THERE ARE MANY INSTANCES IN VIDEO work when it is desirable or necessary to modify a video signal in one way or another. In the home, modifying a video signal usually means a simple color correction attained by adjusting the TV's tint and color controls. But for professional or artistic video-signal control, a much-wider range of signal modification must be available. For example, there must be a way to correct contrast when the the color is OK but the signal's luminance component is weak. Another modification might include deliberate distortions of the signal many applications, and is also great fun—it can be more fun than a video game. Some of its serious applications are:

1. Video Recording
  - **a.** Tint correction
  - **b.** Chroma boost/cut
  - **c.** Luminance/synch boost and cut
  - **d.** Additions of special effects to recordings
  - **e.** Posterization and solarization for effects and titling

2. Photographic Uses
  - **a.** Viewing color negatives as positives (a separate camera is required)

(0–4 MHz) 75-ohm source impedance NTSC video signal having a nominal amplitude of 1 volt peak-to-peak with negative sync is applied to the system via the VIDEO IN jack. A BYPASS SWITCH is provided to bypass the system, and a VIDEO LOOP-THROUGH connection is also provided for loop-through setups. Switches enable AC or DC coupling, and 75 ohm or Hi-Z (high impedance) input, which is useful in loop-through applications or where another 75 ohm device is already terminating the input line.

A video amp boosts the input up to 3

VIDEO EFFECTS GENERATOR

Color correction, deliberate distortion, artistic picture control. Our video palette puts it all at your fingertips.

RUDOLF F. GRAF and WILLIAM SHEETS

for the purpose of creating special effects: such as color and/or luminance reversal (positive-negative); posterization, in which the video signal is altered such that there are only a few discrete values of luminance (usually 2, 3, or 4); or solarization, in which the gray scale (luminance) is "folded" on itself, producing an eerie, surrealistic-looking picture that contains both positive and negative tones. Of course, several effects may be performed simultaneously.

Devices that provide a high degree of color control are used in virtually all major TV production facilities. Regardless what the brand name might be, technicians often refer to such a device as a *video palette*; hence, we will also call our device a video palette.

Our video palette is designed to work on any standard NTSC video signal. It has

  - **b.** Advance predictions of the finished appearance of photographic special effects
  - **c.** Negative inspection and analysis

3. Video Production
  - **a.** Simulation
  - **b.** Special effects
  - **c.** Artistic effects

Some of the video palette's effects are shown in Figs. 1-*a*, 1-*b*, 1-*c*, and 1-*d*, and they are just a tiny sampling of what is possible. It will be evident after an hour or so of experimentation, using a video source (VCR, TV tuner, etc.) and a video monitor to observe the results, that a wide range of effects are possible by manipulating the front-panel controls.

How it works

A block diagram of the video palette is shown in Fig. 2. A standard baseband volts p-p, and at the same time inverts it so that the sync tips are positive. The video signal, which is now still unaltered but greater in amplitude and inverted, is then fed to a sync separator and a SPDT CMOS video switch.

The video switch splits the video signal into two components:

1. Synch, blanking, and burst pulses only;
2. Video and chroma information without sync, burst, or blanking.

The reason for the splitting up of the signal is to allow separate processing and treatment of the four signal components: sync, burst, luminance (black-and-white component), and chroma (color-difference). (Figure 3 shows the four components parts of a standard NTSC color signal.)

