

PATENT SPECIFICATION

(11) 1 521 492

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- (21) Application No. 48335/75 (22) Filed 25 Nov. 1975 (19)
- (31) Convention Application No. 526490 (32) Filed 25 Nov. 1974 in
- (33) United States of America (US)
- (44) Complete Specification Published 16 Aug. 1978
- (41) INT CL² G03B 7/08 15/04
- (2) Index at Acceptance
- | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| G2A | 401 | 403 | 454 | 464 | 474 | 483 | 489 | 506 |
| | 607 | 640 | 661 | 701 | 704 | 706 | 711 | 712 |
| BK | | | | | | | | |



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(54) PHOTOGRAPHIC EXPOSURE CONTROL MEANS

(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 automatic exposure control for both flash and ambient light photography.

An object of the present invention is to provide an improved method and apparatus for regulating exposure during flash photography.

A further object of the present invention is to provide an apparatus for controlling flash exposures that integrates ambient illumination as well as flash illumination during a flash picture-taking sequence.

According to the present invention there is provided a photographic exposure control means, comprising adjustable aperture means, flash bulb ignition means, photo-responsive means arranged to receive light from a flash-illuminated scene to be photographed after attenuation by the aperture means and to produce a first signal representative thereof, signal producing means for producing a second signal representative of the instantaneous value of the illumination produced by the flash bulb and aperture control means for terminating the adjustment of the aperture when the ratio of the first and second signals reaches a predetermined value.

There is further provided a means as above, wherein the signal producing means comprises a photoresponsive means arranged to receive, by a substantially direct path, illumination produced by the flash bulb, to provide the second signal.

Also there is provided a photographic camera including photographic exposure control means as above.

There is further provided a method of controlling a photographic exposure, comprising the steps of igniting a flash bulb, producing a first signal representative of the instantaneous value of the light received from a scene to be photographed and illuminated by the flash bulb, the light being attenuated by an adjustable aperture, producing a second signal representative of the instantaneous value of the illumination from the flash bulb, and terminating adjustment of the aperture when the ratio of the first and second signals reaches a predetermined value.

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

Figure 1a is a graph of the illumination from a typical photographic flash lamp with respect to time;

Figure 1b is a graph with respect to time of the relative effective aperture size when a lens aperture is progressively reduced beginning at a predetermined time, (X), shown in Figure 1a;

Figure 1c shows a family of curves representing the ratio of reflected scene light to direct flash light for various scene photographic conditions with respect to time;

Figure 1d shows the ratio of reflected scene illumination to flash light illumination with respect to time for the various photographic conditions considered in Figure 1c when the reflected scene illumination is projected through a lens aperture that is varied as shown in Figure 1b;

Figure 2 is an exploded perspective view of a portion of a camera including one embodiment of apparatus according to the present invention;

Figure 3 shows an electronic circuit diagram for use in the camera shown in Figure 2;

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Figure 4 is an exploded perspective view of a portion of a camera including a further embodiment of apparatus according to the present invention;

5 Figure 5 shows an electronic circuit diagram for use in the camera shown in Figure 4;

Figure 6 shows the percentage of flashbulb output remaining plotted against time; and

10 Figure 7 shows curves illustrating the factors controlling the shape of the lens aperture shown in Figure 1b.

Because photographic cameras are well known, the present description will be directed in particular to elements forming part of, or cooperating more directly with, apparatus in accordance with the present invention. 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.

Referring to Figure 1a, there is shown a curve 10 which illustrates the illumination from a typical expendable photographic flash device such as a flashbulb or flash lamp. The actual illumination varies according to the type of lamp, but typically the illumination has a duration of the order of 35-40 milliseconds (ms) and includes an initial portion having a relatively rapid rise time of the order of 10 ms and following the peak illumination level a gradually reducing illumination intensity level of the order of 20 ms or more. For a reason made known hereinafter, a time "X" is determined at some predetermined flash illumination level "W". At the time "X" the exposure cycle of the exposure control apparatus of the present invention is initiated, which time, because of the aforementioned varying flash illumination characteristics, differs according to the type of lamp.

Figure 1b shows a curve 12 which is an illustration of the effective lens aperture size as a function of time, with the aperture fully opened at the time "X" and progressively reducing in size, in the manner shown, for times beyond "X".

