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LB-932

A COLORPLEXER FOR THE GENERATION OF COLOR TELEVISION SIGNALS IN CONFORMANCE WITH NTSC SPECIFICATIONS OF JULY 21, 1953

RADIO CORPORATION OF AMERICA
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Approved

Stanton M. Seeley

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Introduction

The apparatus described in this bulletin performs the function of combining or multiplexing three simultaneous color video signals (such as those derived from a color camera, slide scanner or test pattern generator) so as to permit their transmission as a compatible color television signal in a single six-megacycle channel. The apparatus, in addition to the multiplexing operation, provides means for the addition of scanning and color synchronizing information to produce a composite color signal in conformance with the National Television System Committee Signal Specification adopted July 21, 1953.

There are a variety of circuit configurations which might be used to perform the necessary functions. The particular arrangement described herein was chosen to provide a reasonable balance between stability, ease of operation and the requisite adaptability to follow the evolution of the present signal specifications.

The bulletin includes circuit description, construction data and operating notes.

General Discussion

In the generation of the color picture signal[1,2] by the means to be described in this bulletin the basic video signals which are employed are E_R', E_B' and E_G'. These are the gamma-corrected voltages corresponding to the red, blue and green signals during the scanning of a given picture element by the color television camera. In order to obtain the color picture signal, E_M, certain operations are performed on these video signals which include:

(1) The addition of specified portions of each of them to form the monochrome signal E_Y';

(2) The combination of specified portions of the basic signals to form the video color signals E_I' and E_Q';

(3) The bandwidth limiting of the E_I' and E_Q' signals;

(4) The equalization of the time delays of the E_I', E_Q' and E_Y' signals;

(5) The combination of specified portions of the E_Q' and E_I' signals to form the color-difference signals $E_B' - E_Y'$ and $E_R' - E_Y'$;

(6) The phase and amplitude modulation of the subcarrier by video color-difference signals to form the carrier chrominance signal;

(7) The generation of a reference burst of chrominance subcarrier in proper phase

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[1] G.H. Brown and D.G.C. Luck, "Principles and development of Color Television Systems", *RCA REVIEW*, Vol. XIV, No. 2, June 1953.

[2] R.D. Kell and A.C. Schroeder, "Optimum Utilization of the Radio Frequency Channel for Color Television", *RCA REVIEW*, Vol. XIV, No. 2, June 1953.

relationship to the carrier chrominance signal;

(8) The addition of specified portions of the monochrome, the carrier chrominance, the sync and the burst signals.

The signals produced in this manner are in conformance with the NTSC Signal Specification of July 21, 1953, a copy of which is included as Appendix A of this bulletin.

Fig. 1 is a block diagram of the apparatus, which consists of two units. The unit to the left of the dotted line is called the "Matrixer". The unit to the right is called the "Modulator and Adder"; the combination of the two is called a "Colorplexer". The aforementioned functions are performed in the following manner. Portions of the E'_R, E'_G and E'_B signals are added or subtracted in the block labeled Q, I, Y MATRIXES in accordance with the following relationships derived from the Color Signals Specifications

$$E'_Q = 0.21\ E'_R - 0.53\ E'_G + 0.31\ E'_B \quad (1)$$

$$-E'_I = -0.59\ E'_R + 0.28\ E'_G + 0.32\ E'_B \quad (2)$$

$$E'_Y = 0.3\ E'_R + 0.59\ E'_G + 0.11\ E'_B \quad (3)$$

After generation in the matrix, the E'_Q signal passes through the block labeled Q LOW PASS FILTER which limits the bandwidth of this signal to approximately 600 kc. The E'_I and E'_Y signals pass through the delay lines labeled I DELAY and Y DELAY respectively, which serve to equalize the delays of the E'_Q, E'_I and E'_Y signals. The E'_Q and E'_I signals are then combined in a second matrix labeled B-Y, R-Y MATRIXES in accordance with the following relationships derived from the Color Signal Specifications

$$E'_B - E'_Y = -1.1\ E'_I + 1.7\ E'_Q \quad (4)$$

$$E'_R - E'_Y = 0.96\ E'_I + 0.62\ E'_Q \quad (5)$$

These two signals and the E'_Y signal then leave the Matrixer and pass into the Modulator and Adder.

The $E'_B - E'_Y$ and $E'_R - E'_Y$ signals enter the Modulator and Adder and pass through GAIN controls and LOW PASS FILTERS, which limit the bandwidths of these signals to approximately 3 Mc, and then into the SINE and COSINE MODULATORS. Clamp pulses, which are used in the restoring of the d-c component of the color difference signals at the grids of the modulators, are generated from the sync signal in the block labeled CLAMP PULSE GENERATOR. The burst of color subcarrier is obtained by adding a pulse, which is generated from the sync signal in the BURST PULSE GENERATOR block, into the $E'_B - E'_Y$ video channel. The outputs of the modulators are then added to form a signal containing the chrominance information and the burst. The E'_Y signal enters the Modulator and Adder through the Y GAIN control and passes through the Y DELAY NETWORK. It is then added, along with the sync signals, to the carrier chrominance signal, thereby completing the generation of the composite color signal.

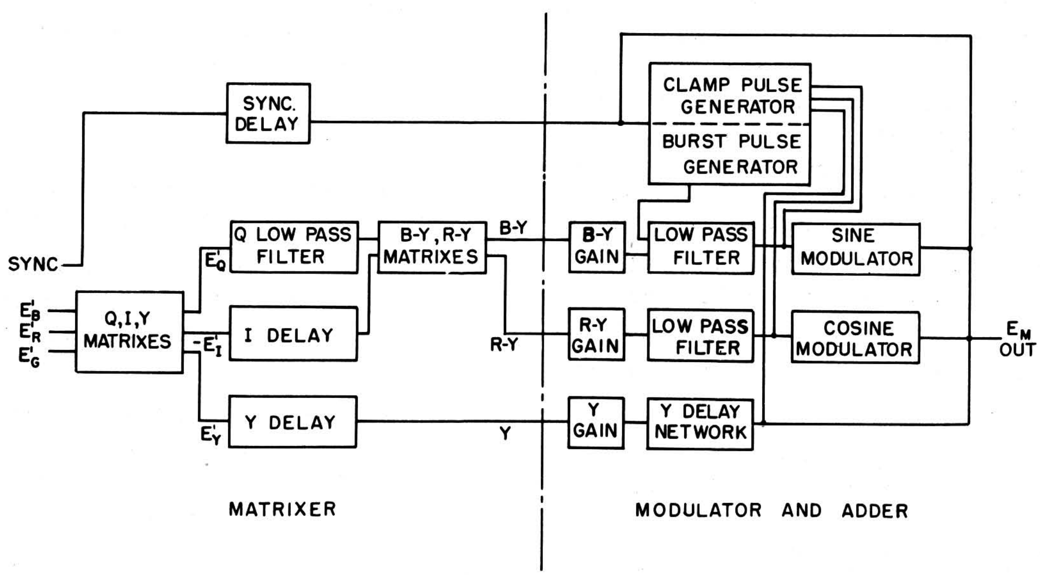

Fig. 1 - Block diagram of Colorplexer.

The total delay of the video signals in passing through the apparatus is approximately 2 μsec; consequently it is desirable to provide for a similar delay of sync signals within the colorplexer. This is done in the Matrixer in the block labeled SYNC DELAY.

The signals required to operate the units are:

(a) black level negative E'_R, E'_G and E'_B video signals at an amplitude of 1 volt peak-to-peak;

(b) negative-going Sync signal at from 3 to 4 volts peak-to-peak;

(c) negative-going Vertical Drive signal at approximately 4 volts peak-to-peak and

(d) 30 volts peak-to-peak of 3.579-Mc subcarrier frequency signal. This may be supplied from apparatus such as that described in *LB-853, Interlaced Sampling-Signal Generator* and supplement *LB-853A*.

The output signal from the colorplexer is 1 volt peak-to-peak into a 75-ohm line.

Since the complete colorplexer consists of two chassis, the detailed description of the units which follows will be presented in two parts.

PART I MATRIXER

Description of Circuits

Referring to Fig. 2, the schematic of the Matrixer, the video signals E'_G, E'_R and E'_B enter the chassis at points labeled G-IN, R-IN and B-IN respectively. The input impedance at these points is 75 ohms.

The generation of the E'_Q signal requires certain specified positive amounts of E'_R and E'_B and a specified negative amount of E'_G as shown in Eq. (1). To obtain the $-E'_G$, the E'_G signal passes through a potentiometer labeled Q BAL, and is then inverted by means of the amplifier V1 whose gain is stabilized by the use of cathode degeneration. The combination of the load resistance and tube output capacitance has a small but undesirable effect on the response of this stage. A 27-μμf high-frequency cathode bypass capacitor is employed to compensate for this effect. The $-E'_G$ signal out of the inverting amplifier V1 is added to the required portions of the E'_R and E'_B signals in a fixed resistance adder labeled Q MATRIX to form the E'_Q signal at the test point labeled Q'. This signal then passes through a low-pass, phase-compensated filter, labeled Q FILTER, whose frequency response is shown in Fig. 3, and thence to the Q ON-OFF switch. The resistance looking back into the Q MATRIX from the filter is 1000 ohms and is of the proper value to terminate the filter at its sending end. With the Q switch in the ON position the total resistance at the receiving end is also 1000 ohms.

The E'_I matrixing is similar to that for the E'_Q signal and is performed in accordance with Eq. (2). In this case negative signal is generated. This is done in the interest of stability and simplicity since only one of the three signals to be added in the I matrix need be inverted.

The E'_R signal passes through a potentiometer labeled I BAL and then into an inverting amplifier V2 which is similar to the E'_G in-

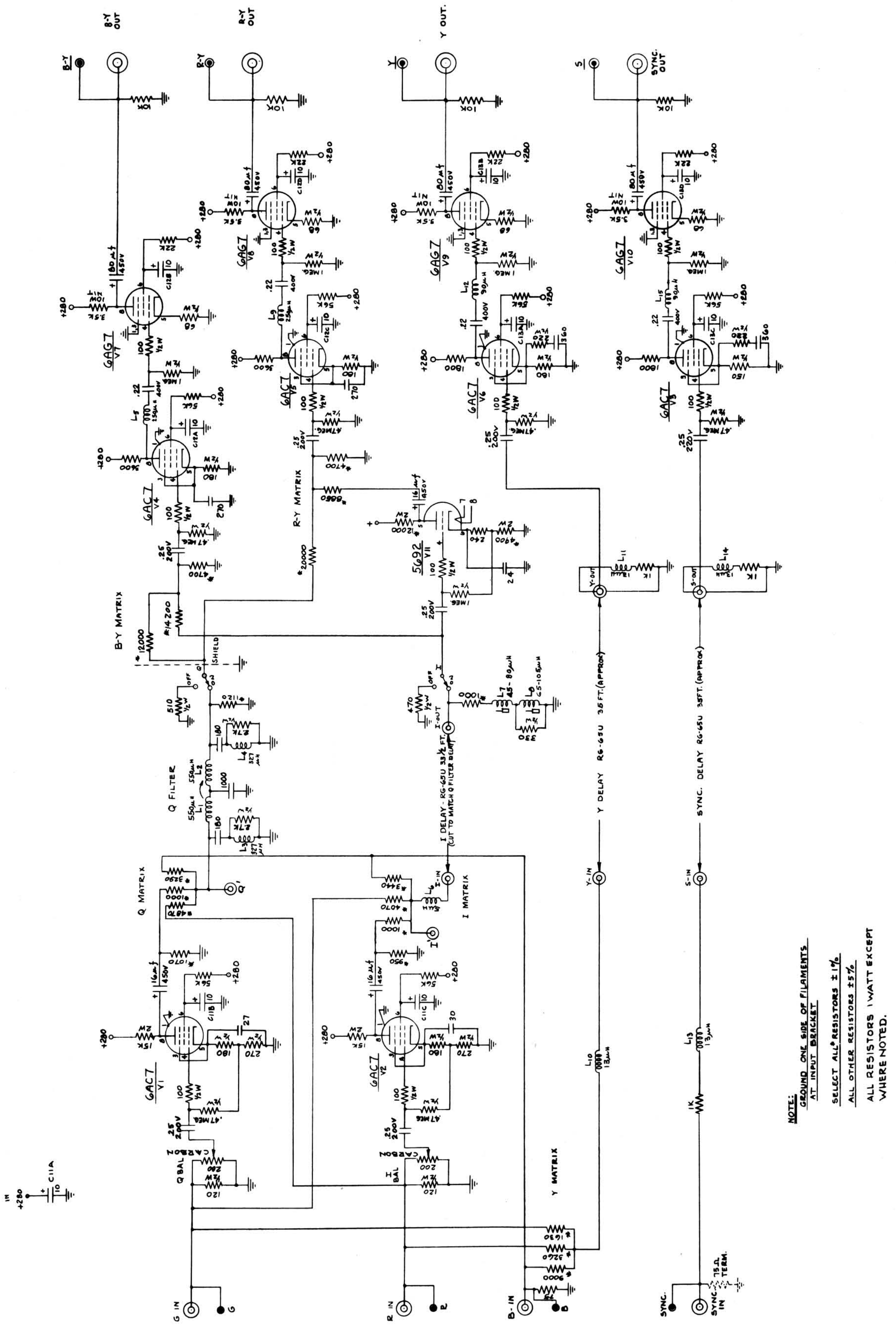

Fig. 2 - Schematic of Matrixer.

verter V1 used in the E'_Q channel. The $-E'_R$ signal from V2 is added to the required portions of E'_G and E'_B in the resistance adder labeled I MATRIX to form the $-E'_I$ signal at the test point labeled I'. The signal then passes through approximately $33\frac{1}{2}$ feet of RG65U delay cable and thence to the I ON-OFF switch. The delay cable is used to give the E'_I signal the same time delay as that experienced by the E'_Q signal in passing through the low pass Q FILTER. The resistance of the I Matrix looking back into it from the I DELAY line is of proper value, when used in conjunction with L6 as shown in Fig. 2, to terminate the sending end of the line. In order to compensate for the high-frequency attenuation along the line, the L7-L8 network is employed in the receiving end termination. The presence of this network results in small ripples on the frequency response of the line because of mismatch at high frequencies. In order to minimize this effect, the resistance portion of the termination, which comprises all the various resistances to ground from the receiving end of the cable, was chosen at a value which is somewhat reduced below the nominal value of the line. A certain amount of high-frequency reflection remains but its effect is negligible since the sending end termination is correct and since the bandwidth is limited in a subsequent filter in the Modulator and Adder unit. E'_Q and $-E'_I$ signals are available at the switches labeled Q and I ON-OFF respectively. The switches are useful in the testing of color television apparatus and are so arranged that when one of them is turned off a resistor is connected into the circuit which maintains the proper relationships in the resistance matrix of the other signal.

In order to make the $E'_B - E'_Y$ signal, portions of the $-E'_I$ and E'_Q signals are added in the resistance adder labeled B-Y MATRIX in the proportions indicated by Eq. (4). The resulting $E'_B - E'_Y$ signal is then amplified in V4 which utilizes a combination cathode-bypass and plate-series-coil (L5) video peaking. The signal then passes through the output amplifier V7 to the output connector, B-Y OUT.

In order to make the $E'_R - E'_Y$ signal, a portion of the E'_Q signal and a quantity of positive E'_I in the proportions shown in Eq. (5) are required. The negative E'_I signal available at the I ON-OFF switch is inverted in amplifier V11 whose gain is stabilized by the use of cathode degeneration. A type 5692 tube is employed which provides sufficiently stable unity gain to obviate the need for a gain control. As in the cases of V1 and V2, a small cathode bypass capacitor is employed. The proper amounts of E'_Q and E'_I are added in the R-Y Matrix resistance adder. The resulting $E'_R - E'_Y$ signal is amplified in V5 which utilizes video peaking similar to that of V4. The signal then passes through the output amplifier V8 to the output connector, R-Y OUT.

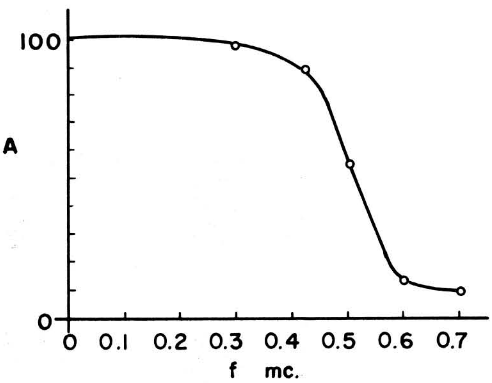

Fig. 3 - Frequency response of Q filter.

