

[54] **COMPARITIVE DISPLAY OF IMAGES
IN COLOR**

[72] Inventors: **George F. Newell**, Pittsburgh; **Paul G. Kennedy**, Monroeville, both of Pa.

[73] Assignee: **Westinghouse Electric Corporation**, Pittsburgh, Pa.

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[58] Field of Search **178/5.2, 5.4, 6.6 A, 6.8, DIG. 33**

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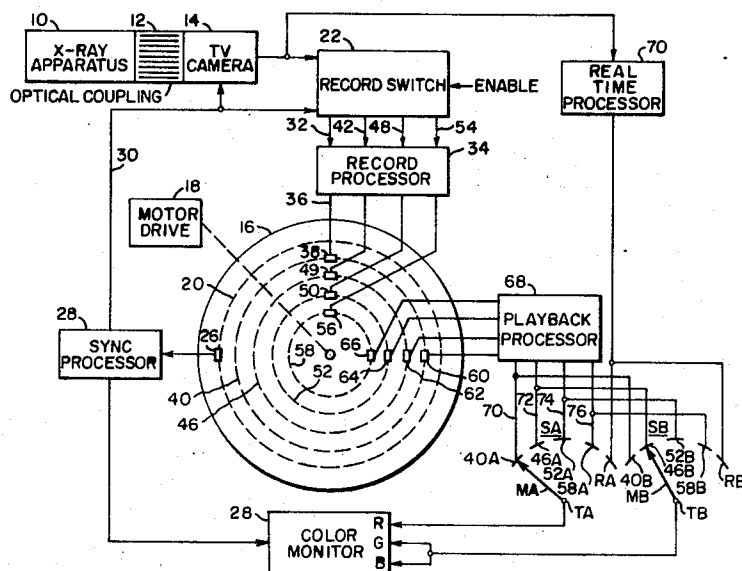
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Primary Examiner—Richard Murray
Attorney—F. H. Henson, C. F. Renz and A. S. Oddi

[57] **ABSTRACT**

A system for the comparative display of video information wherein first video signals, e.g. corresponding to a first X-ray image, are compared with second video signals, e.g. corresponding to a second X-ray image, are applied to a display, such as a color television monitor, in such fashion that the difference between the first and second images is displayed in color while the common portion thereof are displayed in gray tones.

