June 19, 1945. R. E. GRAHAM 2,378,547

TELEVISION SYSTEM

Filed Dec. 31, 1942 2 Sheets-Sheet 1

FIG. 1

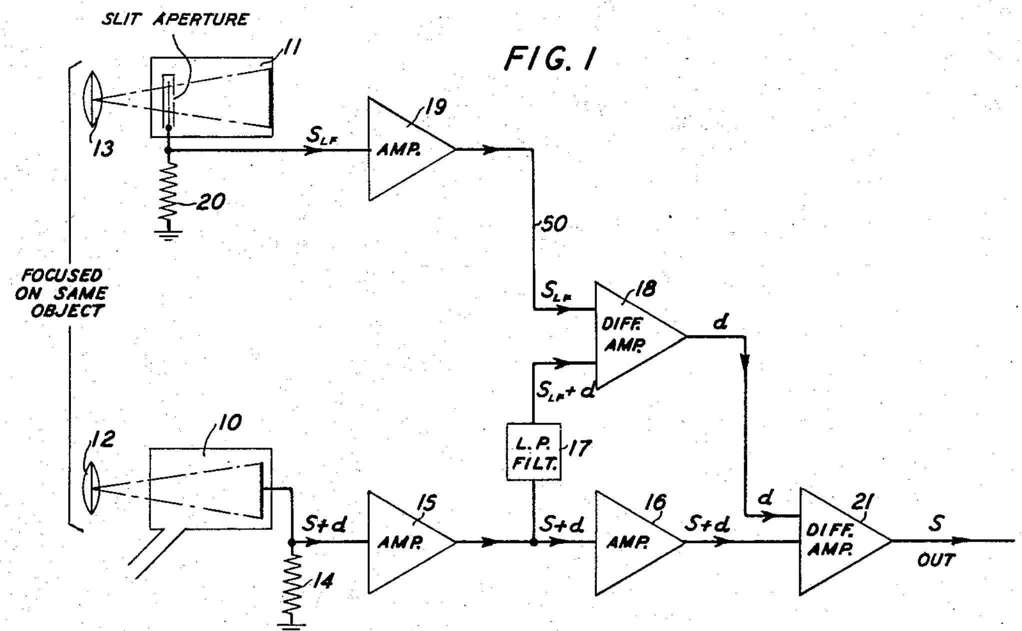

FIG. 2

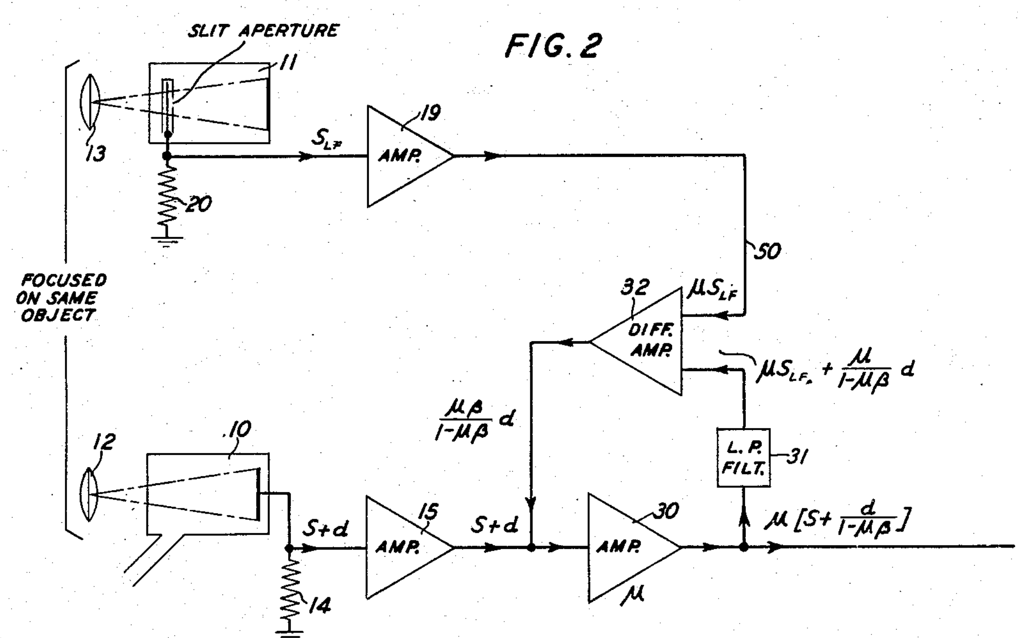

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FIG. 3

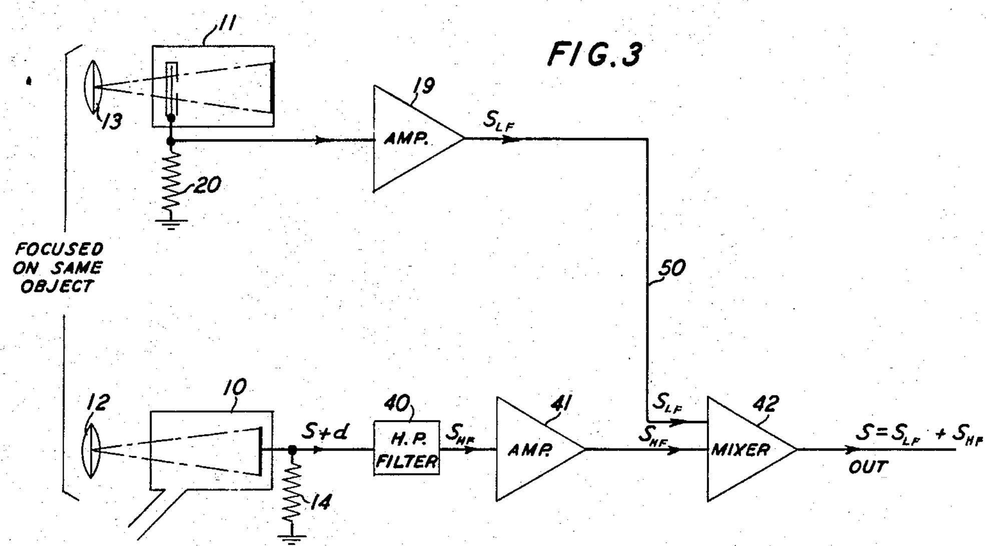
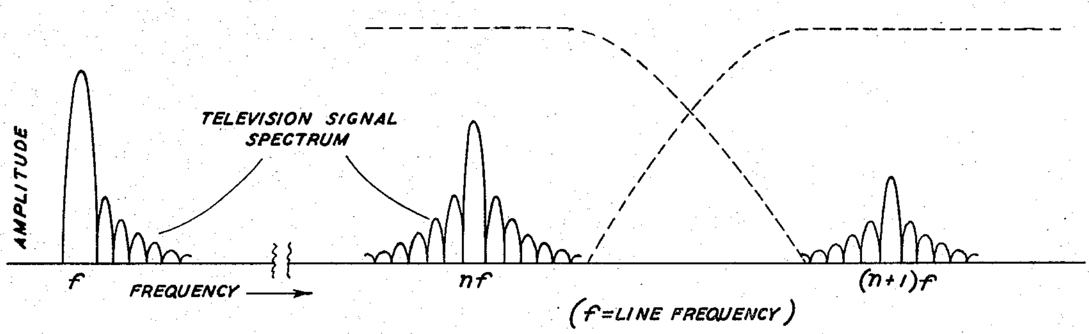


FIG. 4



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TELEVISION SYSTEM

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19 Claims. (Cl. 178—7.2)

This invention relates to electric circuit arrangements and more specifically to means for removing spurious electrical variations from the output currents of electron camera tubes.

It is an object of this invention to provide novel electric circuit means for removing unwanted or spurious components from electric currents.

