United States Patent

Okumura

[15] **3,678,188**

[45] **July 18, 1972**

[54] **METHOD FOR RECORDING A PHOTOGRAPHIC DENSITY**

[72] Inventor: **Minoru Okumura,** Tokyo, Japan

[73] Assignee: **Konishiroku Photo Industry Co., Ltd.**

[22] Filed: **Sept. 22, 1970**

[21] Appl. No.: **74,426**

[30] **Foreign Application Priority Data**

Oct. 4, 1969 Japan.....44/78967

[52] **U.S. Cl.**.....**178/6.6 R,** 178/DIG. 34, 346/33 A, 346/62, 356/203

[51] **Int. Cl.**.....**G01d 9/32,** G01n 21/22, H04n 1/38

[58] **Field of Search**.....178/6.6 R, 6.7 R, DIG. 34; 346/33 A, 62; 356/203

[56] **References Cited**

UNITED STATES PATENTS

3,503,689	3/1970	Miller	346/33 A
3,119,919	1/1964	Pratt	346/74 SB
3,549,887	12/1970	Hansen	178/6.7 R
3,354,266	11/1967	Dinenno	178/DIG. 34
3,214,515	10/1965	Eberline	178/DIG. 34

Primary Examiner—Howard W. Britton

Attorney—Harry C. Bierman, Jordan B. Bierman and Bierman and Bierman

[57] **ABSTRACT**

A method for recording a photographic density in the form of equi-density curves on a plane is described, in which alternate equi-density curves are depicted with different kinds of lines, and in which an equi-density curve corresponding to one particular density value serving as a reference is depicted with a line distinguishable from the other curves.