There are other reasons why it's necessary to extract the discrete signal compo-

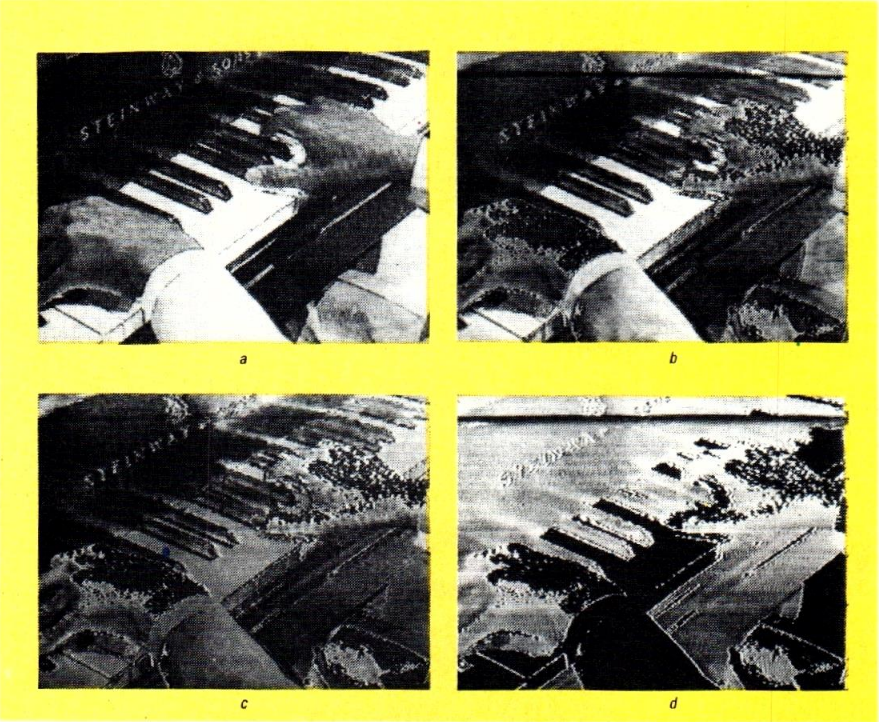

FIG.1—THE VIDEO PALETTE'S EFFECTS CAN BE STACKED. In this black and white series, *a* is a normal picture, *b* is posterized, *c* has solarization added, *d* has negative video added.

nents. For example, the sync signal is used for timing and cannot be modified unless intentional scrambling of the picture is required. If we want an inverted (negative) picture, we cannot just reverse the phase of the whole signal, because the video monitor needs sync pulses of a given polarity; therefore, a simple inverter will not work. If we want to introduce special effects, we may want, for example, to just operate on the chroma signal and leave everything else the same. Therefore, the splitting up of the signal is obviously necessary; otherwise, improper operation of the sync and color-burst circuitry in the monitor, VCR, or TV receiver will result.

Synch and blanking are separated from the burst pulse by a lowpass filter having a cutoff frequency of 2.5 MHz and a maximum rejection frequency of 3.58 MHz.

Luminance and chrominance are separated the same way. Strictly speaking, a comb filter would be the ideal way to separate luminance and chrominance, but it would complicate construction and increase cost. For that application, simple M-derived filters do the job adequately.

Synchronization

A switching signal to control the video splitting is derived from the original signal's sync information. A sync separator strips the horizontal and vertical sync information from the original signal. (Note that the original signal must be a legitimate NTSC signal, with the sync tips most negative. Therefore, a scrambled signal will not operate this unit.)

The horizontal sync drives a monostable multivibrator having a nominal 53-microsecond pulse width. That multivibrator drives a second multivibrator that generates a gating pulse having a nominal 10-microsecond pulse width. The 10-microsecond pulse is timed to be coincident with the blanking pulse on the original NTSC signal; it is done by adjusting the 53-microsecond multivibrator's pulse width. The 10-microsecond pulse causes the video switch to route the video signal into the sync and burst side of the switch. When the pulse is not present (during horizontal line scan), the video is routed to the video and chroma side of the switch.

Vertical sync is separated in a similar manner. A monostable multivibrator having a delay of one frame (nominally 16 microseconds) is used to trigger a second monostable multivibrator whose output is a pulse having a width of nominally 600-microseconds. That pulse should be timed to occur during vertical retrace. Therefore, the entire composite vertical blanking pulse will be gated to the sync and burst side of the video switch. (The setup of the switching circuit consists of adjusting the delays and pulse widths of the four multivibrators so as to correctly switch the sync pulses, blanking pulses, and the burst pulses to the sync and burst outputs of the video switch.)

The video switch's sync output is fed to a lowpass filter that removes the burst. It then goes to an amplitude control, and then into a summing amplifier, which reassembles the video signal.

The burst output goes to a highpass filter that eliminates the sync. Then the signal is fed to a phase-correction network and on to the burst amplifier, a differential amplifier having two outputs 180° out of phase. A potentiometer connected across both outputs functions as both a gain and polarity control: At the center position there is zero output (no burst); fully clockwise and counterclockwise, full positive or negative burst is available respectively. In that way, the burst phase and amplitude can be altered or corrected as required, independent of everything else. The burst can be varied from plus three times normal to minus three times normal. By using a negative burst phase, the monitor or TV screen will show reversed (complimentary) colors. The burst is then fed to the summing amplifier for reassembly into a complete video signal.

