

W. D. HOUGHTON
COLOR BALANCING APPARATUS

2. Sheets-Sheet 1

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Fig_1

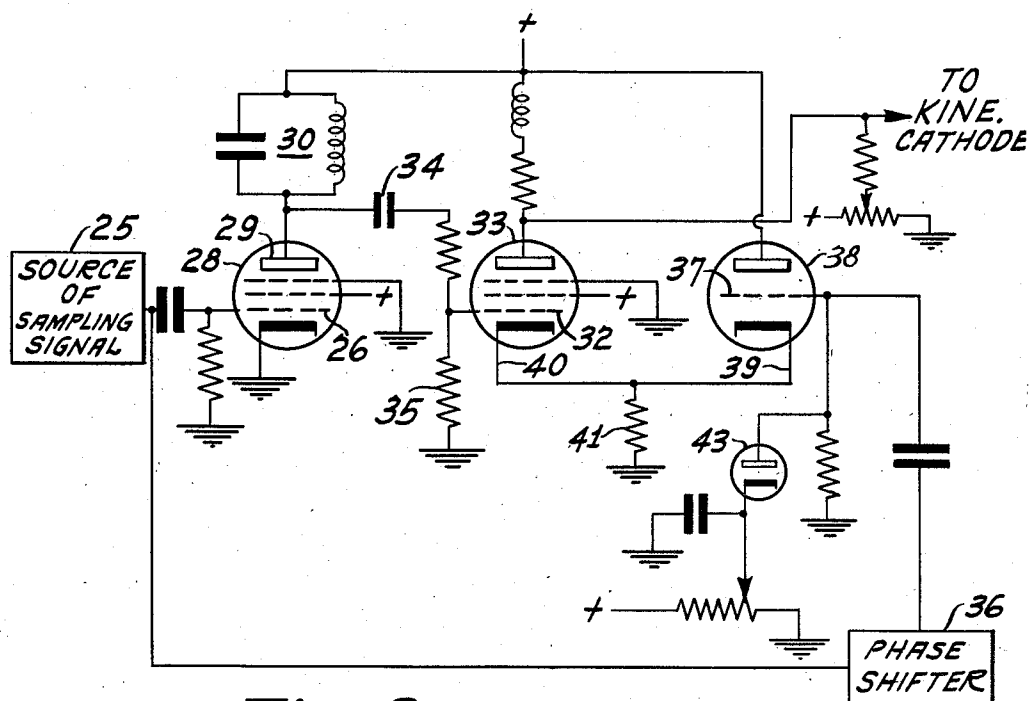
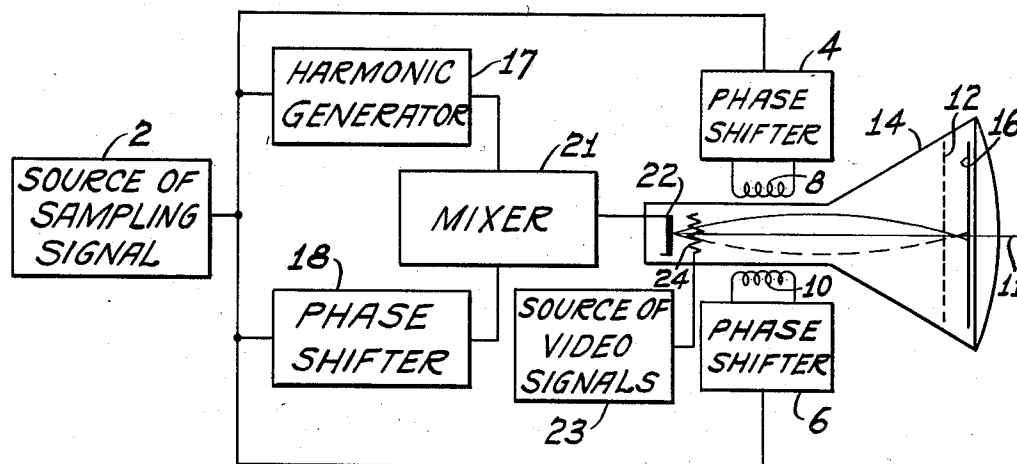


