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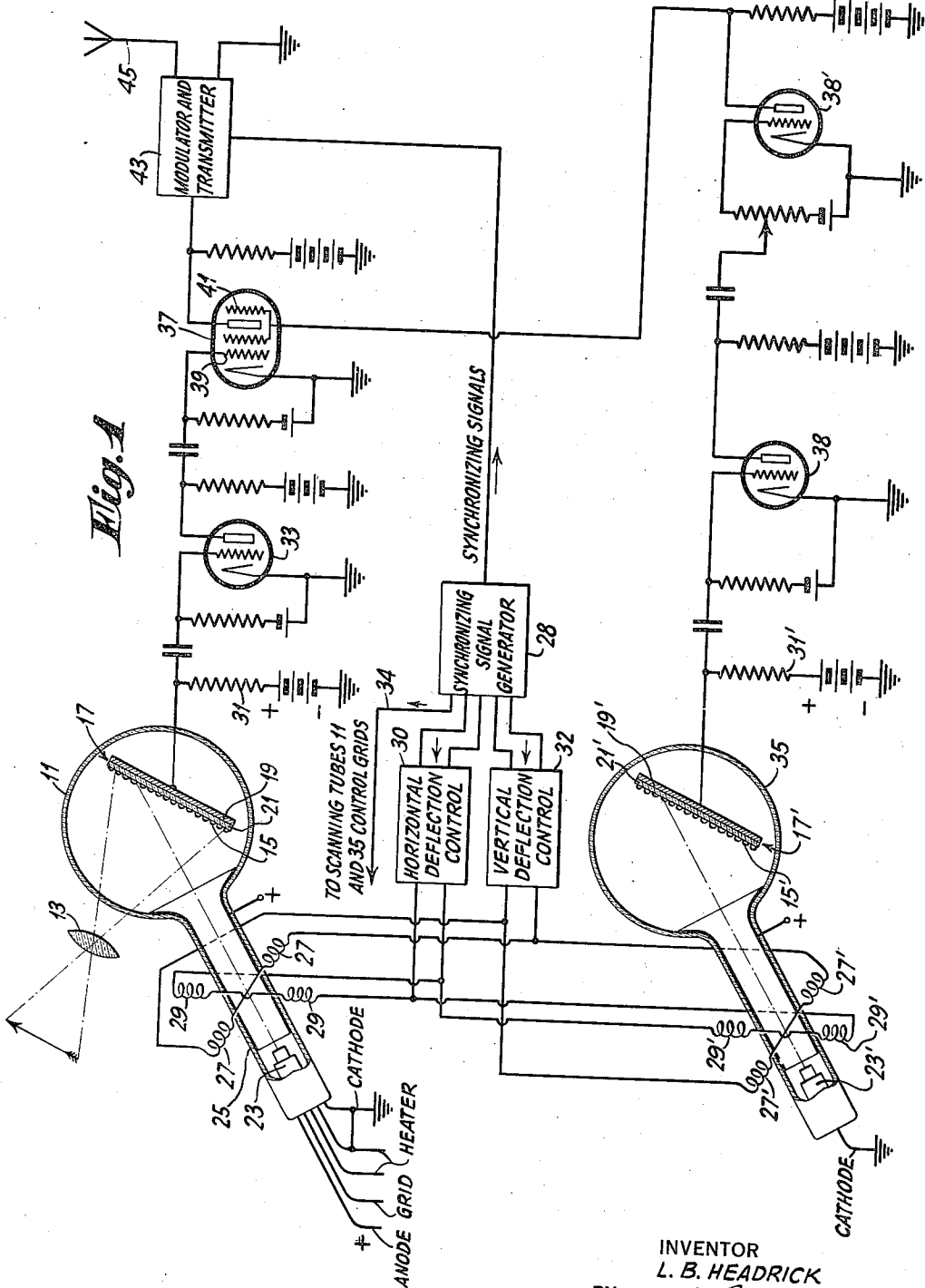
L. B. HEADRICK

