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(54) PHOTOGRAPHIC EXPOSURE CONTROL APPARATUS

(71) We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America, of 343 State Street, Rochester, New York 14650, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to photographic exposure control apparatus, and more particularly to shutter control apparatus responsive to scene light for providing an interval of exposure related to the intensity of scene light.

Cameras frequently employ shutter means which are moved from a closed to an open condition against the bias of a return spring, in response to impetus received from an impact member or impeller. When the shutter means as opened, the interval of exposure may be controlled by a retard unit, such as might include an electromagnet which operates in response to a light responsive circuit by retaining the shutter means in the open condition, or by controlling the action of a latch which retains the shutter means in the open condition. The retard unit is released upon the deactuation of the electromagnet, which permits the shutter means to close under the force of the return spring. The shutter means, once stopped and retained in the open condition, has an operational delay in restarting the movement due to mass or inertia. This delay is often compensated for by actuating the control circuit a period of time before the shutter opens, which time period is at least equal to the delay, so that the control circuit deactuates the electromagnet after an exposure interval which compensates for the delays. However, during high scene light conditions the exposure interval required for proper exposure may be very short, and the adjustment of the time delays in the system is very difficult to achieve. Moreover, when exposure apparatus

utilizing only electronic control is used, the operating structure is restricted to apparatus that allows proper switching of the timing circuitry in relation to the movement of the shutter means to the open condition.

In accordance with the present invention there is provided photographic exposure control apparatus comprising shutter means mounted for movement between open and closed positions relative to an exposure aperture, impact means mounted for movement along a path from a first position to a second position, for moving the shutter means to an open position in which it is retained whilst the impact means is in the second position, and to a third position during which the shutter means is allowed to return to its closed position, a detent mounted for movement from an active position, within the path of movement of the impact means, in which the detent retains the impact means in the second position, to an inactive position out of the path of movement of the impact means to allow the impact means to move to the third position, and a light responsive circuit for locating the detent in its active position for a period of time related to light intensity in response to light intensity below a predetermined level and for locating the detent in its inactive position in response to light intensity above said predetermined level.

In the accompanying drawings:—

Fig. 1 is an elevation of a photographic exposure control apparatus constructed according to one form of the invention, shown in the cocked position;

Fig. 2 is a schematic diagram of an electronic circuit which is suitable for controlling operation of the apparatus of Fig. 1;

Fig. 3 is a view similar to Fig. 1, but showing the apparatus in the actuated position wherein an impact member has been actuated to open shutter means and maintain the shutter means in an open condition;

Fig. 4 is a view similar to Figs. 1 and 3,

but showing the various elements in the positions they assume after the exposure interval has elapsed and the impact means has released the shutter means; and

5 Fig. 5 is a vertical section through the transducer and armature shown in Figs. 1, 3 and 4.

Because photographic cameras are well known, the present description will be directed in particular to elements forming part of or cooperating more directly with the present invention, camera elements not specifically shown or described herein being understood to be selectable from those known in the art.

Referring now to Fig. 1, there is shown one illustrative embodiment of the present invention in the form of exposure control apparatus 10 which is mounted on a camera support plate 11. The apparatus includes shutter blades 12 and 14, pivotally mounted on pins 16 and 18 respectively. The shutter blades 12 and 14 are coupled for movement in a scissor-like manner relative to an exposure aperture 20, by means of a pin 22 on the blade 12 that is received in a slot 24 of the blade 14. The blade 12 is movable against the bias of a spring 26 which is a relatively strong spring to move the shutter blades 12 and 14 rapidly from an open to a closed condition. The closed condition refers to the position of the shutter blades 12 and 14 as shown in Fig. 1, wherein the shutter blades 12 and 14 block the passage of scene light through the exposure aperture 20. In the closed position, a lug 29 on the shutter blade 12 is located in the path of movement of a moving arm 36 of an impeller 30.

