aperture 20. Also, the wall defining the operating slot 27b in the shutter blade 27 is driven by the operating pin 34. The blade 27 is rotated in a clockwise direction about the fixed shaft 31 to open the shutter aperture 20.

As the rotor 44 continues to rotate in the same direction in this way, the edge portions 26a and 27a of the shutter blades 26 and 27 gradually open the shutter opening 20. Thus the exposure is controlled according to the combination of the aperture size and the exposure time. When the desired value is reached, the known control circuit delivers signals to the two coils 47 and 48, for reversing the rotor 41. Thus, the rotor 41 is momentarily reversed to cause the gear 21 to rotate the driving lever 24 in a counter-clockwise direction about the fixed shaft 31. This rotary motion is transmitted to the edge portions 26a and 27a of the shutter blades 26 and 27 via the adjusting slot 24b, the adjusting pin 35, the transmission lever 30, the operating pin 34, and

the operating slots 26b, 27b to close the shutter aperture 20.

5 Since the reduced portion 35a and the enlarged portion 35b of the adjusting pin 35 are eccentric, it is possible to change the phase relation between the stepper motor M_1 and the shutter blades 26, 27 by inserting a screwdriver or the like into a groove formed in the enlarged portion 35b and rotating it. Consequently, the amount by which the two shutter blades 26 and 27 overlap prior to the actuation can be changed. Also, 10 the diameter of the aperture can be varied while the shutter is being opened. Hence, the amount of the overlap and the diameter of the aperture can be easily maintained constant if the phase relation between the motor and the blades differ among shutters because of the backlash of the engaging gears included in the 15 transmission system which transmits rotary motion from the gear 21 to the shutter blades 26, 27 and because of the accumulation of clearance produced between interfitting portions.

The driving lever 24, and the shutter blades 26 and 27 overlap each other such that their inclinations are alternately 20 reversed and so when the shutter aperture 20 is closed, the geometrical path through which light would need to travel is bent at many locations and made long. Therefore, light leakage can be effectively prevented. Conversely, if the inclinations of the driving lever 24 and the blades are alternately reversed, 25 the amount by which the shutter blades 26 and 27 overlap during

the closure can be reduced. The blades 26 and 27 can be reduced in size accordingly. This saves the space occupied by them. The result is that the surrounding components can be arranged with an increased degree of freedom.

5 In the embodiment of Figures 5-7, the shutter blades 26 and 27 are so disposed that they adjoin each other in the direction and thickness of the blades. However, the driving lever 24 can be mounted between the blades 26 and 27. In this case, the driving lever 24 certainly prevents the front end portions 26c and 27c of
10 the blades from coming into contact with each other and getting entangled when the blades 26 and 27 are returning to their original positions after they have been opened fully. Therefore, the length of the front end portions 26c and 27c can be shortened, thus saving space. In addition, the inertia of the blades is reduced.
15 Hence, the responsiveness of the blades can be improved.

 Also in the fourth embodiment, the shutter blades act also as a diaphragm, although the invention can also be applied to blades which function only as a diaphragm or as a shutter.

 In the above described fourth embodiment, the motor
20 is a stepper motor but other motors such as an ultrasonic motor may be employed provided that they can be controlled at will using a control circuit.

 In the fourth embodiment, the amount by which the two blades 26, 27 overlap each other prior to the actuation of the
25 device, and the diameter of the aperture during the operation

to open the shutter can be easily adjusted so as to be maintained constant if the phase relationship between the motor and the blades varies among shutters because of the backlash of the gears which engage each other or because
5 of the accumulation of the clearances between inter fitting portions.

In the embodiments described above, a switch is actuated to cause a control circuit to start a counting operation so as to calculate the exposure. This switch mechanically makes
10 and breaks a circuit. Therefore, dust or the like may induce imperfect contact, hindering the control operation. Also, a mechanical load may impede the operation of the blades.

