INTRODUCTION

The notes which follow have been prepared to supplement the lectures on Color Television Theory given by SPARTON in its servicemens' Color Television Schools.

We believe that a good understanding of theory is very helpful to the serviceman's work. However, explanation of many of the finer points of Color Television can be quite time-consuming. We have, therefore, attempted to clarify these points in the notes and will skim over them lightly in the lectures. The resulting saving of time will be utilized to give you more service-type information on our current color television receivers.

The first major section of the notes covers the developement of the NTSC color signal. The second section, on decoders, is applicable only to color receivers using a three gun kinescope, in the belief that the three gun tube gives the most satisfactory pictures currently attainable. We have attempted to make this decoder section general enough to include the various styles of decoders used today.

Your criticisms and comments will help us to revise these lectures and notes to do the best possible job in the available time; therefore, your suggestions are most welcome.

E. O. Frye
June 7, 1954

LECTURE NOTES

I REQUIREMENTS FOR TRANSMITTING A SCENE IN COLOR:

Any color can be described in terms of three parameters, i.e., luminance, hue, and saturation. The luminance or brightness is self-explanatory. Hue is the actual shade, or color, of the color, while saturation refers to the "density" of the hue, or how much the pure color has been diluted with white light. Thus, if a deep green, for instance, were diluted with white light, or "de-saturated", it would become a pastel green.

It is possible to duplicate practically any color by adding suitable amounts (brightnesses) of three fixed hue "primary" colors. It has been found that primary hues of red, green and blue will enable one, by adding suitable amounts of these hues, to duplicate the widest range of given colors. Red, green and blue are, then, the so called "additive" primaries. Bear in mind that these primaries are different than the "subtractive" primaries of red, yellow and blue used in the subtractive color duplicating processes such as Kodachrome photographic film and color printing.

Therefore, we have two major methods of specifying a color; we can give the brightness, hue and saturation, or we can specify the amounts of red, green and blue.

For a compatible color television system, it is most convenient to describe a color by its brightness, hue and saturation, for the brightness component is necessary to describe the scene in black and white terms for the benefit of monochrome (black-and-white) receivers.

Research into the characteristics of the human eye has shown that the eye is not capable of detecting as fine color detail as it can luminance or brightness detail. Also, the ability of the eye to resolve fine detail in the orange to cyan colors is better than its ability to resolve green to purple detail. There is, of course, no point in transmitting more color detail than the eye can appreciate.

The amount of detail a television receiver is capable of resolving is directly proportional to the overall bandwidth of the television system. Therefore, it is unnecessary to use as much bandwidth to transmit and receive color detail as to handle luminance information.

II THE SIGNAL INTERLEAVING PRINCIPLE:

In order to have a compatible color television system, we must be able to fit the entire color signal into the bandwidth used by the black-and-white signal. How can we do this?

It has been found that only about 50% or less of the nominal video bandwidth used in monochrome television is actually occupied by monochrome information. To explain this statement, let us suppose that we had a television pattern consisting of two vertical bars. The video waveform would be similar to that shown below.

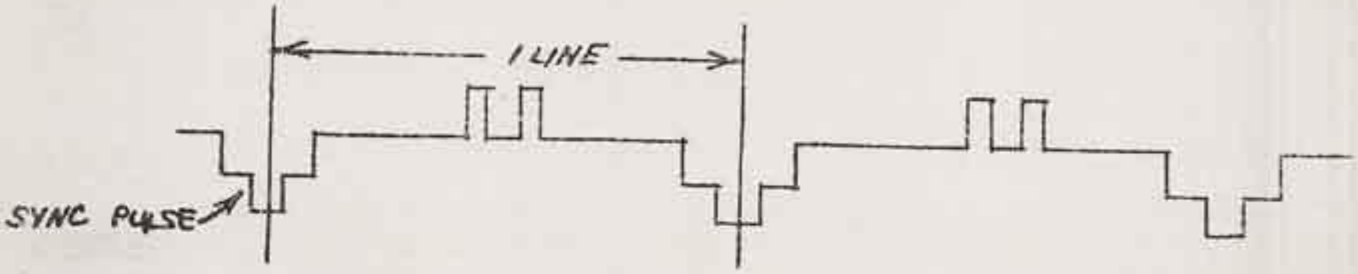


Figure 1.

Notice that the video waveform is periodic, that is, it repeats itself indefinitly, we will ignore the vertical blanking period for the moment. The frequency at which the waveform repeats is the line frequency, or 15,750 cps. Because the waveform is periodic, a Fourier analysis of it may be made. The Fourier analysis shows that the waveform is made up of a DC voltage representing the average level of the waveform, plus a 15,750 cps (fundamental) sine wave of a certain amplitude, plus certain amplitudes of a number of harmonics of 15,750 cps. There are no frequency components other than those of the fundamental and its harmonics. Therefore, a graph of the frequency spectrum used in making up the waveform would look like the figure below.

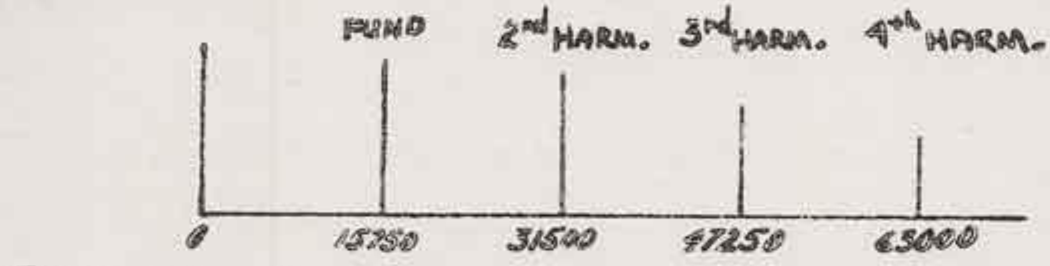


Figure 2.

In this instance, only a very low proportion of the available video bandwidth is actually occupied with the video information representing our two vertical bars.

It certainly is true that the normal television scene consists of more complex material than just vertical bars. However, in general, the video waveform of each scanning line is very nearly the same as the lines on either side. Therefore we may say that the video composing a scene is approximately periodic, and the spectrum will be approximately that of Figure 2. Figere 3 shows a spectrum typical of a TV scene. Notice that all frequency components are clustered about the fundamental and harmonic frequencies.

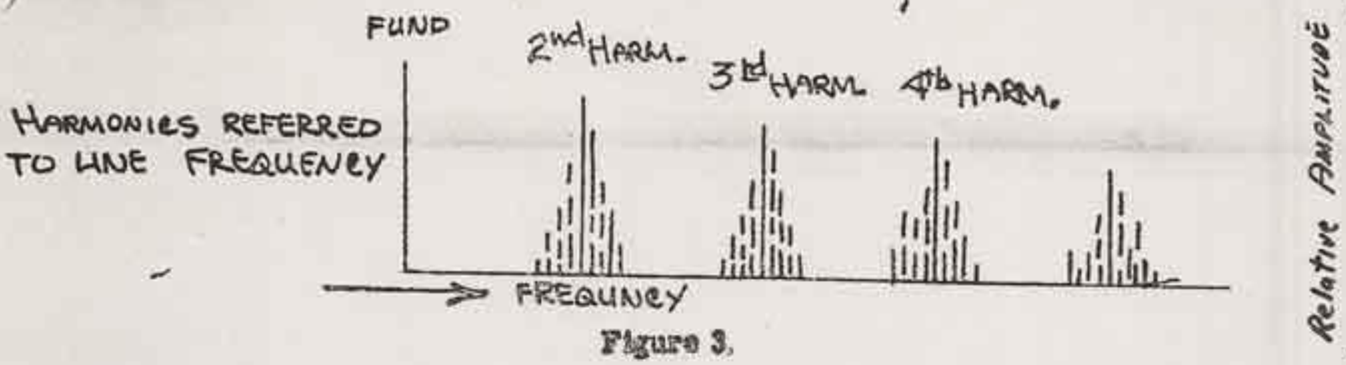


Figure 3.

Notice that the luminance information occupies about one-half or less of the available spectrum space; therefore, there is spectrum space available which we may use for color information. Suppose we did insert color information into the gaps in the monochrome spectrum, let us examine the effect on a monochrome receiver.

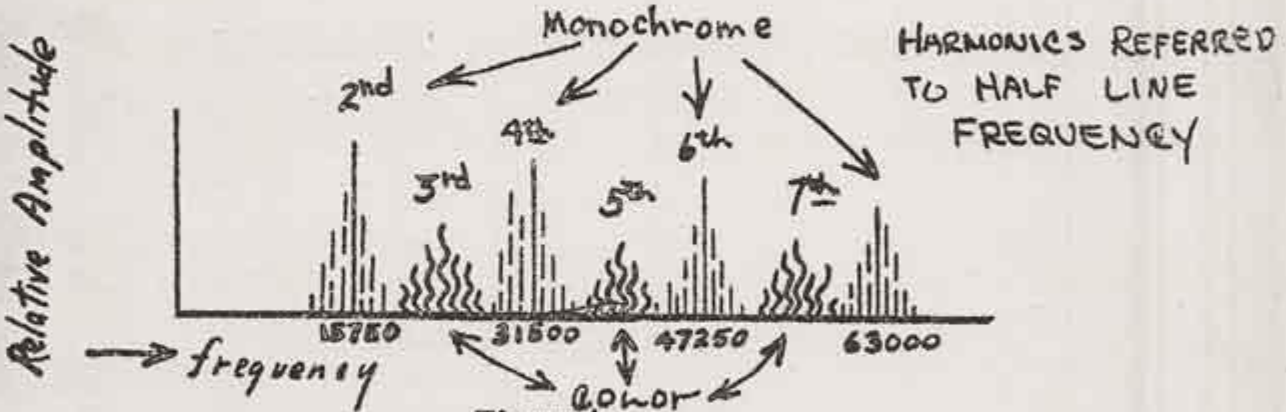


Figure 4.

The harmonic orders shown in Figure 4. have been referred to half line frequency, simply for convenience in expressing the frequencies of the color components. Thus, the second harmonic of half line rate is the first harmonic (fundamental) of the line rate, etc. The even harmonics of half line rate are monochrome components, while the odd harmonics are color components.

If the signal of Figure 4. was impressed on a monochrome receiver, the color components would cancel out in successive frames. Let us consider what happens on successive frames for the second harmonic of half line rate, representing luminance, and the third harmonic, representing color. These two harmonics will be in the form of sine waves impressed on the kinescope grid. See Figure 5.

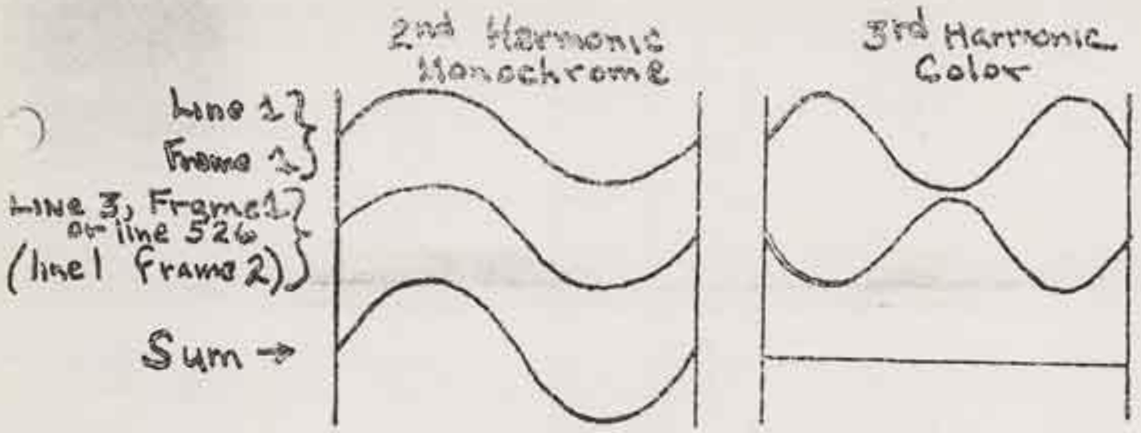


Figure 5.

Therefore, we see that for a monochrome receiver the luminance information adds on successive frames while the color information cancels out. In practice, this color information cancellation is not perfect, mainly due to non-linearities in the picture tube, but is good enough to render the color information of very low visibility. This cancellation process applies equally well to the luminance channel of a color receiver.

III ACTUAL MAKEUP OF THE NTSC COMPOSITE COLOR SIGNAL:

We have so far established that we can get a color signal into the television video spectrum and that that signal will be invisible on monochrome receivers. Now, how do we get it in?

Referring to Figure 4, we can see that if we modulate a color sub-carrier - which is an odd harmonic of half line frequency - with color information, the sidebands, or color components, will fall in the gaps in the monochrome video spectrum. From various technical considerations, it has been decided that the 455th harmonic of half line frequency would be the best choice for our new color carrier, or color subcarrier, frequency. The subcarrier frequency has been chosen as 3579545 cps. The horizontal and vertical scan frequencies are derived from this and turn out to be 15,734.264 cps for horizontal and 59.94 for vertical.

Note that these scan rates are slightly different than the nominal monochrome rates of 15,750 cps and 60 cps. However, the difference is so slight that the television receiver will not notice it.

As was previously stated, the actual color information to be transmitted is the hue and saturation of the colors. The problem is now to modulate these two sets of information upon the single color subcarrier. This is done by amplitude modulating the subcarrier with the saturation information and phase modulating the same subcarrier with the hue information. These modulation components are then detected separately in the receiver. It can be shown that modulating a carrier by both amplitude and phase is exactly equivalent to the amplitude modulation only of two separate subcarriers of the same frequency and in quadrature (90 degrees apart in time).

Because of certain technical considerations, the color information is modulated upon the subcarrier in suppressed carrier fashion; thus, the subcarrier does not exist as such in the composite color video as the carrier. However, there are video components at subcarrier frequency present. The amplitude of the subcarrier frequency present represents the average saturation of the transmitted color scene, while the phase represents the average hue of the scene.

Because the composite color video does not contain the subcarrier frequency necessary to detect or demodulate the color information, the receiver must supply this carrier signal. This subcarrier supplied by the receiver must match some reference signal in frequency and phase. In color television, this subcarrier reference signal consists of about 8 cycles of the true subcarrier frequency superimposed on the back porch of the horizontal sync. pulse. This is known as the "burst". The burst specifications are shown below in Figure 6.

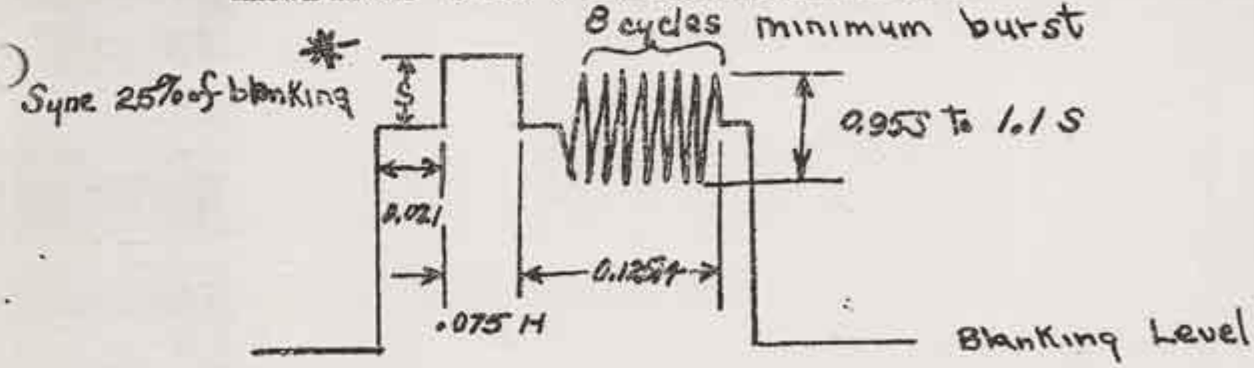


Figure 6.

In practice, a local subcarrier oscillator in the color receiver is synchronized with the burst frequency to provide the local carrier signal necessary for demodulation (detection) of the color components.

The camera equipment used for televising a scene separates out the amounts of red, green and blue primaries present in each picture element of the scene. The resulting red, green and blue video signals are then matrixed or added (after gamma correction) to produce the Y, or brightness, signal and the I and Q, chroma signals.

The Y signal is then modulated in normal fashion upon the picture carrier television frequency. It is made up of the following amounts of red, green and blue:

$$E_Y = 0.30E_R + 0.59E_G + 0.11E_B$$

* SYNC TIP HIGHT S 25% of peak excursion of luminance signal from blanking level.

The Y and primary signals are further matrixed to form the "color difference" signals, R-Y and B-Y. These signals are the result of subtracting the Y signals from the appropriate primary video.

Although the R-Y and B-Y could be used to modulate the color subcarrier, these signals are further matrixed (for reasons stated below) to produce the I and Q signals. The I and Q signals are made up as follows:

$$E_Q = 0.41(E_B - E_Y) + 0.48(E_R - E_Y)$$
$$E_I = -0.27(E_B - E_Y) + 0.74(E_R - E_Y)$$

The I and Q signals are then modulated in suppressed carrier fashion upon two 3579545 cps subcarriers spaced 90 degrees apart in phase. Thus, the I signal is modulated on the particular subcarrier which is 90 degrees ahead of the Q subcarrier. See Figure 7 for the various phase relationships. Not-

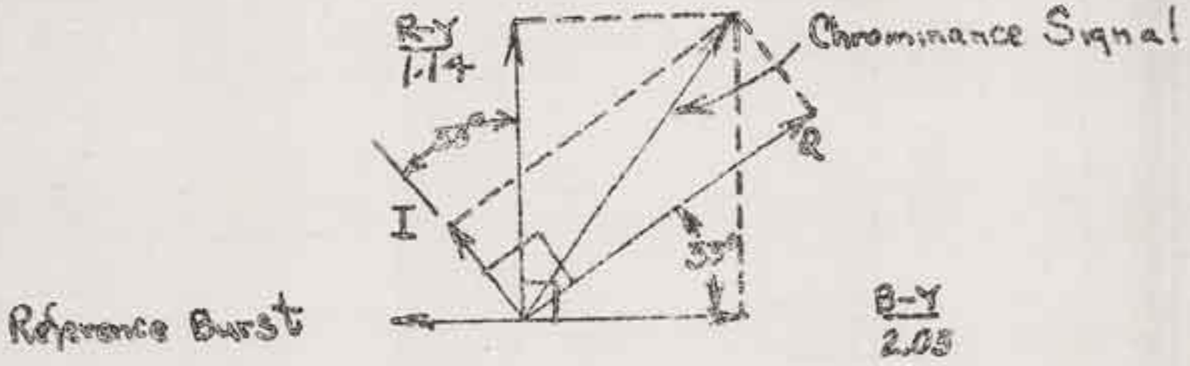


Figure 7.

The I and Q can be considered as artificial signals designed to take advantage of the different resolution powers of the human eye for different colors. The colors represented by the I signal range from orange to cyan and are those which the eye can detect in the greatest detail. The Q signal ranges from green to purple and it is detected in minimum detail by the eye. Therefore, the I is transmitted with more video bandwidth than the Q. The effective bandwidth of the I signal is 1.5 Mc and the Q signal is 500 Kc.

Figure 8 shows the occupancy of the video spectrum by the assorted signals making up the composite color video signal. Notice that the Q is modulated double sideband, while only the first 500 Kc of the I is double sideband; the remaining megacycle being single sideband.

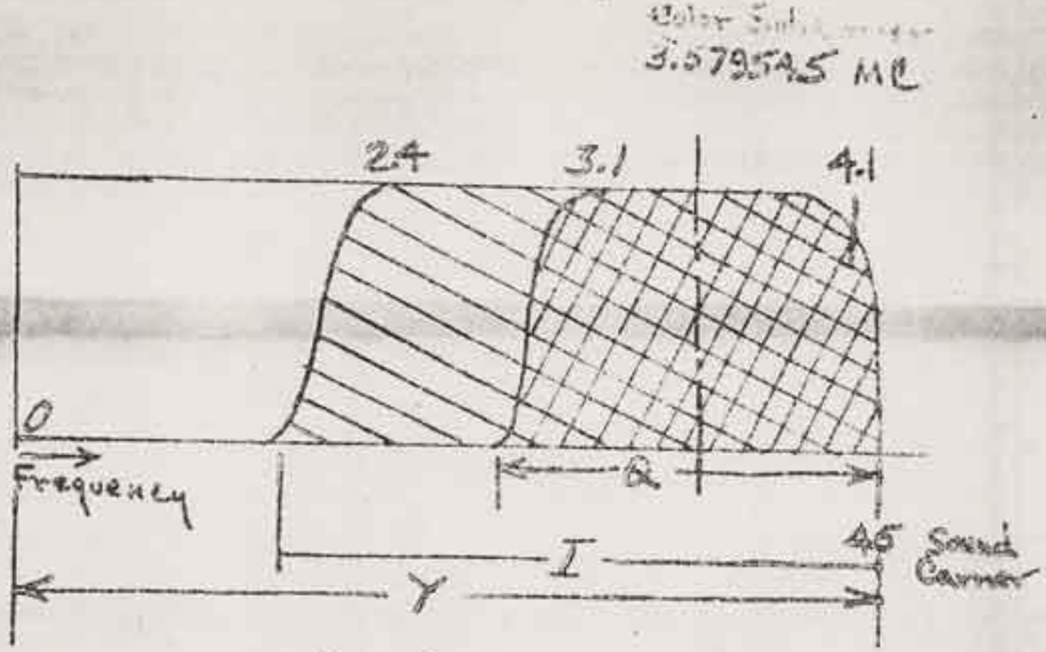
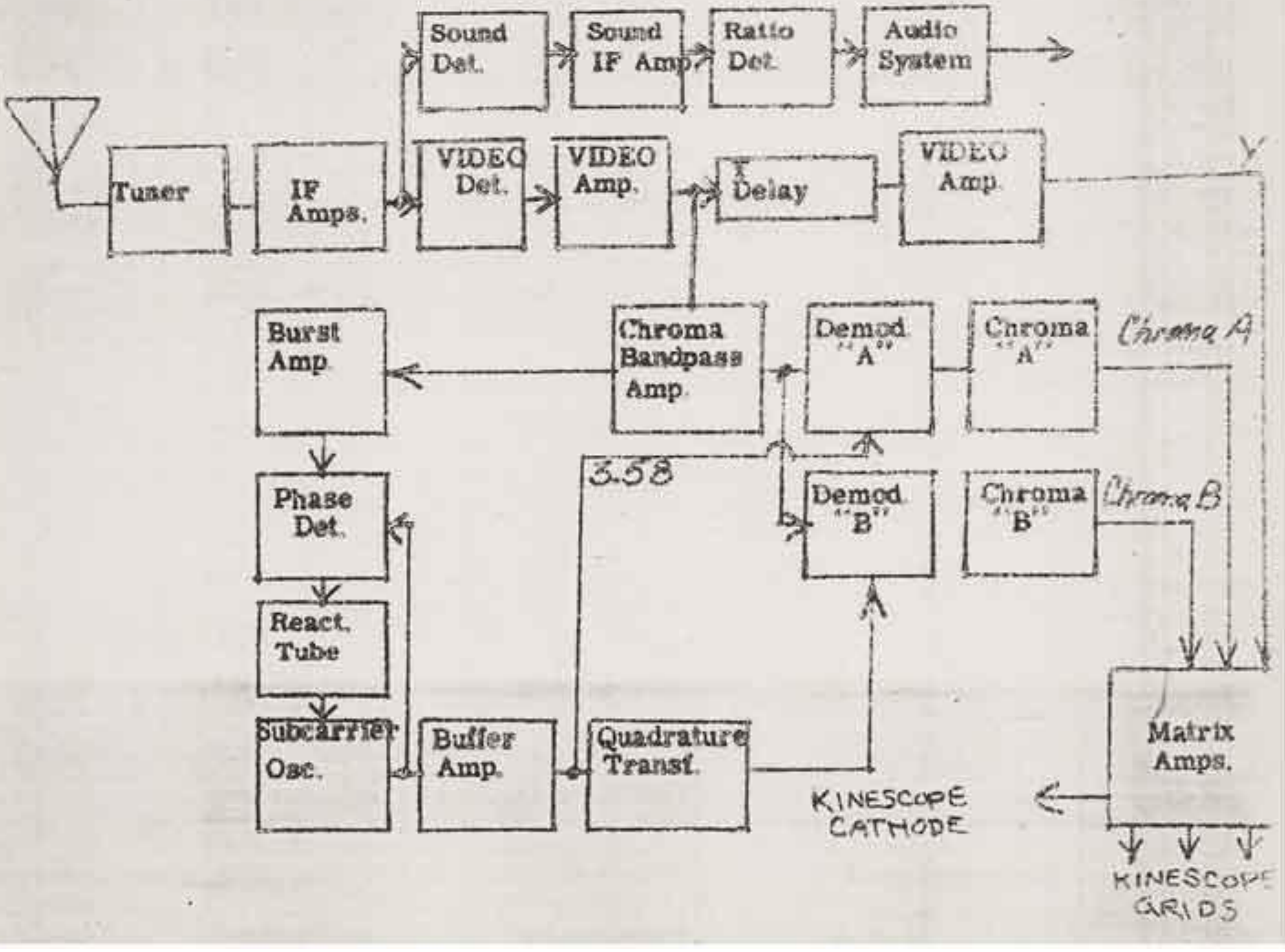


Figure 8

IV A BLOCK DIAGRAM OF A TYPICAL COLOR RECEIVER

Figure 9



V THE BLOCK DIAGRAM

Figure 9 shows the simplified block diagram of the RF, IF and decoder sections of a typical color television receiver designed to operate on the NTSC color signal, using a three gun kinescope. The deflection portion has been omitted in the interests of clarity.

This block diagram has been made as general as possible, consistent with showing all the major sections of a receiver for three gun tubes. Thus this diagram is equally applicable to I-Q or "equiband" decoders, to "RGB" or "color difference" kinescope drives, and to crystal controlled or self-excited subcarrier oscillators.

It is suggested that this diagram be firmly fixed in mind before proceeding to the following sections.

VI THE TUNER AND IF SYSTEM

The tuner and IF system for a color receiver differs from that of a monochrome receiver in the following major respects:

1. More attention is paid to flatness of tuner response throughout the video passband for a color receiver.
2. The flattopped portion of the IF passband is, in general, wider than that of a monochrome set.
3. Avoidance of IF and tuner overloading is of utmost importance.
4. Considerably more sound trapping is necessary in a color receiver.
5. The necessary deeper sound trapping requires a different type of sound take-off than on monochrome receivers.
6. The video detector must be operated without overload or compression.

As far as IF bandwidth is concerned, there are, at present, two schools of thought. The first is to have a very wideband IF amplifier which passes all chrominance components equally well. This type IF requires no peaking in the subsequent chrominance bandpass amplifiers. Because it is more difficult and costly to build a wideband IF amplifier than a narrow one, many color receivers use a somewhat narrower bandwidth, followed up by some video peaking at the high end of the chrominance bandpass amplifier. However, this method has the disadvantage of requiring closer tolerance on the IF and chrominance response shapes.

Most of the differences between color and monochrome tuner, IF systems are due to the necessity, in a color set, of eliminating or minimizing the 920 Kc beat between the sound carrier and chrominance subcarrier. Let us first consider the origin of this beat.

The frequency separation between the sound carrier and chrominance subcarrier is 4.5 Mc minus 3.58 Mc, or about 920 Kc. Now, if these two carrier frequencies are put through a strictly linear (output directly proportional to input) amplifier, the only frequencies present in the output are those present in the input. However, if the amplifier is non-linear, perhaps because of overloading, we get out not only the frequencies we put in, but also frequencies corresponding to the sum and difference of the two input frequencies. We have, in effect, a mixer circuit.

Suppose, now, that we examine in some detail what happens in an overloaded IF stage. Assuming a 45 Mc IF amplifier, the picture carrier will be at 45.75 Mc, the sound carrier at 41.25 Mc and the chrominance subcarrier at 42.17 Mc. The picture and sound carriers will beat to produce 4.5 Mc as we might expect. However, this beat is harmless. Also, the sound carrier and chrominance subcarrier will beat to produce 920 Kc. This 920 Kc will, in turn, beat with the picture carrier to produce 44.83 Mc, which will be passed through the IF amplifier. This new 44.83 Mc signal will be detected at the video detector as 920 Kc which will appear on the kinescope as objectionable coarse diagonal bars. Notice that, once this 44.83 Mc is generated, nothing can be done to get rid of it. Therefore, everything must be done to prevent its generation. This beat may also be generated in the tuner by the same process.

The 920 Kc beat may also be generated in the video detector. If we were using a double sideband method of transmitting television video and, if the video detector were a strictly linear detector, these beats would not be generated. However, with a vestigial sideband system as used in present day TV practice, the sound carrier and color subcarrier will beat to produce the 920 Kc. The remedy is to incorporate sufficient combined sound and subcarrier attenuation ahead of the video detector to render the generated beat invisible. The required combined attenuation has been experimentally determined to be at least 45 db or a voltage ratio of about 200:1.

For reasons stated before, it is generally not wise to have much attenuation at the color subcarrier frequency in the IF system. Therefore, most of the trapping must be done on the sound carrier. Current monochrome television receivers use about 26 db - voltage ratio 20:1 - of sound trapping as the best compromise between minimum intercarrier buzz and maximum sound sensitivity. If a conventional sound takeoff were used with the additional sound trapping necessary for color, poor sound sensitivity and signal-to-noise ratio would result. Therefore, we use a modified form of intercarrier sound system for color television. One form of sound takeoff is illustrated in Fig. 10.

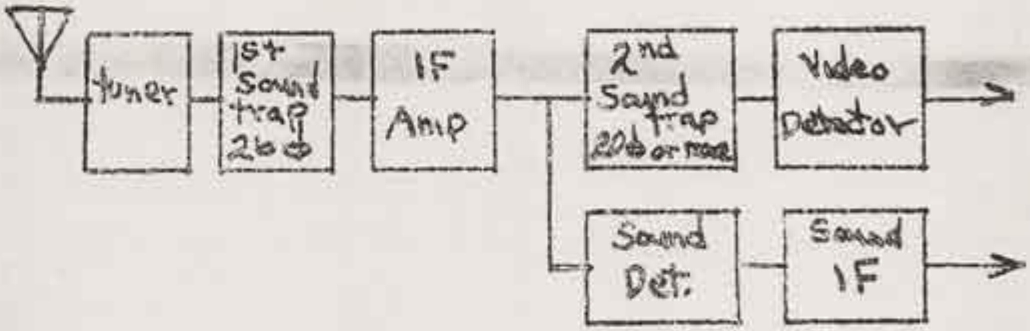


Figure 10

Here the first sound trap sets the desired picture carrier to sound carrier ratio. The sound detector, usually a crystal, picks off the intercarrier 4.5 Mc beat from the plate of the last IF amplifier, before the second sound trap. Another form of sound takeoff is shown in Figure 11.

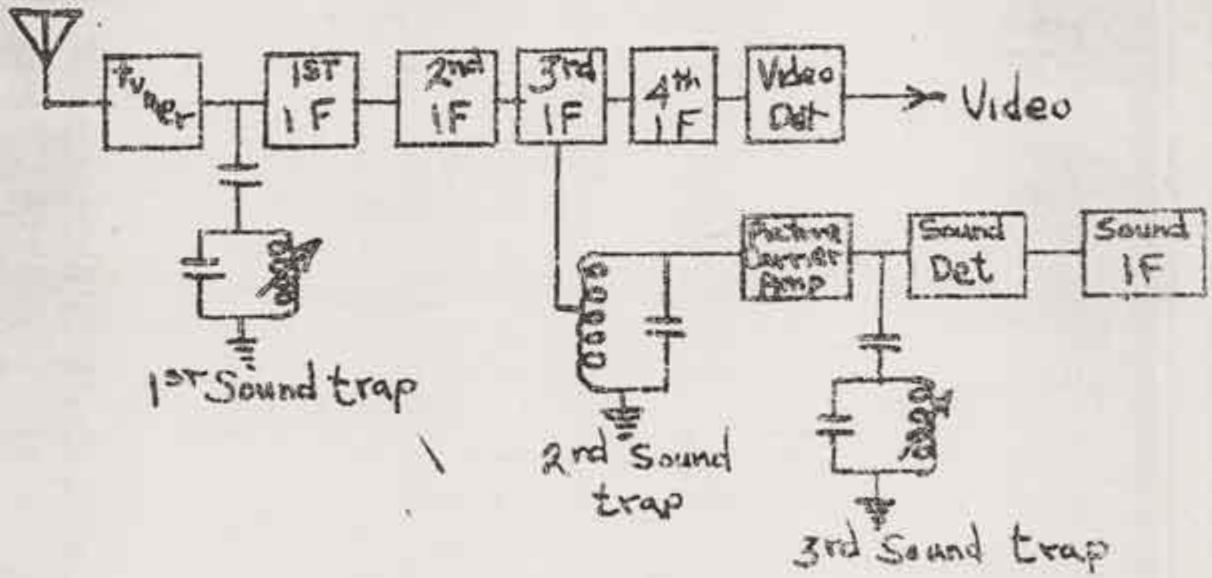


Figure 11.

As far as video at the second detector is concerned, the first and second sound traps are set for about 46 db or more sound attenuation. The three sound traps and picture carrier amplifiers are adjusted so the sound is 20 db down from the picture carrier at the sound detector.

The video detectors used in color television service are similar to those of monochrome with the exception that color detectors usually operate at a somewhat higher level in the interests of linearity.

Conventional inductive or capacitive coupled absorption traps are often used for color television, especially in the receivers with narrower IF passbands. These simple traps are not suitable for wide passband IF amplifiers for several reasons. It is extremely difficult to build a really wideband IF amplifier using absorption traps because the traps take a relatively wide notch out of the passband. Also, even if by use of extremely high Q traps the amplitude response is made very wide, the resultant phase distortion is intolerable. Therefore, wideband IF amplifiers usually use "bridged T" type of sound traps. These traps are not only very sharp and give excellent trap rejection, but also do not ruin the phase response of the amplifier. A typical bridged T sound trap is shown in Figure 12.