Luminance is treated in a similar manner to that of the sync. It goes through a lowpass filter that is similar to the sync filter and is then fed through a level control to the input of the summing amplifier. There it is summed with the sync and the burst information.

Chrominance, or chroma, is extracted by a highpass filter. It is fed through a differential amplifier having positive and negative outputs. (It is similar to the burst differential amplifier). A potentiometer allows either positive or negative amplified chroma to be fed to the summing amplifier at any desired level. That feature allows weak chroma to be amplified or inverted. Since some 2.5 MHz (or higher) luminance components will be present along with the chroma signal, the chroma control functions as a sharpness control in black and white applications. The ability of using either positive or negative burst with positive or negative chroma at first will seem redundant because negative chroma with a negative burst will yield a positive picture. However, the phase of the high-frequency luminance components will not be the same, and the total effect can be used as a sharpness control for color video.

The summing amplifier has a nominal gain of unity when the level controls for chroma, burst, sync, and luminance are about halfway open. Since the video signal was amplified by a factor of three by the input video amplifier, allowing for normal circuit losses within the video palette, about 2 volts of composite video component is present at the input of the summing amplifier. Therefore, a 2-volt peak-to-peak reassembled video signal is present at the output of the summing amplifier.

You may be wondering what we have really accomplished so far. What we now have is the ability to disassemble the video signal, control each of its four components on an individual basis, and recombine them into a new video signal.