8 Claims, 2 Drawing Figures



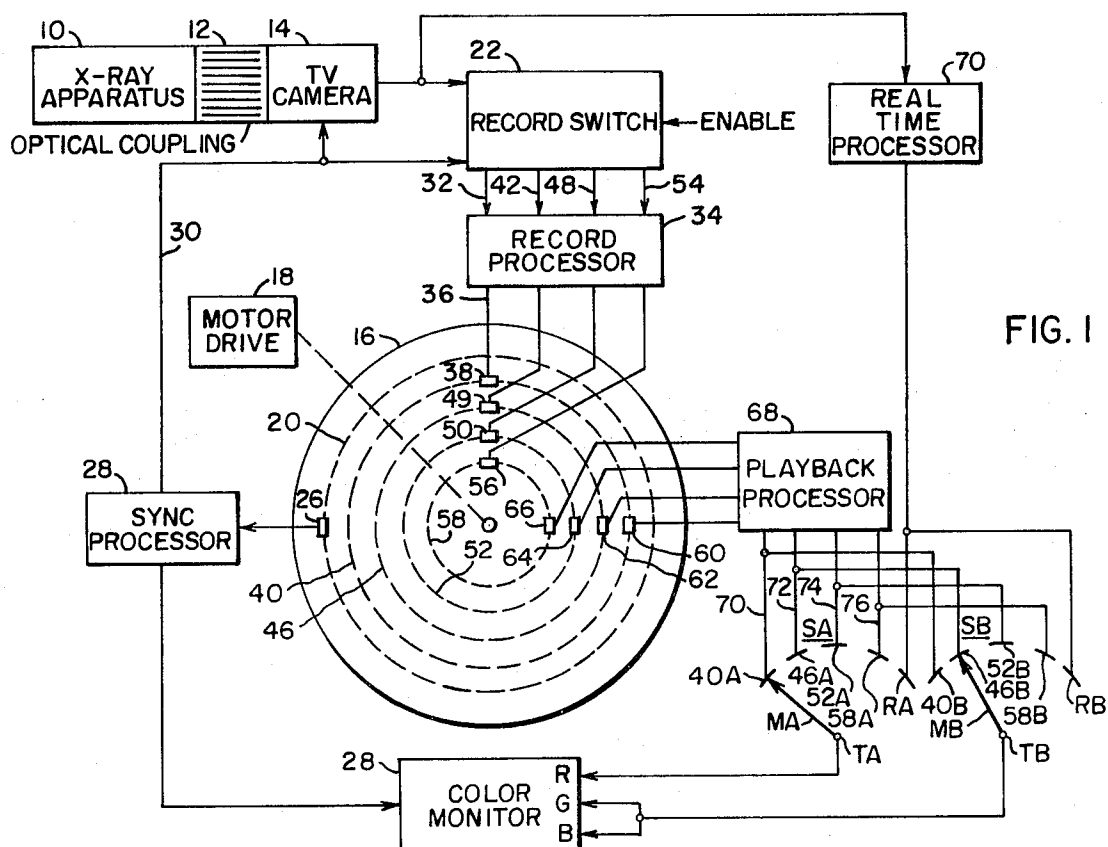


FIG. 1

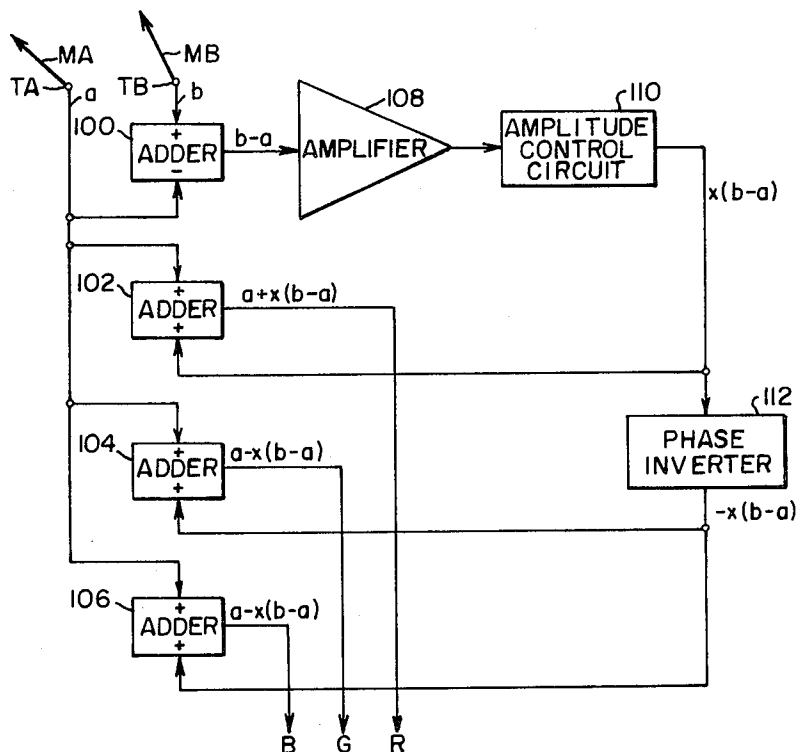


FIG. 2

INVENTORS
George F. Newell &
Paul G. Kennedy.

BY *ymul*
ATTORNEY

The comparative display of the video information corresponding to the recorder video images is accomplished as follows. Playback heads 60, 62, 64 and 66, respectively, associated with recording tracks 40, 46, 52 and 58 sense the processed video information recorded on the respective tracks and apply this information to a playback processor 68. The playback processor 68 converts the recorded information to its original video form prior to processing in record processor 34. For example, if the video information was recorded on the respective tracks by FM modulation techniques, the playback processor 68 would function as an FM demodulator for the conversion of the recorded information to its video form prior to recording.