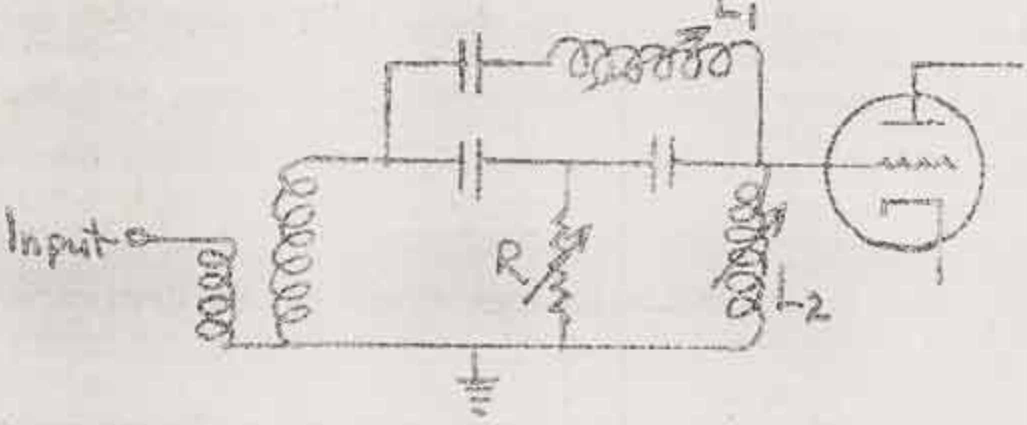


Figure 12

In the bridged T trap above, L_1 is used to set the trap frequency, while R adjusts the depth of the trap. L_2 adjusts the shape of the passband.

The amplitude response for a typical wideband IF amplifier is shown below. This amplifier uses bridged T sound traps and requires no video peaking in the chrominance channel.

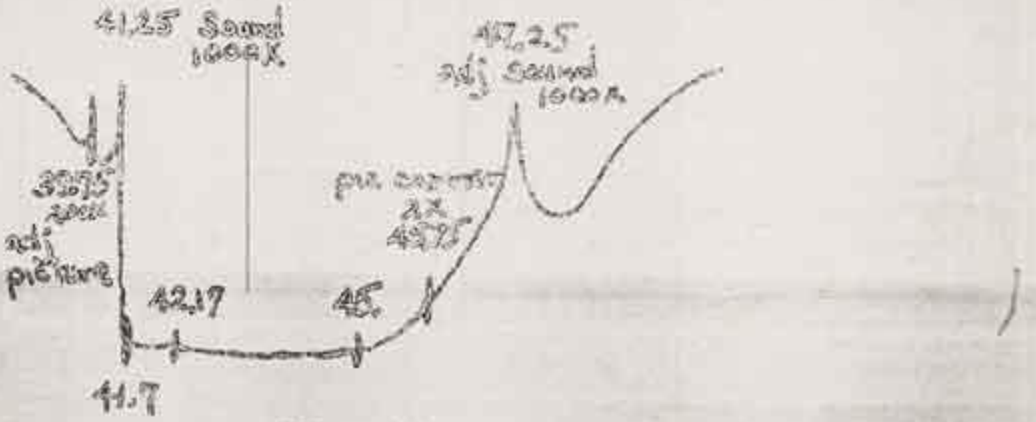


Figure 13.

Figure 14 shows the response of a typical narrower band color IF amplifier. This amplifier used absorption traps and does require video peaking in the chrominance channel for a flat tuner-to-color demodulator response for chrominance signals.

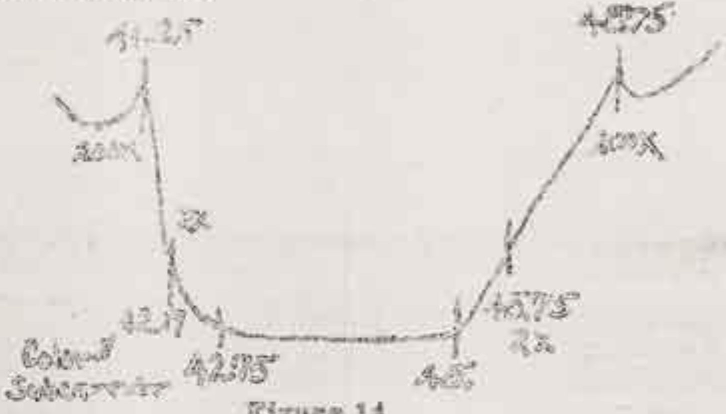


Figure 14

It is of considerable importance to adjust the AGC bias on the tuner-IF portion of the color receiver so that overload does not occur. Also, the tuner local oscillator must be stable enough to keep the sound carrier tuned in the sound trap in order to avoid the 920 Kc beats.

Unlike monochrome television, where the tuner local oscillator setting is not particularly critical, the local oscillator must be set properly to receive a color picture. Fortunately, the 920 Kc beat makes good tuning indicator. Simply set the local oscillator so that the 920 Kc beat suddenly disappears, this is the correct local oscillator adjustment.

VII THE VIDEO SYSTEMS

The luminance channel video system of a color receiver is somewhat similar to that of a monochrome receiver, but has the additional features of a 3.58 Mc trap and a delay line.

The purpose of the 3.58 Mc trap is to reduce the amount of subcarrier and its low frequency sidebands going through the luminance channel. This removes the 3.58 Mc beat which would otherwise appear on the kinescope as a fine crosshatching. The amount of trapping used is not great and is usually of the order of about 15 or 20 db. The trap is also somewhat broad, starting to take a "bite" out of the luminance response at about 3.1 Mc.

With most filter circuits, the amount of delay a signal suffers is inversely proportional to the bandwidth of the filter. The chroma signals pass through circuits having less bandwidth and, hence, more time delay than the luminance signals. Therefore, a delay line of about one microsecond delay must be inserted in the luminance channel in order to let the chrominance "catch up" with the luminance. If this is not done, the colored edge of an object will not show up at the same place as the luminance edge of the same object, thus giving a picture that appears mis-registered.

The delay lines used range from coils wound on long phenolic or paper tubular forms to special flexible delay cables.

The most important thing to watch in using delay lines is to see that they are terminated in their characteristic impedance. This termination proposition is very similar in principle to matching of antenna feed lines to the television tuner. If the delay line is improperly terminated, reflections will exist on the line, causing ghosts on the kinescope. In practice, the delay line terminations may be adjusted by minimizing or eliminating ghosts on the kinescope. Normally, both sending and receiving ends of the delay line are terminated.

A typical luminance channel video response is shown below in Figure 15.

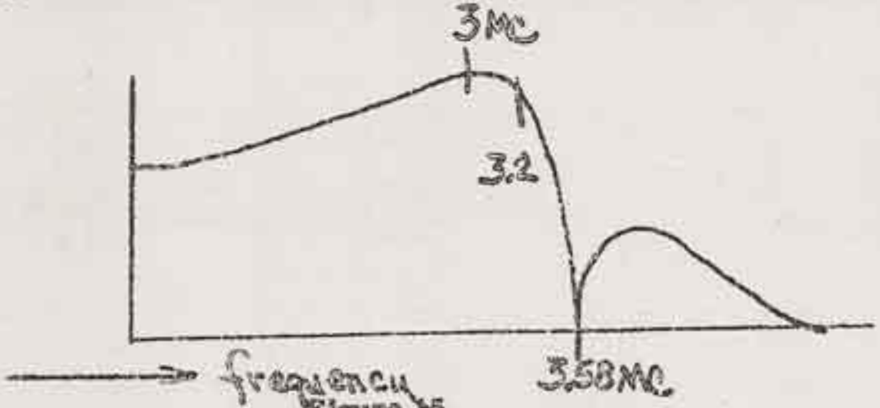


Figure 15.

The chrominance bandpass video response is considerably different than that of the luminance. A typical chrominance response is shown in Fig. 16.

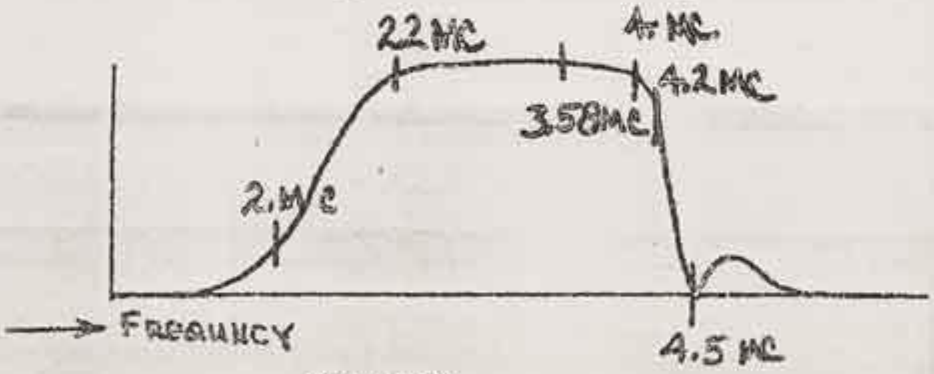


Figure 16.

The above bandpass is suitable for the wideband type of IF amplifier shown in Figure 12. A 4.5Mc sound trap is used to both help shape the response and to remove any incidental 4.5 Mc that might beat with the color subcarrier to produce 920 Kc.

A chrominance bandpass amplifier suitable for a narrower band IF amplifier is shown below in Figure 17.

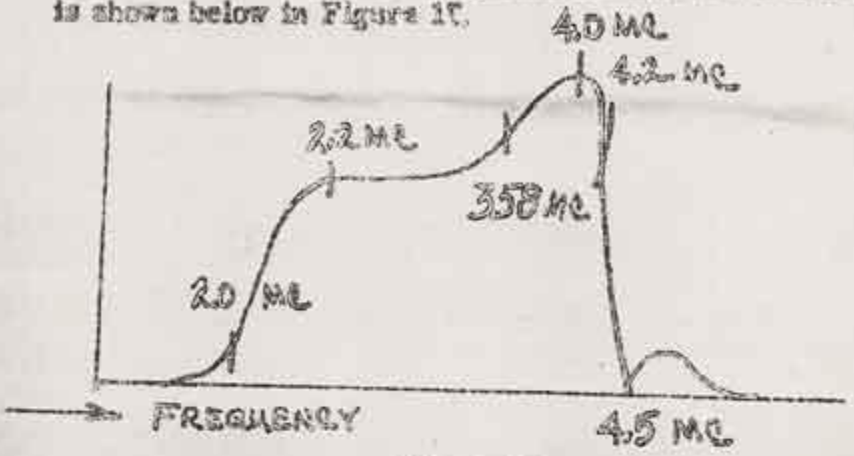


Figure 17.

At some point in the chrominance bandpass amplifier 3.58 Mc must be taken off for the burst amplifier. This point may be either ahead or past the color gain control, depending on the design.

VIII THE COLOR SYNCHRONIZING SYSTEM

Reference to the block diagram of a color receiver shown in Figure 9 will aid in understanding the discussion to follow.

As was previously stated, a local subcarrier oscillator must be locked in frequency and phase with the burst transmitted on the back proch of the horizontal sync pulse. In essence, the burst is separated from the rest of the chrominance video and compared in phase detector with a sample of the subcarrier oscillator output. The phase detector develops a correction voltage proportional to the difference in phase of the two signals applied to the phase detector. The correction voltage developed is applied to a reactance tube, which reflects capacitance to the oscillator tuned circuits in such a manner as to pull the subcarrier oscillator toward the correct phase.

The burst amplifier is keyed on only during the horizontal sync period by a pulse delivered by the flyback transformer. Since the burst amplifier only amplifies during approximately the time when the burst is present, no chrominance video other than the burst is applied to the phase detector. Components of the horizontal sync pulse are greatly reduced by the lack of low frequency response of the chrominance video channel. If the burst amplifier is not keyed on during the burst interval, other frequency components reach the phase detector. Therefore, any DC voltage output from the phase detector is meaningless and color sync cannot be achieved. Thus, the receiver must be in horizontal sync before color sync may be attained. The horizontal hold control must be adjusted correctly, for, even if the horizontal is synchronized, the hold control may be set so that the burst amplifier gating pulse is timed incorrectly, missing all or part of the burst. This also means that the horizontal sync system must be quite stable. Fig. 18 shows a typical output from the burst amplifier.

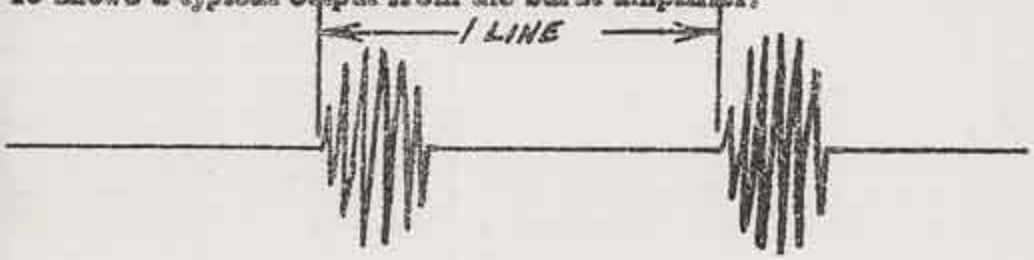


Figure 18.

The phase detector is the error detector for the color synchronizing system. It compares the phase of the burst to the phase of the subcarrier oscillator and develops a DC voltage which is used to correct the phase of the subcarrier. The circuit diagram of a typical phase detector is shown below in Figure 18.

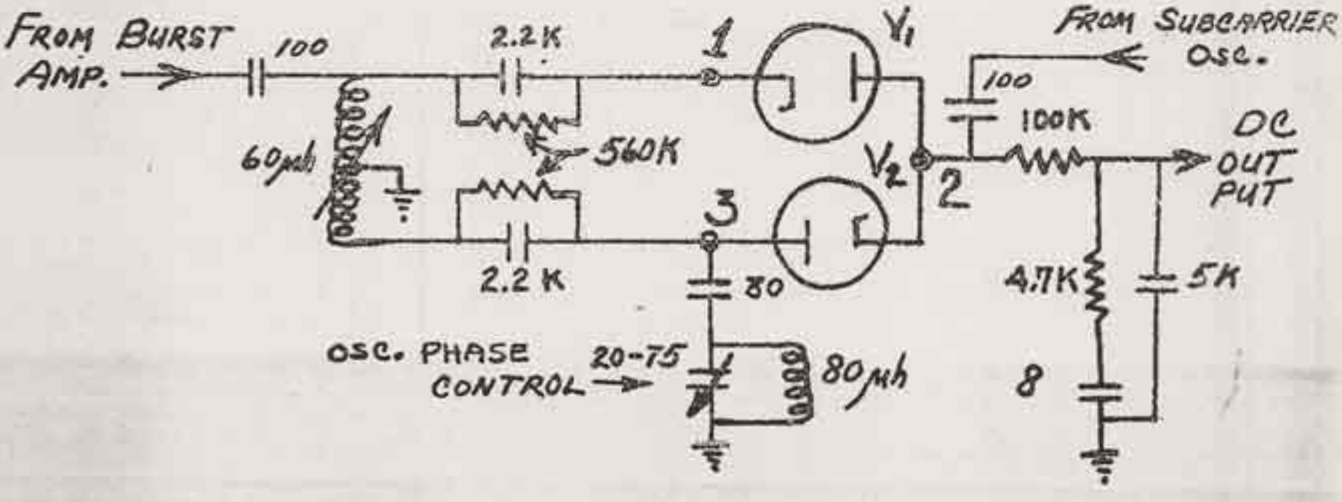


Figure 19.

The burst and subcarrier inputs and the DC output are as shown on Figure 18. Notice that the DC output is well filtered and changes only slowly. With respect to AC, the 60 microhenry coil is placed directly between points 1 and 2. Note that the burst applied to V_2 is 180 degrees out of phase with that applied to V_1. The oscillator phase control adjusts the phase of the burst applied to points 1 and 3 so that the phase of the subcarrier oscillator may be varied to adjust the color phase as seen on the picture tube. It is important that the only DC path from the DC output to ground is through the two diodes. Also, the 560K resistors and 2.2K capacitors tied to points 1 and 3 must be matched to within 3% in value.

In operating, if the input from the subcarrier oscillator is exactly 90 degrees out of phase with the burst signal at points 1 and 3, diodes V_1 and V_2 will conduct equally, and the phase detector DC output will be zero. However, if the subcarrier should not be in quadrature with the burst at points 1 and 3, one diode will conduct more than the other. Since the only path from point 2 to ground is through the diodes, a DC voltage will then be built up at point 2, and the DC output will change to some value other than zero.

If either no burst or no subcarrier is applied to the phase detector, both diodes will conduct equally, and the DC output of the phase detector is zero.

To explain just how the diodes conduct equally with the signals at points 2 and 1-3 in quadrature, suppose that these two signals are exactly 90 degrees apart. After a line interval or two, the 2.2K capacitor and the 560K resistor combinations will be charged up to the peak value of the applied sine waves. Let us call the peak-to-peak voltage of the applied burst EB and that of the applied subcarrier ES. Points 1, 2 and 3 are labeled for easy reference. Figure 19 shows the AC and DC voltages at the three points.

POINT	AC Vector	DC Voltage	Conduction Angle of V_1&V_2
1	↑ $E^B/2$	$+ E^S/2$	
3	↓ $E^B/2$	$- E^B/2$	
2	$\xrightarrow{ES}$	0	
E_{1-2} (Drop between cathode and plate V_1)		$+E^B/2$	
E_{3-2} (Drop between cathode and plate V_2)		$-E^B/2$	

Figure 20.

Now, whenever E_{1-2} is more negative than the DC bias on that point (the length of the projection of E_{1-2} on the vertical line is more negative than $E_B/2$ is positive), the tube V_1 will conduct. Also, when E_{3-2} is more positive than $-E_B/2$ is negative, tube V_1 will conduct. Notice that, although V_1 and V_2 conduct at different times as vectors E_{1-2} and E_{3-2} rotate, they conduct by the same amount, hence, the average DC value at 2 is zero, and the DC output of the phase detector is zero.

Now, let the subcarrier suddenly become 45 degrees out of phase with the burst phase. Figure 21 shows the voltage relationships for this condition.

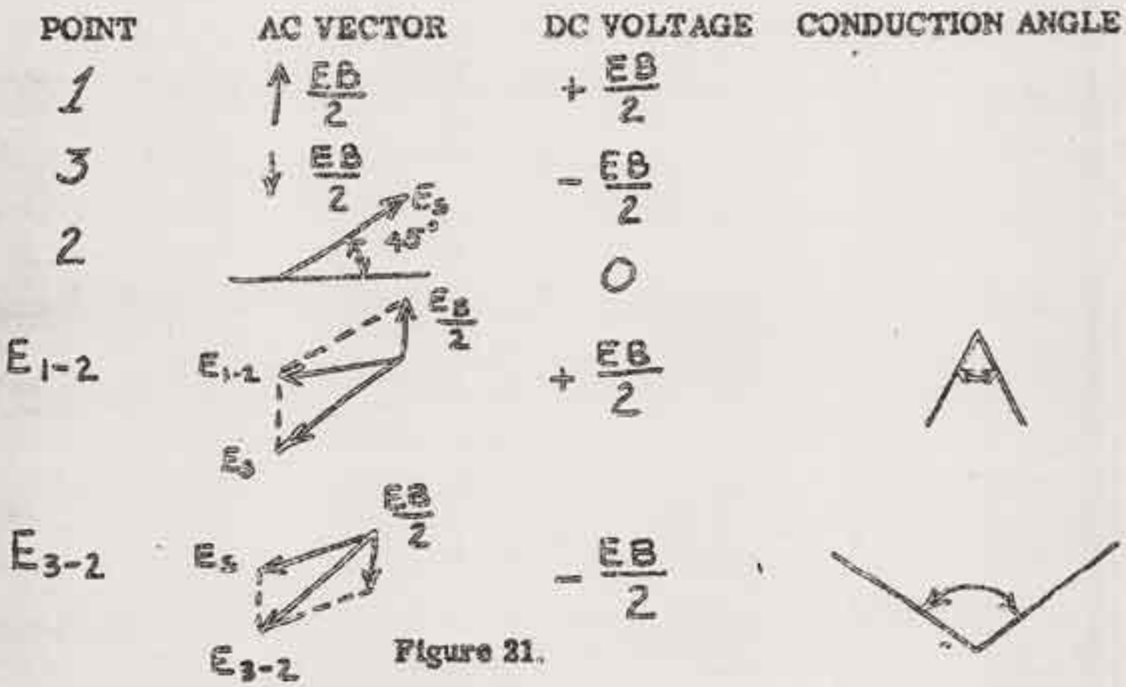


Figure 21.

Notice that now V 2 conducts longer and, since E_{3-2} is a longer vector than E_{1-2}, at a higher rate. Thus, positive voltage is applied to point 2 more rapidly than it is removed; therefore, the phase detector DC output goes positive. Note that, if the E_S vector were sloping <u>downward</u> at 45 degrees, the voltage at point 2 would go negative instead of positive.

Thus, we can see that the phase detector will produce a DC voltage whose magnitude is a function of how much the two input signals are out of quadrature, and whose polarity depends upon which direction the inputs are out of phase from quadrature.

The reactance tube translates the DC voltage developed by the phase detector into actual frequency (or phase) changes of the subcarrier oscillator. This is done by causing the reactance tube to reflect a capacitance across the subcarrier oscillator's frequency determining tuned circuits. Figure 23 shows a typical reactance tube stage.

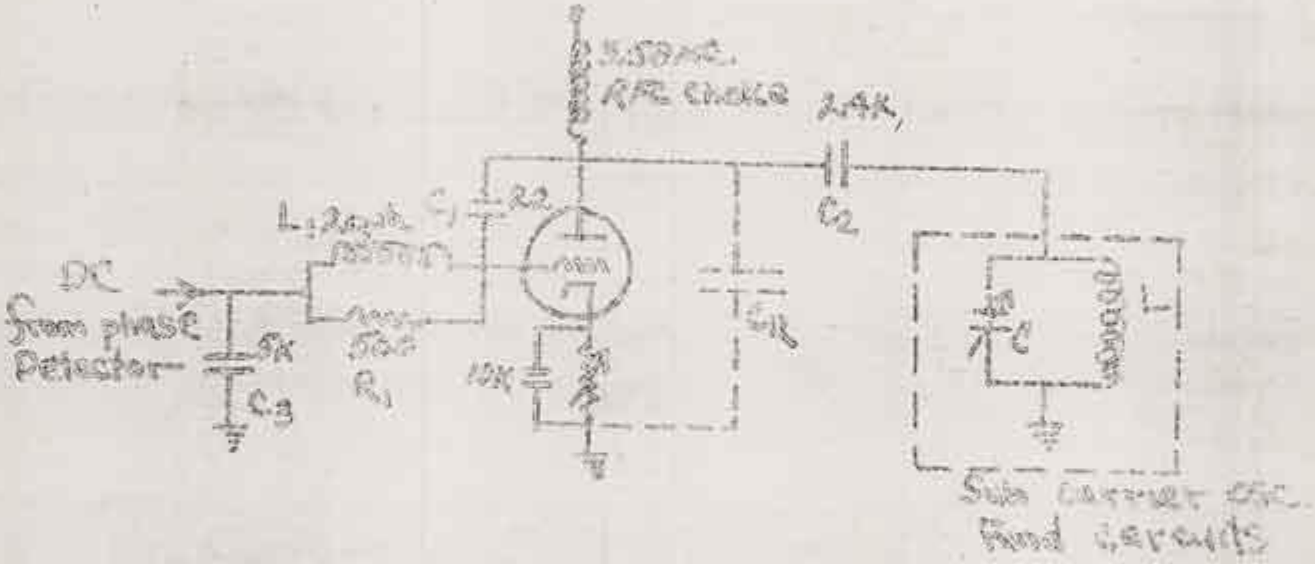


Figure 23.

In the above circuit, C_R represents the capacity reflected by the reactance tube. Since C_2 is much larger than C_R, any change in C_R is reflected back across C to the subcarrier oscillator tuned circuits. In operation, the subcarrier voltage appearing at the plate of the triode is coupled loosely to the grid through C_1. The voltage divider, consisting of C_1 R_1 L_1 and C_3 shifts the phase of the subcarrier voltage applied to the grid so that the grid voltage leads the plate voltage by about 90 degrees. The AC plate current will be in phase with the grid voltage. Therefore, the AC plate current will lead the plate voltage about 90 degrees. Since the current through a capacitor leads the voltage applied to the capacitor by 90 degrees, the reactance tube looks like a capacity as far as C and L are concerned. Notice that, as the DC grid bias goes more positive, the tube gain is increased and more AC plate current flows; this is equivalent to making C_R larger, thus lowering the frequency of the subcarrier oscillator. The cathode resistor, R, acts as a color hold control, since it will set the DC bias on the reactance tube and, hence, will control the subcarrier frequency to a limited degree.

The subcarrier oscillators used in present day color receiver practice are of two main forms, crystal controlled and self-excited. The self-excited oscillator is simple and requires no special components; however, it is difficult to economically build an oscillator of this sort which is stable enough for really satisfactory performance. The crystal oscillator is simple and, with modern inexpensive crystals, is economical to build. However, the crystals must be accurately ground; if, for some reason or other, they should drift off frequency by as little as one kilocycle, they must be replaced.

The possibility of "sidelock" must always be considered with subcarrier oscillators that may drift or be adjusted 15 Kc or more from the nominal burst frequency. Although the nominal burst frequency is 3.579545 Mc, the burst is modulated at line rate, since it is keyed. This means that the burst contains frequency components corresponding to line frequency and its harmonics, both above and below the nominal burst frequency. Therefore, the subcarrier oscillator may lock in on one of these components. On the kinescope tube this is manifested by an area which is known to be of one hue, appearing as having several widely different colors. The color boundaries will be vertical.

IX THE COLOR DEMODULATORS AND QUADRATURE TRANSFORMER

The type of color demodulators used in receivers utilizing three gun picture tubes are "synchronous", or "product" demodulators. They provide an output which is proportional to the product of the instantaneous values of the applied subcarrier and the chrominance video. From a vector standpoint, the output is proportional to the component of the chrominance video in phase with the applied subcarrier.

The schematic diagram of a typical color demodulator is shown in Figure 23.

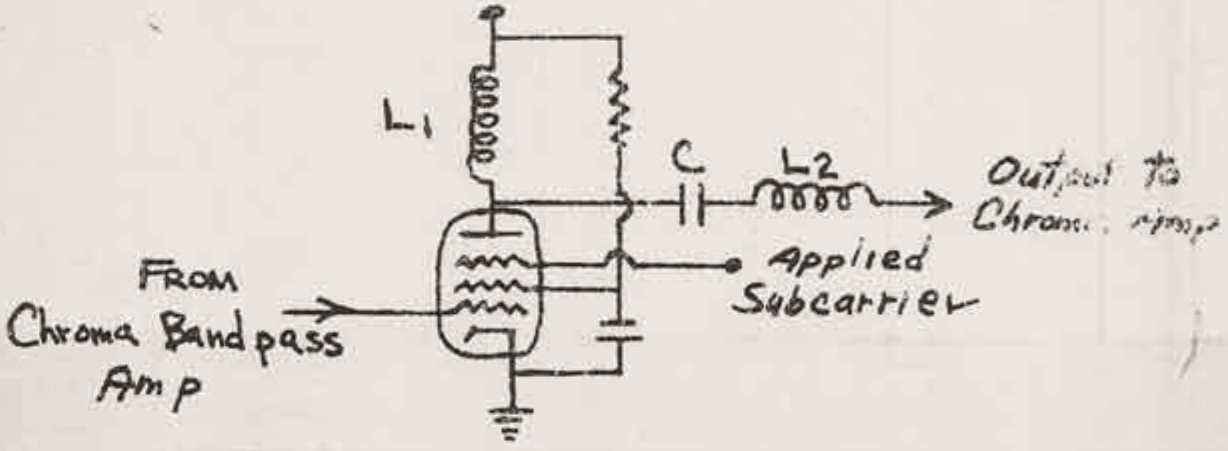


Figure 23

The product demodulation process uses the suppressor grid-to-plate gain of the demodulator tube, as well as the usual control grid-to-plate gain. The output at any instant of time is, therefore, proportional to the product of the control and suppressor grid inputs at that instant.

The inductances L1 and L2 in the demodulator plate circuit act to help shape the passband of the following chroma amplifiers. Also, they form a simple low pass filter to attenuate certain spurious frequencies generated in the demodulators.

Now, if the two inputs to the demodulator were exactly 90 degrees out of phase, the output of the demodulator would be zero, plus the above mentioned spurious frequencies that are filtered out. Since the I and Q color information is transmitted in quadrature, a demodulator may be set up to recognize either I or Q and ignore the other. Therefore, if two demodulators are used with their respective subcarrier inputs 90 degrees apart, the I and Q information can be detected separately and without crosstalk.

The quadrature transformer shifts the subcarrier by 90 degrees for application to one demodulator. Figure 24 shows a typical quadrature transformer.

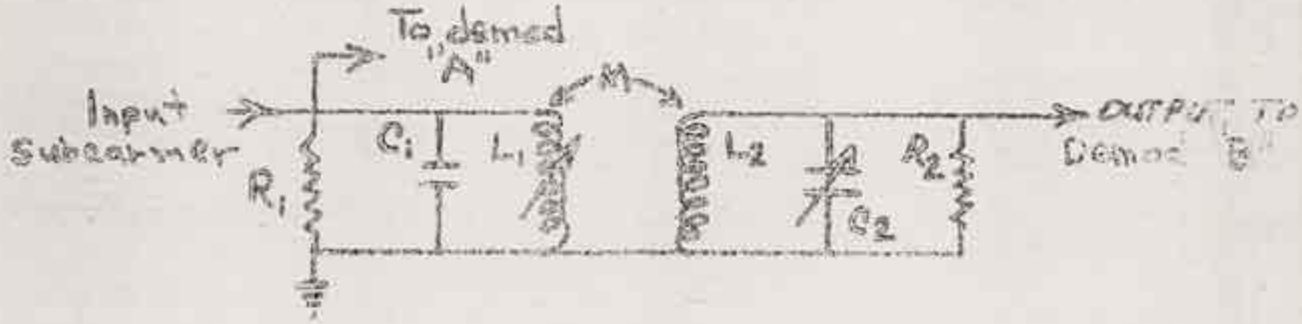


Figure 24.

L_1 and L_2 are mutually coupled coils. L_1C_1 and L_2C_2 are tuned to resonate at the subcarrier frequency. R_1 and R_2 are chosen to give equal RMS primary and secondary voltages. The output phase will then lag the input by 90 degrees.

The subcarrier level supplied to the demodulators must be about 30 volts peak-to-peak for currently available demodulator tubes.

Referring back to Figure 7, we see that there are two ways we might adjust the the phase of the subcarrier oscillator for color detection. We might set the subcarrier phase to Demodulator "A" in phase with the I signal. Then the quadrature transformer output applied to Demodulator "B" will be in phase with the Q signal. Thus, we would detect the I and Q signals, which could then be matrixed to provide the red, green and blue signals for the kinescope. This is called an "I-Q" style of decoder.

Alternately, we might adjust the subcarrier phase to Demodulator "A" to be in phase with the R-Y signal. Then the Demodulator "B" subcarrier would be in phase with the B-Y signal. Thus R-Y and B-Y components will be recovered. A simple matrixing operation will give the G-Y signal. These color difference signals would be applied to the kinescope grids and the Y signal to the cathodes. This is an "equal bandwidth" or equiband decoder.

The I-Q decoder takes full advantage of the NTSC color television signal. However, it requires relatively complex matrixing to obtain the red, green and blue signals. Because of color crosstalk problems, the equiband decoder must be limited to about 700 Kc. in effective bandwidth. Therefore, it does not give quite as much color detail as the I-Q decoder. However, the matrixing operation is simple, hence, this makes an economical decoder.

X. THE CHROMA AND MATRIX AMPLIFIERS:

The design of the matrix amplifiers depends upon the style of the decoder used. For equiband operation, the chroma amplifiers following the decoder both have bandwidths of about 700 Kc. The G-Y signal is derived by following matrix operation:

$$E_G - E_Y = -0.51(E_R - E_Y) - 0.19(E_B - E_Y)$$

Because the G-Y signal requires negative values of R-Y and B-Y, one phase inverter is needed to get the correct polarity of G-Y.

For I-Q operation, the frequency responses of the I and Q chroma amplifiers is different. Typical I and Q channel responses are shown in Figure 25.

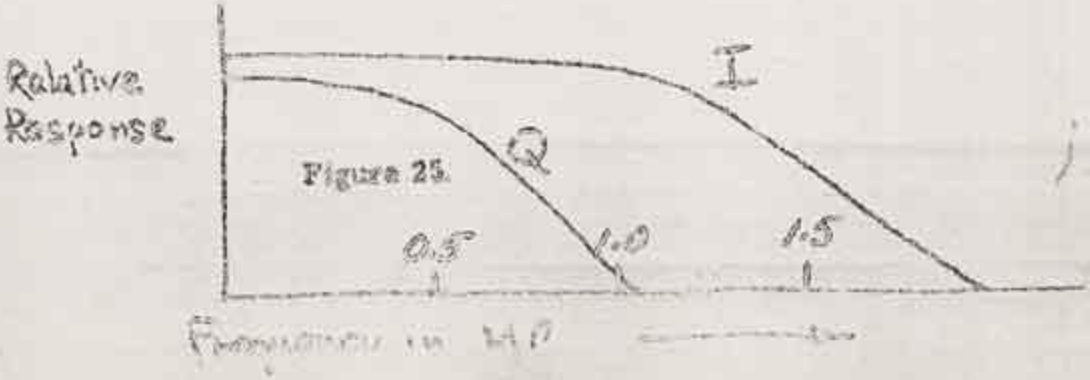


Figure 25.