The generation of the E'_Y signal is more direct than that of the previously discussed $E'_B - E'_Y$ and $E'_R - E'_Y$ signals. As can be seen in Eq. (3), no negative quantities are required. Consequently, the specified portions of the three input video signals are simply added in the Y MATRIX resistance adder. The resistance looking back into the junction point of the Y MATRIX has the proper value to terminate the sending end of the Y DELAY cable which follows the matrix. The Y DELAY is used to delay the E'_Y signal to match the time delay of the $E'_B - E'_Y$ and $E'_R - E'_Y$ signals. The receiving end of the cable is terminated in a 1000-ohm resistor. The inductors L10 and L11 are included to improve the termination at high frequencies. The E'_Y signal is then amplified in V6 which employs a combination of cathode and plate peaking (L12) which serves to boost the high-frequency portion of the signal in order to make up for high-frequency attenuation in the cable. The overall E'_Y channel frequency response is flat to beyond 4.5 Mc. The signal then passes through the output amplifier V9 to the Y output connector, Y OUT.

The sync delay channel is designed to handle 4 volts peak-to-peak of sync signal with unity gain. The input connection may be bridg-

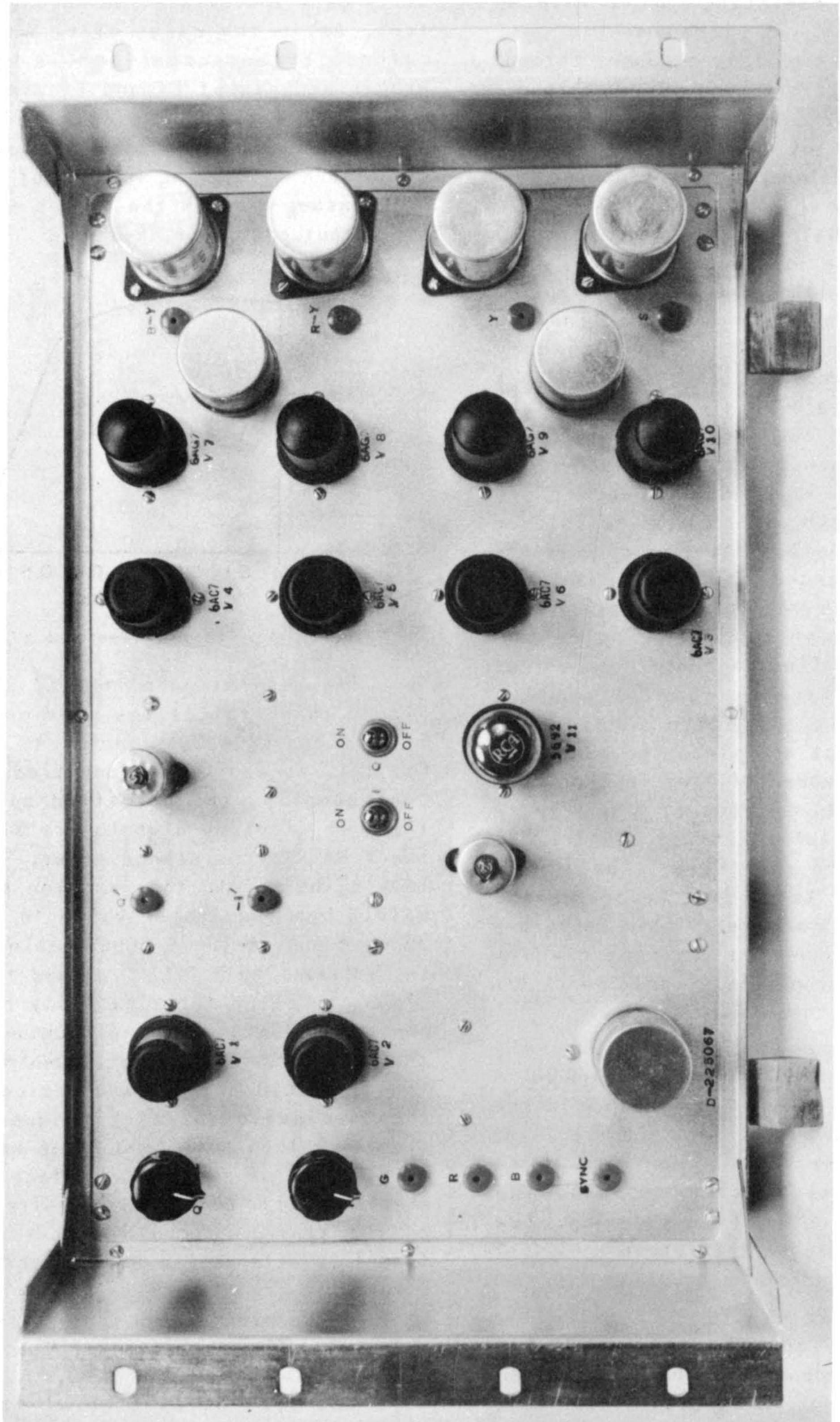

Fig. 4 - Front view of Matrixer.

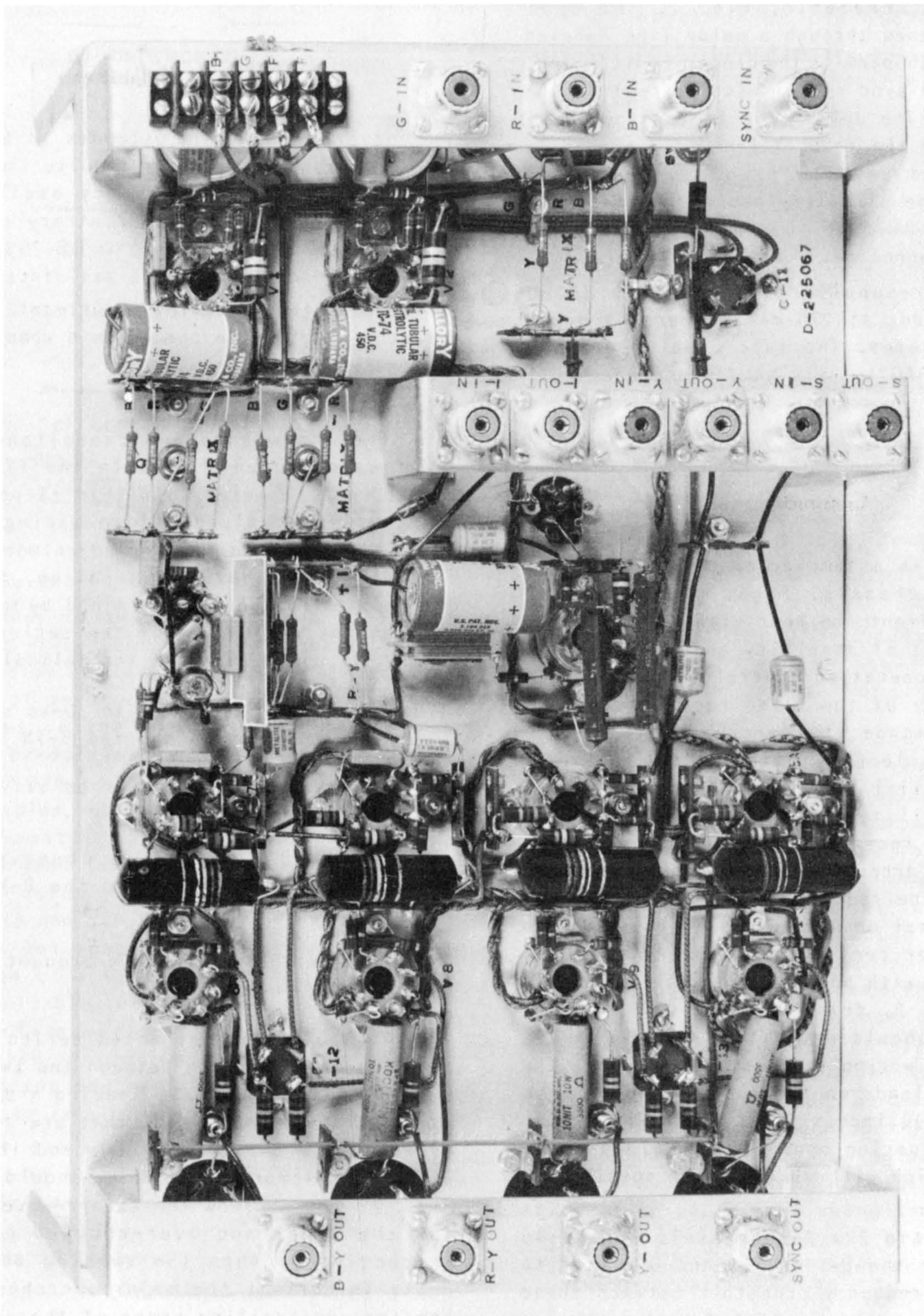

Fig. 5 - Rear view of Matrixer.

ing since the input impedance is approximately 2000 ohms. If termination is desired, a 75-ohm terminating resistor is connected as shown dotted on the schematic, Fig. 2. The sync signal then passes through a delay line labeled SYNC DELAY which permits the proper positioning, in time, of the sync signal with respect to the video signals. The delay line is terminated in the same way as the Y DELAY line. The signal is then amplified and its frequency response corrected in the circuitry associated with V3. It then passes through the output tube V10 to the SYNC OUT connector.

The power-supply requirements are 280 volts (regulated) at 270 milliamperes and 6.3 volts at 6 amperes. The tube complement consists of four 6AG7's, six 6AC7's and one 5692.

Construction

The unit is assembled on a 10½ inch high dishpan-type chassis. Figs. 4 and 5 show, respectively, front and rear views of the unit. In the interest of stability and reduction in the number of operating controls, the matrixes are principally of the fixed resistor type, a fact which demands that proper attention be devoted in the selection of the matrix resistors insofar as initial tolerance, temperature and humidity stability and long time aging are concerned. The recently developed Boron-Carbon and Deposited Carbon types have characteristics which meet these requirements, and are available from several manufacturers in the required value and 1 per cent tolerances. All the resistors marked with an asterisk on the schematic diagram, Fig. 2, form parts of the various matrixes and should be of this type. Care is advisable when wiring these components into the circuits. The leads on the resistors should be kept at least 1¼ inches long, as shown in Fig. 5, and the soldering operation should be done in a manner which will minimize the possibility of overheating.

Note that a 2 x 2-inch strip shield is placed between the B-Y matrix and Q filter to prevent high-frequency crosstalk between these circuits. In general, the high-frequency crosstalk is not serious provided reasonable care in wiring is observed.

The chassis layout and coil data are shown in Figs. 25 and 26 respectively.

Preliminary Adjustments

Several of the adjustments to be made in this and in later sections require the use of a high-quality video-frequency oscilloscope. Except where noted to the contrary an instrument such as that described in LB-793, *A 5-Inch Television Oscilloscope*, is satisfactory.

During the following adjustments, the four output connectors on the chassis should each be terminated in 75 ohms.

Q Low-Pass Filter

The inductance and capacitance of the reactive components used in the filter were checked on a Q meter to within ±1 per cent of the specified values before wiring into the circuit. The only remaining adjustment is the Q channel filter phase compensation, the degree of compensation being determined by the coupling between the two halves of the series coils L1 and L2. It is adjusted in the following manner:

(a) A good quality 15 to 30-kc square wave is inserted into the B-IN connector;

(b) The I switch is turned off and the Q switch turned on;

(c) The B-Y output is observed on the oscilloscope across the B-Y OUT connector; and

(d) The sliding coil is brought nearer to the fixed one.

The coils are connected series aiding so that when the coupling between the two coils L1 and L2 is increased, the leading and trailing-edge overshoot transients that are seen on the oscilloscope should decrease and the compensating undershoot transients should increase. Figs. 6a and 6b show the square-wave responses for the under and over-coupled conditions respectively. When the spacing between the coils is correct the major overshoots on the leading and trailing edges of the square wave will be equal, as in Fig. 6c, and the sliding coil may be cemented into position.

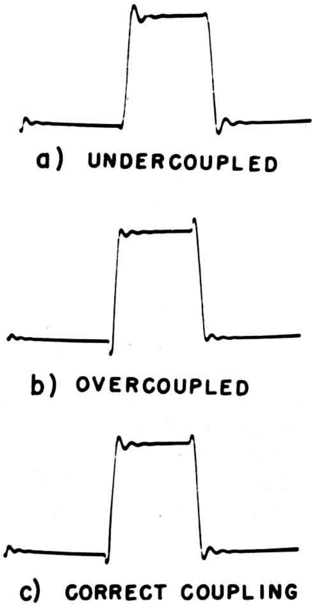

Fig. 6 - Effects of coupling on Q filter square-wave response.

Trimming the Delay Line Lengths

In order to equalize the time delays of the signals which pass through the unit, pieces of RG65U delay cable are used. The lengths of RG65U cannot be specified exactly because of differences in the delay of the cable from different production runs. Delays from 0.041 μs/ft to 0.046 μs/ft have been measured on various samples, so that the lengths called for on the schematic Fig. 2 correspond to the longest lengths (shortest delay per foot) required to match the Q filter delay. It is desirable to use single pieces of the cable but if this is not possible, as for example if a combination of a long and short piece is all that is available to make the required length, the reflections from the coupling are less objectionable if the long piece is at the input or sending end and the short piece is at the output or receiving end of the line.

Before proceeding with the I delay cable adjustment, it is desirable to adjust coils L7 and L8 which are used to compensate for the high-frequency attenuation of the cable. They are adjusted as follows:

(a) A one-volt peak-to-peak video sweep signal such as obtained from the RCA Video Sweep Generator WA-21A is inserted into the R-IN connector;

(b) The I switch is on and the Q switch is off;

(c) The signal at the R-Y OUT connector is observed on the oscilloscope and;

(d) Coils L7 and L8 are adjusted to provide the response shown in Fig. 7.

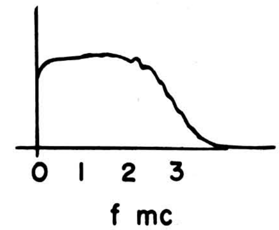

Fig. 7 - I channel frequency response.

To determine the proper length of RG65U for the I delay the following procedure is employed:

(a) Insert the square wave into the R-IN connector;

(b) Turn on the I and Q switches;

(c) Observe the B-Y output on the oscilloscope;

(d) Adjust the I BAL potentiometer to balance out the low-frequency components of the square wave in the output.

The remaining output signal consists of only the high frequencies caused by the differences in rise time in the I and Q channels. When the length of the I DELAY cable is correct, the maximum positive and negative excursions of each of the resulting "spikes" are equal as in Fig. 8c. The effects of making the cable too long or too short are shown in Fig. 8a and 8b respectively. The addition of a 68-μμf capacitor to the end of the cable has the effect of electrically lengthening it by about 1 foot, so that by touching the capacitor off and on, one can determine whether the cable is too long or too short. While the proper length of cable is being determined, a connector is placed on only one end of the cable, contact to the end which is to be trimmed being made by means of short clip leads until the proper length is found, at which time a connector is also placed on this end. The NTSC tolerances on the delay equalization permit maximum differences of ±0.05 μsec. Since ±68 μμf at the end of the cable causes delay changes of approximately this amount, the small differences in capacity between the clip leads and the connector which will finally replace them do not cause an appreciable error.

To adjust the Y channel delay a similar approach is employed:

(a) The square wave is inserted into the R-IN connector;

(b) The I switch is on, the Q switch is off and the I BAL potentiometer is turned to provide maximum signal;

(c) A 2000-ohm potentiometer is connected such that one end is tied to B-Y OUT, its other end to Y OUT, and the oscilloscope is connected to its center contact;

(d) The potentiometer is adjusted to balance out the low-frequency components of the square wave.

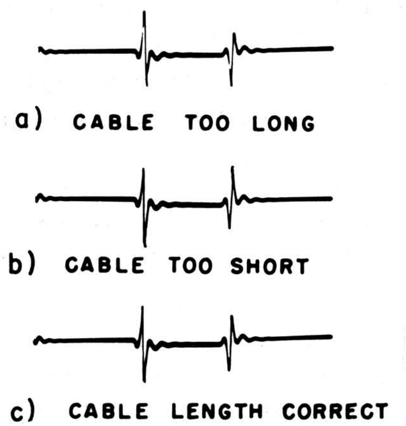

Fig. 8 - Effects of varying length of delay-matching cable.

A picture similar to that of Fig. 8c is seen on the oscilloscope. If the delay is not correct, measures similar to those used in setting I delay are employed.

In order to cut the sync delay cable to proper length, the Modulator and Adder Unit adjustments, which will be described in subsequent sections, should first be completed. Consequently, the manner in which the exact length of sync delay cable is determined will be described in Part II of this bulletin.

