May 28, 1974 P. BOXMAN ET AL Re. 28,021

CHROMA KEY CIRCUIT

Original Filed March 12, 1971 4 Sheets-Sheet 1

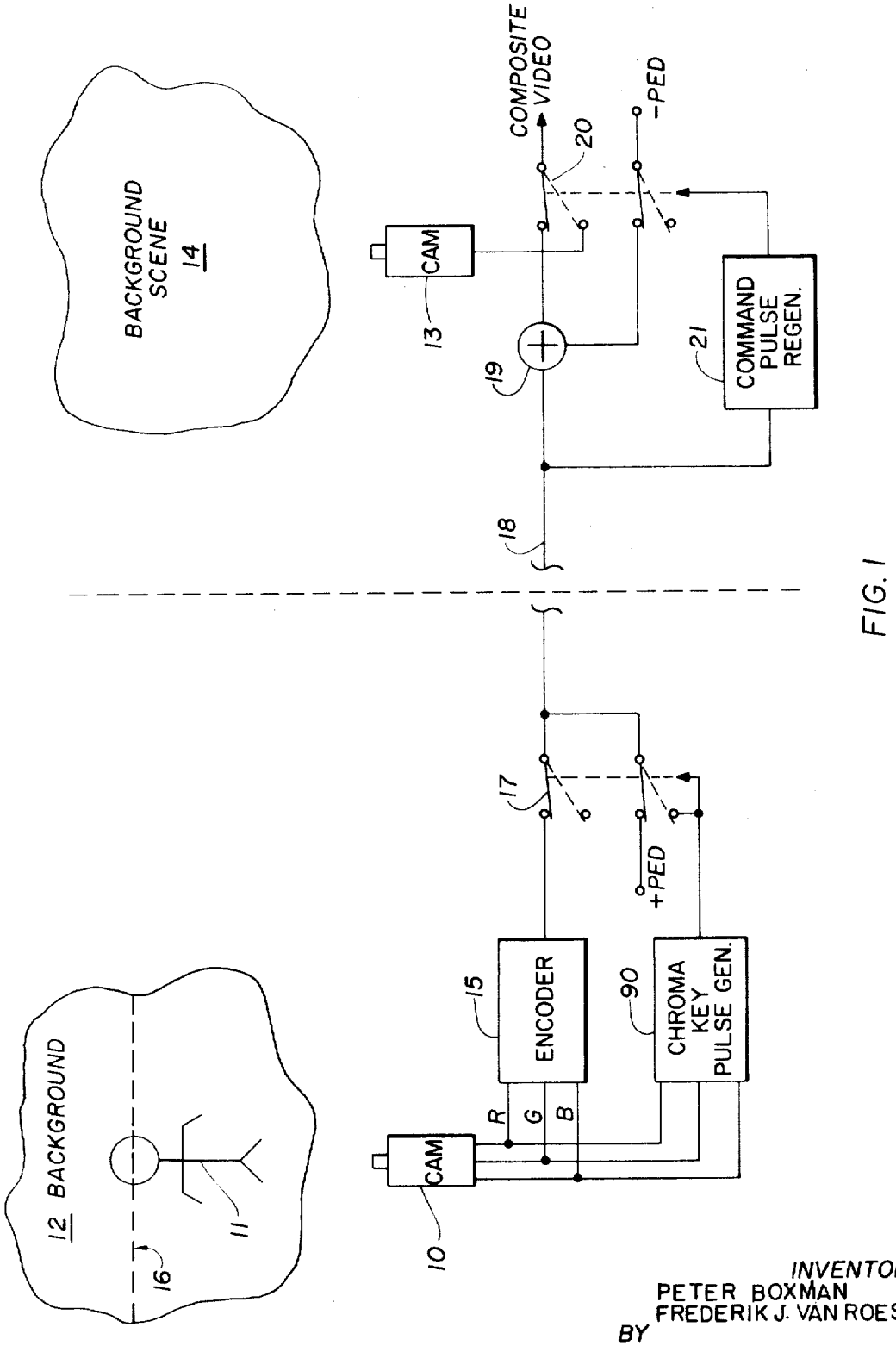


FIG. 1

