

PATENT SPECIFICATION

(11) 1 401 299

1 401 299

- (21) Application No. 25718/72 (22) Filed 1 June 1972
 (31) Convention Application No. 150 074
 (32) Filed 4 June 1971 in
 (33) United States of America (US)
 (44) Complete Specification published 30 July 1975
 (51) INT CL² G01J 1/44
 (52) Index at acceptance

G1A 204 205 208 20Y 210 211 21X 21Y 247 248 269 357
 358 359 369 372 382 387 389 38X 39X 504 590 599
 59Y 773 792 797 798 79Y

G2A 401 404 492 602 603 607 616 709 711 BH

H3T 1A3 1C1 1C2 2A1N 2A1S 2A2 2F2 2F5 2T2X 2T3J
 2T5 3N 3VX 3X

(72) Inventor LEE FITZPATRICK FRANK



(54) A DEVICE FOR MEASURING THE DENSITY OF A
 RADIATION IMAGE

(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 a device for measuring the density of a radiation image.

It is well known that circuitry including photo-sensitive detectors can be used to determine the exposure in a printing process, or the colour balance in a colour printing method. However, this prior art circuitry is concerned with an actual and direct control of the requisite exposure by means of timing of the light source, actuating of one or more shutters, or positioning one or more filters in relation to an optical system, for a determined time. Also, exposure control circuitry, as disclosed by the prior art, is usually concerned with a measurement of the light transmitted through an image in the form of a transparency or reflected from an image in the form of a print arranged in a fixed plane. As a result, there is no actual scanning of the image in the fixed plane by a plurality of photosensitive detectors so as to generate an output signal or signals corresponding to the Dmax and Dmin of the image.

Our Letters Patent No. 1,229,677 shows an apparatus which overcomes some of the above disadvantages. In the British Patent, an average density measurement is made of

the peripheral area of the subject to be measured. The maximum density of a central area is determined by a plurality of discrete photosensitive detectors which are connected to an auctioneering circuit which determines which photosensitive detector is detecting maximum density and produces an output indicative of that density. This arrangement tends to be complicated, however, and is not as flexible as would be desirable.

According to the present invention there is provided a device for measuring the density of a radiation image, comprising an array of photosensitive detectors arranged relative to the image, each detector being responsive to the radiation derived from a respective area of the image and generating an output signal in accordance therewith; first circuit means including a number of discrete sub-circuits connected in parallel across a source of potential, each sub-circuit including a resistor serially connected with one of the detectors; an amplifier circuit having one input terminal connected to control means for producing a control signal, respective means connected to the amplifier circuit and each discrete sub-circuit and responsive to the control signal for successively inhibiting the flow of current through the respective means in dependence jointly on the output signal from the sub-circuit and the control signal and wherein the control means is connected between the one and another input terminal of the amplifier circuit, the arrangement being such that the amplifier output corresponds to successive image density factors associated with said detectors.

Reference is now made to the

[Price 33p]

SEE ERRATA SLIP ATTACHED

accompanying drawings wherein:—

Fig. 1 is a schematic view of a circuit in accordance with the present invention for providing an exposure histogram of an image; and

Fig. 2 is a graph showing voltage output plotted against the centre tap position of the variable resistor shown in Fig. 1.