A fifth embodiment of the invention is hereinafter described with reference to Figures 8 and 9 of the drawings.
15 In this embodiment, a motor is employed which is the same as that illustrated in Figure 5 and which for this reason will not be described further.

Referring to Figure 8, a shutter mount 123 is spaced a given distance from the rear surface of the base plate
20 (not shown) of the stepper motor (not shown). Shutter blades 126 and 127 are disposed between the said base plate and the shutter mount 123. Regions in which the blades can move are formed around them. Figure 8 is a front elevation of the blade-actuating device as viewed from the rear side of the said
25 base plate and in which the said base plate of the motor is omitted.

A fixed shaft 131 is located substantially on the opposite side of the shutter aperture 120 from the gear 121. One end of the shutter blade 126 is secured to the shaft 121 in such a way that the blade 126 can rotate either clockwise or counter-clockwise. Teeth 126c formed at the other end are always in mesh with the gear 121. The shutter blade 127 is directed oppositely to the blade 126. One end of the blade 127 is secured to a fixed shaft 132 that is also located substantially on the opposite side of the shutter aperture 120 from the gear 121. The blade 127 can rotate about the shaft 132 in either angular direction. The other end of the blade 127 has no teeth, unlike the blade 126. The blades 126 and 127 have edge portions 126a and 127a, respectively, which form an aperture. The blades 126 and 127 are further provided with operating grooves or slots 126b and 127b, respectively, in which an operating pin 134 is fitted.

One end of a driving lever 130 is rotatably mounted on the fixed shaft 131. An operating pin 134 extends upright from the other end of the lever 130, and is fitted in the operating slots 126b and 127b.

As schematically shown in Figure 9, a photo-coupler (optical sensor) 139 is disposed near the teeth 126c of the shutter blade 126 to detect the movement of the blade 126, utilizing the condition that the teeth 126c obstruct or pass light. The output signal from the photo-coupler 139 is fed

to a known control circuit (not shown).

The operation of the fifth embodiment is now described. The known control circuit (not shown) operates to deliver signals of two phases for energizing the two coils (not shown) of the motor (not shown) with two polarities. Then, the stators (not shown) of the motor are excited to rotate the rotor (not shown) of the motor in a counter-clockwise direction. The gear 121 rotates the shutter blade 126 whose teeth 126c are in mesh with the gear 121 about the fixed shaft 131 in a clockwise direction. At this time, the wall defining the operating slot 126b drives the operating pin 134 to rotate the driving lever 130 in the same direction. Then, the blade 127 is driven by the pin 134 which is fitted in the slot 127b, and is rotated about the fixed shaft 132 in a counter-clockwise direction. As a result, the edge portions 126a and 127a of the shutter blades 126 and 127 gradually open the shutter aperture 120.

When the gear 121 begins to rotate the shutter blade 126, the teeth 126c which are in mesh with the gear 121 are moved to the right as viewed in Figure 8. The photo-coupler 139 detects the beginning of movement of the blade 126, utilizing the condition in which the teeth 126c obstruct or pass light. The output signal from the photo-coupler 139 is fed to the control circuit, which starts its counting operation upon the application of the input signal. This instant of time is

regarded as the point at which the blade 126 starts to be driven.

5 The aperture and the exposure time are calculated from the brightness of the subject. A decision is made based on the number of blockages of light and on the number of passages of light detected by the photo-coupler 139, to see whether the blade 126 rotates to make the aperture correspond with the calculated values. If the desired value is reached, the shutter is opened for an exposure time corresponding to the calculated values. Then, the two coils are energized to reverse the rotor. The rotor is momentarily reversed to cause the gear 121 to rotate the blade 126 about the fixed shaft 131 in a counter-clockwise direction. The blade 126 cooperates with the blade 127 to close the shutter aperture 120.

15 The output signal from the photo-coupler 139 is applied to a certain display device to permit one to easily see whether the blades 126 and 127 are presently operating or are at fault.