Operating Adjustments

For these adjustments, as well as for several others in Part II of this bulletin, use is made of an electronically-generated color-bar pattern such as can be produced by the unit described in LB-819-819A, *A Color Television Test-Signal Generator*. The test pattern and waveforms required for these adjustments are illustrated in Fig. 9. These signals should be carefully set to an amplitude of 1.0 volt PEAK at the G-IN, R-IN, and B-IN test jacks at the input to the Matrixer.

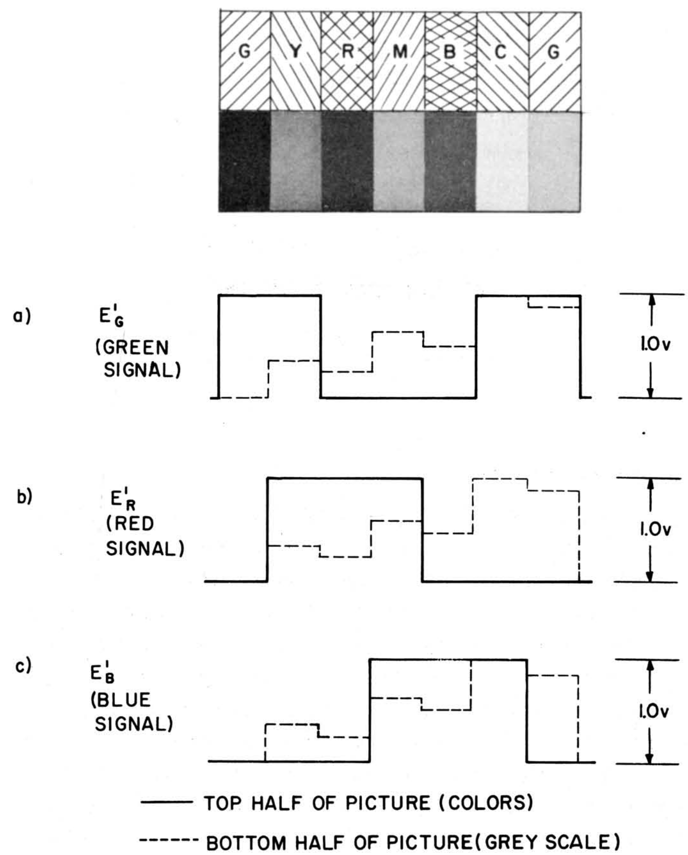

Fig. 9 - Pattern and waveshapes produced by the Color Television Test-Signal Generator.

The Q BAL and I BAL controls are now adjusted as follows:

(a) The oscilloscope is placed across the B-Y OUT connector;

(b) The I switch is turned off and the Q switch is turned on;

(c) The Q BAL control is adjusted to balance out the grey-scale portion of the signal;

(d) The switches are reversed and;

(e) The I BAL control is adjusted to balance out the grey-scale portion of the signal.

These two balances are the only operating adjustments required.

(a)

(b)

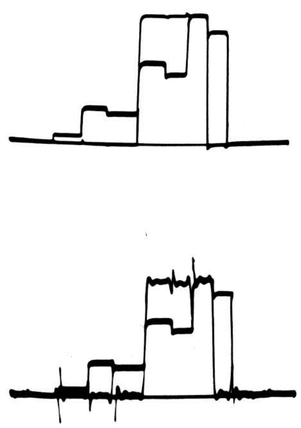

Fig. 10 - Comparison of E_B' input signal (a) with reconstructed E_B' signal (b) at the Matrixer output.

Matrixing Check

To check the overall matrixing accuracy of the B-Y signal the following procedure is employed:

(a) A 2000-ohm potentiometer is tied between B-Y OUT and Y OUT, and the oscilloscope is connected to its center contact;

(b) The potentiometer is adjusted until the output signal most closely resembles the E_B' input signal, as shown in Fig. 10.

With the exception of the edge transients, which are a normal result of the bandwidth limiting performed in this unit, the output signal (b) over its flat portions, should match the input E_B' signal (a) to within ±2 per cent. A similar check is made on the R-Y signal.

Part II MODULATOR AND ADDER

Description of Circuits

Referring to Fig. 11, the schematic of the Modulator and Adder, the three video signals obtained from the Matrixer, $E_B' - E_Y'$, $E_R' - E_Y'$ and E_Y' pass through 75-ohm interconnecting cables and enter the Modulator and Adder chassis at the input connectors labeled B-Y IN, R-Y IN, and Y IN respectively. The cables are terminated by means of a parallel combination of a 120-ohm resistor and a 200-ohm carbon potentiometer. The potentiometers serve as gain controls for the video signals, and are correspondingly labeled B-Y GAIN, R-Y GAIN and Y GAIN. The signals then pass through ON-OFF switches.

The E_Y' signal is then amplified in the parallel combination of tubes V4, V5, and V6, and proceeds through a lumped-constant delay line labeled Y DELAY NETWORK, which forms the plate load of the paralleled tubes. The E_Y' output of the delay line is connected to the plate of V14, at which point the carrier chrominance signal and the sync signal are added to it.

The incoming $E_B' - E_Y'$ signal drives the grid of V1, and a pulse which will generate the burst of reference subcarrier is inserted in the cathode of V1 through an amplitude control labeled BURST HEIGHT. The plate load of V1 is a low-pass filter having good phase response and an amplitude response as shown near the filter on the schematic. The signal is then clamped by means of the gated double diode V7 and passes on to the No. 1 grid of the sine modulator V10.

The d-c clamp level is controlled by the setting of the potentiometer labeled B-Y BACKGROUND. The $E_R' - E_Y'$ signal is treated in a similar fashion by V2 and V8 and is fed to the cosine modulator V11, the d-c clamp level of which is set by the R-Y BACKGROUND control.

The No. 3 grids of the modulator tubes V10 and V11 are supplied with sine and cosine subcarrier-frequency signals, and the outputs are added together in a common load.

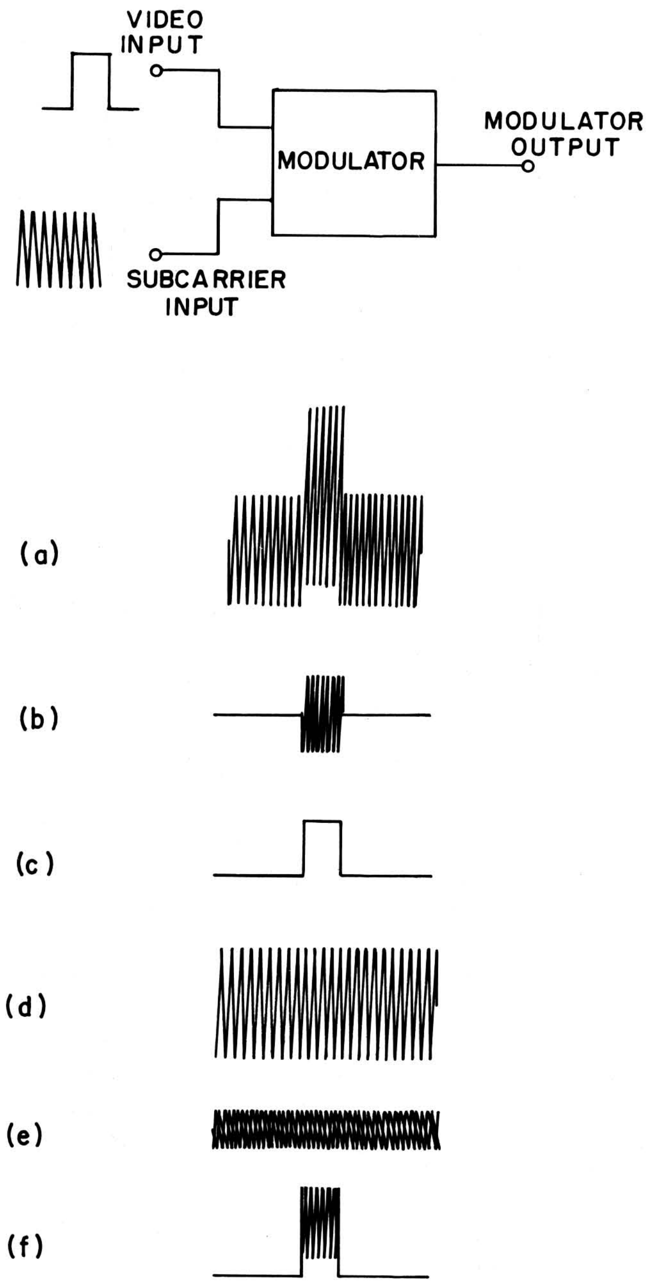

Fig. 12 - Signals involved in the modulation process.

The functions of V12, V14, V9, and V26 can best be understood by reference to Fig. 12, which shows the signals involved in the modulation process. The modulator output (a) contains all of the products of modulation. These include the desired sum and difference terms (sidebands) which form the carrier chrominance signal shown in (b). In addition there are three principal undesired signals which must be removed or balanced out: the original video modulating signal (c), the original subcarrier signal (d) and a strong component at twice the subcarrier frequency (e).

The undesired subcarrier (d) at the output of the modulators V10 and V11 is balanced out by means of the subcarrier bucking amplifier, V12, whose No. 3 grid is supplied with subcarrier signal of the proper phase for balance and whose plate is connected to the common load of V10 and V11. The undesired second harmonic of the subcarrier (e) is removed by a low-pass filter having high attenuation at the second harmonic of subcarrier frequency as shown on the schematic, Fig. 11, above the filter. The signal at the grid of V14 then appears as in Fig. 12f.

The undesired video modulating signals (c) are balanced out in the following manner. A portion of each of them is developed across the 100-ohm resistors in the cathodes of the two modulators V10 and V11. These video balancing signals pass through 1200-ohm isolating resistors and balancing potentiometers labeled B-Y BAL and R-Y BAL respectively, and are added together and amplified in V9 and in V26. Since V26 shares a common cathode load with V14, the video balancing signals applied to the grid of V26 will appear in the plate of V14 without inversion whereas the signals applied to the grid of V14 (and which contain the undesired video signals) will appear in its plate inverted. Consequently by a proper setting of the two balance controls B-Y BAL and R-Y BAL the undesired video components can be balanced out, leaving only the desired chrominance signal at the plate of V14. As shown previously, the E_Y' signal also appears across the plate load of V14. The addition of these two signals at this point produces the color picture signal.

The sync signals are combined with the color picture signal in the following manner. The delayed sync signal is obtained from the

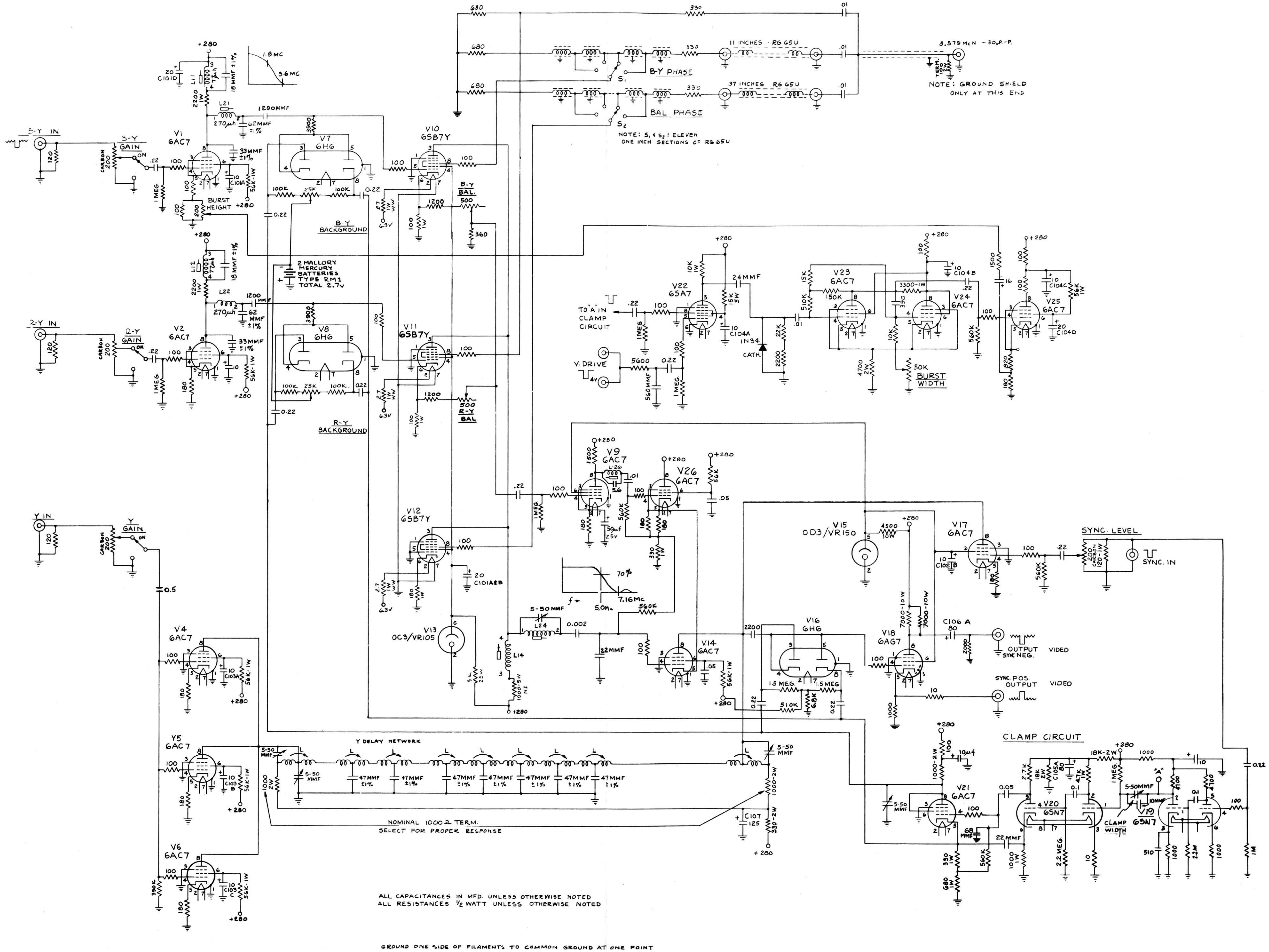

Fig. 11 - Schematic of the Modulator and Adder.

Matrixer. It passes through a 75-ohm interconnecting cable and enters the Modulator and Adder unit at the input connector labeled, SYNC IN. The parallel combination of a resistor and the potentiometer labeled SYNC LEVEL terminate the line, the potentiometer serving as a sync amplitude control. The sync signal is amplified by V17 and then added to the color picture signal at the plate of V14 to produce the composite color signal.

After having been constructed at the plate of V14, the composite color signal is clamped by means of gated diodes, V16, and amplified by the output tube, V18. Negative and positive signal outputs are available, the former as a plate output appearing at the connector labeled SYNC NEG OUTPUT, and the latter as a cathode output from the SYNC POS OUTPUT connector.

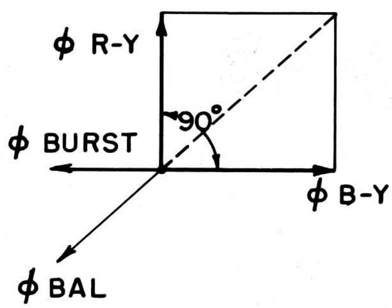

Fig. 13 – Relative phases of the subcarrier driving signals.

The relative phases of the three subcarrier signals required to drive the two modulators, V10 and V11, and the subcarrier bucking amplifier, V12, are shown in Fig. 13. Two of these voltages are separated by 90 degrees resulting in a sine-cosine modulator relationship, while the third is phased so as to balance out the sum of the first two voltages under the condition of zero R-Y and B-Y video signals. The three required phases are derived from the subcarrier-frequency signal which enters the chassis (Fig. 11 schematic) at the connector labeled 3.579 Mc IN. The impedance looking into the following circuit at that point is 330 ohms. Hence, a 100-ohm resistor is added in shunt to provide a net termination of 75 ohms. A combination of fixed and tapped delay line is employed to provide the required phase relationships.

The uppermost path on the schematic Fig. 11 consists of a simple resistance voltage divider, which drives the No. 3 grid of the R-Y, or cosine, modulator V11. The signal which drives the B-Y, or sine, modulator V10 passes through and 11-inch fixed length of RG65U delay cable and as much of the tapped line labeled S1, B-Y PHASE, as is required to provide the 90-degree phase shift. The signal which drives the balance tube V12 passes through a 37-inch fixed length of RG65U and as much of the tapped line, labeled S2 BAL PHASE, as is required to provide the previously-discussed subcarrier balance. The tapped delay lines consist of eleven one-inch sections of RG65U. Since the effective capacitance increases and the effective inductance decreases when the cable is cut into one-inch sections and connected to the switch contacts, the impedance of the tapped line drops from 1000 ohms to approximately 680 ohms. Therefore, 680-ohm resistors are used to terminate the tapped portions of the delay lines. However, the longer fixed pieces of cable have a 1000-ohm impedance so that an additional 330-ohm resistor is placed between the fixed cable and the 680-ohm tapped line.