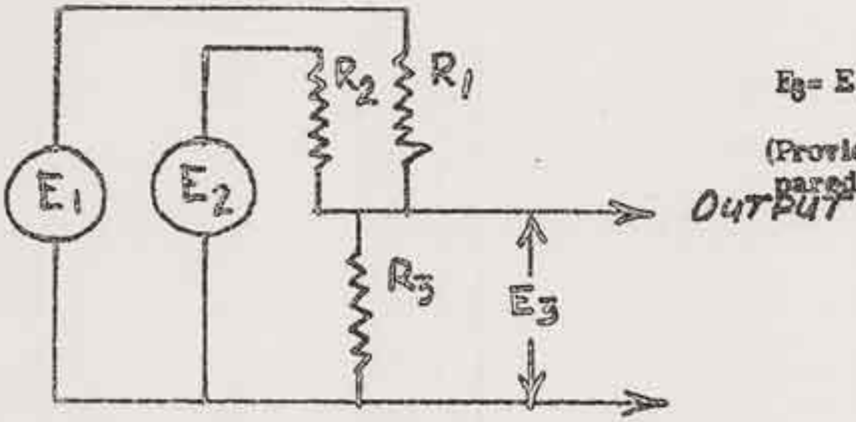
Since the I and Q bandwidths are different, some form of time delay must be provided to delay the I so the I and Q signals coincide in time. This may be done either by providing a separate I channel delay of about 0.5 microseconds, or by using special non-minimum phase networks which will provide the correct delay within the network.

The matrixing operations necessary to provide red, green and blue outputs from an I-Q decoder are as follows:

$$E_R = E_Y + (0.52E_Q + 0.96E_I)$$
$$E_G = E_Y + (-0.65E_Q - 0.28E_I)$$
$$E_B = E_Y + (1.70E_Q - 1.10E_I)$$

It can be seen from the polarities involved in the above equations that both positive and negative I and Q signals are needed. Therefore, the I and Q chroma amplifiers must have phase splitters for both I and Q.

The matrixing is usually done by resistive adders, as shown in Figure 26.



$$E_3 = E_1\frac{R_3}{R_1+R_3} + E_2\frac{R_3}{R_2+R_3}$$

(Provided R_3 is small compared to R_1 and R_2)

Figure 26.

As can be seen from the above equation, these adders are quite lossy.

XI DC RESTORATION AT THE KINESCOPE

The need for DC restoration at the kinescope terminals can be illustrated by the aid of Figure 27. Suppose the scene consisted of a narrow yellow bar lasting one-fourth of the horizontal scan period. Let this yellow bar be followed by a red bar of the same width. The correct signal applied to the kinescope is shown on the left in Figure 27 and the signal that would be applied if AC coupling were used is shown at the right.

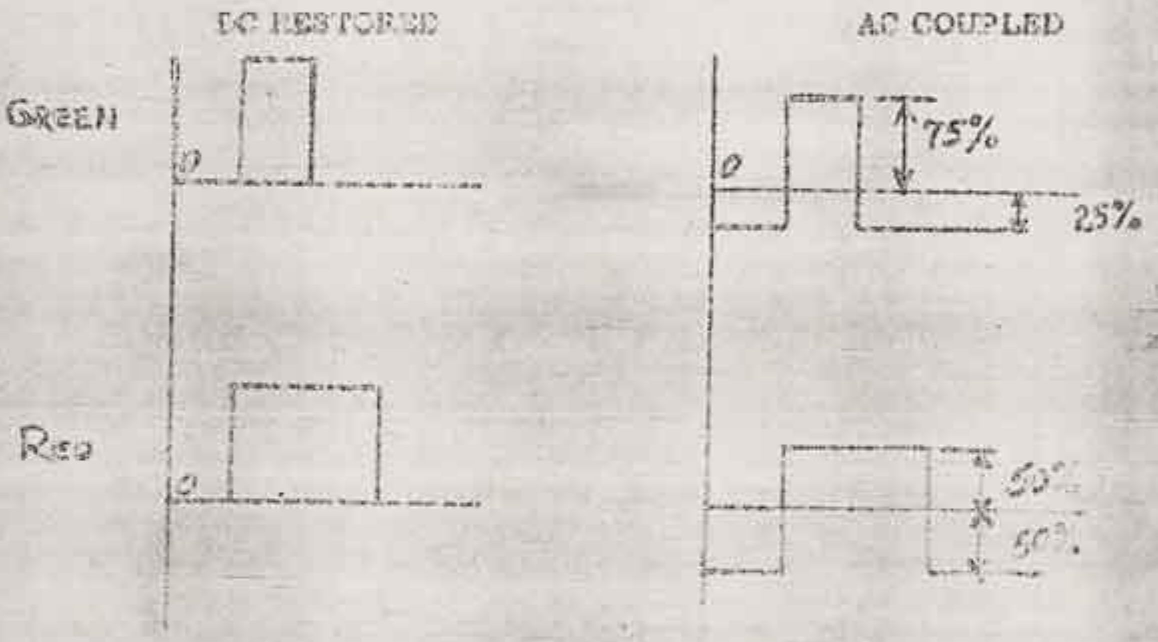


Figure 27.

Notice that on the correct signal on the left the yellow is made up of one unit of green and one of red, whereas, in the AC coupled case, the yellow is made up of 0.75 green and 0.5 red, which would be a greenish yellow. While the kinescope could be adjusted to give the correct yellow and red bars of Figure 27 with AC coupling, if the red bar were then increased to one-half of the scan period the AC zero of the red signal would shift, thus rendering the yellow bar once again incorrect.

Therefore, DC restoration at the kinescope is necessary to provide the proper color balance for all types of scenes to be presented. It would be possible to avoid the troubles of AC coupling by direct coupling the luminance channel from the video detector to the kinescope, and direct coupling the chrominance channel from the demodulators to the kinescope. However, such a system would be unwieldy and unstable. A simple DC restorer is shown in Figure 28.

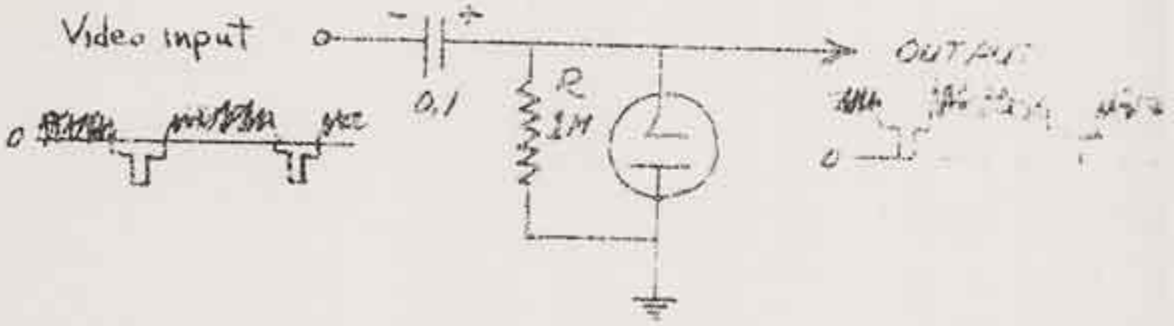


Figure 28.

If sync negative video is applied to the DC restorers, the output cannot go negative because of the rectifying action of the diode. As the diode conducts, capacitor C charges up in such a manner that, after several cycles the diode conducts only enough during sync tips to supply the charge removed by resistor R. Therefore, the output is DC referenced to ground.

In a decoder that supplies red, green and blue signals to the kinescope grids (Usually an I-Q decoder) the DC restorers act between kinescope grids and ground. There is one DC restorer for each grid. Because the Y signal (which contains sync pulses) has been matrixed with the chrominance signals to produce the red, green and blue video , these three components do contain sync pulses to operate the DC restorers. The kinescope brightness is then controlled by varying the kinescope cathode DC voltage.

In the Color difference decoder (usually an equiband decoder) the DC restoration is applied in a slightly different manner. The color difference signals are applied to kinescope grids and the Y signal to the three cathodes tied together. Then the R-Y, B-Y and G-Y signals are added to the Y signal within the kinescope itself to provide the actual red, green and blue kinescope beam currents. In this case, the DC restorers act between the color difference signals and the luminance signal to provide the proper color balances. Figure 29 shows a DC restorer circuit suitable for a color difference decoder.

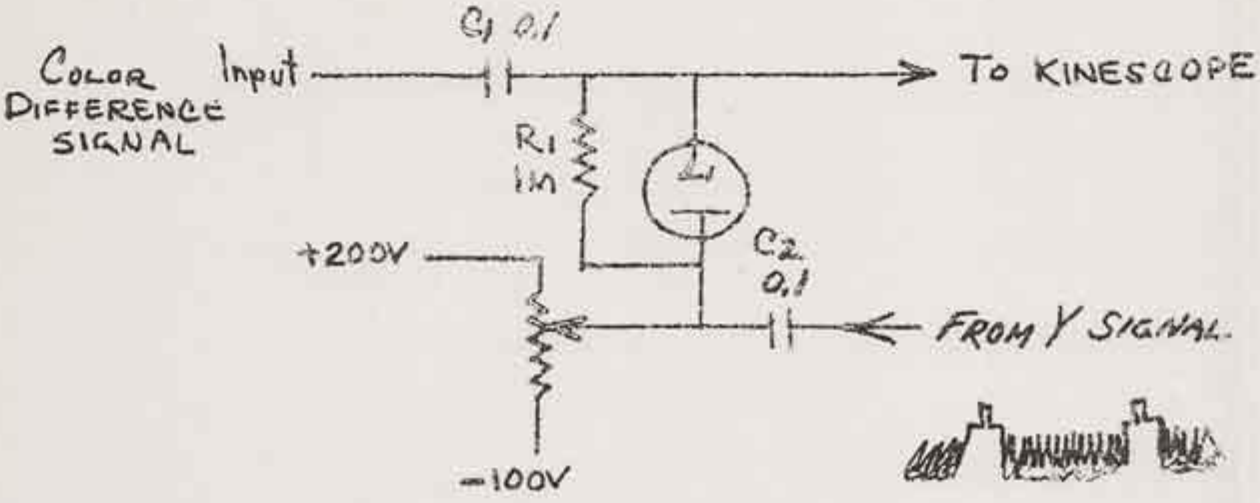


Figure 29.

In the above illustration, the color difference video is DC restored with respect to the sync tip height of the Y signal applied through C_2. Thus, the color difference signals are referenced to the Y signal. Notice that, since the Y signal is applied to the kinescope cathode and the color difference signals to the kinescope grids, this DC restoration gives the effect of direct coupling from the video detector to the kinescope for the luminance signal.

The potentiometer, R_2, sets the DC level at the kinescope grid and, hence, acts as a brightness control for that particular kinescope gun. Of course, a DC restorer is required for each kinescope grid.

XII THE DEFLECTION AND HIGH VOLTAGE:

The following remarks cover only deflection systems for a three-gun, shadow mask type of kinescope.

The high voltage requirements of a color television receiver using a three-gun tube are much more severe than those of a monochrome receiver. A typical color set will require about 800 microamperes of current at 20 Kv, and, also, rather large amounts of focus electrode current. In addition, the high voltage supply must be electronically regulated because of convergence considerations.

The high voltage rectifier is usually of the voltage doubler style. The regulator is often a high voltage triode in shunt with the kinescope high voltage electrode. The regulator tube grid is referenced to the high voltage potential by a voltage divider across the high voltage output. Thus, the regulator tube acts as an automatically adjustable load on the HV supply.

assuming load as the kinescope load drops, thus tending to make the HV potential constant. Another form of HV regulator sometimes used is a corona discharge tube, which acts in much the same manner as an ordinary gas regulator tube (VR tube).

Because considerable focus current is used at about 2 Kv a separate focus rectifier, operating from its own flyback transformer tap, is used.

The horizontal sync circuits must have good stability if the color sync system is to work properly.

The deflection chassis for a color receiver must supply two AC "convergence" voltages in addition to the DC convergence voltage of about 10 Kv. The three electron beams in the kinescope are made to converge, or come together, at a point a certain distance from the guns by use of a potential applied to the convergence electrode of the tube. Because the distance from the guns to the phosphors changes as the electron beam is scanned across the kinescope face, the distance of convergence must also change if good registry is to be achieved. This effect is most pronounced in the planar (flat) shadow mask tubes. In order to correct for this convergence error, parabolic waveforms at both line and field rate must be added to the DC convergence voltage. These parabolic waveforms are generated by applying sawtooth waveforms from the scans to an integrating (bass boost) type of network. The output is then parabolic in form. A single triode with suitable plate loads is used to amplify both 60 and 15,750cps parabolas.

The deflection chassis usually supplies a small DC voltage at about 10 ma. for use of purity and field neutralizing coils of the kinescope. The purpose of these coils is to insure that the electron beams from each gun enter the shadow mask at the correct angles to hit only the phosphors associated with that gun.

XIII TRACKING

The three gun shadow mask kinescopes used today present the problem of "tracking" of the beam currents to provide good gray scale rendition. The problem is derived from the fact that the red phosphors available today have less than half the efficiency of the green and blue phosphors. Therefore, the red beam current must be at least twice the beam currents of each of the other guns. This makes it difficult to maintain the same beam current proportions for widely varying brightness levels. If these proportions are not maintained, the hue of the picture will change as the brightness changes. This, of course, is very undesirable. The usual attack to the problem is to drive the red gun about 20% harder than the green or blue guns and to increase the red screen voltage somewhat, thus increasing the gain of the red gun. The kinescope is made to track by adjusting the kinescope drives, the DC levels of the control grids (background controls) and the screen grids - DC levels (balance controls) for a good grey on a monochrome picture, which does not change hue as the brightness is varied.

INTRODUCTION - SPARTON CTV-2 COLOR TELEVISION RECEIVER

SALIENT FEATURES

The set uses the RCA type, shadow mask 15 inch, round glass envelope, 3 gun tri-color picture tube and the Standard Coil TV2200 series VHF tuner. The color system is of the "equal bandwidth" type, decoding on the R-Y and B-Y axes.

Two chassis are used, one containing the RF, IF and color circuits, and the other housing power supply and deflection systems. The picture tube is mounted in the cabinet separately.

POWER REQUIREMENTS

The CTV-2 set is rated for 117v AC, 60 cycle operation. It consumes 450 watts at this input.

WEIGHT (with tubes)

Decoder chassis	18#
Deflection chassis	53#
Picture tube and mount	54#
Total without cabinet	125#

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Section 1. TUBE LINEUP

Section 2. GENERAL CIRCUIT DESCRIPTION

Section 3. VOLTAGES

Section 4. CTV-2 SPECIFICATIONS

Section 5. ALIGNMENT PROCEDURE
Section 6. INSTALLATION ADJUSTMENTS
Section 7. CHANGING PICTURE TUBE
Section 8. TRACKING PROCEDURE
Section 9 CHARTS AND SCHEMATICS

Tube Lineup

Decoder chassis:

	Function	Tube or Xtal Type	Schematic Symbol
Tuner	RF Amplifier	6BQ7	V-1
	Osc. and mixer	6J6	V-2
	1st video IF amplifier	6CB6	V-3
	2nd video IF amplifier	6BA6	V-4
	3rd video IF amplifier	6BA6	V-5
	4th video IF amplifier	6CB6	V-6
	Video Detector	6AL5	V-7
	Video IF Sound Amplifier	6AU6	V-8
	Sound Detector	1N60	X-1
	1st Sound IF	6AU6	V-9
	2nd Sound IF	6AU6	V-10
	Ratio Detector	6AL5	V11
	Audio Amplifier	6AT6	V-12
	Audio Output Amplifier	6AQ5	V-13
	Video Cathode Follower	1/2-12AU7	V-14a
	Luminance Video Amplifier	6CL6	V-15
	Chrominance Bandpass Amplifier	6CB6	V-16
	Gated Burst Amplifier	6AH6	V-17
	Phase Detector	6AL5	V-18
	Reactance Tube	1/2-12AT7	V-19a
	3.58 MC Oscillator	1/2-12AT7	V-19b
	Isolation Amplifier	6CB6	V-20
	Chrominance Channel Buffer Amp.	1/2-12AU7	V-21b
	B-Y Demodulator	6AS6	V-22
	B-Y Matrix Amplifier	1/2-12AU7	V-23a
	G-Y Matrix Amplifier	1/2-12AU7	V-23b
	B-Y DC Restorer	1/2-6AL5	V-24a
	G-y DC Restorer	1/2-6AL5	V-24b
	R-Y Demodulator	6AS6	V-25
	R-Y Matrix Amp	1/2-12AU7	V-26a
	G-Y Matrix Amp.	1/2-12AU7	V-26b
	R-Y DC Restorer	1/2-6AL5	V-27a
	Burst Amp Gate	1/2-6AL5	V-27b
	AGC Rectifier	1/2-12AU7	V-29a
	1st Sync separator	1/2-12AU7	V-29b
	Sync Amplifier	1/2-12AU7	V-30a
	Sync Cathode follower	1/2-12AU7	V-30b
	Sync Phase Inverter	1/2-12AU7	V-14b
	AGC Amplifier	1/2-12AU7	V-21a

Tube Lineup

Deflection chassis:

Function	Tube or Xtal Type	Schematic Symbol
Medium Voltage Rectifier	5U4G	V-31
Medium Voltage Rectifier	5U4G	V-32
Low Voltage Rectifier	5Y3GT	V-33
Protection Relay Amplifier	1/2-6BL7	V-34a
Convergence Amplifier	1/2-6BL7	V-34b
Vertical Scan Rectifier	1N60	X-2
Vertical Oscillator	1/2-6BL7	V-35a
Vertical Output	1/2-6BL7	V-35b
Synchroguide	6SN7	V-36a & V-36b
Horizontal Output	6BG6-G	V-37
Horizontal Output	6BG6-G	V-38
High Voltage Rectifier	3A3	V-39
High Voltage Rectifier	3A3	V-40
High Voltage Rectifier	3A3	V-41
Damper Diode	6AU4GT	V-42
Focus Rectifier	3A3	V-43
High Voltage Regulator	6BD4	V-44

CONTROLS

Decoder Chassis:

Front Panel:	Schematic Symbol
Channel Selector	
Fine Tuning	
Volume (inner)	R-58A
Tone (outer)	R-58B
AC-ON-Off (inner)	R-58A
Contrast	R-71
Vertical Hold (inner)	R-193B
Horizontal Hold (outer)	R-193A
Color Saturation (inner)	R-93A
Master Brightness (inner)	R-93B
Color On-Off	R-93A
Color Phase	C-117
Color Hold	R-112

Rear Chassis:

AGC Threshold	R-176
Red Background	R-161
Green Background	R-164
Blue Background	R-141

Top

B-Y Demodulator Gain	R-132
3.58 MC Oscillator frequency	C-130

Controls

Deflection chassis:

Rear:	Schematic Symbol
Top row	
Blue Balance	R-207
Red Balance	R-208
Green Balance	R-209
Vertical Convergence	R-290
Vertical Shape	R-293
Height	R-227
High Voltage Adjust	R-284
Top	
Bottom Row	
Color Purity	R-204
Field Neut.	R-205
Vertical Linearity	R-232
Horizontal convergence	R-271
Vertical centering	R-235
Horizontal centering	R-273
Horizontal drive	R-281
Horizontal linearity	L-77
Rear of Hv Case	
Top Row	
DC Convergence	R-282
Convergence Plate Coil	L-80
Width	L-78
Focus	R-279
Top Chassis:	
Horizontal frequency	T-10
Horizontal phase	L-81

General Circuit Description (decoder Chassis)

R. F. Tuner

The Standard Coil TV2200 series cascode VHF tuner is used. UHF performance can be obtained either by the use of strips or an external converter. This is the tuner used on our 27D213 type chassis. The tuner is of the turret type, utilizing a 6BQ7 cascode RF stage feeding a 6J6 oscillator mixer. IF output frequency is in the 21MC region.

Video I. F.

The picture IF consists of 4 staggered stages very similar to that used on the 27D213 chassis. The first three stages, V-3, V-4 and V-5 are AGC controlled. The first stage has co-sound (27.75 MC) traps in the grid and plate circuits respectively of V-3.

The major difference between this IF and that of the 27D213 chassis is the addition of a co-sound trap (L-27) in the cathode of V-6, the 4th IF. This trap is necessary because of the more stringent sound trapping requirements for a color system than a black and white. At least 40db of sound trapping is necessary for a color set as contrasted to about 26db for a B and W system. The trap also serves as a take-off point for sound information as will be discussed in the Sound IF system. The top position on L-27 has been optimized to provide about 20db of trapping, and to locate the trap overshoot on the high frequency side in such a manner as to broaden out the IF passband slightly at frequencies just above the sound trap.

The IF passband of 4.0 MC between 6db points is slightly wider than that used in the 27D213 chassis. This wider passband is necessary to pass color information extending to about 4.2 MC away from the picture carrier. Curve #1 shows the overall IF passband obtained.

Video Detector and Luminance Video Amplifiers:

The video detector (V-7) is a conventional thermionic diode detector circuit utilizing video peaking in order to help shape the overall video response for optimum pictures. The detector is returned to -135v in order to provide the proper DC level to the grid of V-14a, the video cathode follower. The diode detects synd negatives.

The Video Cathode Follower is used to drive the luminance channel delay lint (L-37) and to provide a low impedance output to the chrominance channel and sync circuits. This tube operates between +240v and -135v in order to be able to provide the peak-to-peak video output necessary to drive the subsequent circuits. The contrast control, R-71 in the cathode of the cathode follower, varies the amplitude of both luminance and chrominance information.

Because the color information passes through narrower bandwidth circuits than does the luminance signal, the chroma suffers a greater time delay than the luminance. Therefore, a delay line, L-37, is inserted in the luminance channel to insure coincidence of arrival at the picture tube of both luminance and chroma information. L-37 has a delay of about 0.8 microsecond, and a nominal impedance of 3000 ohms. Its characteristics are shown on Chart #20. The delay line is terminated at both ends to minimize reflections, and, hence, ghosts on the picture.

The luminance video amplifier, V-15 feeds the cathodes of the kinescope. This tube operates between +240v and -135v in order to provide adequate video swing to the kinescope. The 3.58 MC trap (L-39) in the plate of V-15 serves to trap out the 3.58 MC component of the color signal in order to avoid the fine crosshatching on the picture that would otherwise result.

The overall luminance video amplifier response is shown on Chart #11, while the overall set luminance response for channel 8 is shown on Chart #12.

Sound I. F. System

Because of the deep sound trapping necessary on a color set, the use of a conventional intercarrier sound system would result in poor sound sensitivity and signal-to-noise ratio. Therefore, the CTV-2 chassis uses a modified intercarrier system which permits reasonably good sound performance.

Sound and picture information from the top of L-27, the cathode sound trap, are fed to the grid of V-8, the IF sound IF amplifier. The plate of this amplifier is peaked at the picture carrier frequency, while the sound carrier is trapped down somewhat by L-32. Paremeters are adjusted so that the converter grid-to-plate of V-8, response has the sound carrier down about 20db from the picture carrier. These are the conditions ideal for generating the 4.5 MC intercarrier beat at the sound detector crystal, X-1. The output of the sound detector is fed to sound IF system identical to that of the 27D213 chassis. Two 6AU6 stages (v-9 and V-10) amplify the 4.5 MC sound signal and feed it to the ratio detector stage, V-11. The R/D output goes through the volume control where it is amplified in V-12, and is sent to the audio power amplifier, V-13, a 6AQ5. V-13 operates between +115v decoupled from the +240v line and the -135v line. The audio output drives a 10 in. speaker in the cabinet.

Sync Separates and AGC System:

The composite video information from cathode of V-14a goes through a phase inverter, V-14b, which supplies video of the proper phase (sync tips positive) to operate V-29, the AGC rectifier and sync separator. A DC voltage corresponding to the sync tip height is obtained at the cathode of V-29a. This voltage is applied to the grid of the V-21a, the AGC amplifier. V-21a is a DC amplifier operating between ground and -60v, with the plate load composed of the IF strip AGC parameters. R-176, the AGC threshold controls, sets the DC level at the grid of V-21a in such a manner as to cause the AGC line voltage to maintain the peak-to-peak video output of V-14a at the proper operating level. AGC to the tuner is delayed in order to provide optimum overall signal-to-noise ratio.

The sl

The separated composite sync signal passes from V-29 to V-30b, through an amplifier, V-30a. The grid of V-30b is never permitted to swing more positive than -60v, because of the DC restoring action of the diode of V-7b. This improves the appearance of the sync tips as observed at the cathode of V-30b, the composite sync output tube. Because V-30b is a cathode follower, the composite sync output appears across a low impedance, which is very desirable in view of the fact that the composite sync then goes through a cable to the deflection chassis.

Color Synchronizing System:

The color synchronizing signal consists of 8 cycles of a 3.579545 MC signal superimposed upon the back porch of the horizontal sync pulse. This "burst" must be separated out from the composite video and caused to control the frequency and phase of a local subcarrier oscillator. The local oscillator must be exactly on the burst frequency, and must match it to within about 5 degrees in phase.

Composite video from the contrast control passes through the chrominance bandpass amplifier (V-16) to the grid of the gated burst amplifier, V-17. The pulse derived from the flyback transformer in the deflection unit. V-27b keeps the grid of V-17 cut off except during the keying pulse, which occurs during the horizontal sync pulse. At this time, the grid of V-17 is permitted to go positive enough to let the tube act as an amplifier, thus amplifying anything occuring during the horizontal sync, pulse which contains the burst. A filter in the plate of V-17 discriminates against frequency components of the sync pulse not at the burst frequency. The output of this amplifier then consists of bursts of 3.58 MC sine waves recurring every line interval (15,750).

The amplified burst is then fed to the plate of one section and the cathode of the other section of the phase detector, V-18. Notice that the voltages on these tube elements are 180 degrees out of phase with each other. The local subcarrier oscillator signal is then applied to the remaining plate and cathode of the phase detector tied together. If the local oscillator signal at the phase detector is exactly 90 degrees (in quadrature) out of phase with the incoming amplified burst, both halves of V-18 will conduct equally, and the DC voltage at pins 5 and 7 of V-18 will be at ground potential.

However, if the local signal should not be in quadrature (90 degrees) with the incoming burst, one-half of V-18 will conduct and the other will be cut off, thus changing the DC potential at the junction of pins 5 and 7. The polarity of the potential at this point depends upon which side of 90 degrees the local signal is on and the magnitude upon how far it is from quadrature.

This developed DC voltage is filtered and applied to the grid of the reactance tube, V-19a. The reactance tube output appears as a capacity whose magnitude is a junction of the grid-cathode voltage on the tube.

The local burst oscillator, V-19b, is a simple Colpitts type oscillator designed to freerun at 3.579545 MC. The capacity varies, reflected by the reactance tube to the oscillator cathode to very the oscillator frequency (or phase) to keep the oscillator on the correct frequency and phase as seen at the phase detector.

Note that the color phase control, C-117, varies the phase of the incoming burst applied to the reactance tube, thus varying the subcarrier oscillator phase, and, hence, the color phase.

The subcarrier oscillator and control circuits listed above are called "automatic phase control" or APC circuits and are similar in many respects to circuitry used to control the horizontal oscillator circuits in black and white television.

Circuit parameters for the CTV-2 APC system have been optimized to provide the best possible noise immunity and phase accuracy consistant with a reasonable pull in time.

The isolation amplifier, V-20, simply isolates the burst oscillator from the effects of succeeding stages and provides a fairly low output impedance to the color demodulators.

Chrominance Bandpass Amplifiers

Composite video from the contrast control is fed to the chrominance bandpass amplifier, V-16. Tuned circuits on both grid and plate of this tube serve to shape the bandpass of this stage to be approximately flat from 2.8 to 3.8 MC, and to drop off sharply on either side. The 4.5 MC trap (L-45) in the grid of V-16 serves to trap out any fine crosshatching on the picture due to the presence of 4.5 MC sound information. In addition to acting as part of the passband shaping circuitry, L-47 also serves as the burst takeoff point for the burst amplifier. The color saturation control, R-93A, controls the gain of the bandpass stage.

The bandpass amplifier is peaked several db at about 4 MC to compensate for the IF amplifier characteristic, thus resulting in a wider and flatter overall chrominance passband. See Charts #13 and #14 for the chrominance channel responses.

The chrominance buffer amplifier (V-21b) effectively isolates the bandpass stage from the effects of the demodulators. It is simply a triode with a low impedance plate load.

Chrominance Demodulators and Quadrature Transformer

Because the color information components are grouped about the color subcarrier frequency in the video passband, special means must be used to detect or demodulate them. Synchronous detectors (V-22 and V-25) are used for this. The chrominance information is put on the control grids of these demodulators, and the properly phased signal from the local subcarrier oscillator introduced to the suppression grids. The output of the demodulator is the product of the control and suppression grid signals, or, equivalently, the output is proportional to the control grid component in phase with the suppression grid signal plus a double frequency component which must be filtered out.

The R-Y demodulator (V-25) suppression grid is supplied with a local subcarrier signal that is in phase with that supplied to the phase detector, while that signal supplied to the B-Y demodulator, V-22, is shifted 90 degrees from the R-Y by the quadrature transformer, L-63. The quadrature transformer consists of two resonant circuits tuned to thesubcarrier frequency and neutrally coupled together. The result of such a transformer is that the secondary voltage is shifted from that of the primary by 90 degrees Damping resistors R-133 and R-129 on the primary and secondary respectively are adjusted for equal primary and secondary voltages.

The demodulator gain control, R-131, adjusts the B-Y demodulator gain so that the relative gain of the B-Y demodulator with respect to thet of the R-Y is correct.

Coils L-62 and L-66 in the demodulator plates not only help adjust the overall chroma passband, but also serve as a simple low pass filter to eliminate undesired signal components that appear at the demodulator plate. These components consist of the subcarrier frequency and color information grouped about the second harmonic of the subcarrier.

The Matrix Amplifiers

The G-Y signal is obtained from the R-Y and B-Y signals by combining suitable proportions of these signals. This is done in the Matrix Amplifiers, V-23 and V-26. Coils L-65, L-67, L-69, and L-70 are used to shape the individual frequency responses for the B-Y, R-Y and G-Y outputs to the kinescope grids. The demodulator grid to kinescope grid responses are shown on Chart #15. Nominally these responses are flat to about 1 MC, dropping off sharply for higher frequencies.

DC Restorers

The chrona signal must be DC referenced to the luminance signal to maintain proper color balance for all conditions. Since there is no color sync pulse that could be used for this service, the chroma signals must be DC restored with respect to the luminance signal. V-24a, V-27a and V-24b are the DC restorers for the B-Y, R-Y and G-Y outputs respectively. The DC levels at the plates of the DC restorers are individually set by the background controls, R-141, R-161 and R-164 respectively. These DC levels are varied together by the master brightness control, R-93b. Positive sync pulses derived from the luminance signal are applied to the plates of these DC restorers, making them operate/during the horizontal sync pulse tips, since during the sync tip period, little color information appears at the DC restorer cathodes. Notice that although the last luminance video amplifier, V-15 is AC coupled to preceding circuits, these DC restorers give the effect of direct coupling for monochrome information, because the cathode-grid potential difference is reffered to the sync tip amplitude.

The coupling elements, R-78 and L-41, in conjunction with C-149, C-158 or C-157 form a low pass filter for the sync pulses, removing much of the luminance video information to the DC restorer plates, thus making the action of the DC restorers more reliable.

Adding Luminance and Chroma Information

Because the chroma signals, B-Y, R-Y and G-y are not the correct signals to actuate the respective guns of the kinescope directly, these color difference signals must be added to the luminance or Y signals to derive the true blue, red and green signals. CTV-2 performs this final addition in the picture tube itself by putting these color difference signals on the kinescope grids, and the properly phased (sync Positive) luminance signal on the cathodes. The resulting kinescope beam currents are then representative of the proper blue, red and green signals.

The Kinescope Tube

CTV-2 utilized the RCA 15GP22 tri-color kinescope tube. This is a 3-gun planar shadow mask type picture tube using 20 KV for the ultor, and glass cone construction. The tube requires a mumetal or similar external magnetic shield. Focus and beam convergence are electrostatic, while deflection is magnetic.

General Circuit Description (Deflection Chassis)

Power Supply

Two power transformers and two DC supplies are used. Transformer T6 furnishes filament and plate voltage to rectifiers V-31 and V-32. The filtered DC output across this supply is 400 volts. This voltage is split, so the two outputs are +265v and -135v with respect to chassis. The +265v is applied to the horizontal and vertical deflection systems only. The balance of the +265v is chopped to +240v through R-206 and applied to the circuitry requiring +240v.

Transformer T-7 supplies filament and plate power to the low voltage (+140v) rectifier, V-33, as well as filament power for all the filaments in the set. Two filament windings are provided, one a grounded winding supplying filament voltage to tubes whose cathodes work against ground, and a second filament winding returned to -135v to supply tubes whose cathodes operate in the neighborhood of -135v. This is done to keep tubes operating within their cathode filament voltage ratings.

The color purity and field neutralizing coils derive their currents from the -135v supply.

Vertical Deflection

The neutral deflection system is composed of a conventional synchronized blocking oscillator (V-35a) followed by a vertical output tube (V-35b) furnishing power to the vertical deflection coil through output transformer T9. A waveform for operating the vertical dynamic convergence circuits (to be described later) is taken from the cathode of the vertical output tube.

Horizontal Deflection

The horizontal oscillator is of the so called "synchroguide" type consisting of a form of blocking oscillator (V-36b) synchronized by an APC system (V-36a). The output of this oscillator is fed to the grids of the horizontal output tubes, V-37 and V-38 in parallel. The output of these tubes in turn goes to the flyback transformer, T11.

The flyback transformer operates on conventional black and white television principles, but its parameters have been modified by the rather severe high voltage and focus power requirements. Rectifiers V-39 and V-41 act as high voltage rectifiers operated in a voltage doubler circuit at the top end of the transformer. V-40 replaces the resistor conventionally used in such a double circuit, resulting in a saving of high voltage power.

Because the high voltage must be held within close limits, the H.V. output has a triode regulator tube, V-44, in parallel with it. This shunt regulator is simply a high voltage triode whose grid is controlled by a DC voltage proportional to the H.V. This grid voltage is derived from a voltage divider across the H.V. line. Thus, as the H.V. uses lightly, V-44 conducts more and loads down the H.V. line, restoring the H.V. to nearly its normal value.

The DC convergence voltage of 9-11kv is tapped directly off the H.V. voltage divider.

Because the focus anode of the kinescope draws appreciable power at about 3kv., a separate flyback tap and rectifier V-43 are provided for the focus voltage.

Dynamic Convergence

Because the kinescope has a planar aperature mask, the length of path from the center of deflection to the mask is different at the center of the tube than at the edges, the convergence voltage must change somewhat as the beam scans across the front of the kinescope. The focus voltage also must change. In order to get proper convergence, parabolic waveforms of the proper amplitude at both line and field rate must be added to the DC convergence voltage. These parabolic waveforms are shaped and amplified by V-34b, convergence amplifier. The outputs of this amplifier are then fed to the convergence and focus lines by L-80 and T-12 respectively.

