

# High Quality Montage Pictures by a New Color Killer Soft Chromakey System

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A new technique for producing high quality montage chromakey pictures which were not obtainable by the conventional chromakey method has been developed by NHK. In early chromakey methods, gating signals with steep rise and fall times were shaped from the chromakey blue signal. Frequently the borderlines of the pictures produced were very unnatural. In later systems, gating signals with gentle rise and fall times are obtained from the chromakey blue signal, avoiding any clipping or stretching procedures. These gating signals control the level of the foreground key camera video signal and the level of the background video signal to be combined with it, so that the borderline of the two pictures will look more natural. In addition, a blue color killer circuit is provided, in order to eliminate the blue border between the two pictures, caused by the key camera signal. In the new technique, the color killer circuitry operates on the encoded signal rather than on the RGB signals normally used for the purpose. Furthermore, this new blue color killer circuit can be used as a color converter, not only for the blue color but also for other colors, to obtain special color effects. Because the operation is on an encoded signal, it is much easier to integrate into an existing studio complex. Some of the results are illustrated.

Composing pictures by the chromakey method has many advantages. For example, it enables the making of special effects pictures; it facilitates the attaining of scenes which otherwise would be difficult to film; it can reduce set construction expenses; and it facilitates adjustment of the shooting schedule for many scenes. For these reasons, a screen image composition system capable of producing highly refined pictures with no unnaturalness is of considerable interest. With the new chromakey system, the combined picture is indistinguishable from a live broadcast.

## The Principle Behind the New Color Killer Soft Chromakey System

Roughly, the operation of the new soft chromakey system may be divided into: (1) a level control section, which creates a linear gate of two video signals by means of the key signals and finally produces the composite picture; (2) a soft key generating section, which creates the soft contours of the composite image; and (3) the color killing section, which absorbs the chromakey background covered by the foreground subject, and which is the distinctive feature of the new system.

### The Level Control Section

Let us first explain the level control section of a conventional soft wipe. Figure 1 shows the circuit schematics of a differen-

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tial amplifier called a linear gate circuit or level control circuit. This is the fundamental part of the mixing amplifier which has the functions of video fading, gating, etc. When this circuit is activated by a trapezoidal gate signal with a sloping part in its waveform, cross-fading of the composite

"from" and "to" video signals will result. The level of the sloping part of the gate signal controls, in direct or inverse proportion, the slope of the signal waveform. The composite picture produces a soft impression, as if optical blurring had been applied to the contours of the composite picture. This operating principle is utilized in all forms of soft chromakey.

### Soft Key Generating Section

In soft chromakey, however, the gate signal (key signal) is generated by making efficient use of the fall-off characteristic which a video waveform experiences in the low level region. The video signal level distribution of the picture is shown in Figs. 2a through 2c. In these figures, the signal for chromakey blue and the signal for a white subject cross-fade with each other. This well-known phenomenon is caused by the aperture distortion which occurs in the beam scanning of the television camera