The playback processor 68 provides four outputs 70, 72, 74 and 76 corresponding to the information recorded on the tracks 40, 46, 52 and 58, respectively. The outputs 70, 72, 74 and 76 are respectively applied to four fixed contacts of a pair of switches SA and SB. Thus the output 70 is applied to contacts 40A and 40B of the switches SA and SB respectively; the output 72 to the contacts 46A and 46B; the output 74 to the contacts 52A and 52B; and the output 76 to the contacts 58A and 58B. The switch SA is provided with a movable contact MA and the switch SB with a movable contact MB. Movable contacts MA and MB thus may sequentially engage the fixed contacts of the switches SA and SB, respectively. The movable arms MA and MB are operative independently of one another so that different video information from the respective tracks 40, 46, 52 and 58 may be independently outputted by the switches SA and SB from the respective output terminals TA and TB thereof. Hence, as shown in FIG. 1, when the arm MA is connected to the fixed contact 40A, the output appearing at the terminal TA will be that associated with the information previously recorded on the track 40. The arm MB of switch SB is shown in FIG. 1 connected to the fixed contacts 46B so that the output appearing at the terminal TB will be the information previously recorded on track 46.

The output from the terminal TA corresponding to the information previously recorded on track 40 is supplied to a red R input of the color monitor 24. The output appearing at the terminal TB of switch SB corresponding to the previously recorded video information on track 46 is supplied to both a green G and a B input of the color monitor 24. The red, green and blue inputs of the color monitor 24 would comprise the red, green and blue guns of a standard three-gun color picture tube. Suitable amplification of the video signals appearing at the terminals TA and TB may be performed within the color monitor prior to application to the respective color guns if required.

As previously explained the color monitor 24 is synchronized to the disc recorder 16 and the television camera 14 with synchronizing information being provided to the monitor 24 from the sync processor 28, which is responsive to synchronizing information prerecorded on the sync track 20 of the disc recorder 16.

The information thus driving the red input of the color monitor is the video information recorded on the track 40, which as discussed above, may correspond to a reference X-ray image taken prior to the injection of opaque fluid into the blood vessels of the patient. The information applied to both the green and blue inputs of the color monitor 24 corresponds to video information recorded on the track 46 which may correspond to an X-ray image taken at a time somewhat after the opaque fluid has been injected into the patient. Since the common portions of the video signals corresponding to the X-ray images are applied to all three of the inputs to the color monitor 24, the common portions of the images will be produced in monochrome, that is, as a normal black-grey-white background picture defining the common portions of the X-ray images. The difference between the images recorded on the tracks 40 and 46, however, will be reproduced in color. The color reproduced and the intensity of this color will depend upon the magnitude of the difference between the X-ray images as recorded on the respective tracks 40 and 46 and the direction of this difference.

For example, those portions of the image applied to the red input which are less dark (less saturated) than the same portions of the X-ray image applied to the blue-green input will be produced in a shade of red. If the difference between the same portions of the red and green-blue inputs is slight, the displayed picture from a color monitor 24 will be produced as a pink or pastel shade. If, on the other hand, the difference is large, the color reproduced for the common difference portion would be an intense red. If the difference between the two X-ray images is in the other direction, that is, those portions that are applied to the red input which are darker (more saturated) than the same portions applied to the blue-green input would be reproduced by the color monitor 24 as cyan color (blue + green). The intensity of the cyan color reproduced would be dependent upon the magnitude of the difference with the higher intensity cyan being indicative of a greater difference.