The clamp and burst signals are both developed from the sync signal which enters the chassis (Fig. 11 schematic) at the SYNC IN connector. The sync is amplified in V19 at whose plate (pin 2) the signal divides into two paths. One path leads through a 5-50 μμf capacitor labeled CLAMP WIDTH into the grid circuit of triode unit No. 1 of V20 (pin 1), an arrangement which differentiates the sync pulses. However, since the grid is returned to 280 volts through a 1-megohm resistor, the tube is normally drawing grid current, and consequently the negative-going leading edge of the differentiated sync signal is amplified while the positive-going trailing edge is suppressed. The resulting pulse is amplified and clipped in the second triode unit of V20 and appears as a large negative-going pulse at the control grid of V21. V21 is arranged as a phase splitter so that the required positive and negative clamping pulses appear at its plate and cathode respectively. These pulses then gate the three clamping double diodes V7, V8 and V16.

The clamping level in the case of the V7 and V8 clamps is principally determined by a 2.7-volt battery (2 Mallory Type RM1 Mercury cells). Small changes in individual clamping levels may be accomplished by unbalancing the clamps by means of the two BACKGROUND controls.

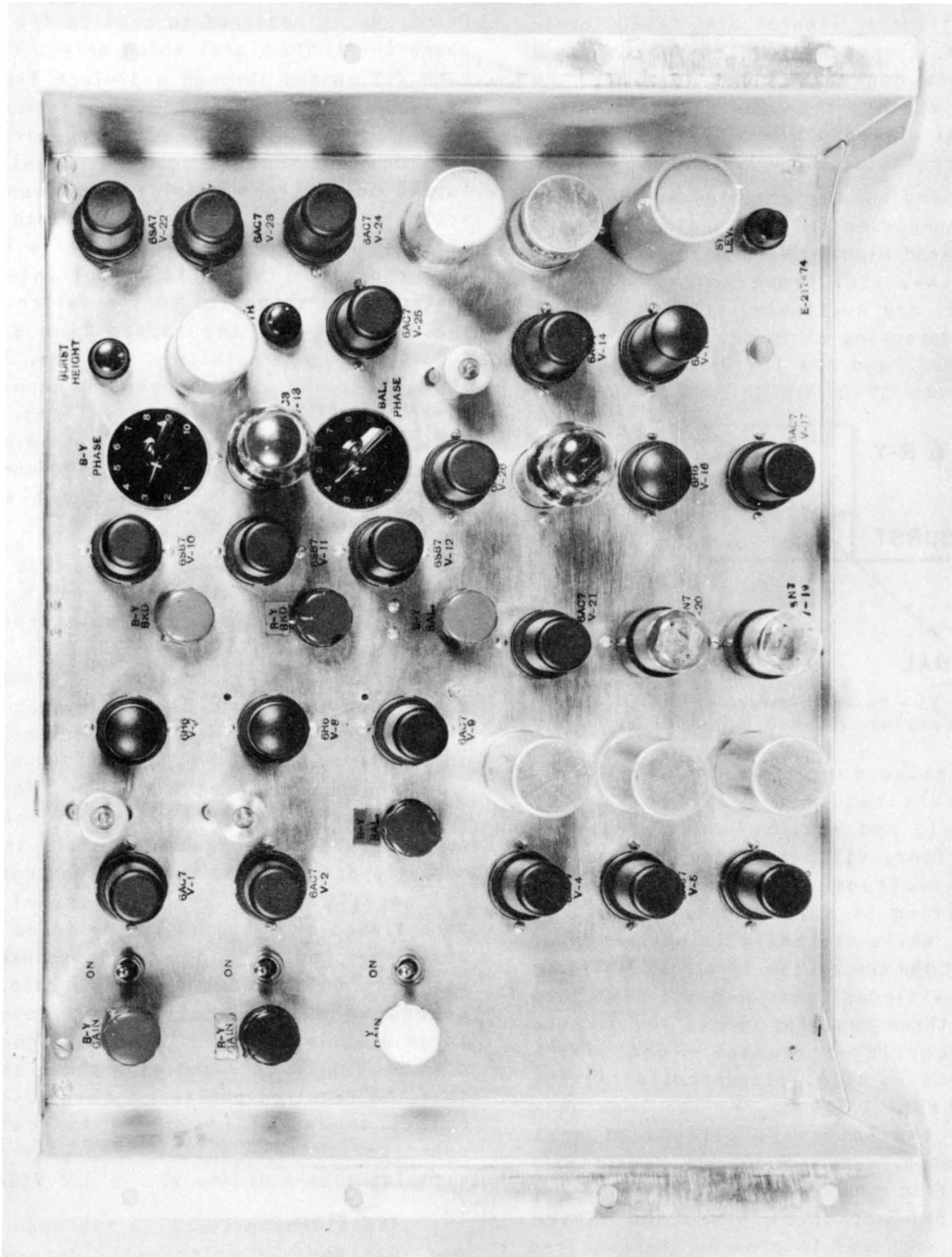

Fig. 14 - Front view of Modulator and Adder.

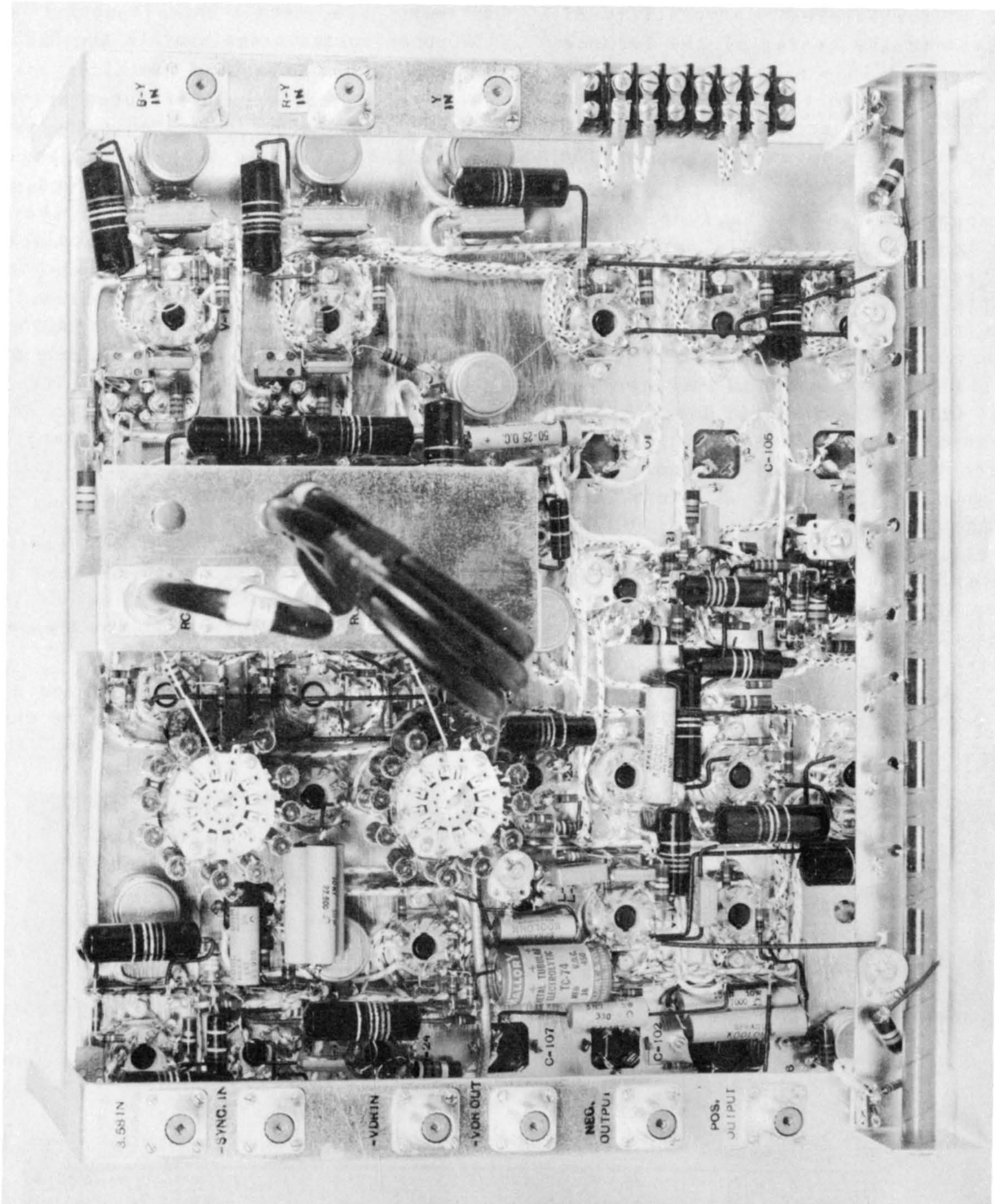

Fig. 15 - Rear view of Modulator and Adder.

In order to minimize the possibility of No. 1 grid emission in the modulators V10 and V11, which may cause an undesirable loading effect on the clamping circuit, the heater voltage of these tubes is lowered to approximately 5.6v. In the interest of stability of subcarrier balance the heater of the balance tube V12 is operated in a similar manner. The lowering of the heater voltage is accomplished by placing resistors in series with the individual heaters of these tubes as shown on the schematic.

The second path which the sync signal takes after leaving the pin 2 plate of V19 (point "A") leads to the No. 3 grid of V22 where it starts its development into the burst signal. First, the equalizing and broad vertical pulses in the sync signal are deleted by gating the No. 1 grid of V22 with a signal derived from Vertical Drive. The Vertical Drive signal enters the chassis through a bridging connection at the V DRIVE connectors and is R-C filtered to lengthen its rise time before being applied to the No. 1 grid of V22. Next, the remaining positive-going sync signal appearing in the plate of V22 is differentiated. The 1N34 crystal diode suppresses the positive portion of the differentiated signal, so that only the negative-going trailing edge appears at the grid of V23. A tap on the differentiating resistor is provided to permit observation of the signal at this point. The negative pulse triggers a monostable multivibrator, composed of V23 and V24. The potentiometer in the grid return of V24 labeled BURST WIDTH permits the adjustment of the width of the multivibrator pulse. This pulse is clipped by the cathode follower, V25, from whence it goes through the 1500-ohm isolation resistor to the BURST HEIGHT control in the cathode of V1.

Two voltage regulator tubes are employed in the unit. The screen grids of the modulators V10, V11 and V12 are supplied by the voltage regulator tube V13, and the screen grids of V9, V17 and V18 are supplied by the voltage regulator tube V15. The power-supply requirements are 280 volts (regulated) at 370 milliamperes and 6.3 volts at 9.5 amperes. The tube complement consists of thirteen 6AC7's, three 6SB7Y's, three 6H6's, two 6SN7's, one 6SA7, one 6AG7, one 0C3/VR105, one 0D3/VR150.

Construction

The unit is assembled on a 14-inch high dishpan-type chassis. Figs. 14 and 15 show, respectively front and rear views of the unit. Fig. 16 is a photograph of the tapped delay line switch.

Coils L11, L21, L12 and L22 and all 1-per cent tolerance capacitors should be checked on a Q meter before wiring.

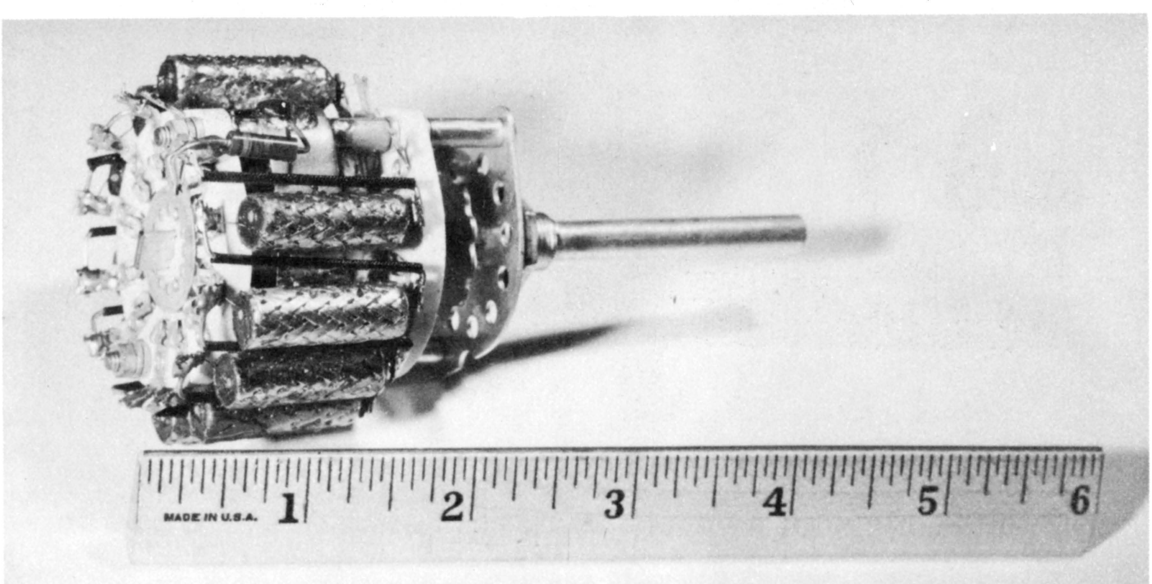

Fig. 16 - Tapped delay-line switch.

A reasonable amount of care is desirable in the handling of the Y DELAY NETWORK which can be seen near the bottom of the chassis in Fig. 15. Undue pressures exerted on it may result in damage to the coil center-tap leads. The leads at the input and output should be wired to achieve minimum stray capacitance. All terminating resistors and capacitors should be mounted on the Y DELAY NETWORK bracket which also serves as a partial shield.

Care must be taken in the wiring of the clamp generating circuit and leads to the clamp diodes to prevent pickup of this signal in the video channels. The clamp-circuit components should be kept away from those components which handle the video signals, and the leads which carry the positive and negative clamping signals should be close together. The wire connecting pin 2 of V19 to the No. 3 grid circuit of V22 should be carefully routed to avoid video-carrying components.

To avoid crosstalk, the components of the B-Y, R-Y and Y channels should be reasonably separated from each other.

The principal construction information for the Modulator and Adder unit is contained in Figs. 27, 28, 29, and 30 which consist of the chassis layout, bracket, Y Delay Network, and coil data drawings respectively.

Preliminary Adjustments

Y Delay Network Terminations

The adjustment of the terminations of the Y DELAY NETWORK requires two operations since the termination at both ends must be set. The 3.579-Mc subcarrier input and the sync signal input are disconnected and V19 is removed from its socket. In order to set the sending-end termination (near V5), the following procedure is employed:

(a) The 1-volt peak-to-peak video sweep is introduced into SYNC IN connector;

(b) The 1000-ohm resistor at the receiving end (near V14 on the schematic) of the Y DELAY NETWORK is disconnected and the 5-50 μμf capacitor at that end is set for minimum capacity;

(c) At the sending end (near V5) a 200-ohm carbon potentiometer is placed in series with the lower end of the 1000-ohm terminating resistor, so that the total termination can be varied between 1000 and 1200 ohms;

(d) The signal developed at the plate of V14 is observed on the oscilloscope.

When first observed the response will contain ripples spaced at approximately 1.5-Mc intervals and in addition may have a gently rising or falling characteristic. This latter characteristic is not a function of conditions at the end of the line being terminated and may therefore be ignored temporarily. The ripples may be removed by proper termination in the following manner:

(a) The terminating resistance is varied and set at the value which results in the smoothest response up to approximately 2 Mc;

(b) The 5-50 μμf capacitor from the first coil center tap to ground is then set at the value which gives the smoothest response up to 4 Mc;

(c) Then the 5-50 μμf capacitor across the first half of the first coil is adjusted to produce the smoothest high-frequency response. Since there is a certain amount of interaction between these three controls the adjustments are repeated until the optimum ripple-free condition is obtained;

(d) The potentiometer is then removed, carefully measured, and replaced by a fixed resistor.