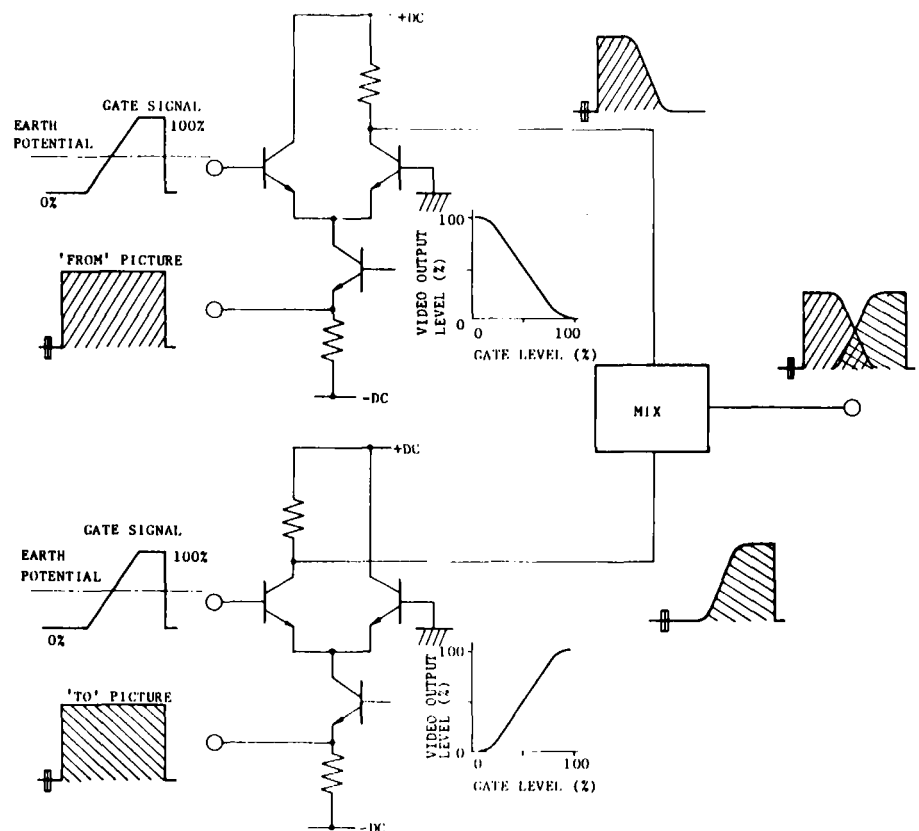
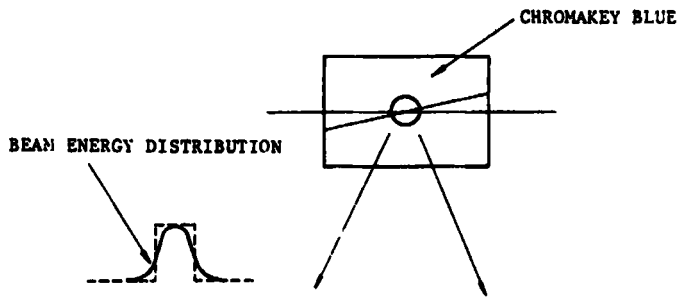
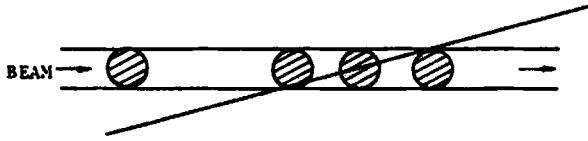


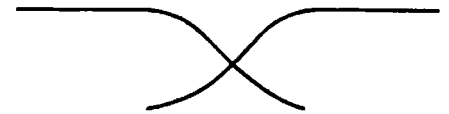
Fig. 1. Schematic of a linear gate or level control circuit.



(a) Screen



(b) Beam scanning



(c) Signal output distribution



(d) Soft key



(e) Hard key

Fig. 2. Video signal level cross-fade distribution and possible waveforms of the key signal.

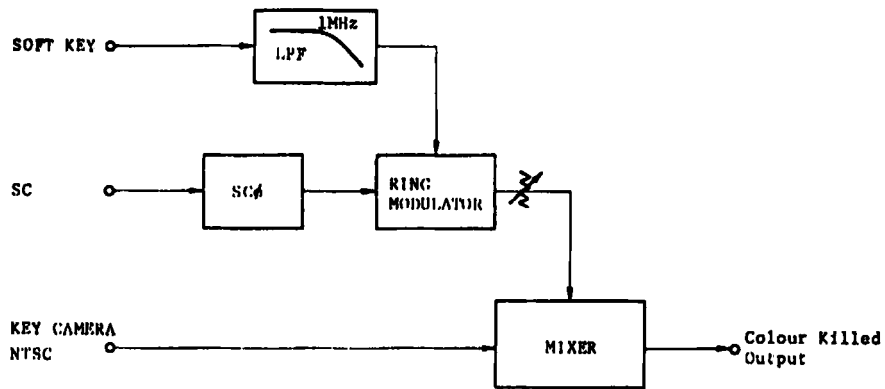


Fig. 3. Basic color killer circuit components.