The storage type of electron camera tube, such as the well-known "Iconoscope," normally produces an output current which contains distorting or spurious variations. These variations are believed to be caused by secondary electrons, emitted from the scanned elemental area, being attracted to more positive elemental areas. Certain of these spurious variations produce the "cloud" or "dark spot" effect which manifests itself in the form of one or more large extraneous dark areas in the reconstituted picture. This effect is essentially a low frequency distortion. The variation producing the "cloud" effect are usually quite appreciable in amplitude in comparison with the amplitude of the desired picture signal, and have been compensated to a certain extent in practice by the introduction into the picture signal of manually controlled electrical "shading" variations or signals. Where the pictorial subject-matter is continually changing, this technique requires continual manual manipulation of the dials controlling the insertion of these shading signals. The present invention relates to the provision of means for the automatic compensation of these spurious electrical variations.

It is another object of this invention to provide novel apparatus for automatically removing or compensating for the spurious variations produced by certain forms of electron camera tubes and which when present with the video signal, produce "cloud" or "dark spot" effects in the reconstituted picture.

A further object is to provide a novel repeater feedback arrangement.

These and other objects will be apparent from the following description of various specific embodiments of the invention hereinafter fully described. In each of these specific embodiments there is utilized an auxiliary electron camera or pick-up tube which produces signals corresponding only to the low frequency components (up to several times the line frequency) of the complete picture signal produced by the main electron camera tube, which preferably is of the storage type. This auxiliary tube is preferably a "Dissector" tube or some other form of pick-up tube which produces a signal which is substantially free from low frequency spurious signals. The output currents of the two tubes are combined to eliminate the low frequency spurious variations appearing in the main camera tube output current.

In accordance with one embodiment of the invention, two electron camera tubes are provided at the transmitting station both of which are focused on the same object. The main camera tube preferably comprises a tube of the storage type such as, for example, the well-known "Iconoscope." The auxiliary tube is preferably a tube of the "Dissector" type but is modified to have a long slit scanning aperture instead of the usual square one, the long dimension of the slit being in the line scanning direction. Some of the output energy from the main camera tube (comprising both video and spurious components) is removed and passed to a side circuit wherein the high frequency components of the by-passed energy are filtered out and the resultant low frequency components are amplified in a differential amplifier to which is also applied, in proper phase to oppose the output of the filter, the amplified output wave from the auxiliary camera tube. The output of this differential amplifier, which contains only the low frequency spurious components as the signal components have been balanced out in the differential amplifier, is then applied to a second differential amplifier to which is also applied, in proper phase so that the spurious variations are balanced out, that portion of the energy from the main camera tube which was not passed to the side circuit. The output current of this latter amplifier contains the full range of video frequencies without the low frequency spurious variations. This output current may be transmitted to the receiving station by well-known means.

In a second embodiment, a similar result is obtained by a negative feedback circuit. A portion of the energy from the main camera tube is, after amplification, passed through a low-pass filter and then combined, in proper phase, with the amplified output of the auxiliary camera tube to produce signals which are fed back into the amplifier circuit of the main camera tube. The output is, as before, substantially free of the spurious variations.

In a third embodiment, the desired result is obtained by passing the video signals from the main camera tube through a high-pass filter, the output of which is, after amplification, combined with the amplified output of the auxiliary camera tube to produce an output wave substantially free of the aforementioned spurious variations.

While the invention in its preferred aspects relates to television, it will be apparent that certain of the principles of this invention have other applications.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof in which:

Fig. 1 is a schematic drawing, in block diagram form, of a circuit arrangement for compensating for spurious variations produced in electron camera tubes of the storage type, which spurious variations will, if not compensated, produce a "cloud" effect in the received picture;

Fig. 2 is another circuit for producing a result similar to that obtained by the circuit of Fig. 1;

Fig. 3 is still another circuit for producing a result of this type; and

Fig. 4 is a diagram to assist in the explanation of the invention.