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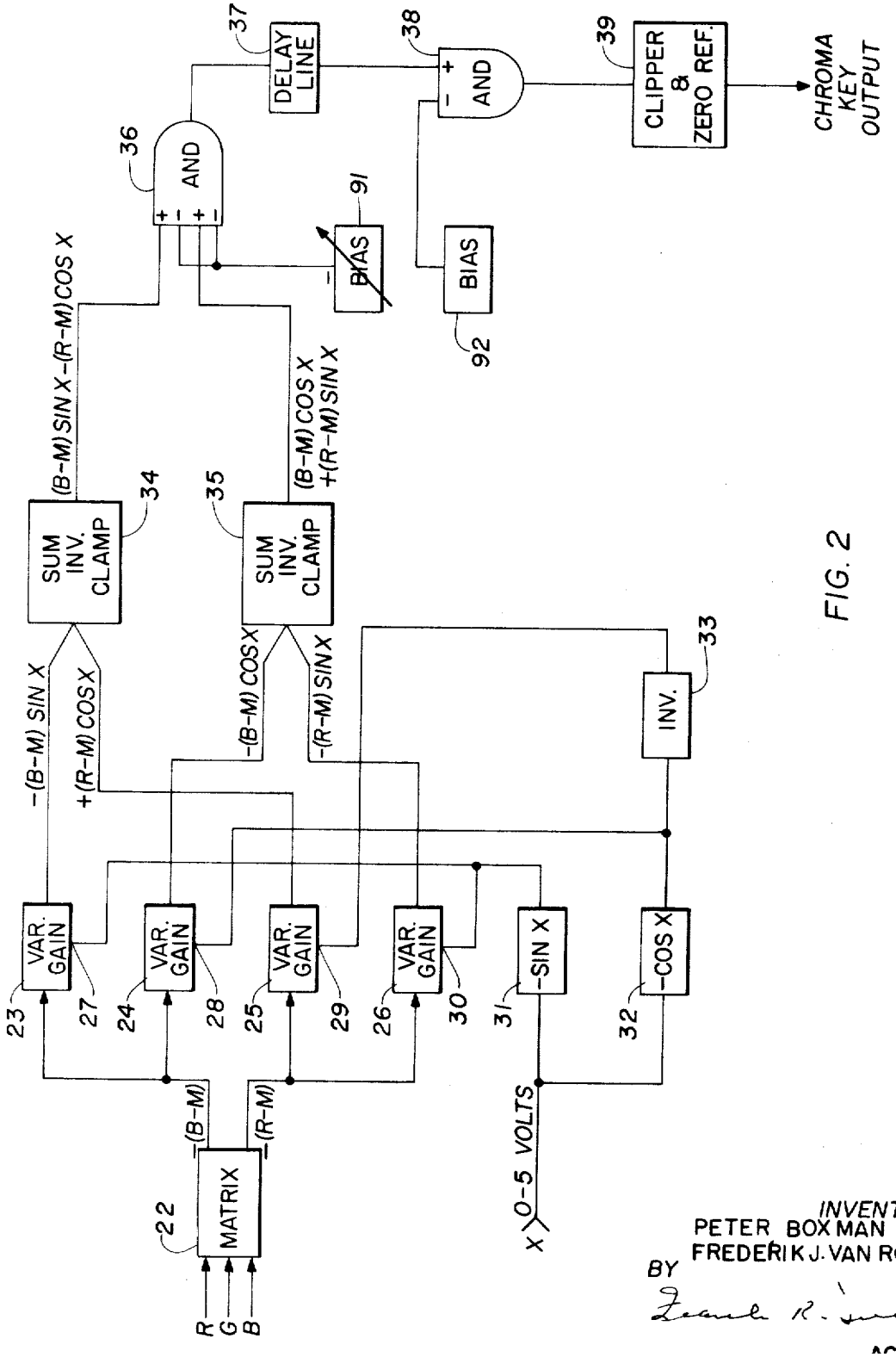


FIG. 2

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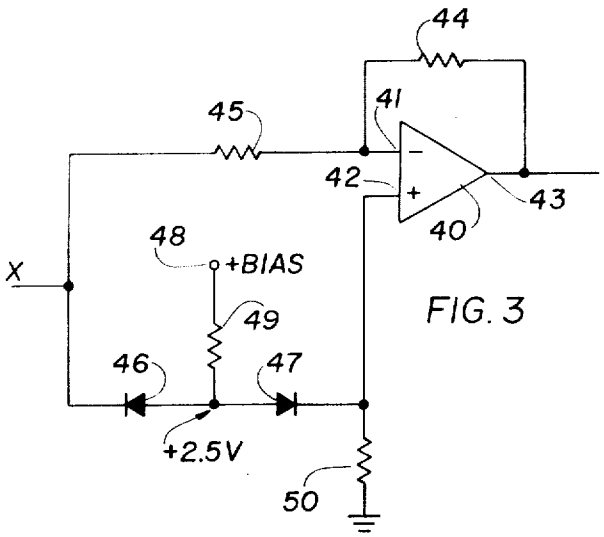


