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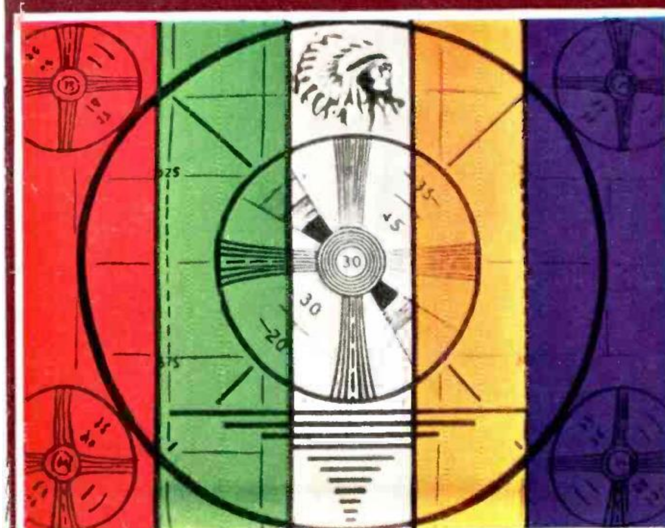
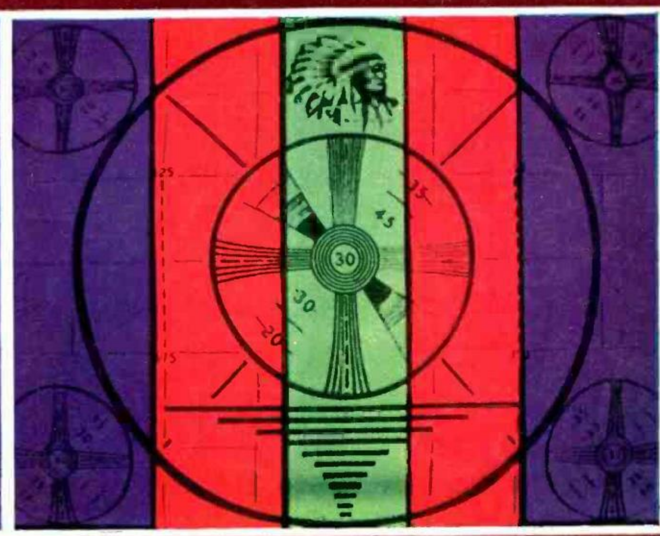
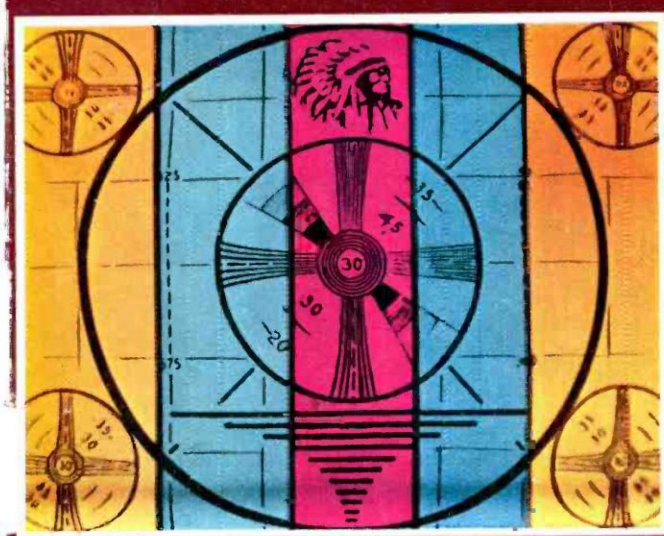