The display of the color monitor 24 would thus be one wherein the common portions of the original X-ray images as recorded on the tracks 40 and 46 would appear in gray tones while the differences therebetween would appear in color (either in a shade of red or a shade of cyan). The intensity of the color difference would depend upon the magnitude of the difference between the same portions of the two recorded X-ray images. By switching the movable contact MB of the switch SB to the fixed contact 52B the image recorded on the track 52 could be compared with the reference image on the track 40. The same type of output would be produced with the common portions being reproduced in gray tones and a difference being reproduced in color. By moving the movable contact MB of the switch SB to the fixed contact 58B the comparison between the images recorded on the tracks 58 and 40 could be reproduced. By moving the movable contact MA to any of the other of the fixed contacts thereof a comparison of the various images recorded on the recording tracks of the disc recorder 16 could be accomplished as desired for the particular examination underway.

Also a comparison of any of the recorded tracks 40, 46, 52 and 58 can be made with the real time X-ray image presently being scanned by the TV camera 14. This is accomplished by applying the output of the TV camera 14 to a real time processor 70 which suitably processes the video output of the camera 14 and delays it to provide a proper comparison with the recorded video information. The output of the processor 70 is applied to a fixed contact RA of the switch SA and a fixed contact RB of the switch SB. Hence by connecting movable arm MA to the contact RA the real time X-ray image would be displayed as a red picture on the monitor 24. Correspondingly if the movable arm MB is connected to the fixed contact RB the real time video signals will be applied to the green-blue input of the monitor 24. By the comparison of the real time image with the recorded image, progressive changes in the color output of the monitor 24 would be indicative of changes occurring in real time as the X-ray image is being scanned. As discussed above the common portions between the real time and recorded images would be reproduced in gray tones.

In the system shown in FIG. 1 the saturation or vividness of the color reproduced for the differences between the images is controlled only by the difference in brightness between the red and blue-green inputs being added. FIG. 2 shows an arrangement which may be added to FIG. 1 which provides all the advantages of the system of FIG. 1 but additionally provides for the separate adjustment of the degree of saturation or vividness of the difference color reproduced as desired by the user.

The arrangement shown in FIG. 2 is connected between the terminals TA and TB of the switches SA and SB, respectively, and the R, G and B inputs of the color monitor 24. The terminal TA supplying output a is connected to the differencing input of an adder 100 and to one summing input of each of three adders 102, 104 and 106. The b output from the terminal TB is applied to the summing output of the adder 100 so that the output thereof is $b-a$. This difference output is ap-

COMPARITIVE DISPLAY OF IMAGES IN COLOR

BACKGROUND OF THE INVENTION

The present invention relates to systems for displaying video information and, more particularly, to such systems for the comparative display of video information.

2. Description of the Prior Art

In X-ray analysis it is often necessary to compare an original X-ray image with a subsequently taken X-ray image, for example, taken after a dye has been inserted into the particular area of the patient under surveillance. Photographic subtraction techniques have been employed to accentuate the difference between the X-ray picture by superimposing a positive and diapositive photograph so that the common portions thereof are cancelled while differences therebetween are fully reproduced. The image differencing may be performed electronically without the registration problems of the photographic technique wherein the X-ray images to be compared are converted into video signals and are electrically subtracted from one another to produce difference video signals which are displayed on a television monitor. Complete cancellation of the common portions of the image is, however, frequently undesirable since the position of the difference portion with respect to the common portions of the image is often required to be visible for examination. It has been proposed to provide one image in one color and the other image in another color and to add the images so that the difference therebetween will appear in two colors while the common portions thereof will be visible as another color. For example, if one X-ray picture is reproduced in red and the other one in green and the images are superimposed upon one another, the differences therebetween will be shown in red and green; however, the common portions thereof will be shown in yellow since the addition of red and green produces yellow. Accordingly the spatial relationship of the common portions with the different portions would be readily ascertainable. It would be highly desirable if electronic processing techniques could be employed rather than photographic superposition requiring color photographs in at least two colors and having the attendant registration problems. Moreover, it would be highly advantageous if readily available television monitoring equipment such as a color television receiver could be employed for the display of the electronically processed images.