FIG. 3

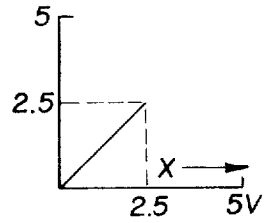


FIG. 3a

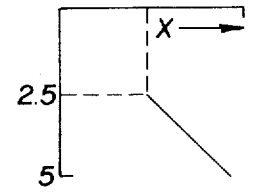


FIG. 3b

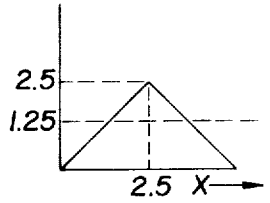


FIG. 3c

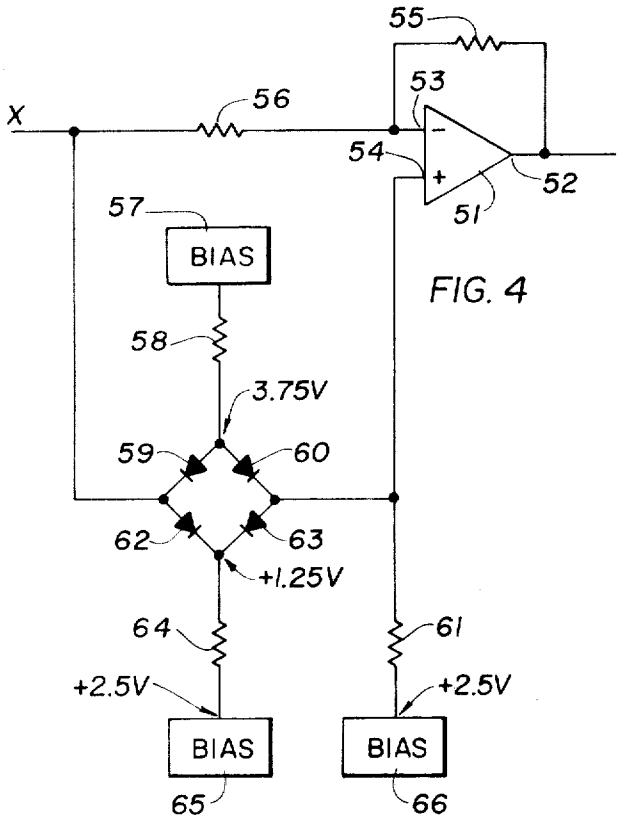


FIG. 4

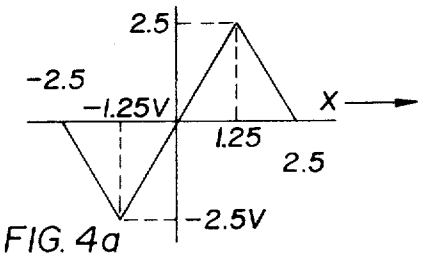


FIG. 4a

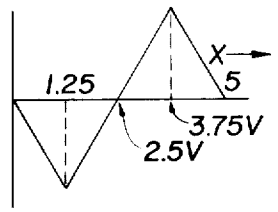


FIG. 4b

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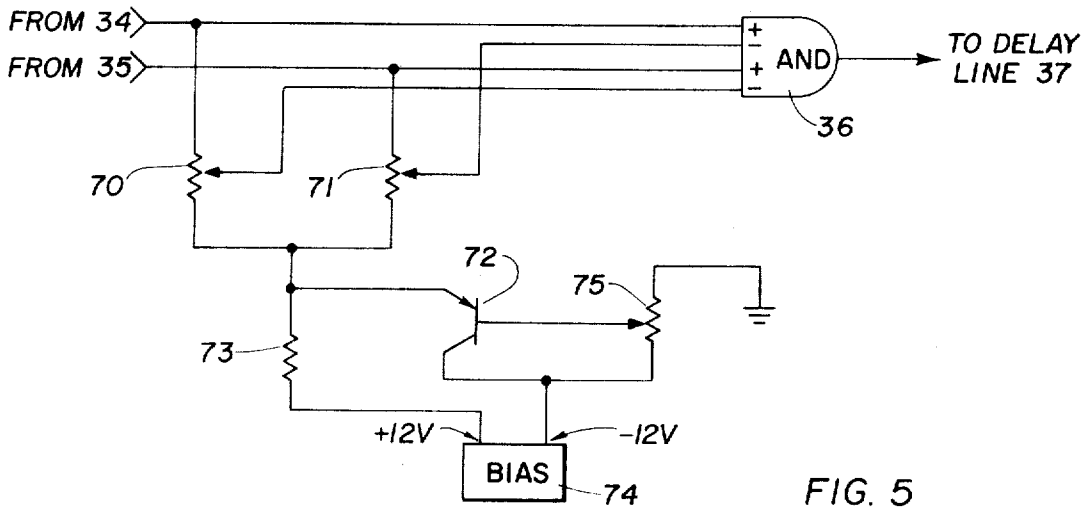


FIG. 5

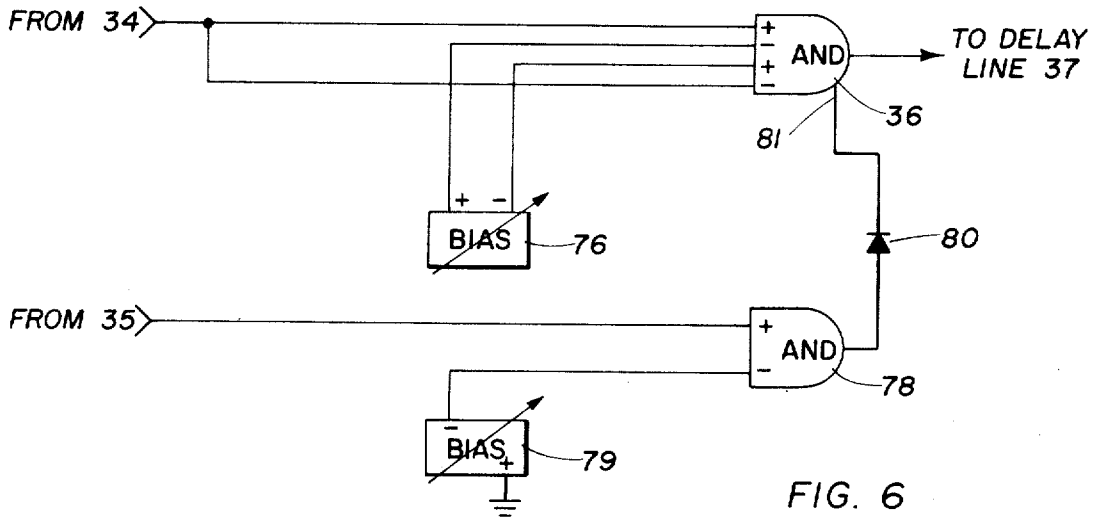


FIG. 6

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CHROMA KEY CIRCUIT

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Int. Cl. H04n *9/02*

U.S. Cl. 178—5.4 R **12 Claims**

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

ABSTRACT OF THE DISCLOSURE

A circuit for generating an output pulse upon the occurrence of a selected color in color television signals features a matrix to form two chrominance difference signals. Four variable gain amplifiers multiply the difference signals by the sine and cosine of a control voltage which is a course color control. Two circuits each comprising a summer, inverter, and clamp circuit each add the outputs of two of the multiplied signals. An AND gate combines the output of the summer circuits and also is coupled to a variable bias supply, which is a fine color control. A delay line, a second AND gate, and a clipper and zero reference then shape the output pulse.

BACKGROUND

This invention relates to a circuit for cutting off the video signal of one camera and substituting that of another camera during the occurrence of a selected color from said first camera.

Typical prior art devices utilize simple variable resistor matrices to select the trigger color. However, such systems have very poor color selectivity, and are cumbersome to operate by remote control because there are three controls.

It is therefore an object of the present invention to have chroma key circuit with a high degree of color selectivity.

It is another object to have such a circuit suitable for remote control.

It is still another object to have such a circuit controlled by a single knob control.

In brief, these and other objects are achieved by means of a plurality of variable gain amplifiers which multiply the color signals by the sine and cosine function of a single control voltage, which selects the trigger color. The multiplied signals are then combined in summers, and then are applied to an AND gate. A variable bias supply can be connected to the AND gate to act as a fine color control.