The curves 13, 14, 15 and 16 of Figure 1c depict on a relative basis for various hypothetical scene light conditions the instantaneous ratio of (1) light reflected from a scene, before attenuation by the camera aperture, which light may consist of ambient illumination as well as flash, to (2) direct flash illumination, the flash illumination having a characteristic as illustrated by curve 10. The term "ambient illumination" as used herein includes not only sun-light or natural illumination but also includes artificial ambient illumination other than light from a photographic flash lamp or flashbulb such as, for example, light from incandescent and luminescent bulbs. The curves 13-16 are drawn for a period of 5-35 mil-

liseconds from flash initiation, and show that the illumination is primarily dependent on subject reflectivity and distance, and ambient illumination, the curve 13 being representative of the light reflected from an object at a close camera distance with a relatively high ambient light level, the curve 14 being representative of the light reflected from a near object under a low ambient light condition, the curve 15 being representative of the light reflected from a far subject in relatively high ambient light and curve 16 being representative of the light reflected from a far subject in low ambient light. These curves 13-16 would be moved upwards for subjects having a high reflectivity, whereas the curves would be moved downwards for subjects having a low reflectivity. With a near subject, the amount of light reflected as significantly greater due to there being a larger component of flash illumination. Consequently, for a particular scene reflectance, the curves 13 and 14 for a near subject have a greater magnitude than the curves 15 and 16 which are for a far subject.

When light reflected from the scene is projected through a lens aperture, which lens aperture has a progressively varying size as illustrated by curve 12, such light is attenuated so that the curves 13-16 become modified to the curves 17-20, respectively, as illustrated in Figure 1d. The curves 17-19 intercept a predetermined level "Y" at points in time which are removed from time "X" at a time related inversely to the exposure time that would be necessary for satisfactory exposure of a film, whereas the curve 20 does not exceed the level "Y" at any time.

If the time "X" is known, it is then known approximately how much flash illumination remains and the approximate remaining flash duration. Furthermore, if the reflected scene light at "X" is determined, the amount of ambient illumination can be determined and exposure parameters such as aperture size and shutter speed may be established accordingly. In accordance with the teachings of the present invention, the lens aperture is preferably reduced during the early part of flash illumination to the smallest aperture that will produce a particular exposure value during the final portion of such illumination.

Consequently, the level "Y" is selected such that it represents the value of the ratio between reflected scene light, when projected through the reduced aperture, and direct flash illumination that results in a correct exposure of the subject utilizing flash illumination without further reduction of the aperture. By choosing an appropriate value of "Y" which takes into consideration the rating of the film being used and camera fac-

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tors, such as the available aperture range and the exposure time, proper exposure of scenes such as are covered by the four curves 17-20 can be closely approximated by preventing further aperture size reduction as soon as the ratio of reflected scene light to direct flash illumination is less than "Y", then opening the camera shutter to expose the film. Thus, in curve 20 an exposure would commence immediately at the time "X", with the aperture fully open. In the cases of curves 17-19 time lags would result, equivalent to those indicated A, B and C, respectively, during which times the lens aperture would be progressively reduced in size to produce the smallest aperture permitted under the existent light conditions, prior to the shutter being opened.

With this arrangement, a maximum depth of field is provided. Most cameras having f/2.8 lenses with normal focal lengths can be operated satisfactorily using one focus position. The increased depth of field consequent on smaller apertures more than compensates for the change in focus over the normal flash picture-taking range of 3.5 to 25 feet.

Referring now to Figure 2, there is shown schematically a camera 21 having a shutter mechanism 24 for controlling the time interval during which a film F is exposed to light from a scene being photographed, and a diaphragm mechanism 26 for forming adjustable exposure apertures in alignment with the objective lenses 22, 30.