Referring to Fig. 1, a circuit comprising three components is shown, but any number of additional components, each comprising a photosensitive detector, a resistor, and a back-to-back set of diodes, can be added in parallel to give N total components without changing the function of the circuit. A group of photosensitive detectors (60—1, 60—2, 60—3, . . . 60—N) is connected across DC voltage supply 62. In each photosensitive detector circuit, a line (61—1, 61—2, 61—3, . . . 61—N) connects its respective photosensitive detector to the negative terminal of DC voltage supply 62, and a line (63—1, 63—2, 63—3, . . . 63—N) also connects the photosensitive detector to the positive terminal of DC voltage supply 62 through a respective resistor (64—1, 64—2, 64—3, . . . 64—N). The lines (61—1, 61—2, 61—3, . . . 61—N) are also connected to the inverting terminal of operational amplifier 66. The output line 67 from operational amplifier 66 is connected to the positive terminal of voltmeter 68 or to a recording device 81. The negative terminal of voltmeter 68 is connected to ground. Lines (63—1, 63—2, 63—3, . . . 63—N) are also connected through a respective set of back-to-back diodes (65—1, 65—2, 65—3, . . . 65—N) to output line 67. The positive terminal of DC voltage supply 69 is connected by line 70 to the non-inverting terminal of operational amplifier 66. Line 70 is also connected to ground via line 71. The positive terminal of DC voltage supply 69 is also connected to the negative terminal of DC voltage supply 72 which has its positive terminal connected through a variable resistor 73 to the negative terminal of DC voltage supply 69. The centre tap 74 of variable resistor 73 is connected through a resistor 75 to the inverting terminal of operational amplifier 66. The centre tap 74 can be moved along resistor 73 in increments determined by a stepping motor 76 which can be connected in any suitable manner to centre tap 74.

As there is no feed back from the output 67 of the operational amplifier 66 to either of its inputs, the loop gain is very large and the amplifier 66 operates in a current limited mode.

The circuit shown in Fig. 1 can be used to provide an exposure histogram 82, see Fig. 2, of the radiation falling on photocells (60—1, 60—2, 60—3, . . . 60—N). As described hereinabove, the photosensitive

detectors (60—1, 60—2, 60—3, . . . 60—N) are arranged relative to the image or focal plane of an optical system so as to receive varying degrees of illumination. If it is assumed that photo-sensitive detector 60—1 is receiving less illumination than photosensitive detector 60—2, and that photosensitive detector 60—2 is receiving less illumination than photosensitive detector 60—3, the resistance of photosensitive detector 60—1 is higher than the resistance of photosensitive detector 60—2 and the resistance of photosensitive detector 60—2 is higher than the resistance of photosensitive detector 60—3. Therefore, the voltage appearing on line 63—1 of photosensitive detector 61—1 is higher than the voltage appearing on line 63—2 which in turn, is higher than the voltage appearing on line 63—3. The output of voltmeter 68 is shown in Fig. 2 as a function of the position of centre tap 74 on variable resistor 73. As is well known, a back-biased diode passes a substantially constant current with an increase in voltage until it breaks down. In this apparatus, diodes are chosen which do not break down within the range in which they are operated. When centre tap 74 is in position A, the current flowing through resistor 75 to the inverting terminal of operational amplifier causes it to produce a current which is positive and which passes through all of the diodes. Since the diode-sets 65—1 etc. can only pass a limited current the output potential of the operational amplifier 66, rises to the positive saturation voltage $+V_{sat}$ as indicated by the voltage reading on voltmeter 68. Centre tap 74 is then moved from point A toward point B. When centre tap 74 reaches the point X_1 (see Fig. 2), the current flowing through resistor 75 to the inverting terminal of operational amplifier 66 no longer causes amplifier 66 to be saturated so that the three parallel paths of diodes and photosensitive detectors are supplied by the amplifier 66 with the current necessary to keep its output tracking with its input. Since the voltage at point 67 is still above the voltages at points 4, 5 and 6, which are produced by the resistances of the photocells alone, all of the diode sets conduct between points X_1 and X_2 . Thus, a voltage is produced on line 67 that is equal to the voltage V_1 (see Fig. 2), which is the voltage at point 6. As the voltage on the inverting input of amplifier 66 becomes more and more positive, the current output of amplifier 66 remains constant. This holds true until the current output of amplifier 66 is no longer sufficient to supply all three diode sets.

