

PATENT SPECIFICATION

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- (21) Application No. 44349/71 (22) Filed 23 Sept. 1971
 (31) Convention Application No. 76 081 (32) Filed 28 Sept. 1970 in
 (33) United States of America (US)
 (44) Complete Specification published 14 Aug. 1974
 (51) International Classification G01S 9/62
 (52) Index at acceptance
 H4D 711 747 75X 763 771 782
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(54) RANGEFINDER

(71) We, EASTMAN KODAK COMPANY, a Company organised 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 rangefinders and more particularly but not exclusively to rangefinders suitable for use with cameras.

It has previously been recognized that when the relative distance between a photocell such as a sulphide or cadmium cell and a lens is varied by moving the lens in an effort to focus an image of an object onto the photocell, a perturbation occurs in the photocell electrical output as the lens passes through the position wherein the image is focused on the photocell. This is due to the property of such cells that they will exhibit different outputs for uniform and non-uniform distributions of light over their surface, despite the fact that the total amount of light remains a constant. This effect has been difficult to use inasmuch as in the instance of low contrast objects such as blank walls, the effect is minimal and extremely difficult to detect.

In accordance with one aspect of the present invention there is provided a rangefinder of the kind in which the electrical output of a photocell is monitored during the movement of a lens which is attempting to focus on the photocell an image of an object whose range is required, a discernable condition of the output indicating the point of sharp focus, in combination with means, including a source of radiation, for projecting a contrast pattern onto the object for focusing onto the photocell.

In accordance with another aspect of the present invention there is provided a range-

finder comprising photosensitive means having an electrical output related to the magnitude of incident radiant energy, a source of radiation, means cooperative with the radiation source for projecting an image having a contrast pattern upon an object whose range is required, a lens disposed in cooperative relation with the photosensitive means for receiving radiation reflected from the object, means coupled to the lens for varying the distance between the lens and the object to move the lens in relation to the photosensitive means through a position wherein the lens focuses radiation reflected from the object including the contrast pattern on to the photosensitive means, the photosensitive means having a discernable output when the lens is moved through the position of sharp focus, and means coupled to the photosensitive means and responsive to the said electrical output for detecting the discernable output.

In the detailed description of the preferred embodiments of the invention presented below, reference is made to the accompanying drawings, in which:

Fig. 1 is a perspective view of a photographic camera including an automatic rangefinder of the type contemplated by the invention;

Fig. 2 is a schematic showing of a rangefinder which may be incorporated in the camera shown in Fig. 1;

Fig. 3 is a curve of the lens displacement vs. photocell output relationship for the apparatus of Fig. 2;

Fig. 4 is a schematic showing of a lens assembly which may be used with the Fig. 2 apparatus;

Fig. 5 is a schematic showing of another alternative lens assembly which may be used with the Fig. 2 apparatus; and

Fig. 6 is a curve showing the lens displacement vs. photocell output relationship prevailing for either lens assembly of Figs. 90

[Price 25p]

4 or 5.

Referring to Fig. 1, an embodiment of the invention is disclosed in connection with a still camera 11 of general arrangement well known in the art and having the usual standard features including a viewfinder aperture 12, a film winding mechanism 13, an objective lens assembly 14, a shutter 42 (see Fig. 2), and a shutter release button 17. It will be understood that the invention is equally applicable to movie cameras and other apparatus.

The camera 11 is provided with apertures 18 and 21 for a photocell lens 22 and a lens 23 (shown in Fig. 2) respectively, and a motor start button 24, the functions of which will become apparent from the description which follows. Referring now to Fig. 2, there is shown a rangefinder apparatus 25, including a lens assembly comprising the photocell lens 22 and the lens 23, mounted in a suitable carriage 27 which is movable forward and reverse in the direction of the arrows but within limits defined by stops 28a and 28b by an electric motor 28.

