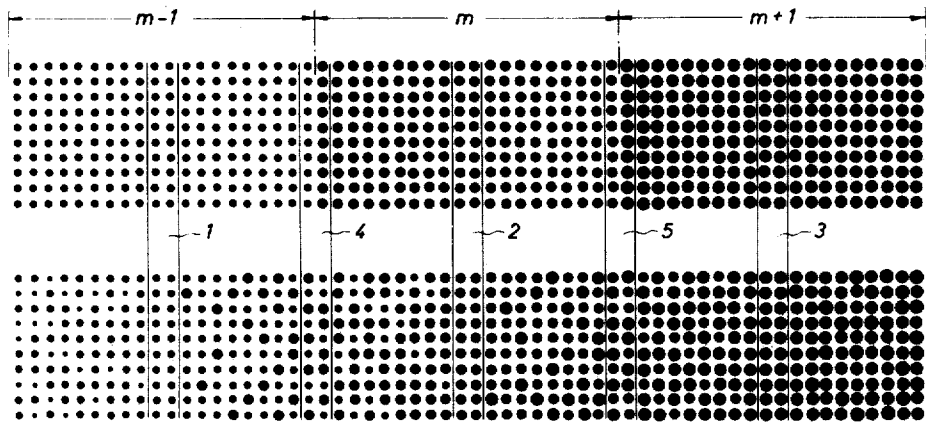


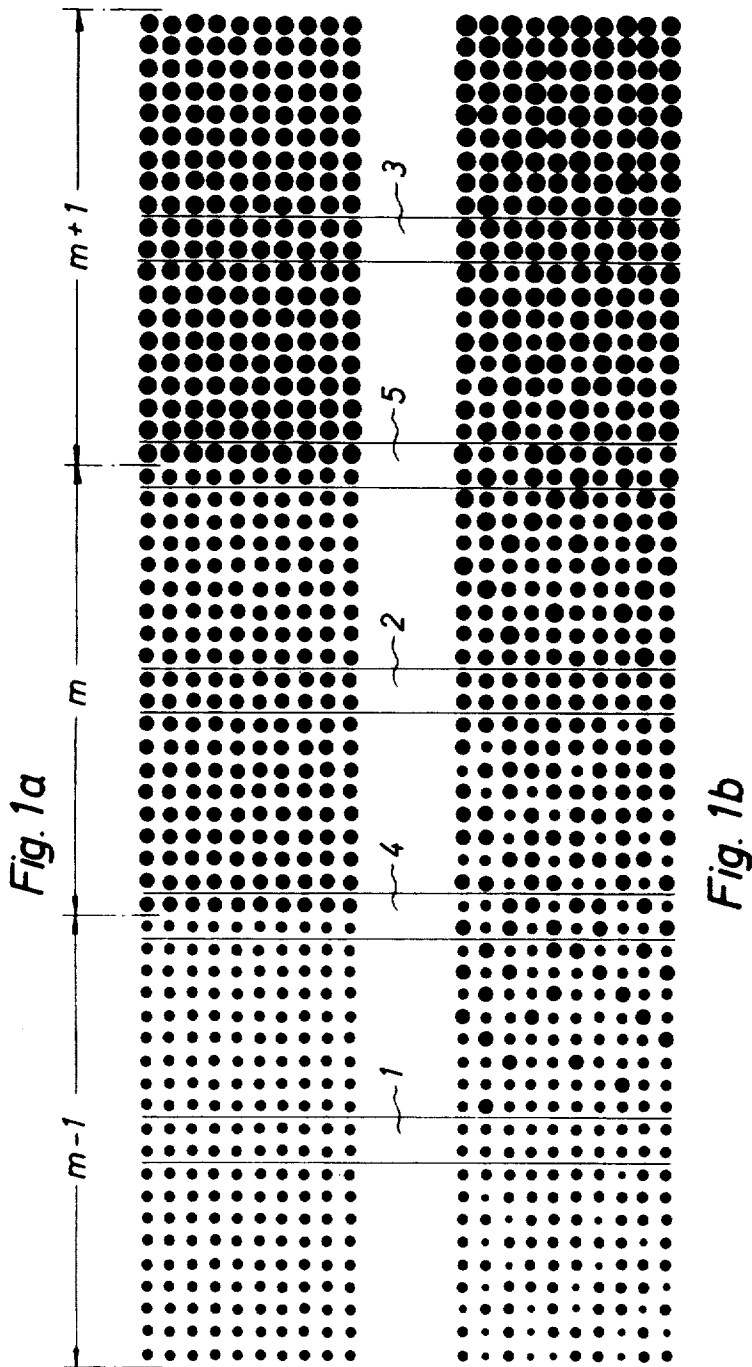
- [54] **METHOD FOR THE RASTERED
REPRODUCTION OF HALF-TONE
PICTURES**
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many
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- [30] **Foreign Application Priority Data**
May 4, 1968 Germany P 17 72 367.0
- [52] U.S. Cl.....**315/30**, 178/6.7
- [51] Int. Cl.....**H01J 29/52**
- [58] Field of Search ...315/30; 178/6.7, 6.6 B, DIG. 3

