

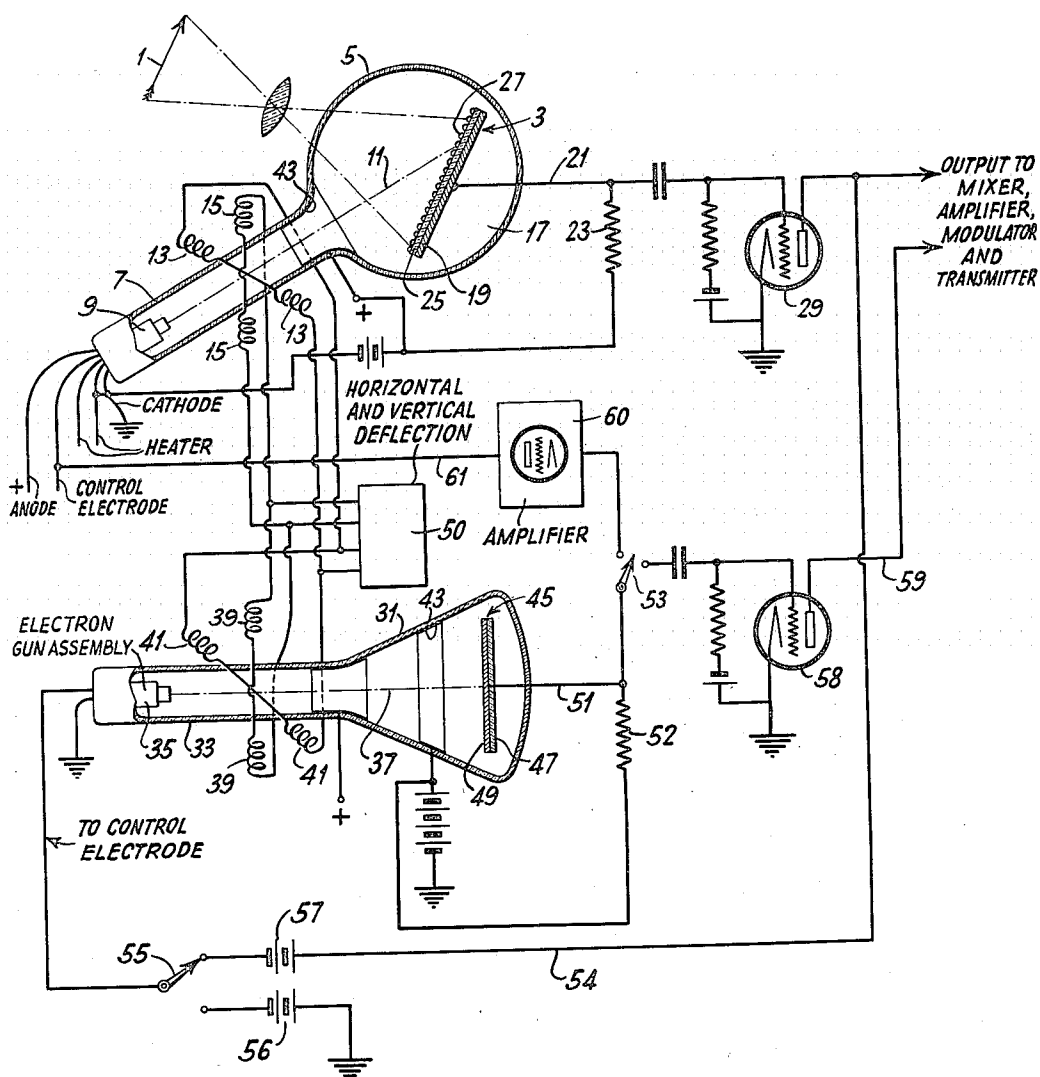
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DISTORTION CORRECTION FOR TELEVISION SYSTEMS

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DISTORTION CORRECTION FOR
TELEVISION SYSTEMS

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This invention relates to television apparatus and principally to television transmitting systems. The invention is more particularly directed to ways and means for compensating for distortions introduced into the produced television signals in transmission. These distortions which arise are due, in part, to the inherent characteristics of electronic types of transmitter scanning systems, and particularly to those electronic types of scanning devices which are known in the art as the "storage" type.