As illustrated, the impeller 30 is a rocker-like member which, upon release from the position of Fig. 1, is pivoted about a pin 32 under the influence of a spring 34. Angular momentum, generated by the pivotally moving impeller 30, is transferred to the blade 12 upon impact of arm 36 and the lug 29. The momentum thus transferred moves the blades 12 and 14 to the open position. The impeller 30 defines a cut-out section 40, providing an inner cam surface 42, upon which a cam follower 44 is disposed to move. The cam follower 44 is mounted on an armature 45 mounted beneath the support plate 11. The armature 45 is a magnetically attractable element that is pivotally mounted on an adjustable screw 43, and positions the cam follower 44 so as to be received in a slot 47 in the support plate 11. Thus, the cam follower 44 will move in the slot 47 and along the cam surface 42 as the impeller 30 pivots on the pin 32. The armature 45 moves about the screw 43 under the influence of a spring 48, depending upon the state of energization of an electromagnet 46 (shown in detail in

Fig. 5). During an energized state of the electromagnet 46, a magnetic field created by the electromagnet 46 retains the armature 45 in the position of Fig. 1. During a de-energized state of the electromagnet 46, the spring 48 moves the armature 45 to the position as shown in Fig. 4.

The impeller 30 is retained in the cocked position by means of a latching lever 50 which is pivotally mounted on a pin 52 for rotational movement against the bias of a spring 54. The latching lever 50 includes a catch 56, disposed to engage an ear 59 on the arm 36, thereby retaining the impeller 30 in the cocked position of Fig. 1.

Release of the impeller 30 from the cocked position of Fig. 1, for movement under the influence of the spring 34, is effected by a three-armed release member 60, which is rotatably mounted on a pin 62. A restoring spring 61 urges the release member 60 against a stop pin 63 to retain it in the position shown in Fig. 1. One arm 64 may be external of the camera for manual actuation of the release member 60. A second arm 66 includes a contact surface 67 disposed adjacent to a similar contact surface 68 of the lever 50, and provides engagement of the contact surfaces 67 and 68 upon depression of the arm 64. A third arm 65 extends downwardly to engage a switch S1 for actuation thereof when the arm 64 is depressed.

An electronic circuit 100 which is suitable for use with the apparatus of Fig. 1, is shown in Fig. 2. The circuit 100 is energized by the closure of the switch S1 which connects a battery 102 into the circuit 100. The circuit 100 includes a trigger circuit 104, of conventional design, such as for example the well known Schmitt Trigger, which is adapted to be normally in a conductive state during average or low (for photographic purposes) scene light intensity conditions. In its conductive state, the trigger circuit 104 controls current flow through coil 106 of the electromagnet 46 or through a lamp 108, either of which may be coupled into the output of the trigger circuit 104, depending upon the position of a rotary switch S2.

The switch S2 may be for example a triple-pole, double throw switch, actuable by the release member 60, or the switch S2 may be rotary and mechanically coupled to the impeller 30 by conventional means so that as the impeller 30 pivots, the switch S2 will rotate to move wipers 105 relative to switch contacts T, R, S, A, C, and D, alternately to connect together pre-selected contacts. When the switch S2 is positioned as in Fig. 2, switch contact pairs T-R, and A-C are connected. When the wipers 105 are moved, the contact pairs R-S and C-D are individually connected; (it will be noted that the contact wiper 105 for switch contacts A-C-D is

a make-before-break wiper). When the switch contacts A-C are connected, the trigger circuit 104 controls the energization of the lamp 108, through switch contacts T-R, which may be used as warning of an existing low light condition. When the contacts R-S are made, the trigger circuit 104 controls the flow of current in the coil 106, thereby controlling energization or de-energization of the electromagnet 46, and thus the exposure interval, which will be explained later.

The choice of the exposure interval is related to selected time constants which are established by selective circuit elements in relation to the position of the switch S₂, and with the position of additional switches S₃ and S₄.

As the switches are operated, the circuit 100 establishes a voltage level related to the exposure interval for switching the trigger circuit 104 from the conductive to the non-conductive state during a variety of scene light conditions, such as for example during illumination by artificial means or during varying scene light intensity conditions. An exposure interval which is dependent upon the scene light intensity is established when a capacitor 118 is coupled in series circuit with a photocell 110 to form a conventional RC integrating circuit having a time constant dependent upon the resistance of the photocell 110 and the capacitance of the capacitor 118. Resistors 114, 116 associated with switches S₃ and S₄ and the photocell 110 also form elements of other circuits which provide for selective fixed time constants.