1 Claim, 6 Drawing Figures

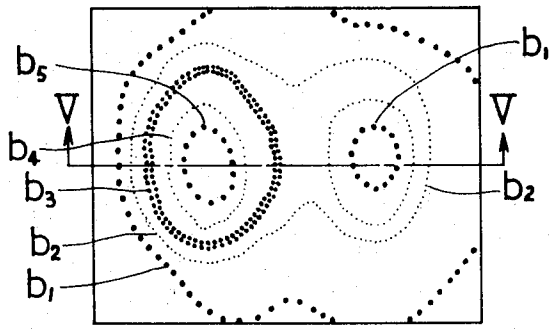


Fig.1

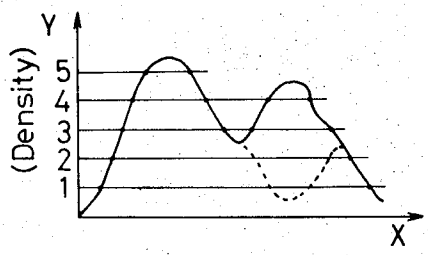


Fig.2

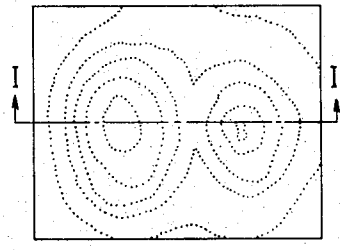


Fig.3

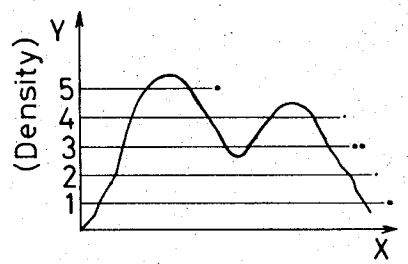


Fig.4

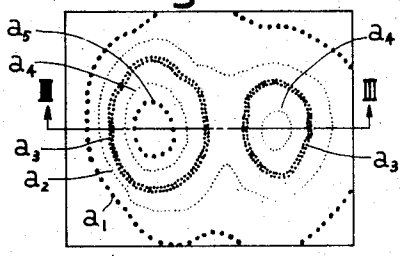


Fig.5

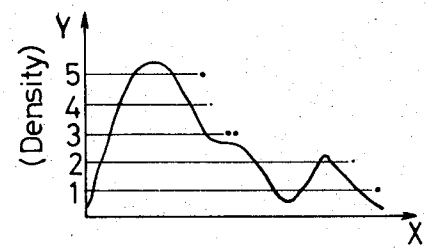
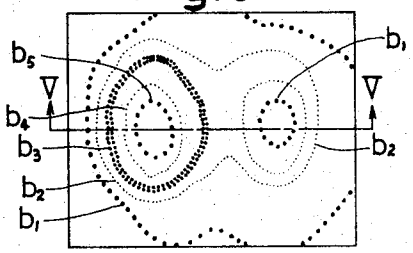


Fig.6



Minoru Okumura, INVENTOR

Brisman & Brisman ATTORNEY

Fig.7

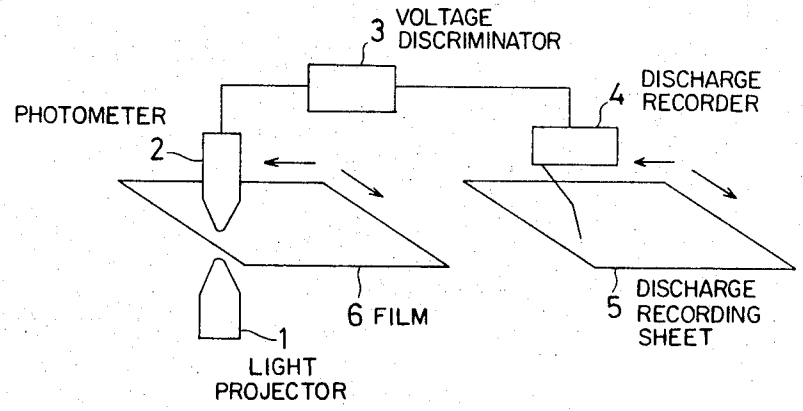
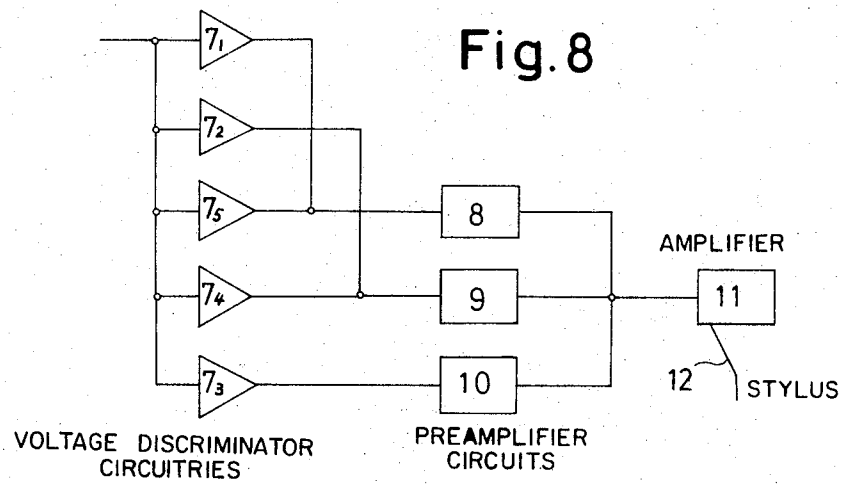


Fig.8



Minoru Okumura, INVENTOR

BY

Bierman & Bierman ATTORNEY

METHOD FOR RECORDING A PHOTOGRAPHIC DENSITY

The present invention relates to improvements in the method for recording a photographic density, in which the photographic density of an image is recorded by depicting equi-density curves.

The method for recording a photographic density by means of equi-density curves is very useful as in the analysis of X-ray photographs, and the apparatus for that purpose has been disclosed, for instance, in the technical journal TÔSHIBA REVIEW Vol. 24, No. 2 (1969) pp. 158–163 "Film Isodose Plotter" published by Tokyo Shibaura Electric Co., Ltd. in Japan, and in U.S. Pat. No. 3,424,534.

