March 19, 1940. HANS-OTTO ROOSENSTEIN ET AL 2,194,456

SIGNALING APPARATUS

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Fig. 1

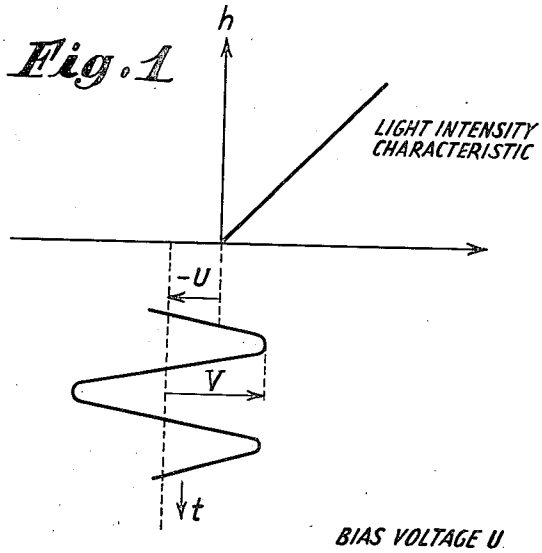
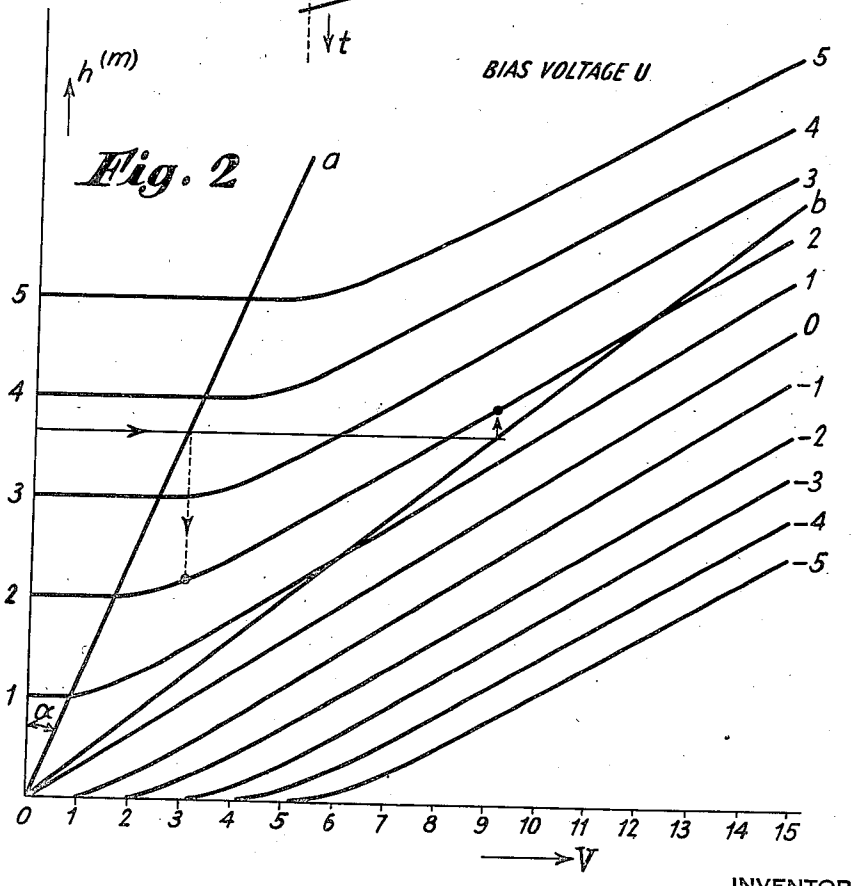