Initially, the switch S₂ is in the position shown in Fig. 2, and the voltage at a junction 109 depends upon the voltage divider circuit comprising the photocell 110, the variable resistor 112, and a second variable resistor 120, all of which are connectable in series circuit with the battery 102 through contacts A-C. This voltage divider circuit is adjustable through resistors 112 and 120 to provide a voltage at the junction 109 that will initially trigger the circuit 104 to the nonconductive state if the resistance of photocell 110 is low (as during a high scene light condition). On the other hand, actuation of switch S₂ to make the contacts C-D, removes the variable resistor 120 from circuit and couples the capacitor 118 in series with only the photocell 110. This combination provides a voltage at the junction 109 which triggers circuit 104 to the nonconducting state after a time interval which is variably related to the intensity of scene light. When the contacts C-D are made, and also the switch S₃ is actuated to connect resistor 114 in circuit with the capacitor 118, by for example insertion of a flash lamp unit into the camera (not shown), a fixed interval of

exposure in the order of 1/30 sec. is established by the series combination of resistor 114 and the capacitor 118. The exposure interval may be varied from the 1/30 sec. by actuation of the switch S₄, as for example during focus control for exposure at shortened distances, wherein the resistance 116 is coupled in parallel with the resistor 114 for providing time interval of exposure which is established by the parallel combination of the resistors 114 and 116 in series with the capacitor 118.

The operation of the apparatus will first be described in an electronically timed mode of operation, for exposure during average or, if desired, low scene light, and may be understood by reference to Figs. 3, 4 and 5 in conjunction with Figs. 1 and 2. Initially, an operator slightly depresses the external arm 64 which rotates the release member 60 in a clockwise direction about the pin 62. As the release member 60 rotates, the switch S₁ is closed by the arm 65, and battery power is applied to the circuit 100. The switch contacts A-C and R-T are as shown in Fig. 2, i.e., the lamp 108 is in circuit with the trigger circuit 104 and a voltage level at the junction 109 is established which depends upon the resistances of the photocell 110 and the resistors 112 and 120. The relative values of resistance may be adjusted (the resistors 112 and 120 being variable) such that if scene light is low, the resistance of the photocell 110 will be high and consequently the voltage level at the junction 109 may be set so that the conduction of the trigger circuit 104 is not affected and the lamp 108 is energized to indicate that a low-light condition exists. At this point the operator has the option of inserting a flash lamp unit to establish the fixed exposure interval by the closure of the switch S₃. The operator may continue to depress the release member 60 and initiate an exposure, however, due to the existing low light condition the exposure interval may be too long for a hand-held camera. In the event that the scene light is average the voltage level at the junction 109 will be such that the lamp will not become energized upon the initial depressing of the arm 64, and the operator may continue to depress the release member 60. As seen from Figs. 1, 3 and 4, the continued rotational movement of the release member 60 brings the contact surfaces 67 and 68 together and the latching lever 50 is rotated in a counterclockwise direction about the pivot pin 52, releasing the ear 59 from the catch 56. The spring 34 pivots the impeller 30 in a counterclockwise direction bringing the arm 36 into engagement with the lug 29, the impact of which moves the pin 22 in the slot 24 and the shutter blades 12 and 14 open in scissor-like fashion against the bias of the spring 26.