- [56] **References Cited**
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3,393,269 7/1968 Zeuthen 178/6.6 B
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Assistant Examiner—R. Kinberg
Attorney—Hill, Sherman, Meroni, Gross & Simpson

[57] **ABSTRACT**
A method for the raster reproduction of half-tone pic-
tures wherein a picture is scanned photoelectrically
dot-by-dot and voltage values are generated and quan-
tified to represent brightness ranges and wherein an
alternating voltage is superimposed on the voltage
values before they are quantified to generate a mixing
of dot sizes indicative of one brightness range with dot
sizes indicative of another adjacent brightness range
and to cause the mixing to occur in such a pattern as
to make transition between brightness ranges to be
more pleasing to the eye.

10 Claims, 7 Drawing Figures





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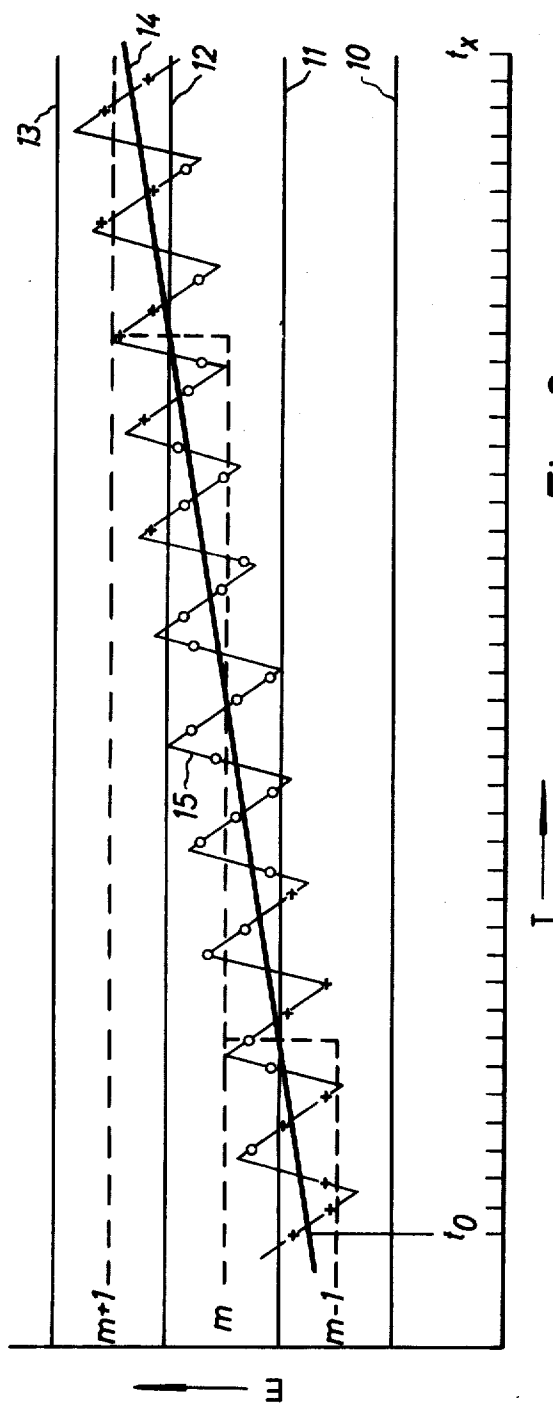