Fig. 2




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Fig. 3

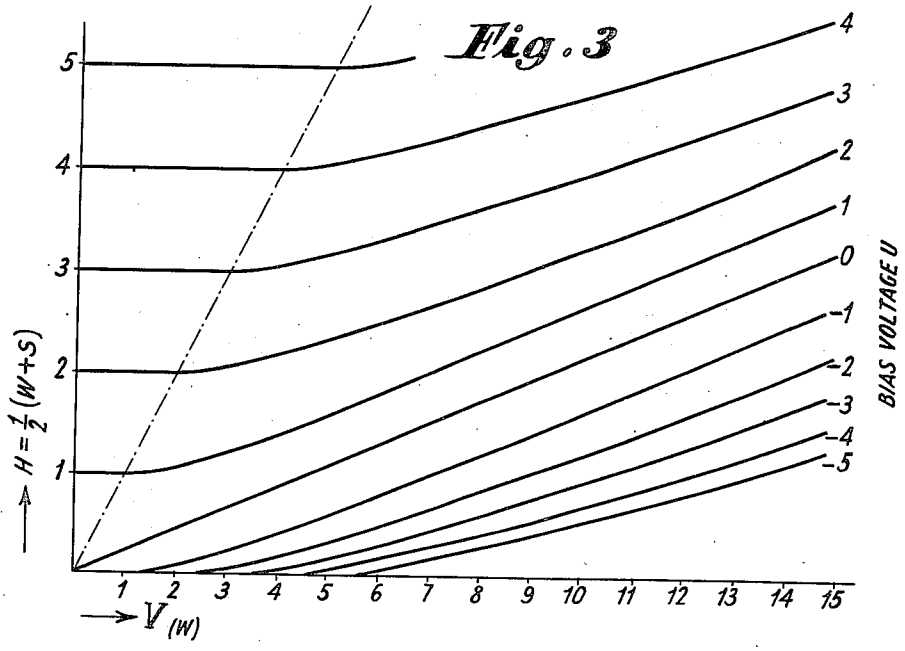
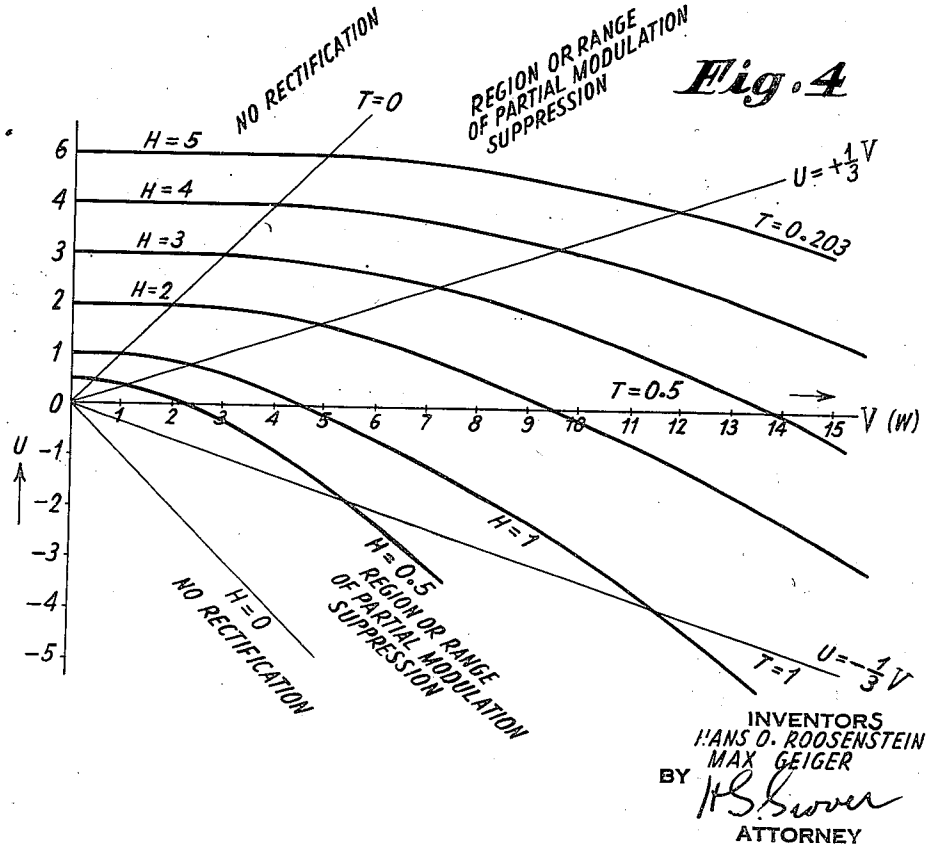