A SINGLE, DOUBLE AND TRIPLE COMBINATIONS

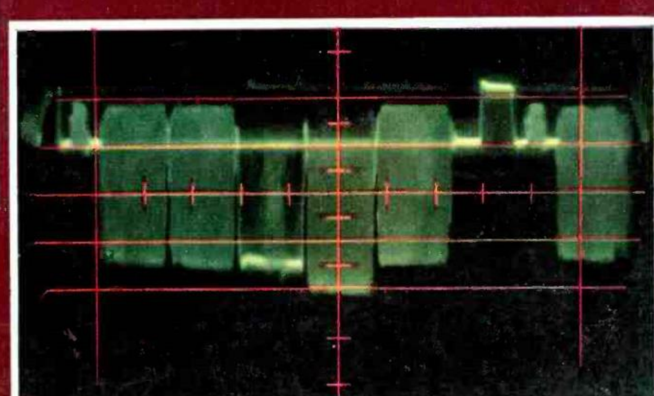


B SINGLE PRIMARIES—blue, red, green

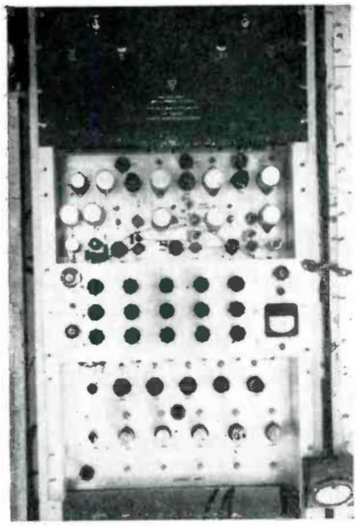


C PAIRS OF PRIMARIES—yellow, cyan, magenta

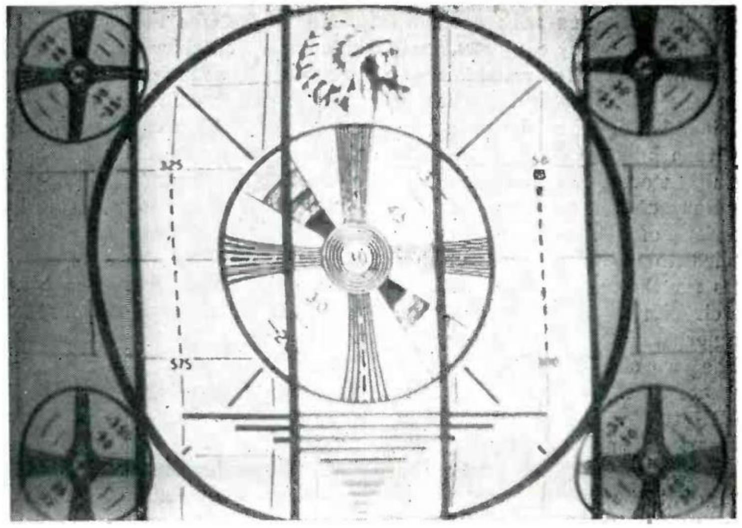
Color-TV Signal-Generator Patterns



D DOT-SEQUENTIAL WAVEFORM—corresponding to picture A



Color generator, exclusive of power supplies, occupies 24½ panel inches



In color, bars from left to right would appear as red, green, white, yellow and blue for this particular setting of color potentiometers

Picture Generator

Simple equipment is added to conventional black-and-white picture-generating setup to provide color-striped pictures for testing either simultaneous and dot-sequential systems or field-sequential system. Complete adjustability of colors is possible

By R. P. BURR, W. R. STONE and R. O. NOYER

Hazeltine Corporation
Little Neck, New York

THE CURRENT INTEREST in color television systems is, among other things, likely to produce the need for a simple means of generating color television signals.

In the early stages of the present monochrome television system, complete camera chains were soon discarded in favor of the simpler and more reliable monoscope pattern generator as a general laboratory and test line video signal source. In the design, development, and manufacture of color television apparatus, a simple and reliable signal generator is also highly desirable. Current techniques for the production of color television signals rely heavily upon flying-spot scanners or direct-pickup cameras. Although these devices may be made reliable, they are not particularly simple, nor are they inexpensive. In addition, the versatility of subject material provided by such apparatus is a feature of questionable merit for routine testing.