In the past it has been one of the established practices in television transmission to provide electronic television tubes, for example, tubes of the type known by the trade names "Iconoscope" and "Iconotron," as the so-called "electric eye" of the system. When using tubes of this nature for the translation, by a suitable scanning operation, of an optical image into a series of electric signalling impulses which are reproduced at receiving points to reconstruct an electro-optical replica of the optical image at the point of transmission, it has been found that certain distortions and failures to represent accurately the exact light values of different portions of the optical image result at the receiver. Such distortions and inaccuracies, naturally, may be of several general types and degrees but the present invention relates principally to overcoming that type of distortion which may be considered as substantially a second order effect and which effect has become known in the art as "black spot" or "dark spot" distortion.

Electronic image transmitting devices of the type to which this invention relates are, it will be appreciated, capable of producing what may be termed generally satisfactory image signals since first order distortions are substantially non-existent. However, with the approach of demand for ultra-high definition and high fidelity it is necessary to provide ways and means for avoiding or compensating all second order effects producing distortion or inaccuracies and hence it is this type of distortion and system defect which is to be considered herein.

The so-called "black spot" distortion manifests itself in the receiver apparatus by producing across the luminescent viewing screen of the cathode ray receiver device dark shadings which are non-existent in the optical image initially projected on the transmitter electronic image scanning tube. One way which has been suggested for overcoming such "black spot" distortion and which has been used with some degree of success involves the injection of compensating signal

energy into the resultant signals produced for transmission by scanning the mosaic electrode of the image translating tube. The compensating signals may have either saw-tooth, sine wave, or other suitable wave form and characteristics and recur with a frequency and position suitable for compensation. A form of "black spot" compensation of such character as has been disclosed, for example, by the copending patent application of Alda V. Bedford Serial Number 750,055, filed Oct. 26, 1934.

When television images are to be transmitted, and the so-called "storage" type of image translating and transmitting tubes are utilized in the system, an optical image of the subject which is to be reconstructed at receiving points is projected through a suitable optical system upon the mosaic electrode of the transmitter scanning tube.

The transmitter scanning tube, as is well known, includes a suitable electron gun for developing (with the application of suitable voltages thereupon) a concentrated beam of electrons or cathode ray which may be projected along a predetermined path and deflected during its projection by suitable electromagnetic or electrostatic means (or a combination of both electromagnetic or electrostatic means) to sweep the electron beam across a predetermined pattern or target. The target which is swept by the cathode ray beam under deflection is known, insofar as the transmitting tube is concerned, as the mosaic electrode. This mosaic electrode comprises a signal plate and an adjacent insulating layer or sheet upon which latter element is carried a multiplicity of electrically isolated and mutually insulated photoelectric elements each of minute size. The mosaic electrode may be prepared in accordance with the method described in U. S. Patents No. 2,065,570, granted on Dec. 29, 1936, and/or No. 2,020,305, granted on Nov. 12, 1935. Each of the photoelectric particles of the mosaic electrode is subjected both to illumination by the image being projected thereon by the optical system and to scansion by the cathode ray beam impinging thereupon. Whenever a light image is projected upon the mosaic electrode, photoelectrons having a density per elemental area proportional to the light image intensity at the same area are released. The release of photoelectrons results in an electrostatic charge image of the light image being developed between the minute photoelectric particles and the signal plate and across the insulating layer or dielectric element. This produced electrostatic charge is released or

neutralized during scansion of the mosaic by the scanning spot or beam and thus functions to initiate or produce the resulting television or video signal.

5 However, during scansion of the photoelectric particles of the mosaic by the scanning beam, not only is the electrostatic charge, which has been produced and stored in accordance with the intensity of the projected light image, released to
10 produce the television signal, but there is also released from the mosaic electrode secondary electrons because of the impact effect of the scanning beam upon the mosaic electrode. During scansion of the mosaic electrode it has been
15 found that the signals which are produced by the release of the stored electrostatic charges by the scanning action of the cathode ray beam and which appear in the input circuit of an amplifier connected to the signal plate of the mosaic electrode are not always completely accurate representations of the actual optical image intensities projected on the mosaic electrode due to the aforesaid phenomena of "black spot." Some of
20 the causes of "black spot" will hereinafter be set forth in more detail in order to appreciate more fully the nature of the present invention.