Fig. 4




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Fig. 5

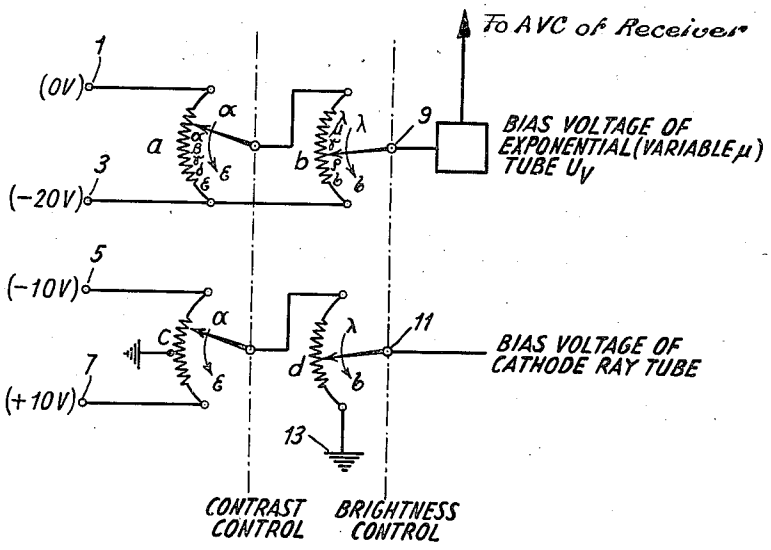
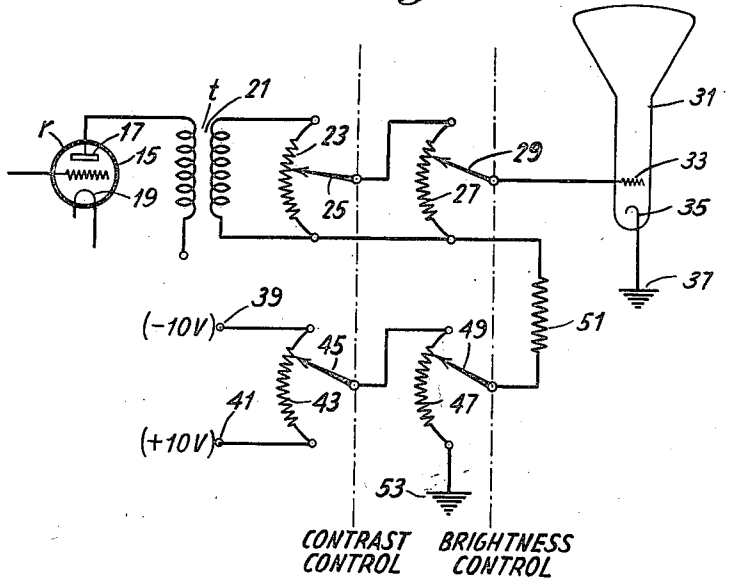