The purpose of this article is to describe a simple all-electronic source of color television images which may be added to an existing black-and-white television installation. The unit will provide signals for either simultaneous and dot-sequential systems employing current monochrome standards or for the recently standardized field-sequential system.

Output from the apparatus consists of a monoscope or other television test pattern upon which is superimposed a series of five vertical bars. The hue and saturation of each bar is independently variable and under the operator's control. Any color combination whatever, including black or white, may be obtained. The color signal generator derives its input signals, including the monoscope pattern, from existing television equipment.

Color Mixers

A block diagram of the signal generator is shown in Fig. 1. The black-and-white video pattern to be "colored" is inserted at the lower left of the sketch. Following amplification in the two-stage video amplifier, the signal is applied simultaneously to the three mixer, or modulator, stages marked green, red and blue. When no modulating

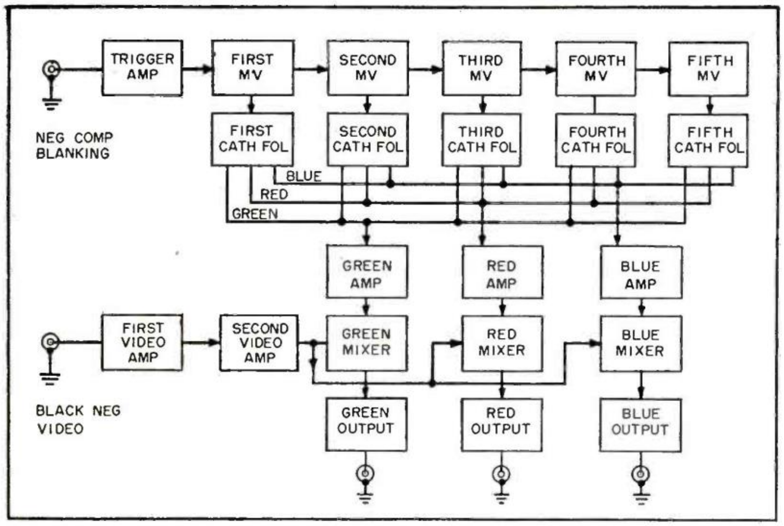


FIG. 1—Chain of five multivibrators, triggered by blanking signal, turns on five different colors during horizontal trace

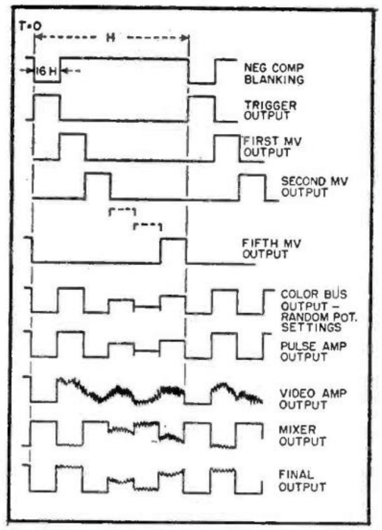


FIG. 2—Waveform chart shows functions of various stages during trace

For Color Television

signal is applied to the three mixers, we may assume that the gains of each mixer-output tube combination may be so adjusted that the green, red, and blue output signals are indentical, or nearly so; that is, the apparatus becomes essentially a triple output distribution amplifier. For a properly balanced three-color display, this condition will correspond, by convention, to a black-and-white picture. To obtain a color picture, the gains of the mixer tubes must be individually modulated in some desirable manner. One form of modulating signal which produces a useful geometrical color pattern may be obtained from the components shown in the upper portion of the diagram.

A negative composite blanking signal, that is, a white picture, is used as the triggering voltage for the input stage of a chain of five one-shot multivibrators. The trigger amplifier and first multivibrator are arranged to fire on the trailing edge of the blanking waveform, so that operation of the circuit begins synchronously with the start of the television system trace time. Upon completion of its turnover cycle the first multivibrator triggers the second of the chain; the second fires the third, and so on, until the action terminates with the operation of the fifth and last stage.