Referring more specifically to the drawings, Figs. 1, 2 and 3 show in block diagram form circuit arrangements for compensating for spurious variations in the output currents of certain types of electron camera tubes, such as, for example, the storage type of camera tube known to the art by the term "Iconoscope." Such a camera tube is described in an article by V. K. Zworykin in the Proceedings of the Institute of Radio Engineers for January 1934, starting at page 16. These tubes have a fairly high signal-to-noise ratio, and it is therefor desirable in many cases to use them. While tubes of the "Dissector" type (described on pages 230 to 233, inclusive of the book "Television" by V. K. Zworykin and G. A. Morton) are substantially free of the abovementioned spurious variations, they have a low signal-to-noise ratio. In the present invention, certain advantages of both are combined to improve the appearance of the received picture. Stated differently, a tube of the "Dissector" type, modified so that the scanning aperture is a long slit (instead of a small square or a rectangle the two dimensions of which are nearly equal), is utilized to produce low frequency video signals representative of the scanned object (which signals are substantially free of the spurious variations found in the "Iconoscope" output current). While high frequency signals are also produced, they are of such small amplitude they can be neglected. The "Iconoscope" or similar tube is utilized as the main camera tube and while it produces a full range of signals, that is, low frequency signals and high frequency signals, there are also present the aforementioned spurious variations of relatively low frequency. These spurious variations are substantially eliminated in the novel circuits of this invention. The output currents of the two tubes are combined in any one of these circuits in such a way that the resultant output current is free of these spurious variations and at the same time (because the high frequency portion of the resultant signal current is supplied by the "Iconoscope"), a relatively high signal-to-noise ratio exists for the high frequency signals (the most important part of the band as far as the signal-to-noise ratio is concerned because it includes much the greater portion of the band width).

In the arrangement of Fig. 1, the "Iconoscope" 10 serves as the main electron camera tube, while the auxiliary tube 11 is of the "Dissector" type modified to have a slit as described above. The length of the slit is preferably of the order of one-fourth to one-third of a scanning line but may be as small as one-tenth. The long dimension of the slit is, as pointed out above, in the direction of line scanning. The effect of such a slit is to produce signals, the highest frequency component (of appreciable amplitude) of which is of the order of several times the line scanning frequency. The camera tubes 10 and 11 are focused on the same object (not shown) by suitable lens systems 12 and 13, respectively, and are arranged so that the images reflected on the targets of the tubes 10 and 11 are substantially the same. While for exactness of result this can be accomplished, if desired, by any well-known optical means, such as by mirrors or prisms, generally two lenses, side by side, will suffice for objects sufficiently far away so that substantially the same view is picked up by each tube.

The output current of the electron camera tube 10 which contains high frequency components and low frequency components (collectively identified as the signal S) and, in addition, spurious variations which are identified in the drawings by the reference character d are applied by means of the usual signal resistor 14 to an amplifier 15, the output signal of which is divided between two paths, a portion of the signal being applied to the amplifier 16 while the rest is applied to the low-pass filter 17 which filters out the high frequency components and passes a current identified in the drawings as $S_{LF}+d$ (or in other words the low frequency portion of the signal plus the spurious variations or disturbances). The output of this filter 17 is applied to the differential amplifier 18, to which is also applied in proper phase so that the signal components balance out, the amplified output from the camera tube 11. This output current which is applied to the amplifier 19 by means of the signal resistor 20 contains the entire frequency range of the output current of the camera tube 11 but, due to the use of the long slit instead of the square aperture, the output wave does not have any components of appreciable amplitude of frequencies higher than those in S_{LF}. If desired, a low-pass filter (not shown) may be inserted before or after the amplifier 19 to ensure that no high frequency components are present in the line 50. The filter 17 is chosen so that the cut-off at the low frequency end generally coincides with the upper limits of the frequency band of the signal current formed by camera tube 11. The output of the differential amplifier 18, which contains only the spurious variations or disturbances d, is applied to a second differential amplifier 21 to which is also applied the unbypassed portion of the output of the amplifier 15 which has been amplified by the amplifier 16. The gain of the amplifier 16 is so chosen that the amplitudes of the spurious components in its output circuit are substantially the same as those in the output of the differential amplifier 18. The output of the amplifier 21 contains, as indicated in the drawings, only the signal S which comprises both high and low frequency components. This signal current may be transmitted to a receiving station by any well-known means.