Fig. 5a




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Fig. 8

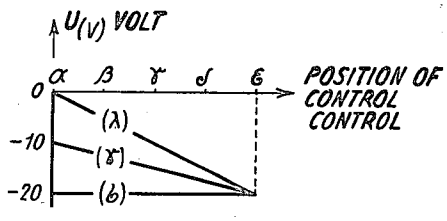



Fig. 6

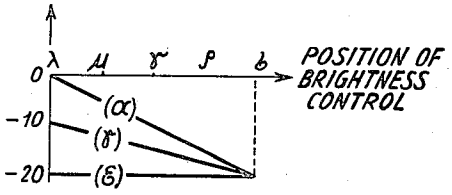



Fig. 9

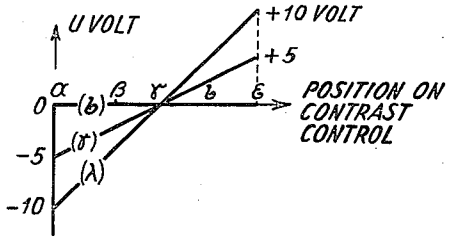



Fig. 7

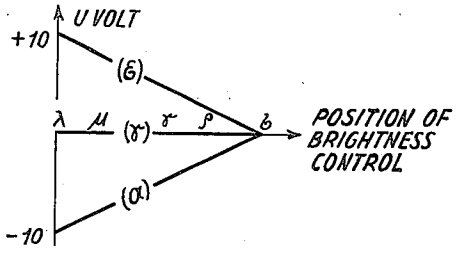
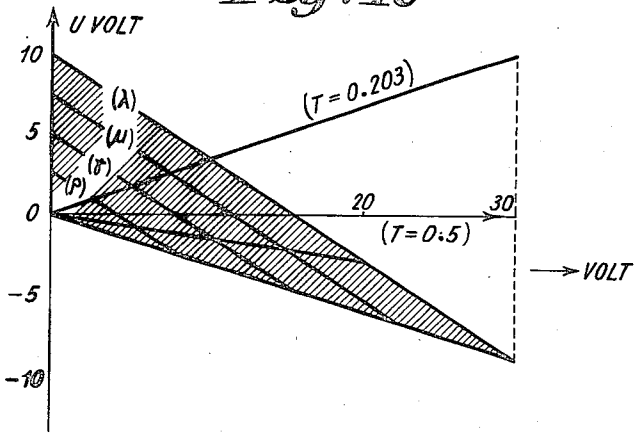



Fig. 10




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Patented Mar. 19, 1940 2,194,456

# UNITED STATES PATENT OFFICE

2,194,456

## SIGNALING APPARATUS

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Application November 27, 1936, Serial No. 113,027
In Germany August 27, 1935

11 Claims. (Cl. 178—7.5)

The invention has for its object to provide the possibility at television reception, of adjusting at will in accordance with personal taste, two of the characteristics which determine the nature of an image, namely the contrast and the billiancy of the image. If the receiver is adapted to such purpose, the image reproduced in the receiver termed "receiver image" can be given a character differing from the picture scanned in the transmitter and termed "transmitter image."

The image brilliancy H' and the image contrast T shall be defined as follows:

$$H'=\sum_{n=1}^{n=\sigma}\frac{h_n}{n} \qquad T=\frac{w-s}{w+s}$$

wherein $h$ designates the instantaneous mean value of the brilliancy of a picture point for $1/s$-th part of a picture duration, when $s$ is the number of picture points for a single picture, and $n$ is the instantaneous number of a picture point, and $w$ and $s$ designate the maximum and minimum value of the picture point brilliancy $h$ appearing during a transmission. Hence there corresponds to a white point or black point respectively of the transmitter image in the receiver image a point having the brilliancy $h=h_{max}=w$, or $h=h_{min}=s$.

According to the definition, the brilliancy H' is the mean value of the picture point brilliancy $h$ considered for all points of an image. In the moving image content this mean value differs in general between the various images. Since it is not the purpose of a brilliancy control, to impart at the moving content to all images the same brilliancy—otherwise the difference between bright and dark images, such as may follow each other in rapid succession on the film band scanned in the transmitter, would become blurred, and the transmission distorted—it is necessary for the control of the brilliancy, to consider the mean value for all brilliances H' of the individual images of an entire transmission or at least during a longer time required to transmit a single frame. In assuming that this mean value corresponds to the average value of gray, there exists the equation: $H=\frac{1}{2}(w+s)$ so that, as in the case of contrast, a definition for this value is obtained which depends upon the content of an individual picture.

According to the definition, the contrast assumes for the various values of $w$ and $s$, the values between 0 and 1. For $w=s$ it has the value 0, and for $s=0$ or $(w=\infty)$ its value is equal to 1. Hence the transmitter signals representative of an image has always the value of contrast 1. The transformation

$$T=(w/s-1)/(w/s+1)$$

reveals that the contrast depends only upon the ratio $w/s$ and that it remains constant therewith.

In the following, there will be explained the conditions at the control of contrast and brilliancy in the television receiver. In the drawings Figs. 1 through 4 and 6 through 10 show graphically relationships between operating parameters of an electro-optical reproducer and the reproduced image characteristics; while

Figs. 5, and 5*a* show embodiments of my invention relating to the control of both the brightness and contrast of pictures.

In the receiver two controllable means exist by which the contrast and the brilliancy of the image are unequivocally determined on the luminescent screen, namely: The amplification of the image receiver (amplitude of the alternating potential at the control electrode of the Braun tube) and the biasing potential of the control electrode of the Braun tube (background illumination). Hitherto the image character has been controlled by direct operation of the control knobs assigned to these two means. As will be seen from the following, this type of control is insufficient, since it is not possible to attain a state of predetermined picture contrast and picture brilliancy in a simple and direct manner. The provision of favorable control of the image character presupposes the possibility of adjusting independently of each other by means of two operating knobs, on the one hand, the contrast at constant brilliancy, and on the other hand, the brilliancy at constant hardness.