One of the causes from which it is thought the so-called "black spot" phenomena results is the non-uniform velocity of scanning of the photoelectric element of the mosaic electrode by the scanning beam. For instance, the scanning beam velocity may not always be entirely constant as it traverses each elemental strip of the mosaic electrode. This variance in velocity of the scanning beam may be particularly evident if the length of the scanning path is varied because, as can be well appreciated, the wave form of the deflection oscillator output energy might change slightly with a change in amplitude of the output energy and thus cause a change in the scanning velocity.

Another cause from which it is thought the "black spot" phenomena results is due to the location of the various minute isolated photoelectric particles of the mosaic relative to the electron beam source (the electron gun and the tube second anode, as well) and to each other. As will be appreciated from a knowledge of the prior art, the mosaic electrode including the insulating support member and the signal plate is positioned within the scanning tube substantially perpendicularly with respect to the direction of the in-falling light of the image cast thereupon by the optical system but at an acute angle with respect to the electron beam source so that one edge of the mosaic electrode is considerably nearer the electron beam source than is the other edge. This angular positioning, naturally, results in the different distances above
60 mentioned and this causes a varying electrical field being developed between the mosaic electrode and the tube electrodes proper.

A further cause from which it is thought the "black spot" phenomena results is due to the varying electrical field distributions across the surface of the mosaic electrode. These varying electrical fields may be either of electromagnetic or electrostatic nature and, for instance, the electrical field distribution across the mosaic electrode may vary not only in accordance with the location of the transmitting tube from time to time but also in accordance with the degree of shielding of the scanning tube from stray fields which is provided.

75 Still a further cause of the "black spot"

phenomena appears to involve the very action of scanning itself which causes a certain degree of distortion. It will be apparent that because of the release of secondary electrons when scanning takes place and because electrostatic charges are being built up between the different photoelectric elements and the signal plate, different photoelectric elements of the mosaic electrode are at different potentials relative to a desired optimum floating potential for the electrode. Consequently, when scanning action of the photoelectric particles by the scanning beam takes place and secondary electrons are released from the photoelectric particles the individual photoelectric particles successively come under the scanning beam. Certain of the released secondary electrons, due to some positions of the scanning beam, will be attracted to portions of the mosaic electrode which are instantaneously at a positive potential relative to the other points on the mosaic electrode. This results in the portions of the mosaic electrode to which the secondary electrons are attracted acquiring potentials, and therefore a resulting electrostatic charge, which is not an accurate or portional representation of the intensity of light and shadow of the optical image projected at the particular point of the mosaic electrode by the optical system.

The foregoing explanations suggest briefly some of the causes from which the undesirable "black spot" phenomena results. These causes which make for this signal resulting from scanning being other than an entirely faithful reproduction of the actual light value of the related elemental area of the optical image indicate the need and desirability of providing ways and means for compensating for such distortions. Accordingly it is one of the primary objects of the present invention to provide a suitable arrangement by which any inherent inaccuracies or defects, so to speak, in the transmitting system, which would result in an unnatural type of reproduced electro-optical image, may be reduced, overcome or compensated.

It is a further object of the present invention to provide suitable ways and means by which "black spot" effects can be overcome in the transmission of image signals. Other objects of the invention are to provide a system for compensating for "black spot" which is relatively simple in its arrangement and functioning and which can be used as a part of presently known types of transmission equipment with a minimum difficulty in order to provide substantially increased efficiency transmission. Other objects and advantages of the present invention will naturally suggest themselves to those skilled in the art from a reading of the following specification and claims in connection with the accompanying drawing wherein the single figure thereof shows one schematic form the invention may assume.

By copending applications filed on even date herewith other forms of "black spot" or "dark spot" correction systems have been described among which are included an arrangement by which the deflection voltage applied to the deflecting system changes in accordance with varying electron beam velocities. Also another form of "black spot" or "dark spot" compensation has been proposed wherein shading impulses are automatically developed and controlled so that the output level of the amplifier connected with the electronic transmitting tube may be varied in accordance with the presence and/or absence of the "black spot".