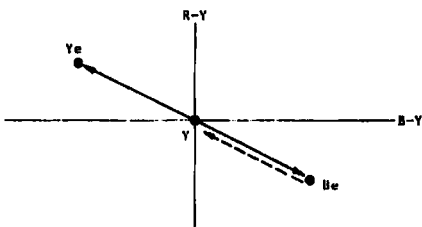


Fig. 4. Vector diagram with cancelled blue chromakey vector.

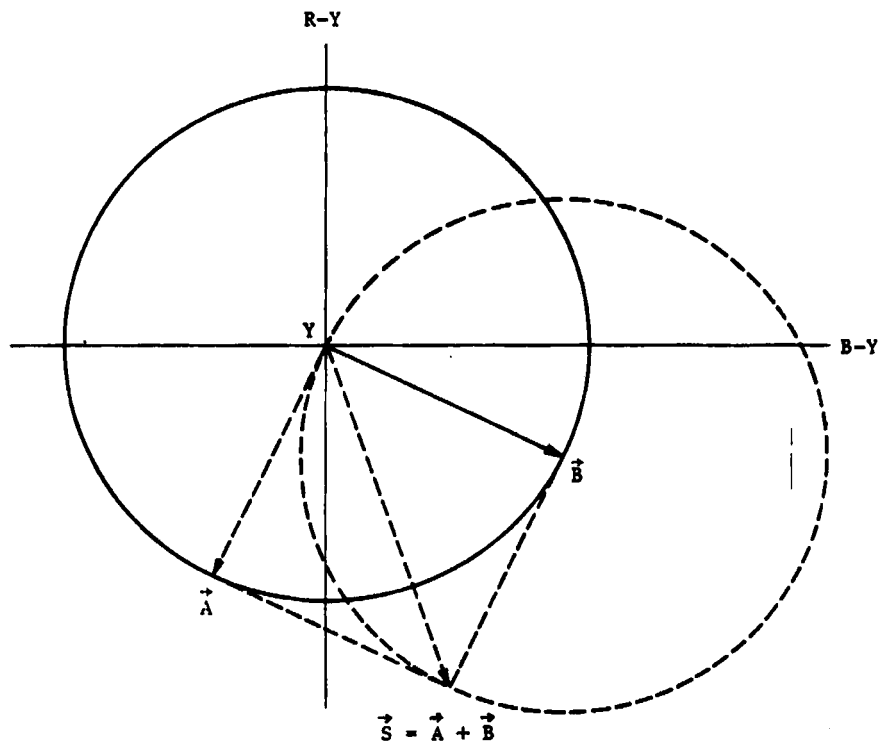


Fig. 5. Color conversion vector diagram.