Fig. 2 shows a modification of the arrangement of Fig. 1. In the arrangement of Fig. 2 a similar result is obtained by a degenerative feedback arrangement. A portion of the energy from the main camera tube 10 is, after amplification by the amplifier 15 and the amplifier 30, passed through a low-pass filter 31 and then combined in proper phase in the differential amplifier 32 with the amplified output from the auxiliary camera tube 11 to produce signals which are fed back into the amplifier 30. Representing the output of the tube 10 as $S+d$ and ignoring (for simplicity of description) the gain produced by the amplifier 15, the current in the output of the low-pass filter 31 may be represented by the expression

$$\mu S_{LF}+\frac{\mu}{1-\mu\beta}d$$

which, when differentially combined with the current from the auxiliary camera tube (S_{LF}), forms in the output of the differential amplifier a current represented by

$$\frac{\mu\beta}{1-\mu\beta}\cdot d$$

which, when fed back into the input of the amplifier 30, produces a current in the output of the amplifier equal to

$$\mu\left(S+\frac{d}{1-\mu\beta}\right)$$

It will thus be seen that the degree of suppression of distortion is represented by the fraction

$$\frac{1}{1-\mu\beta}$$

For low frequencies, the $\mu\beta$ of the feedback circuit is high so the distortion is substantially eliminated.

The arrangement shown in Fig. 3 is another modification of the arrangement of Fig. 1. The functions of the camera tubes 10 and 11 are the same as before. A high-pass filter 40 is inserted in the output circuit of the tube 10 to remove the portion of the output signal falling in the same frequency region as that occupied by the output current of the tube 11. The remaining signal from tube 10 which may be represented by the symbol S_{HF} is then, after amplification by the amplifier 41, applied to the mixer amplifier 42 in such phase that it is added to the amplified low frequency signal from the camera tube 11. The output of the amplifier 42 is then expressed by: $S=S_{LF}+S_{HF}$. Thus, the complete television signal is free of spurious components d.

In the arrangement of Fig. 3 there appears the problem of relating the high-pass cut-off of the current from the system including the tube 11 and the low-pass cut-off of the current from the system including tube 10 in such a manner as to obtain an over-all level response characteristic at frequencies where both systems make appreciable contribution. A similar problem exists, of course, in connection with the arrangements of Figs. 1 and 2. One way of minimizing this difficulty is to place the frequency region where the two signals overlap half way between two successive multiples of the line frequency where (as is well known) there is little energy concentration. This is illustrated in Fig. 4. The load impedance 14 may serve as a portion of the high-pass filter, if desired.

In any of the arrangements described above, if the auxiliary tube 11 is of the type containing a direct current component in its output, it can, of course, be used to provide direct current insertion for the television system by injecting a very low frequency portion into the main signal path at a desired point.

It should be noted that the auxiliary camera tube 11 need have little refinement of any sort. With a long slit aperture extending from one-tenth up to one-fourth or one-third of the length of a line, the signal obtained from such a tube contains, for practical purposes, only low frequency components as the amplitude of the high frequency components is so low that it can be neglected.

Various modifications may be made in the embodiments disclosed above without departing from the spirit of the invention, the scope of which is indicated in the appended claims.

What is claimed is:

1. In combination, electron camera means for producing a video signal having a relatively wide band of frequency components, said signal containing some unwanted or spurious amplitude variations of certain frequency components at least, a second electron camera means for producing a video signal having a smaller band of frequency components, said smaller band overlapping, at least in the part containing said certain frequencies, said wide frequency band but being substantialy free of the unwanted or spurious variations of said certain frequencies in said wide band, and means for combining signals from said two bands to produce a resultant video signal which is substantially free of said unwanted or spurious variations of said certain frequencies.