The method for recording a photographic density by means of equi-density curves is advantageous in that the density distribution of an image can be determined at a glance. However, according to such kind of methods in the prior art, there was a disadvantage that upon determination of the density distribution from the equi-density curves error could readily occur and also quantitative determination of the density was impossible. More particularly, in the aforementioned type of photographic density plotters in the prior art, since it is difficult to inscribe figures representing the value of density corresponding to each curve in view of the nature of the plotter in contrast to the case where contour lines are plotted on a map by hand, two adjacent equi-density curves cannot indicate which one represents the higher density and which one represent the lower density. Therefore, from a group of equi-density curves arranged concentrically, one cannot determine whether the portion of pattern represents a hill of density or a valey of density.

In the above-cited known references, provision is made such that a plurality of pens are used in a plotter which can plot in different colors respectively, or that the equi-density curves are represented with lines of different depths in color within each unit group of curves whereby errors in determination of the density distribution may be obviated.

However, even with such types of improvements, the disadvantage that the quantitative determination of the density cannot be achieved, has been not yet eliminated.

Therefore, an object of the present invention is to overcome the aforementioned disadvantages in the prior art.

One feature of the present invention is to provide a method for recording a photographic density in which equi-density curves are depicted by plotting the points having equal densities while two-dimensionally scanning a photographic image, characterized in that alternate equi-density curves are depicted with different kinds of lines, and that one equi-density curve corresponding to one particular density value serving as a reference is depicted with a line distinguishable from the other curves.

Another feature of the present invention is to provide the above-featured method, further characterized in that said alternate equi-density curves are depicted with lines of different depths in color.

Still another feature of the present invention is to provide the above-featured method, further characterized in that said one equi-density curve is depicted with a line consisting of a series of pairs of dots for the respective plotting points, while said the other curves are depicted with a line consisting of a series of individual dots for the respective plotting points.

Yet another feature of the present invention is to provide an apparatus for recording a photographic density according to the above-featured method, comprising means for detecting a photographic density at each minute area on a photographic film, a recording sheet, means for recording a dot at each minute area on said recording sheet, synchronous scanning means for making said detecting means scan over said photographic film two-dimensionally and for making said recording means scan over said recording sheet two-dimensionally so that the corresponding points on said photographic film and said recording sheet, respectively, may be scanned simultaneously with said detecting means and said recording means,

respectively, a plurality of discriminator means each having its input connected to the output of said detecting means for responding to a predetermined level of output signal from said detecting means to produce a discriminator output signal, a first amplifier having a higher amplification factor connected to alternate ones of sald discriminator means and responsive to alternate ones of said predetermined levels of output signal from said detecting means for producing an impulse having a higher amplitude, a second amplifier having a lower amplification factor connected to the remaining alternate ones of said discriminator means and responsive to the remaining alternate ones of said predetermined levels of output signal from said detecting means for producing an impulse having a lower amplitude, a third amplifier connected to particular one of said discriminator means in place of said first or second amplifier and responsive to particular one of said predetermined levels of output signal serving as a reference level for producing a pair of impulses, and means connected to all of the outputs of said first, second and third amplifiers and responsive to the impulse applied thereto for supplying an appropriate intensity of actuating signal to said recording means.

These and other objects, features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings, wherein:

FIG. 1 is a diagram representing a photographic density distribution along a straight line on a photographic film by means of an X–Y coordinate system,

FIG. 2 is a diagram of the photographic density distribution in FIG. 1 represented by means of equi-density curves according to the method in the prior art, line I—I in this pattern corresponding to said straight line in FIG. 1,

FIG. 3 is a diagram representing another photographic density distribution along a straight line on a photographic film by means of an X–Y coordinate system,

FIG. 4 is a diagram of the photographic density distribution in FIG. 3 represented by means of equi-density curves according to the method of the present invention, line III—III in this pattern corresponding to said straight line in FIG. 3,

FIG. 5 is a diagram representing still another photographic density distribution along a straight line on a photographic film by means of an X–Y coordinate system,

FIG. 6 is a diagram of the photographic density distribution in FIG. 5 represented by means of equi-density curves according to the method of the present invention, line V—V in this pattern corresponding to said straight line in FIG. 5,

FIG. 7 is a schematic view partially in a block form of a photographic density recording apparatus employing the method of the present invention, and

FIG. 8 is a block diagram showing the details of a voltage discriminator in the photographic density recording apparatus in FIG. 7 together with a discharge recorder in the same apparatus.