2.210,078

DISTORTION CORRECTION FOR TELEVISION SYSTEMS

Filed May 29, 1937

2 Sheets-Sheet 1



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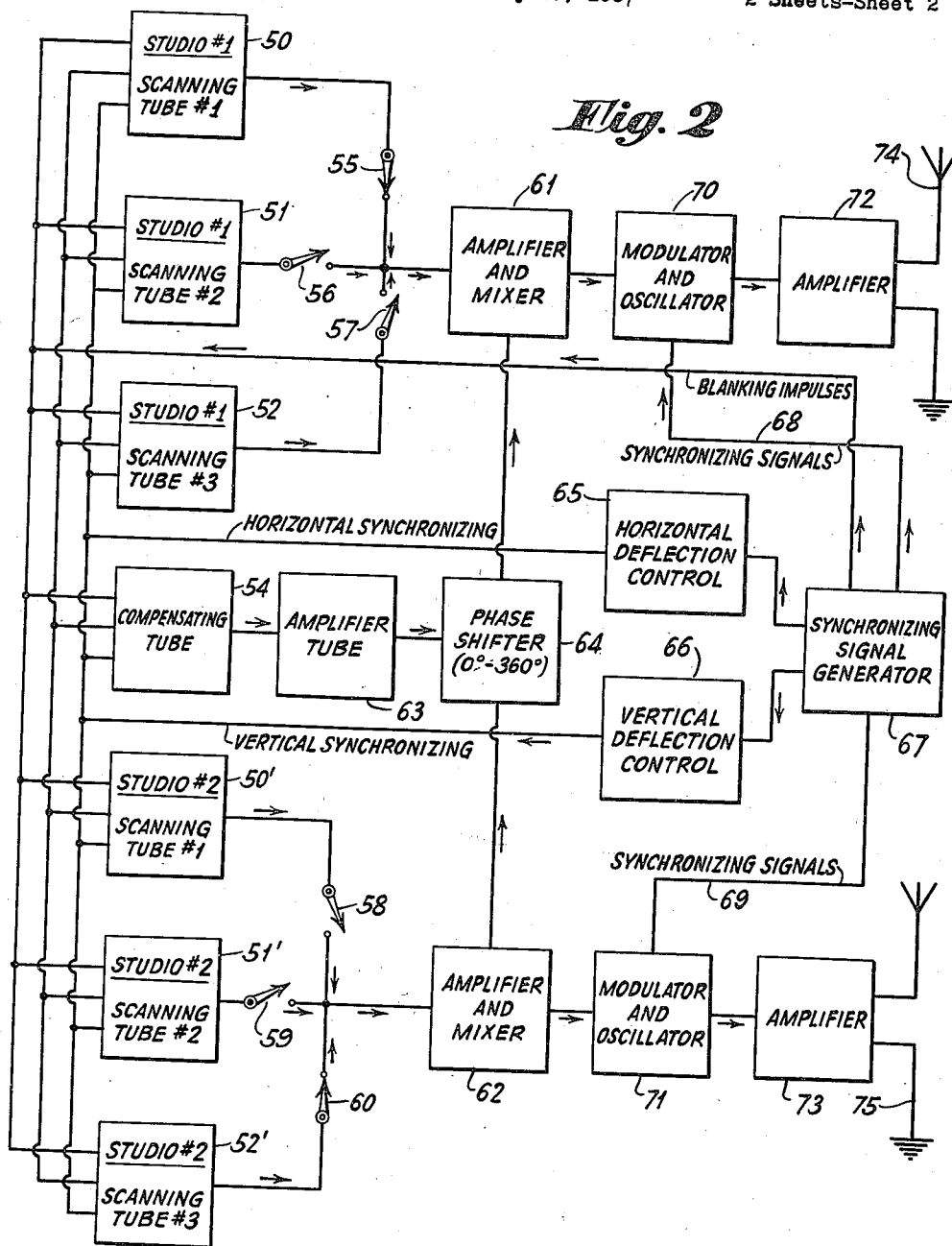
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DISTORTION CORRECTION FOR
TELEVISION SYSTEMS

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6 Claims. (Cl. 178—7.2)

The present invention relates to television apparatus and primarily to systems for transmitting television images. In its more specific applications, the invention is concerned primarily with providing ways and means for compensating for second order distortions which are introduced into the television signals produced by reason of the scanning of a mosaic electrode which is subjected in an electronic image transmitting tube both to the light of an image of which the electro-optical image is to be produced, and to the action of a scanning electron beam used to produce television or video signals.

In a system of the type to which the present invention is directed, it frequently happens that while it is possible and practical to transmit television image signals in which there is substantially a complete absence of first order distortion, which would tend either to prevent a satisfactory electro-optical replica of the light image at the point of transmission being produced at various and selected receiving stations, or would so badly distort the resultant electro-optical image as to make the system completely impractical, presently known systems are not entirely free from second order distortions.