In order to set the Y DELAY NETWORK receiving-end termination a similar procedure is employed:

(a) Make certain that both video output connectors are terminated in 75 ohms. The potentiometer is placed in series with the 1000-ohm receiving end resistor (near V14);

(b) The sending end termination (near V5) is disconnected, the sweep signal is introduced into the Y IN connector;

(c) The signal at the common plate point of V4, V5, and V6 is observed;

(d) The response should be similar to that observed in the preceding case;

(e) The terminating resistor is adjusted to eliminate the ripples in the lower frequencies and the 5-50 μμf capacitor across the last coil is adjusted to minimize the higher frequency ripples;

(f) These two adjustments are repeated until an optimum ripple-free response is produced. The potentiometer is replaced by the proper value of fixed resistor and the send-end termination is reconnected.

In order to make an overall check on the delay line, V16 is replaced by a dummy tube consisting of a 6H6 with pin 7 clipped off, and a 1-megohm resistor is connected from pin 4 of V18 to ground. The response is observed at the SYNC NEG OUTPUT connector. The signal should be flat and ripple free to at least 5.5 Mc. The dummy tube and grid resistor are left in place for use in a following adjustment.

During the normal circuit operation the power dissipation in each of the 2-watt 1000-ohm terminating resistors is below 1 watt. However, during the preceding adjustments, only one of them is available, causing its dissipation to exceed its rated value. Consequently the +280-volt d-c supply should be turned on for only a few minutes at a time.

B-Y, R-Y Low Pass Filters

The components in the low pass filters in the plate circuits of V1 and V2 (see Fig. 11, schematic of the Modulator and Adder) are selected to 1 per cent tolerances so that in general no further adjustment is required. However, a check on the operation of the filters can be made, and in the case of the B-Y filter in the plate of V1, for example, it is performed in the following manner:

(a) A 100-kc square wave of good quality and of approximately one-half volt peak-to-peak amplitude is introduced into the grid of V1 through the B-Y IN connector;

(b) Clamp diode V7 is removed and replaced by a 1-megohm resistor connected from the No. 1 grid of V10 to the center arm of the B-Y BACKGROUND potentiometer;

(c) The 3.579-Mc subcarrier input to the chassis is disconnected and the BURST HEIGHT control set to zero;

(d) The waveform developed across the 100-ohm cathode resistor to V10 is then observed on the oscilloscope. The rise time of the resulting pulse should be in the order of 0.23 μsec, and its corners should be clean, exhibiting neither overshoots nor undershoots in excess of 1 per cent. If the corners are not clean, slight adjustments in the two inductances, L11 and L21, may be employed to improve the response;

(e) Replace V7 and restore normal circuit.

A similar check can be made on the R-Y filter in the plate circuit of V2.

Modulator Plate Load

The peaking of the filter in the common plate connection of the modulators V10, V11 and V12 is accomplished as follows:

(a) The 3.579-Mc input is disconnected;

(b) V9 is removed from its socket;

(c) The grid circuitry is disconnected from the grid of V10 and in its place a 1-megohm resistor is connected from the grid to the center connector of the B-Y BACKGROUND potentiometer;

(d) A video sweep, 0-10 Mc, of approximately 1 volt peak-to-peak is introduced into the grid of V10 through a 0.22-μf capacitor;

(e) The filter response, which appears across the common cathode resistors of V14 and V26 is then observed on an oscilloscope.

The oscilloscope employed in this adjustment should have a video response extending to approximately 8 Mc (e.g., Tektronix model 511A). Alternatively, a video sweep detector may be used with a narrow-band oscilloscope. However, the latter method is less satisfactory because of the low signal levels involved. The desired response is shown on the schematic (Fig. 11) above the filter (below V9) and can be obtained by adjustment of L14, L24 and 5-50 μμf variable capacitor across L24. L14 is adjusted to provide the correct response in the frequency range from 0 to approximately 3 Mc. Coil L24 and the variable capacitor across it form a parallel-resonant trap for the second harmonic of the subcarrier and are adjusted as follows. The capacitor is set near its minimum value and L24 is adjusted to cause a notch to appear in the response at 7.16 Mc. Then keeping the notch at 7.16 Mc, the capacitor is increased and L24 is decreased, until the response shown on the schematic results.

Video Balancing Circuit Load

The adjustment of the trap in the plate of V9 is now made by reinserting V9, reducing the sweep input to approximately 0.2 volt and observing the response at the plate of V14.

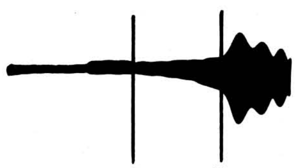

Fig. 17 – Frequency response of residual video signals.

Under these conditions the sweep signal flows through the common modulator plate load to the grid of V14 and also through the video balancing channel V9 and V26 to the cathode of V14. The B-Y BAL control is adjusted to produce the best balance at the low-frequency end of the sweep and the coil in the plate of V9 is adjusted to produce balance at the higher frequencies so that the resulting signal appears as in Fig. 17. After completion of this adjustment, the grid circuits of V10 and V18 may be returned to normal, and V19 and V16 are replaced.

Clamp Pulse Shaping Capacitor

In order to aid in the reduction of spurious clamp signals appearing on the sync pulses of the color video signal, a 5-50 μμf variable capacitor connected from the plate of V21 to ground is employed. The capacitor is set at that value which results in the minimum spurious signals as observed on an oscilloscope across the SYNC NEG OUTPUT connector.

Modulator Phase Relationship

The setting of the phase relationship between the modulators is accomplished as follows:

(a) Both the B-Y PHASE switch S1, and the BAL PHASE switch S2, are set in the position which adds eight of the one-inch sections to the fixed sections of delay cable. These settings are approximately the correct ones;

(b) The B-Y, R-Y and Y input switches are turned off;

(c) An oscilloscope observation is made of the colorplexer output across the SYNC NEG OUTPUT connector;

(d) The B-Y and R-Y BACKGROUND controls are adjusted to reduce the subcarrier in the output to zero.

If zero balance cannot be obtained and optimum balance occurs when one of the background controls is near full clockwise while the other is near the full counterclockwise position, S2 is moved one position and the attempt to achieve balance is repeated. In some instances balance cannot be achieved by means of the above procedure. In these cases one of the modulator tubes may be sufficiently different from the others to warrant its being replaced. An investigation of the cathode voltages of the modulator tubes can usually determine the odd tube. At balance the cathode voltage of V10 and V11 should be approximately 1.1 volt and V12 should be approximately 2.8 volts.

In order to facilitate the remaining adjustments of the colorplexer a constant-impedance Crossover Filter is employed which permits the separate viewing on an oscilloscope of the low, high or total frequency components of the colorplexer signal output without seriously disturbing the signal on the output line. Details of this device are shown in Figs. 18 and 19. In use, the Filter is mounted directly on the oscilloscope input connector and the input to the Filter is bridged across the 75-ohm colorplexer output line by screwing it directly into a Tee connector inserted in the line.

To check the 90-degree phase relationship between the B-Y and R-Y modulators, the Color Television Test-Signal Generator described in *LB-819-819A* is employed in the following manner. It is set up to produce a single color bar approximately 20 microseconds long in the top half of the picture near the center of the horizontal scanning lines. The resulting pulse signal is connected directly to the B-Y IN connector on the Modulator and Adder chassis. The B-Y switch is on and the R-Y and Y switches

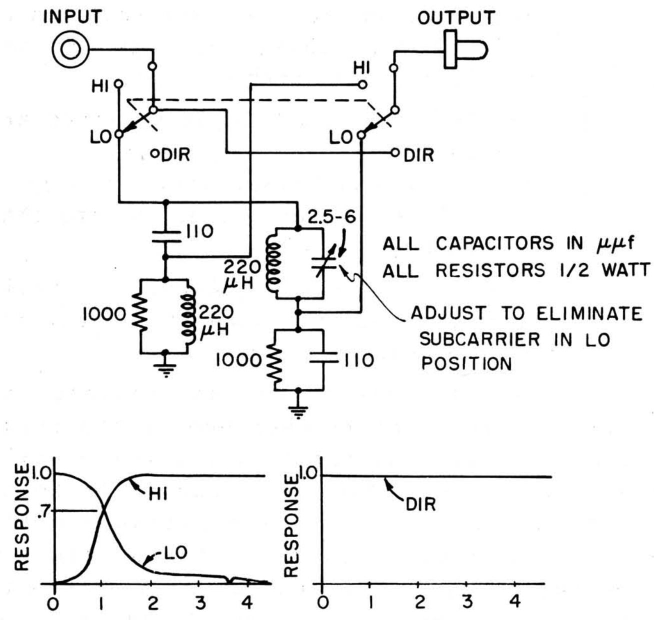

Fig. 18 - Schematic and response characteristics of the Crossover Filter.

are off. The output of the unit is observed on the oscilloscope through the HI (high pass) position of the Crossover Filter. By means of the B-Y and R-Y BACKGROUND controls the subcarrier is balanced out in the black portions of the signal. By means of the B-Y GAIN control, adjust the amplitude of the modulated envelope of the B-Y phase which appears in the output to 0.3 volt peak-to-peak. The envelope of this signal appears on the oscilloscope, as in Fig. 20a. Then turn the B-Y BACKGROUND control in that direction which causes the B-Y envelope to decrease in size as the subcarrier unbalance

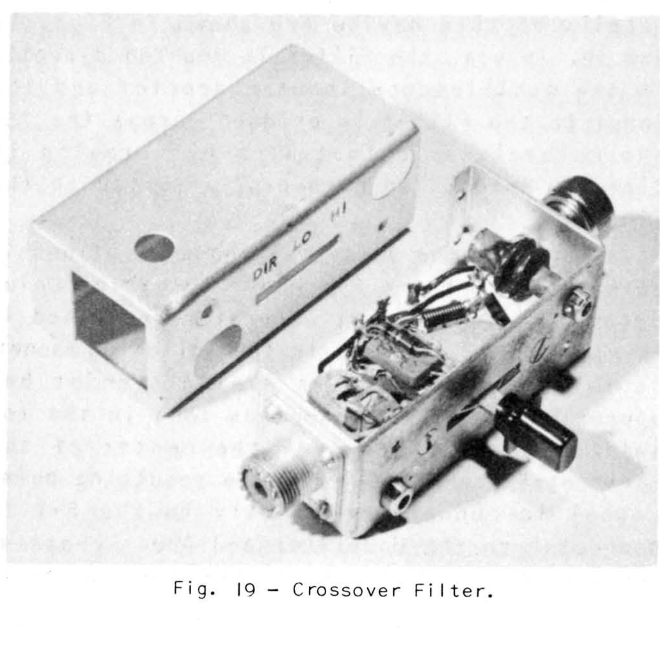

Fig. 19 - Crossover Filter.

during the remainder of the line increases. Continue turning until the two are equal in amplitude as in Fig. 20b. Then slowly turn the R-Y BACKGROUND control in each direction. If the phase difference between B-Y and R-Y is 90 degrees, the R-Y subcarrier unbalance will add equally to all parts of the picture as in Fig. 20c. However if the turning of the R-Y BACKGROUND control causes the B-Y envelope and the unbalanced subcarrier portions of the picture to become unequal as in Figs. 20d and e, the phase relationship is not 90 degrees. Another tap on the B-Y PHASE switch S1 is then tried and the procedure repeated until the optimum setting is found. The taps are made at intervals of approximately 4 degrees; i.e., the accuracy of adjustment is ±2 degrees. When the tap on the B-Y PHASE switch is moved, the BAL PHASE switch (S2) position may be changed in accordance with the discussion in the preceding paragraph when this becomes necessary in order to re-establish subcarrier balance.

During all the succeeding adjustments, as well as in actual operation of the unit, the black-level subcarrier balance should be carefully maintained at zero by means of the B-Y and R-Y BACKGROUND controls. The black-level subcarrier balance can be affected by variations in heater voltage. If the apparatus is operated from a power line which is subject to fluctuation, the use of a voltage-regulating transformer in the heater circuit of the Modulator and Adder unit may be beneficial.

Sync Signal

The proper length of the SYNC DELAY cable on the Matrixer chassis may now be determined in the following manner:

(a) A normal, blanked camera or slide scanner signal is applied to the G-IN connector on the Matrixer chassis;

(b) The I, Q, R-Y, and B-Y switches are turned off and the Y switch is turned on;

(c) The signal at the colorplexer output is observed on the oscilloscope;

(d) By means of the SYNC GAIN and Y GAIN controls the sync and blanking signals are each adjusted to one-half volt peak-to-peak at the output;

(e) The SYNC DELAY cable is adjusted to produce the proper width of front porch on the output signal (see signal specifications, Appendix A).

Adjustment of the duration of the various portions of the synchronizing signal may be facilitated by the use of marker pulses such as those generated by the Companion Unit described in LB-853, *Interlaced Sampling-Signal Generator", part II.*

Burst Width

Prior to adjusting the burst width the horizontal sync pulse width should be checked for conformance with specification and adjustment made at the Synchronizing Generator if necessary.

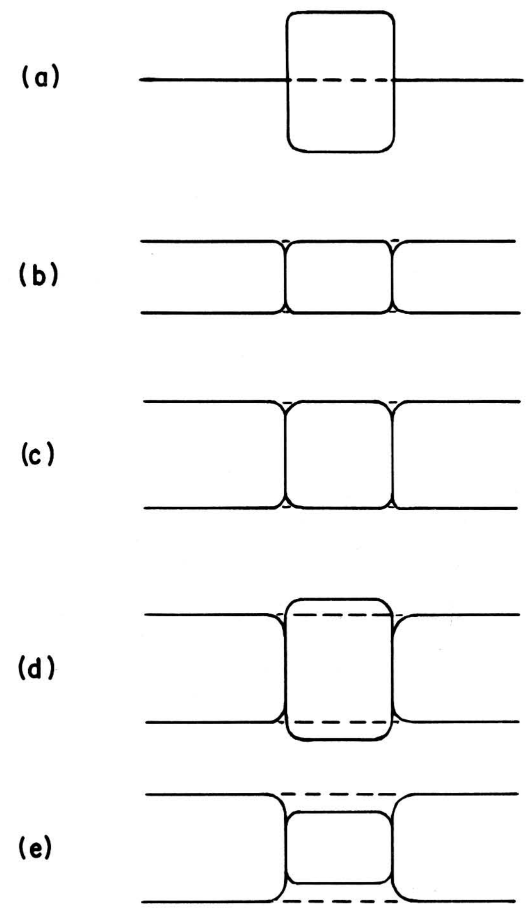

Fig. 20 - Check on 90 degree modulator phase relationship.

In order to set the BURST WIDTH an oscilloscope (such as the Tektronix 511A) on which it is possible to observe the burst in a sufficiently spread out and stable manner to permit the counting of the number of burst cycles is employed. By means of the BURST HEIGHT control, the burst is adjusted to approximately 0.4 volt. Then, by means of the BURST WIDTH control the number of subcarrier cycles in the burst is varied until eight cycles appear. No adjustment of the position of the front of the burst is provided as this is principally determined by the back of sync, the small delay required being provided by the circuits which make the burst-generating pulse.

Clamp Width

The setting of the CLAMP WIDTH control may be checked by observing the output at field rate. The width should be slightly less than that value which causes a transient during the vertical blanking period.

Operating Adjustments

In order to make the required adjustments the equipment should be set up in the following manner:

(a) The video inputs to the Matrixer chassis are connected to the Color Television Test-Signal Generator;

(b) The four outputs on the Matrixer chassis are connected to the correspondingly labeled inputs on the Modulator and Adder chassis by means of 75-ohm coaxial cables;

(c) All other required input connections are made to both chassis;

(d) All switches on both chassis are turned on;

(e) The colorplexer sync negative output signal is observed on the oscilloscope through the Crossover Filter.

The setting of the I and Q BAL controls on the Matrixer may be checked using the *all grey scale* pattern. This pattern is set up and the three resulting step signals are carefully adjusted to 1 volt peak-to-peak at the inputs to the Matrixer. The Crossover Filter switch is in the DIR position. The step signal which appears in the output should have no subcarrier signal on it. If any is visible the I and Q BAL controls on the Matrixer are adjusted to eliminate it.

In order to set the R-Y BAL and B-Y BAL video balancing controls, the signal out of the Test Signal Generator is changed to provide the *all colored bar* pattern. The R-Y and Y switches on the Modulator and Adder are turned off. With the Crossover Filter switch in the HI position, the amplitude of the maximum envelope (during the Blue color bar) at the colorplexer output is set at 0.75 volt peak-to-peak by means of the B-Y GAIN control. The Filter switch is changed to the LO position and by means of the B-Y BAL control the video signal in the output is reduced to as small a value as possible.

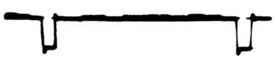

Fig. 21 - Residual video unbalance during Color-Bar-Pattern.