At this point X_2 (see Fig. 2) current no longer flows through diode set 65—1 and the voltage at point 67 drops to V_2 . The

voltage appearing on line 67 will stay at the level of V_2 which is the voltage at point 5, as the centre tap of variable resistor 73 is moved up to point B until diode set 65—2 stops conducting due to insufficient current from point 67. When the centre tap 74 of variable resistor 73 reaches point X_1 , the current at point 67 is no longer sufficient to supply both diode sets, and diode set 65—2 ceases to conduct and the voltage at point 67 drops to the voltage at point 4 which is voltage V_3 . Again the voltage at point 67 is held constant until the current at point 67 is insufficient to supply diode set 65—3, at which point diode set 65—3 ceases to conduct and the output of the amplifier 66 goes to negative saturation.

The description presented hereinabove is based on the assumption that photosensitive detector 60—1 will be receiving the least illumination and photosensitive detector 60—3 the most illumination. Obviously, the circuit will function in a similar manner irrespective of which of the photosensitive detector (60—1, 60—2, 60—3, . . . 60—N) will be receiving the least illumination.

Using the circuit shown in Fig. 1, it can be seen that by noting the height of a discontinuity and its width, in the output of voltmeter 68, as centre tap 74 is moved along variable resistor 73, as described hereinabove, one can determine the amount of light falling on any photo-sensitive detector or detectors and the number of photosensitive detectors on which such a level of light is falling, and adjust the exposure accordingly.

The circuit described hereinabove can be used to determine the minimum and maximum amount of illumination falling on the photosensitive detectors. The photosensitive detectors are understood to be arranged relative to the focal plane of an optical system in which a photographic transparency or print transmits or reflects varying degrees of illumination. The transparency or print can be moved relative to a linear array of such photosensitive detectors or positioned relative to an areal array thereof. In either case, means must be provided to remember the element that receives the least or the most illumination. With a linear array, the illumination can continuously vary from one element to another as scanning takes place. In the case of an areal array, the illumination incident on each photosensitive detector remains the same but can vary from one to another.

In certain applications of the circuits described hereinabove, a lens can be positioned relative to each photosensitive detector or to the complete array. In either case, the radiation or light meter formed by such a combination of lens and

photosensitive detector will measure essentially only the shadow area in any scene toward which the meter is directed. If relatively few photosensitive detectors are used to cover the field of view, it is believed that more consistent exposures can be obtained than with present exposure meters. For example, in a scene or picture in which a bright light source is in the field of view, an exposure meter based on the circuitry shown in Fig. 1 would ignore the light source (most illuminated cell) and provide an exposure (based on least-illuminated cell) which would yield a printable negative. With respect to a cinematographic camera, the exposure would be relatively independent of the amount of sky in the picture. If a photocell samples too small a field of view, there is a possibility of its providing for exposure of a small, dark detail in the shadows; therefore, there is an advantage in using a simple, small array of photosensitive detectors.

In the present invention the voltage indicative of a most illuminated or least-illuminated photosensitive detector light-sensitive cell, photocell or photo-transistor is used to augment an exposure control device or system. In Fig. 1, the voltmeter 68 could be replaced by a recording device 81 which would provide a histogram 82, such as that shown in Fig. 2. In any such application, the measured voltage as derived from the circuitry disclosed herein, would be used to supplement or adjust the exposure factor already independently generated.

WHAT WE CLAIM IS:—

1. A device for measuring the density of a radiation image, comprising an array of photosensitive detectors arranged relative to the image, each detector being responsive to the radiation derived from a respective area of the image and generating an output signal in accordance therewith; first circuit means including a number of discrete sub-circuits connected in parallel across a source of potential, each sub-circuit including a resistor serially connected with one of the detectors; an amplifier circuit having one input terminal connected to control means for producing a control signal, respective means connected to the amplifier circuit and each discrete sub-circuit and responsive to the control signal for successively inhibiting the flow of current through the respective means in dependence jointly on the output signal from the sub-circuit and the control signal and wherein the control means is connected between the one and another input terminal of the amplifier circuit, the arrangement being such that the amplifier output corresponds successively to image density factors associated with said detectors.



voltage appearing on line 67 will stay at the level of V_2 which is the voltage at point 5, as the centre tap of variable resistor 73 is moved up to point B until diode set 65—2 stops conducting due to insufficient current from point 67. When the centre tap 74 of variable resistor 73 reaches point X_1 , the current at point 67 is no longer sufficient to supply both diode sets, and diode set 65—2 ceases to conduct and the voltage at point 67 drops to the voltage at point 4 which is voltage V_3 . Again the voltage at point 67 is held constant until the current at point 67 is insufficient to supply diode set 65—3, at which point diode set 65—3 ceases to conduct and the output of the amplifier 66 goes to negative saturation.