Fig. 2

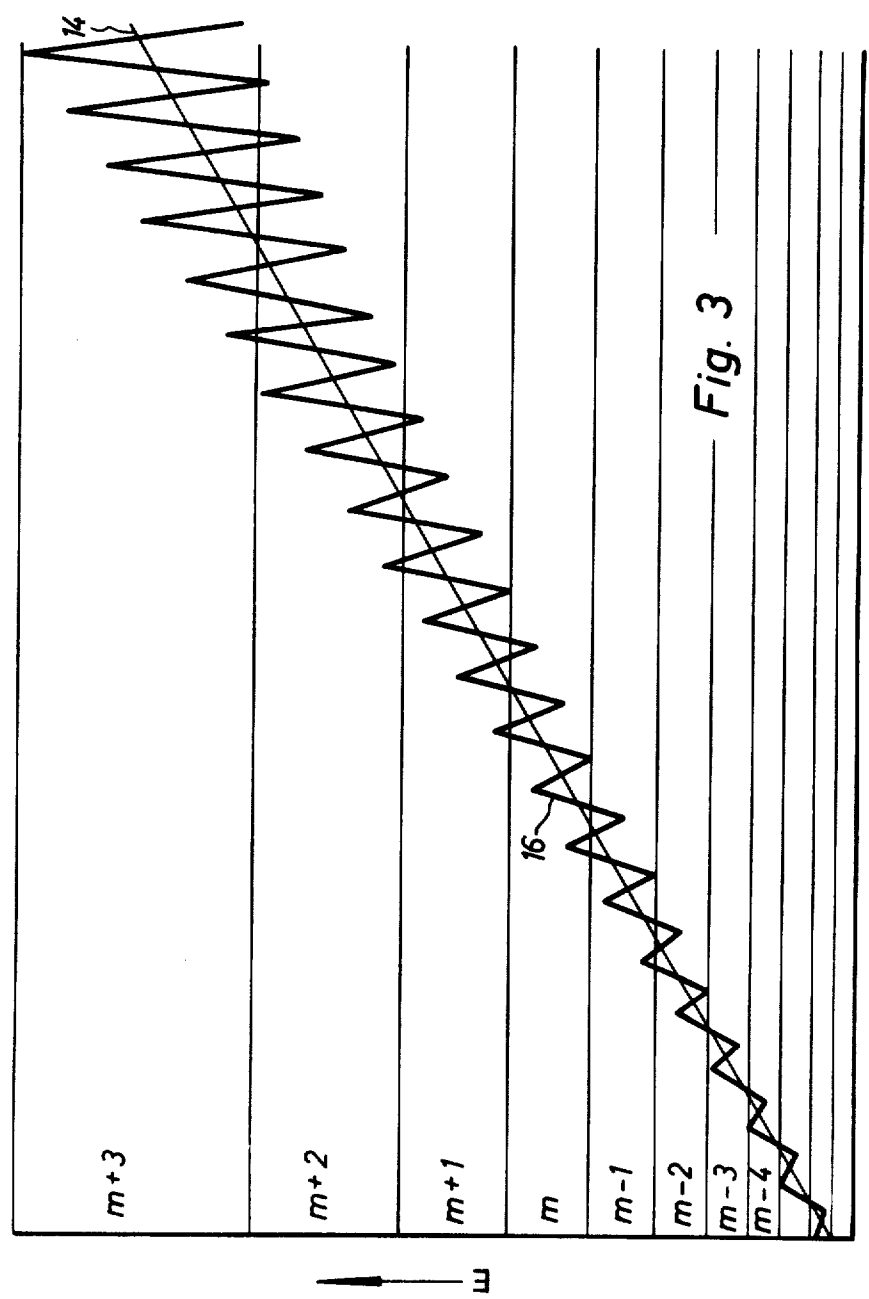
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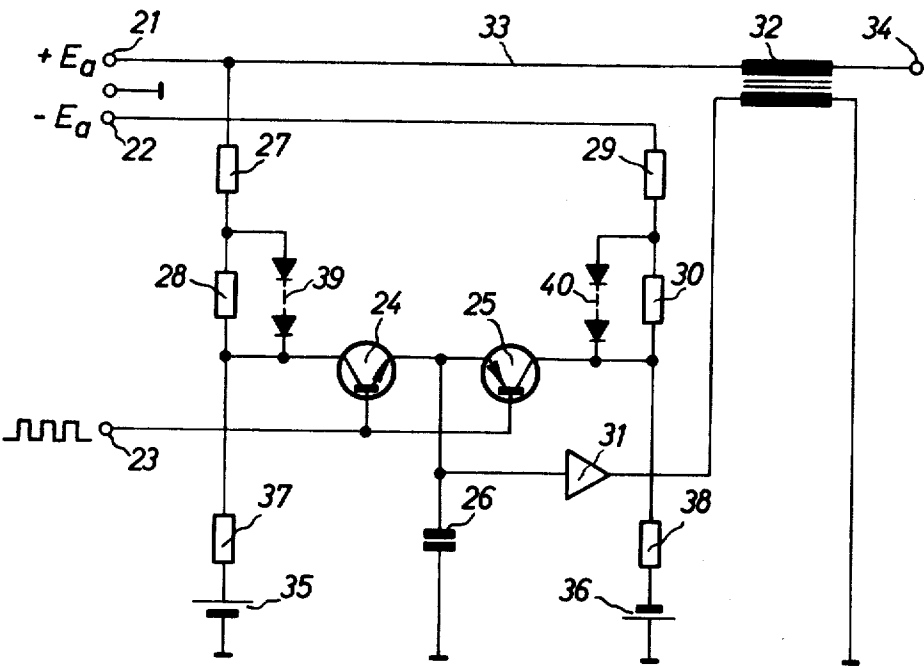