The diaphragm mechanism 26 includes a pair of apertured blades 27, 28 mounted in front of the objective lens 22, 30 the objective lens 22 being arranged and located for directing scene light onto the photographic film F and the objective lens 30 being located for directing a proportionate amount of light onto a photo-responsive means such as a photocell 32. The blades 27, 28 are mounted for opposed slidable movement relative to each other and to the axes of the objective lenses 22, 30 by means of a pair of pins 29 which are mounted on a camera support plate (not shown) and are extended through elongate slots in each of the diaphragm blades 27, 28 respectively. An interconnecting lever 34 is pivoted to the blades 27, 28 as shown and is mounted on a pivot 35 to impart movement to the diaphragm blades 27, 28 in opposition to each other under the influence of a spring 36. The diaphragm blades 27, 28 are respectively provided with teardrop-shaped apertures 27a, 27b, and 28a, 28b, the apertures 27a and 28a, and 27b and 28b overlapping to form a variable lens exposure aperture 37 aligned with the optical axis 38 of the objective lens 22, and a variable photocell aperture 39 aligned with the optical axis 40 of the objective lens 30. Each of the blade

apertures 27a, 27b 28a 28b is aligned with its tapered end portion extending in a direction such that relative movement of the blades 27, 28 under the influence of the spring 36 progressively diminishes the size of the exposure aperture 37 and the photocell aperture 39 until each of such apertures is fully closed.

During the aperture setting movement notches 41 on the blade 28 pass over a locking latch 43 connected by an elongate pin 44 to an arm 46 resting on a shoulder detent 48 on a shutter blade 54 which holds the latch 43 away from the notches 41 against the influence of a spring 50. However, an opening movement of the shutter mechanism 24 to commence a film exposure interval permits the latch 43 under the influence of the spring 50 to engage one of the notches 41 to thereby lock the blades 27, 28 and set the exposure aperture 37. The shutter opening movement is initiated by a light-sensitive exposure control circuit 100 which is illustrated more completely in Figure 3.

The shutter mechanism 24 includes an apertured shutter blade 54 mounted within the camera by means of a pin 56 mounted on the camera support plate (not shown) received in a slot 58. The shutter blade 54 may move, transverse to the optical axis 38, between an initial, cocked position shown by the solid lines in Figure 2 and a final, released position, shown by the dotted lines, adjacent to a stop member 59. The shutter 54 is biased by a spring 60 to move from its cocked position toward its released position, one end of the spring 60 being hooked to a projection 61 integral with the shutter blade 54, while the other end of the spring 60 is secured to the camera body by means not shown. The shutter blade 54 is releasably retained in its cocked position covering the exposure aperture 37, against the bias of the spring 60, by means of both an electromagnetic latch 62 and a retaining arm 63, which is shown symbolically in Figure 2 by dashed lines. The latch 62 comprises an electromagnetic keeper 64 positioned adjacent to the poles of an electromagnet 65, having a coil 65a which is energized and deenergized by the electronic circuit 100. The arm 63 is secured to a lever 66 biased in a clockwise direction, by a spring 77 to a position shown whereat it operates to retain the shutter blade 54 in its initial position when the electromagnet 65 is deenergized.

The rate at which the shutter blade 54 moves across the exposure aperture 37 is controlled mechanically by means of an escapement mechanism 67 which includes a spring-biased restraining arm 68 mounted on a pivot 69. The arm 68 is biased in a clockwise direction by a spring 70 against a stop member 71. In its biased position, a finger member 72 extends across the path of

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a projection 54b on the shutter blade 54 so as to be engaged thereby during movement of the shutter blade 74 to expose the film F. Mounted on the opposite end of the arm 68 is a restraining mass 74. The restraining force produced by the spring 70 and the mass 74 are selected so that the exposure aperture 54a is caused to move across the exposure aperture 37 in approximately 1/30 second. This time corresponds to the approximate duration of the flash lamp illumination illustrated in Figure 1a.

The diaphragm blades 27, 28 may be actuated to move from their maximum apertured position to a reduced apertured position upon manual depression of a release member (not shown) mounted on the camera 21. Such a release member would be mechanically coupled to the lever 66 so as to pivot it in a counterclockwise direction against the spring 77 when actuated. A hook portion 66a on the lever 66 is then disengaged from the lever 34 to permit the blades 27, 28 to commence the aperture closing movement under the influence of the spring 36.

Some ambient light is generally present during a flash exposure. A flash is frequently used merely as a "fill-in" to reduce the harsh effects of dark shadows. Consequently, in order to expose film accurately in flash photography, it is necessary to take into account ambient illumination.