The lenses 22 and 23 are preferably identical and are supported by the carriage 27 in duplex relationship so that during use of the camera, they are positioned substantially the same distance from the object 41, and they are movable in synchronism by the motor 28. The object 41 is in a line of sight view of objective lens 14 of the camera 11. Reflected light from the object is projected by the lens 22 upon a photocell 44 and the resulting output therefrom is provided as an input to suitable circuitry described hereinafter, for controlling the motor 28 to the camera objective lens 14 in a film plane F. For clarity of illustration some details of the camera 11 have been omitted. For example, the lens 14 is, of course, disposed between the object 41 and the film plane F. The photocell 44 is advantageously disposed along the lens axis of the lens 22 and is of a general class of devices wherein its electrical output is related to the magnitude and contrast of incident light such as the aforementioned sulphide or cadmium cells which have an electrical output which varies directly with the amount of light incident thereon, but also have the characteristic that their output changes when the distribution of incident light varies even when the total incident light remains the same. This phenomenon is characterized by the fact that the output will vary abruptly (viz. a perturbation) at the point where the cell is moved through a position when an image of an object is sharply focused thereon.

In accordance with the invention, the perturbation effect is augmented. Towards this end, there is provided a suitable light source 47 with reflector 48 for projecting

light rays through a plano-convex lens 51 to the transmitting lens 23. In order to provide contrast to the object, a transparency 53 passes light which is directed to the object 41. Advantageously, the transparency 53 is formed with a checkerboard pattern of light and dark areas. The projected light rays are pulsed at a predetermined frequency either electrically or by suitable mechanical means such as the illustrated mechanical chopper 54 which increases the effectiveness of the apparatus 25, especially in the process of electrically detecting a perturbation in the output of the photocell 44 as described later in this specification.

Advantageously, the transparency 53 and the photocell 44 are so disposed that they occupy the same position relative to their respective lenses (viz. they are disposed at optical conjugate positions). Thus, when the projected light which passes through the transparency forms a pattern which is blurred when projected on the object 41, so too the reflected image is rendered even more blurred by the lens 22 when transmitted to form an image on the photocell 44. However, when both lenses are focused at the same time and the contrast of the reflected image is a maximum, the perturbation effect is more pronounced at the output from the photocell 44 inasmuch as the contrast of the image formed on the object is a maximum. The photocell lens 22 may advantageously be provided with a centrally positioned stop means 57 to prevent the passage of all except the rim rays, which further enhances the perturbation effect.

The perturbation effect can be still further enhanced by improving the contrast of the reflected image formed on the photocell 44. Towards this end, there is provided a band pass optical filter represented by dotted line 58 which is designed to limit the emission spectrum of the light 47 and the receiving spectrum of the photocell 44 to that portion of the light spectrum to which the photocell 44 is most responsive. Thus, by reducing the general ambient light seen by the photocell, the signal to noise output of the photocell 44 can be enhanced. This effect could also be achieved by placing the filter 58 only in front of the receiving lens 22 although the illustrated arrangement is preferred.

To commence operation, the button 24 is depressed which may be arranged to close contacts and apply a source of potential to the motor 28, light source 47, and a circuit 60 hereinafter described. The reflected image of the objective having the contrast pattern is formed by the lens 22 on the photocell 44. The resulting electrical voltage output of the photocell 44 is (discounting noise) a relatively smooth line curve (except at the best focus position, see Fig. 3) and is applied to the circuit 60 which includes a band-pass

filter 77, adapted to pass frequency components centered on the frequency of the chopper 54. The filtered output is then applied to a current detector 78. The detector output is applied to a switch network 81 which is designed to maintain a constant signal to an amplifier 82 so long as the photocell output remains on the smooth portion of the curve of Fig. 3, but functions to switch the amplifier OFF when a perturbation in the photocell output occurs. The output from amplifier 82 is applied as a driving voltage to the servo motor 28, and when cut off causes the motor 28 to stop. The servo motor 28 may take various known forms such as a traversing lead screw arrangement used for imparting transverse motion to such items as coil winders, line guides, or the like. Whatever arrangement is used, as the motor 28 is operated, the lens carriage 27 is moved back within the limits defined by stops 28a and 28b (shown schematically near the carriage 27) searching for the best focus position, and when it is found the search is ended by stopping the motor 28. The carriage is initially moved from a position corresponding to infinity focus for the lens 22 (see point *a* on the curve of Fig. 3) to the position wherein the lens 22 sharply focuses the image of the object 41 on the photocell 44 and a perturbation occurs. At this position the carriage is stopped. If a perturbation is not detected, then the objective lens 14 should be disposed at an infinity focus position.