Fig. 4

Fig. 5

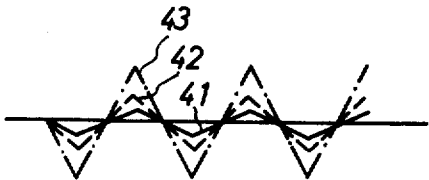
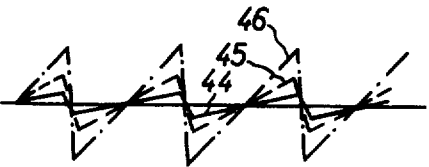


Fig. 6



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METHOD FOR THE RASTERED REPRODUCTION OF HALF-TONE PICTURES

BACKGROUND OF THE INVENTION

The invention relates to a method for raster reproduction of half-tone pictures which have high quality in color density gradations and which only requires the usual number of raster dot sizes, normally associated with an inferior quality of reproduction.

It is well known that in order to reproduce half-tone pictures in relief or offset print, the printer's forms must be rastered since it is not possible to reproduce the half-tones by suitably adjusting the thickness of the printing ink. Density gradations are obtained by using different size raster dots.

Where the printer's forms are produced by the chemical etching process, the raster is produced through photomechanical means by photographically copying a transparency or negative of the picture together with a contact raster film. The raster areas in this type of contact raster are vignettted, i.e. the degree of blackness decreases from a maximum at the center of the raster field towards the edge. The material used for copying in such cases is a film which is very "hard," that is to say, which has a very sharply rising density characteristic. By vignetting the contact raster in conjunction with the sharp sensitivity threshold of the film it is possible to determine the size of each raster dot from the local density value of the half-tone picture.

It is well known that printer's forms for relief printing may also be produced using engraving machines, the depth of penetration of the engraving stylus being controlled in dependence upon the brightness of an original which is photoelectrically scanned. The raster is achieved by means of a raster frequency current which is superimposed on the engraving stylus control current.

In each of the raster forming methods described above, a defined size of raster dot results from each degree of density of the half-tone picture which size varies continuously with the density.