Still another method has been proposed whereby the mosaic electrode of the scanning tube is simultaneously traversed with two separate electron beams following each other both by minute time and distance separation and wherein the trailing electron beam not useful for producing signals is modulated at high frequency and also an arrangement wherein there has been provided a photographic record of the dark face of the image reproducing tube from which is produced a replica of the "dark" or "black spot" signal provided with a carbon ink upon a conducting sheet which may be the back of the signal plate and which has a higher secondary emission ratio than the carbon.

The present invention is concerned with a system for "black spot" correction which is more closely related to the last above named correction system. Briefly, the invention comprises the formation of a surface which is positioned within an electronic tube and which is arranged to be scanned by an electron beam synchronously and co-phasally with the scanning of the mosaic of the transmitter tube. The surface scanned in the compensating tube is a surface formation which varies from elemental area to elemental area in accordance with the presence and/or absence of "dark spot" upon the mosaic surface of the image scanning tube.

In accordance with the present invention the surface to be formed is preferably a metallic surface, such as silver which has been oxidized and coated with caesium and baked at a low temperature. When an electron beam is modulated in accordance with the presence and/or absence of "dark spot" on the tube used for transmission by the translation of an optical image into a train of electrical signals, and the compensating tube has developed therein an electron beam of relatively high current, such an electron will warm substantially the surface upon which it impinges so that the character of the surface upon which the beam impinges will have its secondary emission properties altered in such manner that the surface areas warmed to the greatest extent will have a higher secondary emission factor than those elemental areas of the surface which have been warmed to the least extent.

Referring now more particularly to the drawing for a further understanding of this invention, an optical image 1 is projected through a suitable optical system upon the mosaic electrode 3 of a storage type electronic image transmitting tube 5 in known manner. The electronic image transmitting or signal producing tube 5, as was above described, comprises within the neck 7 of the tube an electron gun structure 9 from which a concentrated electron scanning beam 11 is developed. This scanning beam is projected longitudinally through the tube neck and is subject to deflection in two mutually perpendicular directions of deflection through the aid of pairs of mutually perpendicular electromagnetic deflecting coils 13 and 15. Suitable electrostatic deflection means or a combination of electrostatic and electromagnetic can readily be substituted for the deflecting coil pairs 13 and 15 shown.

In the rounded or bulbous portion 17 of the image transmitting tube envelope 5 is positioned the mosaic electrode 3 which is located at an acute angle to the direction of the impinging electron beam 11 but normal to the direction of the light of the image 1. In this way the light of the image comes to fall upon the mosaic elec-

trode in a direction normal to the plane of the mosaic electrode 3.

The mosaic electrode 3 comprises a signal plate 19 which is connected by conductor 21 to an external circuit comprising a suitable number of stages of amplification used for amplifying the resultant output signal from the tube in accordance with the voltage drop taking place across a resistor element 23 connected to the signal plate and the amplifier input circuit. Supported from the signal plate 19 of the mosaic electrode 3 is an insulating sheet 25, preferably of mica, and carried upon the opposite face of this insulating sheet member 25 are a multiplicity of small photo-electric elements 27 each of substantially microscopic size but all electrically isolated from the other as was described in the above mentioned U. S. Patent No. 2,065,570, granted Dec. 29, 1936. The manner in which the varying light intensities are converted into electrostatic charges was previously described in this specification.

When the electron beam 11 scans the photo-electric elements 27 of the mosaic electrode 3, it releases the stored charges from the mosaic area where beam impact takes place and produces a voltage drop across the resistor 23 connected to the input circuit of amplifier tube 29. The amplifier unit (of which only the first stage is shown) is preferably one which is substantially "flat" throughout a band of frequencies varying between the lowest frame projection frequency, of say 30 cycles, up to and including the highest frequency developed, which may be of the order of several million cycles. Hence, such an amplifier may be of the general character shown and described in previously issued patents of J. P. Smith, No. 2,045,315, and/or A. C. Stocker, No. 2,045,316, each granted on June 23, 1936.