One objectionable second order distortion effect is that which is known in the art as "black spot" or "dark spot" distortion. By "dark spot" distortion is meant the production on the viewing plane at the points of reception of an image in which there is dark shading, frequently distributed at random points or small areas about the viewing area of the receiver observation screen. Such distortion tends to cause both an unduly dark image at many places on the receiver viewing screen and also tends to make the highlights of the image at areas, where "dark spot" is observable, less bright than should be the case. The general effect observable is that of dark shadows which would not actually be present in the optical image from which is developed the video signals for causing the electro-optical image at the receiver.

As is well known in the art, in television transmission systems it is customary, where the so-called "storage type" of transmitter system of the electronic type is used for the conversion of the optical image into video signals, to provide an image translating tube of the general type known by the registered trade names "Iconoscope" and/or "Iconotron" (registered trade-marks of RCA Manufacturing Co. Inc. #325,875 and #342,360 respectively). Such an image transmitting tube, which is the so-called "electrical eye"

of the system, is a cathode ray tube wherein there is provided means for developing and moving in desired co-ordinates an electronic scanning beam. The scanning beam is arranged to impinge upon and to traverse under the control of suitable deflecting voltages or currents, a mosaic electrode. In one type of transmitting tube, which may be illustrated by way of example in order to show an application of the present invention, the mosaic electrode is formed from a conducting signal plate which is connected to a first amplifying stage in such manner that the amplifier input circuit receives the signal energy in accordance with a varying voltage drop across a resistor connected in series with the signal plate. Supported directly upon the signal plate is an insulating member or dielectric sheet (such as a mica layer) which, in turn, supports photosensitive material which releases primary photoelectrons in accordance with the light of the optical image impinging thereupon. The photosensitive material is formed as a series of minute-size particles, each electrically insulated one from the other, and may be formed according to the methods described and claimed by U. S. Patents #2,065,570 and #2,062,122 granted to S. F. Essig and assigned to Radio Corporation of America.

The optical image of which an electro-optical replica is to be produced, is projected directly upon this photosensitive portion of the mosaic electrode, and the release of the photoelectrons causes electrostatic charges to build up between the photoelectric particles and the signal plate or back plate. When the cathode ray beam traverses and scans the photosensitive particles of the mosaic electrode, the stored electrostatic charges are neutralized or released. The charge accumulated and then released represents the light value of related elemental area of the optical image and causes the production of signal modulations which constitute the video signals for transmission. However, during the time when the scanning electron beam or cathode ray is traversing the mosaic electrode, there develops frequently a spurious or undesired signal which causes the above mentioned phenomena of darkened areas of the image reproducing screen of the receiver. Such "dark spot" signal may result from many causes, and while it is considered unnecessary to describe in detail all of these causes, inasmuch as a rather complete analysis thereof has been made in application of Harley A. Iams entitled "Distortion correction for television systems" filed concurrently herewith, it may be mentioned in passing that the "dark spot" signal at the receiver is

thought to result from the non-uniform velocity of the scanning of the photoelectric elements of the mosaic electrode by the scanning beam, also it results from the location in space of the various minute-size isolated photoelectric particles of the mosaic relative to the source of the scanning beam, as well as from the various electrical field distributions occurring across the surface of the mosaic electrode, and, in addition, results from the action of the scanning spot itself upon the mosaic electrode releasing secondary electrons upon impact which because of the potential distribution over the mosaic electrode surface frequently come to rest in an undesirable pattern.

It has been found in practice that the "dark spot" phenomena usually results from the character of the photosensitive portion of the mosaic electrode. While the "dark spot" characteristics are not entirely uniform from one scanning tube to the next, there is, nevertheless, a considerable degree of relationship between the characteristics of different scanning tubes, and the "dark spot" signal resulting from various image scanning tubes is usually closely related in position of occurrence on the viewing screens at the receivers or monitors. Consequently, it is possible to provide a substantial degree of compensation for the "dark spot" phenomena through the use of two separate scanning tubes operating simultaneously and co-phasally. Upon one of these scanning tubes is projected the optical image which it is desired to reproduce electro-optically at receiving points, while on the other of which no optical image need be projected. If the two tubes are operating simultaneously and co-phasally with respect to each other, then it is possible, by combining the outputs from each in phase opposition, to utilize the output signal from the non-illuminated transmitting tube (which is, in reality, only a "dark spot" signal output) to compensate for the "dark spot" signal accompanying and distorting the video signal output of the illuminated tube during scanning of the illuminated mosaic.