It has recently become necessary to compose half-tone pictures in rastered form using electronic phototype letters in which the elements of the picture are stored in quantified and binary coded form and are read out to control an electron beam which traces the picture to be reproduced on a screen. If a rastered picture is to be traced, the picture content of the raster dots of different sizes must be readily available, for example, in a ring core store.

In order to keep the store capacity to be used for this purpose within reasonable limits, the number of quanta or the number of different raster dot sizes must be kept very small. The number of quanta regarded as a minimum for reproduction of any accuracy is, as known from the communications art, 32.

A relatively rough gradation of this type may be sufficient for portions of the picture which are highly structured but in sections which are not so highly structured, that is to say, in areas where the density only varies very gradually, the quality of reproduction leaves much to be desired. In these areas the density gradations show as equally dense zones which are markedly shifted relative to one another. This is known to be disturbing to the eye.

SUMMARY OF THE INVENTION

It is an object of the invention to make possible the reproduction of pictures without gradations in density transition and without increasing the number of raster dot sizes which have to be stored.

According to the invention, in order to achieve those density values which lie between any two adjacent density gradations which correspond to the specified raster dot sizes, raster dots of different, but preferably adjacent sizes are mixed with a statistical distribution, particularly in a proportion which corresponds to the ratio of the differences between the density value to be achieved and the two adjacent density gradations.

There exists conventional machines in which the original picture is scanned dot-by-dot photoelectrically and the voltage values of the picture signal analogous with the brightness values are quantified, i.e. assigned at regular moments in time determined by a timer each to one of a number of discrete voltage values which correspond to the different raster dot sizes and are expressed in binary code. In such devices, the method of the invention may be used by superimposing an alternating voltage on the picture signal voltages before the process of quantification, the amplitude of the said alternating voltage preferably being equal to half the difference between two successive, discrete voltage values while its frequency is not a harmonic in relation to the frequency of the timer.

The frequency of this alternating voltage is advantageously at least a quarter of the timer frequency.

It has proved advantageous from the point of view of statistical distribution of different raster dots which it is desired to achieve, to use a triangular or sawtooth alternating voltage as the voltage to be superimposed on the picture signal.

It is a well known fact that the human eye sees many fewer contrasts in the light portions of a picture than it does in the dark ones. Thus, in order not to have too few density gradations in the light portions and too many in the dark portions, there will be no uniform gradation but the discrete voltage stages will increase with increasing density, in accordance with the well known physiological sensitivity curve (Munsell function of like physiological differences in sensitivity). Consequently the amplitude of the voltage for superimposition will also be increased as density increases.

It is impossible to express the amplitude of the superimposed voltage analytically since the physiological sensitivity curve is merely an empirical function. In general all that can be said is that the amplitude of the superimposed voltage follows another non-linear function. Its real development can, however, be determined in actual cases without difficulty from the condition already mentioned, viz. that it is preferably equal to half the quantum stage, in this case therefore the quantum stage passed at a time.

In order to achieve a non-linear increase in the superimposed voltage, the invention further proposes that the amplitude of the superimposed voltage be rendered dependent upon a voltage obtained by a non-linear distortion of a voltage proportional to the density of the picture.

The quantified and binary coded voltage values are then either used immediately to control the reproduc-

tion of a picture or are stored on a record carrier such as a punched tape from which it can be read out at any subsequent date. The data for the picture contents of the various raster dot sizes may be stored in ring core stores and the reproduction of the picture consists in recalling the raster dot sizes required when the picture was recorded from the ring core store using the data readout of the record carrier and in using them to control the recording of the picture.