Other objects, and advantages will become apparent from the description when, taken in conjunction with the drawings in which:

FIG. 1 is a block diagram of the overall system;

FIG. 2 is a block diagram of the chroma key circuit;

FIG. 3 is a schematic diagram of a block in FIG. 2;

FIGS. 3 a, b, c are graphs of voltage transfer functions of FIG. 3;

FIG. 4 is a schematic diagram of another block in FIG. 2;

FIGS. 4 a and b are graphs of voltage transfer functions of FIG. 4; and

FIGS. 5 and 6 are alternate embodiments of a block in FIG. 2.

FIG. 1 shows the basic overall system of the invention. A first camera **10** is viewing a scene consisting of, for example, a person **11** against a background **12**, which for

example, may be blue in color. A second camera **13** is viewing a background scene **14**, such as a street scene, a landscape, or other forms of desired background. It is desired to add the figure **11** into the background scene **14** in the final video output signal. To accomplish this in accordance with the invention, the system comprises an encoder **15**, which takes the red, green, and the blue color components coming from the camera **10** and encodes them into a single composite signal. Assume that the camera **10** is scanning along a particular scanning line **16**, and at a particular instant the video signal coming from camera **10** corresponds to the head of figure **11**. Then the video signal from the encoder **15** will pass through the switch **17**, which is in the position shown by the solid line, and along a cable **18** to the adder **19**. The lower half of switch **17**, which is also in the position indicated by the solid lines, is coupled to a source of positive pedestal voltage, which is added to the output of the encoder **15** to prevent the output signal from going negative thereby to prevent distortion. At the location of camera **13**, switch **20** is in the position shown by solid lines, and therefore, a source of negative pedestal voltage is applied to the adder **19** so that it cancels the positive pedestal voltage applied at switch **17**. Therefore, the output of adder **19** is a video signal representing the figure **11**, and this signal is passed on to other circuits (not shown) within the television studio. Since, in the assumed example, the chroma key **90** generates a pulse upon the occurrence of a blue signal, when the camera **10** is scanning the blue background **12**, which is to the right of figure **11**, the chroma key **90** will generate a control pulse to move the switch **17** into the lower position as shown by the dotted lines. This chroma key pulse will then go through the lower portion of switch **17**, along the cable **18**, and into the command pulse regenerator **21**. Here the key pulse will be regenerated and will actuate the switch **20** to go into the lower dotted position. In this position the video signal from camera **13** will go through switch **20** and on to the other portions of the television studio. Therefore, it will be seen that the video signal from the figure **11** will be superimposed upon the background scene **14** in the output composite video signal. In general, it is desired to have the chroma key **90** adjustable, so that it will generate a keying pulse upon the occurrence of a selected color. This enables its use with any color for the background **12**.

FIG. 2 shows in more detail the adjustable chroma key pulse generator **90**. The input red, green, and blue color component signals from the camera **10** are applied to a matrix **22** which forms two output signals, —(B—M), and —(R—M). By "M" is meant a luminance signal, which can be composed of equal proportions of the R,G, and B signals, or other proportions which may give better results. As is well known in the art, the color difference signals contain the same information as the original color signals albeit in different form. The first of these signals, —(B—M), is applied to the inputs of two variable gain amplifiers **23** and **24**; and the second of these signals, —(R—M), is applied to the inputs of variable gain amplifiers **25** and **26**. Amplifiers **23**, **24**, **25** and **26** have amplification gain control terminals **27**, **28**, **29**, and **30** respectively. The gain of these amplifiers linearly varies from —2 to +2 over an input gain control voltage range of 0 to 2 volts. A manually adjustable input control voltage labelled "X" varies from 0 to 5 volts and is applied to DC control voltage generators **31** and **32**. Control voltage generator **31** generates a triangular approximation to the —sine of the input voltage, while control voltage **32** generates a triangular approximation to the —cosine of the input voltage X. The —sin X voltage from generator **31** is applied to terminals **30** and **27** of amplifiers **26** and **23** respectively. The variable gain amplifiers generate output