In order to focus the objective lens 14, the motor 28 is adapted to rotate a lens adjusting cam 83 such that all of the lenses 22, 23, and 14 will simultaneously be in focus when the perturbation is detected and the motor stopped. Other means which are effective to focus the lens 14 in response to the perturbation will undoubtedly suggest themselves to those skilled in the art.

Referring in detail to Fig. 3, the illustrated curve is a typical lens displacement vs. cell output curve resulting when the carriage 27 is moved. For sake of illustration, the curve is shown smooth and depicts a gradual decrease in the cell output with lens displacement from the infinity position "*a*" on the curve. This is, of course, due to the fact that the amount of light directed to the photocell 44 decreases as the lens 22 moves away from the photocell. However, a marked discontinuity or perturbation occurs in the curve as the lens passes through the point of best or optimum focus indicated by dotted line "*f*" wherein the image formed by the lens 22 on the photocell 44 is focused and the contrast pattern is a maximum. The provision of contrast to the light reflected from the object 41 results in a readily detectable rise in the curve. The curve may, of course, not be completely smooth due to

noise in the output of the cell 44, but this small ripple should not be enough to actuate the switch 81. Thus, where the term smooth is used, it will be understood to be used in a relative sense.

Turning now to an alternative lens assembly 90 shown in Fig. 4, there is provided an arrangement for maintaining constant the acceptance angle " θ " for the photocell 44 to maintain the amount of light received by the photocell at a relative constant level. For this purpose, the carriage 27 is provided with a gate 71 which is adapted to open the viewing aperture as the lens carriage 27 moves the lens 22 away from the photocell from position "*a*" to position "*b*".

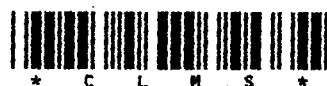
Alternatively, a similar effect (viz. maintaining a constant angle θ) may be attained by use of a fixed stop 74 positioned between the lens 22 and the photocell 44. For both of the embodiments of Figs. 4 and 5, the output of the photocell 44 will be a smooth, straight line output curve (except for the best focus perturbation) such as shown in Fig. 6. This type of an output will facilitate detection by the circuitry 60 wherein the switch 81 may be a conventional threshold detector.

The invention has been described in detail with particular reference to the preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the scope of the appendant Claims.

WHAT WE CLAIM IS:—

1. A rangefinder of the kind in which the electrical output of a photocell is monitored during the movement of a lens which is attempting to focus on the photocell an image of an object whose range is required, a discernable condition of the output indicating the point of sharp focus, in combination with means, including a source of radiation, for projecting a contrast pattern onto the object for focusing onto the photocell.

2. A rangefinder comprising photosensitive means having an electrical output related to the magnitude of incident radiant energy, a source of radiation, means cooperative with the radiation source for projecting an image having a contrast pattern upon an object whose range is required, a lens disposed in cooperative relation with the photosensitive means for receiving radiation reflected from the object, means coupled to the lens for varying the distance between the lens and the object to move the lens in relation to the photosensitive means through a position wherein the lens focuses radiation reflected from the object including the contrast pattern on to the photosensitive means, the photosensitive means having a discernable output when the lens is moved



filter 77, adapted to pass frequency components centered on the frequency of the chopper 54. The filtered output is then applied to a current detector 78. The detector output is applied to a switch network 81 which is designed to maintain a constant signal to an amplifier 82 so long as the photocell output remains on the smooth portion of the curve of Fig. 3, but functions to switch the amplifier OFF when a perturbation in the photocell output occurs. The output from amplifier 82 is applied as a driving voltage to the servo motor 28, and when cut off causes the motor 28 to stop. The servo motor 28 may take various known forms such as a traversing lead screw arrangement used for imparting transverse motion to such items as coil winders, line guides, or the like. Whatever arrangement is used, as the motor 28 is operated, the lens carriage 27 is moved back within the limits defined by stops 28a and 28b (shown schematically near the carriage 27) searching for the best focus position, and when it is found the search is ended by stopping the motor 28. The carriage is initially moved from a position corresponding to infinity focus for the lens 22 (see point *a* on the curve of Fig. 3) to the position wherein the lens 22 sharply focuses the image of the object 41 on the photocell 44 and a perturbation occurs. At this position the carriage is stopped. If a perturbation is not detected, then the objective lens 14 should be disposed at an infinity focus position. In order to focus the objective lens 14, the motor 28 is adapted to rotate a lens adjusting cam 83 such that all of the lenses 22, 23, and 14 will simultaneously be in focus when the perturbation is detected and the motor stopped. Other means which are effective to focus the lens 14 in response to the perturbation will undoubtedly suggest themselves to those skilled in the art. Referring in detail to Fig. 3, the illustrated curve is a typical lens displacement vs. cell output curve resulting when the carriage 27 is moved. For sake of illustration, the curve is shown smooth and depicts a gradual decrease in the cell output with lens displacement from the infinity position "*a*" on the curve. This is, of course, due to the fact that the amount of light directed to the photocell 44 decreases as the lens 22 moves away from the photocell. However, a marked discontinuity or perturbation occurs in the curve as the lens passes through the point of best or optimum focus indicated by dotted line "*f*" wherein the image formed by the lens 22 on the photocell 44 is focused and the contrast pattern is a maximum. The provision of contrast to the light reflected from the object 41 results in a readily detectable rise in the curve. The curve may, of course, not be completely smooth due to