In order to obtain a basis for examining the conditions, it is necessary to consider the detection of the intermediate frequency, and thereby to consider certain assumptions. It be assumed:

(*a*) That the intermediate frequency is detected in the Braun tube,

(*b*) That for the picture modulation the amplitude of the high-frequency voltage applied across an intermediate frequency transformer to the light control electrode of the Braun tube, decreases at the most to one third of the maximum amplitude,

(*c*) That for the Braun tube, the relationship between the brilliancy of the luminous spot and voltage at the light control electrode, i. e., the characteristic of the light intensity, be estab-

lished by a straight line originating in the zero point,

(*d*) That furthermore, in the control range to be considered, the expansion of the luminous spot does not vary to an appreciable extent, and finally,

(*e*) That the intermediate frequency control potential at the light control electrode of the Braun tube has a pure sine shape.

The conditions at detection will be most clearly understood on hand of a set of detection characteristics. Using the designations of Figure 1 and as long as the biasing potential U is negative and as regards its absolute value smaller than the amplitude V of the applied alternating potential, there will be obtained for the set of detection characteristics, the expression:

$$(1)\quad h=SV\left[\frac{1}{\pi}\left\{\frac{V}{U}\sqrt{1-\left(\frac{U}{V}\right)^2}+\text{arc sine}\left(\frac{U}{V}\right)\right\}-0.5\right]$$

and as long as U is positive and its absolute value smaller than V, the expression reads:

$$(2)\quad h=SV\left[\frac{1}{\pi}\left\{\sqrt{\left(\frac{V}{U}\right)^2-1}+\text{arc sine}\left(\frac{U}{V}\right)\right\}+0.5\right]$$

Contrary to the usual representation of the detection characteristic the bias may be herein treated as parameter. In this case there will be obtained the set of curves shown in Figure 2. For $V \gg U$ the lines approach assymptotically the straight line

$$(3)\qquad h=S\left(\frac{V}{\pi}\mp 0.5U\right)$$

whereby the minus sign is for the expression (1) and the plus sign for the expression (2). The tangents at the beginning of all curves have zero inclination, except in case of the straight line for U=0. The horizontal portions at the beginning of the detection characteristics and which are not contained in the analytical expressions, correspond to the case in which the bias, as regards its absolute value, is higher than the amplitude of the alternating potential, so that detection does not take place at all.

In order that for each degree of control of the Braun tube, the brilliancy values *w* and *s* may be measured at a detection characteristic, there is indicated in Figure 2 the straight lines *a* and *b* through the zero point, and having the inclinations $\tan\alpha$ and 3 $\tan\alpha$ towards the ordinate . For a certain control assumed to be marked in the ordinate, these straight lines will be intersected in the corresponding height by a parallel line to the *v*-axis. Then the projection of the intersection points upon the detection characteristic to be considered, furnishes the desired brilliancy values between which lie all other brilliancy values of the points as designated by *h* and which can possibly appear in an image at the given amplification of the image receiver and given amplitude at the amplifier input.

At biasing potentials differing from zero, the detection characteristics take a curved course—they would only have a straight line course (bent) at rectangular curve shape of the applied alternating potential—and therefore signify a distortion in the reproduction of the brilliancy modulation, especially notable at brilliancies lying near the value $h=s$.

In the following, there will be characterized the control by the maximum voltage amplitude $V_{(w)}$ belonging to the value of white designated by *w*. This control is proportional to the amplification of the image receiver at a given input voltage at the receiver.

With the *w*- and *s*-values obtained from Figure 2 there can be determined for any desired control, the contrast T and brilliancy H as defined. In Figure 3 the brilliancy H is shown accordingly in relation to $V_{(w)}$. Figure 3 is derived from Figure 2 in that there is a transformation of the variable *h* to H in accordance with the equation $H=\frac{1}{2}(w+s)$ which represents the grey value as pointed out above. It will be noted in this respect that the curves in Figure 3 are derived by arbitrarily drawing horizontal lines as shown in Figure 2 and reading off the values of *w* and *s* along the lines of constant bias voltage U. The abscissa likewise now has its value transformed to represent the amplitude of the white value, which value is read off of the curves of Figure 2 corresponding to the maximum value related to the intercept of the horizontal line. From this representation there can be easily derived for the present solution a solution even more suitable, namely the lines of constant brilliancy H, as shown in Figure 4. These lines were obtained from Figure 3 in that for each amplitude that bias is plotted at which the brilliancy is the same. That is to say, the curves of constant brightness shown in Figure 4 are derived from Figure 3 by drawing a line parallel to the abscissa and reading off the intercepts of this parallel line with the curves representative of constant bias voltage U. Since the lines parallel to the abscissa represent lines of constant brightness by plotting the intercept value of bias voltage against $V_{(w)}$ the curves in Figure 4 can be drawn.