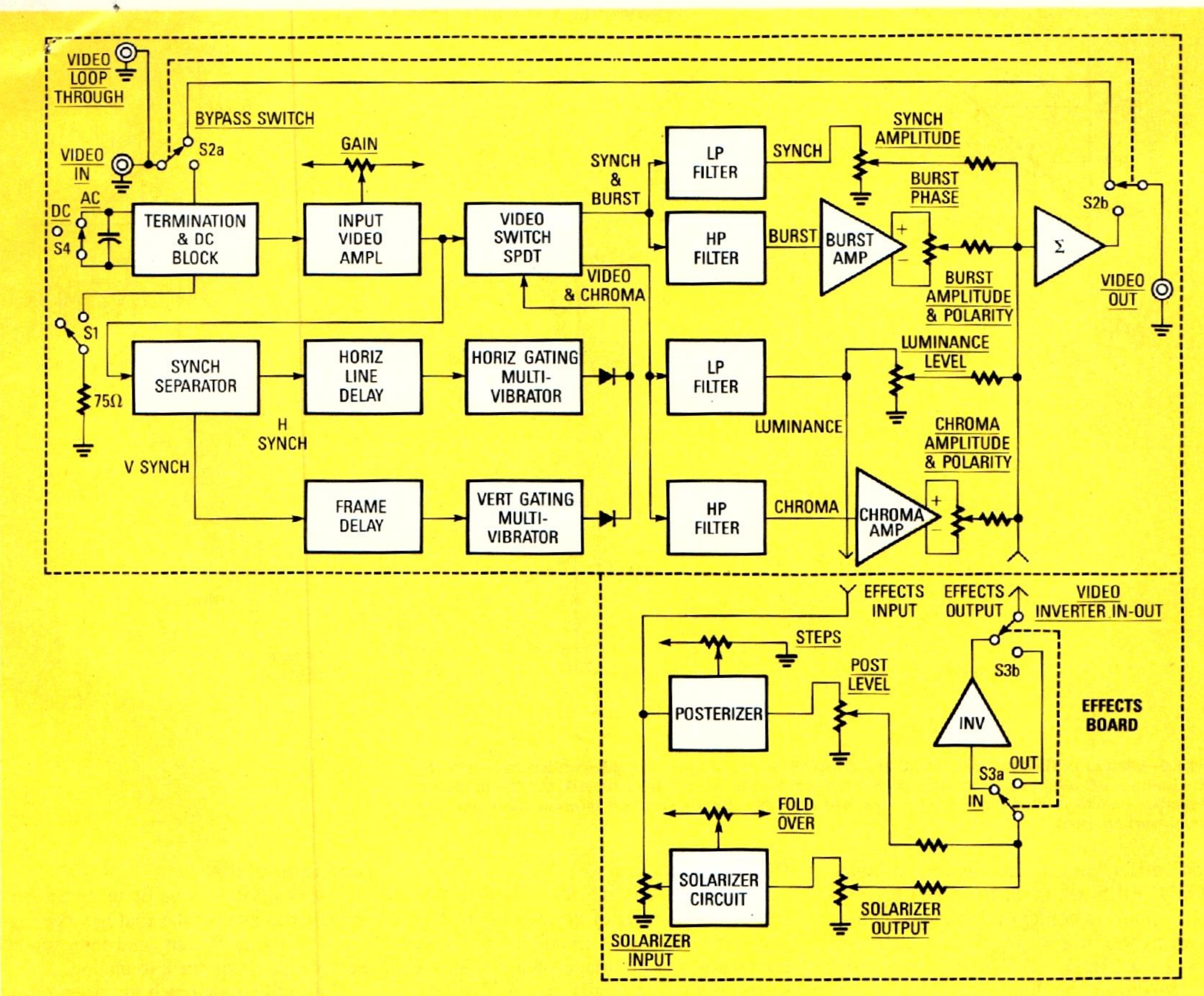

Fig. 2—THE CIRCUITS FOR THE video palette are arranged on two separate circuit boards. A bypass switch allows all functions to be instantly bypassed without having to reset the individual controls.

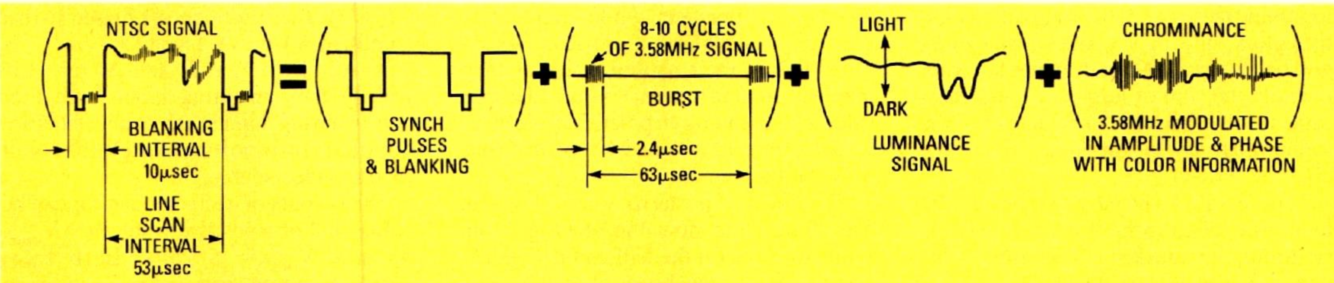

FIG. 3—AN NTSC COLOR SIGNAL has four individual components, all of which can be separately controlled by the video palette.

Depending on the settings of the controls, we might get an improved picture, a degraded picture, or an altered picture. By this method, we can custom-correct individual faults in the video signal. For all practical purposes, we have a graphic equalizer for video.

Analog effects

A few analog effects are incorporated in the video palette. Those are inversion, posterization, and solarization.

Inversion, shown in Fig. 4, is simply what it implies: the video signal levels are inverted about a given reference axis. For example, if zero volts represents maximum white and 1 volt represents maximum black (Fig. 4-*a*), passing the signal through an inverter such that the output is 1 volt when the input is zero volts, and the output is zero volts when the input is 1 volt, will produce an inverted video signal (Fig. 4-*b*).

Note that a true inverter would just change the sign. For example, let us take the case of a signal at +0.5 volt, which would represent a middle gray. Ideally, if we invert a gray tone, it is gray. (Gray is its own complementary color.) However, a true inverter would give −0.5 volts output, which would be whiter than white. Therefore, we must add a DC offset of +1 volt to the output so a that a zero volt input produces a +1 volt output, thereby restoring the original gray (Fig. 4-*c*). As shown in Fig. 4-*d*, that can be done by adding a