Accordingly, it is an object of the present invention to provide a simplified method and means for compensating for objectionable "dark spot" phenomena in a reproduced television image.

It is also an object of the present invention to provide a system of "dark spot" compensation which will require the continuous operation of only a single compensating tube which will, in turn, when switching the control of the transmission from one to another of several separate transmitting tubes usually required in studios for remote close-up and inter-image "shots" as well as for shots from different directions, provide a means by which it is possible to compensate for "dark spot" signal distortion at all times with a reasonable degree of accuracy.

Further, it is an object of the present invention to provide a system for compensating for "dark spot" by which the compensating tube, operating synchronously and co-phasally with the active one of a plurality of selected scanning tubes, may be positioned in the control room of the transmitting station and have its output signal combined in phase opposition with the signal of the instantaneously active scanning tube at each of a plurality of selected scanning locations.

Still another object of the present invention is to provide a system of "dark spot" compensation which will lend itself to use in a television transmitting station whereat a plurality of different programs are being simultaneously trans-

mitted from different transmitters, and which, with the synchronized controls of the scanning tubes for each independent transmitter will require but a single compensating tube for compensating for all of the scanning tubes used on the different transmitters. This compensation is possible because by suitably amplifying the signal output from the compensating tube to such a degree that the "dark spot" signal resulting from scanning the mosaic electrode of the compensating tube shall be sufficiently strong to compensate for the "dark spot" signal introduced into the produced video signals for each of the independent transmitters.

Still other objects and advantages of the present invention will become apparent and at once suggest themselves to those skilled in the art to which the invention is directed and related from a reading of the following specification and claims in connection with the accompanying drawings wherein:

Fig. 1 shows somewhat schematically a system for "dark spot" compensation wherein the "dark spot" signal from an unilluminated scanning tube compensates for the "dark spot" distortion in the main scanning tube; and,

Fig. 2 thereof shows schematically an arrangement for utilizing one compensating tube for compensating for each of a plurality of separate image scanning tubes for a plurality of separate transmitters.

Referring now to the drawings, which illustrate schematically a control system of the type above referred to, there is provided for the purpose of translating the optical image of a subject into video signals, an image scanning tube 11 of the character above described, and, for instance, a tube of the character more particularly referred to by Zworykin in the "Institute of Electrical Engineers' Journal" (British) for October, 1933, vol. 73, No. 442, pages 437 et seq., and also in the "Proceedings of the Institute of Radio Engineers" for January, 1934. The image transmitting tube 11 of the aforesaid type may be positioned within a scanning camera of the type described for example in Bedford and Magnusson application Serial No. 109,391, filed November 5, 1936, or the image scanning tube may be arranged to receive the light passed through a film subject in accordance with disclosures previously filed by A. V. Bedford and R. D. Kell, Serial Nos. 653,947 and 649,766, filed January 28, 1933 and January 3, 1933, respectively, or may be used out-of-doors.

In any of these forms of devices, the optical image is projected through a suitable lens system 13 to fall upon the photosensitive side 15 of the mosaic electrode 17. When the mosaic electrode 17 is illuminated, as above described, electrostatic charges are produced between the photosensitive elements 15 and the signal plate 19 across the dielectric 21 of the mosaic electrode 17. The scanning beam issuing from the gun structure 23 contained within the neck 25 of the tube 11 and projected longitudinally of the neck portion thereof, is suitably deflected by means of electromagnetic deflecting coils 27 and 29 (or electrostatic means not shown) so as to traverse the photosensitive side 15 of the mosaic electrode 17 in two mutually perpendicular directions. When the scanning action takes place, the charges which have accumulated between the photoelectric particles 15 and the signal plate or the back plate 19 of the mosaic electrode are released and a potential drop takes place across