The exposure control circuit 100 includes, together with the photocell 32, a second photoresponsive means, such as a photocell 102 located to receive direct illumination from a photographic flash device, such as flashcube 103, whereas the photocell 32 is arranged to receive light reflected from the scene being photographed as described previously herein. The photocell 102 receives but a portion of the flash illumination, the remaining portion being projected towards a scene being photographed, and the reflected light impinging on the photocell 32 consists of not only reflected flash illumination but reflected ambient illumination.

The circuit 100 further includes a switching circuit 104 which is connected to the photocell 102. The circuit 104 is a switching circuit arranged so that its output is switched ON once its input signal, that is, the signal produced by photocell 102, exceeds a level corresponding to the aforementioned predetermined level "W".

The output of the switching circuit 104 is connected to the gate electrode 106b of a silicon controlled rectifier (SCR) 106, which has its anode 106a connected to the photocell 102 at a terminal 108. With the SCR 106 and the switching circuit 104 interconnected as shown in combination with the photocell 102, an electrical signal is produced at the cathode 106c of the SCR 106

related to the photocell signal once the latter signal exceeds the level "W". It may be necessary to include an amplifier (not shown) between the terminal 108 and the anode 106a to provide adequate current to maintain the SCR 106 ON once the output of the circuit 104 is turned OFF, removing the signal to the gate 106b, due to the signal from the photocell 102 falling below the level corresponding to the level "W".

A circuit 109 produces a control signal at an output 113 equal to the instantaneous ratio of the output signal from the photocell 32 to the signal from the photocell 102 switched by the SCR 106. The circuit 109 includes dual inputs 109a, 109b, the input 109a providing one of two inputs to a multiplier circuit 110 which is connected in the feedback loop of an operational amplifier 112. The multiplier 110, the amplifier 112 and the input 109b are interconnected with respect to SCR 106 as shown to produce the aforementioned control signal at the output 113.

The output 113 of the circuit 109 is connected to the input of a switching circuit 109 in which the output is OFF when the level of its input signal is below the level corresponding to the aforementioned level "Y". The output of the switching circuit 116 is connected to the cell 65a to energize and deenergize the electromagnet 65 to control the shutter blade 54.

To expose the film F, the shutter release member is actuated rotating the lever 66 in a counterclockwise direction, closing a normally-open switch S1 to connect a battery to energize the circuit 100 and then disengaging the retaining arm 63 from the shutter blade 54. Ignition of the flash device 103 is initiated by means not shown, and the electromagnet 65 is energized to retain the shutter blade 54 temporarily in its cocked position through the keeper 64. The flash lamp 103 may be ignited electrically by applying an electrical signal to the lamp or mechanically by means for percussively firing the lamp. After the flash 103 is energized, the hook portion 66a is disengaged from the lever 34 and the diaphragm mechanism 26 is released for aperture closing movement under the influence of the spring 36.

Lever 66 causes the flash 103 to fire in a timed relationship with the initial diaphragm setting movement. The lever 34 is released for aperture setting movement at, or as close as possible to the time that the magnitude of the electrical output signal produced by photocell 102 is that corresponding to the level "W". This may be achieved electrically by utilizing an electronic switching circuit (not shown) that interconnects the cathode of SCR 106 to a latching device (also not

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shown) such as an electromagnet that latches the lever 34. With this electrical arrangement, when SCR 106 is turned ON, that is, the photocell signal corresponds to that at the level "W", the aforementioned switching circuit would switch so as to energize the latching device, to release, the lever 34 for commencing diaphragm blade movement. The circuit 109 then commences to produce an output control signal equal to the instantaneous ratio of the signal produced by the photocell 32, which signal is applied to the input 109a, and the signal produced by the photocell 102, which signal is applied to the input 109b, as the blades 27, 28 commence aperture closing movement. The magnitude of the signals produced by both photocells 32, 102 should closely follow or track the magnitude of the light impinging respectively thereon. Due to the flash illumination, both light signals are transient and for accurate tracking to occur, it is necessary that these photocells are comprised of a light-sensitive material that responds rapidly to changing light levels.

When the amplitude of the control signal produced by the circuit 109 falls or is below the level "Y", the output of the switching circuit 116 is switched OFF, and the electromagnet 65 is deenergized and the shutter blade 54 is released for shutter closing movement under the influence of the spring 60. As this movement occurs, the shoulder 48 moves from beneath the control arm 46. Under the influence of the spring 50, the pawl 43 is rotated in a counterclockwise direction to engage a notch 41 to latch the diaphragm blade 28 in a particular aperture regulating position, which is functionally related to the time interval between the time "X" and the time at which the control signal reaches or drops below "Y", as illustrated in Figure 1d.