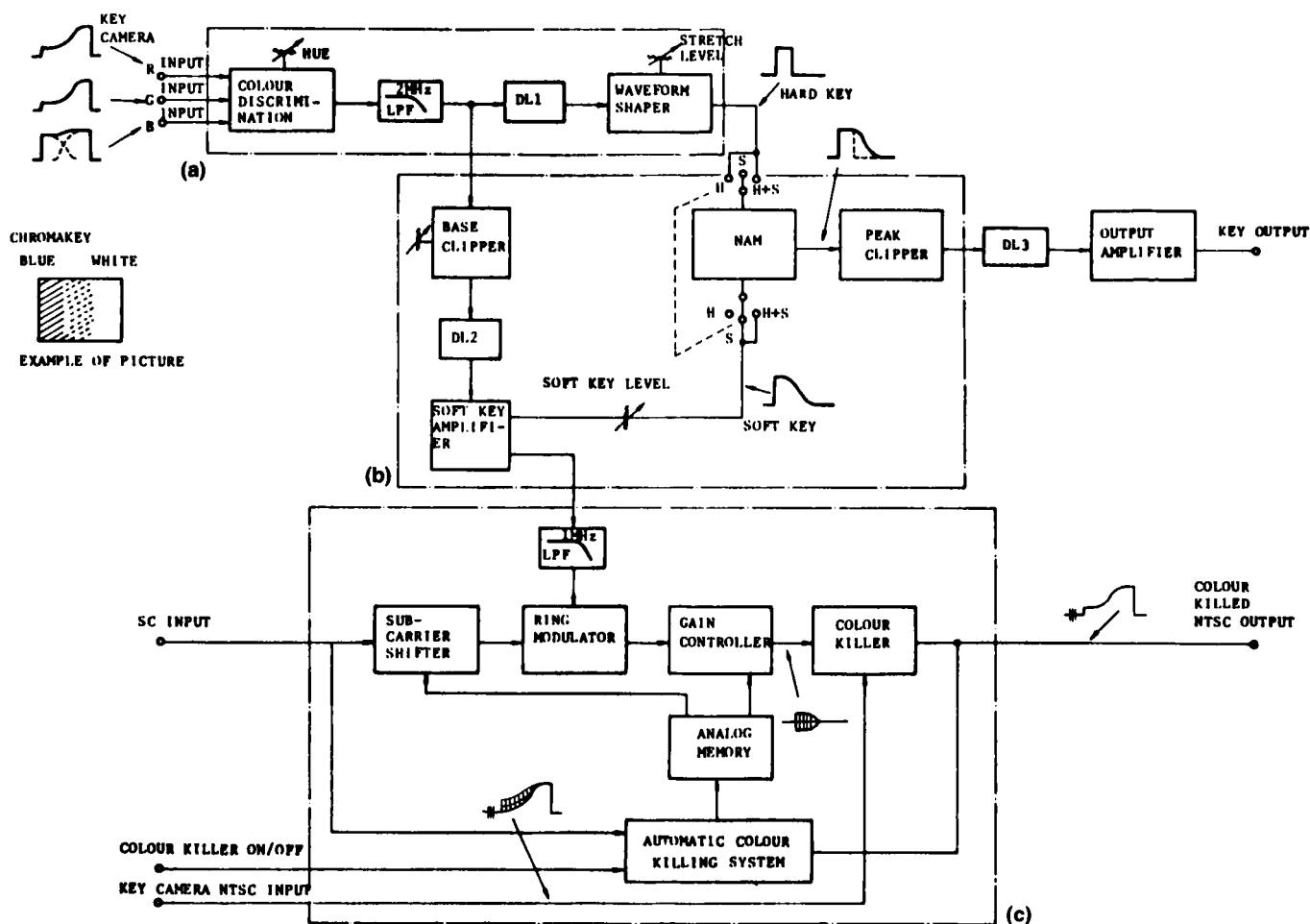


Fig. 6. Circuit layout of a soft chromakey system with incorporated automatic color killer.

pickup tube (Fig. 2b). When optical blurring is present, the waveform also is similar to Fig. 2c, but the time axis interval during cross-fading is much longer.

Soft key is obtained by extracting the waveform of these chromakey blue signals without deteriorating their linearity and signal-to-noise ratio (Fig. 2d). The key signal, which is usually step-shaped (Fig. 2e), is called the hard key as distinguished from the soft key.

By controlling the above described level control circuit with regard to the sloping part of the soft key, it is possible to realize the natural composition of pictures where the outline or contour of the inserted foreground picture is cross-faded with the background picture. The functioning of the level control section is almost linear for the key signal. Therefore, even with optical blur, fine detail such as hairs and even transparent subjects such as glass and smoke can be reproduced faithfully as long as the linearity of the blue chromakey waveform remains in the soft key.

#### Basic Principle of the Color Killer Section

As illustrated in Fig. 2c, when the blue chromakey signals cross-fade with the signal of the foreground subject, a blue border occurs on the picture being inserted. In ad-

dition, unnatural color areas will appear if flare and reflection of chromakey blue are present in any part of the foreground subject.

As a solution, we were able to obtain good results by including a color killer circuit in the design. The soft key signal holds all the chromakey blue signals that are distributed in the low level region in question here. The principle of the color killing system using the soft key signal is shown in Fig. 3. Here, the soft key signals pass through a lowpass filter and become the modulation signal for the ring modulator. A continuous subcarrier input (SC) to the ring modulator is set to a phase just opposite to the color phase of the chromakey blue.