20 In the fifth embodiment, the shutter blades also act as a diaphragm. The embodiment can also be applied, however, to blades which function only as a diaphragm or only as a shutter.

25 Also in the fifth embodiment, the motor is a stepper motor but other motors such as an ultrasonic motor may be

employed provided that the rotation of such motor can be controlled at will using a control circuit.

In the fifth embodiment, the teeth 126c formed to transmit power are detected and so the construction is simple. The device does not suffer from imperfect contact which can be caused by dust or the like. Therefore, the control operation is not hindered. Further, the shutter blades can be smoothly operated with high responsiveness, since no mechanical load is applied.

In the case of the switch SW of Figure 1, the switch is actuated by the use of a number of separate members and, as a result, the backlash of the engaging gears of the transmission system and the accumulation of clearances produced between inter fitting portions can cause mechanical error. Therefore, the timing of the operation of the switch is liable to get out of order. Hence, there arises the possibility that the control circuit does not appropriately control the blades.

A sixth embodiment of the invention is hereinafter described with reference to Figure 10 of the drawings. In this embodiment, a motor is employed which is the same as that illustrated in Figure 5 and which for this reason will not be described further.

Referring to Figure 10 a shutter mount 223 is spaced a given distance from the rear surface of the base plate

(not shown) of the stepper motor (not shown). Shutter blades 226 and 227 are disposed between the said base plate and the shutter mount 223. Regions in which the blades can move are formed around them. Figure 10 is a front elevation of the blade-actuating device as viewed from the rear side of the said base plate, and in which the said base plate is omitted.

A fixed shaft 231 is located substantially on the opposite side of the shutter aperture 220 from the gear 221. One end of the shutter blade 226 is secured to the shaft 231 in such a way that the blade 226 can rotate in either angular direction. Teeth 226c formed at the other end are always in mesh with the gear 221. The shutter blade (second blade) 227 is directed oppositely to the blade 226. One end of the blade 227 is secured to a second fixed shaft 232 that is located substantially on the opposite side of the shutter aperture 220 from the gear 221. The blade 227 can rotate about the shaft 232 in either angular direction. The other end of the blade 227 has teeth 227c like the shutter blade 226. The blades 226 and 227 have edge portions 226a and 227a, respectively, which form an aperture.

An idle gear 242 which has a larger diameter and a larger number of teeth than the gear 221 is disposed near the teeth 227c of the shutter blade 227 and the gear 221. The idle gear 242 is in mesh with the gear 221 and the teeth 227c. A switch 244 for detecting the operation of the

blades 226 and 227, utilizing the rotation of the idle gear 242, is disposed near the idle gear 242. The switch 244 includes a switch contact 247 wound around the fixed shaft 233. The contact 247 has elasticity and conducts electricity. One
5 end of the switch contact 247 is in contact with a contact pin 249. The other end of the switch contact 247 can make resilient contact with a driving pin 251 extending upright from the idle gear 242 and also with a contact pin 253 extending upright from the shutter mount 223.

10 When the shutter blade 227 is in its fully closed position, the driving pin 251 on the idle gear 242 moves the switch contact 247 away from the contact pin 253. When the blade 227 is rotated to open the shutter, the pin 251 is rotated in a counter-clockwise direction to bring the switch contact
15 247 into contact with the pin 253. The idle gear 242 has more teeth than the teeth 227c of the blade 227. For this reason, the idle gear 242 rotates through an angle less than 360° when the blade 227 is rotated to its fully open position.

The operation of the sixth embodiment is now described.
20 The known control circuit (not shown) operates to deliver signals of two phases for energizing the two coils (not shown) of the motor (not shown) with two polarities. Then the stators (not shown) of the motor are excited to rotate the rotor of the motor in a clockwise direction. Then, the gear 221
25 rotates the shutter blade 226 in mesh with the teeth 226c about

the fixed shaft 231 in a counter-clockwise direction.
At this time, the gear 221 drives the idle gear 242
in a counter-clockwise direction. The idle gear 242
rotates the blade 227 whose teeth 227_c are in mesh with
5 the gear 242 in a clockwise direction. Thus, the edge
portions 226_a and 227_a of the blades 226 and 227 gradually
open the shutter aperture 220.