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Alternatively, a similar effect (viz. maintaining a constant angle θ) may be attained by use of a fixed stop 74 (Fig. 5) positioned between the lens 22 and the photocell 44. For both of the embodiments of Figs. 4 and 5, the output of the photocell 44 will be a smooth, straight line output curve (except for the best focus perturbation) such as shown in Fig. 6. This type of an output will facilitate detection by the circuitry 60 wherein the switch 81 may be a conventional threshold detector.

The invention has been described in detail with particular reference to the preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the scope of the appended Claims.

WHAT WE CLAIM IS:—

1. A rangefinder of the kind in which the electrical output of a photocell is monitored during the movement of a lens which is attempting to focus on the photocell an image of an object whose range is required, a discernable condition of the output indicating the point of sharp focus, in combination with means, including a source of radiation, for projecting a contrast pattern onto the object for focusing onto the photocell.

2. A rangefinder comprising photosensitive means having an electrical output related to the magnitude of incident radiant energy, a source of radiation, means cooperative with the radiation source for projecting an image having a contrast pattern upon an object whose range is required, a lens disposed in cooperative relation with the photosensitive means for receiving radiation reflected from the object, means coupled to the lens for varying the distance between the lens and the object to move the lens in relation to the photosensitive means through a position wherein the lens focuses radiation reflected from the object including the contrast pattern on to the photosensitive means, the photosensitive means having a discernable output when the lens is moved



- through the position of sharp focus, and means coupled to the photosensitive means and responsive to the said electrical output for detecting the discernable output.
- 5 3. A rangefinder as claimed in Claim 2, for positioning an objective lens with respect to a film plane to focus an image of the object in the film plane, comprising means for focusing the objective lens, and means
- 10 coupling the focusing means to the discernable output detecting means.
4. A rangefinder as claimed in Claim 3, wherein the objective lens and the lens co-operating with the photosensitive means are
- 15 arranged to be focused simultaneously.
5. A rangefinder as claimed in Claim 2, wherein a lens comprising the said projection means and the lens cooperating with the photosensitive means are substantially
- 20 identical and are arranged to be disposed at substantially the same distance from the object.
6. A rangefinder as claimed in Claim 2, wherein the radiation from the source is
- 25 arranged to pulsate at a predetermined frequency.
7. A rangefinder as claimed in Claim 6, wherein the discernable output detecting means includes a band-pass filter tuned to the predetermined frequency.
8. A rangefinder as claimed in Claim 2, wherein a transparency providing the contrast pattern is arranged to be disposed between the object and the source of radiation.
9. A rangefinder as claimed in Claim 8, wherein the transparency carries a checker-board pattern.
10. A rangefinder as claimed in Claim 2, including means for maintaining a constant radiation acceptance angle for the photosensitive means during operation of the said lens.
11. A rangefinder as claimed in any of Claims 1 to 10, and incorporated in a photographic camera.
12. A rangefinder substantially as hereinbefore described with reference to Fig. 2 alone or to Figs. 2 and 4 or to Figs. 2 and 5 of the accompanying drawings.
13. A photographic camera incorporating a rangefinder, substantially as hereinbefore described with reference to Figs. 1 and 2, or 1, 2 and 4, or 1, 2 and 5 of the accompanying drawings.
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