the resistor 31 connected to the signal plate and forming a part of the input circuit of the first tube of the amplifier 33. The coupling may be either the A. C. type shown or the well known D. C. type in which the coupling condenser and bias resistor are omitted and the bias voltage for the amplifier is placed in series with resistor 31. As above described, not only is the voltage drop across the resistor 31 due to the charge produced in accordance with the optical image projected upon the mosaic electrode 17, but it is also due in some part at least in accordance with some positions of the scanning beam on the mosaic electrode to the above mentioned causes by which the "dark spot" phenomena results. Consequently, the video signals amplified in the first stage of the amplifier 33 and those stages following it does not represent the highest possible degree of accuracy of translation of the projected optical image in the video signals. Since a wide band of frequencies is to be dealt with, it is desirable that the video amplifier shall have a substantially "flat" response from the lowest to highest frequency. Hence, it is desirable that the amplifier for video signals shall be of the type disclosed, for example, by Smith and Stocker Patents #2,045,315 and 2,045,316 respectively, or equivalent types.

In order to overcome this defect and the lack of complete accuracy of the video signals to represent the optical image, there is positioned a second scanning tube 35 having characteristics substantially similar to those of the optical image scanning tube 11 is arranged to operate without illumination, synchronously and co-phasally with respect to the tube 11. Even though this second scanning tube 35 is not illuminated with an optical image, the scanning of the photosensitive surface 15' of the mosaic electrode 17' by a scanning beam developed in a manner substantially similar to that described in connection with the optical scanning tube 11 causes the development of output energy signals. These signals are those due to the characteristics of the scanned surface and simulate substantially the "dark spot" signals of the illuminated scanning tube 11. In order to provide both co-phasal and synchronous operation of this compensating tube 35 with respect to the tube 11, the deflecting coils 27' and 29' of the compensating tube 35 are controlled by the same source of synchronizing control impulses 28 (not shown in detail) as are the deflecting coils 27 and 29 of the image scanning tube 11.

As shown, the synchronizing signal generator 28 controls the operation of the horizontal and vertical deflection control circuits 30 and 32 for each tube 11 and 35, and the output connection 34 from the synchronizing signal generator controls or arrests the scanning beams in these tubes during "return line" periods. Such a system of control is usually provided in the case of electromagnetic deflection of a cathode ray beam by introducing into the deflecting coils a voltage wave of such a form that a sawtooth of current is passed through the coils so as to deflect the scanning beam slowly in one direction to build up a maximum strength deflecting field which, when it suddenly collapses, returns the scanning beam rapidly to a position of zero or initial position of deflection. A suitable form of arrangement for controlling this operation of the deflection system and the synchronizing control signals, especially in connection with transmitter apparatus of the type herein referred to, is known as

the controlled blocking oscillator. The blocking oscillator control has been shown, for example, by U. S. Patent 1,999,378 and the control thereof of the transmitter has been described in co-pending applications of J. P. Smith, Serial Nos. 748,773 and 8,659, filed October 18, 1934, and February 28, 1935, respectively. These systems, per se, form no specific part of the present disclosure except insofar as the method of controlling the deflection of the cathode ray beams is concerned.

From the above, it is apparent that with no illumination of the mosaic electrode of the compensating scanning tube 35 the only signals which can result from scanning of the mosaic are those signals which produce a voltage drop across the resistor 31' connected in the input circuit of the amplifier 33' and which are due to the "dark spot" signal resulting from the impact of the cathode ray beam upon the mosaic electrode or from any of the other causes hereinabove defined or otherwise discovered which initiate the objectionable "dark spot" or "black spot" signal.

If now the image scanning tube 11 and the compensating tube 35 are operating synchronously and co-phasally it is apparent that the output signal of the compensating tube 35, if in 180° phase opposition to the output signal from the image scanning tube 11, is combined with the output of the image scanning tube 11 and the two "dark spot" signals are of substantially the same character and magnitude and occur at substantially the same time in the train of signal impulses produced through each separate scanning of the mosaic electrodes, one "dark spot" signal will balance out or neutralize the other "dark spot" signal. The result will be that in the output of the combined amplifier there will be produced a signal representing only the desired video signal.