If the ring modulator output level is properly adjusted and mixed with the encoder output (NTSC signal) of the key camera, the chromakey blue subcarrier will be cancelled and a color-killed NTSC output signal will be obtained (Fig. 4). If this color-killed NTSC signal is added to the inserted picture signal, it is possible to obtain a composite picture without any unnatural border colors. Moreover, the color killer effect greatly improves the faithful reproduction of transparent glass, smoke, etc.

#### Color Conversion

By using the color killer circuit it is also possible to convert the hue of a certain color on the picture screen. To change the hue of a given color, the phase of subcarrier SC (Fig. 3) is set to an arbitrary value by means of the shifter SC. It is then modulated by the soft key signal through the ring modulator and mixed with the key camera output. If the subcarrier output from the ring modulator is vector A (Fig. 5), and the subcarrier output of the picture area to be extracted by the soft key is B (Fig. 5), then the sum of A and B will be the vector S, and this will be the vector of the new converted hue. As the subcarrier vector A rotates about the coordinate origin Y, the color extracted by the key camera vector B becomes a fixed vector determined by the arbitrary value of the shifter SC. As the terminus of vector A rotates about the circumference of a circle centered at Y, the terminus of vector S will rotate about a circumference that has as its center the terminus of vector B, and the vector S will become the new color hue.

However, as the amount of chroma is modulated in advance by the soft key, the light and shade of the chroma is faithfully reproduced. Also, the luminance components are subject to no deterioration, and hence natural color conversion is achieved.



Fig. a. Long shot obtained with the new soft chromakey system.



Fig. b. Close-up obtained with the new soft chromakey system.



Fig. c. A transparent object: (left) with conventional chromakey; (right) with the new soft chromakey.



Fig. d. Hair contour: (left) with conventional chromakey; (right) with the new soft chromakey.

### Results in Program Use

At present, the system is used mostly for drama features, but it is also finding application in musicals and children's programs where the soft chromakey characteristics can be employed to best advantage. The color illustrations are a sample of the results obtained in practical applications.

Figures a and b show that the borderlines of the composite picture appear

natural and that, consequently, a quasi-stereoscopic picture is obtained. The color killing effect is most effective, and the flare from chromakey blue in the dark portions has been erased completely.

Transparent objects such as a glass of water (Fig. c), smoke, etc., can be reproduced in a natural way. Note how the color killer eliminates the blue from the water level (Fig. c, left) and the glass. The feeling of the softness of hair, which used

to be a weak point in chromakey, can also be obtained. Figure d (left) shows blue hair contours which have been eliminated in Fig. d (right) by the use of the color killer.

A soft focus transition from foreground to background can be reproduced as a true soft borderline (Fig. e). The shadow of a foreground object, as projected on the chromakey panel (Fig. f, left), can be reproduced as a natural shadow on the backdrop (Fig. f, right).

### Layout and Operation of a Circuit with Incorporated Color Killer

Figure 6 shows the circuit layout of the soft chromakey system with an incorporated automatic color killer system. The operating waveforms for each part of the circuit are shown as small diagrams within the circuit layout. They illustrate the case where a chromakey blue and white foreground subject occupy respectively the left and the right half of the picture.

Section (a) of Fig. 6 represents a circuit similar to the conventional type of chromakey generator. Section (b) is the soft key generating part, and section (c) is the color killing circuit. In what follows we shall outline the functioning of the complete circuit. The key signal is obtained by color discrimination and is applied to a low-pass filter (roll-off characteristics above 2 MHz, 6 dB/octave). This improves the signal-to-noise ratio.

The output of the low-pass filter is fed into the soft key amplifier having a maximum gain of 12 dB where the soft key is obtained. An additional output of the low-pass filter is wave-shaped by the stretch circuit and becomes the hard key output. In the nonadditive mixing (NAM) circuit the two key signals are subjected to nonaddi-

tive mixing. This is followed by peak clipping, and the mixed signals become the key output. At the input to the NAM circuit, in addition to determining the mode in which each single key signal is used, three key modes are possible: hard key only ( $H$ ), soft key only ( $S$ ), and hard plus soft key ( $H + S$ ).