In accordance with the present invention a portion of the output from the amplifier 29 is taken from the output signal circuit in the first instance and utilized to modulate a separately developed cathode ray beam in a compensating tube 31. This compensating tube 31 is of a type somewhat similar to the electronic image transmitting tube 5 except that no light image is projected thereon and no storage effect takes place. However, the likeness between the two types of tubes develops from the fact that in each tube, in accordance with the instantaneous position of electron beam impact on the target electrode, secondary electrons are emitted in accordance with the condition of the surface upon which the electron beam is instantaneously impinging.

The image compensating tube 31 comprises a neck portion 33 wherein there is provided an electron gun structure 35 comprising a cathode, a control electrode or grid and an anode. Controlling signals are applied to the grid electrode and between the anode and cathode there is supplied a suitable potential difference to cause electrons emitted from the heated cathode member to be released and formed into an electron beam 37. Means are provided in connection with the compensating tube 31 for deflecting the electron beam developed therein in a manner identical to the manner of deflection of the electron beam developed within the image scanning tube and the same deflection voltages or currents which are supplied to the deflecting electrode system of the image scanning tube 5 are also applied to the electron beam deflecting means 39 and 41 of the compensating tube 31.

As is the case with the image scanning tube, a second anode arrangement 43 is provided both

for accelerating and assisting in the focus of the electron beam 37 developed to a fine or sharply defined spot on the impact surface 45 and also for the purpose of collecting secondary electrons which are emitted from the surface of impact due to the action of the produced electron beam thereupon.

In the case of the compensating tube, the surface of impact comprises a target or impact surface 45 preferably, although not essentially, having an insulating support sheet 47, such as a mica sheet, for carrying the beam impact target member 49. Upon this mica or support sheet member on the side toward the developed electron beam is coated a thin film of silver which has been oxidized and had a coating of caesium applied thereto. The surface 49 is produced within the tube, first by admitting oxygen into the tube in the manufacturing process, after the silver has been placed therein and the tube evacuated then the oxidation process is continued as desired by following the high frequency method described by Patent No. 2,020,305 above referred to; then the oxygen is pumped out and the caesium distilled over onto the oxidized silver surface. The caesium in the preparation of the tube is carried in a tip portion (not shown since it can later be broken away after the tube has been prepared) in the form of a pellet of caesium and this is distilled over onto the oxidized silver surface by the application of heat to the caesium and the metallic electrode members (such as the electron gun 35) are maintained warm to prevent deposition of caesium thereon. When the caesium has been deposited upon the oxidized silver surface, the tube is then baked for a short period of time at a temperature of about 100° C.

After the target electrode 45 has thus been prepared, the output signals taken from the electronic image scanning tube which is in an unilluminated state but operating to scan the mosaic electrode 3 and whose output signal tubes have included therein only the "dark spot" signal are then applied to the grid electrode of the compensating tube 31.

At this time the average beam current developed within the compensating tube is preferably of the order of about 1 milliamperere but modulated in accordance with the output from the image scanning tube with the electron beam developed therein traversing the mosaic electrode member 3 at the same rate and under the same deflection control 50 as the electron beam developed within the compensating tube traverses its target.

Under these conditions, it will be appreciated, that within the space of a few seconds the caesiated target of the compensating tube 31 will become sufficiently warmed by the action of the impinging electron beam 37 to change the secondary emission ratio of the target 45 considerably making the secondary emission ratio higher for the parts of the target which have been warmed most or, in other words, over those portions of the target which have been subject to the greatest intensity beam current. This condition of the caesiated silver-oxide surface of target 45 then remains and the beam current is then reduced to an intensity of about a microampere, for using the compensating tube 31 for the purpose of compensating for the dark spot conditions in the image scanning tube 5.

There is connected to the silver surface of the target 45 of the tube 31 in the fabrication of the device a conducting member 51 which leads to an

external circuit so that if this conducting member has connected to it a resistor 52 which, in turn, connects to ground or back to the source of the electron beam, a voltage drop will take place across the resistor in accordance with the beam current flowing. This voltage drop then is applied simultaneously with the output signal from the image scanning tube to the input circuit of a mixing tube (not shown) so that the "dark spot" signal from the image scanning tube will be compensated by signal changes due to "dark spot" conditions on the target 45.