As previously suggested, the impeller may be coupled to the switch S_2 so that the movement of the impeller 30 rotates the switch S_2 to make the switch contacts C-D to disconnect the variable resistor 120 from the photocell 110, capacitor 118 and variable resistor 112, thereby initiating the timing by closing a path for current flow from the battery 102 to charge the capacitor 118 through the photocell 110, and to make the contacts R-S coupling the electromagnet 46 in circuit with the trigger circuit 104. The magnetic field of the electromagnet 46 holds the armature 45 as the impeller pivots; therefore, the cam follower 44 moves along the cam surface 42 and abuts an angle 49, arresting the movement of the impeller 30 with the arm 36 engaging the lug 29. Consequently, the shutter blades 12 and 14 are held in the open position as shown in Fig. 3. When the voltage level at the junction 109 reaches a predetermined level, the trigger circuit 104 is switched from the conducting to the nonconducting state, and the flow of current through the coil 106 is terminated thereby deenergizing the electromagnet 46. When the electromagnet 46 deenergizes, the magnetic field collapses and the armature 45 is released for movement under the influence of the spring 48, removing the cam follower 44 from the angle 49. The disengagement of the cam follower 44 from the angle 49 release the impeller 30 for continued movement in the counterclockwise direction, under the influence of the spring 34, and the arm 36 releases the shutter blade 12; the shutter blades 12 and 14 then close under the influence of the spring 26 as shown in Fig. 4.

The operation of the apparatus in the electronically time mode as previously described has an inherent delay in operation of from 3.5 to 6 msec. due to inertia of the moving parts. Therefore, in order to accomplish an exposure for an interval in the order of for example 8 msec. (1/125 sec.), the electronic circuitry must initiate the release of the impeller 30 from the lug 29 prior to the actual desired exposure termination point of time, thereby taking into account the inertia delay. For the example given, the release initiation may be at a time 4 msec. prior to the end of the exposure. However, during high scene light intensity conditions, such as for example 2,000 foot lamberts (the exposure aperture dimensions, film speed, etc. being constant), an exposure interval of approximately 4 msec. 1/250 sec. may be required. Thus it may be seen that the exposure interval is equal to or shorter than the inherent inertia delay in the system. For this purpose, the apparatus provides for an exposure interval during high scene light conditions which is not subject to the inertia delay by providing a fixed shutter speed hav-

ing an interval of time which may be equal to or less than the inertia delay.

The operation of the apparatus during high scene light conditions, however, is similar to that of the average scene light conditions. During high scene light conditions the resistance of the photocell 110 is low and the resistance of variable resistor 120, in parallel circuit with the capacitor 118, has been preset to a value which establishes an initializing charge on the capacitor 118. During high scene light intensity, the initial charge is equal to or above the voltage level required to switch the trigger circuit 104 to the nonconducting state. As a result of this initializing charge, the trigger circuit 104 is immediately switched to the nonconducting state as the switch S_2 is rotated to make switch contacts C-D. The electromagnet 46 is accordingly de-energized during the initial pivotal motion of the impeller 30. With the electromagnet 46 initially de-energized, the spring 48 biases the armature 45 clockwise, and the cam follower 44 does not arrest the motion of the impeller 30 to retain the shutter blades 12 and 14 in the open position. Therefore, automatically after impact of the arm 36 and the shutter blade 12, the arm 36 moves beyond the shutter blade 12, as shown in Fig. 4, and the spring 26 rapidly closes the shutter blades 12 and 14. Thus a fixed shutter speed is established which is dependent upon the engagement of the impeller 30 with the lug 29, and the strength of the spring 26.

WHAT WE CLAIM IS:—

1. Photographic exposure control apparatus comprising shutter means mounted for movement between open and closed positions relative to an exposure aperture, impact means mounted for movement along a path from a first position to a second position, for moving the shutter means to an open position in which it is retained whilst the impact means is in the second position, and to a third position during which the shutter means is allowed to return to its closed position, a detent mounted for movement from an active position, within the path of movement of the impact means, in which the detent retains the impact means in the second position, to an inactive position out of the path of movement of the impact means to allow the impact means to move to the third position, and a light responsive circuit for locating the detent in its active position for a period of time related to light intensity in response to light intensity below a predetermined level and for locating the detent in its inactive position in response to light intensity above said predetermined level.