### Layout of the Automatic Color Killer Section

The basic principle of the color killer has already been described. In the actual device (Fig. 6), the phase of the color killing subcarrier and the level of the ring-modulated output are controlled automatically by the automatic color killing section. Its controlling circuits form a closed loop circuit.

Figure 7 shows a detailed layout of the automatic color killing system. The automatic phase control (APC) and automatic gain control (AGC) circuits consist of two similarly composed loops (right side of Fig. 7). The only difference is a  $90^\circ$  phase difference between the two subcarriers fed to the respective APC and AGC demodulators. As the APC and AGC loops are actuated simultaneously, a constant phase difference of  $90^\circ$  is applied to each demod-

ulator ensuring stable operation of the APC and AGC loops.

For the initial setup of the automatic color killer circuit, the chromakey blue color to be extracted should fill the crosshatched central window of the finder of the key (foreground) camera (close to center of Fig. 7). Then, by turning the switch of the color killer section to "on," a closed loop is sustained for a period of two seconds, during which the two resulting voltages will reduce the extracted chroma signal to zero. The two generated dc voltages are stored in the analog memories and are then applied to control the phase control section and the gain control section respectively.

It should be noted that the analog memories will hold the optimum voltages thus obtained for more than 100 hours, once the closed loop has been opened. It should also be noted that the operating range of the APC loop is  $\pm 35^\circ$  and that it is important to adjust the phase canceller (cancel  $\phi$  in Fig. 7) so that the APC will always operate at the center point of the operating range. Furthermore, it is necessary to adjust the AUTO  $\phi$  portion so that the subcarriers fed to the two demodulators will in effect reduce the chromakey color. As a result, the



Fig. e. A strongly out-of-focus foreground object: (left) with conventional chromakey; (right) with the new soft chromakey.



Fig. f. Shadows projected by the foreground object on the blue background: (left) with conventional chromakey; (right) with new soft chromakey.