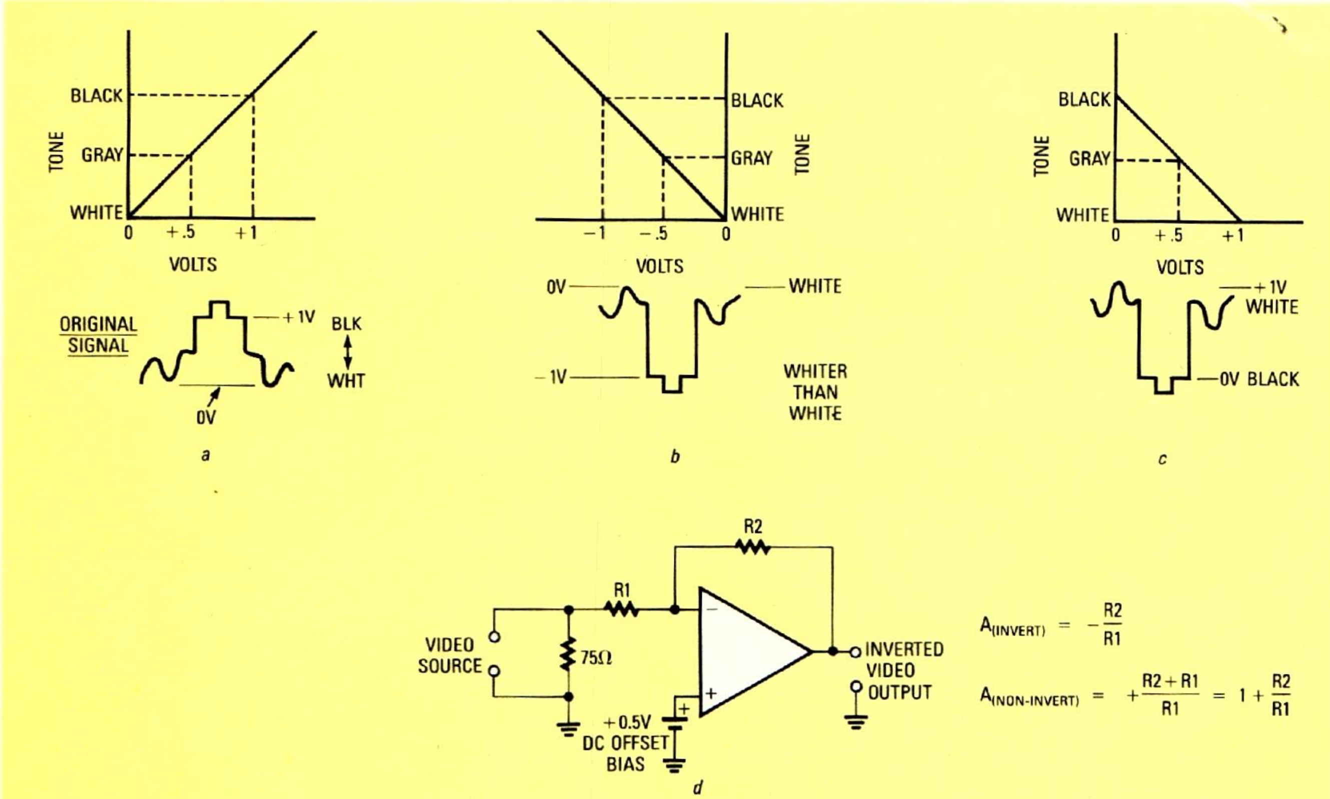

FIG. 4—SIMPLY INVERTING THE VIDEO signal (*a*) will result in a signal that goes whiter-than-white (*b*). By using a DC offset bias for the amplifier the signal-level values are restored, but the tones are reversed—white is now black (*c*). In *d* we see how the offset is applied through the amplifier's noninverting input.

DC offset level to the amplifier's input. Only +0.5 volt input is needed because the op-amp's configuration has a gain of two at the non-inverting input. (A + INPUT = 1 + R2/R1.)

Inverting the luminance signal produces a negative picture. If the original picture is black-and-white it will have the appearance of a black and white photographic negative. If the original is color, the colors will still be correct but the tones will be reversed. (Actually, since the color is really the sum of luminance and chrominance, the hues are unchanged but the saturations may be different, giving the effect described.)

In order to get a negative picture similar to a true color photographic negative (without the masking built into color negative film that is needed to make a color print), you would also invert either the chroma or the burst.

Using the correct light source, if you looked at a photographic color negative with a video camera/monitor set-up, and ran the resulting video through the video palette, you would see a positive color image. In fact, that technique is widely used by the commercial color-photo printing industry to predetermine correct color-printing exposure and filtration (light source color balance) so that the final photographic print is correct the first time. That kind of photo printing technique is known as *video analysis*.

Posterization

Posterization is the term used to describe the process of converting a photographic or video image of a scene containing a wide range of tones into a scene containing only a few discrete tones, sometimes only two (black and white). No intermediate shading between tones are present. Commonly, four tones are used in practice: white, light gray, dark gray, and black. Colors are sometimes left in their natural state, or they may be saturated (chroma is limited to one value—maximum). In practice, a pleasing visual effect is attained by posterizing only the luminance.

