

PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION. Exposure Control Apparatus.

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 exposure control apparatus and more particularly concerns automatic exposure control apparatus for photographic cameras.

The exposure of film in a camera may be regulated automatically by adjusting the aperture as a function of scene brightness. It has been common practice to employ a galvanometer for moving one or more diaphragm blades as a function of the intensity of scene light as monitored by a photo-voltaic cell connected to the galvanometer. Also, instead of using a photo-voltaic cell, it is well known to use a battery connected in series with a photoresistive cell. These prior art systems have been considered unsatisfactory because of the difficulties encountered in closely matching the closing characteristic of the diaphragm to the sensitivity of the cell at various levels of illumination.

In order to overcome this difficulty, "null" type systems have been used in which a servomechanism simultaneously controls the aperture(s) masking both the photocell and the camera's taking lens. The system is designed so that the apertures are fully open when the photocell is exposed to the minimum intensity of light required to make an acceptably exposed photograph. When the light intensity increases, the aperture(s) masking both the

photocell and the film are simultaneously closed until the intensity of light reaching the photocell is reduced to the calibrated level; i.e., to the minimum level for acceptable film exposure. In some prior art devices of this general "null" type, the galvanometer has no return spring but instead has two oppositely poled coils for controlling the aperture-forming diaphragms, one tending to close the aperture and the other tending to open it.

Although these "null" type systems are more satisfactory than the other exposure control systems referred to above, they also require the use of expensive, sensitive galvanometer-type mechanisms and, like most automatic exposure control systems, suffer the disadvantage that the bearing surfaces of the mechanism tend to "bind" due to static friction. Such friction problems tend to reduce accuracy, particularly at low current levels, and also result in jerky diaphragm movement.

It is an object of this invention to provide an automatic exposure control system which causes the exposure setting means to remain in continuous motion to prevent friction "binding".

According to the present invention there is provided an exposure control apparatus of the type having an exposure aperture regulator controlled by a photoelectric device, comprising a source of cyclical current pulses, an electro-mechanical transducer for actuating the regulator, means for passing the current pulses through the transducer to provide vibration of the regulator about a mean position, the photoelectric device being arranged to control the energy content of one polarity of the current pulses to determine the mean position.

[Price 4s. 6d.]

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

Figure 1 is a schematic circuit diagram of the device according to one embodiment of the invention;

Figure 2 shows an alternative embodiment of a transducer used in the invention;

Figure 3 shows a further embodiment of a transducer used in the invention;

Figure 4 shows an additional embodiment of a transducer used in the invention;

Figure 5 shows an alternative embodiment of the invention using an amplifier for one of a pair of coils of a transducer used in the invention;

Figure 6 shows an embodiment of the invention using an amplifier for each of the coils of the transducer;

Figure 7 shows an embodiment of the invention using two amplifiers for each of the coils of the transducer; and

Figures 8 and 9 show an embodiment of the invention, using a Schmitt trigger.

Figure 10 shows an embodiment using a multivibrator with a noise suppression network.

Figure 11 shows a further embodiment of the invention using a single battery and a single coil reversible transducer.

Referring to Figure 1, there is shown schematically a camera having a photosensitive surface F which receives light through a lens O along an axis L. Between the lens O and the photosensitive surface F is a movable aperture plate A which controls the brightness of the image reaching the photosensitive surface. Of course, there may be a shutter (not shown) to determine the time of exposure of the photosensitive surface.

The aperture plate A, while controlling the amount of light to the photosensitive surface F, simultaneously controls the light to a photoresistance type photocell R4 which regulates the circuitry shown schematically in Figure 1. A battery V supplies the device. This battery is controlled by a switch SW and feeds a multivibrator which consists of PNP transistors Q1 and Q2. Connected between the bases of the transistors and the negative terminal of the battery are respective resistances R1 and R2. Also in series with the base of each transistor are respective capacitors C1 and C2, resistors R5 and R6, and coils N1 and N2 of a galvanometer. The collector of each transistor is connected to the junction between the series condenser and resistor of the opposite transistor, i.e., the collector of Q1 is connected to the junction of the capacitor C2 and the resistance R5, while the collector of Q2 is similarly

connected to the junction of the capacitor C1 and the resistance R6.