signals which are equal to the negative (due to the phase inversion within the amplifiers) of the product of the color and gain control signals. Therefore, amplifiers **23** and **26** generate the $-(B-M)$ sin X voltage and the $-(R-M)$ sin X voltage respectively. The $-\cos X$ voltage is applied to terminal **28** of amplifier **24**, which thereby generates the $-(B-M)$ cos X voltage. The $-\cos X$ voltage is also applied to inverter **33** whose output voltage, cos X, is in turn applied to variable gain amplifier **25**, which therefor generates the $(R-M)$ cos X voltage. In other words, the color difference signals coming out of the variable gain amplifiers have an amplitude which is controlled from the input voltage X in accordance with either the cosine or the sine of X, as determined by the circuits **31** and **32**. As is known in the art, by varying the amplitudes of sinusoidal and cosinusoidal color difference signals, any resultant color can be generated. Thus, by varying the voltage "X" the color which will cause the key **90** to generate a key pulse can be selected. The voltage X serves as a course color selection for the key **90**. The outputs of amplifiers **23** and **25** are applied to circuit **34** which is a summer, inverter, and a clamp, in the order recited. The output of circuit **34** is therefore a $[(B-M)\sin X]-[(R-M)\cos X]$ voltage. Likewise the output signals of amplifiers **24** and **26** are applied to a circuit **35** which also is a summer, inverter, and a clamp, and which therefore generates a $(B-M)$ cos $X+(R-M)$ sin X voltage. The output signals from circuits **34** and **35** are applied to the non-inverting signals of AND gate **36**. This AND gate **36** can be a Fairchild type 711, which generates a low output pulse when both non-inverting inputs are low, i.e., it is a negative logic AND gate. Applied to the inverting inputs of the AND gate **36**, is a variable negative bias supply **91** which will determine the trigger level of the AND gate **36**. This variable bias supply **91** serves as a fine color adjust for the chroma key circuit. The output signal from AND gate **36** is applied to a delay line **37**, which corrects for delay in the encoder **15**. The output signal of delay line **37** is applied to the non-inverting input of an AND gate **38** which can be a Fairchild type 710 and which has applied to its inverting input a bias voltage from supply **92**, which is set to about half of the peak value of the pulse, and thus reshapes the pulse coming from delay line **37**. The output signal from AND gate **38** is applied to the clipper and zero reference **39** which clips the output pulse to a half a volt maximum value and sets a zero reference to correct for tolerance of the components of the system. Thus in operation the voltage X would be varied to coursely select the background **12** color upon which a pulse will appear out of the clipper **39**, and the variable bias applied to AND gate **36** would select a fine adjustment of this color.

FIG. 3 shows the details of the cosine generator **32** of FIG. 2. An operational amplifier **40**, which can be a Fairchild type 741, has an inverting input **41**, a non-inverting input **42**, and an output terminal **32**. A feedback resistor **44** coupled between input **43** and the inverting input **41** equals the input resistor **45**, and therefore the gain of the input voltage X through the inverting input **41** to the output **43** is equal to -1. Oppositely poled series connected diodes **46** and **47** are coupled between the non-inverting input **42** and the source of input voltage X. A source of positive bias potential (not shown) is coupled to the terminal **48** and it together with the resistor **49** and **50** bias the junction of the diodes **46** and **47** to a potential of $+2.5$ volts. Therefore, if the input potential is below 2.5 volts it will flow through the diodes **46**, **47** and into the terminal **42**. The gain between the non-inverting input **42** and the output **43** is equal to 2, and therefore if the input voltage X is below 2.5 volts, the resulting output voltage at terminal **43** will be the sum of the gain through the inverting input terminal **41**, which has a gain of -1, and the non-inverting input **42**, which has a gain of $+2$. This results in overall system gain of $+1$. This is shown in FIG. 3a, which shows the output voltage graphed as a function of the input voltage X. When the input voltage X exceeds 2.5 volts the diode **46** becomes reversed biased, opening input terminal **42** from the input voltage, and the gain is therefore -1, as is shown in FIG. 3b which is drawn with the same horizontal axis as that of FIG. 3a. Therefore, the input-output transfer function of the entire cosine generator is shown in FIG. 3c, which shows a first portion increasing for the first 0 to 2.5 volts of the input signal and a second decreasing portion for the 2.5 to 5 volts range of the input signal. It will be appreciated that if a -1.25 volts negative bias is applied to the output voltage, the overall triangular waves form would be shifted downward by this amount. This results in an approximation to the $-\cos X$ voltage, which is required by the variable gain amplifier **24**.