When the gear 221 begins to rotate the idle gear 242,
the driving pin 251 turns in a counter-clockwise direction
10 to bring the switch contact 247 into contact with the contact
pin 253. This actuates the switch 244, which then delivers a
signal to the control circuit (not shown). This signal is
used as a reference for determining the starting point or for
a counting operation. Since the idle gear 242 rotates within
15 360°, it is unlikely that the driving pin 251 makes one
revolution and again makes contact with the switch contact
247, damaging the contact 247.

After the shutter aperture 220 has been opened, the
exposure is controlled according to the combination of
20 the aperture and the exposure time, using the aforementioned
signal as a reference. When the desired value is reached,
the known control circuit transmits signals to the said two
coils to reverse the rotor. The rotor is then momentarily
reversed. The gear 221 rotates the shutter blades 226 and 227
25 about the fixed shafts 231 and 232, respectively, to close

the shutter aperture 220. At this time, the idle gear 242 returns to the illustrated original position. The driving pin 251 moves the switch contact 247 away from the contact pin 253 de-actuate the switch 244.

5 In this way, the switch 244 can be actuated from the idle gear 221 via only one member, i.e. the idle gear 242. The resulting mechanical error can be reduced as compared with the error which would otherwise be produced. The blades can be adequately controlled at more precise timing.

10 In the sixth embodiment, the shutter blades also act as a diaphragm. The sixth embodiment, however, can also be applied to blades which function only as a diaphragm or only as a shutter.

 Also in the sixth embodiment, the motor is a stepper
15 motor, but other motors, such as an ultrasonic motor, may be employed provided that their rotation can be controlled at will using a control circuit.

 In the sixth embodiment, the transmission system consists of a smaller number of components, thus reducing mechanical
20 error. Moreover, the switch is actuated at more precise timing, thereby appropriately controlling the operation of the blades.

 A seventh embodiment of the invention is hereinafter described with reference to Figure 11 of the drawings. In this
25 embodiment, a motor is employed which is the same as that

illustrated in Figure 5 and which for this reason will not be described further.

Referring to Figure 11, a shutter mount 323 is spaced a given distance from the rear surface of the base plate (not shown) of the stepper motor (not shown). Shutter blades 326 and 327 are disposed between the said base plate and the mount 323. Regions in which the blades can move are formed around them. Figure 11 is a front elevation of the blade-actuating device as viewed from the rear side of the said base plate, and in which the said base plate is omitted.

A first fixed shaft 331 is located substantially on the opposite side of the shutter aperture 320 from the gear 321. One end of a first shutter blade 326 is secured to the shaft 331 so as to be rotatable in either angular direction. Outer teeth 326c which are always in mesh with the gear 321 are formed at the other end of the blade 326. A second shutter blade 327 is directed oppositely to the blade 326. One end of the blade 327 is mounted on a second fixed shaft 332 so as to be rotatable in either angular direction. The shaft 332 is also located substantially on the opposite side of the shutter opening 320 from the gear 321. Inner teeth 327c which are kept in mesh with the gear 321 are formed at the other end of the blade 327. The blades 326 and 327 are provided with

edge portions 326a and 327a, respectively, which form an aperture.

Since the outer teeth 326c of the blade 326 mesh with the gear 321 while rotating about the fixed shaft 331, the centre of the pitch circle of the outer teeth 326c lies at the centre of the shaft 331. The radius of the pitch circle is the distance L_1 between the pitch circle and the centre of the shaft 331. The inner teeth 327c of the blade 327 also mesh with the gear 321 while rotating with the fixed shaft 332 and, therefore, the centre of the pitch circle of the inner teeth 327c is situated at the centre of the shaft 332. The radius of this pitch circle is the distance L_2 between the pitch circle and the centre of the shaft 332., The distance L_1 is set equal to the distance L_2 .

