

PATENT SPECIFICATION

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(54) 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:—

This invention relates to an automatic exposure control apparatus for controlling film exposure in a photographic camera.

It is an object of the present invention to provide an automatic exposure control apparatus which is of simple design and economical to manufacture.

In accordance with the present invention, there is provided an exposure control apparatus comprising a photosensitive element responsive to scene illumination, an electromechanical light regulating member driven by pulses to establish a correct exposure value and to control the light falling on the photo-sensitive element, the member being spring biased towards a minimum light passing rest position, and a control circuit for modifying the pulses in accordance with the light impinging upon the element.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a portion of a photographic camera having an automatic exposure control apparatus in accordance with the teachings of the present invention including a schematic diagram of a circuit for controlling such apparatus;

Figure 2 is a perspective view of a portion of the camera shown in Figure 1, illustrating an aperture plate of the exposure control apparatus in a light blocking position and in a particular light unblocking position; and

Figure 3 illustrates, for various scene light conditions, signal waveforms which

appear at particular terminals in the control circuit shown in Figure 1.

As photographic cameras are well known, the present description will be directed in particular to camera elements forming part of, or co-operating more directly with, the exposure control apparatus disclosed herein. It is to be understood camera elements not specifically shown or described may take various forms well known to those having skill in the art.

There is shown schematically in Figure 1, a camera 10 having an objective lens 12 for receiving and directing light from a scene to be photographed along an optical axis 14 onto a photographic film F, which is located at the camera focal plane. Disposed between lens 12 and film F is a pivotably mounted light regulating member or aperture plate 16 of the type having a variable width aperture or slot 17 for controlling the amount of image forming light reaching film F. Member 16, while controlling the amount of scene light reaching film F, simultaneously controls, by means of a variable slot 18, the light impinging on a photo-sensitive element 19, which regulates the electrical network 20 also shown in Figure 1.

Photo-sensitive element 19 may be any one of a number of such elements conventionally used as light-measuring devices in photographic apparatus. In the present embodiment, a photoconductive element is used which has a resistance inversely proportional to the level of light incident thereon. As is known in the art, photo-sensitive elements of this type respond faster to light level changes going from a dark or dull condition to a bright light condition than when the light changes from a bright to a dark level. It is for this reason that it is desirable to maintain photo-sensitive element 19 in a dark environment during periods when camera 10 is not being used. Therefore, member 16 is biased by suitable biasing means such as a spring 21, in a direction to block light, as

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shown by the dashed lines in Figure 2, with respect to element 19 (and film F).

Member 16 which is mounted for pivotal movement about a pivot 22, is mechanically coupled to a motor or other electro-mechanical transducer 23 (Figure 1) of the type generally found in movable meters. Motors of this type are movable in response to a magnetic force of a localized magnetic field, which is produced by a current passing through the motor. When this current is produced motor 23 functions to drive aperture member 16 in a direction opposite to the bias force produced by spring 21 into a light unblocking position with respect to element 19 (and film F).

Electrical network 20 includes a source of electrical power such as a battery 26 for supplying power through an actuable control switch S_1 to a conventional astable (free running) multivibrator 28 comprising transistors 30 and 32, respectively. Switch S_1 is closed by means known in the art such as a shutter release member (not shown) actuable by a camera user for initiating the film exposure interval.

Transistor 30 includes emitter, base, and collector electrodes 30a, 30b and 30c, respectively, electrode 30a being connected to electrical ground 31, electrode 30b being connected to a terminal 33 connecting one electrode of a capacitor 34 to a biasing resistor 36, and electrode 30c being connected to a terminal 35 connecting one electrode of a capacitor 38 to a resistor 40.

Transistor 32 having emitter, base, and collector electrodes 32a, 32b and 32c, respectively is connected in a manner similar to that of transistor 30, with electrode 32a being connected to ground 31, electrode 32b being connected to a terminal 41, which connects the other electrode of capacitor 38 to a biasing resistor 42, as shown, and collector electrode 32c being connected to multivibrator output terminal 43, which connects the other electrode of capacitor 34 as shown to a resistor 44.