The effect of posterization is shown in Fig. 5-*a*. Note how the shading from white to black on the ball and cylinder is changed to discrete bands of gray by posterization. Figure 5-*b* shows how the video ramp waveform is changed to discrete steps by the posterization. A posterized video scene has a distinct computerized or cartoon effect because there are only a few discrete values of luminance. Since a very small difference in luminance at the transition points may produce a large difference in the posterized output, small noise signals, snow, and glitches are enormously magnified, which produces a grainy effect. Although grain is usually considered objectionable, as shown in Fig. 5-*c*, it can be used to add an artistic effect to the picture.

Analog to digital

Posterization is done by using an A/D converter to convert the analog video signal to a digital format, and then immediately converting back to analog.

A simplified approach to posterization is shown in Fig. 6. Four comparators are biased with a reference voltage obtained from a resistance voltage divider ($R_X \times 4$). The amplifiers are biased so that amplifier A4 has +1 volt, A3 has +¾ volt, A2 has +½ volt, and A1 has +¼ volt on their inverting inputs. All four non-inverting inputs are connected to a nominal zero-volts (white) to 1-volt (black) video source.

The outputs of each comparator can be either zero or a positive voltage ($+V_{out}$). Assume V_{out} = 5 volts. Each comparator's output terminates in common load resistor R_L, which is much smaller than R_Y. Typically, R_X = 10 ohms, R_Y = 4700 ohms and R_L may be about 220 ohms. The comparator amplifiers must be capable of fast response since the video input components are as high as 3 MHz.

Assume the video level is zero. All four amplifiers will have a zero output. As the video level rises to ¼ volt, amplifier A1 will suddenly change state and about ¼ volt will appear across R_L (5-volt output from A1 attenuated by voltage divider R_Y and R_L). As the video level exceeds ½ volt, A2 will change state and now A2 will contribute a current through its R_Y, so now there is ½ volt across R_L. (With a high-gain comparator, a few millivolts change in the video level produces an abrupt ¼-volt change in the output across R_L.) Amplifier A3 conducts at ¾ volt, and A4 conducts at 1 volt. Therefore, a ramp input voltage produces a staircase output with four discrete levels +¼, +½, +¾, and +1 volt (actually five discrete levels because zero volts is a level as well). In that way, we can produce only several discrete levels from a continuously varying level.

By varying the reference voltage we can vary the spacing between the steps, and, hence, for a given input video level the number of steps can be varied.

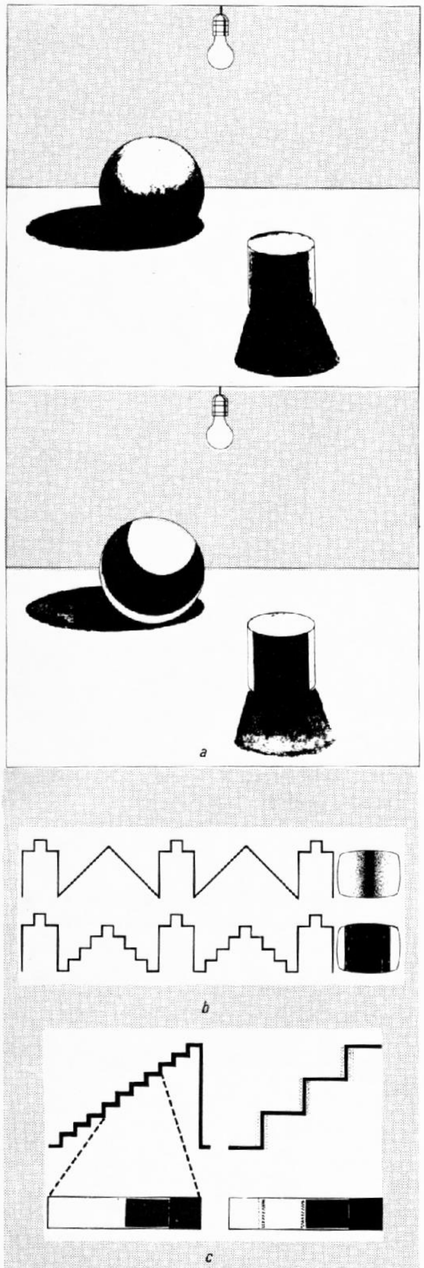

FIG. 5—POSTERIZATION CHANGES GRADUAL shading to discrete transitions (*a*). In *b* we see how the normal video signal, which originally represented increasing and decreasing ramps, is changed to a stairstep. In *c* we see how posterization creates grain at each transition. The grain isn't necessarily a problem because it's often used as a special video effect.