2. Photographic exposure control apparatus according to Claim 1, wherein the

As previously suggested, the impeller may be coupled to the switch S_2 so that the movement of the impeller 30 rotates the switch S_2 to make the switch contacts C-D to disconnect the variable resistor 120 from the photocell 110, capacitor 118 and variable resistor 112, thereby initiating the timing by closing a path for current flow from the battery 102 to charge the capacitor 118 through the photocell 110, and to make the contacts R-S coupling the electromagnet 46 in circuit with the trigger circuit 104. The magnetic field of the electromagnet 46 holds the armature 45 as the impeller pivots; therefore, the cam follower 44 moves along the cam surface 42 and abuts an angle 49, arresting the movement of the impeller 30 with the arm 36 engaging the lug 29. Consequently, the shutter blades 12 and 14 are held in the open position as shown in Fig. 3. When the voltage level at the junction 109 reaches a predetermined level, the trigger circuit 104 is switched from the conducting to the nonconducting state, and the flow of current through the coil 106 is terminated thereby deenergizing the electromagnet 46. When the electromagnet 46 deenergizes, the magnetic field collapses and the armature 45 is released for movement under the influence of the spring 48, removing the cam follower 44 from the angle 49. The disengagement of the cam follower 44 from the angle 49 release the impeller 30 for continued movement in the counterclockwise direction, under the influence of the spring 34, and the arm 36 releases the shutter blade 12; the shutter blades 12 and 14 then close under the influence of the spring 26 as shown in Fig. 4.

The operation of the apparatus in the electronically time mode as previously described has an inherent delay in operation of from 3.5 to 6 msec. due to inertia of the moving parts. Therefore, in order to accomplish an exposure for an interval in the order of for example 8 msec. (1/125 sec.), the electronic circuitry must initiate the release of the impeller 30 from the lug 29 prior to the actual desired exposure termination point of time, thereby taking into account the inertia delay. For the example given, the release initiation may be at a time 4 msec. prior to the end of the exposure. However, during high scene light intensity conditions, such as for example 2,000 foot lamberts (the exposure aperture dimensions, film speed, etc. being constant), an exposure interval of approximately 4 msec. 1/250 sec. may be required. Thus it may be seen that the exposure interval is equal to or shorter than the inherent inertia delay in the system. For this purpose, the apparatus provides for an exposure interval during high scene light conditions which is not subject to the inertia delay by providing a fixed shutter speed hav-

ing an interval of time which may be equal to or less than the inertia delay.

The operation of the apparatus during high scene light conditions, however, is similar to that of the average scene light conditions. During high scene light conditions the resistance of the photocell 110 is low and the resistance of variable resistor 120, in parallel circuit with the capacitor 118, has been preset to a value which establishes an initializing charge on the capacitor 118. During high scene light intensity, the initial charge is equal to or above the voltage level required to switch the trigger circuit 104 to the nonconducting state. As a result of this initializing charge, the trigger circuit 104 is immediately switched to the nonconducting state as the switch S_2 is rotated to make switch contacts C-D. The electromagnet 46 is accordingly de-energized during the initial pivotal motion of the impeller 30. With the electromagnet 46 initially de-energized, the spring 48 biases the armature 45 clockwise, and the cam follower 44 does not arrest the motion of the impeller 30 to retain the shutter blades 12 and 14 in the open position. Therefore, automatically after impact of the arm 36 and the shutter blade 12, the arm 36 moves beyond the shutter blade 12, as shown in Fig. 4, and the spring 26 rapidly closes the shutter blades 12 and 14. Thus a fixed shutter speed is established which is dependent upon the engagement of the impeller 30 with the lug 29, and the strength of the spring 26.

WHAT WE CLAIM IS:—

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2. Photographic exposure control apparatus according to Claim 1, wherein the



impact means comprises a member, pivotally mounted for movement to engage the shutter means.

3. Photographic exposure control apparatus according to Claim 2, wherein the light responsive circuit includes a transducer and an armature, the armature being responsive to actuation of the transducer for retaining the pivotally mounted member in the second position, and being responsive to deactuation of the transducer for releasing the pivotally mounted member for movement to the third position.

4. Photographic exposure control apparatus according to Claim 3, wherein the transducer holds the armature in a position in

which it engages the pivotally mounted member and, when the pivotally mounted member reaches the second position, arrests the motion thereof.

5. Photographic exposure control apparatus according to Claim 4 wherein means are provided for urging the armature out of engagement with the pivotally mounted member.

6. Photographic exposure control apparatus according to Claim 1, substantially as herein before described with reference to, and as shown in, the accompanying drawings.

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