Fig-2

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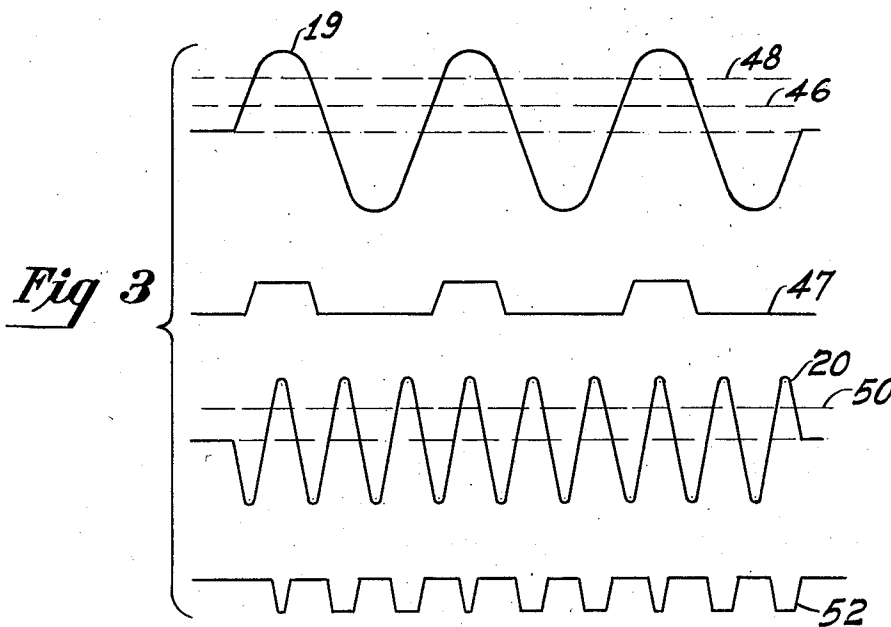
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2 Sheets-Sheet 2



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COLOR BALANCING APPARATUS

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4 Claims. (Cl. 178—5.4)

This invention relates to apparatus for keying a single beam cathode ray tube of the type adapted to reproduce colored images from a series of video signals that represent by time multiplex the intensities of the different component colors employed. In particular, it relates to a keying apparatus wherein the time duration of the various keying pulses is varied so as to produce color balance.

In dot sequential color television systems, the transmitted signal successively represents the intensity of the different component colors employed in the system. The sequence is repeated as the horizontal scanning proceeds. Single beam cathode ray tubes have been devised to reproduce colored images from this type of signal. In one such tube the beam of electrons is bent away from the principal axis of the tube and then back toward the principal axis of the tube. The plane in which the bending takes place is rotated about the principal axis. The apex of the cone of generation thus produced lies in one of a plurality of apertures in a mask. Beyond each aperture are mounted plurality of spots of phosphor, each spot being capable of reproducing a different component color when struck by a beam of electrons. These spots are so oriented with respect to the apertures in the mask that the particular spot struck by the beam depends upon the direction of approach of a beam to the aperture. Unless the space between the spots is greater than the beam diameter, it is apparent that the beam can strike more than one spot at a time. This produces color dilution in the reproduced image for the reason that the intensity modulation of the beam at any one particular time corresponds to only one color. For this reason, means must be provided to key the beams during the time that they are impinging on any one particular spot. This prevents the beams from striking two different spots and producing two different colors at any given time.

Generally speaking, the key operation has been such that the beam strikes each of the spots mentioned above for uniform intervals of time. However, due to differences in the light producing powers of the spots, it often occurs that one component color will be accentuated with respect to the others even when all spots are subjected to substantially the same amount of electron bombardment. In an effort to overcome this problem, it has been previously suggested that the intensity of the phosphor be varied from spot to spot, so that the beam producing the smaller amount of light will be struck by more electrons during a uniform interval. However, unless some dynamic correction circuits are provided, this system produces color balance for only a single light level.

It is therefore an object of this invention to provide improved means for achieving color balance in a single gun cathode ray tube by changing the duration of the keying pulses and thereby achieving color balance for all signal levels and all light levels.

Briefly, the above objective of achieving color balance may be obtained by keying the beam of the cathode ray tube with a sequence of keying pulses which key on the scanning electron beam for varying duration intervals so

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that it impinges on each color phosphor spot or segment for the proper length of time to provide the variation in electron bombardment from spot to spot to an extent which yields the required color balance. The sequences of keying pulses may be produced by providing both a source of the fundamental sampling frequency and a source yielding a harmonic of the sampling frequency, shifting the phase of the fundamental sampling frequency with respect to this harmonic, combining the fundamental and the harmonic in such a way as to produce a sequence of signals whose duration periods vary depending upon the phases of the fundamental sampling frequency and the harmonic. This sequence of signals may be used directly as keying pulses for keying the beam of the cathode ray tube or may be subjected to an amplitude clipping process to more closely form pulse waveforms of varying periods. Means are also provided for applying these pulses so as to vary the duration time during which the beam impinges on each color phosphor spot in accordance with the requirements of color balance.