SUMMARY OF THE INVENTION

Broadly, the present invention provides a system for the comparative display of video information wherein the difference between first and second images are displayed in color and the common portions thereof are displayed in gray tones.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a block-schematic diagram system of the present invention; and

FIG. 2 is a block diagram showing a modification for inclusion in the system of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, X-ray apparatus 10 supplies an X-ray image in response to irradiation of a particular area of a patient under surveillance. This X-ray image is supplied via an optical coupling 12 to the target of a television camera 14 which may comprise a standard monochrome television camera which scans the X-ray image at standard line and field repetition rates. The output of the television camera 14 thus comprises video signals corresponding to the scanned X-ray image. A magnetic disc recorder 16 is provided which is driven at a predetermined speed by a motor drive 18. The speed of rotation as determined by the motor drive 18 is selected so that one complete rotation of the disc recorder 16 corresponds to a predetermined number of vertical fields of scan of the camera 14. For example, if one frame (two fields) of video information are desired to be recorded on a single cir-

cumferential track of the disc recorder 16, the time period required for one complete rotation of disc recorder 16 would be selected to be one thirtieth of a second, that is, the time required for two fields at the standard vertical rate of 60 Hz.

The disc recorder 16 includes a sync track 20 whereon synchronizing signals are prerecorded. The function of the prerecorded synchronizing signals is to provide a clock reference for the TV camera 14, the record switch 22 and a color monitor 24. The synchronizing signals on the sync track 20 are sensed by a playback head 26 and applied to a sync processor 28 wherein horizontal and vertical synchronizing information are generated at an output 30 in response to the prerecorded synchronizing signals. The vertical and horizontal synchronizing information is supplied to the TV camera 14 for controlling the horizontal and vertical scanning operation thereof.

When it is desired to record a particular frame of video information corresponding to a particular X-ray image under consideration, an enable output is provided to the record switch 22. The record switch 22 is thus enabled in response to the next vertical sync output 30 of the sync processor 28 to cause the record switch 22 to translate the video input from the TV camera 14 to a first output 32 thereof for application to a record processor 34. The record processor 34 is operative to process the input video signals thereto to a suitable form for recording, such as by well known FM modulation techniques or other suitable recording techniques. The processed video output appears at an output 36 of the record processor 34 and is applied via a record head 38 for recording on a track 40 of the disc recorder 16. Once two complete fields, for example, of the video information from the TV camera 14 have been recorded on the track 40, the record switch 22 will revert to its blocking state so that the output 32 thereof is terminated.

When it is desired to record another frame of video information, the record switch 22 will then be activated by the application of an enable input thereto so that commencing with the first complete field after the enable input the video output of the TV camera 14 will appear at a second output 42 of the record switch 22. The output 42 will be processed in the record processor 34 and recorded via a record head 44 on a track 46 of the disc recorder 16. One complete frame of video information will therefore be recorded on the track 46.

In response to the next enable input thereto the record switch 22 will provide a video output at its third output 48 for processing in the record processor 34 and recording via a record head 50 on a track 52 of the recorder disc 16. The recording process continues as described above with a video output appearing at a fourth output 54 of record switch 22 after an enable input to the record switch 22 is provided. This output is recorded via a record head 56 on a track 58 of the record disc 16. Thus a complete frame of video information is recorded respectively on the tracks 40, 46, 52 and 58. For the purpose of simplicity of explanation only four recording tracks and the sync track 20 are illustrated in FIG. 1. However it should be understood that a greater or lesser number of recording tracks could be employed as desired for the particular implementation.

For medical diagnosis, such as involving angiography, an opaque fluid is introduced into the blood vessels of the patient under examination and X-ray pictures taken as the fluid progresses through the vessels. The present system may be effectively used in such examination. Just prior to the injection of the opaque fluid into the patient an X-ray image would be recorded as described above on the first recording track 40 of the disc recorder 16. At various time increments after the introduction of the fluid into the patient the record switch 22 would be enabled so that the X-ray image at that instant in time would be recorded on subsequent recording tracks of the disc recorder 16. Hence a complete record of the fluid progression through the blood vessels of the patient would be recorded and stored on the respective tracks of the disc recorder 16. These various tracks would be available for later analysis and comparison without the need for continuous radiation of the patient by the X-ray apparatus 10.