The voltage at the cathode of the vertical output tube, V-35b parabolic in form. This is fed to the grid of the convergence amplifier, through the vertical convergence control, R-290. The voltage at the cathodes of the horizontal output tubes (V-37 and

V-38) is also a parabolic waveform. This, too, is introduced to the grid of the convergence amplifier through the horizontal convergence control, R-271. The vertical convergence shape control, R-293, changes the symetry of the neutral parabola, while the horizontal convergence phase control, L-81, does the same for the horizontal.

The convergence amplifier plate load, L-80, is tuned for maximum horizontal parabola output.

Scan Protection

If the vertical scan should fail while the horizontal operated normally, the resulting bright line on the kinescope would shortly damage the aperature mask. Should the horizontal scan be inoperative, there is no such problem, for there would be no high voltage.

In order to prevent possible damage to the kinescope from this source, a portion of the vertical output to the deflection yoke is rectified by X-2 and applied to the grid of V-34a, the scan protection tube. Then the tube conducts and holds the plate relay (RY-1) contacts closed. Screen voltage for the horizontal output tubes (V-37 and V-38) is applied through these relay contacts, so if the vertical scan fails, screen voltages are removed from the horizontal output tubes, effectively disabling them so there is no horizontal scan or resulting high voltage developed.

GENERAL COMMENTS ON CTV-2

This is a so called "equal bandwidth" set, wherein color demodulation is along the R-Y and B-Y axes, and the overall R-Y and B-Y frequency responses are identical. This implies that the best compromise between color detail and color crosstalk is an overall chrominance bandwidth of about 700 KC. This is considerably less than the 1.5 MC effective (as far as the eye is concerned) bandwidth obtainable with an "I-Q" style decoder. However, the Sparton CTV-3 set now under development will take maximum advantage of the NTSC color signal.

CTV-2 does not provide red, green and blue signals directly to the kinescope, but supplies the color difference (R-Y, B-Y and G-Y) and luminance (Y) signals which are added within the kinescope to provide the 3 color signals. This is certainly an economical way to do it, for one set of adders, or matrix amplifiers, is eliminated. However, this system is not quite as flexible as is adding outside the picture tube.

The picture and sound sensitivities of CTV-2 are not quite as good as on sensitive black and white sets, due to the necessity of broadening out the IF response to accomodate the color signal.

The luminance detail of this set is about as good as could be achieved by any set using the NTSC color system. The detail is about 280 lines as observed on monoscope test pattern.

We feel that the most marginal feature of the CTV-2 chassis is the performance of the color synchronizing system. The main difficulty with the APC system is that upon warmup the pull in time for synchronization may be as long as a minute. Since lack of color sync upon a color signal is about as obvious a picture defect as loss of horizontal sync on a black and white signal, it is thought that the color synchronizing system should have about the same order of stability as that of the horizontal sync system.

The noise immunity and phase accuracy of the CTV-2 color sync system are excellent. The noise immunity is comparable to the horizontal sync system, and no phase errors are noticeable to the eye within the pull in range of the APC system.

In any APC system there are three major operational parameters to be considered, i.e., noise immunity, phase accuracy, and pull in performance. For a simple APC system as used in CTV-2, good performance in any two of these may be achieved, but only at the expense of the third parameter. For CTV-2, noise immunity was considered to be of paramount importance, followed closely by phase accuracy. Thus, pull in performance has been sacrificed for good noise immunity and phase accuracy. Because the pull in range of CTV-2 is only several kilocycles, the free running frequency of the subcarrier oscillator must be within this range if the system is to pull in to synchronism at all. Also, because the pull in time is proportional to at least the square of the amount the oscillator is off frequency, the inherent oscillator stability must be very good if the pull in time is to be reasonably short, say one or two seconds.

PERFORMANCE DATA FOR CTV-2

Unfortunately, because of lack of time, the performance data shown below were taken on only one CTV-2 set, namely, CTV-3 (CTV-2, Ser. #3) hence, due care must be exercised in using and interpreting these data. Performance wise, this particular chassis seems to be a median set of the CTV-2 variety; its picture and sound sensitivities and bandwidths are about average, and it gives about an average quality color picture for this model chassis.

The conditions and setup procedures are described below in sufficient detail to duplicate the conditions for each performance measurement. It is assumed that the set has been properly aligned according to the alignment procedure before performance data are observed.

1. Converter Grid Picture IF Response: Set tuner on Channel 13. Put no signal on tuner input leads. Apply -6V to a 229K resistor in series with the tuner converter grid "looker point". Connect Ferris 18FS signal generator to convertor grid (accessible through small hole in side of tuner - do <u>not</u> solder) through a 1K ceramic blocking capacitor. Ground termination head of 18FS to chassis with a short lead. Attach source of bias voltage to IF AGC line (across C-47) and set to desired level. Put VTVM between pin 2 of V-14a and the -135v line. Use negative DC scale. Record microvolts input at each desired frequency to give -1.0v DC above noise at the VTVM. A word of caution about traps. In measuring attenuation of traps, the measurement will be in error if the input level is high enough to saturate any circuits. Therefore, trap rejections are best measured by using a lower output than 1v above noise. Try 0.5 or 0.3 v. Determine microvolts input necessary to give this output both at the trap frequency and at a frequency f_1 at the flat part of the passband. The trap response is then down from the response of f_1 by the amount of the two microvolts input rations.

Results are shown on Chart #1 for AGC biases of 0, -4.5 and -7v. Note that the co-sound trapping is 46db and the adjacent sound trapping 40 db down from the picture center. The 6 db passband width is 4.0 MC., and picture center sensitivity 210 microvolts at 0 AGC.

2. Progressive IF Strip Response: Remove AGC line bias. Leave VTVM and converter grid bias as in Paragraph 1. Attach 18FS to grid of V-6 through a 1K blocking capacitor. This need not be soldered. Ground case of 18FS terminating head by laying it on the chassis inside the stage shield. If a small hook is bent on the end of the 1K condenser, the 18FS can be attached to the circuit very conveniently. Measure microvolts input at the various frequencies necessary to give -1.0V DC above noise on the VTVM. Repeat procedure for the grids of V-5, V-4 and V-3. The results are shown on chart #2.

3. 1st Sound IF: Set up tuner, biases and 18FS signal input as in paragraph 1. Put VTVM across C-63 on the sound detector. Record microvolts input to the converter grid for +1.0V DC above noise.
Results are shown on Chart #3. Note that the picture carrier-sound carrier input ration is 1:10.

4. Antenna Terminal to Video Detector Response: Remove tuner and AGC biases. Put VTVM between Pin 2 of V-14a and the -135V line. Attach 18FS signal generator directly to the tuner antenna terminals through 150 ohm resistors in series with each terminal. Do not use twin lead from the tuner. Set tuner to desired channel and record microvolts input from the 18FS for 1.0 DC above noise. Before taking data, be sure the tuner local oscillator is adjusted correctly.

Results for channels 4 and 8 are shown on Charts #4 and #5 respectively.

5. System sensitivities:
(a) Antenna to video detector sensitivity: Proceed as in paragraph4, but noting the microvolts input necessary to give -1.0V DC above noise on the VTVM at the picture center frequency of the desired channel.

(b) Antenna to kinescope cathode sensitivity: Put Ballantine VTVM between kinescope cathode and ground, through a noise filter consisting of a 10K resistor in series between the meter and cathode, shunted by a 1K ceramic capacitor between ground and the meter side of the 10K resistor. Use shielded lead from the filter to the VTVM. Leave 18FS set up as in paragraph 4, but modulate 18FS with 400 cps, 30% A.M. Record the sensitivity as the microvolts input from the 18FS at picture center frequency to give 7V RMS above noise on the VTVM.

(c) Antenna-to-speaker sound sensitivity: Connect the output head of a Boonton 202-B AM-FM signal generator to the tuner antenna terminals through 300 ohm resistor in series with each antenna terminal. Do the same with a 18FS generator. Remove tuner and AGC bias. Put a DC VTVM between pin 2 of V-14a and the -135v line. Turn the volume control to maximum. Put an audio wattmeter set for 3 ohm impedance on the chassis speaker terminals. With the fine tuning control in mid-position, set the tuner channel selector to the desired channel. Leaving 18FS output at zero, set the 202-B generator at about 2000 microvolts output and set to the approximate sound carrier frequency. Tune the 202-B carefully to the correct sound carrier frequency by tuning for a sharp dip on the VTVM, thus putting the sound carrier in the sound trap. Reduce the 202-B output to about 500 microvolts, and advance the 18FS output to that value. Modulate the 202-B with ±7.5 KC deviation at 400 cps. Set the 18FS to the approximate picture carrier frequency and tune carefully for maximum output on the wattmeter. Now reduce both 18FS and 202-B outputs (keeping each at the same value) until the wattmeter reads 1 watt above noise. Note the signal generator attenuation settings and divide them by 2 because of the 2:1 attenuation in the resistance pads on the tuner input. This figure is the sound sensitivity.

The three sensitivity measurements discussed above are shown below for all VHF channels.

SENSITIVITY IN MICROVOLTS

	(a)	(b)	(c)
Channel	ant-to-video det.	ant-to-kine. cathode	sound
2	40	96	45
3	38	84	43
4	43	89	35
5	45	130	40
6	46	130	49
7	49	130	52
8	43	120	52
9	42	130	55
10	40	130	55
11	50	170	50
12	39	120	52
13	30	100	60

6. The Sound System

(a) A progressive response of the sound IF: Put VTVM across R-59 in the ratio detector load. Reduce IF sensitivity by putting about -7V bias on the AGC line. As a signal generator, use a Boonton 202-B in conjunction with a Boonton 203_b univerter to provide small frequency increments about 4.5 MC. Attach a signal generator between ground and the grid of V-10 (pin 1) through a 5 K blocking capacitor. Record microvolts input from the signal generator to provide -1 V DC above noise on the VTVM. Repeat above procedure introducing signal from the grid (pin 1) of V-9, and finally from junction of L-33, X-1 and C-61.

These data are plotted on Chart #6. Notice that the stages peak at a frequency slightly different than 4.5 MC; the sound system was aligned using an output

level of 8 V, but because of the limitations of the signal generator output, a 1V output level was used. Because the sound system has some intentional regeneration, these frequency shifts are to be expected.
(b) The ratio detector response (static). Put the signal generator used above on the grid of V-10 through a 5K blocking capacitor. Put VTVM across C-77. Put a -6V battery across C-83 (observing correct polarity) to provide a normal load for the ratio detector. Maintain the input level of the signal generator at 100 K microvolts, and record a curve of VTVM reading vs. frequency.
Results are plotted on Chart #7.

7. AGC Performance: Put a DuMont 208 or 304 type oscilloscope directly across the contrast control. Connect PMG to the tuner input and modulate with the monoscope test pattern. Set tuner channel selector to channel of PMG. Put VTVM on AGC line (across C-47) and another on the tuner AGC line (across C-29). Vary the PMG output and note both VTVM readings and the peak-to-peak video on the scope. The PMG must be adjusted properly for this test.
Results are shown on Chart #8.

8. Subcarrier Oscillator Synchronizing Performance: The only convenient way to measure the subcarrier oscillator frequency is by the H-P 524A frequency counter, which loads down the circuit under test considerably. Therefore, in order to avoid counter loading effects on the APC system, the measurements were made indirectly. The phase detector, V-18, was removed, and the counter coupled to the plate (pin 5) of V-20 through a 100 mfd blocking capacitor. Turn color saturation control off. Adjustable battery bias is put across C-119. Set color hold control, R-112, in mid-position. C-130 is adjusted so that the free running frequency of the subcarrier oscillator is 3.579545 MC when the voltage across C-119 is -1.0 V. Record data for oscillator frequency vs. C-119 voltage. Results expressed as deviation from 3.579545 MC are shown on Chart #9.

Modulate PMG with color bar pattern and synchronize both color and scans. Turn color saturation control to maximum. Put VTVM across C-119. Vary C-130 in both directions noting both the positive and negative VTVM voltages at which color sync is lost. Then note positive and negative voltages at which the system will just barely start to pull into synchronism. Adjust C-130 so VTVM reads -1.0 V with bar pattern synchronized. Next note the VTVM voltages corresponding to CCW and max CW rotation of the color hold control. Reset color hold control to mid-position.

Now obtain frequency corresponding to VTVM voltages from chart similar to that of Chart #9.

Results for CTV-2 are tabulated below.

FUNCTION	VOLTS ACROSS C-119	FREQ. from Chart #9
Hold in range	-6 V +5 V	+3 KC -6 KC
Pull in range	-4 V +0.3 V	+2.4 KC -1.3 KC
Color hold control range	CCW-0.4 V CW-1.3V	+650 cps -300 cps

9. High voltage regulation: With zero beam current, H.V. adjust (R-284) is set so H.V. is 20 KV. A microammeter (0-1000mma) is inserted in series with the high voltage line between the H.V. supply add the point where the H.V. meter is attached. Control the beam current with the master brightness control and record H.V. potential vs. total H.V . current (including current drawn by H.V. voltmeter).
Results are plotted on Chart #10.

10. Luminance Video Response: Before taking the following responses, disable the horizontal output tubes by wedging the scan protection relay, RY-1, open and by putting a 2500 ohm, 100 W resistor between the +265 and -135 V terminals to provide normal power supply loading. This will remove the horizontal spikes from the video lines, thereby reducing the noise level on these lines.

Remove heater voltage from V-7, the video detector. Connect a video frequency RF generator to Pin 2 of V-7 through a series 0.47 mfd blocking capacitor and series 3300 ohm carbon resistor. The resistor is connected directly to Pin 2 of V-7. Put a GR 1800A VTVM between kinescope cathodes and ground. Use another VTVM to monitor the input signal level at the junction of the 0.47 jfd capacitor and the 3300 ohm resistor. Set input level at 1.0 V RMS and record data for a curve of RMS output volts (above noise) at the kinescope cathodes vs. frequency. Have contrast control at maximum.
Results are shown on Chart #11.

11. Chrominance Video Response: Introduce signal to the video detector as in paragraph 12, except change the 0.47 mfd blocking capacitor to a 5 K ceramic. Connect GR 1800A VTVM between junction of R-126 and R-127 and the -135V line. Set color saturation at maximum. Set input signal level at 0.5v RMS (at junction of 5K capacitor and 3300 ohm resistor.) Record data for a curve of output RMS volts on VTVM vs. frequency. Restore video detector circuitry to normal.
Results are plotted on Chart #13.

12. **Overall Luminance Channel Response:** In order to be able to duplicate results in procedures involving the PMG, it is of utmost importance that the PMG be set up to modulate both the color bar and monoscope patterns properly. Set tuner local oscillator correctly using any of methods outlined in Section IV-4 of the alignment procedure. Modulate PMG with monoscope test signal. With a VTVM on the AGC line (across C-47) set PMG attenuator so AGC bias measures -4.5V. Note this setting. Modulate PMG with 1.0V p-p of video frequency sine wave. Using same PMG attenuation setting noted above, put -4.5 v bias on the AGC line. Put GR 1800A VTVM on kinescope cathodes as in paragraph 11. Holding input level modulating PMG constant, record data for a curve of RMS volts above noise at the kinescope cathodes vs. frequency.
Results are plotted on Chart #12.

13. Overall Chrominance Channel Response: Set up and modulate PMG as outlined in paragrpah 13. Attach GR 1800A VTVM to demodulator grids as shown in paragraph 12. Maintaining video modulation of PMG at 1.0v p-p, redord data for a curve of RMS output voltage (above noise) on VTVM vs. frequency. Set color saturation control at maximum.
Results are plotted on Chart #14.

14. Video Response of the Chroma or Matrix Amplifiers: Attach a video frequency RF generator between R-126 and R-127 through a 0.47 mfd blocking capacitor and ground. Remove subcarrier oscillator tube, V-19. Remove antenna signal. Put GR 1800A VTVM between the R-Y output to kinescope grids (junction of C-155 and R-163) and ground. Turn color saturation control off. Maintain input level to 0.47 mfd. blocking capacitor at 1.0v p-p. Record data for RMS output volts at kinescope grid vs. frequency. Repeat above procedure for B-Y and G-Y outputs.

Note that because of the method of introducing signal to the demodulator grids, these data are not representative of the true conditions below about 75KC. Therefore, data below this frequency are erroneous.

Results for R-Y, B-Y and G-Y amplifiers are shown on Chart #15. Restore V-19.

15. Waveforms on Color Bar Pattern: Modulate PMG with color bar pattern, and set PMG output at about 2000 microvolts, or a fairly strong signal. Sync in color. Use wideband oscilloscope such as Tektronix 514AD scope. Waveforms were drawn carefully from the scope face. Special care was taken to record amplitude levels accurately. The contrast and color saturation controls were set for best looking picture.

Chart #16 shows the luminance and color difference signals applied to the kinescope. For comparison purposes, the ideal waveforms for each are shown by dotted lines.

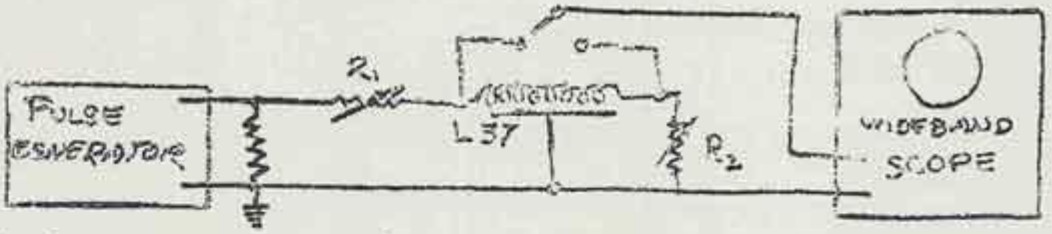
Chart #17 shows the composite color bar pattern signal at the video detector and also the chrominance signal at the demodulator grids. The dotted lines on the composite signal indicate the ideal waveforms.

Chart #18 shows the R-Y and B-Y demodulator outputs for a color bar pattern.

Chart #19 shows the action of the burst amplifier and the sync separators.

16. Delay Line (L-37) Performance:

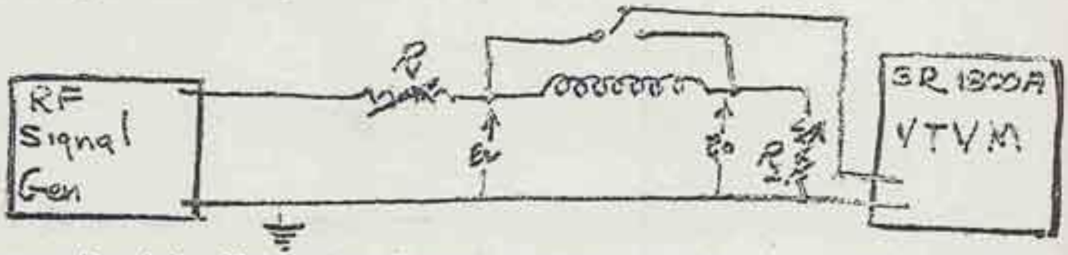
(a) Determinimg characteristic impedance. Use the test setup sketched below:



Set pulse generator to give about a 1 microsecond pulse. Repetition rate is not critical. Use lo-capacity probe on scope. With scope on line input, adjust R2 for minimum reflections following the pulse. Put scope on line output and do the same with R1. The DC resistance of R2 will then be very close to the characteristic impedance of the line. R1 and R2 are carbon (not wirewound) controls.

(b) Amplitude transfer characteristic:

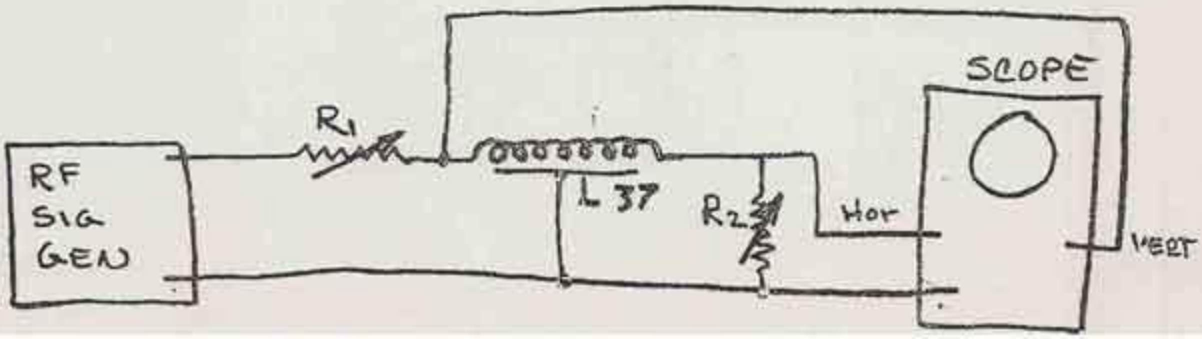
Use setup sketched below:



Be sure the delay line is terminated peoperly at both ends. Maintain input voltage to the line at 1.0v RMS and record data of output voltage vs. frequency. Because the driving point impedance of the line fluctuates widely with frequency, the input voltage will probably have to be reset for every frequency.

(c) Time Delay Characteristics:

Use setup shown below:



Terminate the delay line properly. The two scope inputs should be put directly on the deflection plates, or use a scope with identical horizontal and vertical amplifiers (WO-56A scope for example). Starting with a low (100 KC) frequency, increase frequency until a straight, downward sloping line is seen on the scope. Record this frequency as f_1. Increase frequency again until an upward sloping straight line is seen. This is f_2. Repeat until a downward sloping line is seen. This is f_3. Continue as far up in frequency as is desired. Note that the slopes of the lines alternate. The time or phase delay at each frequency, f_n is:

$$\frac{n}{2 f_n}$$

Although this method gives only a discreet number of points for the line, it is satisfactory for these delay lines.
The performance data for the delay lines used in CTV-2 are shown on Charts #22 and #23.

17. Subcarrier Oscillator Warmup Drift: Start with the complete CTV-2 set at room temperature. This is best done after the set has been turned off for at least 4 hours. Couple a H-P 524A frequency counter to the plate of V-20 through a 100 mfd blocking capacitor. Ground out C-119. Turn set on and record frequency as a function of elapsed time after turning on. Maintain line voltage for CTV-2 at 117 V. Results are plotted on Chart #21, expressed as frequency deviation from the final mean value.

POWER SUPPLY AND DEFLECTION CHASSIS FOR CTV-1 COLOR RECEIVER

V-31 and V-32 - Medium Voltage React.

Pins 4-6 380V AC
2-8 400V ** or 280 against chassis ground

V-33 - Low Voltage React.

Pins 4-6 280V AC
2-8 150V

V-34a- Vert. Osc.

Pins 1. 22V **
2. 100V **
3. -135V

V-34b - Protective Tube

Pins 4. 1-6 V
5. 160 V
6. 2.4 V

V-35 - Vert. Output

Pins 1. 0
2. 6.3V AC
3. } 235V
4. }
5. -34V from pin 8 to 7
6. 0
7. 6.3 V AC
8. 34V **

V-36 - Horiz. Osc.

Pins 1. -46V **
2. 80V
3. -18V **
4. -125V **
5. 265
6. -135V
7. 6.3V AC
8. 6.3V AC

V-37a

Pins 7. } 110V **
6 }
8. 125V **

V-37b

Pins 1. 90V
2. -.6V
3. 0

V-38 - Dummy Load Tube

Pins 4. 240V
5. 66V
6. 90V

V-39 - Horiz. Output

Pins 3. 17V **
5. -21V **
6. 165V **

V-40 Damper

Pins 2. 250V

V-43 - Vert. Conv. Amp.

Pins 1. 260 **
2. -135V
3. 10V **
4. 6.3V AC
5. 6.3V AC
6. 220 **
7. -120V
8. 6V **
9. 6.3V AC

V-44 - Horiz. Conv. Amp.

Pins 1. 250V
2. 0
3. -135V
4. 6.3V AC
5. 6.3V AC
6. 0
7. 3V **
8. 0**
9. -

Tube Socket D. C. Voltage Measurements (Decoder Unit)
For CTV-2 Color Receivers

All controls set for proper operating conditions for black and white and color, except for contrast control which is at maximum.

Line Voltage 117V AC, zero signal at tuner.

* Measurements taken against -60V.
** Measurements taken against -135V.

All other voltages measured from chassis

Voltages were measured with a vacuum tube Voltmeter.

V1 and V2 Voltage at tube sockets not available.

Pins	V-3-1st I.F.	V-4-2nd I.F.	V-5-3rd I.F.
1.	0	0	0
2.	2V	0	0
3.	0	0	0
4.	6.3V AC	6.3V AC	6.3V AC
5.	135V	135V	135V
6.	135V	135V	135V
7.	1.4V	2.2V	2V

Pins	V-6-4th I.F.	V-7-Video Det.	V-8-Sound I.F.
1.	0	-60V	0
2.	2V	-135V	0
3.	0	0	0
4.	6.3V AC	6.3V AC	6.3V AC
5.	135V	-135V	140V
6.	135V	0	140V
7.	0	-70V	1V

Pins	V-9 1st sound I.F.	V-10 2nd sound I.F.	V-11 Ratio Det.
1.	-.5V	.6V	.1V
2.	0	0	.1V
3.	0	0	0
4.	6.3V AC	6.3V AC	6.3V AC
5.	130V	125V	0
6.	130V	125V	0
7.	1V	0	0

V-12-audio amp.

Pins 1. .6V
2. 0
3. 0
4. 6.3V AC
5. 0
6. 0
7. 58V

V-13-Power amp.

Pins 1. -14.5V pin 2 to 1
2. 15V**
3. } 6.3V AC
4.
5. 260V **
6. 270V **
7.7 0

V-14a-cathode follower

Pins 1. 230V
2. -130V
3. 12V **

V-14b-Phase Inv.

Pins 6. -33V
7. -115V
8. 13V **

V-15-Video Amp.

Pins 1. 1.4V **
2. -1.6V Pin 1 to 2
3. 0
4. } 6.3V AC
5.
6. 290**
7. 0 **
8. -1.6V pin 1 to 2
9. 0

COLOR CHANNEL

V-16 Bandpass Amp.

Pins 1. -15V pins 1 to 2
2. IV ** saturation cont. max., 7.8V Sat. Cont. Off.
3. } 6.3V AC
4.
5. 250V
6. 8V **
7. 1V

V-17 Gated Burst Amp.

Pins 1. 15V **
2. -38 Pin 2 to 1
3. } 6.3V AC
4.
5. 250V
6. 220V
7. 15V

V-18

Pins 1. 15V
2. -15V
3. 0
4. 6.3V AC
5. .9V } Phase cont. center of range
6. 0
7. .9V

V-19-Reactance tube 3.6MC osc.

Pins 1. 25oV
2. 5V
3. -.6V
4. } 6.3V AC
5. }
6. 240
7. -34V
8. .3V
9. o

V-20-Isol. Amp.

Pins 1. -34V
2. 2.4V
3. 0
4. 6.3V AC
5. 240V
6. 115V
7. 0

V-21A AGC Amp.

Pins 1. 0
2. -68V **
3. -60V

V-21b-Isol. Amp.

Pins 6. 13V
7. -135V
8. -135V

V-22-B-Y Demod.

Pins 1. 18V **
2. 20V **
3. } 6.3V AC
4. }
5. 60V
6. 0
7. 18V **

V-23-Matrix Amp.

Pins 1. 135V
2. -130V
3. 10V **
4. } 6.3V AC
5. }
6. 110V
7. 3V **
8. 12.5**
9. 6.3V AC

V-24a Blue D.C. Rest.

Pins 2. 70V
5. 70V
6. 0

V-24b Green D.C. rest.

Pins 1. 74V
2. 72V

V-25-R-Y-Demod.

Pins 1. 18 **
2. 20 **
3. } 6.3V AC
4. }
5. 60V
6. 0
7. 18V **

V-26-Matrix Amp.

Pins 1. 195V
2. - 130
3. 15V **
4. } 6.3V AC
5. }
6. 110V
7. 7 **
8. 15**
9. 6.3V AC

V-27a-Red D.C. Rest.

Pins 2. 70V
5. 72V
6. 0

V-27b-Burst Amp. Gate

Pins 1. -125V
7. -155V

V-29-AGC React. S 1st sync Sep.

Pins 1. 90V
2. -34V
3. 26V
4. } 6.3V AC
5. }
6. 90V
7. -34V
8. 34V *
9. 0

V-30-Sync Amp. S Cathode follower

Pins 1. 190V
2. 40V
3. 0
4. } 6.3V AC
5. }
6. 250V
7. -1.4V *
8. 13.5V * Tuner set between channels
9. 0

Bob Davies
February 16, 1954

copied 5-20-54 das

COLOR TELEVISION RECEIVER CTV-2 - SPECIFICATIONS

VOLTAGE AND CURRENT REQUIREMENTS

1. Conditions

Set warmed up for 30 minutes
Voltmeter 20,000 ohm per volt or higher
AC Line Voltage 117V AC

With a modulated signal the height control shall be set for normal picture height. The width control shall be set for correct aspect ratio. Linearity (vertical and horizontal) and drive controls shall be adjusted properly. Then, with no signal input to receiver, contrast control set for maximum and brightness minimum, the voltages and currents shall be as follows:

2. Voltage and Current

a. The DC voltage measured from the B- end of R195 to chassis must be -135 ± 15 volts.

b. The DC voltage between the B+ end of R195 and chassis must be +250 ±15 volts.

c. The voltage from the -60V top of R195 to chassis must be -60 ± 2 volts.

d. The voltage from the +88V top of R195 to chassis must be +88 ± 5 volts.

e. The total DC current measured in the secondary center top lead of T-6 should be between 400 ma and 425 ma.

f. The total DC current measured in the secondary center top of T-7 should be between 100 ma and 120 ma.

PICTURE IF SELECTIVITY

1. Test Conditions

Signals are applied to the converter grid through a device containing a suitable blocking capacitor and a means of supplying -3 volts bias to the converter tube. Tuner must be tuned to one of the high channels (7-13). A bias voltage of -4.5 volts is applied to the AGC line (across C-47).

2. Picture IF Selectivity

a. An oscilloscope is connected between Pin 2, V-14a and the -135v line.

Video IF sweep signals are applied to the converter grid and the input level adjusted so the signal at the oscilloscope is approximately 1.5 volts peak to peak.

The swept curve must be flat within 15% between 22.4 mc and 25.5 mc.

The picture carrier (26.25 mc) must be between 40% and 55% of the distance from the base line to the top of the response curve.

b. With signals from a Ferris Type 18FS signal generator applied to the converter grid, and with a vacuum tube voltmeter connected between Pin 2, V-14a and -135 volt line, readings shall be taken every half megacycle from 21 mc to 28 mc, and at 21.75 mc, 22.4 mc, 26.25 mc and 27.75 mc.

turned to -135 v. so be careful. Attach an 18FS or similar RF generator to the converter grid (accessible through small hole in tuner) through a 1K capacitor.

2. Trap Tuning: With IF generator output about 1,000 microvolts, and frequency 21.75MC, tune 21.75MC trap on grid of V-3 (L-21) for minimum reading on the VTVM. Tune the 21.75 MC trap in cathode of V-6 (L.27) for minimum. If necessary, increase RF generator output if trapping action is difficult to see. Note - tuner L-27 so that the slug is through the coil, not entering it. Set IF generator to 27.75 MC and tune 27.75MC trap in plate, V-3 (L-22) for minimum indication on the VTVM.

3. Spot Alignment of I.F.

a. Set RF generator at 22.2MC and peak converter plate load in tuner (slug mounted on a slant) for maximum indication on meter. Set RF generator output so that VTVM reads about 1-1 1/2 volts.

b. Set RF generator at 25.25 MC and tune L-23 in plate of V-3 for maximum on meter, using output level of 1-1 1/2 volts.

c. Set RF generator at 24.25MC and tune L-24 in plate of V-4 for maximum on meter, using output level of 1-1 1/2 volts.

d. Set RF generator at 23.25 MC and tune L-25 in plate of V-5 for maximum on meter, using output level of 1-1 1/2 volts.

e. Set RF generator at 26.0MC, and tune T-1 in plate of V-6 for maximum on meter, using output level of 1-1 1/2 volts.

4. Touchup of Picture IF: Remove RF generator from converter grid and replace with 21MC sweep through proper attenuator box. Attach a good 60 cycle sweep scope (DuMont 208, 304 etc.) between Pin 2, V-14a and the -135v line. The VTVM leads may remain connected as in II-1. Scope is returned to -135v line and is "hot". Touch up the converter plate coil, and L-23, L-24, L-25 and T-1 until the response shown below is obtained:

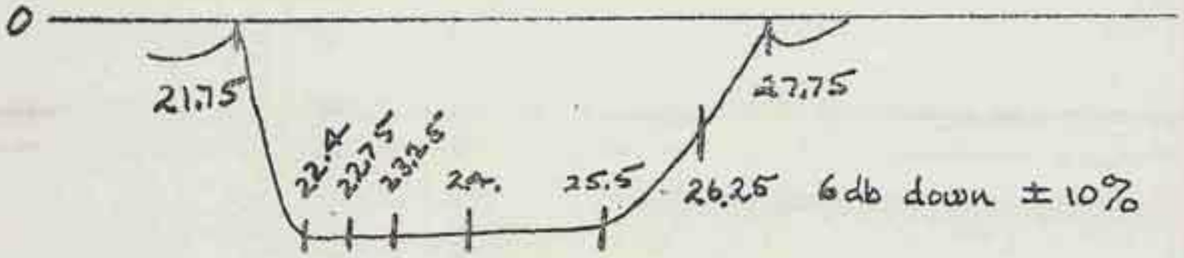


FIGURE 1. Desired Picture IF response

5. Check Sound Carrier Attenuation and Converter Grid IF Sensitivity: Check the sound carrier attenuation by noting the microvolts input necessary to give 0.3v. on the VTVM at 24.0 MC. and that needed to give same voltage at 21.75MC, ratio of two input voltages shoudl be at least 1:200 or 46db. Use 18FS RF generator on converter grid for this measurement. Now remove -4.5v AGC bias, (leaving the -6v tuner bias in place) and note microvolts input to converter grid at 24.0MC necessary to give 1 v DC above noise as observed between Pin 2 of V-14a and the -135v line. This input should be 200 microvolts or less.