The operation of the seventh embodiment is now described. The known control circuit (not shown) operates to deliver signals of two phases for energizing the two coils (not shown) of the motor with two polarities. Then, the stators (not shown) of the motor are excited to rotate the rotor of the motor in a clockwise direction. The gear 321 rotates the shutter blade 326 in mesh with the teeth 326c about the fixed shaft 331 in a clockwise direction.

At the same time, the gear 321 rotates the shutter blade 327 whose inner teeth 327c are in mesh with the gear 321 about the shaft 332 in a counter-clockwise direction, so that

the edge portions 326a and 327a of the blades 326 and 327 gradually open the shutter aperture 320.

Although the blades 326 and 327 are rotated by the same gear 321 simultaneously in this way, they move toward or away from each other at the same speed, because the radius L_1 of the pitch circle of the outer teeth 326c is equal to the radius L_2 of the pitch circle of the inner teeth 327c. Therefore, the amounts of movement made on opposite sides of the shutter opening 320 do not differ. Consequently, the blades 326 and 327 are prevented from angularly moving through different angles, or if they move through different angles, the effects of the inequality between the two amounts of movement can be eliminated.

The exposure is controlled according to the combination of the aperture and the exposure time. When the desired value is reached, the known control circuit delivers signals to the said two coils for causing the coils to reverse the rotor. Then, the rotor is momentarily reversed. The gear 321 rotates the blades 326 and 327 about the shafts 331 and 332, respectively, to close the shutter aperture 320.

In the seventh embodiment, the shutter blades act also as a diaphragm. The seventh embodiment, however, can also be applied to blades which function only as a diaphragm or as a shutter.

Also in the above example, the radius L_1 of the pitch

circle of the outer teeth 326c of the shutter blade 326 is set equal to the radius L_2 of the pitch circle of the inner teeth 327c of the shutter blade 327, but this is not essential to the present embodiment. The fixed shafts 331 and 332 may be located at positions which are close to each other but renders the difference between the two amounts of movement practically acceptable. The inequality between the two amounts of movement made by the blades 326 and 327 makes the shape of the aperture asymmetric, and renders the changes in the areas of the apertures formed near the centre of the opening by the blades different. To accommodate these asymmetric factors, the edge portions 326a and 327a may be made different in shape.

Further in the seventh embodiment, the fixed shafts 331 and 332 are located at different positions. These two shafts may be located at the same position and made common. Also in this case, the edge portions 326a and 327a may be made different in shape to compensate for the asymmetry of the shape of the aperture caused by the inequality between the amounts of movement made by the blades 326 and 327, as well as for the inequality between the changes in the areas of the apertures created by the blades. In consequence, the effects of the inequality between the amounts of movement made by the blades 326 and 327 can be reduced.

Furthermore in the seventh embodiment, the motor is

a stepper motor but other motors, such as an ultrasonic motor, may be employed provided that their rotation can be controlled at will using a control circuit.

5 In the case of the seventh embodiment, the blades can be driven at positions which are as remote as possible from the axes of rotation of the blades. Consequently, the effects of the rattle produced by the clearances between interfitting portions and the effects of inertia are reduced. Hence, the responsiveness of such a device is
10 good, while the exposure can be controlled accurately.

Since the axes of rotation, the motor, and the gear are evenly distributed on opposite sides of the shutter opening, the arrangement of the lens as viewed from the whole camera can be prevented from becoming unusual. Furthermore,
15 the device is made up of a fewer number of components. Hence, the cost can be reduced.