When transistor 30 is turned ON, transistor 32 is turned OFF and vice versa. The duration of the ON time of transistor 30 (the OFF time of transistor 32) is determined by the product of the resistance of resistor 42 and the capacitance of capacitor 38 and the duration of the ON time of transistor 32 (the OFF time of transistor 30) is related to the product of the resistance of the resistor 36 and capacitance of the capacitor 34. The aforementioned multivibrator parameters are selectively varied such that the multivibrator output signal that appears at multivibrator output terminal 43 consists of a train of pulses, shown representatively in Figure 3(a), each pulse having a relatively

long positive voltage portion followed by a relatively short zero voltage portion.

Responsive to the voltage signal at terminal 43 is a light sensitive modifying circuit 46 for positioning light regulating member 16 in its light unblocking position in accordance with the intensity of scene light. Modifying circuit 46 comprises photosensitive element 19 which, in this embodiment, is a photoconductor connected between terminal 43 and a terminal 48, to which is also connected a timing capacitor 50 and the input of a voltage sensitive trigger circuit 52. Connected in parallel with element 19 is a diode 54 as shown.

Element 19 and capacitor 50 form an RC integrator circuit which produces a generally periodic signal at terminal 48 in the form of a modified sawtooth waveform each pulse in the sawtooth being representative of the integral of one of the pulses in the multivibrator output signal appearing at terminal 43. Because of the aforementioned relationship between the resistance of element 19 and scene light intensity, the amplitude of each pulse in the signal at terminal 48 is related to the intensity of scene light.

Examples of the type of signals which appear at terminal 48 are shown in Figures 3(b) to 3(d) for various levels of illumination of the element 19. Specifically, the voltage signal shown in Figure 3(b) is for a dark or relatively low illumination level, the signal shown at Figure 3(c) is for an intermediate illumination level, and the signal shown in Figure 3(d) is that signal produced when the element 19 is in a relatively bright light condition. The positive slopes and amplitude of the respective signals vary as shown because as the light level increases, the electrical resistance of photoconductor 19 decreases, thereby shortening the time constant of the RC integrator circuit, which condition permits capacitor 50 to be charged more rapidly. When the signal at terminal 43 drops to zero, that is, the zero voltage portion corresponding to when control transistor 32 is turned ON, capacitor 50 discharges rapidly through diode 54, which condition is represented by the negative slopes of the curves illustrated in Figure 3(b) to 3(d).

Trigger circuit 52 may be of the type known in the art as a comparator circuit and, more specifically as a Schmitt trigger circuit or the like having a normally non-conducting input stage and an output stage of the type which is normally conducting. So long as the signal appearing at its input, that is, terminal 48, is below a predetermined level, the input stage of trigger circuit 52 is OFF while its output stage is ON. When its input signal exceeds

(this predetermined percentage, the output stage is turned OFF. The application of a pulsed signal to the input stage, exceeding in part the predetermined level, provides a series of output pulses from the circuit 52.

To illustrate more clearly the operation of trigger circuit 52, there is shown, for illustrative purposes only, superimposed on the curves of Figure 3(b) to 3(d) a curve 56 representative of the threshold or input trigger level V_T for circuit 52. The threshold level has been selected as being, for example, approximately 50 percent of the output voltage of battery 26. It shall be understood that other threshold levels may be selected in accordance with practice and procedures well known in the art.

It can be seen that the input signal under a low light condition, that is, the signal illustrated in Figure 3(b) is inadequate for turning OFF the output stage of trigger circuit 52, but that at least a portion of the signals represented in Figures 3(c) and 3(d) are sufficient for turning the output thereof OFF. With the latter two input signals, the pulsed output signal from trigger circuit 52 is as shown in Figures 3(e) and 3(f), respectively. It should be noted from the latter two figures that the greater the intensity of light impinging on photosensitive element 19, the longer the output of circuit 52 is OFF, i.e. the shorter are the current pulses therefrom, but that under a low light condition, i.e., when its input is not turned ON, the magnitude of the output signal from circuit 52 is constant providing a single pulse.