2. In combination, means for producing a signal having a relatively wide band of frequency components, said signal containing some unwanted or spurious amplitude variations of certain frequency components at least, means for producing a signal having a smaller band of frequency components, said smaller band overlapping, at least in the part containing said certain frequencies, said wide frequency band but being substantially free of the unwanted or spurious variations of said certain frequencies in said wide band, and means for combining signals from said two bands to produce a resultant signal which is substantially free of said unwanted or spurious variations of said certain frequencies, said last-mentioned means including a negative feedback circuit for feeding back and combining with the variations of the first band a portion of the energy of said first band.

3. In combination, means for producing a signal having a relatively wide band of frequency components, said signal containing some unwanted or spurious amplitude variations of certain frequency components at least, means for producing a signal having a smaller band of frequency components, said smaller band overlapping, at least in the part containing said certain frequencies, said wide frequency band but being substantially free of the unwanted or spurious variations of said certain frequencies in said wide band, and means for combining signals from said band to produce a resultant signal which is substantially free of said unwanted or spurious variations of said certain frequencies, said last-mentioned means including a negative feedback circuit for feeding back and combining with the variations of the first band a portion of the energy of said first band, and means for feeding energy of said second band into said feedback circuit.

4. A signal transmission system comprising a transmission path including an amplifier, a source of variable electromotive force, means for applying energy from said source to the input of said amplifier, a negative feedback connection, including an amplifying device, between the output and input of said amplifier, a second source of vari-

able electromotive force, and means for applying to said amplifying device energy from said second source to modify the variations impressed upon the input of said amplifier by said amplifying device in accordance with the variations in the electromotive force from said second source.

5. A signal transmission system comprising a transmission path including an amplifier, a source of signals containing undesired components at one end of said path and a load circuit at the other end thereof, a negative feedback connection, including a repeating device, between the output and the input of said amplifier to balance out at least a portion of said undesired components, a second source of signals, and means for applying to said repeating device signals from said second source in such phase that at least a portion of the signals in said feedback path taken from the output of said amplifier is balanced out.

6. A signal transmission system comprising a transmission path including an amplifier, a source of signals containing undesired components at one end of said path and a load circuit at the other end thereof, a negative feedback connection, including a repeating device, between the output and the input of said amplifier to balance out at least a portion of said undesired components, a second source of signals, and means for applying to said repeating device signals from said second source in such phase that at least a portion of the signals in said feedback path taken from the output of said amplifier is balanced out, the second source being substantially free from said undesired components.

7. A signal transmission system comprising a transmission path including an amplifier, a source of signals containing undesired components at one end of said path and a load circuit at the other end thereof, a negative feedback connection, including a repeating device, between the output and the input of said amplifier to balance out at least a portion of said undesired components, a second source of signals, and means for applying to said repeating device signals from said second source in such phase that at least a portion of the signals in said feedback path taken from the output of said amplifier is balanced out, said second source producing signals having a much smaller frequency band width than said first source.

8. In combination, means including an electron camera tube for producing, when radiations from an object are applied thereto and by a scanning operation, a video signal and, mixed therewith, some low frequency spurious signals, means including an auxiliary scanning device for producing, when radiations from the same object are applied thereto and by a scanning operation at the same rate of scanning as said first scanning operation, a video signal corresponding to the same object or field of view as the video signal of said electron camera tube, but which signal has a relatively small band width compared with the video signal of said camera tube and is relatively free of said low frequency spurious signals, and means for utilizing the two video signals to produce a resultant video signal which has a band width comparable to that produced by said electron camera tube but which is substantially free of said low frequency spurious signals.

9. The combination as in claim 8 in which said auxiliary scanning device is a camera tube of the type having a scanning aperture which scans an electron image, said aperture being rectangular with sides of unequal length, the long dimension being in the direction of line scanning.

10. The combination as in claim 8 in which said auxiliary scanning device is a camera tube of the type having a scanning aperture which scans an electron image, said aperture being rectangular with sides of unequal length, the long dimension being in the direction of line scanning, said long dimension being from one-third to one-tenth the length of a scanning line.