The method for the raster reproduction of half-tone pictures comprises the steps of forming raster dots of a first size in correspondence with a first tonal value which is representative for a first range of tonal values of a tone control scale, forming raster dots of a second size in correspondence with an adjacent second tonal value which is representative for a second range of tonal values of a tone control scale, intermixing said first and second size raster dots if the tonal value to be achieved lies between said first and second tonal values, and reproducing said intermixed first and second size raster dots. More specifically this is accomplished by photoelectrically scanning a half-tone picture dot by dot, generating voltage values, quantifying said values to represent brightness ranges, and superimposing an alternating voltage on said voltage values before they are quantified to generate a mixing of dot sizes indicative of one brightness range with dot sizes indicative of another adjacent brightness range and causing the mixing to occur in such a pattern as to make the transition between brightness ranges more pleasing to the eye. The mixing of the dots may be best illustrated with the following example. Thus, if a brightness or density value has been obtained during the scanning process which lies between the median tone values of the individual tone-value ranges, a mixing of the raster dots will be effected during the recording whereby the raster dots which correspond to the higher tone value of the higher tone value range will be mixed with the lower tone value of the lower tone value range. Depending on whether the scan brightness or density value is near to the upper tone value or to the lower tone value median, the mixture ratio of the raster dots will be favorable for the higher or lower tone value, i.e. to the raster dot sizes which are assigned to those tone values. Let us assume that the density or brightness values which correspond to the tone values of 17.5 percent, 20, 21.25 and 22.5 percent have been obtained during the scanning process. With the tone value of 17.5 percent, 100 percent raster dots of the tone value of 17.5 percent and 0 percent of the raster dots having the tone value of 22.5 percent will be printed. When we have a tone value of 20 percent there will be a mixture of 50 percent raster dots of the tone value of 17.5 percent and 50 percent of the tone value of 22.5 percent. Similarly, the tone value 21.25 percent will be reproduced by means of 25 percent raster dots of the tone value of 17.5 percent and 75 percent of the tone value of 22.5 percent. For a tone value of 22.5 percent 100 percent raster dots of the tone value of 22.5 percent will be printed.

Other objects, features and advantages of the invention will be readily apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings, although variations and modifications may be effected

without departing from the spirit and scope of the novel concepts of the disclosure, and in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1a shows a three-stage grey wedge built up from quantified raster dots.

FIG. 1b shows a similar grey wedge which is, however, formed according to the invention by mixing the raster dots.

FIG. 2 shows a diagram of the superimposing of three equal quantum stages.

FIG. 3 shows the superimposing of a triangular voltage with an amplitude which increases when the quantum stages increase.

FIG. 4 shows a circuit diagram of a system for producing the triangular voltage of FIG. 3.

FIGS. 5 and 6 show examples of different superimposed voltages.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIGS. 1a and 1b, the area marked m is a medium shade of grey, the area marked $m - 1$ is the next lightest and the area marked $m + 1$ the next darkest.

If it be assumed that the raster dot size in each case represents the shade of grey which occurs in a non-graduated grey wedge in the center of the area 1 or 2 or 3, in FIG. 1a, each area on the righthand boundary is thus half a shade too light and on the lefthand boundary half a shade too dark. In the boundary areas 4 and 5 there thus occurs, according to FIG. 1a, a sharp change in density. This change has been eliminated in FIG. 1b by causing each of the two vertical lines of raster dots to contain equal proportions of raster dots of the lighter and darker shade which are, moreover, differently distributed in the two rows. As will be described in more detail below, this is a statistical distribution. The result is a grey shade which, as was intended, corresponds to the average of the values of the grey shades involved.

The continuous transitions between the middle and the limits of the range are achieved in a similar manner, viz. by reducing as continuously as possible the portion of inserted raster dots of an adjacent grey shade from the end of the range towards the middle of the range.

When assessing the effect of FIGS. 1a and 1b, it should be remembered that these show the raster dots substantially magnified. In practice the largest raster in use is, as is well known, 400 raster dots per square centimeter. Even here, the individual raster dot is so small that the human eye is incapable of resolving a picture which has been so rastered into the individual raster dots. In order to reconstruct these conditions it would be necessary to view the Figures from a distance of several meters.

The above remarks made in connection with the grey shades also apply for the saturation values of colors.

In the diagram given in FIG. 2, the values on the ordinate are voltage values E which correspond to degrees of blackness. In the diagram, $E = 0$ is appropriated to the value "white." The abscissa is the time axis, on which are marked the scanning clock pulses.

By means of lines 10, 11, 12 and 13 there are marked on the ordinate voltage ranges of equal size, of which it is intended to consider the ranges $m - 1$, m and $m + 1$.