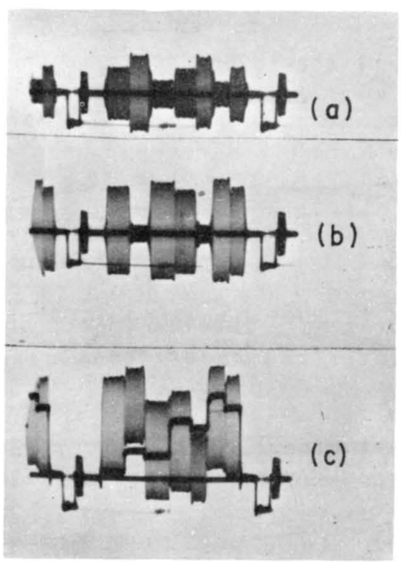

Fig. 22 - Colorplexer output waveshapes.

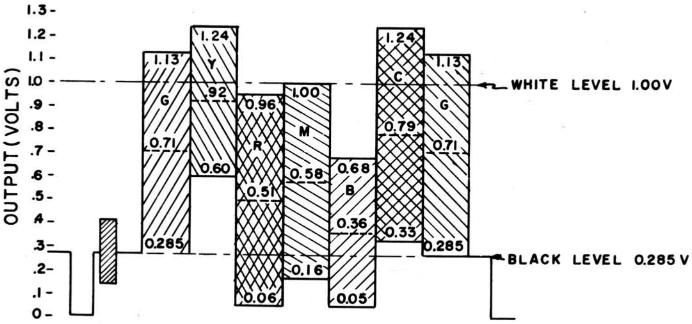

Fig. 23 - Calculated composite-color-signal output from colorplexer.

The Filter switch is returned to the HI position and the black-level subcarrier balance is made if necessary. The R-Y BAL adjustment is made in a similar manner. The R-Y input switch is turned on, the B-Y and Y input switches are turned off and by means of the R-Y GAIN control the amplitude of the maximum R-Y envelope (during the Red color bar) is set at approximately 0.9 volt peak-to-peak. The Filter switch position is changed to the LO position and by means of the R-Y BAL control the video signal in the output is reduced to as small a value as possible. Both the B-Y and R-Y switches are then turned on. The output signal appears as in Fig. 21 and a typical figure for the maximum remaining unbalanced video voltage is 0.03 volt. The Filter switch is returned to the HI position and the black-level subcarrier balance is made if necessary. When setting up the equipment for the first time it is desirable to repeat these adjustments at least once.

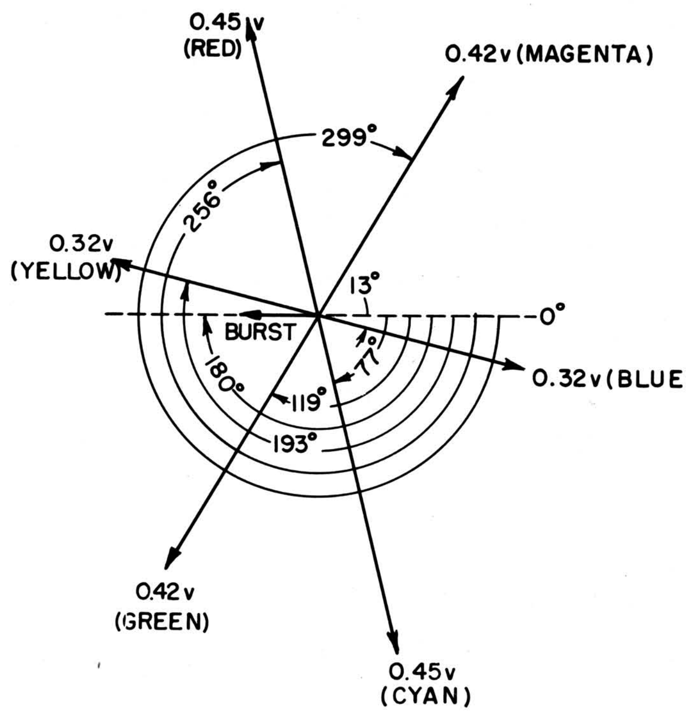

Fig. 24 - Vectorial representation of the carrier chrominance portions of the colorplexer output signal.

The final adjustment of the apparatus requires that all the preceding adjustments be completed and that normal operating conditions prevail. The Filter switch is set in the DIR position and by means of the SYNC LEVEL control the output sync is set at 0.28 volt. By means of the BURST HEIGHT control the burst is set to 0.28 volt peak-to-peak. The color Television Test-Signal Generator is set up to provide the pattern of Fig. 9. The B-Y and R-Y input switches on the Modulator and Adder are turned off, and the Y switch is turned on. The Y GAIN control is adjusted until the total peak-to-peak video signal including sync is 1.0 volt. The Y switch is turned off and the B-Y switch is turned on. The resulting $E_B' - E_Y'$ chrominance signal is shown in Fig. 22a and by means of the B-Y GAIN control, the peak-to-peak amplitude of its envelope during the Blue color input is set at 0.62 volt. The B-Y switch is turned off and the R-Y switch is turned on. The resulting $E_R' - E_Y'$ chrominance signal is shown in Fig. 22b and by means of the R-Y GAIN control, the peak-to-peak amplitude of its envelope during the Red color input is set at 0.88 volt.

All input switches are now turned on. The resulting signal, shown in Fig. 22c, is the composite color signal.

Fig. 23 is a drawing of the composite color signal output of the colorplexer under conditions similar to those of Fig. 22c except that *all colored bar* signal from the Color Television Test-Signal Generator is applied to the colorplexer inputs. The signal of Fig. 23 is 1.0 volt in amplitude from the tip of sync to white level and the amplitude values which are shown were derived from the color "Signal Specification" (Appendix A). The amplitudes shown at the center of the color envelopes are the values of the luminance components of the respective colors. Fig. 24 is a vector representation of the amplitude and phase of the carrier chrominance portions of the signal of Fig. 23. The color designations shown in parenthesis near each vector on Fig. 24 refer to the colorplexer input colors which result in the vector at the colorplexer output.

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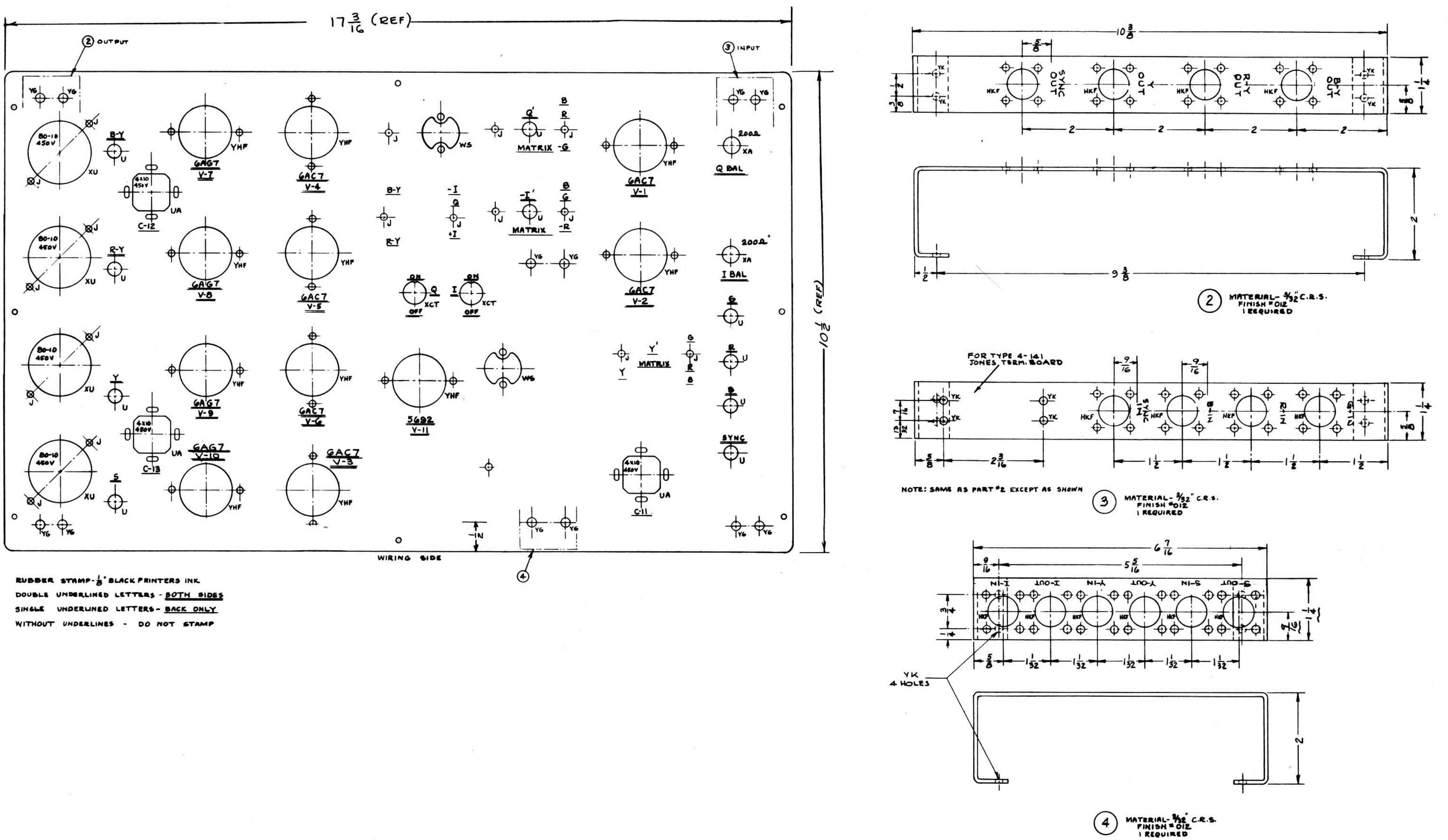
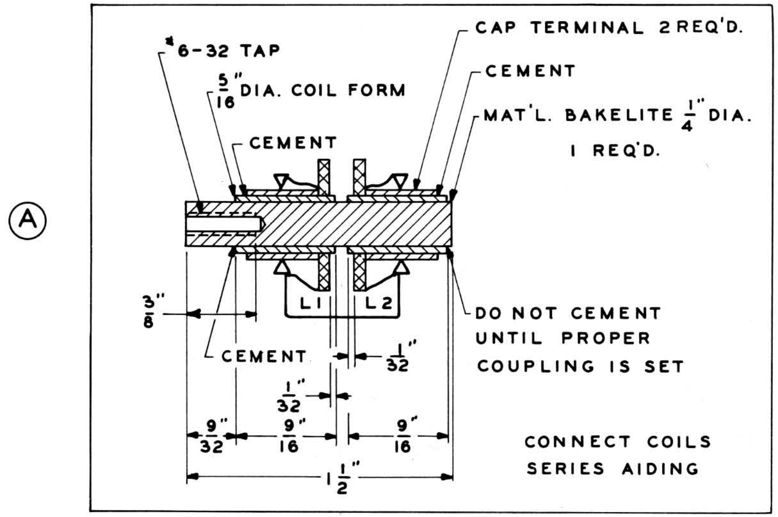
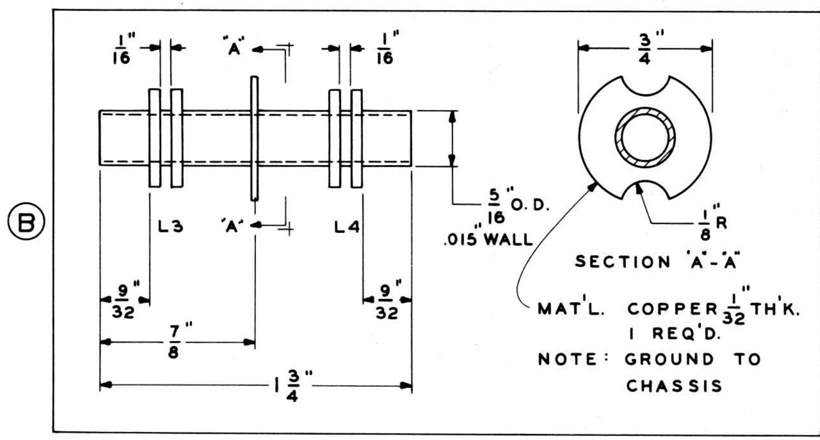


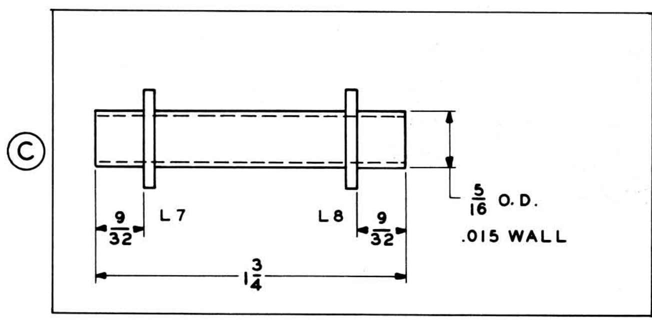
Fig. 25 - Chassis layout of the Matrixer.

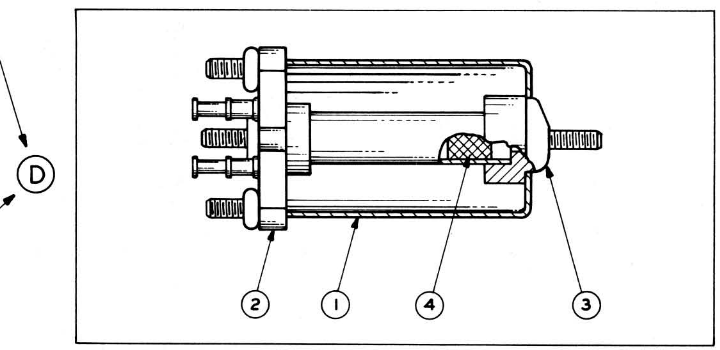


COIL DESIGNATION	μh	TURNS PER COIL	PIES	FORM
L1, L2	*550	216	1	SEE DETAIL Ⓐ
L3, L4	*327	204	2	SEE DETAIL Ⓑ AND ASSEMBLY Ⓓ
L5, L9	250	194	2	1/4" DIA (SPEER RESISTOR CO. CF 250)
L6	5	30	1	3/32" DIA. (SPEER RESISTOR CO. CT 156)
L7	65	70	1	SEE DETAIL Ⓒ ASSEMBLY Ⓓ
L8	96	108	1	
L10, L11, L13, L14	13	48	1	1/4" DIA. (SPEER RESISTOR CO. CF 250)
L12, L15	95	90	1	1/4" DIA. (SPEER RESISTOR CO. CF 250)

ALL WINDINGS 38SSE, 1/16" PIE, 83/40 GEARS, CUMAR DOPED
* SET INDUCTANCE TO ±1% ON Q METER







May be purchased from the following vendors:

1. Shield Can; Cat. No. Tele-Coil 739772-523, Tele-Coil Co., Inc., 207 Federal St., Camden, N. J.
2. Terminal Board; Cat. No. 48XX2004, and
3. Bushing; Cat. No. 48B1033, Grayhill Corp., 4524 W. Madison, Chicago, Ill.
4. Cores; Cat. No. RCA 92457-507, Electronic Parts Specialties, Coles Ave., Lumberton, N. J.

Fig. 26 - Matrixer coil data.