The description presented hereinabove is based on the assumption that photosensitive detector 60—1 will be receiving the least illumination and photosensitive detector 60—3 the most illumination. Obviously, the circuit will function in a similar manner irrespective of which of the photosensitive detector (60—1, 60—2, 60—3, . . . 60—N) will be receiving the least illumination.

Using the circuit shown in Fig. 1, it can be seen that by noting the height of a discontinuity and its width, in the output of voltmeter 68, as centre tap 74 is moved along variable resistor 73, as described hereinabove, one can determine the amount of light falling on any photo-sensitive detector or detectors and the number of photosensitive detectors on which such a level of light is falling, and adjust the exposure accordingly.

The circuit described hereinabove can be used to determine the minimum and maximum amount of illumination falling on the photosensitive detectors. The photosensitive detectors are understood to be arranged relative to the focal plane of an optical system in which a photographic transparency or print transmits or reflects varying degrees of illumination. The transparency or print can be moved relative to a linear array of such photosensitive detectors or positioned relative to an areal array thereof. In either case, means must be provided to remember the element that receives the least or the most illumination. With a linear array, the illumination can continuously vary from one element to another as scanning takes place. In the case of an areal array, the illumination incident on each photosensitive detector remains the same but can vary from one to another.

In certain applications of the circuits described hereinabove, a lens can be positioned relative to each photosensitive detector or to the complete array. In either case, the radiation or light meter formed by such a combination of lens and

photosensitive detector will measure essentially only the shadow area in any scene toward which the meter is directed. If relatively few photosensitive detectors are used to cover the field of view, it is believed that more consistent exposures can be obtained than with present exposure meters. For example, in a scene or picture in which a bright light source is in the field of view, an exposure meter based on the circuitry shown in Fig. 1 would ignore the light source (most illuminated cell) and provide an exposure (based on least-illuminated cell) which would yield a printable negative. With respect to a cinematographic camera, the exposure would be relatively independent of the amount of sky in the picture. If a photocell samples too small a field of view, there is a possibility of its providing for exposure of a small, dark detail in the shadows; therefore, there is an advantage in using a simple, small array of photosensitive detectors.

In the present invention the voltage indicative of a most illuminated or least-illuminated photosensitive detector light-sensitive cell, photocell or photo-transistor is used to augment an exposure control device or system. In Fig. 1, the voltmeter 68 could be replaced by a recording device 81 which would provide a histogram 82, such as that shown in Fig. 2. In any such application, the measured voltage as derived from the circuitry disclosed herein, would be used to supplement or adjust the exposure factor already independently generated.

WHAT WE CLAIM IS:—

1. A device for measuring the density of a radiation image, comprising an array of photosensitive detectors arranged relative to the image, each detector being responsive to the radiation derived from a respective area of the image and generating an output signal in accordance therewith; first circuit means including a number of discrete sub-circuits connected in parallel across a source of potential, each sub-circuit including a resistor serially connected with one of the detectors; an amplifier circuit having one input terminal connected to control means for producing a control signal, respective means connected to the amplifier circuit and each discrete sub-circuit and responsive to the control signal for successively inhibiting the flow of current through the respective means in dependence jointly on the output signal from the sub-circuit and the control signal and wherein the control means is connected between the one and another input terminal of the amplifier circuit, the arrangement being such that the amplifier output corresponds successively to image density factors associated with said detectors.

2. A device for measuring the density of a radiation image, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

L. A. TRANGMAR, BSc., C.P.A.,
Agent for the Applicants.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1975.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from
which copies may be obtained.



* C L M S *