In the formation of the surface 49 on the target 45 of compensating tube 31, the output from the amplifier 29 of the image scanning tube 5 is supplied by way of the conductor 54 and the switch 55 (which is then closed on the upper contact shown) and the biasing source 57 to the control electrode (not shown) of the gun structure 35. The gun structure 35 is of the usual standard type, as above stated, and comprises the usual electron emitter (cathode), anode (accelerator electrode) and control electrode interposed therebetween. Under this condition, the other switch 53, later to be described, is in open position and not resting upon either of the contacts shown therefor. The bias 57 is so adjusted as to give a relatively high beam current as above explained or of the order of 1 milliamperere.

As soon as the surface 49 has been prepared and has secondary emission properties which would compensate for the "dark spot" condition of the mosaic electrode 3 of the image scanning tube 5, a switch 55 is closed upon its lower contact so as to apply bias from the source 56 to the control electrode of the tube 31 and thus reduce the beam current to the order of approximately 1 microampere (although this value like the beam current above suggested is not critical). This control or reduction in beam current having taken place the switch 53 is then closed upon either of the contacts shown. When the switch 53 is closed upon the righthand contact the signal output appearing across the resistor 52 from the target electrode 45 of the compensating tube 31 is applied by way of the capacity resistance coupling to the amplifier tube 58 whose output is applied by way of the conductor 59 to a mixer tube (not shown). In this form of arrangement the amplifier 58 may include one or more stages as is necessary in order to provide that the compensating signal appearing in the conductor 59 shall be of the desired phase to compensate for the "dark spot" signal in the image scanning tube 5 and the mixing tube, for example, may be either of the triode or tetrode type. For example, with the triode type of mixing tube the output signals from the amplifiers 29 and 58 are applied to the control grid in out-of-phase fashion, whereas if a tetrode type tube is used as the mixing tube the output signals from the image scanning tube 5 may be applied for example, to the control grid and the compensating signal output from the amplifier 58 applied to the screen grid, in which case the signals will be applied co-phasally.

However, instead of mixing the output of the compensating tube with the energy of the scanning tube by way of a mixer tube whose output which connects with the amplifier, modulator and transmitter of known character, it is also possible to compensate for the "dark spot" condition of the mosaic electrode 3 directly in the image scanning tube 5 by closing the switch 53 upon the left contact shown so that the output from

the compensating tube 31 is applied through the amplifier 60 in desired phase to the control electrode of the gun structure 9 of the image scanning tube 5 so as to vary thereby the strength of the beam current 11 and accordingly vary the output signal appearing across the resistor 23 so that compensation for "dark spot" condition takes place directly and instead of feeding an output of the amplifier 29 to a mixer the output may be fed directly to an amplifier and modulator arrangement or to some type of mixer to which is applied the desired form of bias to provide uncompensated output directly in the mixer.

It will be appreciated that the compensation provided by the compensating tube takes care of conditions resulting not only from varying beam velocities of traversal of the mosaic electrode surface, but also takes care of the conditions of charge on the mosaic electrode, the spacing of the adjustments on the mosaic electrode and the varying electrical fields to which the image scanning tube is subjected so that when an optical image is projected on the mosaic electrode of the image scanning tube and the image compensating tube has its electron beam scanning its target electrode simultaneously and synchronously with the scanning of the mosaic electrode of the scanning tube and the output signal from each tube is combined, it will be appreciated that the resultant output signal is substantially an actual electrical replica of the optical image falling upon the mosaic electrode of the image translating tube. While one form of device for compensating for the "dark spot" condition has been described herein, it will be appreciated that many other forms of compensating systems may be utilized without departing from the spirit and scope of the invention.