6. Sound IF: Put VTVM across C-63, capacitor near the 1N60 sound detector. Set RF generator (18FS) at 26.25 MC, and using a level to give about 1 volt on the VTVM, tune L-31 in the plate of V-8 for maximum on meter. RF generator goes to converter grid through 1K capacitor. Set generator at 21.75MC and tune L-32 trap on plate, V-8 for minimum on meter. Check microvolts input necessary to give 0.3v on meter at 26.25 and 21.75MC. Ratio between two inputs should be about 1:10 or 20db.

7. Second Sound IF: Aplly 4.5MC from an accurate crystal controlled source to the junction of C-61, X-1 and L-33. Put VTVM between ground and either side of Ratio Detector capacitor C-83. Adjust input level until output at meter is about 8 volts at the R/D. Adjust T-2 in the grid of V-9 for maximum indication on the meter. Adjust, in order, primary of T-3 (top), secondary of T-3 (bottom), and primary of T-4 (top). Move VTVM to between ground and the top of C-77, R/D takeoff capacitor. Adjust secondary of T-4 (bottom) for a balance, i.e., zero voltmeter reading. Put VTVM back on C-83, retune primary and secondary of T-3 and primary of T-4. Put VTVM on C-77 and rebalance T-4 secondary.

8. Set Local Oscillator Slugs and Check Antenna Sensitivity: Remove bias cells. Put 18FS RF generator on the tuner antenna terminals through 120 and 150 ohm resistors (to match tuner input), and with VTVM between Pin 2 of V-14a and the -135v line, adjust L/O slugs in tuner by first setting the L/O vernier in mid-position, and the tuner on channel 2, then setting the RF generator on the sound carrier frequency of channel 2. Adjust L/O slug for a minimum on VTVM. Use about 200 microvolts input to tuner. Be careful not to adjust the sound carrier into the wrong (27.75MC) trap. Then check sensitivity by decreasing the RF frequency between 1 and 2 MC below the sound carrier frequency and reducing RF input until the voltmeter reads 1 volt from the noise level. RF input should then be 50 microvolts or less. Repeat for each channel.

9. AGC Threshold: Connect the tuner leads to a PMG, modulate the PMG with a monoscope pattern. Set output of PMG at about 5000 microvolts, or a setting of roughly 30db on the PMG. Use no external tuner or AGC biases. Connect a scope between the cathode of V-14a and the -135v line. If a low frequency scope such as a DuMont 208 or 304 is used, adjust the AGC threshold control, R-176 so that the video seen on the scope is 3.5v peak to peak. If a wide band scope such as a Tektronix is used, set the AGC threshold control so that the voltage between the sync tips and <u>average</u> white level is 3.5v. Now set the attenuator so that the AGC line runs at -4.5v bias. Note this attenuator setting for future reference.

III Deflection Adjustments

Connect PMG to tuner antenna terminals. Modulate PMG with monoscope or a linearity pattern. Turn red and blue background controls (CR-161)and(R-141) at minimum. Turn green background control, R-164, at about 2/3 of maximum. Advance master brightness control, R-93b, until a moderately bright green raster is observed. Focus the raster.

Set height and width controls (R-227 and L-73) until a raster of approximately the correct size is obtained.

Adjust the horizontal oscillator using the procedure indicated on the attached sheet entitled "CTV-2 Horizontal Oscillator Adjustment."

Set Vertical Linearity. Center picture on kinescope.

CTV-2 HORIZONTAL OSCILLATOR ADJUSTMENT

Horizontal frequency adjustment - Tune in a station and sync the picture. If the picture cannot be synchronized with the horizontal hold control, R-193a, then adjust the T-10 frequency core (top screw) until the picture will synchronize. If the picture still will not sync, turn the T-10 waveform adjustment core (under the chassis) out of the coil several turns from its original position and readjust the T-10 frequency core until the picture is synchronized.

Examine the width and linearity of the picture. If picture width or linearity is incorrect, adjust the horizontal drive control, R-261, the width control, L-78, and the linearity control, L-77, until the picture is correct.

Horizontal Oscillator Waveform Adjustment - connect the low capacity probe of an oscilloscope to terminal C of T-10. Turn the horizontal hold control one-quarter turn from the clockwise position so that the picture is in sync. The pattern on the oscilloscope should be as shown in Fig. 1. Adjust the waveform adjustment core of T-10 until the two peaks are at the same height. During this adjustment, the picture must be kept in sync by readjusting the hold control if necessary.

Remove the oscilloscope upon completion of this adjustment.

Horizontal Locking Range Adjustment - Set the horizontal hold control to the full counter-clockwise position. Momentarily remove the signal by switching off channel then back. The picture may remain in sync. If so, turn the T-10 frequency core slightly and momentarily switch off channel. Repeat until the picture falls out of sync with the diagonal lines sloping down to the left. Slowly turn the horizontal hold control clockwise and note the least number of diagonal bars obtained just before the picture falls into sync.

If more than 3 bars are present just before the picture pulls into sync. Adjust the horizontal locking range trimmer, C-232, slightly clockwise. If less than 2 bars are present, adjust C-232 slightly counter-clockwise. Turn the horizontal hold control counter-clockwise, momentarily remove the signal and recheck the number of bars present at the pull-in point. Repeat this procedure until 2 or 3 bars are present.

Turn the horizontal hold control to the maximum clockwise position. Adjust the T-10 frequency core so that the diagonal bar sloping down to the right appears on the screen and then reverse the direction of adjustment so that the bar just moves off the screen leaving the picture in synchronization.

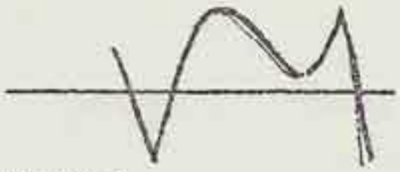


Figure 1

IV. Color Decoder Alignment

1. Burst Oscillator Adjustments: Set Color Saturation Contsol, R-93a, to minimum. Remove signal from tuner. Reduce IF strip sensitivity by either pulling out V-6 or by applying about -7v or more to the AGC line. Couple a frequency counter or other accurate frequency meter to the plate of V-20, 6CB6 Isolation Amplifier through a 100 mfd blocking capacitor. Set Color Hold Control (R-112) and Color Phase Control (C-117) in mid position. Adjust C-130 in V-19, Burst Oscillator, so counter reads 3.579545MC. Next put VTVM on the primary of the quadrature transformer, L-63. Primary is at junction of C-144 and C-145. Use RF probe and scales. Tune primary slug of L-63 for maximum RF at primary, making sure the coil slug is just entering the primary coil (coil closest to chassis). Then tune the secondary tuning capacitor, C-140, for a minimum of RF at the primary. This dip is slight, but should be carefully tuned.

2. Luminance Channel Burst Frequency Trap and the Burst Phase Detector: Set Color Saturation control at maximum and Color Hold and Color Phase controls at midrange. Couple the output of V-20 to the cathode of V-14a through a 5K blocking capacitor. Put RF probe of VTVM on the junction of the kinescope cathode leads, (kinescope pins 19, 2, 7). Or, alternately, connect a signal generator set at 3.579 MC ± 10KC to the cathode of V-14a through a 5K blocking capacitor. In either case, tune the luminance channel 3.58MC trap, L-39, for minimum RF on the VTVM. Now put the VTVM between ground and Pin 1 of V-18, 6AL5 Phase Detector. Use DC scales. Tune L-50 for maximum DC on the meter.

3. Chrominance Channel Sound Trap: Set Color Saturation control fully clockwise (maximum). Connect the output of a 4.5MC RF oscillator to the cathode of V-14a through a 5K blocking capacitor. Put RF probe of VTVM on the junction of R-126

and R-127 in the Demodulator grids. Tune chrominance channel 4.5MC trap, L-45, for minimum RF on the VTVM.

4. **Accurate Setting of Tuner Local Oscillator for RF Sweep Use:** Remove VTVM and RF generator. Restore IF strip sensitivity. Put -4.5v on AGC line. Set the tuner channel selector on the channel number of the output of the available PMG. If a crystal controlled source of sound carrier is available, couple this sound carrier to the antenna leads, using an input of about 1000 microvolts. Put DC VTVM across Pin 2 of V-14a and the -135v line. Tune the L/O for minimum reading on the VTVM. The L/O is now set, and do not disturb for the remainder of the procedure. If no crystal controlled source of sound carrier is available, couple PMG and 18FS together to the antenna leads through a suitable resistance matching pad. Set PMG output at about 40db down (about 2000 microvolts), and the 18FS output at about 2000 microvolts. Put DC VTVM on the Ratio Detector output capacitor, C-77. It will be found convenient to set the VTVM zero at center scale for the following measurement. Set 18FS at the approximate sound carrier frequency. Then tune 18FS carefully for a balance on the VTVM. Note figure below for explanation of balance. Remove PMG, do not disturb 18FS, put VTVM between Pin 2 of V-14a and the -135v line. Tune L/O vernier for minimum indication on the VTVM (Have VTVM zero restored to left edge of scale.) The L/O is now set, and do not disturb for the remainder of the procedure.

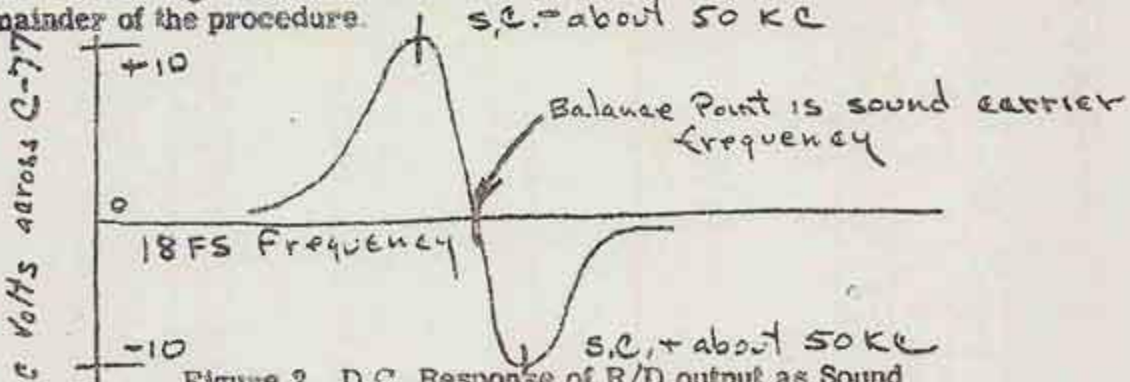


Figure 2. D.C. Response of R/D output as Sound Carrier Generator frequency is changed

5. **Bandpass Stage Adjustments:** Remove 18FS. Remove V-19, Burst Oscillator. Put video detector probe between the -135v line and the junction of R-126 and R-127. Connect this probe to a good low frequency scope. Modulate the PMG with video sweep extending to 5MC. Set the PMG attenuator to the same setting as that noted in II-9. Put -4.5v on AGC line. Set Color Saturation control at maximum. Adjust the video sweep generator output so that the signal at the scope is large enough to be useful, but not large enough to show evidence of overload. Overload occurs at about 0.5v p-p of the swept curve.

Adjust C-100, L-46 and L-47 in the Bandpass Amplifier, V-16, 6CB6, for the response shown below, making sure that maximum gain consistent with the desired response is achieved. For a marker, use an RF generator coupled to the detector probe through a 2-5 mfd capacitor.

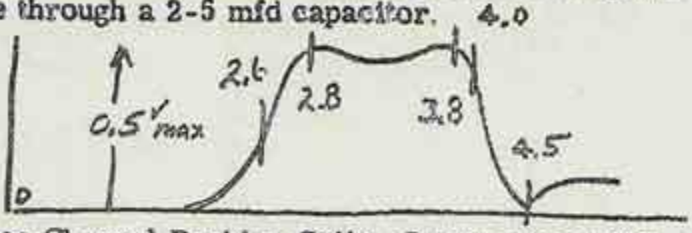


FIG 3
Response of Chr. bandpass Amp.

6. Chrominance Channel Peaking Coils: Remove the PMG, and reduce the sensitivity of the RF strip. Remove V-19, Color Burst Oscillator. Set Demodulator Gain control, R-131, at midrange. Connect the scope detector probe between the B-Y output to the kinescope grid and to ground. Connect the video sweep generator to the junction of R-126 and R-127 through a 0.1 mfd paper capacitor. Adjust L-62 and L-65 for the response shown below.

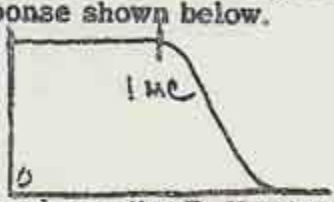


FIG 4
Response of Chr. channel peaking coils

Next, put the demodulator probe on the R-Y output and adjust L-66 and L-69 for the response shown below.
Put the probe on the G-Y output and adjust L-70, and perhaps L-69, for the same response as above. Note that because of the matrixing process, all inductors listed above interact on each other somewhat, so go back and repeat the adjustments in this paragraph until satisfactory responses are obtained for the B-Y, R-Y and G-Y outputs. In general, the amplitudes of the three responses will not be the same but the shapes should be.

7. Quadrature Transformer Touchup: To check the phase relationship between the primary and secondary outputs of the quadrature transformer, L-63, first put V-19 back in. Attach an RF generator to the cathode of V-14a through a 5K blocking capacitor. Set the frequency at 3.58MC. Using a scope with identical horizontal and vertical amplifiers (RCA WO-56A for example), attach a lead from one amplifier to the junction of L-62 and C-139 in the plate circuit of V-22, B-Y Demodulator. Connect the other scope amplifier to the junction of L-66 and C-152 in the plate of V-25, R-Y Demodulator. Ground the scope to the Decoder Chassis. An elipse will now be seen on the scope. Now carefully tune the RF generator until the elipse collapses to a point. Decrease the generator frequency slightly, about 10-20KC, restoring the elipse. Adjust C-140 in the secondary of the quadrature transformer so that the major axis of the elipse is either vertical or horizontal, or a circle is obtained. As an aid to this adjustment, set the scope gains so an approximate circle is obtained, then adjust C-140 and the scope gains for the best circle. Note that if the adjustments of IV-1 have been carefully made, C-140 will only have to be touched slightly if at all.

8. Color Synchronizing Touchup: Remove scope and RF generator. Restore IF sensitivity. Remove AGC bias battery. Attach tuner antenna leads to the PMG. PMG attenuator setting should be the same as in II-9. Set the Master Brightness Control, R-93b, at about midrange. Advance the Red, Green, and Blue Background Controls (R-141, R-161 and R-164) for an approximate white field with no antenna signal. Advance the Color Saturation Control, R-93a, to the full clockwise position. Modulate the PMG with a color bar pattern. The color oscillator should pull into synchronism. With the Oscillator Phase control, C-117, and Color Hold Control, R-112, in midposition, put VTVM back on Pin 1 of V-18, Phase Detector, and touch up L-50 for maximum DC voltage. This should be about 100 volts. Now put VTVM across C-119, 8 mfd capacitor in the V-18 circuit, and adjust the oscillator frequency control, C-130, for a voltmeter reading of -1.0v. Check color synchronizing performance by rotating tuner channel selector off channel for a few seconds and returning to the proper channel. Color should return to synchronism within 5 seconds. Check the amplitude of the color burst signal at the phase detector by putting a wideband scope (Tektronix or equivalent) on Pin 1 of V-18. The burst amplitude should exceed 200v peak-to-peak with the Color Saturation Control at maximum.

9. Demodulator Gain Setting: Attach scope (DuMont 208 will do) to the R-Y output to the kinescope grids. Leave the color bar pattern on and synchronized. Set Color Saturation control about 2/3 of maximum, or safely below evidence of saturation on the scope. Referring to the attached chart, note the desired R-Y output waveshape. Adjust the oscillator phase control slightly to make the waveform the approximate proper shape. Then adjust scope gain so that relative amplitudes shown on the chart may be recognized. Without changing the scope gain setting, move the probe to the B-Y output, and adjust the Demodulator Gain control, R-131, so that the B-Y output has the correct relative amplitude shown on the chart. Check the G-Y. It should come out automatically, but if it doesn't, recheck the R-Y and B-Y. If the G-Y is still out of line, the matrixing circuits are out of order, or the color bars not set up properly at the generating station. Note that these outputs may not match the charts perfectly in shape, but should come within 20%.

V Convergence Adjustments

1 Color Purity: Set tuner between channels and the Color Purity control at minimum. Set Field Neutralizing control at midrange. Fully unscrew beam positioning magnets on the neck of the kinescope. Set Green and Blue Background controls, R-141 and R-164, at minimum. Set Red Background control, R-161, at maximum, and adjust the Master Brightness Control, R-93b, for a moderately bright red field. Be careful not to exceed the beam current rating on the kinescope tube. Increase the purity coil current and rotate the purity coil at the same time until the best red is obtained at the center only of the kinescope. Also adjust field neutralizing coil current for best red. Then slide the deflection yoke back and forth along the neck of the tube until

the most uniform red field is obtained. Work back and forth with the yoke position and the purity and field neutralizing coil adjustments until a uniform, or nearly so, red field is obtained. In general, use the minimum pruity coil current necessary for a satisfactory red field. Now check the green and blue fields. They should be more uniform than the red, but in some cases may have to be optimized with the red.

2. Static Convergence: With the Master Brightness control about midrange, adjust red, green and blue background controls for an approximate white field. Set the dynamic convergence controls at minimum. Set tuner to correct channel and modulate PMG with a white dot pattern. Rows of "clumps" of red, blue and green dots will now be seen on the face of the kinescope. Set DC convergence control at minimum and focus. Set beam positioning magnets directly over the kinescope guns. Looking at the clump of dots in the center of the screen only, adjust the beam positioning magnets at the rear of the kinescope tube so the red, green and blue dots form an equilateral triangle with the base in a horizontal line, and the blue dot at the apex, either above or below the base as the case may be. If it is impossible to move a given dot in the correct direction to form the equilateral triangle, by adjusting magnet (screw) depth, remove appropriate screw and insert the other end of the screw toward the tube neck. Advance the DC convergence control until the center triangle diminishes in size and collapses to a point, forming a white dot. Readjust focus. If the three beams do not quite coincide, touch up the beam positioning magnets. If the DC convergence control should not make the dots come together, but instead the dots seem to rotate, the relative positions of the dots in the triangle are not correct. Try to use the minimum amount of magnet necessary to get convergence, for if the magnets are too close to the tube neck, the minimum spot size will be large, and the spot shape poor. Also color purity might be adversely affected.

3. Dynamic Convergence: Adjust DC convergence control, R-282 and Focus Control, R-279, so that a small, sharply focused triangle of dots is at the center of the screen. Advance Horizontal Dynamic Convergence control, R-271 to maximum. Put an oscilloscope (any scope with response to 100KC will do) on Pin 2 (plate) of V-34b, 1/2 6BL7 Dynamic Convergence Amplifier. A 15KC parabolic wave will appear on the scope. This waveform has several cycles of high frequency ripple synchronized with and superimposed upon it. Tune both L-81, Horizontal Convergence Phase, and L-80, Horizontal Convergence Peaking control so that the ripple appears on the positive peaks of the parabolic wave. See figure below.

Fig. 5. Correct waveform at Convergence
Amplifier Plate

Work back and forth between both controls until maximum gain consistant with proper phasing is achieved. This wave should be about 200v. peak-to-peak. In the event the high frequency ripple is too weak to be detected, couple a 100 mfd capacitor between Pin 2 of V-34b and terminal B of T-11, Horizontal Flyback Transformer. Remove scope.

Looking at the row of triangles extending in a horizontal line through the center of the kinescope, adjust the Horizontal dynamic convergence control so that the triangles of this row are all the same size. The Horizontal Convergence Phase control may have to be touched up a bit.

Now looking at the triangles extending in a vertical line through the center of the kinescope, adjust the Vertical Convergence control, R-290, and the Vertical Convergence Shape control, R-293, so that the triangles in this now are all the same size.

Now adjust the DC Convergence and Focus Controls until the center triangle comes together, forming a white dot. If the preceding steps have been carefully executed, the convergence should now be good over the whole kinascope tube. It may, however, have to be optimized somewhat. Sometimes the beam positioning magnets affect color purity, so return to a plain red field and check color purity. Touch up, if necessary, then repeat the convergence procedure.

VI Tracking and Final Checkout.

1. Modulate PMG with Color Bar Pattern. Turn off Color Saturation control. Set contrast control at maximum and master brightness for best black-and-white picture. Observe chrominance differences between light and dark bars. Adjust between the Red, Green and Blue Background controls, and the Red, Green and Blue Balance Controls (R-208, R-209, & R-207) on the Deflection Chassis for best black and white picture, making sure that the white on bright bars does not shift to another color (usually a reddish hue) on dark bars. This adjustment is more an art than a science, therefore no hard and fast rules can be given for it.

2. Modulate PMG with a color signal, preferably a suitable slide, and check kinescope picture for defects that can be remedied by adjustment.

E. O. Frye
February 12, 1954

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ALIGNMENT PROCEDURE FOR CTV-2 COLOR TELEVISION SETS

I. Initial setup and adjustment:

Before applying AC line voltage to the receiver for the first time, the controls should be set as follows:

Decoder Chassis:

Master Brightness at minimum (extreme CCW).
Contrast at maximum (extreme CW).
Color Saturation switched off.
Horizontal Hold at center.
Red, blue and green background controls at minimum.

Deflection Chassis:

Horizontal convergence at minimum.
Vertical convergence at minimum.
Red balance at center.
Green and blue balance at minimum.
Color purity at minimum.
Field neutralizing at center.
High voltage control at center.
Locking range capacitor should be set at maximum capacity (screw tightened down).

Apply AC line voltage to receiver and immediately adjust high voltage control so that high voltage is 20KV.

Advance Master Brightness control and Green Background control until a raster is obtained. Care should be taken so that the picture tube is not damaged by excessive brightness.

The Horizontal Drive control should be adjusted until the drive line in the raster just disappears.

Check B voltages to chassis in the Decoder chassis to see that they are:
-135V +15V and +240V +15V
Also set +88 and -60V on voltage divider taps at front of chassis.

II Tuner, IF and Sound Alignment.

1. Preparation for IF alignment: Put -4.5v bias on the AGC line (yellow). Apply -6v to a 220K resistor in series with the "looker point" on tuner converter grid. Hook a VTVM from Pin 2, V-14a, Composite Video Cathode Follower, and the -135v line. Set VTVM on a low negative DC scale. Note that the VTVM is re-

The input required to produce 1.0 volt DC output (above noise) shall be plotted, and the resulting curve shall have the following characteristics:

Between 22.4 and 25.5 mc the curve shall be flat with 15%.
The input at 21.75 mc shall be at least 200 times the average input between 22.4 mc and 25.5 mc.
The input at 26.25 mc shall be between 1.65 and 2.5 times the average input between 22.4 and 25.5 mc.
The input at 27.75 mc. shall be at least 80 times the average input between 22.4 and 25.5 mc.

3. Sound I.F. Selectivity

With the signal applied as in Par. 2 (b), connect a vacuum tube voltmeter across C-63.

The input at 21.75 mc required to produce a 1 volt DC reading on the VTVM shall be between 7 and 12 times the input required at 26.25 mc.

SELECTIVITY AND SENSITIVITY AT THE ANTENNA

Terminals:

1. Set up of AGC threshold control

Connect the antenna terminals to a Picture Modulated Generator modulated with monoscope pattern. With an input of about 5000 microvolts, connect an oscilloscope across Contrast Control, R131. Adjust AGC threshold control, R176, so that the video signal is 3.5 volts from sync. tips to average white.

2. Selectivity

With signals applied to the antenna terminals from an RF sweep device such as a Mega-Sweep, the response curve must be flat within 30% over a frequency range of 3.5 megacycles.

The oscilloscope should be connected between Pin 2 of V-14a and the -135 volt line, and a -4.5 volts bias applied to the AGC line. The tuner fine tuning must be properly set on each channel.

3. Sound Sensitivity

Signals from two signal generators, one at picture carrier frequency and one at sound carrier frequency, are applied to the antenna terminals, each signal being supplied through two 300 ohm carbon resistors. With the receiver tuning adjusted so that the IF sound carrier is in the sound trap and equal output from the two generators, the input to the receiver must not exceed 125 uv. on any channel for 1 watt (above noise level) audio output in a 3 ohm load. The sound carrier generator (Boonton 202B) should be modulated ±7.5 Kc with 400 cycles.

Volume control set for maximum output; tone control set for maximum treble.

There is a 6db insertion loss through the above 300 ohm resistors so that the signal input to the receiver is one-half of the output of either generator.

4. Maximum Audio Output

With signals applied as in Item 2, and the output of each generator set at 1000 uv. the audio power output in a 3 ohm load must be at least 3 watts.

5. Ratio Detector Linearity

With signals applied as in Item 2 above, increase deviation of the sound carrier to ±40 Kc. Connect the vertical amplifier terminals of an oscilloscope across C-77. Connect the horizontal amplifier terminals of the oscilloscope to the 400 cps audio signal which modulates the sound carrier. With the output of each generator set at 1000 uv., vary the frequency of the sound carrier signal generator so that the d-c voltage across C-77 is zero. The overall discriminator curve observed on the oscilloscope must be linear within 5%.

6. Picture Channel Sensitivity

With signals applied to the antenna terminals from a Ferris 18FS signal generator, or equivalent, through two 150 ohm carbon resistors, (one in series with each antenna terminal) the input necessary to produce 7 volts RMS rise with modulation at the picture tube cathodes shall be 150 uv. or less on all VHF channels. Signal generator to be 30% modulated at 400 cps. Output voltmeter to be high impedance type and a low pass filter consisting of a 10,000 ohm resistor and a 1000uufd capacitor should be inserted in the voltmeter leads. Measurements to be made at the frequency in each band which gives maximum output. Contrast control to be at maximum. AGC threshold control to be set as described above.

7. Overall Chrominance Channel Selectivity

Apply signal from PMG modulated with monoscope pattern to antenna terminals, and adjust input signal level until AGC is -4.5 volts DC. Adjust tuner vernier to proper setting. Apply -4.5 volts of battery bias to AGC line, modulated PMG with video sweep signal (100 Kc to 4 Mc) of approximately .25 volts p-p. Set Color Saturation Control at maximum. Connect a video detector probe between -135v line and the junction of R-126 and R-127, and observe the overall chroma passband on oscilloscope. The passband should have the following characteristics:

The swept curve should be flat within 25% between 2.8 MC and 3.9 MC.
The response at 2.6 MC and at 4.0MC should not be down more than 50%.
The alignment of the bandpass amplifier (C100, L46 and C-47) shall be such that maximum gain consistent with the desired response is obtained.

8. Chrominance Video Response

Apply video sweep signal to junction of R126 and R127. Connect the video detector probe to the R-Y (Pin 5, V-27a) and B-Y (Pin 5, V-24a), and G-Y (Pin 1, V-24b) outputs respectively, and observe the swept curves on an oscilloscope. The passband should be flat within ±10% between 250 Kc and 1.0Mc. The response at 1.4 Mc shall be between 30% and 60% of the average amplitude between 250 Kc. and 1.0 Mc.

9. Color Synchronization

Apply a signal from PMG modulated with color bar pattern. With all controls adjusted for proper color bar pattern, but with color saturation control at maximum position, the d-c voltage measured with a VTVM from Pin 1, V-18 phase detector to chassis shall be at least 90 volts

PICTURE APPEARANCE

1. Apply RF Monoscope picture and sound signals to the receiver.

Receiver to be tuned with sound carrier in sound trap and contrast and brightness adjusted for best picture. Color saturation to be switched off.

The picture to be as follows:

a. Horizontal resolution shall be at least 275 lines.
b. Color Purity: There shall be no noticeable change in color of the picture except for slight discolorations within one inch of the edge of the screen.
c. Convergence: Apply a dot pattern to the receiver. The mis-registration shall not exceed 1/32 in. within 3 in. of the center of the screen, and shall not exceed 1/16 in. for remainder of picture except area within 3/4 in. of the edge of the screen where 1/8 in. misregistration is permitted.
d. Color Bars: Apply a color bar signal to receiver antenna terminals. Proper color bars shall be obtained with Color Phase control approximately at mid-range. The transients at the edges of the bars shall not be excessive.
e. Color Slide: Apply a color slide signal to the receiver and observe the full color picture for the following defects.

Improper color rendition
Poor focus or registration
Excessive video ringing
Excessive transients at color edges
Poor interlace.

Compiled by R. T. White

Approved by H. V. Fisk

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Effective 15 April 1954

SPARTON

Model CTV-2 Color Receiver

INSTALLATION ADJUSTMENTS OF THE TRICOLOR PICTURE TUBE

The Tricolor Tube

Three electron guns are used and operated on the shadow mask principle. The main components are the phosphor screen, the aperture mask and the gun assembly.

The picture is viewed directly on the phosphor screen which is made up of several hundred thousand phosphor dots one-third of which emit red light, one-third blue, and one-third green. The dots are arranged in the way shown in Fig. 1, that is, in such a way that if the screen is regarded as being made up of a number of equilateral dot triangles, one primary color appears at each corner of a triangle.

Located a small distance behind the screen is the aperture mask - a thin metal plate in which are etched a number of circular holes, one for each dot triangle on the face of the tube. The openings in the aperture mask are so aligned that there is one directly behind each dot triangle.

The electron guns are at the usual place in the tube and each one is responsible for energizing the dots which produce one of the three primary colors. This is likewise indicated in Fig. 1.

Now assume that we wish to produce a red field. The blue and green guns will be turned off and the beam from the red gun allowed to strike the screen through the holes in the aperture mask. It is apparent that unless the beam approaches the aperture mask at the correct angle it will not excite the red phosphor alone but may cause some emission by the blue or green phosphors as well. When the correct angle of approach is used, the field produced is said to be pure. Setting up the purity correctly is one of the problems involved in the operation of the tube.

Notice that because of the mask and if the approach angle is correct, the red beam can strike only red phosphor dots as it scans the tube face. Since the dots are separated by a finite distance, this amounts to keying the beam mechanically rather than electrically as would be necessary were the mask not used.

It should be clear that for proper operation all three electron beams must pass through the same opening in the aperature mask at the same time. The process of achieving this condition is known as converging the tube and it and the purity problem are considered in the next section.

Purity and Convergence of the Picture

There are four adjustments which can be made to affect the quality of the picture in terms of purity and convergence assuming, of course, that all operating voltages remain constant. These are (1) yoke position, (2) purity coil current and position, (3) static and dynamic convergence voltages, (4) beam deflecting magnets. Were the tube, in manufacture, so put together that the electron guns, aperture mask and phosphor screen were in perfect alignment, items 2 & 4 above could be eliminated. The basic problem is that, because of manufacturing difficulties in the tube, it is impossible to provide with the yoke alone a magnetic field which will give uniform operation over the entire face of the tube. It can be seen that for a given tube, a particular field is needed and the problem at hand is to determine by a cut and try process the configuration of that field. Since the deflecting field is affected in a different way be each of the operations 1-4 above, it would be desirable if these adjustments could be made independently of one another. It must be pointed out at the start, however, that such is not the case, the interaction between the various fields being quite severe in some instances.

The adjustment of color purity is properly the first step in setting up the tube. This is accomplished by means of the yoke position and the purity coil. Before describing the procedure it is well to discuss the factors governing color purity and the external means which have been devised to control them.

The basic requirement for obtaining pure color fields is that the deflection and color centers be coincident. A deflection center may be defined as the apex point of the pyramidal volume produced by each of the three electron beams as it scans a raster, while a color center may be defined as a point from which the phosphor dots of only one color can be "seen" when "looking" through the aperture mask. A study of the tube and screen geometry will show that the locations of both deflection and color centers are functions of the tolerances established for the manufacturing process and may be expected to vary among tubes. This fact at once implies that external controls must be available for positioning these centers not only as a trio but individually with respect to each other.

The purity coil acting as a long magnetostatic lens positions the three beams as a group, and the three small permanent magnets affect the individual beams, but unfortunately not without some interdependence. These magents are usually referred to as the convergence magnets. Their function is to place the beams in the correct relationship to obtain an area of convergence in the center of the screen, but it should be obvious from the foregoing discussion that they must also affect the purity of the color fields. This is the first factor precluding a step-by-step setup procedure for the tricolor tube. The second disturbing result of these external fields is the occurrence of rather severe defocusing. It is obvious that the focus point of the beams will shift with a change in purity coil current, but experimental evidence also indicates that the field produces different focus points for the three beams. It is impossible to explain this fact satisfactorily without knowing the potential distribution of the three electron guns and the field configurations produced by the purity coil. It is likewise evident that the three convergence magnets will affect the focus of the beams, but it is also obvious that in this case the focus points are very likely to differ if only for the reason that the magnets normally exert different fields on the beams. In spite of these deficiencies, the purity coil and permanent magnets will serve their designed purpose of positioning the color centers.

It may be inferred from the foregoing discussion that the purity controls are capable of superimposing the color centers upon the deflection centers established by the position of the yoke; but while this is true, it does not guarantee that pure color fields will result, for the deflection centers chosen must satisfy not only the usual requirements for proper deflection, but must also be the correct ones required to produce color purity. Certain defects may exist within the tube which prohibit the existence of good purity unless the yoke is tilted as well as properly positioned axially. This is the reason it is mandatory to use a universal yoke mounting so that up and down, forward and back and left and right movements are possible. Under these conditions satisfactory purity can be achieved only by a series approximation process.

To make the purity adjustment, the red field is used. This is done because under proper operating conditions, the red gun must supply a considerably higher beam current than the other two for the same brightness of color. Therefore, if the red beam impinges on either blue or green phosphor dots, considerable brightness of those color s will result and will be quite noticeable. If, however, the green or blue beams were employed, their normally lower currents would provide very little brightness of red dots which might be excited.

The blue and green guns, then, should be biased off and the red beam current increased until a reasonable brightness of field is obtained. The convergence magnets should be positioned maximum counter-clockwise (all the way out). The dynamic convergence voltages should not be applied. Purity coil current should be zero. Under these conditions, the yoke should be so positioned as to give the best possible purity over the face of the tube. This will very often be quite poor and the field not easily recognizable as red.

A small amount of purity current should next be allowed to flow and the coil oriented for the best purity. By successive readjustment of the yoke and coil, the best purity is obtained.

It should be emphasized that it is essential to use as little purity current as possible, for when the field of the coil is made too strong, smearing of the beam results which may be objecticnalbe in a picture. After the red field has been purified, the blue and green fields should be checked for any obvious defects. In general, when the red field is pure, the blue and green fields will be also.