FIG. 4 shows the details of the sine generator **31** of FIG. 2. It also comprises an operational amplifier **51** also a Fairchild type 741 having an output **52**, an inverting input **53**, and a non-inverting input **54**. The feedback resistor **55** and the input resistor **56** are equal and therefore the gain of the input voltage X through the inverting input **53** to the ouput **52** is equal to -1. The bias supply **57** is coupled through a resistor **58** to the oppositely poled series connected diodes **59** and **60** which are coupled between the non-inverting input **54** and the source of the input voltage X. The resistor **61** is coupled to the diode **60**. Assume that the bias supply **57** with the resistor **58** biases the junction of the diodes **59** and **60** to that of $+1.25$ volts, and also assume that the resistor **61** is grounded at the end that is indicated to be connected to a bias supply **66** of $+2.5$ volts. The aforesaid components will then act similarly to the corresponding components of FIG. 3, and will give an input output transfer function as shown in the right hand portion of FIG. 4a where X has a positive value. This is very similar to that shown in FIG. 3c except that the break point occurs at X equals $+1.25$ volts. The other diodes of the bridge network, namely diodes **62** and **63**, are also oppositely poled and have their junction connected to a bias resistor **64** which is coupled to a bias supply **65**. Assume that the bias supply **65** together with the resistor **64** biases the junction of the diodes **62** and **63** to a potential of -1.25 volts. Therefore, since diodes **62** and **63** are poled opposite with respect to diodes **59** and **60** respectively, these components will give a transfer function as is shown in the left hand of FIG. 4a with a break point of -1.25 volts. Since X, the control voltage, is only a positive value it is desired to shift the entire transfer function as shown in FIG. 4a to the right. This is accomplished by adding 2.5 volts to the previously mentioned potential of bias supply **65**, as well as that to the previously mentioned zero potential of bias supply **66** coupled to the resistor **61**. This results in the junction of diodes **59** and **60** being at a potential of $+2.5$ and $+1.25=+3.75$ volts, and the junction of diodes **62** and **63** being at a potential of $+2.5-1.25=+1.25$ volts. This moves all the breakpoints to the right as required, and the results as is shown in FIG. 4b. It will be seen therefore, that the generator **31** generates a triangular approximation to the $-\sin X$ voltage.

FIG. 5 shows alternative ways of biasing the AND gate **36** so as to achieve a more accurate fine color control. As in FIG. 2, the output signals from the summer, inverter, and clamp circuits **34**, **35** are applied to the respective non-inverting inputs of the AND gate **36**. However, instead of just having a selectable fixed bias on the inverting inputs of the AND gate **36**, there is in addition, a bias proportional to the signal present at the non-corresponding non-inverting input. This is achieved by having the tapped resistor **70** apply a portion of the signal coming from circuit **34** to the inverting input of AND gate **36** which is associated with the inverting input of AND gate **36** to which the signal from circuit **35** is applied. Likewise the resistor **71** applies a signal coming from circuit **35** to the inverting input of the AND gate **36** which is associated with the non-inverting input of said AND gate to which is applied the signal from circuit **34**.

The proportion of these signals which are applied to the inverting inputs are normally equal and would be fixed set initially. To apply a selectable fixed bias to the inverting inputs, a transistor **72** is coupled as an emitter follower with the resistor **73** coupled to the bias supply **74**. The use of an emitter follower circuit is desirable so that a low AC impedance is presented to the lower ends of the resistors, **70, 71**. A potentiometer **75** applies selectable bias to the base of the transistor **74**, thereby adjusting the amount of potential at the lower ends of the resistors, **70, 71**. In operation the voltage dividing ratio of the resistors, **70, 71** will effect a fine selection of the color upon which the overall chroma key will trigger, and the adjustment of the resistor **75** will control the saturation of the color upon which the overall key will trigger. It will therefore be seen, that extremely fine control of the overall circuit is obtained.

FIG. 6 shows a third way of achieving more color selectivity. The signal from the circuit **34** is applied a non-inverting input and a non-corresponding inverting input of the AND gate **36**. A variable bias supply **76** has a positive voltage output coupled to the remaining inverting input and an equal but negative voltage output coupled to the remaining non-inverting input. By adjusting the voltages from bias supply **76**, the triggering color is selected. The signal from the circuit **35** is applied to the non-inverting input of an AND gate **78**. A variable bias supply **79** supplies a negative bias to the inverting input of said AND gate **78**, and the output of said AND gate **78** is coupled through a diode **80** to an inhibit terminal **81** on the AND gate **36**. By adjusting the variable bias supply **79**, the saturation of the color on which the chroma key is to trigger can be selected.