Each multivibrator is adjusted to have a pulse width of approximately one-fifth the system trace time, so that the entire action requires one line of the television picture. Consequently, the voltages applied to the cathode follower stages consist of five successive pulses occurring in time sequence across the picture from left to right.

The cathode followers (which also operate as limiters) are provided with a network of three potentiometers and three resistors in each of their cathode circuits. The object of this arrangement is to permit any amplitude of any one or more of the five pulses to be delivered to the three bus bars marked green, red and blue. The bus bars, in turn, are connected via suitable amplifiers to the suppressor grids of the green, red and blue mixer-modulator tubes, so that modulation of the input video signal in accordance with the various pulse amplitudes is the end result.

Figure 2 illustrates the functions of the various components of the block diagram. The blanking signal which triggers the five multivibrators is at the top. The second line shows the output of the trigger amplifier, an inversion of the input voltage. The first pulse generator output is shown on the third line of the chart. The second, third, fourth, and fifth pulses are generated in sequence—each one generated by relaxation of the previous stage.

A random mixture of the five pulses is shown at the center of the figure, while modulation of a video signal by this waveform is shown on the remaining lines. It should be noted that the bottom line, marked final output, represents the signal for one color only. When the apparatus is adjusted to produce a color picture, the three signal outputs will differ from one another as the green, red, and blue content of the picture varies across the image.

Since the timing of the pattern generator is determined entirely by

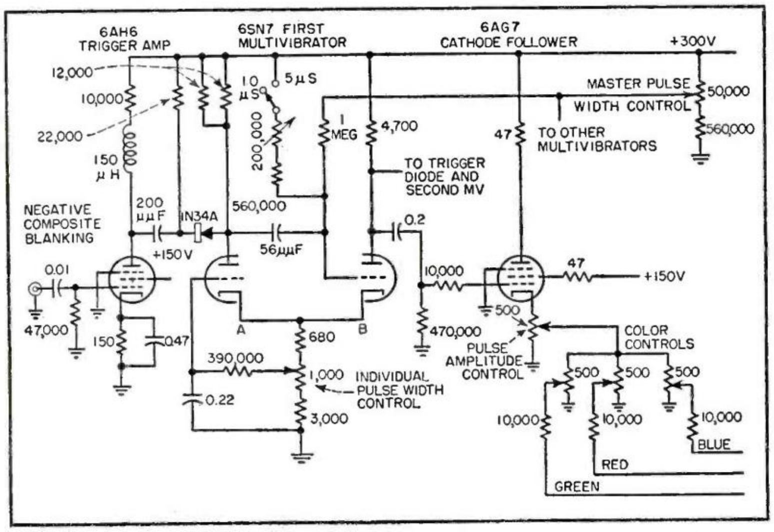


FIG. 3—Circuit of keying pulse generator. The switch adjusting the multivibrator time constant allows quick changeover from present standards to field-sequential standards

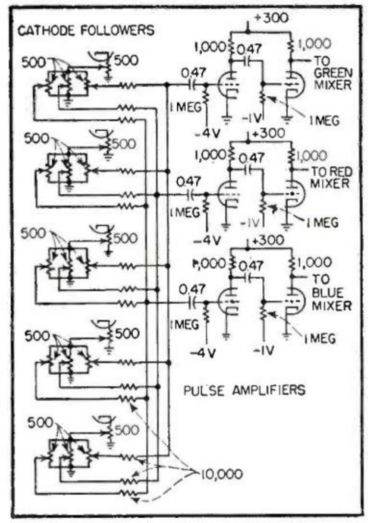


FIG. 4—Fifteen potentiometers in pulse mixer circuit shown permit adjustment of color in each band

the repetition rate of the input blanking signal, operation at line rates other than that standardized for black and white television may be obtained by changing the five pulse durations appropriately. To accommodate operation with the field-sequential color television system, we have included a ganged switch in the active grid time constant of each multivibrator, which may be used to halve the pulse width. The waveform chart would be the same for the higher speed operation.