The next step in setting up the tube is the matter of convergence. This, as stated before, means assuring that the three beams will pass through the same opening in the aperature mask at the same time. It is accomplished chiefly by means of an electrostatic lens formed by the convergence electrode and the neck coating. When the potential between these elements is correct, as a function of position, the beams meet in a point at the aperature mask.

For the next step in the convergence procedure, the adjustment of the magnets, two patterns have been found useful. One is a linearity pattern - a series of thin lines extending over the face of the tube in both horizontal and vertical directions. The other is an array of fairly fine dots, about 1/8 inch in diameter, which covers the face of the tube. Choosing this pattern is effectively the same thing as using only the intersections on the linearity pattern with the lines connecting them removed. It is up to the operator to select the pattern he prefers, but after the magnets are set up, the linearity pattern should be used in the remainder of the alignment.

With either pattern applied to all three guns, the DC convergence voltage should be adjusted to give the best approximation to convergence in the center of the screen. In all probability the approximation will be a poor one, resulting in a display in which the positions of the green, red, and blue intersections in the case of the linearity pattern, or dots, in the case of the second pattern, will not form an equilateral triangle. It may be that the intersections or dots will be only slightly separated and, in that case, it is well to readjust the DC convergence so that they are perhaps 1/4 inch apart.

The adjustment of the magnets must next be undertaken. In doing this, the object is to align the beams so that, depending on which pattern is used, either the dots or the intersections of the vertical and horizontal lines of the same color form the corners of an equilateral triangle. Fig. 2A shows a section of the dot pattern in a possible configuration before using the magnets and as it should look when the magnets are properly placed. Fig. 2B shows similar set of conditions for the linearity pattern. The arrows indicate the direction of motion of dots and intersections. The conditions of these figures obtain for low DC convergence voltage. If the DC voltage were too high, the patterns would be similar to those shown but the relative positions to the three colors would be as shown in Fig. 2C.

In making this adjustment with the magnets, they should be used as sparingly as possible. It is preferable to obtain the desired configuration by using small amounts of all three magnets rather than using one or two magnets to a large degree, since this insures minimum defocusing.

There are two important points which must be kept in mind during this procedure. First, if too much magnet field is used, the interaction between it and the purity field will result in some degradation of the purity. This effect is especially noticeable if a high purity current is flowing. A Check should be made to see if this change has taken place. If it has, the appropriate readjustments must be made. Second, if a strong magnet field is used, smearing of the beam is likely to occur. The red beam, because of its high current, is especially susceptible to this trougle, which may generally be avoided if the magnet field is made up of a small contribution from each magnet.

When the equilateral triangle configuration of the line intersections has been achieved, the DC convergence voltage should be readjusted so that the intersections coincide at the center of the screen. This coincidence is quite critical in terms of a well converged picture and barely visible errors at this point may lead to quite obvious discrepancies when, for example, a monoscope pattern is examined.

Assuming that the center of the tube has been properly converged, the pattern on the screen will be like that in Fig. 3. The most noticeable point about this pattern is that the convergence becomes poorer at the edges of the picture. This is due to the fact that when the beams are at the edges they must travel slightly farther than at the center in order to reach the aperature mask. Consequently, somewhat more voltage is required to converge.

It may be found in some cases that the pattern on the screen at this point is not uniformly out of convergence away from the center of the picture. In general, this effect will be revealed as an overly wide separation of the vertical lines at the bottom of the picture, which cannot be compensated for by the dynamic voltages. If this situation arises, some improvement can usually be made by shifting the yoke a small distance toward the back of the tube and reorienting it. This adjustment may, of course, affect the purity and a check on that aspect of the operation must be made.

To correct for these errors, AC voltages are superimposed on the DC convergence voltage. As might be expected, they are approximately parapolic in shape and are derived by integration of the sawtooth current in the cathode of the horizontal and vertical output tubes. As a result of unbalance conditions which may arise from manufacturing tolerances in the tube and yoke, the waveforms of the dynamic converging voltages must be controlled to some extent. A phasing coil achieves this result for the horizontal convergence voltages, and a differentiating circuit adds an adjustable sawtooth component to the vertical waveform. The resultant voltages are then added together and applied in such a way as to increase the convergence voltage at the left, right, top, and bottom.

Considering the pattern of Fig. 3 as regard the horizontal direction the most obvious thing is the curvature of the blue line with respect to the red and green which are superimposed. It is this line which serves as a guide in the adjustment of the horizontal dynamic convergence. With the tube correctly converged in the center, the horizontal dynamic convergence voltage should be increased. It will be seen that the horizontal blue line becomes more parallel to and separated slightly from the superimposed red and green. When the lines appear to be parallel the DC convergence should be readjusted to superimpose them. If they do not coincide over their length, adjustment of the phasing coil is necessary. By varying the amplitude and phasing of the horizontal dynamic convergence voltage properly, optimum horizontal convergence will be obtained.

Attention is next given to the vertical convergence. In this case, the red vertical line, which is curved so it opens at the right, is a good one to use as a gauge. The amplitude of the vertical dynamic convergence voltage should be increased along with adjustment of the vertical shaping control until the red line is as parallel to the other two as possible.

It may appear here that a control called "horizontal dynamic convergence" is being used to provide an adjustment in the vertical direction, and that one called "vertical dynamic convergence" is being used to provide an adjustment in the horizontal direction. To resolve any confusion on this point, consider the horizontal dynamic convergence control. The name implies an effect in the horizontal direction and the desired effect is the superposition of the horizontal red, green and blue line. This is actually what the horizontal dynamic convergence control does, although as the procedure has been described it is done by first separating the lines using the DC convergence voltage, then making the blue line parallel to the other two. In the final step to be discussed next, the DC voltage is readjusted to superpose the lines. A similar explanation clarifies the action of the vertical dynamic convergence voltage.

The DC convergence voltage should now be adjusted so as to bring the pattern into convergence over the major portion of the screen. The only areas that should now remain misconverged are the corners of the screen. Without further correction some misconvergence in the corners is inevitable as a result of the fringe fields produced by the turned-up ends of the yoke coils. It may be found that good convergence over the entire screen except at the edges is not easily accomplished. If so, it is usually possible, by accepting a slight underconvergence near the edges, to obtain a more satisfactory overall effect from the convergence

The subject of focus has been left until last as no difficulty should be experienced in this regard if the suggestions previously presented are followed. Heavy purity current and strong fields from the magnets are most likely to impair focus and this should be kept in mind during the adjustment of these elements. It is worth while noting that if some step in the procedure cannot be properly completed without defocusing, it is best to try to concentrate the defocusing in the blue field since it is least obvious there.

In summary, the steps to be followed are:

1. Purity using yoke and purity coil.
2. Converge at center using DC convergence and magnets.
3. Converge over face using dynamic convergence voltages.

There are two items which whould be pointed out in regard to the overall problem of convergence and purity and which should be borne in mind at all times while setting up the tube.

First, the interaction between the various magnetic fields is significant in many cases and to keep this at a minimum, the compensating adjustments - purity coil, magnets, should be used as sparingly and uniformly over the three guns as possible.

Second, the convergence process, while fairly logical a procedure, must be considered as fundamentally a cut and try routine in which constant checking and re-adjustment are necessary. Practice may not make perfect but it is a vital ingredient of success.

SPARTON RADIO-TELEVISION

Service Technical Department

TRACKING PROCEDURE FOR CTV-2 TO PRODUCE UNIFORM HUE WITH VARYING BRIGHTNESS

1. Turn contrast and color saturation controls to minimum. Master background at maximum. Red, green and blue balance controls at minimum. Red, green and blue background controls at minimum.

2. Advance red background until a very dull red is seen. Advance green background until a sickly greenish-brown is obtained. Advance blue background until a gray is seen. It may be necessary to vary the green and blue backgrounds for the best gray.

3. Apply color bar pattern or crosshatch pattern to the antenna. Turn contrast control to a maximum and reduce master brightness until a moderately bright picture shows on the screen. Color saturation control remains off. If necessary, readjust green and blue backgrounds for a good white on the bright portions of the picture.

4. Now observe the darker areas of the picture. If the darker areas should have a reddish cast, for example, the red balance control is set too high. To correct this, return to a bright picture, reduce the red balance control somewhat, then readjust the red background for a good white on the bright portions of the picture. Now observing a dark part of the picture, the hue shift should not be as severe as originally. Continue until the hue shift with brightness is minimized. The above procedure holds for hue shifts to other colors; use appropriate controls to correct it.

5. Should the picture shift red with the 3 balance controls at minimum, advance the green and blue balance controls, readjusting the green and blue background controls. Continue adjusting until good tracking is obtained.

CHANGING THE PICTURE TUBE IN SPARTON COLOR RECEIVER

Tip cabinet forward and rest on square pad from picture tube carton.

Remove protective back and two front decoder chassis bolts, Fig. 1.

If a short ratchet wrench with a 3/8 in. socket is not available, it may be necessary to remove the power supply chassis in order to remove two rear bolts of decoder chassis.

Tip set upright and remove front control knobs and remaining two decoder chassis bolts, Fig. 1.

Clear all cables and remove decoder chassis; set aside.

Five screws are holding picture tube mounting board, three across back edge and one on either side of yoke mount. Remove these and slide picture tube mounting out. Place on bench with brackets up, Fig. 2. Disassemble tension brace by removing wing nut and remove picture tube strap.

Obtain insulating sleeve and wrap the tube so that high voltage lead will protrude as shown in Fig. 3.

NOTE: BLUE GUN MUST BE DOWN WHEN TUBE MOUNTING IS IN POSITION OF FIG. 3. NOTE DUODECAL SOCKET KEY IN RELATION TO BREAK OR LAP IN INSULATING SLEEVE IN BOTH FIG. 1 AND FIG. 3.

Place mu-metal shield firmly over picture tube, covering insulating sleeve; positioning of aquadag grounding spring is not critical.

Insert tube, insulating sleeve, and mu-metal shield into picture tube mounting assembly with blue gun down as in Fig. 3. Lap in the insulating sleeve is on the right when looking from front of picture tube face. Square picture tube screen with mounting board.

Loosely attach picture tube strap and reassemble tension bracket. Snug picture tube strap, at the same time centering picture tube in yoke.

Hook field neutralizing coil in position with leads dressed as shown in Fig. 3.

Position purity coil, beam positioning (converbence) magnets and neck shield assemble, Fig. 3., with clamping ring located approximately 1/4 in. from duodecal socket. Tighten in position. Note position of adjustable convergence magnets; one centered over each gun. Refer to Fig. 1 and Fig. 3.

Clean face of picture tube and slide assembly into cabinet. Mu-metal shield and yoke bracket have been positioned during final assembled test operation at the factory and should need no further adjustment to center tube with mask.

Tighten down five screws previously removed from picture tube mounting board.

Slide decoder chassis back into position, positioning chassis for proper alignment of front panel control knobs. Tighten down.

Replace knobs and hook up cables as follows:

  Connect male plug from speaker to female plug coming from decoder chassis, near tuner, Fig. 4.

  Connect ground lead from decoder to tube assembly, visible in Fig. 1.

  Run H.V. cable (from front of H.V. cage) up thru hole in decoder chassis shelf on right side and connect to lead from picture tube rim.

Connect male plug (black and yellow wires) Fig. 3, from field neutralizing coil to plug (red and white wires) from back of decoder chassis, Fig. 4.

Connect male plug from purity coil, Fig. 3, to plug (black and blue wires) Fig. 4) coming from back of decoder.

Drop male plug coming from yoke assembly down in back of decoder chassis and connect to socket on inside of H.V. cage, Fig. 5 and Fig. 7.

Connect duodecal socket from decoder chassis to picture tube socket, Fig. 4.

Obtain signal cable from power supply and plug into signal socket on back of decoder chassis, Fig. 6.

Connect H. V. lead from duodecal socket with orange code to H. V. from back of H. V. cage with orange code.

Connect H. V. lead from duodecal socket, no code, to H.V. lead from back of H.V. cage, no code.

Connect ground lead from decoder to power supply.

Chart #1

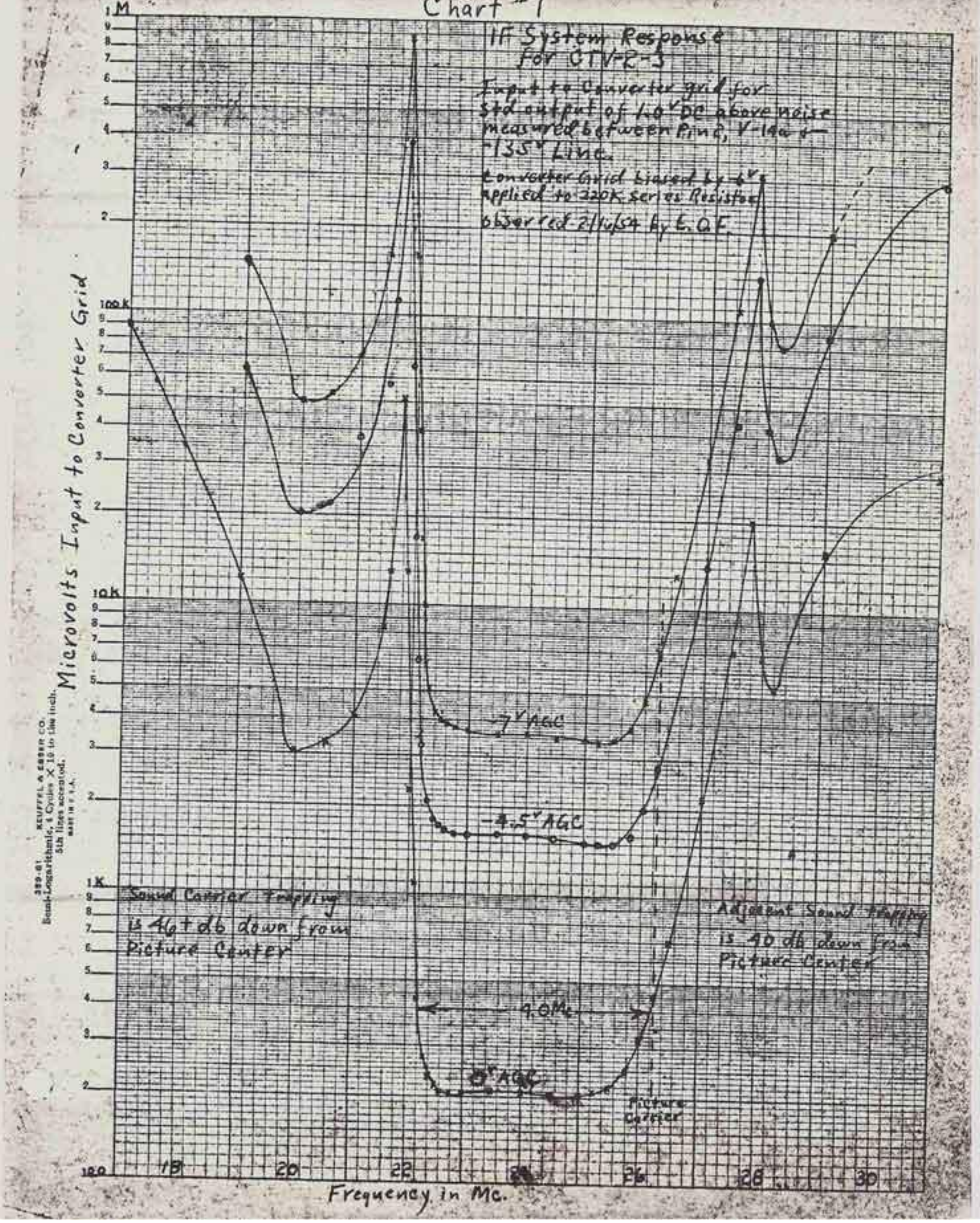

IF System Response
For CTV-2-3
Input to Converter grid for
std output of 1.0ᵛ DC above noise
measured between Pin 2, V-14a &
-135ᵛ Line.
Converter Grid biased by -6ᵛ
applied to 220K series Resistor
observed 2/16/54 by E.Q.F.
-7ᵛ AGC
-4.5ᵛ AGC
0ᵛ AGC
4.0Mc
Picture Carrier
Sound Carrier Trapping
is 46+ db down from
Picture Center
Adjacent Sound Trapping
is 40 db down from
Picture Center
Microvolts Input to Converter Grid
1 M
9
8
7
6
5
4
3
2
100 K
10 K
1 K
100
18
20
22
24
26
28
30
Frequency in Mc.
359-61 KEUFFEL & ESSER CO.
Semi-Logarithmic, 4 Cycles × 10 to the inch.
5th lines accented.
MADE IN U.S.A.

Chart #2

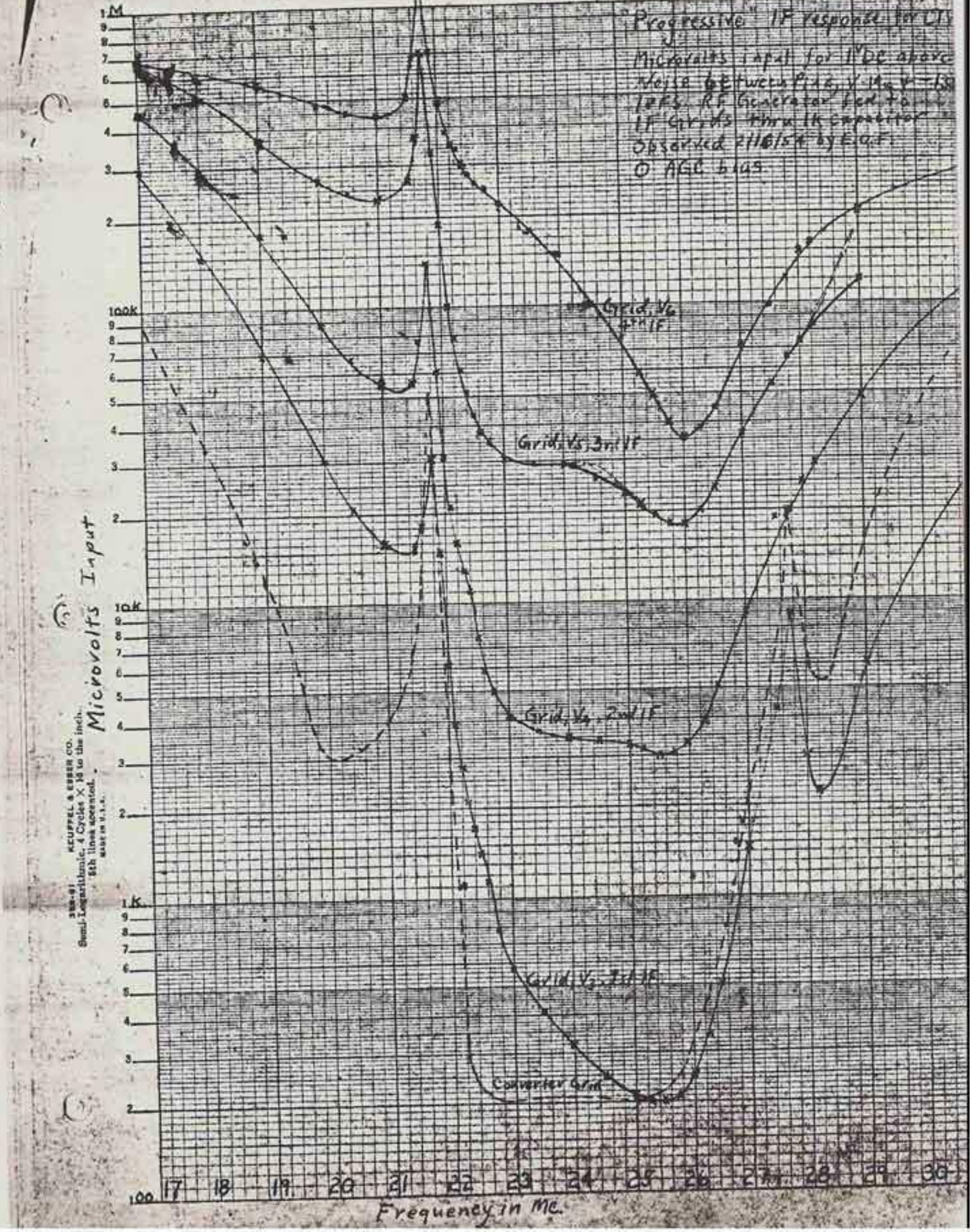
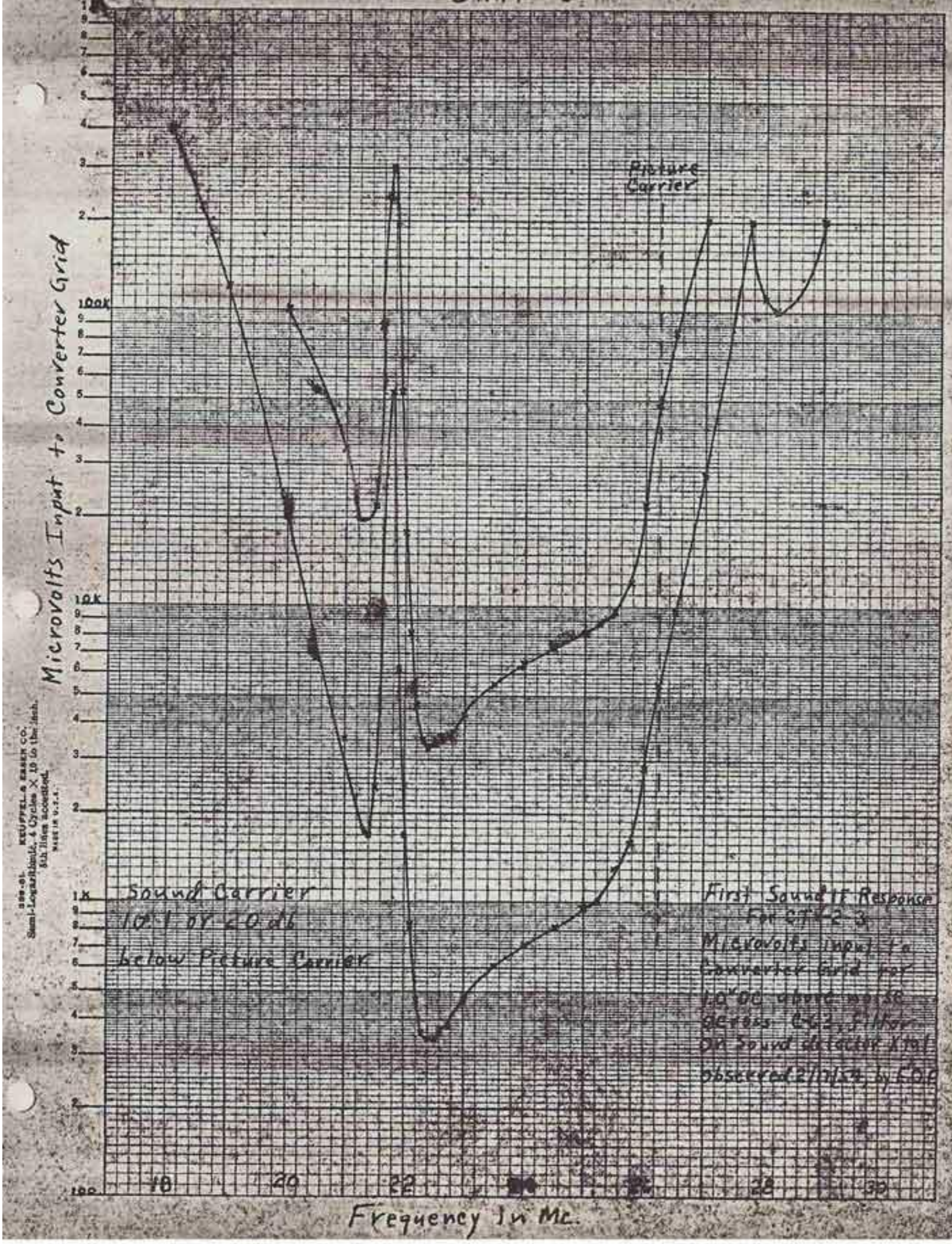

Progressive IF response for LTV
Microvolts input for 1V DC above
Noise between Pin 6, V 14 & V = 6.8
1 KCS. RF Generator fed to
IF Grids thru 1k capacitor
Observed 2/16/54 by E.G.F.
0 AGC bias
Grid, V6 4th IF
Grid, V5, 3rd IF
Grid, V4, 2nd IF
Grid, V3, 1st IF
Converter Grid
Microvolts Input
1 M
100k
10k
1 k
100
17
18
19
20
21
22
23
24
25
26
27
28
29
30
Frequency in Mc.
359-81 KEUFFEL & ESSER CO.
Semi-Logarithmic, 4 Cycles X 10 to the inch.
5th lines accented.
MADE IN U.S.A.

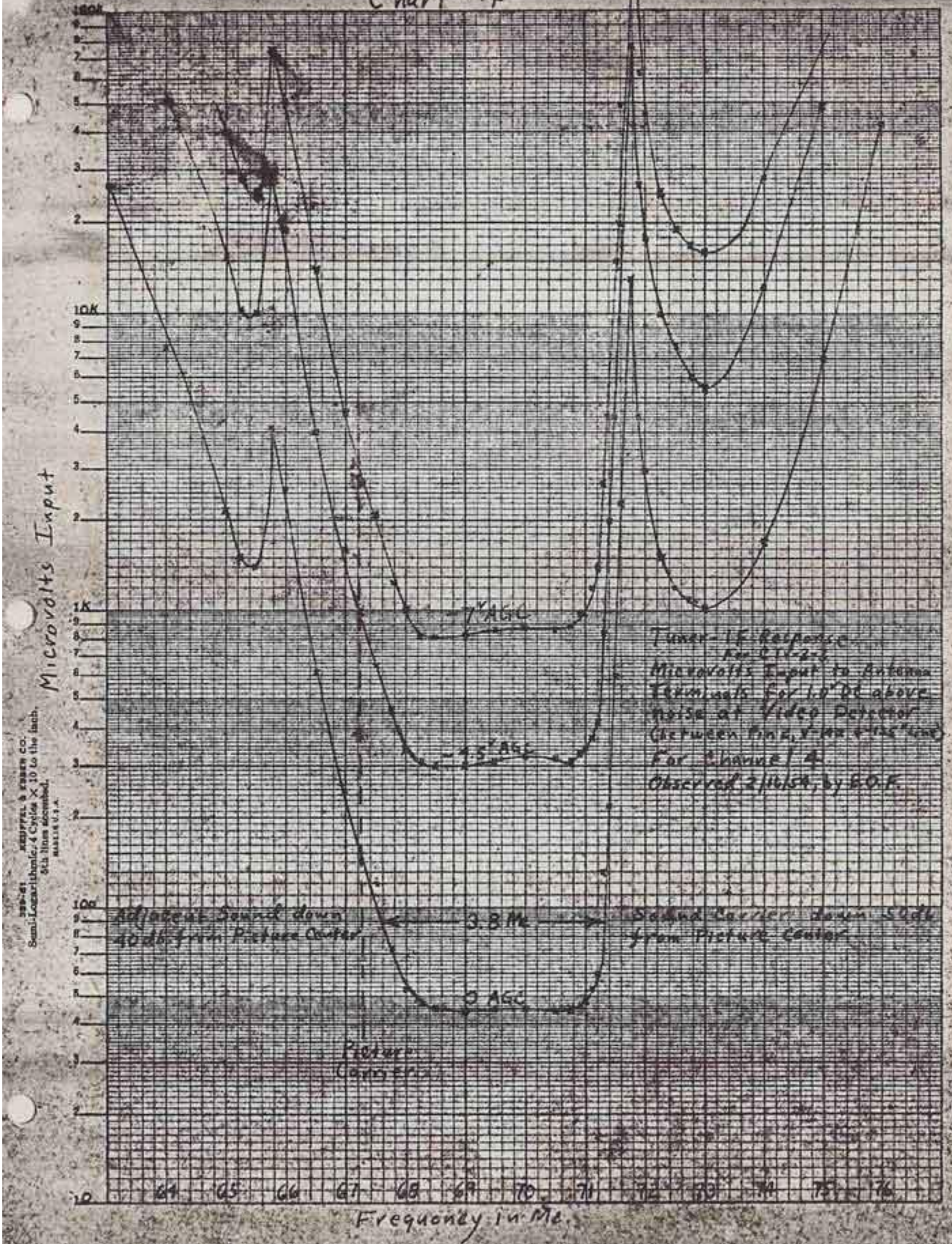
Chart #3



Sound Carrier
10:1 or 20 db
below Picture Carrier

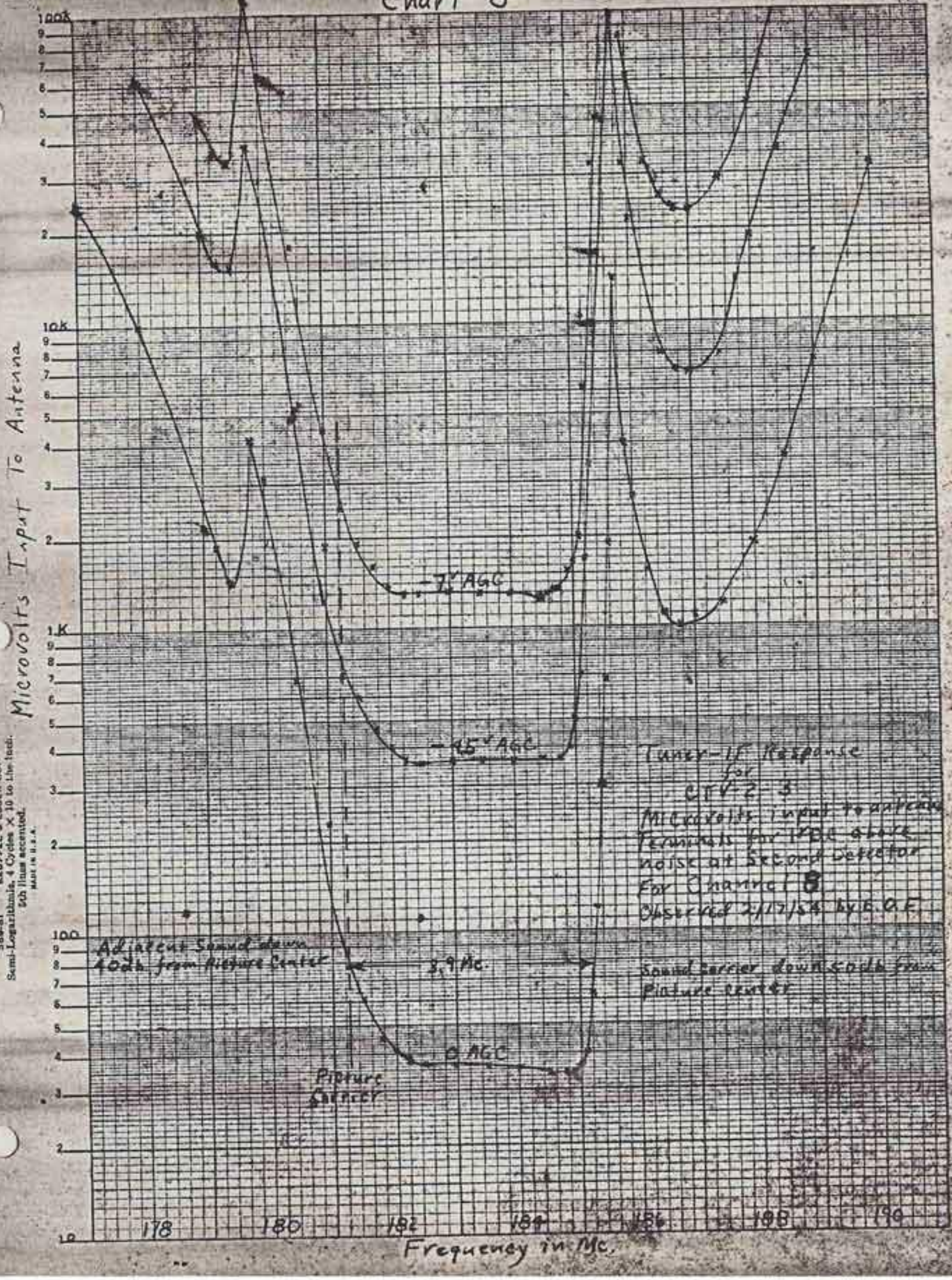
First Sound IF Response
For CT-2-3
Microvolts input to
Converter Grid for
1.0 DC above noise
across C62, Filter
on Sound detector X101
observed 2/17/54, by CDC

Chart #4



Tuner-IF Response
For CTV-2-2
Microvolts Input to Antenna Terminals for 1.0V DC above noise at Video Detector (between Pin 2, V-14A & 125V line)
For Channel 4
Observed 2/16/54, by E.O.F.