The details of an apparatus for achieving the new results outlined above will be better understood from a detailed consideration of the drawings in which:

Figure 1 illustrates the general arrangement of this novel combination in block diagram form.

Figure 2 illustrates some of the details that may be incorporated into a block diagram of Figure 1, and

Figure 3 is comprised of waveforms useful in the operation of the invention as illustrated in Figures 1 and 2.

Each of the spots opposite a single aperture of the cathode ray tube mask described above is struck by the beam and each of the component colors is reproduced during every complete cycle of rotation of the beam about its principal axis. This cyclic repetition frequency is generally called the sampling frequency. A sine wave of this frequency is supplied by a source 2 to phase shifters 4 and 6, each having their outputs coupled to physically displaced deflection coils 8 and 10 respectively. In this way a rotating magnitude field is established in accordance with principles well known to those skilled in the art. Thus for every cycle of the sampling signal provided by the source 2, the electron beam passing through this rotating coil is rotated about its principal axis 11. The apex of the cone thus generated lies in one of the apertures 12 of the mask 14 and strikes one or the other of the spots of phosphor mounted on target 16. The beam is scanned back and forth, so as to trace out a raster across the mask 14 and the target 16 by any conventional means.

The sampling frequency provided by the source 2 is also applied to a harmonic generator 17 and a phase shifter 18. If three component colors are being employed, the 3rd harmonic output of the harmonic generator is used. The fundamental sampling frequency supplied by source 2 is indicated by the waveform 19 in Figure 3, and the 3rd harmonic is illustrated by the waveform 20 of Figure 3. It will be apparent then that a peak of the fundamental sampling frequency can be made to coincide with any peak of the harmonic frequency by a suitable adjustment of the phase shifter 18. Generally, the peak of the 3rd harmonic 20 should occur when the electron beam impinges upon the center of one of the spots on the target 16.

The outputs of the harmonic generator 17 and the phase shifter 18 are combined in a mixer 21, so as to control the time duration of the 3rd harmonic keying energy that is applied to a cathode 22 of the cathode ray tube. The video signals supplied by a source 23 are applied to a control grid 24 so as to modulate the intensity of beam.

Turning now to Figure 2, there is illustrated in schematic form a circuit arrangement for carrying out the general operations noted above in connection with Figure 1. A fundamental sampling signal such as illustrated by the curve 19 of Figure 3 is supplied by a source 25

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to a control grid 26 of an harmonic generator amplifying tube 28. A plate 29 of the tube 28 is connected to a source of B+ potential via a tuned circuit 30 that is resonant to the 3rd harmonic of the sampling signal if a three color system is being used. The 3rd harmonic of the sampling signal that is present at the plate 29 of the tube 28 is coupled to the control grid 32 of an amplifier tube 33 via a condenser 34 and a grid resistor 35. A grid current limiting resistor is connected between the grid 32 and the junction of the coupling condenser 34 and the grid leak resistor 35. The time constant of the condenser 34 and the grid leak resistor 35 is such as to bias the amplifier into a non-conducting condition in between positive pulses of the 3rd harmonic. The amplified negative pulses of the 3rd harmonic appear at the plate of the tube 33 and are coupled to the kinescope cathode as shown.

The fundamental sampling signal supplied by the source 25 is also coupled directly to any well known type of phase shifter indicated by the numeral 36. The output of the phase shifter 36 is coupled to the control grid 37 of another amplifier 38. The cathode 39 of the tube 38 is coupled to the cathode 40 of the tube 33. These cathodes are connected to the ground via a common cathode load resistor 41.

A diode 43 is connected between the grid 37 of the tube 38 and a suitable value of positive potential so as to limit the amplitude and duration of the biasing wave coupled to the amplifier 38 from the phase shifter 36.

The overall operation of the apparatus shown in Figure 2 is as follows:

The quiescent current drawn by the tube 33 through the common cathode resistor 41 is sufficiently large to bias the tube 38 to cut off. However, when the sampling signal illustrated by the curve 19 of Figure 3 reaches a level indicated by the numeral 46, the voltage applied to the grid 37 of the tube 38 is sufficiently great to overcome this cut-off bias.

The voltage waveform thus applied to cathode 40 of the tube 33 due to the cathode coupling is illustrated by the waveform 47 of Figure 3. A diode 43 is preferably employed to limit the voltage applied to the grid 37 of the tube 38 so as to make the top of the pulses in the waveform 47 flat as shown. In the waveform 19, this limiting level is indicated by the numeral 48.