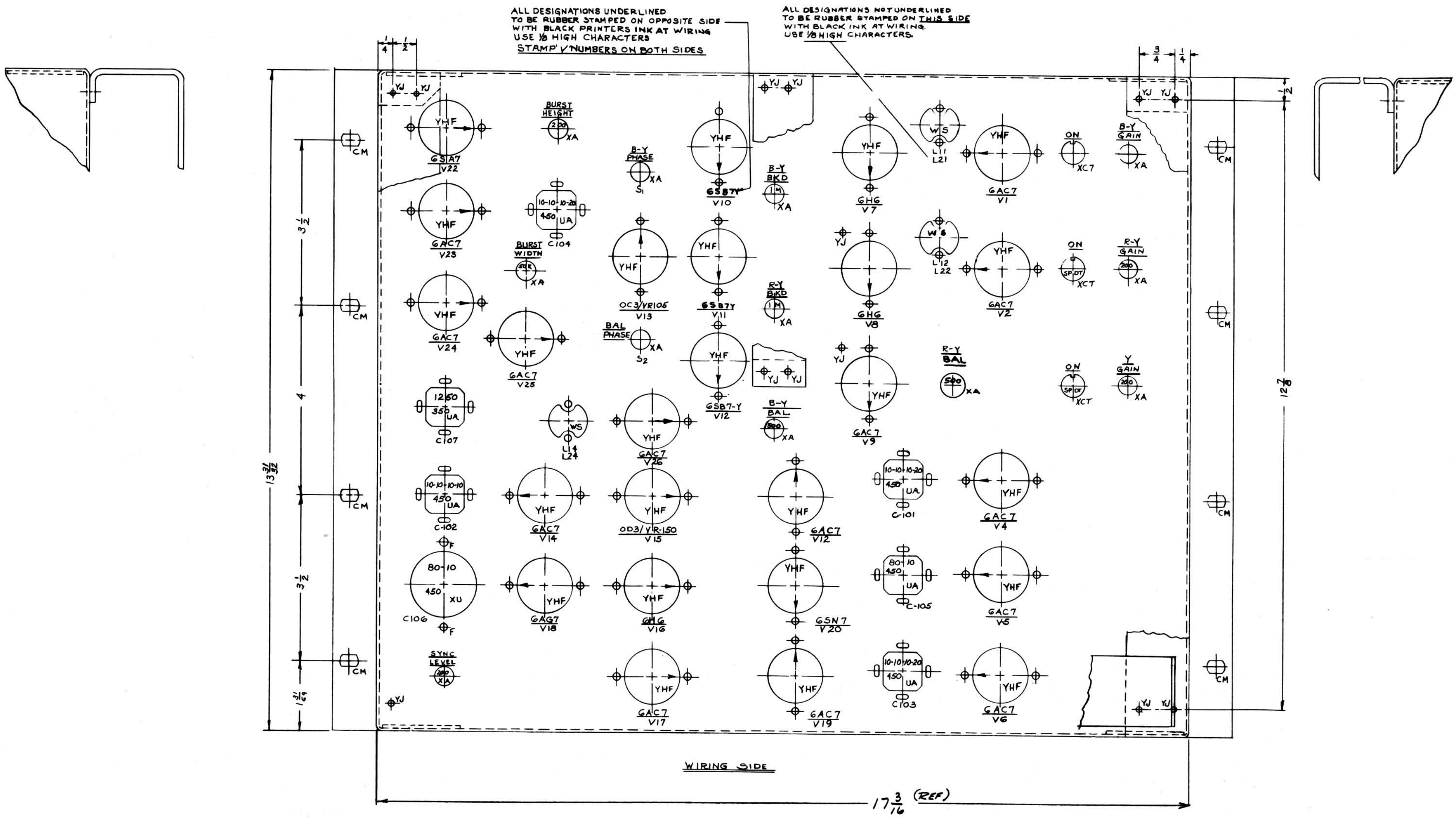


Fig. 27 - Chassis layout of the Modulator and Adder.

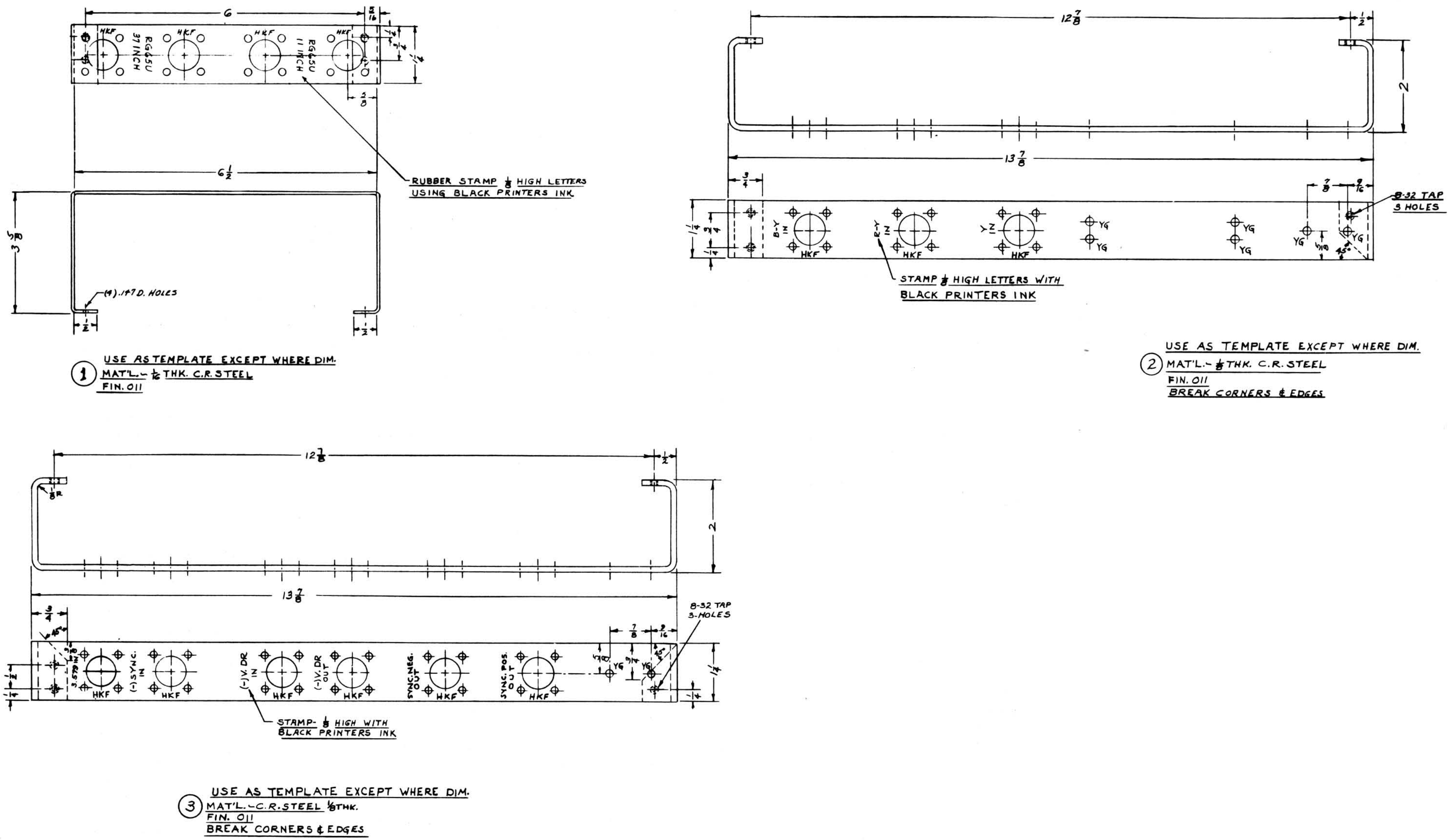


Fig. 28 - Bracket drawings of the Modulator and Adder.

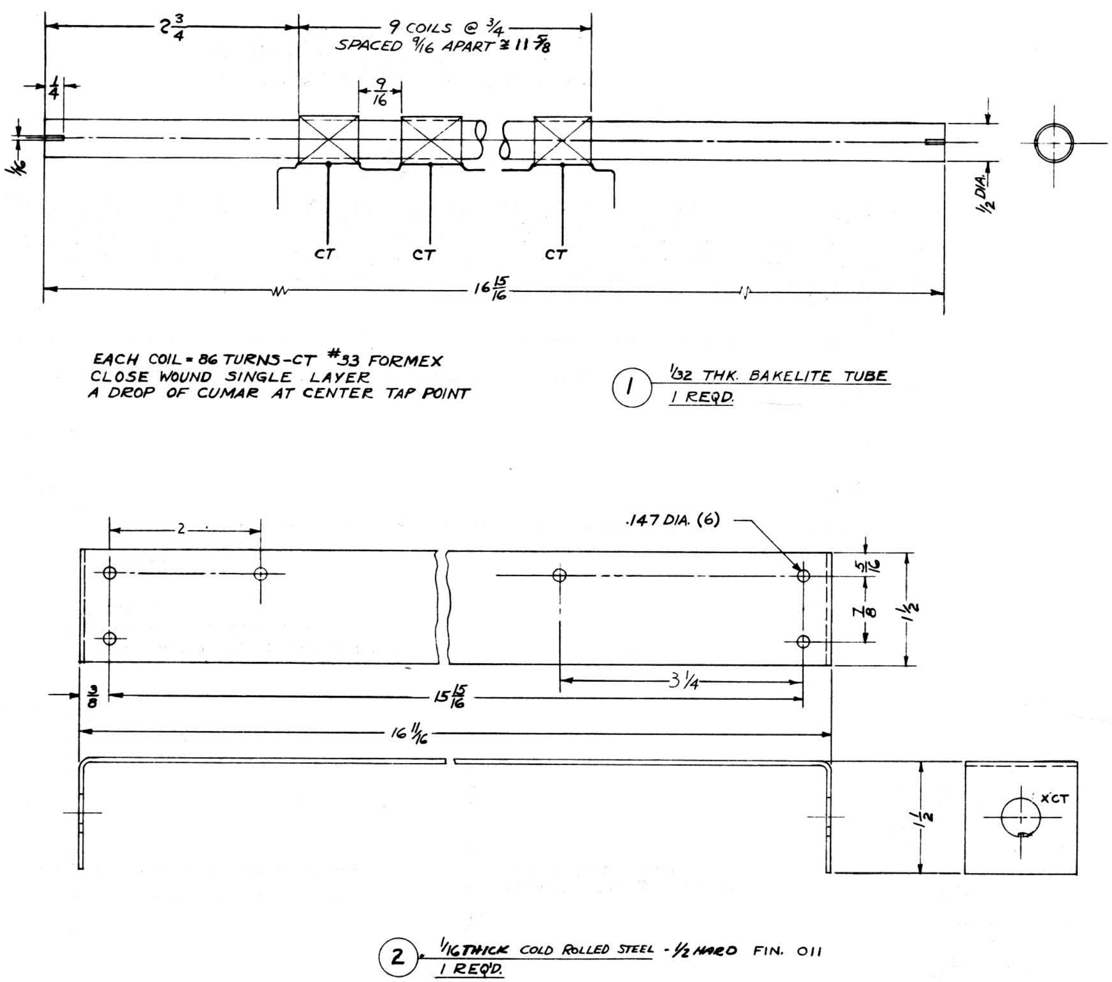
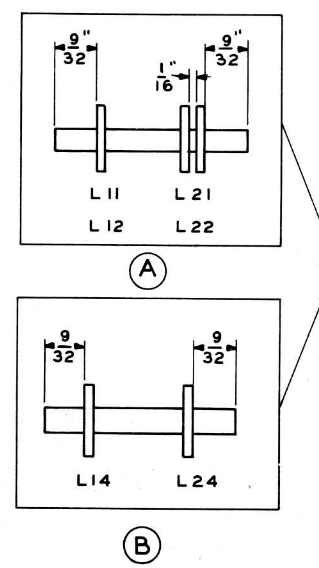


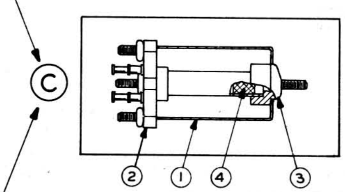
Fig. 29 - Construction of the Y delay network.

COIL DESIG.		μh	TURNS PER COIL	PIES	FORM
L11	L12	* 77	75	1	SEE DETAIL A
L21	L22	*270	170	2	AND ASSEMBLY C
L26	CAMBRIDGE THERMIONIC CORP. LSM 5 MC				
L14	L24		45	1	SEE DETAIL B ASSEMBLY C

* SET TO 1% ON Q METER



ALL COILS #36 SSE 1/16" PIE, 83/40 GEARS. COIL FORM 1 3/4" X 5/16" O. D. .015" WALL. CUMAR DOPED.



May be purchased from the following vendors:

1. Shield Can; Cat. #Tele-Coil 739772-523 Tele-Coil Co., Inc., 207 Federal St., Camden, N. J.
2. Term. Bd. Cat. #48XX2004, and
3. Bushing; Cat. #48B1033 Grayhill Corp., 4524 W. Madison, Chicago, Ill.
4. Cores; Cat. #RCA 92457-507 Electronic Pts. Spec., Coles Ave., Lumberton, N. J.

Fig. 30 - Modulator and Adder coil data.

Appendix A

TECHNICAL SIGNAL SPECIFICATIONS PROPOSED AS STANDARDS FOR COLOR TELEVISION.*

I. GENERAL SPECIFICATIONS

A. CHANNEL

The color television signal and its accompanying sound signal shall be transmitted within a 6 megacycle channel.

B. PICTURE SIGNAL FREQUENCY

The picture signal carrier, nominally 1.25 Mc above the lower boundary of the channel, shall conform to the frequency assigned by the Federal Communications Commission for the particular station.

C. POLARIZATION

The radiated signals shall be horizontally polarized.

D. VESTIGIAL SIDEBAND TRANSMISSION

Vestigial sideband transmission in accordance with Figure 2 shall be employed.

E. ASPECT RATIO

The aspect ratio of the scanned image shall be four units horizontally to three units vertically.

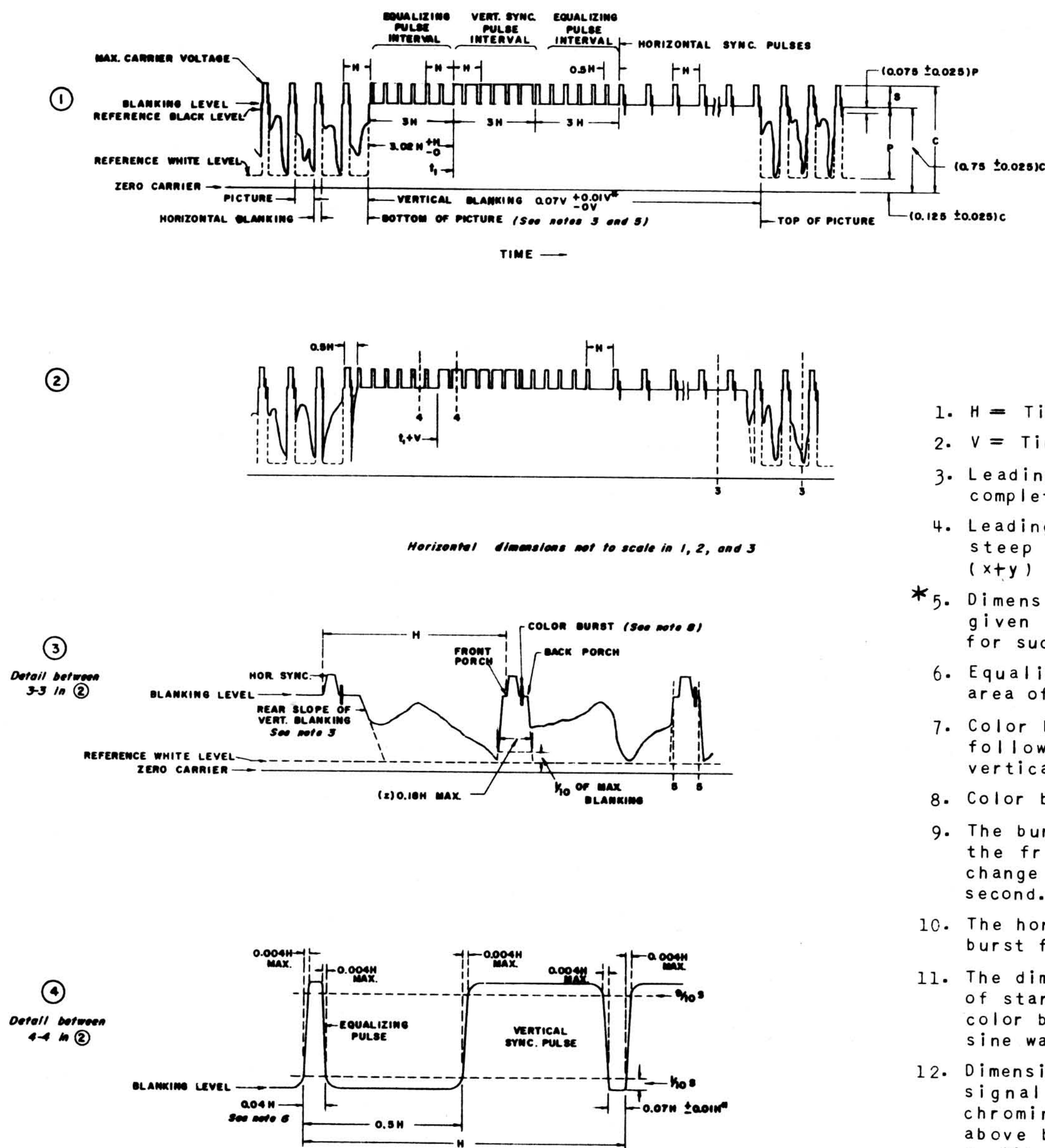
F. SCANNING AND SYNCHRONIZATION

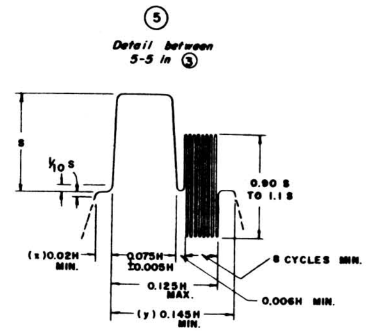
1. The color picture signal shall correspond to the scanning of the image at uniform velocities from left to right and from top to bottom with 525 lines per frame interlaced 2:1.