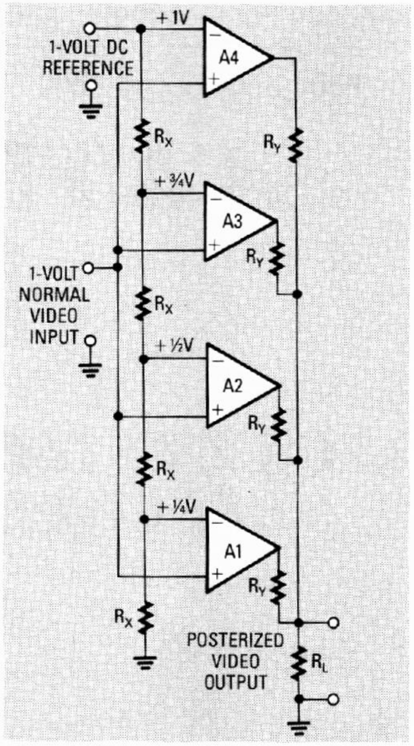

FIG. 6—AN ELEMENTARY POSTERIZER circuit. The value of the DC reference voltage determines the width of each step.

WHERE TO GET PARTS

Next month we will present the schematics and construction detail for the video palette, for which the following items are available from North Country Radio, P.O. Box 53, Wykagyl Station, NY 10804. The main printed-circuit board, $12.50; the effects printed-circuit board, $12.50; the main printed-circuit board and all parts that mount on the board, $49.95; the effects printed-circuit board and all parts that mount on the board, $39.95. A kit containing both the main and effects boards and their parts is $84.95. The effects board, with or without components, is sold only in conjunction with the main board. Include $2.50 postage and handling per total order. New York State residents must add appropriate sales tax.

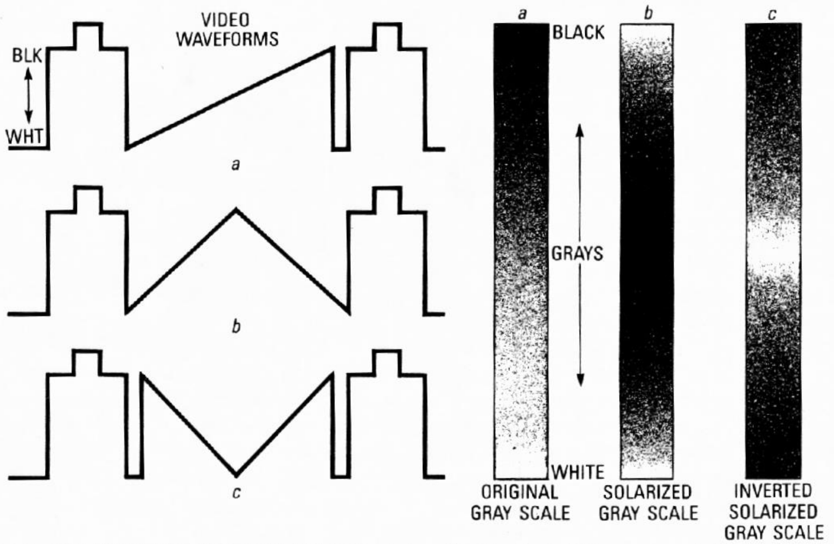

FIG. 7—SOLARIZATION FOLDS THE SIGNAL back on itself so that white remains white, gray becomes black, and black becomes white, or vice versa. The original signal is shown in *a*. The solarizied signal is shown in *b*. An inverted solarized signal is shown in *c*. The original waveform for each condition is shown in *d*.

Solarization

In contrast to posterization, solarization is a linear distortion technique. However, as shown in Figs. 7-*a*, *b*, *c*, and *d*, what is done is to fold the gray scale back on itself. White becomes white, light gray becomes dark gray, gray becomes black. As the tones tend further toward black, the video output goes back towards white. Therefore, the picture highlights are positive and the shadows turn negative. Inversion can be used in conjunction with solarization, so that the shadows are positive and the highlights are negative.