Due to the fixed shutter speed, the film exposure interval is terminated a predetermined time after the aperture is set. Thus, if scene conditions were such as to produce a control signal similar to the curve 20, an exposure would commence immediately at time "X" with the aperture fully opened and would terminate 1/30 second thereafter. In the cases of curves 17-19 the actual exposure interval would terminate 1/30 second following each of the time lags A, B and C respectively. In the absence of a high ambient light level the effective exposure interval can be considered for curves 17-19 as being effectively terminated 1/30 second after the flash lamp is energized since by that time the flash illumination has been reduced to a relatively insignificant level as illustrated in curve 10.

Referring now to Figures 4 and 5, a further embodiment according to the present invention is shown where elements

common to those shown in Figure 2 and/or 3 have been identified with the same numerals. In general, the embodiment shown in Figures 4 and 5 differs from that shown in Figures 2 and 3 in that the shutter closing movement is controlled electrically by a conventional integrating electronic exposure control circuit rather than mechanically with an escapement mechanism as described previously.

A shutter mechanism 80 has two apertured blades 81, 82. Blades 81, 82 have slots 81a, 82a, respectively, for receiving a common mounting pin 84 which is connected to a camera support plate (not shown), each blade being mounted on the pin for movement transverse to axis 38 between an initial or cocked position shown in solid lines in Figure 4 and a released position shown by the dashed lines in Figure 4. The opening and closing blades 81, 82, respectively, have apertures 81b, 82b, respectively, which when they overlap permit scene light to impinge on the film F. The opening blade 81 is in its "light-blocking position" when in its cocked position, and is in its "light-unblocking position" when in its released position. Conversely, the closing blade 82 is in its "light-unblocking position" when in its cocked position, shown in Figure 4 and is in its "light-blocking position" when in its released position.

In the same manner as shown for the shutter blade 54 in the embodiment shown in Figure 2, the opening blade 81 is retained in its cocked position against the bias of the spring 60 when the electromagnet 65 is energized. In a similar manner the closing blade 82 is retained in its cocked position, against the action of a spring 90, when an electromagnet 88 is energized. Both electromagnets 65, 88 are energized and deenergized by the electronic control circuit 200 illustrated in detail in Figure 5, which circuit includes the aforementioned integrating circuit.

The circuit 200 includes a normally-closed switch S2 which is held open by a projection 89 on the opening blade 81 when it is in its cocked, light-blocking position but is closed in response to the initial opening movement of the opening blade 81. A conventional integrating circuit 202 is connected to the switch S2 for integrating with respect to time the signal produced by the photocell 32 after switch S2 is closed. The circuit 202 may, for example, include a resistor and a timing capacitor interconnected to form a conventional RC integrating circuit, the capacitor being coupled to switch S2 to prevent it being charged while the switch is opened. In this manner, once switch S2 is closed initiating an exposure interval, the timing capacitor commences to charge. Once the capacitor is charged to a pre-

determined level (which level represents a constant film exposure value) this charge is used to trigger the input of a switching circuit 204 to turn its output OFF, to deenergize the electromagnet 88. When this occurs, the closing blade 82 is released to travel to its light-blocking position under the influence of the spring 90 to terminate the film exposure.

In a manner identical to the operation of the embodiment shown in Figure 2, the electromagnet 65 is deenergized when the control signal produced by the circuit 109 falls below level "Y". When this happens, the opening blade 81 travels under the influence of the spring 60 to commence the film exposure interval while at the time releasing the pawl 43, which moves urged by the spring 50 to latch the diaphragm mechanism, by engaging a notch 41. Furthermore, the projection 89 is disengaged from the control switch S2, which closes once the aperture 81b is aligned with the objective 22 so as to expose the film F to scene light. With the switch S2 closed, the signal produced by the photocell 32 is applied through the switch S2 to the integrating circuit 202 to be integrated thereby. After the aforementioned constant of exposure is reached the output of the switching circuit 204 is turned OFF, the coil 88a is deenergized and the closing blade 82 is released to terminate the film exposure interval.