For the purpose of combining the two output signals, the signals may be fed to any suitable form of mixing tube 37, such as 37 after amplification desired in amplifiers 38 and 38' and, for example, in one form of the invention a combination of the video and the transient "black spot" signal may be fed to the control electrode 39 of the mixing tube, whereas the transient "black spot" or "dark spot" signal from the compensating tube may be fed to the screen electrode 41 of this mixing tube. Of course, it is desirable in view of the fact that the "dark spot" signal applied to the screen electrode of the screen grid type tube 37 and the video plus the "dark spot" signal is applied to the control grid of this mixing tube 37 that the two signals be applied out of phase upon the screen and control electrodes. In instances where it is desired to use the triode type of tube as the mixing tube both the video and its accompanying "dark spot" signal as well as the compensating "dark spot" signal are applied upon a single control electrode of the mixing tube and the signals from the two separate sources should be 180° out of phase with each other when applied to the grid. The output from the mixing tube is then fed with any amplification desired to the input of the modulator 43 and to the transmitter 45, from which point the signals are distributed by way of a radio or wire lined link to desired receiving points.

In connection with the use of this form of compensation for studio work where it is desired to provide a plurality of independent image scanning tubes as shown by Fig. 2 for producing either different views of the same subject or for

the projection of entirely different programs, compensate by a single compensating tube, the compensating tube output signal may be fed to a plurality of mixing tubes to mix with the signals from the different scanning tubes or different scanning tubes may be connected to be fed to a common mixing tube in order to combine the output with the compensating tube output. In either event, the compensation introduced by the compensating tube will tend to reduce substantially any distortion signals due to the "dark spot" phenomena.

In the form in which the invention has been schematically shown by Fig. 2, the form of compensation is shown as applicable to use with two (although more may be desired and used) studios simultaneously. In each of the two studios (studios shown as "studio #1 and studio #2") provision is made, as shown, for the use of two scanning tubes 50, 51 and 50', 51' which are intended for studio "shots" and also provision is made for one (or more where desired) additional scanning tubes 52 and 52' which may, for example, be used for film scanning. A single compensating tube 54 of the general type of tube 35 previously described, may be provided for the purpose of compensating the outputs of all of the tubes, although it is usually desirable that only one of the tubes 50, 51 and 52 or tubes 50', 51' and 52' be used at the same time in each of studios #1 and #2. For the purpose of limiting the operation instantaneously to a single tube in each studio suitable switches 55, 56, and 57 are provided for studio #1 and switches 58, 59 and 60 are provided for studio #2. These switches serve to connect one of the scanning tubes of each studio with the amplifier and mixer 61 or 62 of studio #1 or #2 to which the output energy from the compensating tube 54 is supplied.

The output energy from the compensating tube 54 is amplified in a suitable amplifier 63 and after being passed through a phase shifting network 54 (from which different phase outputs may be taken for the scanning tubes of each of studios #1 and #2) is fed to the mixing tubes 61 and/or 62. The manner of controlling the mixing tube may be provided in the identical manner above explained.

Each scanning tube 50, 51, 52, 50', 51', and 52' as well as the compensating tube 54 has the electronic scanning beam developed therein moved across the target mosaic under the control of the output signals from the horizontal deflection control 55 and the vertical deflection control 66, as was also explained above, and each of these controls 65 and 66 is, in turn, controlled by a synchronizing signal generator 67, of the character above explained. The output from the synchronizing signal generator is also supplied to the control electrode (not shown) of each of the separate scanning tubes to "block" the developed electron beam during "return line" periods in the beam deflection. This prevents the production of any output signals during this period and permits the introduction into transmitted signal energy from the scanning tubes of each or both studios of signals which serve to provide the line and frame synchronization for the electro-optical effects produced at any desired receiving points. These signals are supplied to the transmitted signal energy by way of conductors 68 and 69 connecting the output from the synchronizing signal generator 67 with the modulator and oscillator 70 and 71 for each of the studios. The output energy from each in-

dividual amplifier and mixer 61 or 62 for the two studios is also supplied to the associated modulator and oscillator 70 or 71 and from there further amplified (if desired although usually not necessary if modulation is done at high power) in amplifiers 72 and/or 73 to be transmitted by way of the transmitting antenna 74 and 75 (or by equivalent wire line link, such as the known co-axial cable) to desired points of reception.

The general arrangement of the transmitting equipment is quite analogous to that now known except insofar as it involves the provision of the "dark spot" compensation and the selection of the control of the correction as herein explained.

While the invention has been described in one of its preferred forms, it is of course obvious that many and various modifications may be made without departing from its spirit and scope, and therefore it is believed that any and all of these modifications may be used provided they fall fairly within the spirit and scope of the herein-after appended claims.