Additionally, the two shutter blades move toward or away from each other at the same speed, because the radius of the pitch circle of the outer teeth of one shutter blade
20 is equal to the radius of the pitch circle of the inner teeth of the other shutter blade. Consequently, it is unlikely that the shutter opening is closed or opened in an asymmetrical manner, resulting in a decrease in the accuracy.

Another advantage arises from the fact that the two
25 shutter blades are driven directly by one gear. That is,

the shutter opening can be opened and closed quickly.

Further, the responsiveness can be improved.

C L A I M S

1. A motor-driven blade device for controlling the size of an aperture comprising a motor which can be rotated both clockwise and counter-clockwise; a drive gear which is driven by the motor and which is disposed on one side of an aperture; at least one fixed shaft which is disposed on the opposite side of the aperture; and a plurality of blades each of which is rotatably mounted on a said fixed shaft for clockwise and counter-clockwise rotation about the latter to control the size of the aperture; each of the blades being driven, directly or indirectly, by the drive gear.
2. A motor-driven blade device as claimed in claim 1 in which the motor is an electric motor which is arranged to be driven clockwise and counter-clockwise in accordance with a control signal from an electronic circuit.
3. A motor-driven blade device as claimed in claim 1 or 2 in which at least one of the blades has teeth which are in mesh with the teeth of the drive gear.
4. A motor-driven blade device as claimed in any preceding claim in which at least one of the blades has a drive connection with the said one blade.



* C L M S *

5. A motor driven blade device as claimed in claim 4 in which the drive connection comprises a lever which is rotatably mounted on the fixed shaft of the said one blade and which has a pin and slot connection with each of the blades.
6. A motor-driven blade device as claimed in claim 3 in which there is at least one further gear which is driven by the drive gear, at least one said blade having teeth which are in mesh with the teeth of the or a further gear.
7. A motor-driven blade device as claimed in any preceding claim in which each of the blades is driven from the drive gear by way of a drive transmission comprising a plurality of parts, adjusting means being provided for relatively adjusting said parts so as to adjust the phase relationship between the motor and the blades.
8. A motor-driven blade device as claimed in claim 7 in which the said parts comprise a driving lever having teeth in mesh with the teeth of the drive gear, the driving lever being mounted on one of a plurality of fixed shafts so as to be rotatable in opposite angular directions, and a transmission lever mounted on the last-mentioned fixed shaft so as to be rotatable in opposite angular directions, the transmission lever acting to transmit rotary motion from the driving lever to the blades.



9. A motor-driven blade device as claimed in claim 2 or any claim dependent thereon in which there is an optical sensor which detects movement of a blade, the optical sensor being arranged to produce an output signal which controls the operation of the electronic circuit.

10. A motor-driven blade device as claimed in claim 9 in which the electronic circuit is arranged to use the said output signal to find the time at which blade operation starts, or to check whether the said operation is proceeding satisfactorily, or for a counting operation.

11. A motor-driven device as claimed in claim 2, or in any of claims 3-8 when dependent upon claim 2, in which there is a switch which is opened and closed in dependence upon the rotation of the drive gear or of means driven thereby, the switch controlling the operation of the electronic circuit.

12. A motor-driven device as claimed in claim 11 in which the switch is actuated by an idle gear which is in mesh with the drive gear, the idle gear having a larger diameter and a larger number of teeth than the drive gear.

13. A motor-driven blade device as claimed in claim 3 in which a first blade has external teeth in mesh with the drive gear and a second blade has inner teeth in mesh with the drive gear.

14. A motor-driven blade device as claimed in claim 13 in which the arrangement is such that the difference between the distance of the said inner teeth from the centre of the



shutter aperture and the distance of the external teeth from the said centre is such as to make the change in the area of the aperture formed by the first-mentioned blade at the said centre substantially equal to the change in the area of the aperture formed by the second blade at the said centre.

15. A motor-driven blade device substantially as hereinbefore described with reference to and as shown in Figures 1-4; 5-7; 8 and 9; 10 or 11.