What I claim is:

1. A system for providing compensation for distortion in television apparatus wherein an electronic image is developed comprising a scanning tube having a target area upon which electrostatic charges are developed in accordance with the light intensity of an optical image projected thereupon, means for scanning the target area in a non-illuminated condition to produce signal output therefrom, means for producing under the control of the produced signals an electronic replica of the electrostatic condition of the target during said scansion, means for projecting an optical image upon the target of the scanning tube, subsequent to the production of the electronic replica, means to scan the illuminated target to produce under scansion signal output representations of the optical image added to the initially produced signals, means to scan synchronously the electronic replica, and means for combining with the output signals representing the optical image and the initial signal condition signals resulting from scansion of the electronic replica of the initial conditions of the scanning tube whereby distortions in the signal output representing the optical image are neutralized.

2. A distortion compensating system for television apparatus comprising an electronic tube having a target area upon which electrostatic charges are developed in accordance with the light intensity of an optical image projected thereupon, means for scanning the target area in a non-illuminated condition to produce signal output therefrom, means for producing a secondary electron emissive replica of the electrostatic condition of the target during scansion under the control of the produced signals, means

for projecting an optical image upon the target of the scanning tube subsequent to the production of the secondary electron emissive replica to produce, under scansion, signal output representation of the optical image added to the initially produced signals and means for combining with the output signals representing the optical image and the initial signal condition signals resulting from scansion of the secondary electron emissive replica of the initial conditions of the scanning tube whereby distortions in the signal output representing the optical image are neutralized.

3. The method of compensating for distortion in television systems wherein a target area upon which electrostatic charges are developed in accordance with the light intensity of an optical image projected thereupon is scanned by an electronic scanning beam the method of compensation which comprises scanning the target area in a non-illuminated condition to produce signal output therefrom, producing a secondary electron emissive replica of the electrostatic condition of the target during scansion under the control of the produced signals, projecting an optical image upon the target of the scanning tube to produce under scansion signal output representation of the optical image added to the initially produced signals and combining with the output signals representing the optical image and the initial signal condition signals resulting from scansion of the secondary electron emissive replica of the initial conditions of the scanning tube whereby distortions in the signal output representing the optical image are neutralized.

4. A television distortion compensation system comprising an electronic image translating tube having a target upon which an optical image is adapted to be projected to cause the production of electrostatic charges of magnitude proportional to the intensity of the optical image, an external circuit associated with the target, means for scanning the target to produce in the external circuit signal impulses representative of the conditions of electrostatic charge upon the target surface, a compensating tube having a target positioned at one end thereof, means for developing within the compensating tube an electron beam and directing the beam at the target, means for modulating the developed electron beam projected at the target under the control of the signals produced in the external circuit to cause on the target electrode a permanently maintained electronically active record of the beam current flowing within the compensating tube, means for moving the developed cathode ray beam in the image scanning tube and in the compensating tube synchronously and co-phasally so that the electronically active record produced on the target area of the compensating tube coincides in spacial position with a related target area of the scanning tube and thereby represents the condition of signal output from the scanning tube.

5. The method of compensating in television systems distortion arising due to a light sensitive mosaic target element upon which a light image is directed by the use of a distortion compensating tube which comprises the steps of translating the light values of an optical image into electrostatic charges upon the target element, scanning the charges on the target element to develop output signal energy of a magnitude proportional to the charges, developing an electron beam within the distortion compensat-

ing tube, modulating the developed electron beam by the produced output signal energy, moving the developed beam within the compensating tube synchronously with the scanning of the target element so that the developed beam is instantaneously spatially related in position to the scanning operation, producing a substantially permanent electronically active record of the modulated beam under the control of the modulated beam in the compensating tube, disconnecting the control of the developed electron beam within the compensating tube subsequent to the development of the permanent electronically active record produced, scanning the permanent electronically active record subsequent to its production synchronously and cophasally with the scanning of the mosaic target element to produce output signals representative of the electronically active record in the compensating tube, and com-

bing the last named output signals with the originally produced output signals so that the output signals developed in the compensating tube tend to nullify signal distortion present in the originally produced output signals resulting from scanning the target element.

6. An electronic tube comprising means for developing an electron beam, a target electrode position in the path of the developed electron beam, means for controlling the intensity of the electron beam in accordance with signals supplied from an external circuit and means for varying and permanently establishing under initial conditions of beam impact upon the target electrode the secondary emission properties of the target electrode in accordance with the magnitude of the beam current produced.

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