It is to be understood that many other embodiments are possible without departing from the spirit and scope of the invention.

What is claimed is:

1. A circuit for generating an output pulse upon the occurrence of a selected color in a plurality of color component signals, comprising means for receiving a control voltage, means for generating a voltage having a value substantially equal to the sine of said control voltage, means for generating a voltage having a value substantially equal to the cosine of said control voltage; first means for multiplying a first of said component signals by said sine voltage, second means for multiplying said first component signal by said cosine voltage, third means for multiplying a second of said component signals by the negative of said cosine voltage; fourth means for multiplying said second component signal by said sine voltage; first means for adding the multiplied signals from said first and third multiplier means, second means for adding the multiplied signals from said second and fourth multiplier means, and means for combining the outputs of both of said adding means, thereby to produce an output pulse upon the occurrence of a selected color in said component signals.

2. A circuit as claimed in claim **1** further comprising a matrix having an input for receiving red, blue, and green color signals and an output means for applying luminance color difference signals to said respective multiplier means, said luminance color difference signals being said color component signals.

3. A circuit as claimed in claim **1** wherein said each of said generating means comprises an amplifier having inverting and non-inverting inputs, and an output; a feedback resistor coupled between said inverting input and said output; an input resistor coupled to receive said control voltage and to said inverting input; a first pair of oppositely poled series coupled diodes having an end coupled to said non-inverting input and a remaining end coupled to receive said control voltage; and first means for biasing the junction of said first pair of diodes.

4. A circuit as claimed in claim **3** wherein said cosine generating means said biasing means biases the junction to a potential approximately equal to one-half of said control voltage maximum value.

5. A circuit as claimed in claim **3** wherein said sine generating means said first biasing means biases said junction to a potential approximately equal to three-quarters of said control voltage maximum value, and further comprising a second pair oppositely poled series coupled diodes, said pair having its ends coupled to said first diode pair ends respectively; and second means for biasing the junction of said second diode pair to a potential approximately equal to one-quarter of said control voltage maximum value.

6. A circuit as claimed in claim **1** wherein said combining means comprises an AND gate having two non-inverting inputs coupled to said adding means respectively, two inverting inputs corresponding to said non-inverting inputs respectively, and an output for providing said output pulse; and means for biasing said inverting inputs.

7. A circuit as claimed in claim **6** wherein said biasing means comprises a bias supply connected to said inverting inputs.

8. A circuit as claimed in claim **6** wherein said biasing means comprises a pair of tapped resistors each having one end coupled to said non-inverting inputs respectively, said taps being coupled to the non-corresponding inverting inputs respectively; and a bias supply coupled to the remaining ends of said resistors.

9. A circuit as claimed in claim **8** further comprising a transistor emitter follower coupled between said bias supply and said resistors.

10. A circuit as claimed in claim **1** further comprising a delay line coupled to said combining means; an AND gate having a non-inverting input coupled to said delay line, an inverting input, and an output; a bias supply coupled to said inverting input; and a clipping and zero reference means coupled to said AND gate output.

11. A circuit as claimed in claim **1** wherein said combining means comprises a first AND gate having two inverting inputs, two corresponding non-inverting inputs, an inhibit input, and an output for providing said output pulse; an inverting input and the non-corresponding non-inverting input being coupled to one of said adding means; means for variably biasing said remaining inverting and non-inverting inputs; a second AND gate having an inverting and a non-inverting input, and an output coupled to said inhibit input; said second AND gate non-inverting input being coupled to the remaining adding means; means for variably biasing said second AND gate inverting input.

12. A circuit for generating an output signal upon the occurrence of a selected color in at least two color component signals, said circuit comprising means for receiving a control voltage and for generating a pair of voltages having values substantially equal to the sine and cosine of said control voltage respectively, four means for multiplying, each of said component signals by one of said sine and cosine voltages respectively, one of said multiplied signals having a sign opposite from the remaining multiplied signals, a pair of means for adding said multiplied signals in combination of two signals, and means for combining both of said added signals and for producing a pulse upon the occurrence of a selected color signal.

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RICHARD MURRAY, Primary Examiner

U.S. Cl. X.R.

178—DIG. 6, 5.2 R