The lines of constant contrast shown in Figure 4, are straight lines through the zero point, since for the same ratio

$$\frac{V}{U}$$

the value

$$\frac{w}{s}$$

remains constant in accordance with Equations (1) and (2) respectively. These equations, furthermore, furnish for each straight line the appertaining contrast. There is $T=1$ along the line $U=\frac{1}{3}V$, since there is hereby $s=0$ (Figure 2), and there will be found $T=0.5$ on the line $U=0$, since there is hereby $s=\frac{1}{3}w$. In the region $/U/>V$ no detection takes place, no difference exists between *w* and *s*, and hence, there is $T=0$.

If, at the reproduction of the brilliancy modulation in which a part of the modulation is suppressed, regions of such distortions of the transmission are excluded, i. e., when the "black values" coincide with the "gray values" then for the brilliancy-contrast control only the region between the lines $U=-\frac{1}{3}V$ and $U=+\frac{1}{3}V$ in Figure 4 need be considered. The contrast increases in this region from 0.203 to 1. The value $T=0$ can thus not be obtained which however is of no consequence since in practice only brilliancy values greater than 0.5 will be of importance.

For example, if it is desired to change the brightness from 2 to 5 while maintaining the contrast constant at a value given by $U=\frac{1}{3}V$, then it will be noted that since the straight line of constant contrast $U=\frac{1}{3}V$ intersects the line of constant brightness 2 at the coordinates of $V_{(w)}=5$ and $U=1.6$. To now change to the required conditions it will be noted that the line of constant brightness 5 is intersected at the coordinates of $V_{(w)}=12$ and $U=4$. Accordingly, the amplitude of the signals must be increased

from 5 to 12 while the bias must have its value changed from 1.6 to 4. Under these conditions there will result a change in brightness of from 2 to 5 with the constant ratio, however, maintained constant. Conversely, if it is desired to change the contrast range while maintaining the brightness constant then assuming that it is desired to change the contrast range from $T=0$ to that where $U=\frac{1}{3}V$ at a constant brightness of $H=5$, then the value of $V_{(w)}$ must be changed from 5 to 12 while the bias U is changed from 6 to 4. It is believed that these two examples will readily point out the usefulness of the derived curves shown in Figure 4.

When varying the image character as hitherto, by means of the amplification control knob V and bias control knob U, in both cases the contrast as well as the brilliancy will be varied, and only if there is provided a simultaneous control of amplification and bias as indicated in Fig. 4, such as is provided by the invention, is it possible to adjust an image for a predetermined contrast and brilliancy in a simple manner. Where the relation between amplification and bias is not provided by the control system, then one cannot obtain in a simple direct fashion the required predetermined contrast and brilliancy. In Figure 4 it is seen that at turning of the amplification control knob, the contrast varies in an entirely different manner according to the adjusted bias. In the prior state of practice, a definite value of contrast and brilliancy can only be achieved by cut and try in operating simultaneously or alternatively both control knobs.

As compared therewith a possibility of control of the image character, by operating on the lines of constant contrast and constant brilliancy in the diagram of Figure 4, represents an appreciable advance, as already pointed out. Also the following condition merits attention.

At the setting of the image character ordinarily no definite end state desirable of achievement presents itself, and at the setting among the various states observed, a certain state thereof is chosen. This selection can be carried out more favorably by first adjusting a brilliancy agreeable to the eye, and thereafter attempting to obtain the most favorable contrast for this brilliancy, just as if it would be a matter of incident which contrast and brilliancy states would be encountered when operating the control means.