11. In combination, a main camera tube, an auxiliary camera tube, means including said main camera tube for producing a band of high frequency video signals representative of a scanned object or field of view and mixed therewith some low frequency spurious signals, means including said auxiliary camera tube for producing a band of low frequency video signals representative of the same object or field of view scanned at the same rate, and means for combining the two bands to produce a resultant video signal current in which the low frequency spurious signals are substantially absent.

12. The combination of elements as in claim 11 in which the upper boundary of the low frequency band substantially coincides with the lower boundary of the high frequency band.

13. In combination, a main camera tube, an auxiliary camera tube, means including said main camera tube for producing a band of high frequency video signals representative of a scanned object or field of view and mixed therewith some low frequency spurious signals, means including said auxiliary camera tube for producing a band of low frequency video signals representative of the same object or field of view scanned at the same rate, said video signals being characterized in that they have in their frequency spectrums high energy regions and low energy regions, and means for combining the two bands to produce a resultant video signal current in which the low frequency spurious signals are substantially absent, the effective upper boundary of the low frequency band and the effective lower boundary of the high frequency band each being within the same low energy region of the combined spectrum.

14. In combination, means including a first electron camera tube for producing a video signal and, mixed therewith, some low frequency spurious variations, means including a second camera tube for producing a video signal corresponding to the same object or field of view which controls the formation at the same scanning frequency as the video signal of the first tube but which signal has a relatively small band width compared with the video signal produced by the first tube and is relatively free of said low frequency spurious variations, means for diverting some of the output energy of said first tube, means for filtering out the frequencies in the diverted energy which are higher than the upper boundary frequency of the signal produced by the means including the second camera tube, means for combining the energy passed by said filtering means with the video signal produced by the means including the second camera tube in such phase that only the spurious variations remain, and means for combining the spurious variations with the undiverted portion of the output energy of said first tube in such phase and amplitude that the spurious variations therein are balanced out.

15. The combination of elements as in claim 14 in which said last-mentioned means includes a negative feedback circuit.

16. The combination of elements as in claim 11 in which said means for producing a band of high frequency video signals comprises an electron camera tube of the charge storage type, and a filter which passes only those frequencies in the output current of said storage type tube which are above the highest frequencies of appreciable amplitudes produced by said auxiliary camera tube.

17. In combination, a scanning device for setting up signal variations representative of a subject scanned by it, which device introduces spurious low frequency variations into the signal current produced by it, a second scanning device of a type which does not produce said spurious low frequency variations and which produces a signal frequency spectrum limited in range to the lower portion of that which said first scanning device produces when the two scan the same subject in the same direction and at the same rate, means for causing both said devices simultaneously to scan the same subject in the same manner and at the same rate, and means for combining the signals from said devices to produce a resultant signal in which the low frequency suprious signals are substantially absent.

18. The combination of claim 17 in which said first scanning device is an electron beam tube having a target comprising elemental electron storage elements and said second scanning device is an electron tube in which an electron image of the subject scanned is moved progressively over a stationary aperture which is long enough in the direction in which it scans said image to make the effective upper limit of the resulting signal frequency spectrum much lower than that of the spectrum produced by said first scanning device.

19. In combination, a scanning device for setting up signal variations representative of a subject scanned by it which device introduces spurious low frequency variations into the signal current produced by it, a second scanning device of a type which does not produce said spurious low frequency variations and which produces a signal frequency spectrum limited in range to the lower portion of that which said first scanning device produces when the two similarly scan the same subject, means for causing both said devicles simultaneously to scan the same subject in the same direction and at the same rate, means for selecting those frequencies in the signal current produced by said first scanning device which are higher than the effective upper boundary of the frequency spectrum produced by said second scanning device, said selection eliminating the spurious low frequency variations, and means for combining the selected frequencies from said first device and the signal from said second scanning device to produce a resultant signal in which the low frequency spurious signals are substantially absent.

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