Connected in parallel with the resistance R2 is the photoresistance R4. Because the resistance value of the cell R4 tends to be low at high illumination levels, a resistor R3 is connected in series therewith to raise its minimum effective resistance.

The coils N1 and N2 which are oppositely poled coact with a magnet M to control the position of the double aperture plate A by means of a shaft B. When the aperture plate is moved, it varies the amount of light falling on the photoresistance R4, as well as varying, in the same manner, the amount of light passing through the lens O and falling on the film F.

The transistors Q1 and Q2 are connected to operate as an astable (free running) multivibrator. When the transistor Q1 is "on", the transistor Q2 is "off" and vice versa. The current from the transistor Q1 is fed to the coil N1. The current from the transistor Q2 is fed to the coil N2. Thus, in operation, there are alternate pulses passing through the coils. The duration of the "off" time of the transistor Q1 is determined by the product of the resistance R1 and the capacitance C1. The "on" time of the transistor Q1 is determined by the product of C2 and the parallel combination of R2 with R3 and R4. Stated another way,

$$T_2 = K_1 R_1 C_1$$

$$T_1 = \frac{K_2 C_2 R_2 (R_3 + R_4)}{R_2 + R_3 + R_4}$$

where T1 and T2 are the "on" times of the transistor Q1 and Q2 respectively, K1 and K2 are constants, and R1, C1, R2, R3 and R4 are the values of the several respective components.

The resistances are adjusted so that when the photo-resistance R4 is illuminated with the minimum light for an acceptable exposure of the film F, the multivibrator gives equal pulses to each of the oppositely poled coils and the apertures are adjusted to their fully open condition. When a brighter scene illuminates the photocell, its resistance falls, thus decreasing the "on" time of the transistor Q1. Because of the resulting decrease in current through the coil N1, the magnet of the transducer pulls the aperture plate toward the coil N2 which decreases the light both to the photocell and to the film. The magnet continues to pull the aperture plate until the light falling on the photocell has been reduced to the minimum level for which it was originally set, thereby restoring the predetermined equal and opposite

current pulses to the coils N1 and N2 to balance the transducer.

The frequency of oscillation of the multivibrator is adjusted, by well known means, so that the aperture plate A has a barely perceptible vibration at its null point. This keeps the aperture plate in motion so as to overcome static friction, but does not perceptibly affect the picture-taking capability of the lens aperture.

Figure 2 shows a transducer in which the stator is a permanent magnet M, and the rotor carries the oppositely wound coils N1 and N2. The operation of the device is exactly the same as in Figure 1.

Figure 3 shows a transducer wherein the rotor carries a permanent magnet M, and the stator carries oppositely wound coils N1 and N2. Again, the operation is the same as in Figure 1.

Figure 4 shows a transducer similar to Figure 2, but where the permanent magnet has been replaced by an electromagnet, constituted by a winding N3 around a core.

Figure 5 is similar to Figure 1, except that it provides an additional transistor Q3 to alleviate the load on the multivibrator transistor Q1. The transistor Q3 is NPN and has its base connected to the collector of Q1. Its emitter collector path is connected from one of the oppositely wound transducer coils to the negative terminal of the source.

Figure 6 is similar to Figure 1 except that PNP transistors Q3¹ and Q4 are inserted to control oppositely wound coils N1 and N2. Each base of the transistors Q3¹ and Q4 is connected to its respective collector electrode of transistors Q1 and Q2. The emitter collector paths of the transistors Q3¹ and Q4 is connected from each respective oppositely poled coils N1 and N2 to the negative terminal of the source.

Figure 7 is similar to Figure 6 except that two additional PNP transistors Q5 and Q6 have been inserted further to isolate oppositely poled coils N1 and N2 from their respective multivibrator resistors.