A particular individual voltage value is associated with each of these ranges, and in the present case this is always the average value in the range. This value is recorded as long as the picture signal voltages which occur are located within the range concerned. The average value of the range is shown in the drawing in each case by a horizontal dotted line.

Let us assume that a portion of the picture being scanned becomes gradually darker. This produces a picture signal voltage which may be represented by a rising straight line 14. As a result of the quantification and without further measures, there would occur at the locations at which the straight line 14 intersects one of the range limits, e.g. 11 and 12, sudden variations in the degree of blackness such as are found in FIG. 1a. The result of the superimposition, on the picture signal voltage, of an alternating voltage which in the present case is a triangular voltage, is that the resultant voltage which is to be quantified, which follows the line 15 has, for certain scanning clock pulses, a momentary tonal value which lies in the quanta range immediately above or immediately below that which passes through the picture signal voltage range.

In FIG. 2 all the scanned momentary tonal values in the range m are indicated by small circles and all those which occur, for one of the scanning clock pulses in the range $m + 1$ or $m - 1$ are indicated by small crosses.

If, as is here the case, the peak-to-peak rise of the alternating voltage (double amplitude) is equal to the quanta shade voltage, the following is true: If the picture signal voltage passes straight through the center of a range (dotted line), all scanned momentary values fall correctly into this range. If, on the other hand, it passes straight through a range limit, e.g. 11, the scanned momentary tonal values lie in equal portions in the range through which the voltage has passed and in the adjacent range, e.g. $m - 1$ and m . If the picture signal voltage approaches the center of the range, the portion of the momentary values which lie in this range during scanning increases steadily.

The size of the peak-to-peak rise of the alternating voltage mentioned above represents an optimum. Thus, if this rise is smaller than the quanta shade voltage, the mixture of raster dots becomes imperfect. If, on the other hand, it is larger, raster dots from a non-adjacent range will be mixed in, and this results in a certain coarseness in the picture as reproduced.

As already mentioned, the frequency of the scanning clock pulses t_s and the frequency of the superimposed voltage should not be harmonic. This avoids a periodic repetition of the raster dot distribution and ensures instead that the distribution is statistical, as when a random generator is used.

Instead of superimposing a triangular voltage as shown, it is equally possible to superimpose a sawtooth voltage. The only condition is that the alternating voltage used should have straight flanks and as far as possible no horizontal curved portions.

In the diagram of FIG. 3, the ordinate is divided into increasing voltage ranges corresponding to the physiological curve mentioned, i.e. $m - 4$ $m + 3$ and the picture signal voltage 14 has superimposed on it an alternating voltage 16, the amplitude of which increases as a function of the size of the picture signal voltage. The degree of this dependence is chosen so

that the peak-to-peak rise of the alternating voltage is always approximately equal to the voltage range through which the picture signal voltage passes. If the picture signal voltage passes beyond a range limit, the peak-to-peak rise assumes corresponding intermediate values. FIG. 3 shows a voltage variation which takes into account the well known Munsell physiological sensitivity curve of the human eye and FIG. 2 is a system of curves in which the Munsell physiological sensitivity curve of the human eye is not taken into account. The amplitude values of the voltage in FIG. 3 show clearly the course of this sensitivity curve.

FIG. 4 shows a circuit arrangement which enables the above-described triangular voltage of variable amplitude to be produced.

The inverted (increasing with the degree of blackness) picture signal voltage E_a is applied to the terminals 21 and 22 so as to be balanced to ground.

The voltage applied to the terminal 23 is a rectangular voltage which is conveyed to the bases of the two transistors 24 and 25. Since the transistor 24 is an npn-transistor and the transistor 25 is a pnp-transistor, the transistor 25 is blocked when the transistor 24 is gated, and vice versa.

As soon as the transistor 24 becomes conductive, the capacitor 26 begins to be charged through this transistor, and via the resistors 27 and 28. By suitably choosing the resistance values and the capacitor value it is possible to determine the time constant for the charging process so as to make it large in relation to the gating time. This means that only the first, still approximately linear, portion of the charging curve is used.