Trigger Circuit

A simplified schematic diagram of the trigger amplifier and one of the pulse generators is shown in Fig. 3. The multivibrator is of the cathode-coupled one-shot type and is straightforward in design. The negative composite blanking signal applied to the grid of the 6AH6 trigger amplifier causes an abrupt drop in the amplifier plate voltage synchronous with the trailing edge of the blanking signal. The 6SN7 multivibrator and the 1N34A diode are arranged in such a way that the pulse generator is sensitive only to negative-going voltages. Accordingly, operation of the multivibrator is initiated by the trailing edge of the blanking signal.

The relaxation time of the multivibrator is controlled in the usual manner through the application of a variable bias voltage to the active control grid. In addition, as previously noted, a switch is provided to vary the time constant in this grid by a factor of two-to-one so that operation on either field sequential color standards or current black and white standards may be obtained. The second multivibrator of the chain is triggered by recovery of the first inasmuch as a large negative voltage drop appears at the first multivibrator output plate at this point in the cycle.

Mixing of the pulses generated by the multivibrators of Fig. 3 occurs in the cathode circuits of the five cathode followers which are shown at the center of the block diagram. In Fig. 4 may be seen the manner in which the five cathode-follower outputs are combined into three independently variable modulating waveforms. The word "independent" is based on the assumption that one percent cross-coupling between the various pulse amplitude controls is tolerable. Practical laboratory experience with the equipment indicates this to be the case.

Mixer Circuit

The circuit arrangement is such that any amplitude of any pulse may be applied to any one of the three bus bars by appropriate manipulation of the fifteen potentiometers. With reference to the generated color pattern, it might be said that the potentiometers of cathode-follower number one correspond to the red, green, and blue values of bar number one in the color picture, and so on.

Initial amplitude adjustment of each keying pulse is provided by a screw-driver adjustment, so that the pulse voltages from the cathode followers may be equalized. The 10,000-ohm resistors between the potentiometers and the bus bars provide isolation from crosscoupling. A simple two-stage amplifier is provided to raise the output from each color bus bar to a level suitable for operation of the video modulator tubes.

One of the modulator stages is shown in Fig. 5. The video signal is applied to the control grid of a 6AS6, while the pulse modulation voltage is applied to the suppressor. The d-c component is reinserted for both input signals so that operation of the modulator will be unaffected by variations in duty cycle of the video or pulse information. A meter is provided which may be switched into the cathode circuit of each modulator tube for the purpose of setting black current to within a few hundred microamperes of cutoff. Each modulator is followed by a conventional high-impedance current driver for low-impedance lines. The signal delivered to a 75-ohm cable from each output may be adjusted to a maximum of two volts peak-to-peak. The output signal does not contain synchronizing information since sync is seldom, if ever, present on a video signal at this point in a color television system.

Color-Monochrome Switch

Finally, the pattern generator contains one very useful device which will be appreciated by those who have been working with color television systems. This is a switch, called a COLOR-MONOCHROME switch, which may be operated to produce an unmodulated black-and-white output from the apparatus. When set to the COLOR position, the generator produces the color pattern set-up on the control panel. When the switch is set to MONOCHROME, the generator becomes essentially a distribution amplifier; that is, the video signals on all three outputs are identical, and are unmodulated. This arrangement is useful for checking the color balance of subsequent apparatus.

Some typical laboratory applications of the pattern generator's color signals might be of interest. For this purpose we will choose a monoscope test chart modulated so that the colors produced are red, green, white, yellow and blue as shown in the test pattern photo.