Figures 8 and 9 show embodiments which a Schmitt trigger has been substituted for the multivibrator of the other embodiments. The Schmitt trigger consists of NPN transistors Q7 and Q8 together with their associated resistors and operates in a manner well known in the art. The Schmitt trigger drives a pair of transistors Q10 and Q11 whose emitters are connected to a motor M which, instead of being a two-coil movement as in the previous embodiment, is a single coil element which is reversible and responds in a direction dependant upon the direction of current flow therethrough. One of the

transistors Q10 and Q11 is on at all times. In Figure 9, when Q7 is on, and Q8 is off, transistor Q10 provides motor current in one direction whereas when Q8 is on, Q11 provides motor current in the opposite direction.

The motion of the aperture plate can be rotary or linear depending on space requirements of the application. Furthermore, as shown in Figures 2 to 4, the coils can be either movable or stationary, and the magnet can be either permanent or electromagnetic. Also, opposite supply voltage polarity can be used and the opposite transistor types can be used in the manner known in the art.

Figure 10 shows an embodiment using a dual coil element wherein a filter network consisting of a capacitor C3 and a resistor R7 has been connected across the voltage supply of the circuit. A capacitor C4, which is connected between the collectors of the multivibrator transistors, also acts as a filter. The combination of these two filters minimizes any noise that might be generated by other loads which may be connected to the same source, such as a motor. Diodes D1 and D2 protect the transistors from voltage spikes generated by coils N1 and N2. A diode D3 protects the circuit from voltage spikes that originate in other loads connected to the same source.

Figure 11 shows a circuit using a multivibrator but using a single coil reversible element N. When multivibrator transistor Q1 is on, transistors Q13 and Q14 are on, which passes current through the element N in one direction. When transistor Q1 is off, the transistors Q13 and Q14 are off, and transistors Q2, Q15 and Q12 are on, which passes current through element N in the opposite direction.

Because the currents through coils N1 and N2, or the single coil elements of Figures 8, 9 and 11, are flowing alternatively, the total current drain is low. Furthermore, the continuous microscopic motion of the device permits the use of a mechanism with higher friction and lower tolerances, thus decreasing the cost of manufacture.

Additionally, since the device tends to come to rest always with the same amount of light falling on the photocell and on the film, the exposure control need only be calibrated at a single light level, i.e., the minimum usable light level, which, of course, may be made to vary in accordance with exposure variables such as film sensitivity, shutter speed, filter factors, etc., by the provision of variable components in the circuit in the manner well known in the art. These circuits are well adapted to being manufactured by the integrated circuit techniques. All of the semiconduc-

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tors and the photoconductor could be part of the same crystal. This could be done on a silicon wafer, monolithic type of construction, or on a thin film deposited type of construction, both of which are well known in the art.

5 In addition to being useful on a photographic camera, this exposure control would be suitable for use on a television camera such as a vidicon, image orthicon, or iconoscope. In fact, this control would be useful in any application where a movable object is controlled in response to the amount of light, such as an application where a rheostat is varied in response to ambient light.

10 The foregoing examples are merely illustrative and are not meant to be limiting. Other applications of the invention will be readily apparent to one skilled in the art. The invention is therefore to be limited only by the appended claims.

WHAT WE CLAIM IS:—

25 1. An exposure control apparatus of the type having an exposure aperture regulator controlled by a photoelectric device, comprising a source of cyclical current pulses, an electro-mechanical transducer for actuating the regulator means for passing the current pulses through the transducer to provide vibration of the regulator about a mean position, the photoelectric device being arranged to control the energy content of one polarity of the current pulses to determine the mean position.

30 2. A control apparatus as claimed in Claim 1 wherein the source of cyclical current pulses is a multivibrator having two outputs, and the electro-mechanical transducer comprises two oppositely poled coils and a further means for producing a magnetic field, each of the outputs being connected to a respective coil.

45 3. A control apparatus as claimed in Claim 2 wherein the aperture regulating member also controls the light reaching the photoelectric device, and wherein the photoelectric device controls the energy content of the pulses coming from one of the outputs, so that the movable means will tend to assume a position wherein the light reaching the cell has a predetermined value.