If the transistor 24 is blocked again and the transistor 25 gated instead, the capacitor 26 is re-charged via the resistors 29 and 30. When this is effected with the same time constant, a symmetrical triangular voltage is produced on the capacitor 26. This triangular voltage is first amplified by means of the amplifier 31 and then passed through the transformer 32 to the line 33, so that the picture signal voltage on which the triangular voltage has been superimposed is available on the terminal 34.

Since it is desirable that a not inconsiderable superimposing voltage be available when the picture signal voltage becomes very small (white value), the auxiliary voltage sources 35 and 36 have been provided which supply the capacitor 26 via the resistors 37 or 38.

Not only the physiological sensitivity curve, but also the curve representing the increase in the amplitude of the superimposed voltage is non-linear. It is thus necessary to produce a non-linearity between the picture signal voltage E_a or $-E_a$ and the amplitude of the superimposed voltage. This is effected by means of the diodes 39 and 40 which are connected in parallel each to one of the resistors 28 and 30. Because of the shape of the diode characteristics, the influence of this shunt will be slight when the value of the voltage E_a is low, but as this voltage E_a increases it will increase to such a degree that finally the resistors 28 and 30 are practically short-circuited.

When a sawtooth voltage is desired instead of a symmetrical triangular voltage, the time constants, i.e. the resistances of the resistors 27, 28 and 29, 30 and also the gating ratio of the rectangular voltage which controls the transistors 24 and 25 must be changed in a

well known manner to effect the desired time constants.

FIG. 5 shows triangular voltages 41, 42, 43 and FIG. 6 sawtooth voltages 44, 45, 46 of varying amplitudes such as occur for various picture signal voltage values.

The invention claimed is:

1. A method for the raster reproduction of halftone pictures comprising: scanning the picture dot-by-dot photoelectrically and quantifying the voltage values of the picture signal analogous with the brightness values of the picture being reproduced, assigning different raster dot sizes to each quantified voltage value and expressing the same in binary code, superimposing on the voltage values before the process of quantification an alternating voltage.

2. A method in accordance with claim 1 including forming the amplitude of the alternating voltage to be approximately equal to half the difference between two successive quantified voltage values.

3. A method as claimed in claim 2, including timing the points at which the voltage values are quantified and forming the alternating voltage to have a frequency which is at least one-quarter of the timing frequency.

4. A method as claimed in claim 2 wherein the alternating voltage is a triangular-shaped voltage.

5. A method as claimed in claim 2 wherein the alternating voltage which is superimposed is a sawtooth-shaped voltage.

6. A method as claimed in claim 2 wherein the quantified voltage stages increase with increasing density in accordance with the Munsell physiological sensitivity curve, and wherein the amplitude of the alternating voltage for superimposition also increases with increasing density.

7. A method as claimed in claim 6, including forming the amplitude of the superimposed voltage to be a function of a voltage which is obtained by a non-linear distortion of a voltage proportional to the density of the picture.

8. A method for the raster reproduction of half-tone pictures comprising the steps of: forming raster dots of a first size in correspondence with a first tonal value which is representative for a first range of tonal values of a tone control scale, forming raster dots of a second size in correspondence with an adjacent second tonal value which is representative for a second range of tonal values of a tone control scale, intermixing said first and second size raster dots if the tonal value to be achieved lies between said first and second tonal values, reproducing said intermixed first and second size raster dots.

9. A method as claimed in claim 8 wherein the raster dots of said first and second sizes are mixed in a proportion which corresponds to the ratio of the differences between the tonal value to be achieved and said two adjacent first and second tonal values.

10. A method for the raster reproduction of half-tone pictures comprising the steps of photoelectrically scanning a half-tone picture dot by dot, generating voltage values, quantifying said values to represent brightness ranges, and superimposing an alternating voltage on said voltage values before they are quantified to generate a mixing of dot sizes indicative of one brightness range with dot sizes indicative of another adjacent brightness range and mixing the dot sizes in a proportion which corresponds to the ratio of the differences between the value to be achieved and the adjacent values.

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