Oscillograms

First, this color signal may be applied to a dot-sequential color transmitter and the resulting video output observed on an oscilloscope operating at line rate. The oscillogram of Fig. 6A shows the sync signal, the color sync burst, and the video information together with the superimposed color carrier. The transmitter we are observing samples the color information at symmetrical angles, and is adjusted in accordance with the operating practice implied in the early proposals for a color television system of this type. It can be seen that the red, green, and blue areas, being saturated single colors, cause the color carrier to swing below black. For the yellow area, which is a saturated two-color area, overmodulation beyond reference white occurs, while for the white central area, the color carrier disappears altogether.

If the color carrier is removed, as in Fig. 6B, it may be seen that this transmitter is correctly adjusted to weigh red, green, and blue equally in the monochrome component of the transmitted signal. It is worthy of note that for any one color the contribution to the monochrome is one-third; for yellow it is two-thirds; and for white, of course, three-thirds.

Having checked the transmitter adjustments, the performance of the color receiver may be examined. It is desirable that the receiver reproduce the colors of the original scene with reasonable accuracy. That is, the phase of the local color subcarrier oscillator at the receiver must be correctly located.

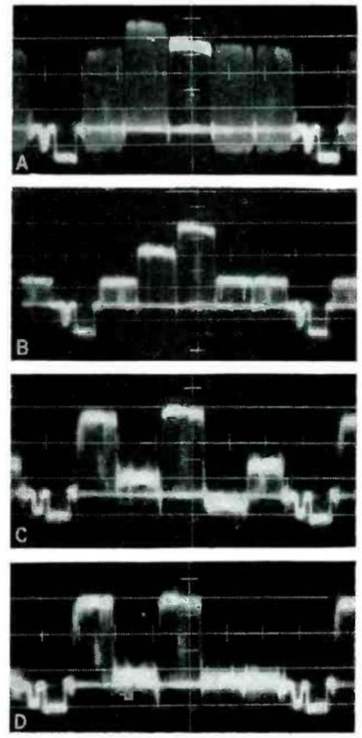


FIG. 6—Oscillograms show waveforms with different combinations of information, as explained individually in text

Let us connect the oscilloscope to the blue video signal channel of the receiver and observe the result. The original colors were red, green, white, yellow and blue, in that order. Therefore, an oscilloscope connected to the blue channel should show no signal during the red and green bars, full signal for the white area, no signal for the yellow bar, and full signal for the blue area. The oscillogram of Fig. 6C shows that this is not the case. Due to misphasing at the receiver, both the red and green areas of the signal show some output in the blue channel. In particular, the blue tube is slightly illuminated during the red area while it is driven below cutoff during the green area. In addition, the blue tube is not at full brightness during the blue area. Obviously, a readjustment of the receiver phase control is required. This operation is readily performed by adjusting for minimum signal in the red and green areas.

Figure 6D shows conditions prevailing in the blue channel for correct phasing.

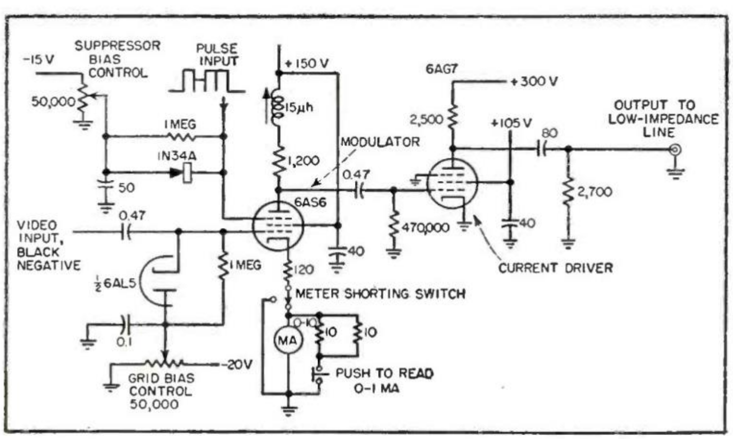


FIG. 5—Video information is fed to control grid of modulator, while pulse modulation voltage is applied to the suppressor