What I claim is:

1. In a television system, a plurality of image scanning tubes each having a target electrode upon each of which there is adapted to be projected an optical image for causing electrostatic charges of a magnitude proportional to the optical brilliance to result and wherein in each tube spurious electrostatic charges also result, a compensating tube having a target electrode of similar character whereupon only electrical conditions of a spurious nature are adapted to be developed, means for illuminating with an optical image any portion of the plurality of image scanning tubes to produce upon each illuminated tube electrostatic charges of magnitudes proportional to the brilliance of the optical image projected thereupon, means for producing from each illuminated tube image signals, said image signals being accompanied by inherent spurious signals, means for synchronously producing from the compensating tube only inherent spurious signals of a character simulating the spurious signals produced by scanings of the target electrodes of the illuminated scanning tubes, means for combining the output of the compensating tube with a signal output of each illuminated tube separately to produce separate series of image signals corresponding in number to the illuminated scanning tubes wherein the inherent spurious signals are neutralized by the output of the compensating tube.

2. A television system for correcting for distortion comprising a plurality of image tubes each having a mosaic electrode upon which electrostatic charges are adapted to accumulate, means for projecting upon one of the image scanning tubes an optical image for causing the production of electrostatic charges of a magnitude proportional to the light brilliance, means for simultaneously and synchronously scanning the mosaic electrode of each of the scanning tubes, said scanning actions being accomplished with an optical image being projected upon one of the tubes and the lack of an optical image upon the other of the tubes, means for producing from each scanning action output signals from each of the tubes, means for combining in opposition the signal output from each tube, and means for transmitting the resultant signals.

3. A television system comprising a plurality of scanning means each having a target electrode whereupon under conditions of illumination elec-

trostatic charges are adapted to be developed in a magnitude proportional to the brilliance of an optical image cast thereupon and whereupon spurious electrostatic charges are adapted to be developed while in both an illuminated and an unilluminated state, means for casting an optical image upon one of the scanning means to develop electrostatic charges proportional to the brilliance of the optical image, means for simultaneously and synchronously scanning each of the means to produce from one of the scanning means image signals accompanied by spurious signals and to produce from other scanning means only spurious signals, means for combining the two signals produced in such manner as to neutralize the effects of the spurious signals and means for transmitting only the combined signals.

4. In a television system comprising a plurality of optically responsive scanning means each having a target electrode whereupon under conditions of illumination electrostatic charges are adapted to be developed in a magnitude proportional to the brilliance of an optical image cast thereupon and whereupon substantially similar spurious electrostatic conditions are adapted to develop while in either an illuminated or an unilluminated state, the method of compensating for spurious signal distortion which comprises casting an optical image upon one of the scanning means to develop electrostatic charges proportional to the brilliance of the optical image, simultaneously and synchronously scanning each of the target electrodes independently to produce thereby from one of the targets image signals accompanied by spurious signals arising as an incident to scanning and to produce thereby from the other target only spurious signals incidental to the scanning and of a character substantially like the first produced spurious signals, combining the two produced signals in such manner as to neutralize the effects of the spurious signals accompanying the image signals and transmitting, subsequent to the combination, substantially only the image signals.

5. A television method to compensate for distortions comprising scanning simultaneously and synchronously a pair of like character surfaces, illuminating one only of the surfaces during the scanning with an optical image, producing from one scanning, image signals and the distortion signals incidental to the scanning, producing from the other scanning only distortion signals incidental to scanning and combining the output from each scanning operation in phase opposition to produce a substantially distortion free output signal.

6. A television system comprising a plurality of substantially like character scanning tubes, each having included therein a light-sensitive target electrode element adapted to accumulate electrostatic charges, means for directing the light of an optical image upon one only of the scanning tubes to vary in accordance with the light and shade variations of the optical image the magnitude of the accumulated charges, means included in each of the tubes for producing and directing an electronic scanning beam upon the said target electrodes to release thereby electrical signaling impulses proportional to the magnitude of the accumulated charges over the elemental area of the target electrode instantaneously subjected to impact by the scanning beam, means to direct the produced electronic scanning beams of each tube instantaneously upon co-ordinating and substantially related areas of each target electrode and for causing the scanning beams of each tube to traverse each target electrode in synchronism, an output circuit for each scanning tube indicated to be energized from the target electrode elements by the action of the scanning beam and means for combining the output energies of each of the tubes in an out-of-phase manner whereby spurious signals developed in each scanning tube are substantially neutralized and the resultant signal is a substantial true representation of the optical image.

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