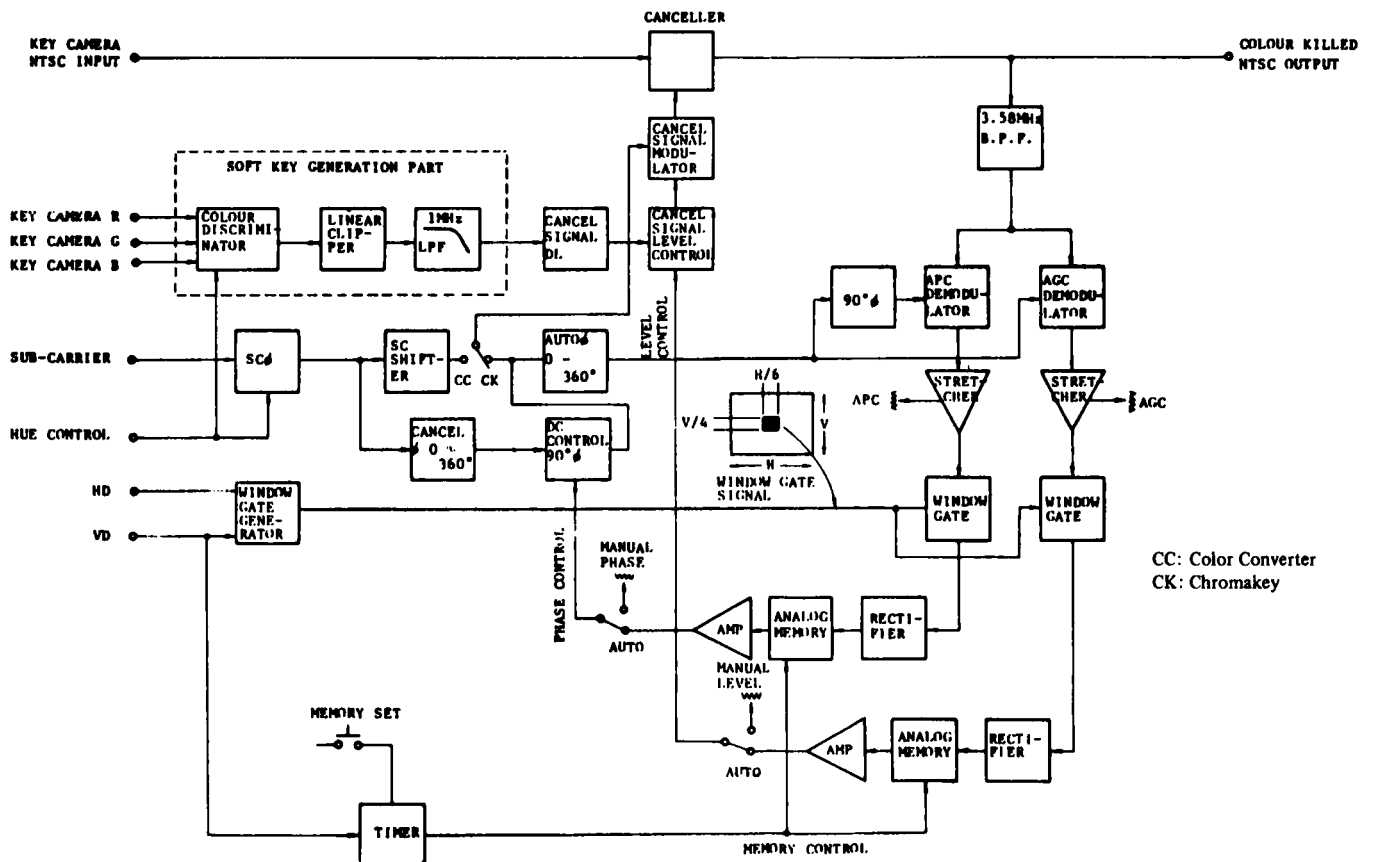


Fig. 7. Layout of an automatic color killer system.

AGC loop will actively reduce the gain, and the APC loop will actively minimize the phase difference in a most effective manner. Figure 8 shows the complete general layout of the operation of the soft chromakey color killer system.

**Conclusion**

It can be said that the soft chromakey system incorporating a color killer improves the quality of composite television images remarkably. It also makes it possible to use the chromakey method in programs of a type where it has not yet been commonly employed. At present, NHK is installing the new soft chromakey system mainly in its studios for dramatic productions. It is expected that in the future the new soft chromakey method will come into general use.

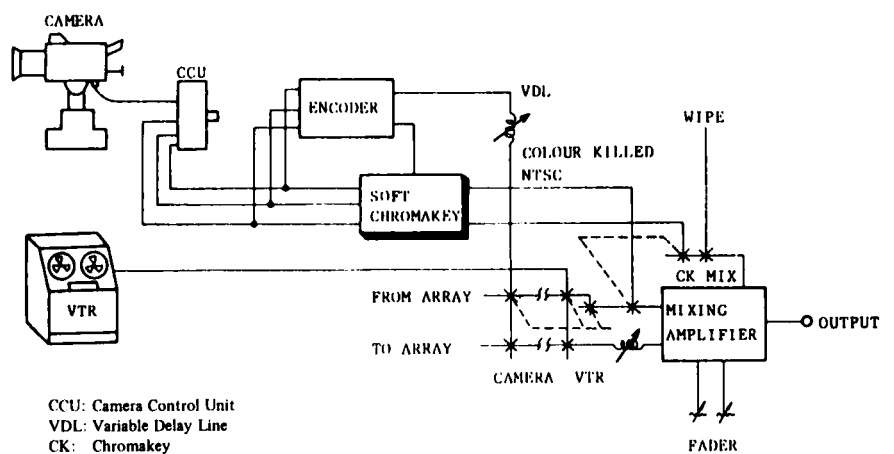


Fig. 8. Complete general layout of the soft chromakey color killer system.