Referring now to FIGS. 1 and 2 of the drawings, a photographic density distribution and the corresponding equi-density curves depicted according to the prior art method are shown in order to illustrate the disadvantage of the prior art method.

The photographic density distribution along a certain straight line as illustrated in FIG. 1, may be represented, for example, by the equi-density curves in FIG. 2, assuming that the density distribution in FIG. 1 is taken along a straight line I—I passing through the center points A and B, respectively, of the two groups of concentric curves in FIG. 2. The same assumption is also true for FIGS. 3 and 4, and for FIGS. 5 and 6.

However, from the equi-density curves in FIG. 2, it is impossible to determine whether the center portion A or B is a hill portion of the density or a valey portion of the density. More particularly, with respect to the portion B, either the density distribution represented by a solid line or that represented by a dotted line in FIG. 1 may equally correspond to the equi-density curves as illustrated in FIG. 2. In addition, since the equi-density curves are depicted by plotting equi-

density points while scanning over a photographic film two-dimensionally, and since in such a process it is substantially impossible to inscribe a scale of density onto the diagram in view of the functional restriction the plotter, it is not known a curve representing what density value is a certain curve, and therefore, quantitative determination of a density cannot be obtained from the equi-density curves. This is a disadvantage caused by the quite different condition for depicting the curves from that for depicting contours of a map where the scale indicating a height may be easily printed together.

Now, at first, a photographic density recording apparatus employing the method of the present invention as illustrated in FIGS. 7 and 8 will be explained, and the correspondence between the density distribution and the equi-density curves obtained according to the present invention as illustrated in FIGS. 3 and 4 as well as in FIGS. 5 and 6 will be explained later.

FIG. 7 generally shows a photographic density recording apparatus embodying the present invention, in which the apparatus for measuring the photographic density and recording the same consists of a light projector **1**, a photometer **2**, a voltage discriminator **3**, a discharge recorder **4**, and a discharge recording sheet **5**.

A photographic film **6** whose photographic density is to be measured, is placed between the light projector **1** and the photometer **2**, and the photographic film **6** and recording sheet **5** are moved while maintaining a predetermined mutual positional relation.

The photographic film **6** is scanned two-dimensionally by the light projector **1** and the photometer **2** in combination to generate a voltage corresponding to the photographic density of the photographic film **6** from the photometer **2**. This voltage is discriminated by the voltage discriminator **3** so that a signal may be generated from the voltage discriminator **3** and fed to the discharge recorder **4** when the voltage coincide with voltages preset in the voltage discriminator **3**. This output signal is converted by the discharge recorder **4** into a voltage adapted for discharge recording to record the signal on the recording sheet **5**.

Now the construction of the discriminator **3** will be described in more detail with reference to FIG. **8**.