The appearance of the positive pulses 47 at the cathode 40 of the tube 33 coincides with the arrival of one or another of the positive swings of the 3rd harmonic voltage represented by the curve 20 at the grid 22. The particular positive swing of the harmonic occurring at this time is selected by the adjustment of the phase shifter 36. The application of these pulses 47 to the cathode 40 of the tube 33 establishes the cut-off bias of the tube 33 at a level 50 as shown in the waveform 20. Therefore, whenever the 3rd harmonic voltage exceeds the level 50, the tube 33 conducts. The time duration of this conducting period is reduced as the level 50 is increased as is illustrated by the waveform 52. Therefore, the negative pulses applied to the cathode of the kinescope are varied in duration. By shifting the phase of the fundamental sampling frequency any one of the pulses 52 can be made narrower than the others. Also as explained above, reducing the time duration of the pulses reduces the light emitted by the spot struck during this time. The pulses 52 are all of the same amplitude due to the limiting action of the resistor connected between the grid 32 of the tube 33 and the condenser 34.

Having thus described my invention, what is claimed is:

1. Apparatus for reproducing images in color, comprising in combination; an image reproducing kinescope including an electron gun having a cathode, a control grid, and screen having a plurality of phosphors mounted thereon, each of said plurality of phosphors being adapted to luminesce in a desired color when energized by a beam of electrons; means varying the potential between

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said control grid and cathode in accordance with a video signal; and apparatus comprising a source of sampling waves of a predetermined frequency, a harmonic generator coupled to said sampling wave source for providing a harmonic wave having a frequency which is a multiple of said sampling wave frequency, a phase shifter coupled to said sampling wave source for shifting the phase of said sampling wave relative to said harmonic wave, an amplifier coupled between said harmonic wave source and the cathode of said color reproducing kinescope, and biasing means coupled between said phase shifter and said amplifier whereby the bias on said amplifier is varied in accordance with said phase shifted sampling wave.

2. Apparatus for reproducing images in color, comprising in combination, a single gun color image reproducing kinescope including an electron gun for providing an electron beam and screen having a plurality of phosphors mounted thereon, each of said plurality of phosphors being adapted to luminesce in a desired color when energized by a beam of electrons, means modulating said electron beam in accordance with a video signal, and color balancing apparatus comprising a source of sampling waves of a predetermined frequency, a harmonic generator coupled to said sampling wave source for providing a harmonic wave having a frequency which is a multiple of said sampling wave frequency, a phase shifter coupled to said sampling wave source for shifting the phase of said sampling wave relative to said harmonic wave, an amplifier coupled to said harmonic wave source, biasing means coupled between said phase shifter and said amplifier whereby the conduction of said amplifier is varied in accordance with said phase shifted sampling wave, and keying means coupled between said amplifier and said electron gun whereby said electron beam is keyed in accordance with the conduction of said amplifier.

3. Apparatus for reproducing images in color, comprising in combination; a single gun color image reproducing kinescope including a cathode, a control grid, and screen having a plurality of phosphors mounted thereon, each of said plurality of phosphors being adapted to luminesce in a desired color when energized by a beam of electrons; means varying the potential between said control grid and cathode in accordance with a video signal; and color balancing apparatus comprising a source of sampling waves of a predetermined frequency, means generating a harmonic wave having a frequency equal to three times said predetermined frequency, a phase shifter coupled to said sampling wave source for shifting the phase of said sampling wave relative to said harmonic wave, an amplifier coupled between said harmonic wave source and the cathode of said color reproducing kinescope, and biasing means coupled between said phase shifter and said amplifier whereby the bias on said amplifier is varied in accordance with said phase shifted sampling wave.

4. Apparatus for reproducing images in color, comprising in combination; a single gun color image reproducing kinescope including a cathode, a control grid, and screen having a plurality of phosphors mounted thereon, each of said plurality of phosphors being adapted to luminesce in a desired color when energized by a beam of electrons; means varying the potential between said control grid and cathode in accordance with a video signal; and color balancing apparatus comprising a source of sampling waves of a predetermined frequency, a harmonic generator coupled to said sampling wave source for providing a harmonic wave having a frequency which is a multiple of said sampling wave frequency, a phase shifter coupled to said sampling wave source for shifting the phase of said sampling wave relative to said harmonic wave, an amplifier having at least a cathode, a control electrode, and an anode, means coupling said amplifier control electrode to said harmonic wave source,

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means coupling said amplifying electron tube anode to said kinescope cathode, a cathode resistance connected between said amplifier electron tube cathode and a fixed reference potential, and biasing means coupled between said cathode resistance and said phase shifter whereby the bias voltage on said amplifier electron tube is varied in accordance with said phase shifted sampling wave.

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