The new type of control can be practically carried out with satisfactory result, when being content with moving along straight lines having the inclination of a mean tangent at the lines of constant brilliancy in Figure 4. If, as is the case in the receiver, the amplitude $V_{(a)}$ is controlled by the grid potential of an exponential tube $U_{(v)}$, the control arrangement shown in Figure 5 can be employed for controlling the character of the image. In this figure the two coupled controls are provided one for controlling the contrast without affecting the brightness, and the other which controls the brightness without affecting the contrast. This assumes that the contrast is determined by the potentials supplied to the exponential tube which controls the amplification of the received signal, and the brightness controlled by the bias voltage of the cathode ray tube. This arrangement consists of four potentiometers *a*, *b*, *c* and *d* connected in the manner shown. It is hereby assumed that by varying the voltage $U_{(v)}$ from 0 to −20 volts, the amplitude $V_{(w)}$ can be controlled from its maximum value down to the zero value. For the sake of simplicity, a linear relationship between $V_{(w)}$ and $U_{(v)}$ be assumed. Then the potentiometers *a*, *b*, and *c*, *d* must also have a linear characteristic. At a different relationship between $V_{(w)}$ and $U_{(v)}$ a linear relationship between the bias U of the Braun tube and the amplitude $V_{(w)}$ can again be obtained through corresponding shaping of the potentiometer characteristics. The gliding contacts coupled on the one hand at the potentiometers *a* and *b*, and on the other hand at *b* and *d*, can be moved by means of the adjustment knobs. By means of knob 1 there can be controlled the brilliancy at constant contrast, and by means of knob 2, the contrast at constant brilliancy.

The operating performance of the arrangement will now be explained.

When moving the variable contact 1 from any initial position to its end position, the biasing potential simultaneously with the amplitude at the Braun tube are brought to zero for any position of the variable contact 2. Thus according to Figure 4, a movement along lines of constant contrast takes place, and the brilliancy will be varied (see Figures 6 and 7).

When moving the variable contact 2, there takes place a variation of U according to Figure 8 and of $V_{(w)}$ according to Figure 9 for various positions of the variable contact 1. There results therefrom according to Figure 10, the relationship between U and $V_{(w)}$. Only parallel lines are obtained whose inclination can be set through the value of the potential difference applied to the potentiometer *c*. These lines correspond to the lines of constant brilliancy in Figure 4.

The range that can be covered is shaded in Figure 10. It is limited by a line of constant brilliancy belonging to the highest adjustable brilliancy, and furthermore by the positive U-axis, and by a line of constant contrast whose inclination is to be so adjusted, through suitable choice of the relative position of the potentials applied to the potentiometer *c* with respect to the voltage zero point, that the equation $T=1$ is fulfilled. Under these conditions, the contrast can be controlled from 0 to 1 by means of the arrangement. The region in which the contrast is less than 0.203 thus lies within the range of control, and can however not be easily avoided when operating the control arrangement, since the distortions of the control of black appearing in the image are immediately noticeable.

In place of the circuit arrangement according to Figure 5, that according to Figure 5*a* may likewise be used, and in which the end tube *r* of the image current amplifier feeds the one of the potentiometers across a transformer *t*. In this arrangement the contrast control is derived directly from the two potentiometers 23 and 27 and not by the gain control of an exponential tube, as provided in Fig. 5.

Furthermore, in accordance with a further feature of the invention, it can be accomplished by means of kinematic arrangements of corresponding adaptation, that at the operation of the control knob for the biasing potential of the Braun tube for instance, the other control knob, namely that for the amplitude of the alternating potential appearing at the control grid of the tube, will at the same time be so adjusted that the contrast of the image varies at constant image brilliancy. In this latter arrangement, the

control knob for the bias of the Braun tube then serves for controlling the image contrast and that for the amplitude of the alternating potential serves for controlling the image brilliancy at invariable image contrast.

Previously, for the control arrangement, the voltage was considered proportional to the amplification of the image receiver, and said voltage was substituted accordingly by the amplification. It was hereby assumed that the factor of proportionality be constant as set forth by the repeated reference to "At given input potential at the image receiver." However at the receiver this assumption is not complied with at all. The factor of proportionality rather varies with the value of the voltage amplitude at the receiver input corresponding to $V_{(w)}$, for instance if the apparatus is situated at different places in which the electromagnetic field of the transmitter differs in intensity. But a variation in the proportionality factor is identical to a shortening of the diagram in Figure 10 in the $V_{(w)}$ direction, i. e., the gauging of the contrast control becomes invalid and the brilliancy varies at variation of the contrast. For the practical application of the results obtained, it is thus necessary that in the receiver additional amplification be provided, by whose use it will be possible to bring the voltage $V_{(w)}$ up to the same value at any receiver input potential existing up to a certain minimum value. Hence a kind of fading control is required.