More specifically, consider the operation of light sensitive circuit 46 when light regulating member 16 is positioned in its light blocking position, a condition obtained by spring 21 urging or biasing the member 16 in the clockwise direction to the position shown by the dashed lines of Figure 2. In this position, the resistance of element 19 is very high, thereby creating a relatively long time constant for the RC integrator circuit so that the voltage signal appearing across capacitor 50 is of the type shown in Figure 3(b), that is, ineffective for turning ON the input stage of trigger circuit 52. When this condition exists, the output stage of circuit 52 is continuously ON and current flows through motor 23 and variable resistor 57. As this happens, motor 23 functions to drive light regulating member 16 in the counterclockwise direction towards its light unblocking position counter to the bias force produced by spring 21. As this occurs, scene light is permitted to impinge on element 19 and film F, which condition functions to decrease the resistance of the element 19, thereby decreasing the time constant of the

RC integrator circuit. Correspondingly capacitor 50 charges more rapidly. As additional light is permitted to impinge on the element 19 capacitor 50 charges even more rapidly and the amplitude of the signal appearing at terminal 48 increases more rapidly. Eventually member 16 is moved relative to optical axis 14 such that the threshold voltage of trigger circuit 52 is reached and exceeded during each positive voltage portion of the pulse train appearing at terminal 43. When this happens, the output stage of trigger circuit 52 is turned OFF and current is prevented from flowing through motor 23, which condition causes the drive force associated therewith to fall to zero during that portion of each cycle that the threshold voltage is exceeded.

As the element 19 (and film F) are exposed to increased amounts of scene light which are sufficient to turn the output of trigger circuit 52 OFF, the average drive force urging the member 16 in the counterclockwise direction may still be greater than the continuous bias force produced by spring 21 (this, of course, depends on the brightness level of the scene light) so that member 16 may continue to be driven such that apertures 17 and 18 are increasingly aligned with optical axis 14, thereby permitting increased amounts of scene light to impinge, respectively, on photosensitive element 19 and film F. Eventually, however, member 16 is driven to a "null" position, that is, to a position wherein the output of trigger circuit 52 is turned OFF on average a period of time such that the drive force produced by motor 23 is equal and opposite in direction to the continuous bias force produced by spring 21. In this position, film F is exposed to an amount of light adequate to obtain a high quality photograph. It will be understood that when member 16 is driven into its null position, the member 16 has a slight vibration due to the ON/OFF characteristics of the pulsed output of circuit 52. This enables the light regulating member to overcome static friction, yet does not perceptibly affect the picture-taking capability of the lens aperture.

Electrical power is removed from electrical network 20 when actuable switch S_1 is opened by means known in the art such as completion of actuation of a shutter mechanism (not shown). When this occurs, current ceases flowing through motor 23 and member 16 is returned to its closed position under the influence of spring 21. As a result, when camera 10 is not being utilized, or the shutter is closed and the camera user is aiming the camera for another photograph, photosensitive element 19 is covered and is in a darkened condition. When camera 10 is actuated,

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 5 element 19 is always operated in an environment which subjects the element to increased amounts of scene light rather than from a bright to a low light environment. A photoconductor's response is faster when subjected to increased amounts of light, this ensures a rapid, as well as a more accurate response since the photoconductor is exposed to light pattern changes which are always variable in the same direction.

10 The invention has been described in detail with particular reference to a preferred embodiment thereof, but it will be understood that variations and modifications can be effected within the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:—

20 1. An exposure control apparatus comprising a photosensitive element responsive to scene illumination, an electromechanical light regulating member driven by pulses to establish a correct exposure value and to control the light falling on the photosensitive element, the member being spring biased towards a minimum light passing rest position, and a control circuit for modifying the pulses in accordance with the light impinging upon the element.

25 2. An apparatus as claimed in Claim 1 in which the light regulating member comprises a pivotably mounted plate

35 having a first tapered aperture alignable with an optical axis of a camera and a second tapered aperture alignable with the photosensitive element for regulating the light impinging thereon.

3. An apparatus as claimed in Claim 1 or 2 in which the photosensitive element is a photoconductor.

4. An apparatus as claimed in any preceding claim, wherein the light regulating member comprises a motor coupled thereto to drive the same against spring bias from its rest position.

5. An apparatus as claimed in any preceding claim comprising a pulse generator for providing a train of pulses and wherein the photosensitive element is part of an RC circuit modifying the characteristics of the output of the pulse generator.

6. An apparatus as claimed in Claim 5, wherein the response of the photosensitive element determines the periodic peak voltage in the RC circuit, and level sensing means are provided for sensing the said periodic voltage and for terminating each pulse when the voltage rises to a predetermined level.

7. An exposure control apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.

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2. An apparatus as claimed in Claim 1 in which the light regulating member comprises a pivotably mounted plate

having a first tapered aperture alignable with an optical axis of a camera and a second tapered aperture alignable with the photosensitive element for regulating the light impinging thereon.

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