plied to an amplifier 108 for amplification therein and is applied to an amplitude control circuit 110, which for example may comprise a potentiometer. The output of the amplitude control circuit 110 may be varied so it provides an output $x(b-aa)$ where x is a multiplication factor as determined by the amplifier 108 and the setting of the amplitude control circuit 110. The output of the amplitude control circuit 110 is applied to the other summing input of the adder 102 to provide the output $a + x(b-a)$ which is supplied directly to the red input R of the color monitor 24. The output $x(b-a)$ of the amplitude control circuit 110 is also applied to a phase inverter 112 wherein the polarity thereof is reversed to provide the output $-x(b-a)$. The output of the phase inverter 112 is applied respectively to the other summing inputs of the adders 104 and 106, which each supply outputs $a-x(b-a)$. The output of the adder 104 is supplied directly to the green input G of the color monitor 24 and the output of the adder 106 is directly applied to the blue input B of the color monitor 24.

It can thus be seen that the input a from the switch SA appears at each of the inputs R, G and B so that the picture produced by the monitor 24 in response thereto will be a monochrome gray tone picture. The difference signal $b-a$ produced by the adder 100 is controlled in amplitude by the amplitude control circuit 110 which may be varied to control the saturation or vividness of the difference signal. The difference signal modified by the factor x is introduced into the red, green and blue inputs via the adders 102, 104 and 106 so that the modified difference signal $x(b-a)$ will be displayed on the color monitor 24 according to the magnitude of the difference therebetween and the direction of this difference as discussed above with reference to FIG. 1. However, in addition, the saturation or vividness of color displayed may be controlled by the factor x as desired by the user by setting the amplitude control circuit 110.

What is claimed is:

1. In a system for the comparative display of video signals the combination of:

means for providing first video signals corresponding to a first video image and second video signals corresponding to a second video image;

color display means including first, second and third primary color means respectively responsive to video signals applied thereto for effecting the display of the corresponding primary color on said color display means; and

means for applying said first video signals to said first primary color means and said second video signals to said second and third primary color means so that the differences between said first and second images are displayed by said color display means in color and the common portions thereof are displayed in gray tones.

2. The combination of claim 1 wherein:

said means for providing includes recording means for recording said first video signals on a first track thereof.

3. The combination of claim 2 wherein:

said recording means includes a second track for recording said second video signals.

4. The combination of claim 1 wherein:

said means for providing include television camera means for scanning said first and second images to provide said first and second video signals, and

recording means for recording said first and second video signals on first and second tracks respectively thereof,

said recording means includes a synchronizing track having synchronizing signals prerecorded thereon for synchronizing said television camera means, said recording means and said display means.

5. The combination of claim 4 wherein said means for producing includes

first switch means for selectively enabling the recording of selected fields of video signals on respective tracks of said recording means in response to said synchronizing signals, and

second switch means for selectively effecting the comparison of video signals from selected tracks of said recording means.

6. The combination of claim 1 wherein:

said means for applying includes

means responsive to said first and second video signals for applying said first video signal plus a portion of the difference between said first and second video signals to said first primary color means and said first video signals less a portion of the difference between said first and second video signals to said second and third primary color means respectively.

7. The combination of claim 6 wherein:

said means responsive to said first and second video signals includes means for controlling the amplitude of the difference between said first and second video signals so that the portion of the difference is controlled in such a manner that the color saturation of the displayed difference can be controlled.

8. The combination of claim 6 wherein:

said means responsive to said first and second video signals includes first summing means for providing difference signals in response to the difference between said first and second video signals,

means for controlling the amplitude of said difference signals,

second summing means for adding said first video signals with said amplitude controlled difference signals to supply said first primary color means,

third summing means for differencing said first video signals and said amplitude controlled difference signals to supply said second primary color means, and

fourth summing means for differencing said first video signals and said amplitude controlled difference signals to supply said third primary color means.

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