In FIG. **8**, reference numerals 7_1, 7_2, 7_3, 7_4 and 7_5 represent voltage discriminator circuitries, respectively, reference numerals **8**, **9** and **10** represent preamplifier circuits, respectively, reference numeral **11** represents an amplifier, and reference numeral **12** represents a discharge recording stylus. The preamplifier circuit **8** is a circuit for amplifying the signal from the discriminator circuitry 7_1 or 7_5, but has a higher amplification factor, and accordingly, the discharge record made by the signal from the discriminator circuitry 7_1 or 7_5 is so intense that the depth in color of the dots plotted on the recording sheet **5** through this channel is large. Whereas, the preamplifier circuit **9** is a circuit for amplifying the signal from the discriminator circuitry 7_2 or 7_4, but has a lower amplification factor, and accordingly, the depth in color of the dots on the recording sheet **5** plotted in accordance with the output of the discriminator circuitry 7_2 or 7_4 is small. On the other hand, the preamplifier **10** is an amplifier circuit for processing and amplifying the output signal from the discriminator circuitry 7_3 so as to produce two amplified pulses. Therefore, upon discharge recording due to the pulse from the preamplifier **10**, in response to the output signal from the discriminator circuit 7_3 two dots are recorded on the recording sheet **6**. The discriminator circuitries 7_1, 7_2, 7_3, 7_4 and 7_5 are preset so that they may generate a signal in response to the photographic densities **1**, **2**, **3**, **4** and **5**, respectively, in FIGS. **3** and **5**. In other words, the method for recording by means of the discriminator illustrated in FIG. **8**, is the method in which the equi-density curves are depicted so as to have different depths in color alternately and also in which one of the group of equi-density curves is made distinguishable from the other curves.

FIGS. **4** and **6** represent equi-density curves depicted according to the method of the present invention. The pattern in FIG. **4** shows equi-density curves representing a density distribution having two hills as illustrated in FIG. **3**. Since the reference curve a_3, which is distinguishable from the other curves a_1, a_2, a_4 and a_5, exists as two loops corresponding to the two hills in FIG. **3**, it is possible to read out the density distribution illustrated in FIG. **3** on the basis of the equi-density curves in FIG. **4**.

The pattern in FIG. **6** shows equi-density curve representing a density distribution having a hill on the left side and a valey on the right side as illustrated in FIG. **5**. In this case, since the loop of a reference curve b_3 exists on the left side only, it is possible to read out the density distribution illustrated in FIG. **5** on the basis of the equi-density curves in FIG. **6**.

Furthermore, if the plotter is preset so that the reference curves a_3 and b_3 may correspond to a known density, and if the difference in density between the adjacent equi-density curves is predetermined, then it is possible to read out the density at the respective points quantitatively from FIG. **4** or **6** by counting the number of the curves starting from the reference curve to the point in question.

The correspondence between the reference curve a_3 or b_3 and a particular density value can be altered as by changing the connection between the discriminator circuitry 7_1, 7_2, 7_3, 7_4 or 7_5 and the preamplifier circuit **10**.

The alteration of the correspondence may be conveniently carried out in accordance with the general density of the photographic film whose photographic density is to be measured, from a practical point of view.

While the above-described method for recording a photographic density employs five channels, it is a matter of course that any desired number of channels such as, for example, ten channels can be employed by the method.

As described, the present invention enables to determine the density distribution without errors, and also provides a method for recording a photographic density which enables a quantitative determination of the density, and thus it proves to be an industrially very useful invention.

What is claimed is:

1. An apparatus for recording a photographic density, comprising means for detecting a photographic density at each minute area on a photographic film, a recording sheet, means for recording a dot at each minute area on said recording sheet, synchronous scanning means for making said detecting means scan over said photographic film two-dimensionally and for making said recording means scan over said recording sheet two-dimensionally so that the corresponding points on said photographic film and said recording sheet, respectively, may be scanned simultaneously with said detecting means and said recording means, respectively, a plurality of discriminator means each having its input connected to the output of said detecting means for responding to one of a series of predetermined distinctive levels of output signal, a first amplifier having a higher amplification factor connected to alternate ones of said discriminator means and responsive to alternate ones of said predetermined levels of output signal from said detecting means for producing an impulse having a higher amplitude, a second amplifier having a lower amplification factor connected to the remaining alternate ones of said discriminator means and responsive to the remaining alternate ones of said predetermined levels of output signal from said detecting means for producing an impulse having a lower amplitude, a third amplifier connected to particular one of said discriminator means in place of said first or second amplifier and responsive to particular one of said predetermined levels of output signal serving as a reference level for producing a pair of impulses, and means connected to all of the outputs of said first, second and third amplifiers and responsive to the impulse applied thereto for supplying an appropriate intensity of actuating signal to said recording means.

* * * * *