Since, at a 7 m. wave, ordinarily disturbing brief fadings do not exist to an appreciable degree, it will be sufficient to provide a third (additional) control knob at the receiver, by which the additional amplification is once readjusted whenever the receiver operates under new conditions. In this case, the knob for the contrast if set to $T=1$ and the knob for the amplification reserve is so turned that the contrast of the image actually assumes the value 1. The criterion for this is that the black value in the image assumes the color of the non-irradiated luminescent screen.

A further possibility of so varying the aforementioned proportionality factor that the control operates properly, resides in rendering adjustable at the potentiometer $c$, the value of the applied voltage by means of an adjustment knob. The action of this means will be readily understood on hand of Figures 6–10. In this case, the provision of an amplification reserve becomes superfluous. The attainable image brilliancy then varies of course directly with the input potential at the receiver.

Moreover, it can be said that also in such cases in which the contrast and brilliancy control due to any causes can only roughly be carried out, the advantages over the older type of control are still obtainable to the greater part.

Having described our invention, what we claim as new and desire to secure by Letters Patent is:

1. In an electro-optical device for producing an image, the method of improving the operation of the device, which comprises steps of electro-optically producing a light image from electrical signals, controlling the brightness of the image while maintaining the contrast of the image constant, and independently controlling the contrast of the image while maintaining the brightness of the image constant.

2. In a cathode ray tube wherein is provided a control electrode and a fluorescent screen upon which an image is to be produced, the method of operation which comprises the steps of supplying potentials to the control electrode for controlling the brightness of the image, supplying potentials to the electrode for controlling the contrast of the image, and varying both of the supplied potentials simultaneously while maintaining the brightness of the image constant while varying the contrast of the image.

3. An electro-optical device for producing an image, the method of operation which comprises the steps of simultaneously controlling the brightness of the image and the contrast of the image to vary the brightness of the image while maintaining the contrast of the image constant.

4. An electro-optical device for producing an image, comprising means for electronically producing a light image, means for controlling the brightness of the image while maintaining the contrast of the image constant, and means for independently controlling the contrast of the image while maintaining the brightness of the image constant.

5. A cathode ray tube wherein is provided a control electrode and a fluorescent screen upon which an image is to be produced, comprising means for supplying potentials to the control electrode for controlling the brightness of the image, means for supplying potentials to the electrode for controlling the contrast of the image, and means for varying both of the supplied potentials simultaneously while maintaining the brightness of the image independent of the contrast of the image.

6. An electro-optical device for producing an image, comprising means for simultaneously controlling the brightness of the image while maintaining the contrast of the image constant, and means for varying the contrast of the image while maintaining the brightness of the image constant.

7. In a television receiver, a source of electrical signals representative of an image to be reproduced, a cathode ray tube for producing an image, means for independently controlling the brightness and contrast of the produced image without influencing each other, and means for supplying signals from the source to the control means.

8. A cathode ray tube having contained therein a control electrode and a fluorescent screen for producing an image thereon, a source of electro-optical signals representative of an image to be reproduced, and means connected between the source of signals and the control electrode for independently controlling the brightness and contrast of the image produced on the fluorescent screen.

9. A cathode ray tube having contained therein a control electrode and a fluorescent screen for producing an image thereon, a source of electro-optical signals representative of an image to be reproduced, and means connected between the source of signals and the control electrode for simultaneously and independently controlling the brightness and contrast of the image produced on the fluorescent screen.

10. In combination, a cathode ray tube in a television receiver, means for receiving signals representative of an image to be reproduced, means for deriving a linearly varying voltage proportional to the image brightness to be represented by the received signals, means for simultaneously deriving an exponentially varying voltage in accordance with non-pictorial changes in picture contrast in the picture to be reproduced

under the control of the received signals, and means for controlling the cathode ray tube in accordance with both of the derived voltages.

11. In combination, a cathode ray tube in a television receiver, means for receiving signals representative of an image to be reproduced, means for deriving from the received signals a potential proportional to the received signals, means for simultaneously deriving a constant potential proportional to first derived potential, and means for supplying both of the derived potentials to the cathode ray tube.

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