16. A camera provided with a device as claimed in any preceding claim.

17. A device for activating the shutter blades of a motor-driven shutter, comprising: an electric motor which can be rotated either forwardly or reversely according to a control signal from an electronic circuit; at least one gear driven by the motor; fixed shafts located on the opposite side of a shutter opening from the gear; and blades which have teeth in mesh with the gear and are rotated either forwardly or reversely about the fixed shafts to define an aperture.



18. A device for activating motor-driven blades, the device having an electric motor capable of being rotated either forwardly or rearwardly according to a control signal from an electronic circuit, a gear rotated by the motor, a pair of fixed shafts located substantially on the opposite side of a shutter opening from the gear, and a pair of blades held to the shafts so as to be rotatable either forwardly or rearwardly, the gear acting to transmit rotary motion to the blades to open or close the shutter opening, said device comprising; a driving lever having teeth in mesh with the gear, the driving lever being held to one of the fixed shafts so as to be rotatable either forwardly or rearwardly; a transmission lever mounted to the fixed shaft to which the driving lever is held, the transmission lever being capable of rotating either forwardly or rearwardly, the transmission lever acting to transmit rotary motion from the driving lever to the blades; and an adjusting means mounted between the transmission lever and the driving lever for adjusting the phase relation between the motor and the blades.
19. In a device for activating motor-driven blades, the device having an electric motor which can be rotated either forwardly or rearwardly according to a control signal from an electronic circuit, a gear driven by the motor, fixed shafts located substantially on the opposite side of a shutter opening from the gear, and blades that are rotated about the



fixed shafts either forwardly or rearwardly to open or close the shutter opening, one of the blades having teeth in mesh with the gear, the improvement wherein there is provided an optical sensor which detects movement of the blades, utilizing the condition in which the teeth obstruct or pass light, and wherein the electronic circuit delivers a control signal for controlling the operation of the motor, according to the output signal from the optical sensor.

20. A device for activating motor-driven shutter blades, the device having an electric motor that can be rotated either forwardly or rearwardly according to a control signal from an electronic circuit, a gear driven by the motor, a fixed shaft located substantially on the opposite side of a shutter opening from the gear, a first blade which has teeth in mesh with the gear and is rotated about the shaft either forwardly or rearwardly to open or close the shutter opening, said device comprising; an idle gear that is in mesh with the first-mentioned gear and rotated by it through an angle less than 360° , the idler gear having a larger diameter and a larger number of teeth than the first-mentioned gear, a second blade which has teeth in mesh with the idle gear and is rotated in a direction opposite to the first blade about a second fixed shaft located substantially on the opposite side of the shutter opening from the first-mentioned gear, the second blade cooperating with the first blade to open or close the shutter opening; and a switch which detects the operation of the blades, utilizing the rotation of the idle gear.



21. A device for activating motor-driven blades,
comprising: an electric motor which can be rotated either
forwardly or rearwardly according to a control signal from
an electronic circuit; a gear driven by the motor; a first
5 fixed shaft located substantially on the opposite side of a
shutter opening from the gear; a first blade which has outer
teeth in mesh with the gear and can be rotated about the first
fixed shaft either forwardly or rearwardly; a second fixed
shaft located substantially on the opposite side of the
10 shutter opening from the gear; a second blade which has inner
teeth in mesh with the gear and is directed oppositely to the
first blade, the second blade being rotated about the second fixed
shaft in a direction opposite to the direction in which the first
blade is rotated, the first and second blades cooperating to open
15 or close the shutter opening; and a compensating means which
compensates for the difference between the distance of the inner
teeth meshing with the gear from the centre of the shutter opening
and the distance of the outer teeth meshing with the gear from
the centre of the shutter opening, to make the change in the
20 area of the aperture formed by the first blade in the centre
of the shutter opening substantially equal to the change in
the area of the aperture formed by the second blade in the
centre of the shutter opening.