It is not, of course, essential that the flashbulb is received in a socket in the camera. It is simply necessary that the camera has means for firing a flashbulb, and that the second photoresponsive means is arranged to receive illumination from the flashbulb by a substantially direct path. The illumination received by the second photoresponsive means must not be modified by the scene being photographed.

The embodiments disclosed herein and shown in Figures 2 to 5 can also be used to obtain photographs taken utilizing only ambient illumination. When no flash lamp is used, a constant signal in the place of the signal produced by the photocell 102 is applied to the terminal 108. This is done by coupling the battery through a variable resistor 118 and a normally closed switch S₃ to terminal 108, switch S₃ being associated with the camera flash lamp receiving socket as is diagrammatically illustrated by arrow A in Figures 3 and 5. When a flash lamp is not utilized, the switch S₃ is closed and a constant electrical signal through the resistor 118 is applied to the terminal 108.

The photocell 102 may be dispensed with, to provide an exposure control circuit requiring a single photocell. This is possible where the output illumination, such as is illustrated in Figure 1a, is predictable, at least in so far as rate of rise and decay, and

peak output are concerned. The signal corresponding to the output from the second photo-responsive means may then be provided by a curve generator which simulates the signal corresponding to the flash device illumination. The curve generator signal is initiated by the operation of the switch S1.

The aperture for the photocell 32 is preferably such as to provide the correct shape for curve 12 in Figure 1b.

Figure 6 is a curve 250 showing the percentage of the total flashbulb illumination remaining, plotted against time, for an idealised flashbulb.

If the embodiment of Figures 2 and 3 is used, the shutter being open for a fixed time, then the value given by the relative aperture from Figure 1b, divided by the percentage of the total flashbulb illumination remaining from Figure 5, multiplied by the appropriate constant of proportionality, should be unity.

In the embodiment of Figures 4 and 5, where the shutter opening time is variable, the value should be greater than unity, typically approaching 2, to provide an exposure greater than that theoretically required to allow for variations in flashbulb outputs, and other factors.

These values are shown in Figure 7, the lower curve 252 being for the fixed shutter opening time embodiment of Figures 2 and 3, and the upper curve 254 being for the variable shutter opening time embodiment of Figures 4 and 5.

WHAT WE CLAIM IS:-

1. A photographic exposure control means, comprising adjustable aperture means, flash bulb ignition means, photoresponsive means arranged to receive light from a flash-illuminated scene to be photographed after attenuation by the aperture means and to produce a first signal representative thereof, signal producing means for producing a second signal representative of the instantaneous value of the illumination produced by the flash bulb and aperture control means for terminating the adjustment of the aperture when the ratio of the first and second signals reaches a predetermined value.

2. A means as claimed in Claim 1, wherein the signal producing means comprises a photo-responsive means arranged to receive, by a substantially direct path, illumination produced by the flash bulb to provide the second signal.

3. A means as claimed in Claim 1 or 2, further comprising a circuit for providing an output signal proportional to the ratio of the first and second signals.

4. A means as claimed in Claim 3, wherein the aperture defined by the adjustable aperture means is progressively reducible, and further comprising latching means for latching the aperture means when the



determined level (which level represents a constant film exposure value) this charge is used to trigger the input of a switching circuit 204 to turn its output OFF, to deenergize the electromagnet 88. When this occurs, the closing blade 82 is released to travel to its light-blocking position under the influence of the spring 90 to terminate the film exposure.

In a manner identical to the operation of the embodiment shown in Figure 2, the electromagnet 65 is deenergized when the control signal produced by the circuit 109 falls below level "Y". When this happens, the opening blade 81 travels under the influence of the spring 60 to commence the film exposure interval while at the time releasing the pawl 43, which moves urged by the spring 50 to latch the diaphragm mechanism, by engaging a notch 41. Furthermore, the projection 89 is disengaged from the control switch S2, which closes once the aperture 81b is aligned with the objective 22 so as to expose the film F to scene light. With the switch S2 closed, the signal produced by the photocell 32 is applied through the switch S2 to the integrating circuit 202 to be integrated thereby. After the aforementioned constant of exposure is reached the output of the switching circuit 204 is turned OFF, the coil 88a is deenergized and the closing blade 82 is released to terminate the film exposure interval.