Solarization is accomplished by using an amplifier that has the transfer characteristic shown in Fig 8. As shown, two amplifiers, one having a gain of two and one with a delayed gain of minus four—with their outputs combined—result in the necessary transfer characteristic. Although gains of two and four are shown, we can use any other 2:1 combination, resulting in a different gain figure. In our palette, we used gains of 0.5 and 1, giving an overall loss. That was done so that a larger input signal could be used.

As shown in Fig. 9, the solarization circuit uses a single op-amp. Assume that diode D1 is reverse biased, and that resistor R3 provides unity gain. Since R1 = R2, only half of the input signal appears at the inverting input.

As the input goes positive, D1 gradu-
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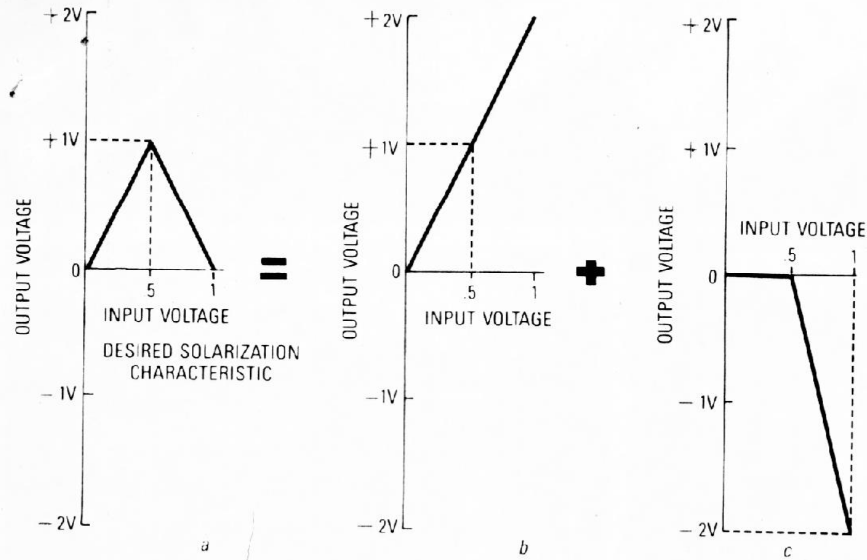

FIG.8—THE DESIRED AMPLIFIER characteristic needed for solarization, shown in *a*, can be attained by using two amplifiers having the characteristics shown in *b* and *c*. The video palette, however, accomplishes the same task using single controlled-gain amplifier.

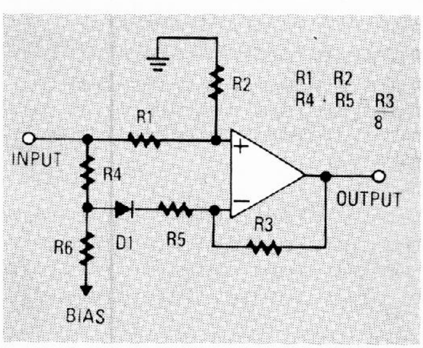

FIG. 9—BY VARYING THE FEEDBACK characteristics of an op-amp, a single stage of amplification can be made to function as a solarizer.

ally becomes forward-biased: The bias from R6 determines the level at which that occurs. When D1 conducts, resistors R3, R5, and R4 form a new feedback network that causes the amplifier gain to increase and also change polarity, which causes the output to reverse direction as the input gets larger.

Strictly speaking, R3 should equal four times R4 and R5. We got visually more pleasing results when R3 equaled eight times R4 and R5; but that is a matter of personal taste, and is left to the reader's preference. The point at which gain reversal occurs depends on R6's bias. (Optimum visual effect requires adjusting both the solarization input drive level and the foldover controls. The output level determines the picture contrast and also can be adjusted separately. We decided to use three controls in the circuit for best flexibility.

Referring back to Fig. 2, the three circuits on the effects board can be operated simultaneously to create various interesting effects. The inverted output, or the uninverted but processed luminance is eventually fed into the summing amplifier. When using the special effects, the main luminance level control is usually—but not always—set to zero. The only thing the operator must watch for is that the video levels do not exceed the sync tip or blanking levels, which can cause picture instability. Bear in mind that the summing amplifier merely combines everything; it can handle only two to three volts peak before clipping occurs.

Next time we'll show how to build, adjust, and troubleshoot the palette. **R-E**