Chart #5

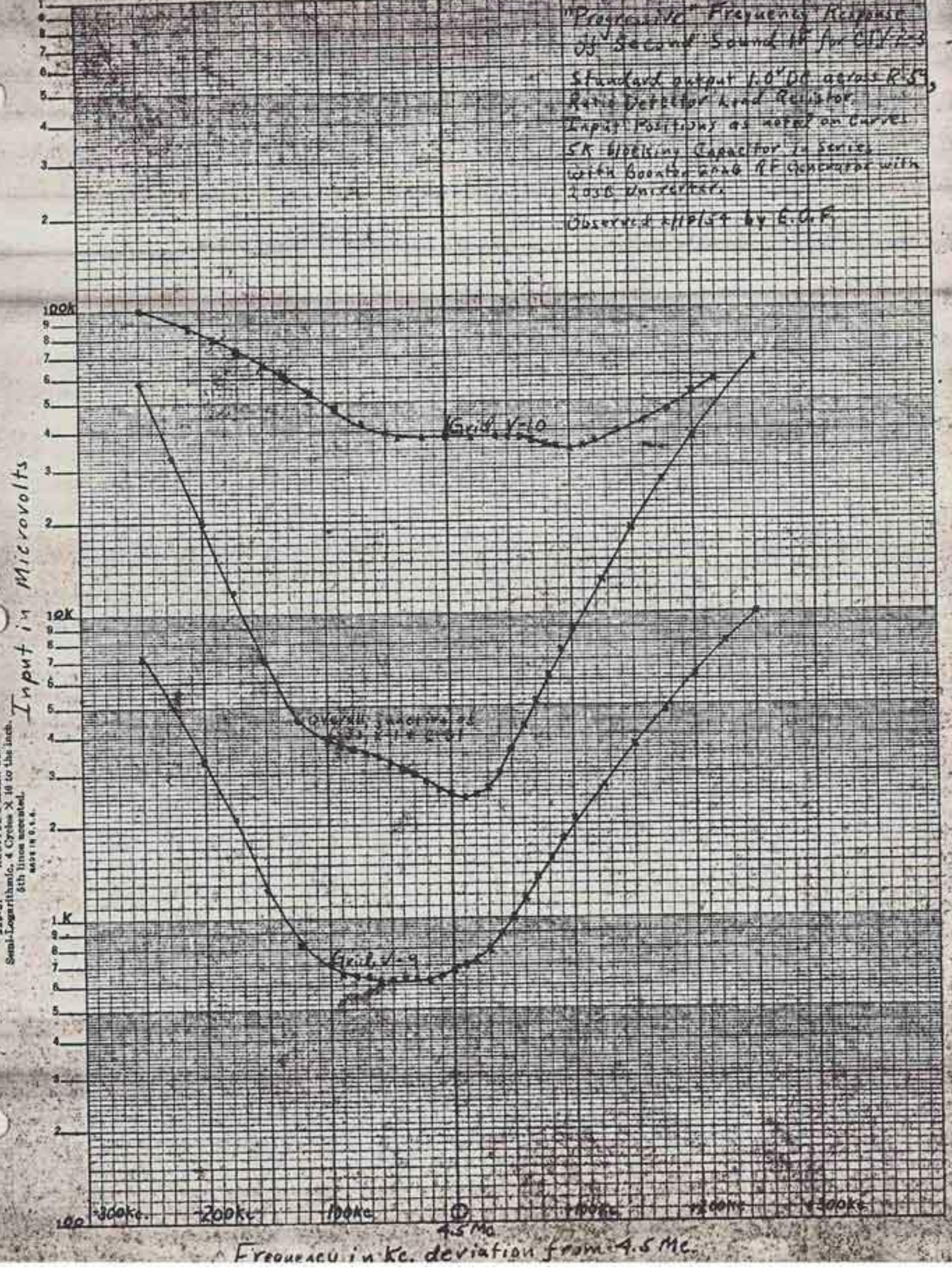


Tuner-IF Response
for
CTV-2 5
Microvolts input to antenna
terminals for 1 DB above
noise at Second Detector
For Channel 8
Observed 2/17/54 by E.O.F.

Adjacent Sound down
40db from Picture Center

Sound Carrier down 50db from
Picture center

Chart #6

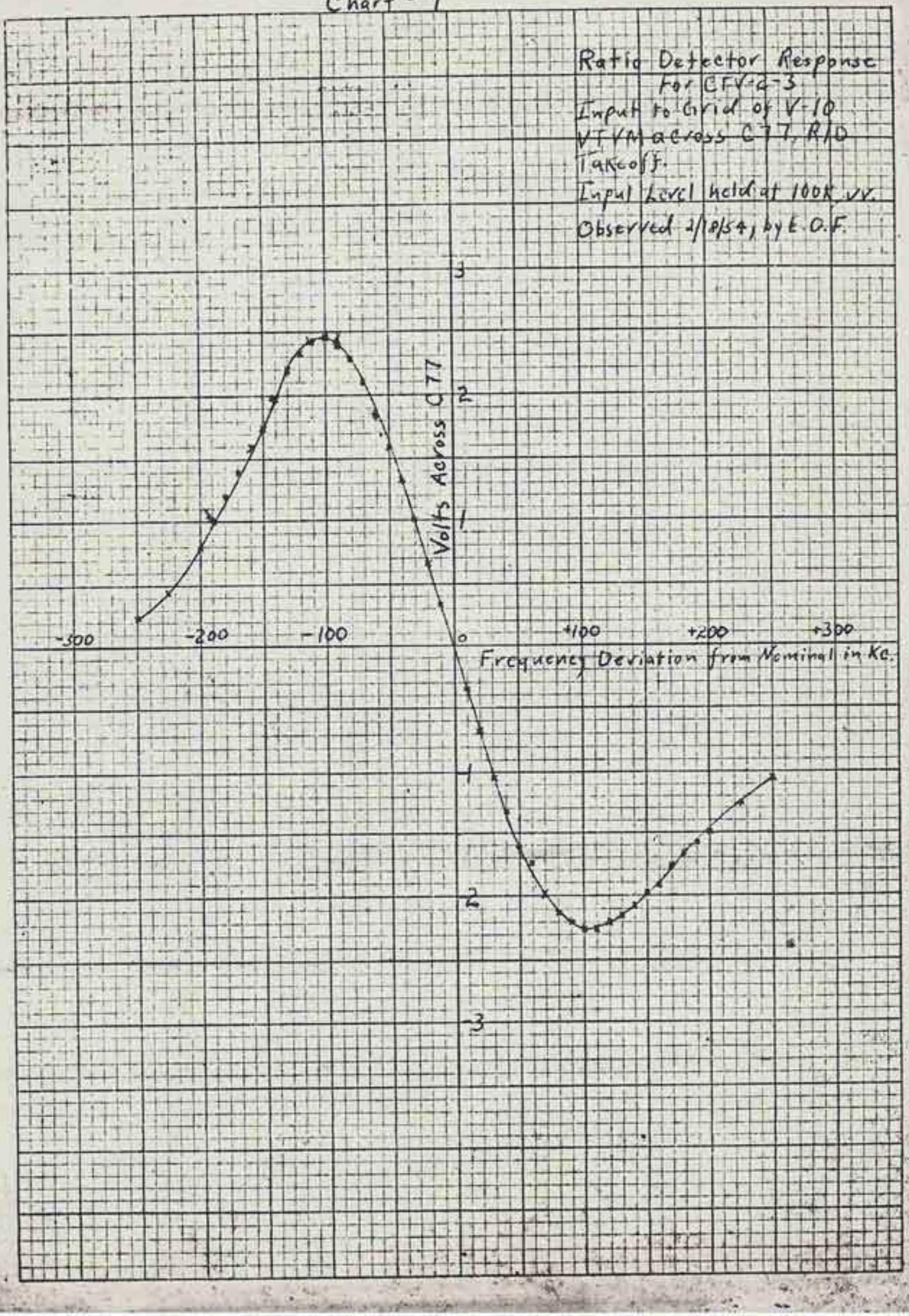


"Progressive" Frequency Response of Second Sound IF for CTV-23

Standard output 1.0 V DC across R-59, Ratio Detector Load Resistor.
Input Positions as noted on Curves
5K blocking Capacitor in Series with Boonton 202B RF Generator with 203B Univerter.

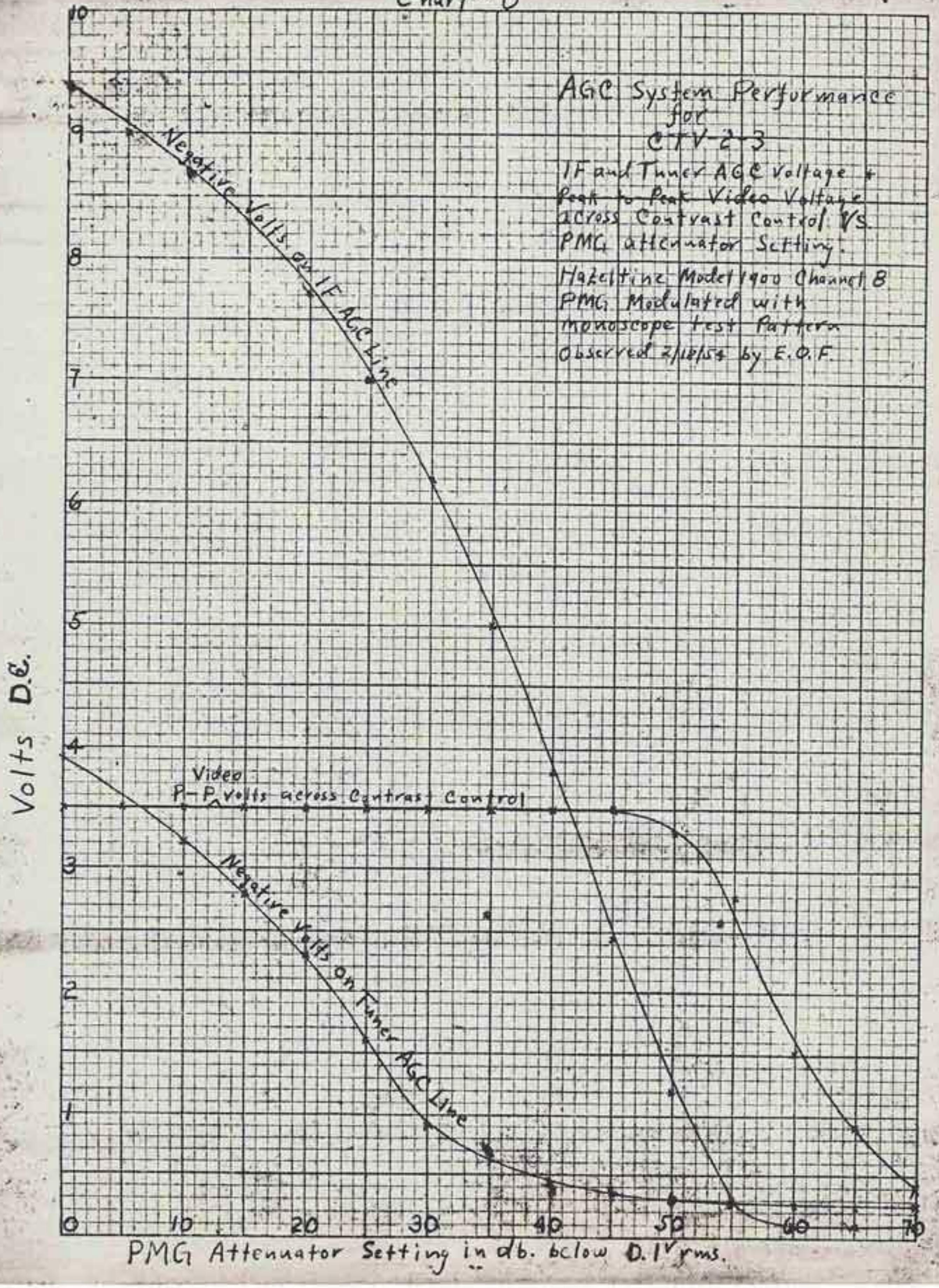
Observed 4/18/54 by E.O.F.

Chart #7



Ratio Detector Response
For CFV-a-3
Input to Grid of V-10
VTVM across C77, R/D
Takeoff.
Input Level held at 100K μv.
Observed 2/18/54, by E.O.F.

Chart # 8



AGC System Performance
for
CTV-2-3

IF and Tuner AGC Voltage &
Peak to Peak Video Voltage
across Contrast Control VS.
PMG attenuator Setting.

Hazeltine Model 1900 Channel 8
PMG Modulated with
monoscope test Pattern
Observed 2/18/54 by E.O.F.

Chart #9

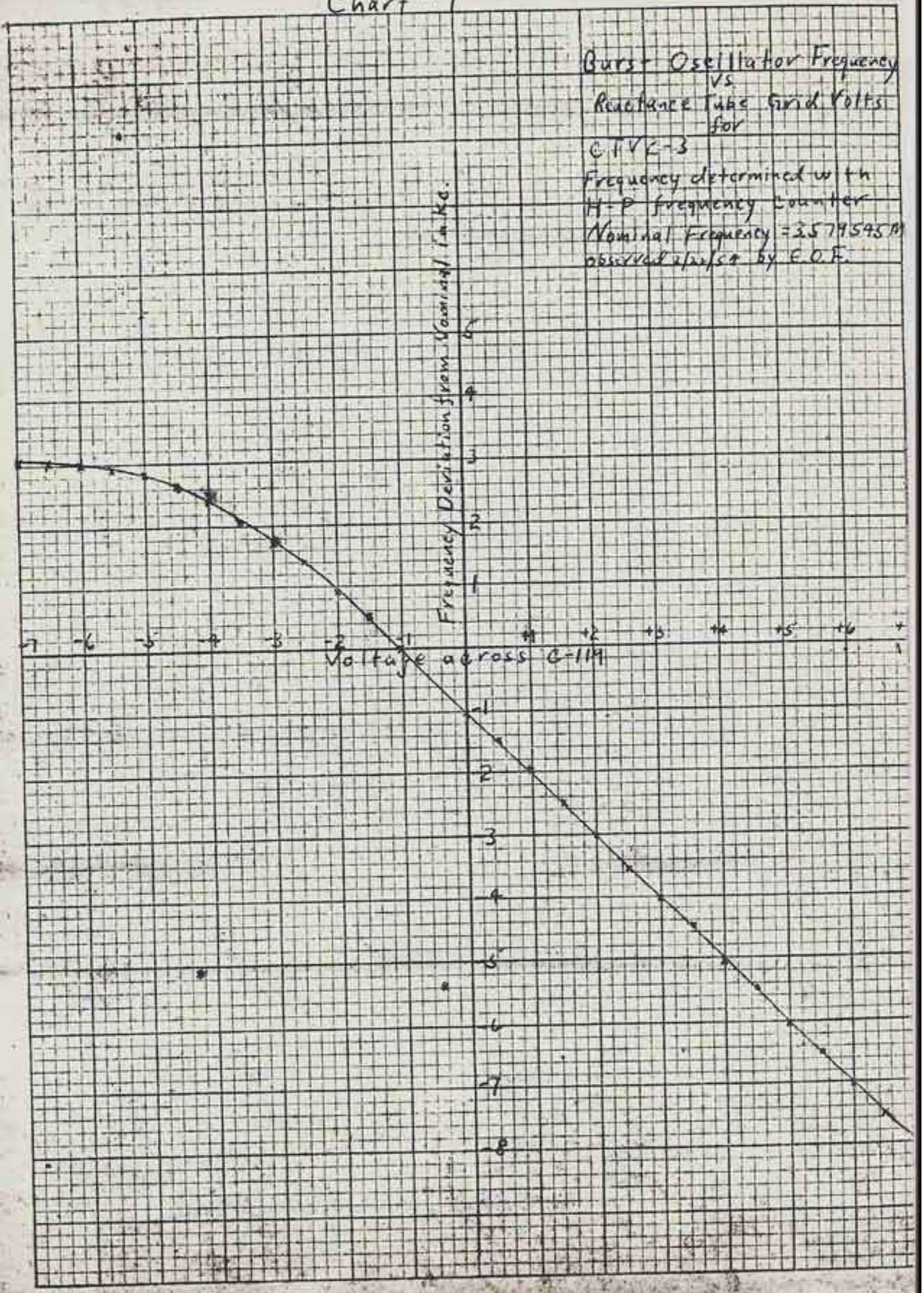
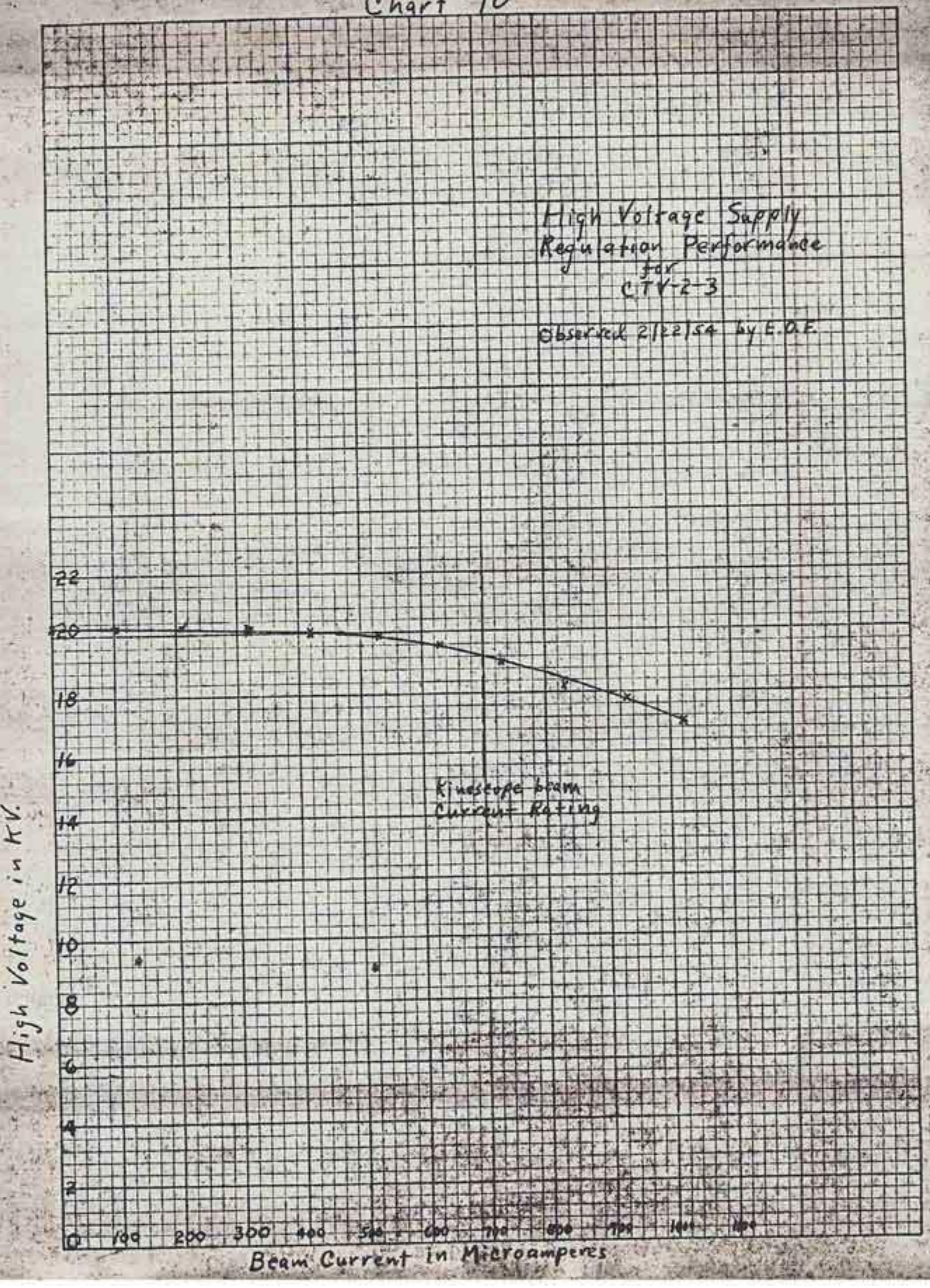

Burst Oscillator Frequency
vs
Reactance Tube Grid Volts
for
CTVC-3
Frequency determined with
H-P frequency Counter
Nominal Frequency = 3.579545 M
observed 2/22/54 by E.O.F.
Frequency Deviation from Nominal in Kc.
Voltage across C-114
-7
-6
-5
-4
-3
-2
-1
+1
+2
+3
+4
+5
+6
+7
6
4
3
2
1
-1
-2
-3
-4
-5
-6
-7
-8

Chart #10



High Voltage Supply Regulation Performance for CTV-2-3

Observed 2/22/54 by E.O.F.

Chart #11

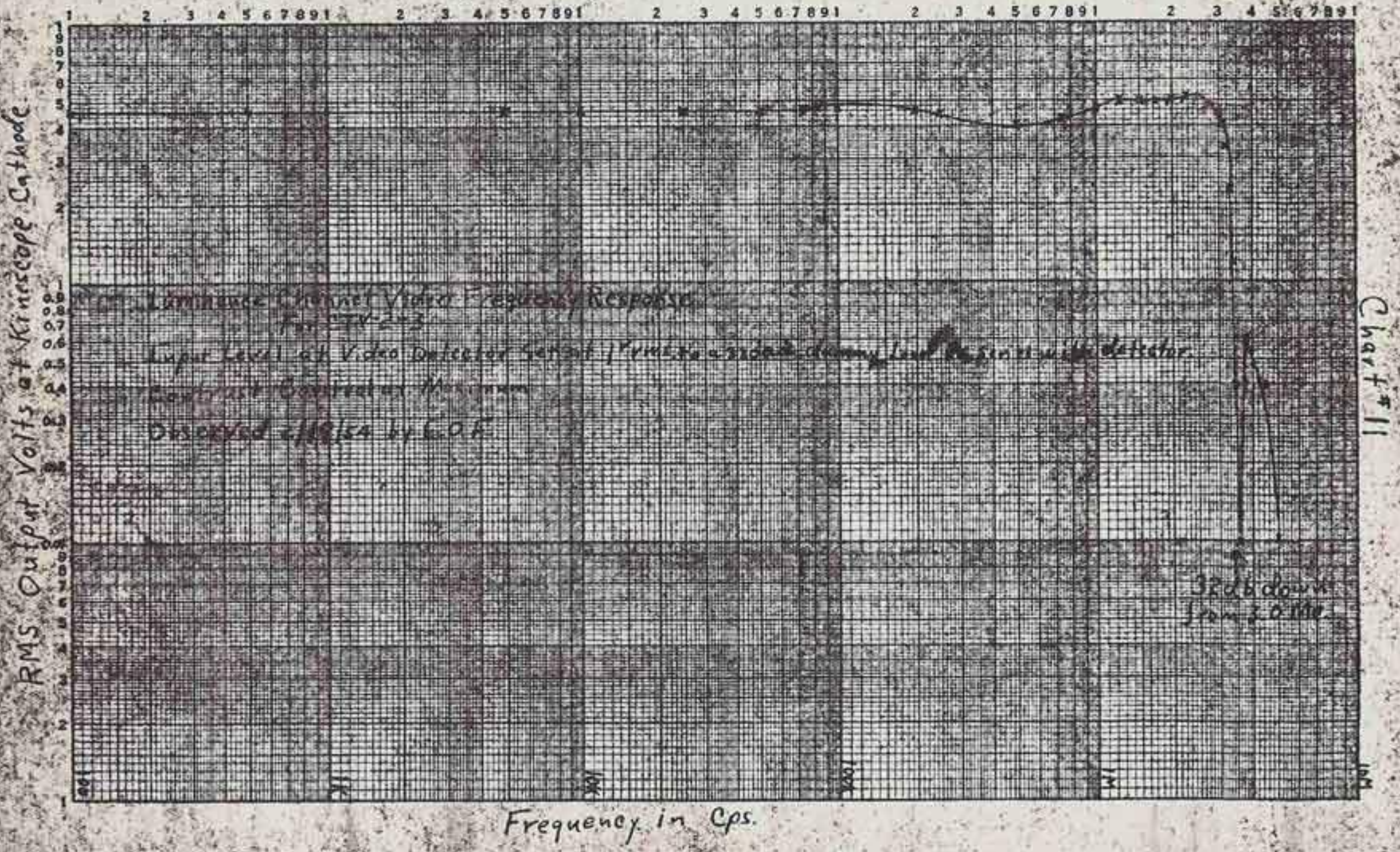
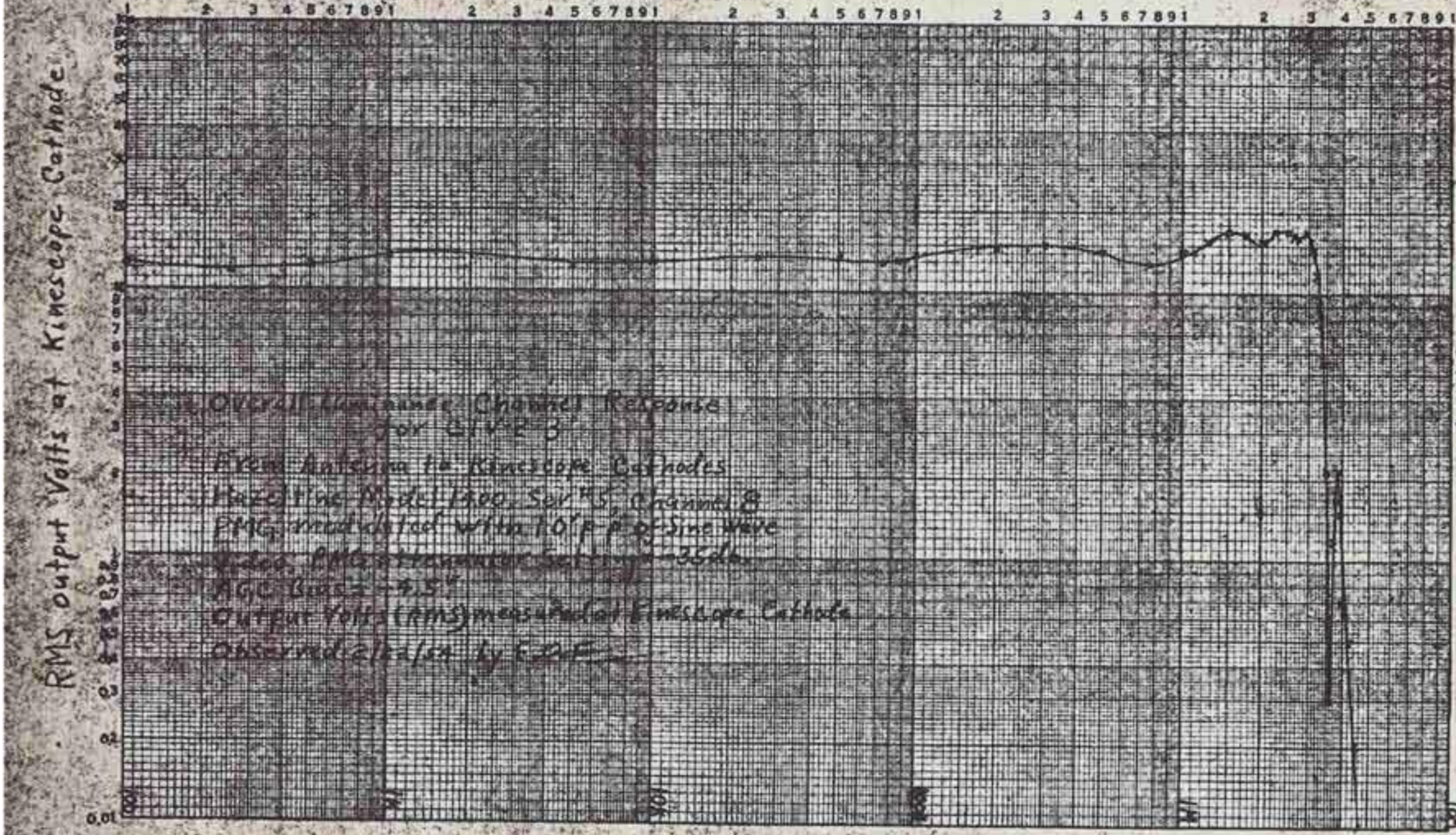

Luminance Channel Video Frequency Response
For CTV-2+3
Input Level at Video Detector Set at 1 Vrms to a 330 ohm dummy load in series with detector.
Contrast Control at Maximum
Observed 6/18/54 by C.O.F.
32db down from 3.0 Mc.
100
1K
10K
100K
1M
10M
RMS Output Volts at Kinescope Cathode
Frequency in Cps.

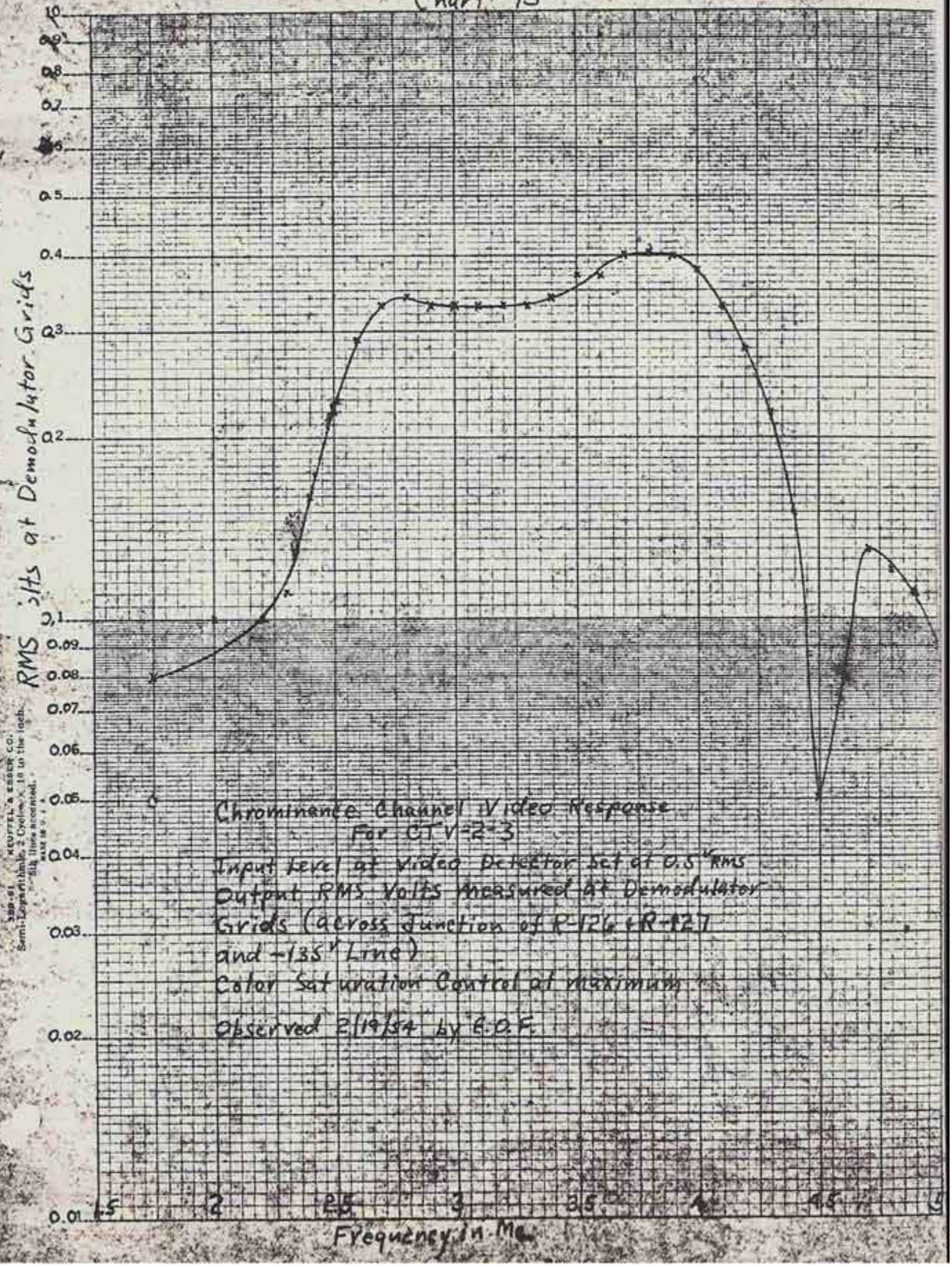
Chart #12



Overall Luminance Channel Response
for CTVR 3

From Antenna to Kinescope Cathodes
Hazeltine Model 1400, Ser #5, Channel 8
RMG modulated with 1.0V p-p of Sine Wave
Video. RMG attenuator setting -35db.
AGC Bias = -4.5V
Output Volts (RMS) measured at Kinescope Cathode
Observed 2/24/54 by [illegible]

Chart # 13

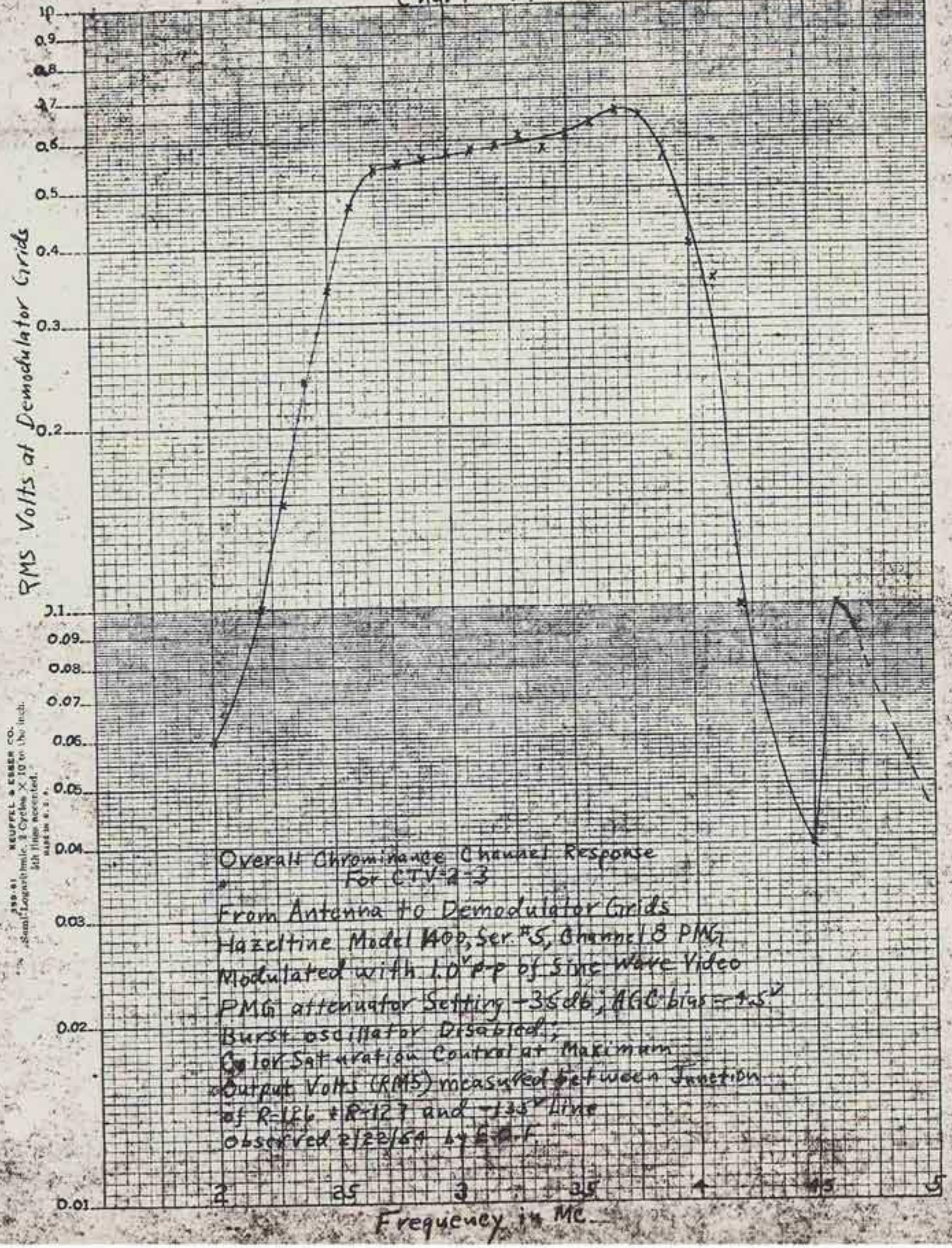


Chrominance Channel Video Response
For CTV-2-3

Input Level at Video Detector Set at 0.5 V RMS
Output RMS Volts measured at Demodulator
Grids (across Junction of R-126 + R-127
and -135 V Line)
Color Saturation Control at maximum

Observed 2/19/54 by E.O.F.