50 4. A control apparatus as claimed in claim 3 in which an output of the multivibrator is connected to the input of an amplifier which in turn drives one of the coils.

5. A control apparatus as claimed in claim 3 or claim 4 in which the further means for producing a magnetic field comprises a permanent magnet.

6. A control apparatus as claimed in claim 5 in which the permanent magnet is rotatable, and the oppositely poled coils are mounted on a stator.

7. A control apparatus as claimed in claim 2, 3, 4 or 5 in which the further means for producing a magnetic field comprises an electromagnet.

8. A control apparatus as claimed in claim 3 or any claim appendant thereto wherein the multivibrator comprises two transistors, and wherein the photoelectric device is a photoresistance, and varies the "on" time of one of the transistors.

9. A control apparatus in accordance with claim 3 or any claim appendant thereto in which the aperture regulating member is arranged so that movement thereof varies both the exposure light and the light to the photoelectric element similarly.

10. A control apparatus as claimed in claim 8 or claims 8 and 9 wherein the transistors have their emitters connected together to one side of a voltage source, and their collectors are connected to the respective outputs.

11. A control apparatus as claimed in claim 8, claims 8 and 9 or claim 10 wherein the two coils have a common terminal connected to the other side of the source, and wherein the photoelectric device has at least two terminals, one of the terminals being connected to the other side of the source, and another of the terminals being connected to the base of one of the transistors.

12. A control apparatus as claimed in claim 1 wherein the source of cyclical current pulses is a Schmitt trigger and the electro-mechanical transducer is a single coil element which is reversible in that it can respond in a direction dependant upon the direction of current flow.

13. A control apparatus of the type having a movable means controlled by a photoelectric device, substantially as hereinbefore described with reference to and as illustrated in Fig. 1; or Fig. 1 as modified by Fig. 2 or Fig. 3 or Fig. 4; or Fig. 5 or Fig. 6 or Fig. 7 or Fig. 8 or Fig. 9 or Fig. 10 or Fig. 11 of the accompanying drawings.

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tors and the photoconductor could be part of the same crystal. This could be done on a silicon wafer, monolithic type of construction, or on a thin film deposited type of construction, both of which are well known in the art.

In addition to being useful on a photographic camera, this exposure control would be suitable for use on a television camera such as a vidicon, image orthicon, or iconoscope. In fact, this control would be useful in any application where a movable object is controlled in response to the amount of light, such as an application where a rheostat is varied in response to ambient light.

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WHAT WE CLAIM IS:—

1. An exposure control apparatus of the type having an exposure aperture regulator controlled by a photoelectric device, comprising a source of cyclical current pulses, an electro-mechanical transducer for actuating the regulator means for passing the current pulses through the transducer to provide vibration of the regulator about a mean position, the photoelectric device being arranged to control the energy content of one polarity of the current pulses to determine the mean position.

2. A control apparatus as claimed in Claim 1 wherein the source of cyclical current pulses is a multivibrator having two outputs, and the electro-mechanical transducer comprises two oppositely poled coils and a further means for producing a magnetic field, each of the outputs being connected to a respective coil.

3. A control apparatus as claimed in Claim 2 wherein the aperture regulating member also controls the light reaching the photoelectric device, and wherein the photoelectric device controls the energy content of the pulses coming from one of the outputs, so that the movable means will tend to assume a position wherein the light reaching the cell has a predetermined value.

4. A control apparatus as claimed in claim 3 in which an output of the multivibrator is connected to the input of an amplifier which in turn drives one of the coils.

5. A control apparatus as claimed in claim 3 or claim 4 in which the further means for producing a magnetic field comprises a permanent magnet.

6. A control apparatus as claimed in claim 5 in which the permanent magnet is rotatable, and the oppositely poled coils are mounted on a stator.

7. A control apparatus as claimed in claim 2, 3, 4 or 5 in which the further means for producing a magnetic field comprises an electromagnet.

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9. A control apparatus in accordance with claim 3 or any claim appendant thereto in which the aperture regulating member is arranged so that movement thereof varies both the exposure light and the light to the photoelectric element similarly.

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