2. The horizontal scanning frequency shall be 2/455 times the color subcarrier frequency; this corresponds nominally to 15,750 cycles per second (with an actual value of 15,734.264 ± 0.047 cycles per second). The vertical scanning frequency is 2/525 times the horizontal scanning frequency: this corresponds nominally to 60 cycles per second (the actual value is 59.94 cycles per second).

*These signal specifications are identical with the signal specifications approved by the National Television System Committee on July 21, 1953.

TELEVISION SYNCHRONIZING WAVEFORM





NOTES

1. H = Time from start of one line to start of next line.
2. V = Time from start of one field to start of next field.
3. Leading and trailing edges of vertical blanking should be complete in less than 0.1 H.
4. Leading and trailing slopes of horizontal blanking must be steep enough to preserve minimum and maximum values of (x+y) and (z) under all conditions of picture content.

*5. Dimensions marked with asterisk indicate that tolerances given are permitted only for long time variations and not for successive cycles.

6. Equalizing pulse area shall be between 0.45 and 0.5 of area of a horizontal sync pulse.
7. Color burst follows each horizontal pulse, but is omitted following the equalizing pulses and during the broad vertical pulses.
8. Color bursts to be omitted during monochrome transmissions.
9. The burst frequency shall be 3.579545 Mc. The tolerance on the frequency shall be ± 0.0003% with a maximum rate of change of frequency not to exceed V10 cycle per second per second.
10. The horizontal scanning frequency shall be 2/455 times the burst frequency.
11. The dimensions specified for the burst determine the times of starting and stopping the burst, but not its phase. The color burst consists of amplitude modulation of a continuous sine wave.
12. Dimension "P" represents the peak excursion of the luminance signal from blanking level, but does not include the chrominance signal. Dimension "S" is the sync amplitude above blanking level. Dimension "C" is the peak carrier amplitude.
13. Refer to text for further explanations and tolerances.

FIGURE I

3. The color television signal shall consist of color picture signals and synchronizing signals, transmitted successively and in different amplitude ranges except where the chrominance penetrates the synchronizing region, and the burst penetrates the picture region.

4. The horizontal, vertical, and color synchronizing signals shall be those specified in Figure 1, as modified by vestigial side-band transmission specified in Figure 2 and by the delay characteristic specified in III.B.

G. OUT-OF-CHANNEL RADIATION

The field strength measured at any frequency beyond the limits of the assigned channel shall be at least 60 db below the peak picture level.

II. SOUND

A. SOUND SIGNAL FREQUENCY

The frequency of the unmodulated sound carrier shall be 4.5 Mc ± 1000 cycles above the frequency actually in use for the picture carrier.

B. SOUND SIGNAL CHARACTERISTICS

The sound transmission shall be by frequency modulation, with maximum deviation of ± 25 kilocycles, and with pre-emphasis in accordance with a 75 microsecond time constant.

C. POWER RATIO

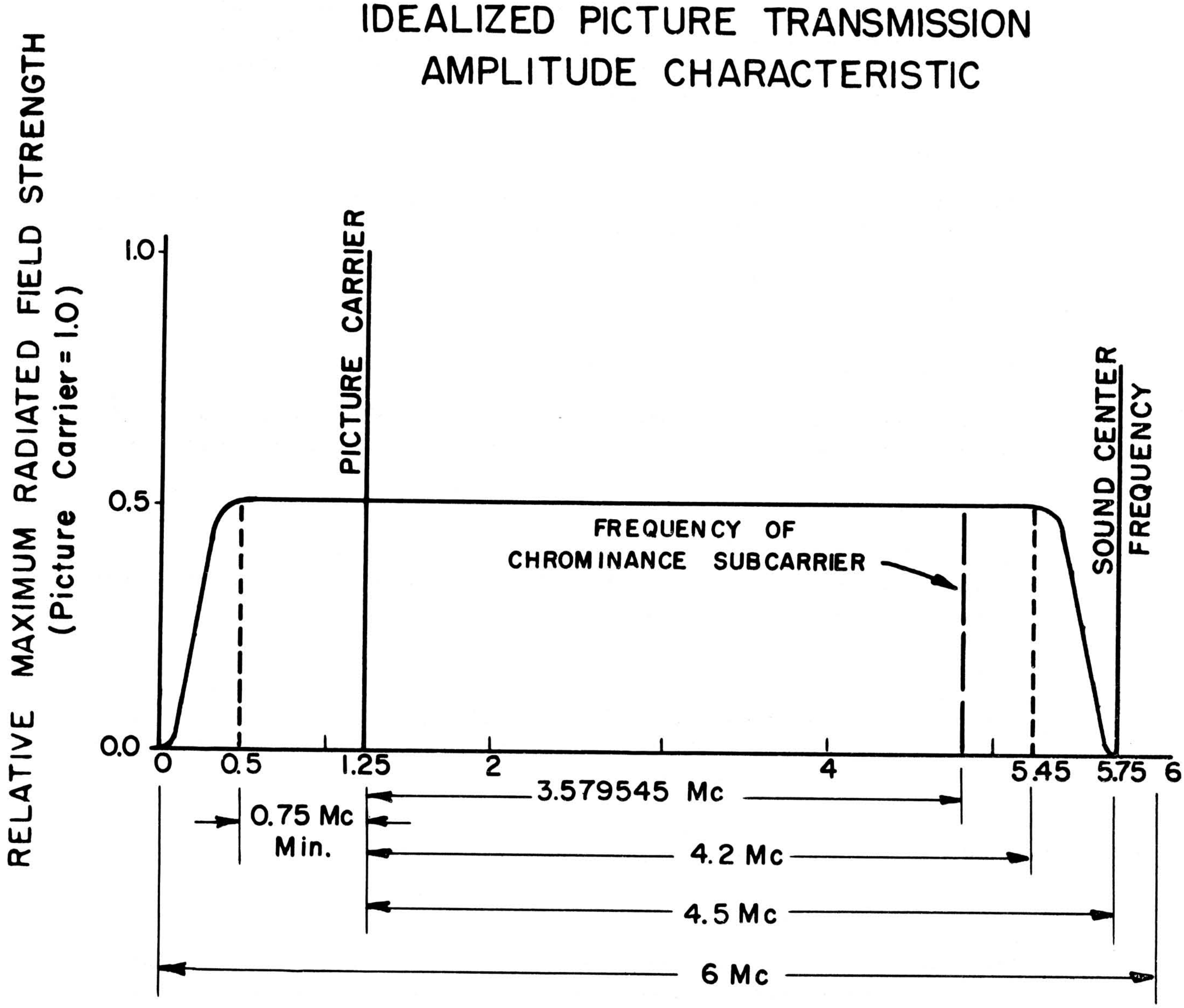
The effective radiated power of the aural-signal transmitter shall be not less than 50 per cent nor more than 70 per cent of the peak power of the visual signal transmitter.

III. THE COMPLETE COLOR PICTURE SIGNAL

A. GENERAL SPECIFICATIONS

The color picture signal shall correspond to a luminance (brightness) component transmitted as amplitude modulation of the picture carrier and a simultaneous pair of chrominance (coloring) components transmitted as the amplitude modulation sidebands of a pair of suppressed subcarriers in quadrature having the common frequency relative to the picture carrier of + 3.579545 Mc ± 0.0003 per cent with a maximum rate of change not to exceed 1/10 cycle per sec per sec.

IDEALIZED PICTURE TRANSMISSION AMPLITUDE CHARACTERISTIC



Note: Not drawn to scale

FIGURE 2

B. DELAY SPECIFICATION

A sine wave, introduced at those terminals of the transmitter which are normally fed the color picture signal, shall produce a radiated signal having an envelope delay, relative to the average envelope delay between 0.05 and 0.20 Mc, of zero micro-seconds up to a frequency of 3.0 Mc; and then linearly decreasing to 4.18 Mc so as to be equal to -0.17 μsecs at 3.58 Mc. The tolerance on the envelope delay shall be ± 0.05 μsecs at 3.58 Mc. The tolerance shall increase linearly to ± 0.1 μsec, down to 2.1 Mc, and remain at ± 0.1 μsec down to 0.2 Mc.* The tolerance shall also increase linearly to ± 0.1 μsec at 4.18 Mc.

C. THE LUMINANCE COMPONENT

1. An increase in initial light intensity shall correspond to a decrease in the amplitude of the carrier envelope (negative modulation).

2. The blanking level shall be at (75 ± 2.5) per cent of the peak amplitude of the carrier envelope. The reference white (luminance) level shall be (12.5 ± 2.5) per cent of the peak carrier amplitude. The reference black level shall be separated from the blanking level by the setup interval, which shall be (7.5 ± 2.5) per cent of the video range from the blanking level to the reference white level.

3. The overall attenuation versus frequency of the luminance signal shall not exceed the value specified by the FCC for black and white transmission.

D. EQUATION OF COMPLETE COLOR SIGNAL

1. The color picture signal has the following composition:

$$E_M = E'_Y + \{E'_Q \sin(\omega t + 33°) + E'_I \cos(\omega t + 33°)\}$$

where

$$E'_Q = 0.41\,(E'_B - E'_Y) + 0.48\,(E'_R - E'_Y)$$

$$E'_I = -0.27\,(E'_B - E'_Y) + 0.74\,(E'_R - E'_Y)$$

$$E'_Y = 0.30\,E'_R + 0.59\,E'_G + 0.11\,E'_B$$

The phase reference in the above equation is the phase of the (color burst + 180°), as shown in Figure 3. The burst corresponds to amplitude modulation of a continuous sine wave.

*Tolerances for the interval of 0.0 to 0.2 Mc should not be specified in the present state of the art.

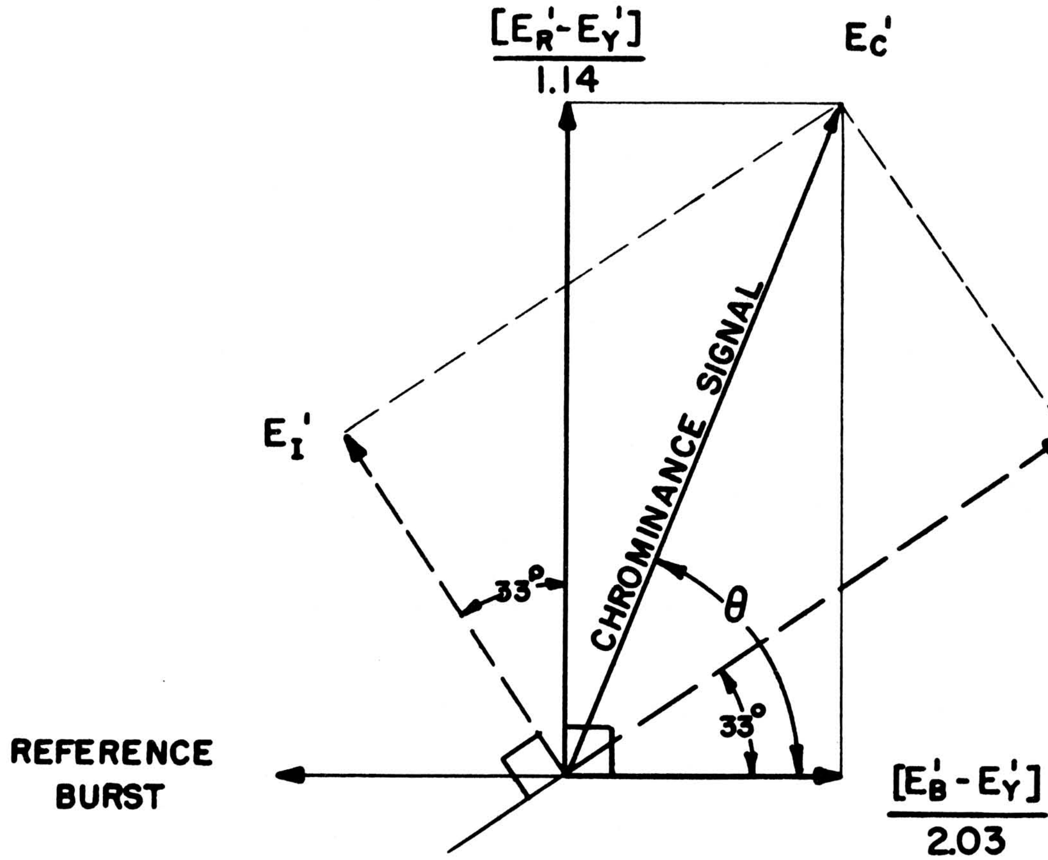

[E'_R - E'_Y] / 1.14
E'_C
CHROMINANCE SIGNAL
E'_I
E'_Q
33°
θ
33°
REFERENCE BURST
[E'_B - E'_Y] / 2.03

FIGURE 3

Notes: For color-difference frequencies below 500 Kc, the signal can be represented by

$$E_M = E_Y' + \{\frac{1}{1.14}[\frac{1}{1.78}(E_B' - E_Y') \sin \omega t + (E_R' - E_Y') \cos \omega t]\}$$

In these expressions the symbols have the following significance:

E_M is the total video voltage, corresponding to the scanning of a particular picture element, applied to the modulator of the picture transmitter.

E_Y' is the gamma-corrected voltage of the monochrome (black-and-white) portion of the color picture signal, corresponding to the given picture element.*

E_R', E_G', and E_B' are the gamma-corrected voltages corresponding to red, green, and blue signals during the scanning of the given picture element.

The gamma-corrected voltages E_G', E_R', and E_B' are suitable for a color picture tube having primary colors with the following chromaticities in the CIE system of specification:

	x	y
Red (R)	0.67	0.33
Green (G)	0.21	0.71
Blue (B)	0.14	0.08

and having a transfer gradient (gamma exponent) of 2.2** associated with each primary color. The voltages E_R', E_G', and E_B' may be respectively of the form $E_R{}^{1/\gamma}$, $E_G{}^{1/\gamma}$, and $E_B{}^{1/\gamma}$ although other forms may be used with advances in the state of the art.

E_Q' and E_I' are the amplitudes of two orthogonal components of the chrominance signal corresponding respectively to narrow-band and wide-band axes, as specified in paragraph D.5.

The angular frequency ω is 2 π times the frequency of the chrominance subcarrier.

The portion of each expression between brackets represents the chrominance subcarrier signal which carries the chrominance information.

*Forming of the high frequency portion of the monochrome signal in a different manner is permissible and may in fact be desirable in order to improve the sharpness on saturated colors.

**At the present stage of the art it is considered inadvisable to set a tolerance on the value of gamma and correspondingly this portion of the specification will not be enforced.

2. The chrominance signal is so proportioned that it vanishes for the chromaticity of CIE Illuminant C ($x = 0.310$, $y = 0.316$).

3. E'_Y, E'_Q, E'_I and the components of these signals shall match each other in time to 0.05 μsecs.

4. A sine wave of 3.58 Mc introduced at those terminals of the transmitter which are normally fed the color picture signal shall produce a radiated signal having an amplitude, (as measured with a diode on the R.F. transmission line supplying power to the antenna) which is down (6 ± 2) db with respect to a radiated signal produced by a sine wave of 200 kc. In addition, the amplitude of the radiated signal shall not vary by more than ± 2 db between the modulating frequencies of 2.1 and 4.18 Mc.

5. The equivalent bandwidths assigned prior to modulation to the color-difference signals E'_Q and E'_I are given by Table I.

TABLE I

Q-CHANNEL BANDWIDTH

at 400 kc less than 2 db down
at 500 kc less than 6 db down
at 600 kc at least 6 db down

I-CHANNEL BANDWIDTH

at 1.3 mc less than 2 db down
at 3.6 mc at least 20 db down

6. The angles of the subcarrier measured with respect to the burst phase, when reproducing saturated primaries and their complements at 75 per cent of full amplitude, shall be within ± 10° and their amplitudes shall be within ± 20 percent of the values specified above. The ratios of the measured amplitudes of the subcarrier to the luminance signal for the same saturated primaries and their complements shall fall between the limits of .8 and 1.2 of the values specified for their ratios. Closer tolerances may prove to be practicable and desirable with advance in the art.