It is not, of course, essential that the flashbulb is received in a socket in the camera. It is simply necessary that the camera has means for firing a flashbulb, and that the second photoresponsive means is arranged to receive illumination from the flashbulb by a substantially direct path. The illumination received by the second photoresponsive means must not be modified by the scene being photographed.

The embodiments disclosed herein and shown in Figures 2 to 5 can also be used to obtain photographs taken utilizing only ambient illumination. When no flash lamp is used, a constant signal in the place of the signal produced by the photocell 102 is applied to the terminal 108. This is done by coupling the battery through a variable resistor 118 and a normally closed switch S₃ to terminal 108, switch S₃ being associated with the camera flash lamp receiving socket as is diagrammatically illustrated by arrow A in Figures 3 and 5. When a flash lamp is not utilized, the switch S₃ is closed and a constant electrical signal through the resistor 118 is applied to the terminal 108.

The photocell 102 may be dispensed with, to provide an exposure control circuit requiring a single photocell. This is possible where the output illumination, such as is illustrated in Figure 1a, is predictable, at least in so far as rate of rise and decay, and

peak output are concerned. The signal corresponding to the output from the second photo-responsive means may then be provided by a curve generator which simulates the signal corresponding to the flash device illumination. The curve generator signal is initiated by the operation of the switch S1.

The aperture for the photocell 32 is preferably such as to provide the correct shape for curve 12 in Figure 1b.

Figure 6 is a curve 250 showing the percentage of the total flashbulb illumination remaining, plotted against time, for an idealised flashbulb.

If the embodiment of Figures 2 and 3 is used, the shutter being open for a fixed time, then the value given by the relative aperture from Figure 1b, divided by the percentage of the total flashbulb illumination remaining from Figure 5, multiplied by the appropriate constant of proportionality, should be unity.

In the embodiment of Figures 4 and 5, where the shutter opening time is variable, the value should be greater than unity, typically approaching 2, to provide an exposure greater than that theoretically required to allow for variations in flashbulb outputs, and other factors.

These values are shown in Figure 7, the lower curve 252 being for the fixed shutter opening time embodiment of Figures 2 and 3, and the upper curve 254 being for the variable shutter opening time embodiment of Figures 4 and 5.

WHAT WE CLAIM IS:-

1. A photographic exposure control means, comprising adjustable aperture means, flash bulb ignition means, photoresponsive means arranged to receive light from a flash-illuminated scene to be photographed after attenuation by the aperture means and to produce a first signal representative thereof, signal producing means for producing a second signal representative of the instantaneous value of the illumination produced by the flash bulb and aperture control means for terminating the adjustment of the aperture when the ratio of the first and second signals reaches a predetermined value.

2. A means as claimed in Claim 1, wherein the signal producing means comprises a photo-responsive means arranged to receive, by a substantially direct path, illumination produced by the flash bulb to provide the second signal.

3. A means as claimed in Claim 1 or 2, further comprising a circuit for providing an output signal proportional to the ratio of the first and second signals.

4. A means as claimed in Claim 3, wherein the aperture defined by the adjustable aperture means is progressively reducible, and further comprising latching means for latching the aperture means when the

- output signal is reduced below a predetermined level.
5. A means as claimed in Claim 4, wherein the latching means is rendered operable simultaneously with the opening of shutter.
6. A means as claimed in Claim 5, wherein the latching means is biased towards its latching position and is released by movement of an opening blade of the shutter.
7. A means as claimed in any preceding Claim, further comprising shutter control means responsive to the integral of the first signal to control the exposure time.
8. A photographic exposure control means, substantially as hereinbefore described, with reference to, and as illustrated in the accompanying drawings.
9. A photographic camera including photographic exposure control means as claimed in any preceding claim.
10. A method of controlling a photographic exposure, comprising the steps of igniting a flash bulb, producing a first signal representative of the instantaneous value of the light received from a scene to be photographed and illuminated by the flash bulb, the light being attenuated by an adjustable aperture, producing a second signal representative of the instantaneous value of the illumination from the flash bulb, and terminating adjustment of the aperture when the ratio of the first and second signals reaches a predetermined value.
11. A method as claimed in Claim 10, wherein the second signal is produced by sensing the illumination from the flash device.
12. A method of controlling a photographic exposure substantially as hereinbefore described.

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Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1978.
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