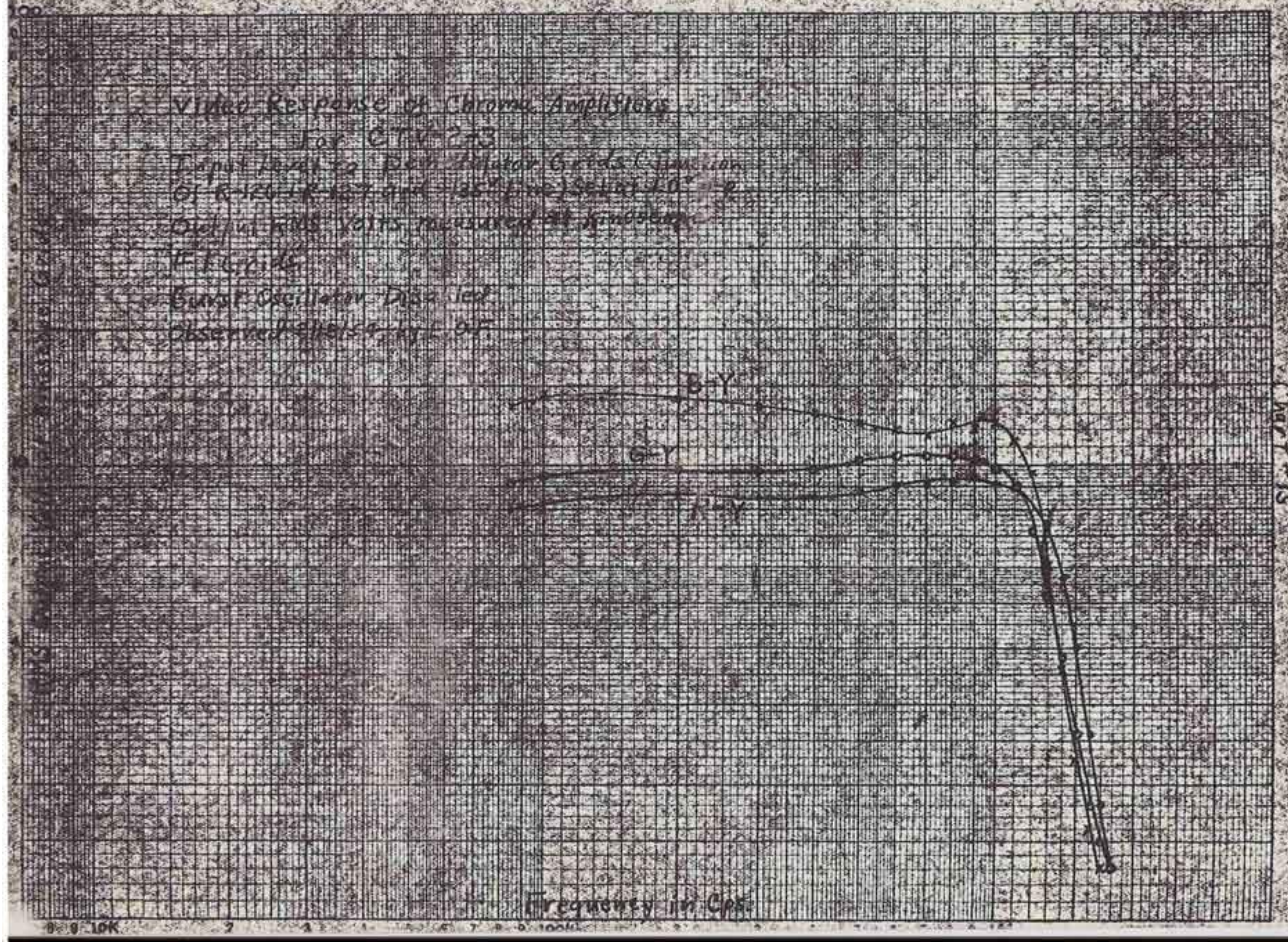
Chart # 14



Overall Chrominance Channel Response
For CTV-2-3

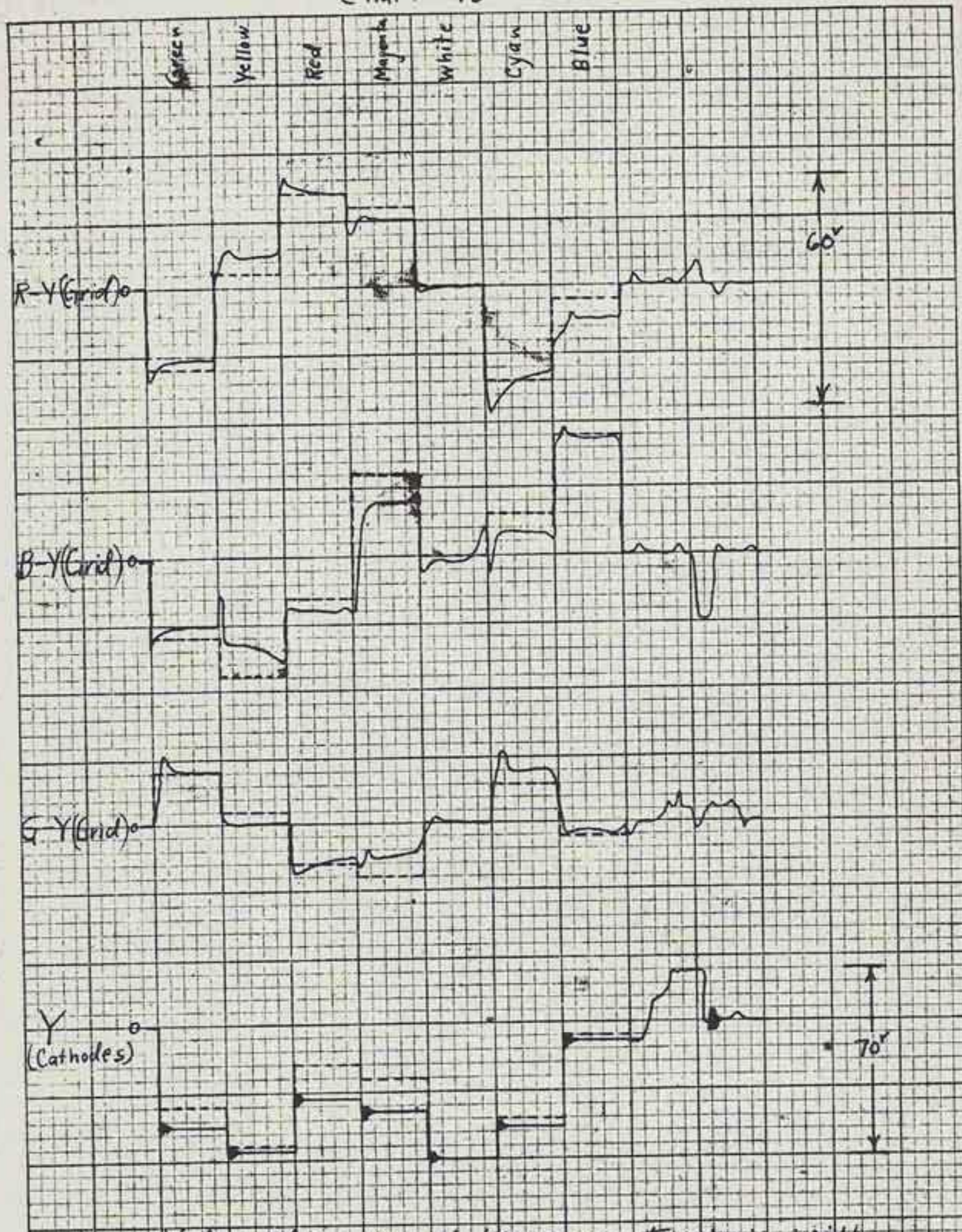
From Antenna to Demodulator Grids
Hazeltine Model 1400, Ser #5, Channel 8 PMG
Modulated with 1.0v p-p of Sine Wave Video
PMG attenuator Setting -35db; AGC bias = -4.5v
Burst oscillator Disabled;
Color Saturation Control at Maximum
Output Volts (RMS) measured between Junction
of R-126 & R-127 and -135v Line
Observed 2/22/64 by E.O.F.

Chart #15



Video Response of Chroma Amplifiers
For CTV-273
Input Lead to Dem. Modulator Grids (Junction
Of R-[illegible] and [illegible] Series [illegible]
Output RMS Volts measured at Kinescope
F T Grids
Burst Oscillator Disabled
Observed effects [illegible] off

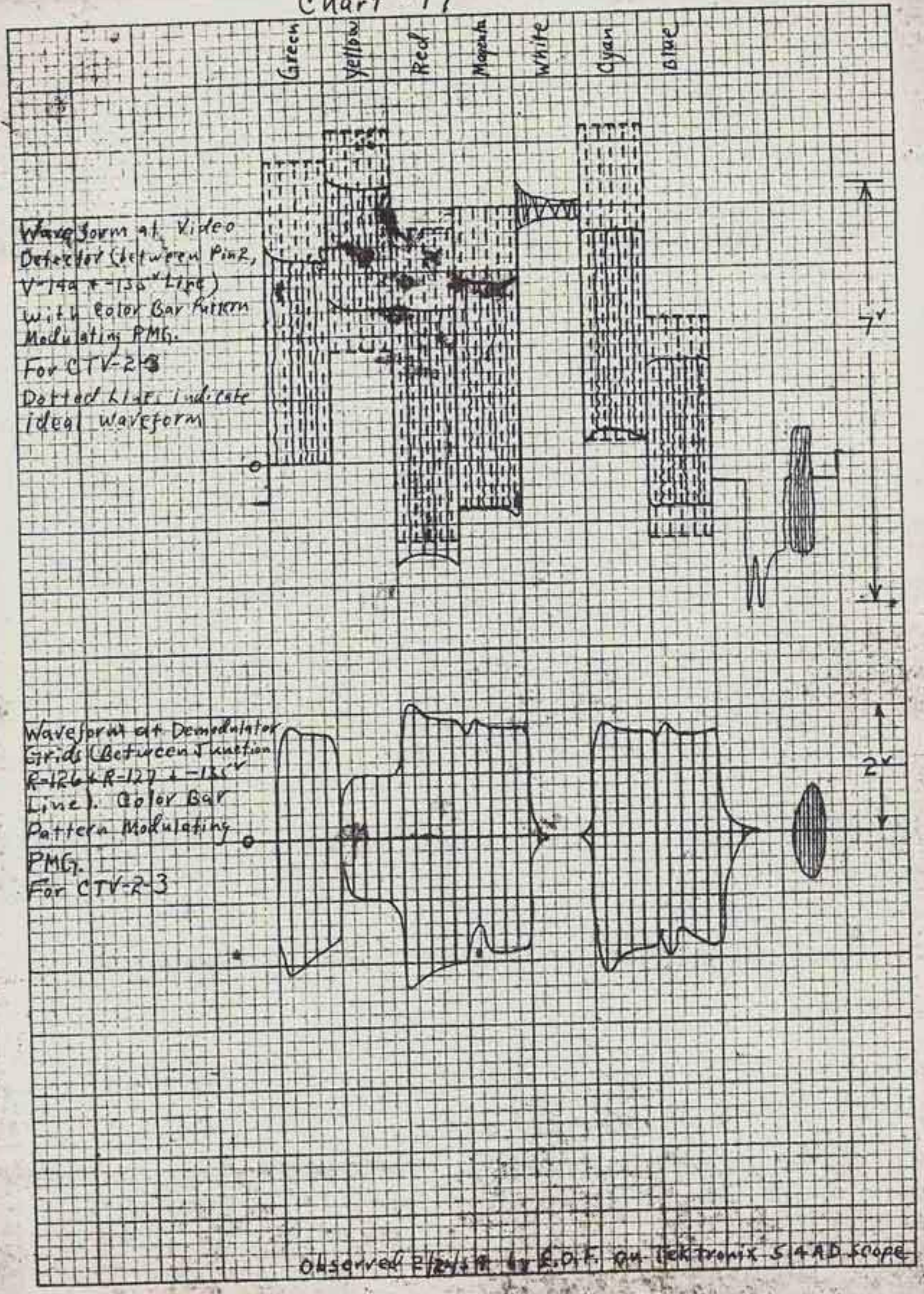
Chart # 16



Video Waveforms at Kinescope Terminals with Color Bar Pattern Modulated on PMG. For CTV-2-3
Dotted Lines indicate Ideal waveforms

Observed 2/22/54 by G.O.F. on Tektronix 514AD Scope

Chart #17

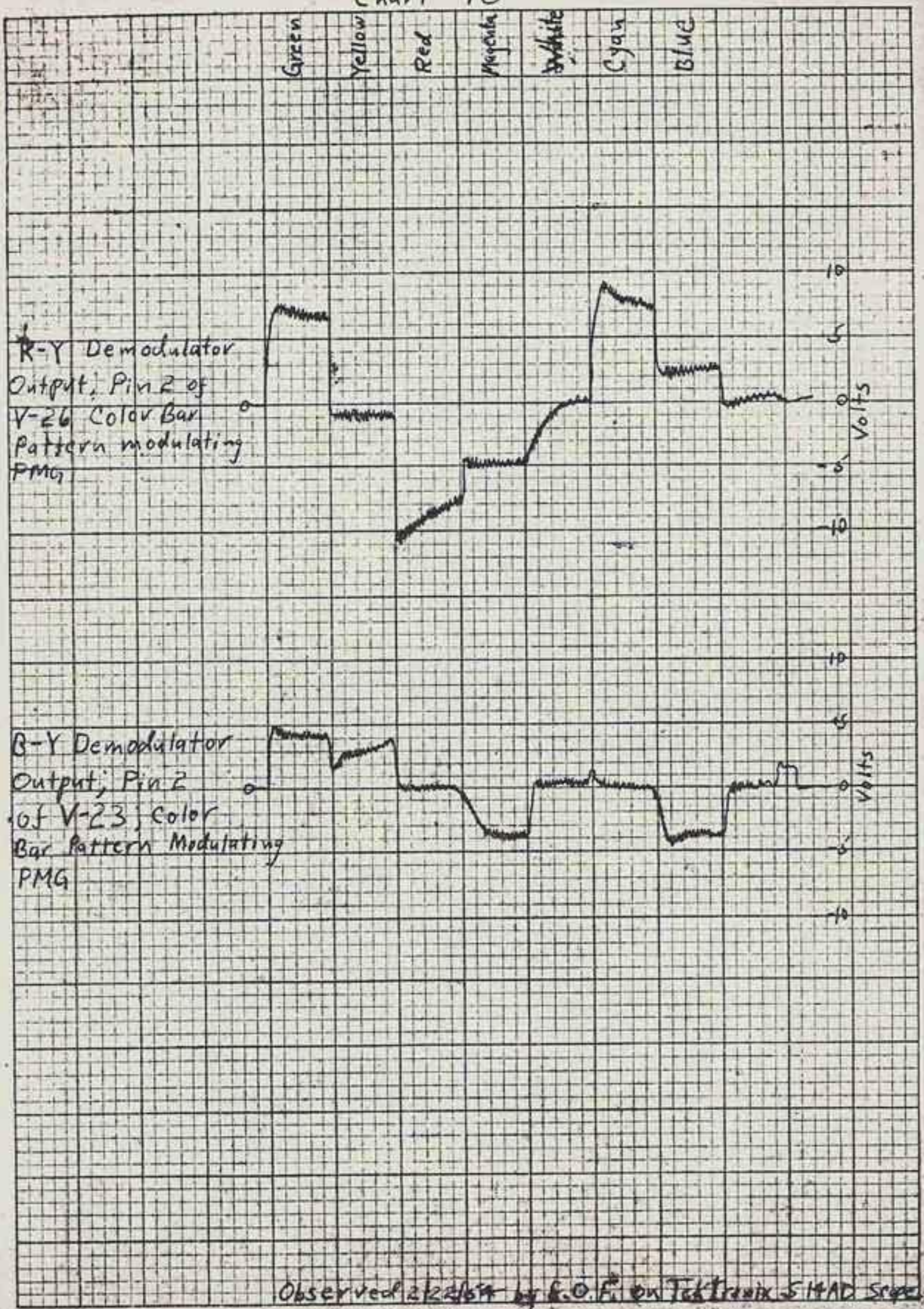


Waveform at Video Detector (between Pin 2, V-144 & -130V Line) with Color Bar Pattern Modulating PMG.
For CTV-2-3
Dotted Lines indicate ideal waveform

Waveform at Demodulator Grids (Between Junction R-126 & R-127 & -135V Line). Color Bar Pattern Modulating PMG.
For CTV-2-3

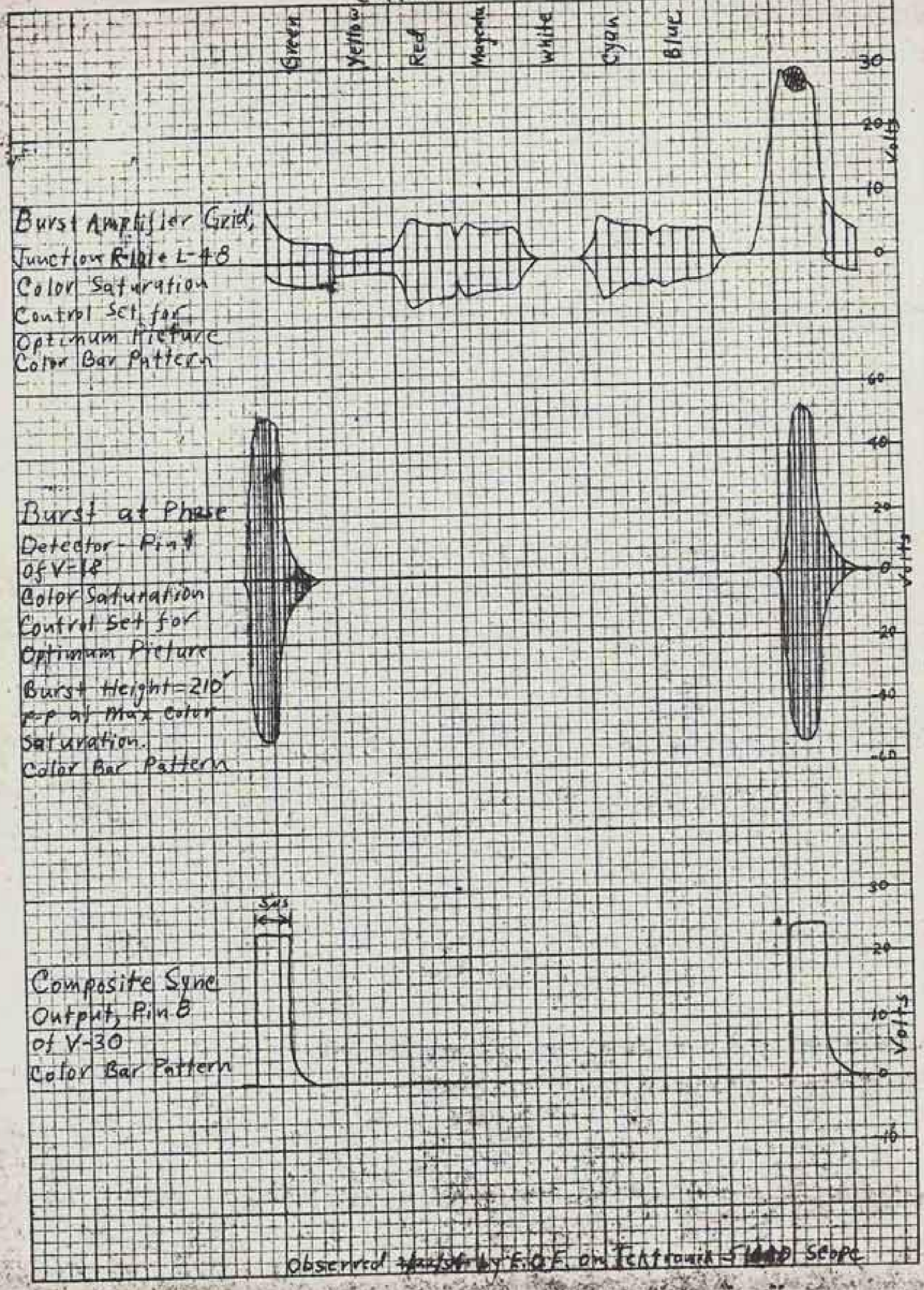
Observed 2/24/54 by E.O.F. on Tektronix 514AD Scope

Chart #18



Observed 2/22/64 by E.O.F. on Tektronix 514AD Scope

Chart #19



Burst Amplifier Grid;
Junction Plate L-48
Color Saturation
Control Set for
Optimum Picture
Color Bar Pattern

Burst at Phase
Detector - Pin 4
of V-18
Color Saturation
Control Set for
Optimum Picture
Burst Height = 210v
p-p at Max Color
Saturation.
Color Bar Pattern

Composite Sync
Output, Pin 8
of V-30
Color Bar Pattern

Observed ~~[illegible]~~ by E.O.F. on Tektronik 5[illegible] Scope

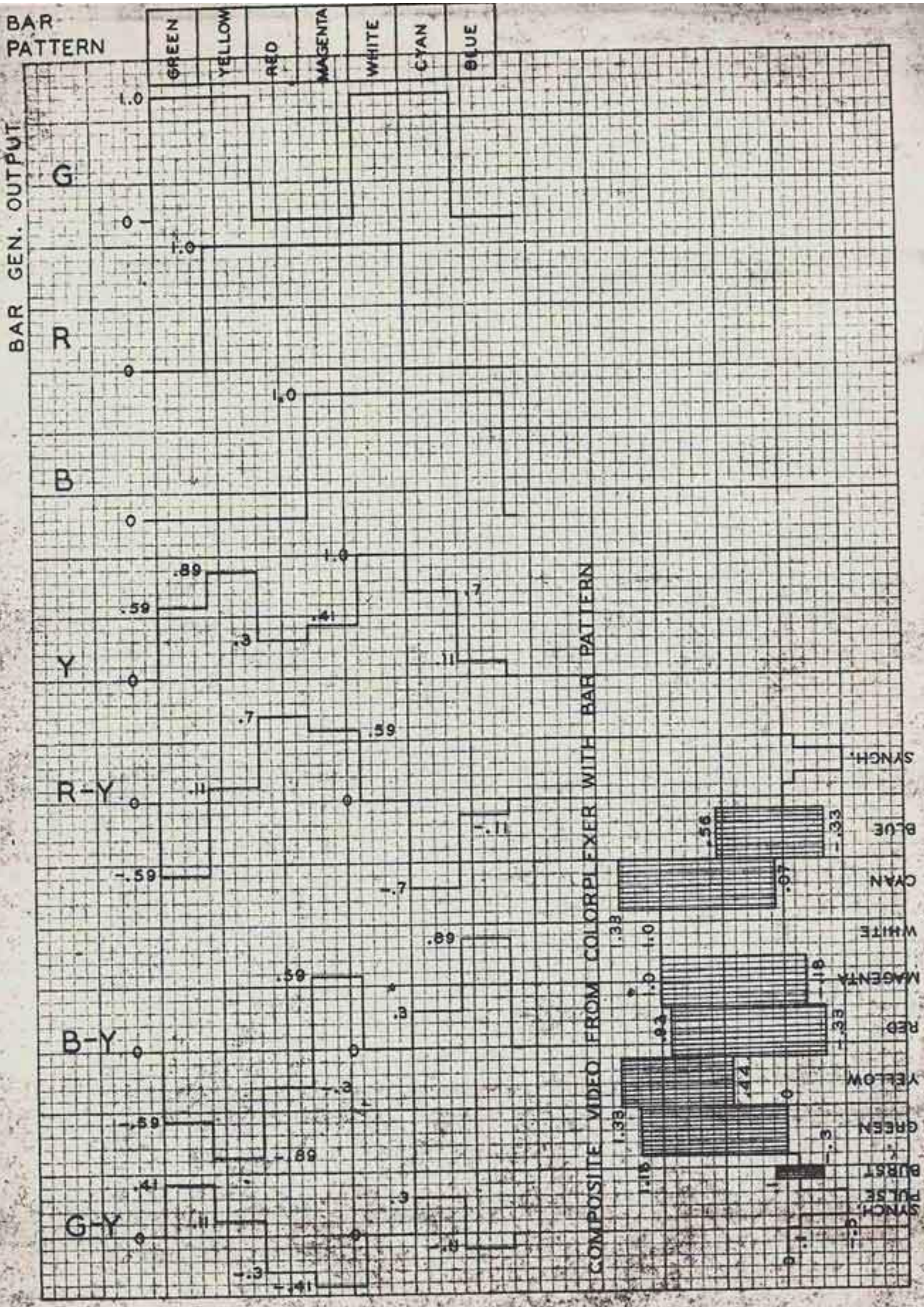
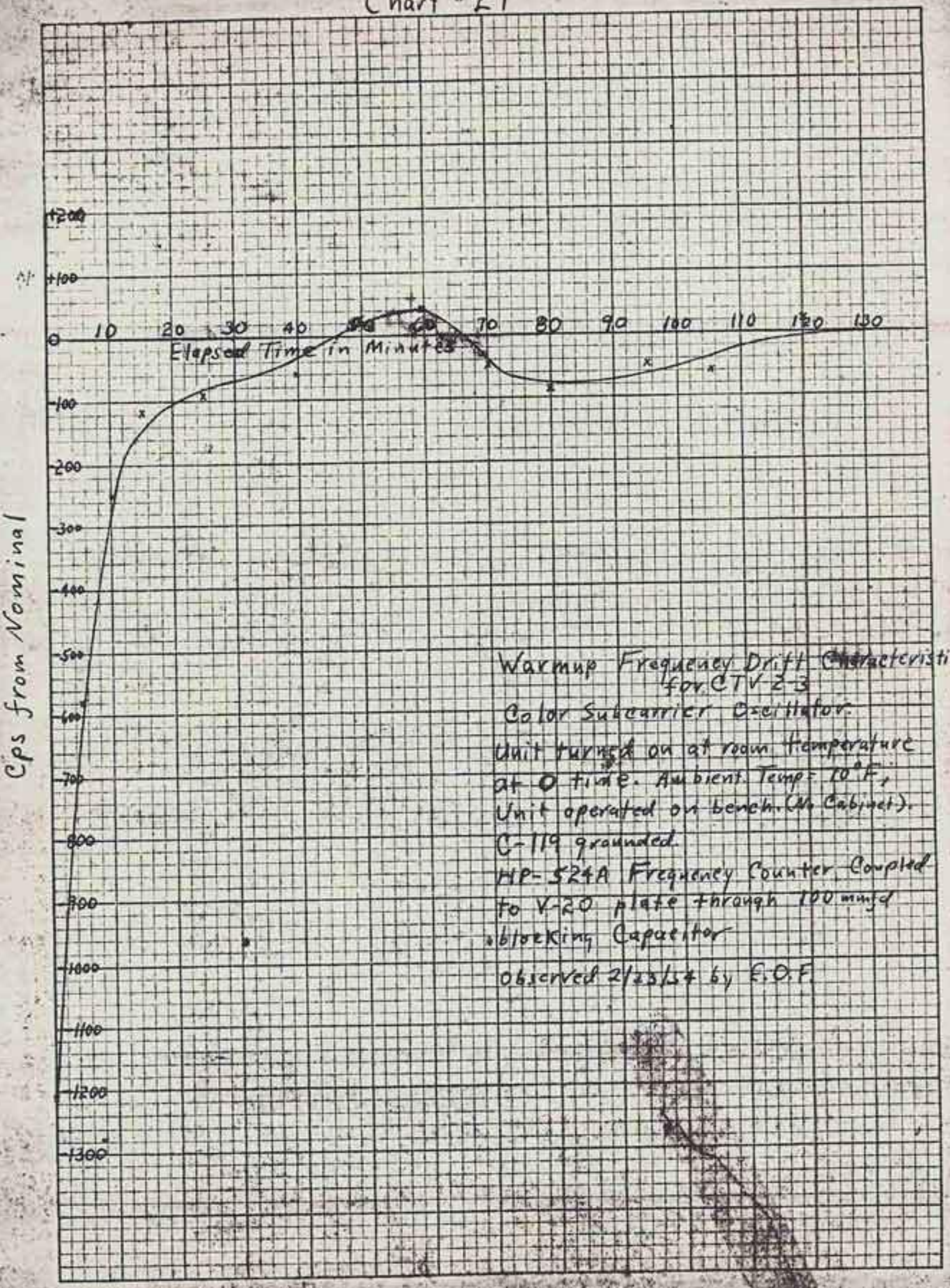

BAR PATTERN
GREEN
YELLOW
RED
MAGENTA
WHITE
CYAN
BLUE
BAR GEN. OUTPUT
G
1.0
0
R
1.0
0
B
1.0
0
Y
.89
.59
1.0
.41
.3
.7
.11
0
R-Y
.7
.59
.11
-.59
-.7
-.11
0
B-Y
.59
.89
.3
-.3
-.59
-.89
0
G-Y
.41
.11
.3
-.3
-.41
-.6
0
COMPOSITE VIDEO FROM COLORPLEXER WITH BAR PATTERN
SYNCH.
BLUE
CYAN
WHITE
MAGENTA
RED
YELLOW
GREEN
BURST
SYNCH. PULSE
.56
-.33
.07
1.33
1.0
-.18
.93
-.33
.44
0
1.33
1.18
-.3
.1
0
.1
-.3

Chart #21



Warmup Frequency Drift Characteristic for CTV-2-3

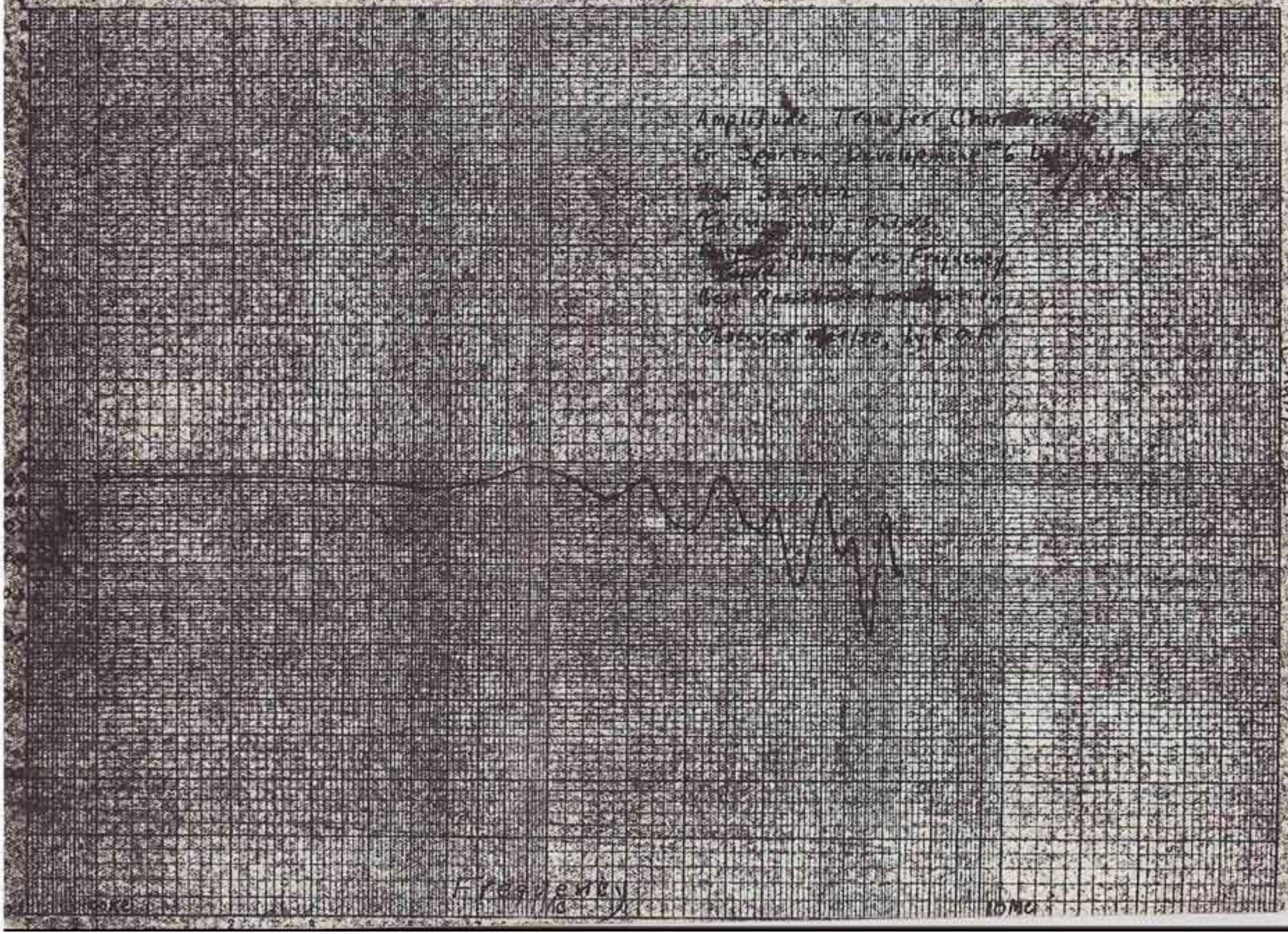
Color Subcarrier Oscillator.

Unit turned on at room temperature at 0 time. Ambient Temp = 70°F, Unit operated on bench. (No Cabinet). C-119 grounded.

HP-524A Frequency Counter Coupled to V-20 plate through 100 mmfd blocking Capacitor

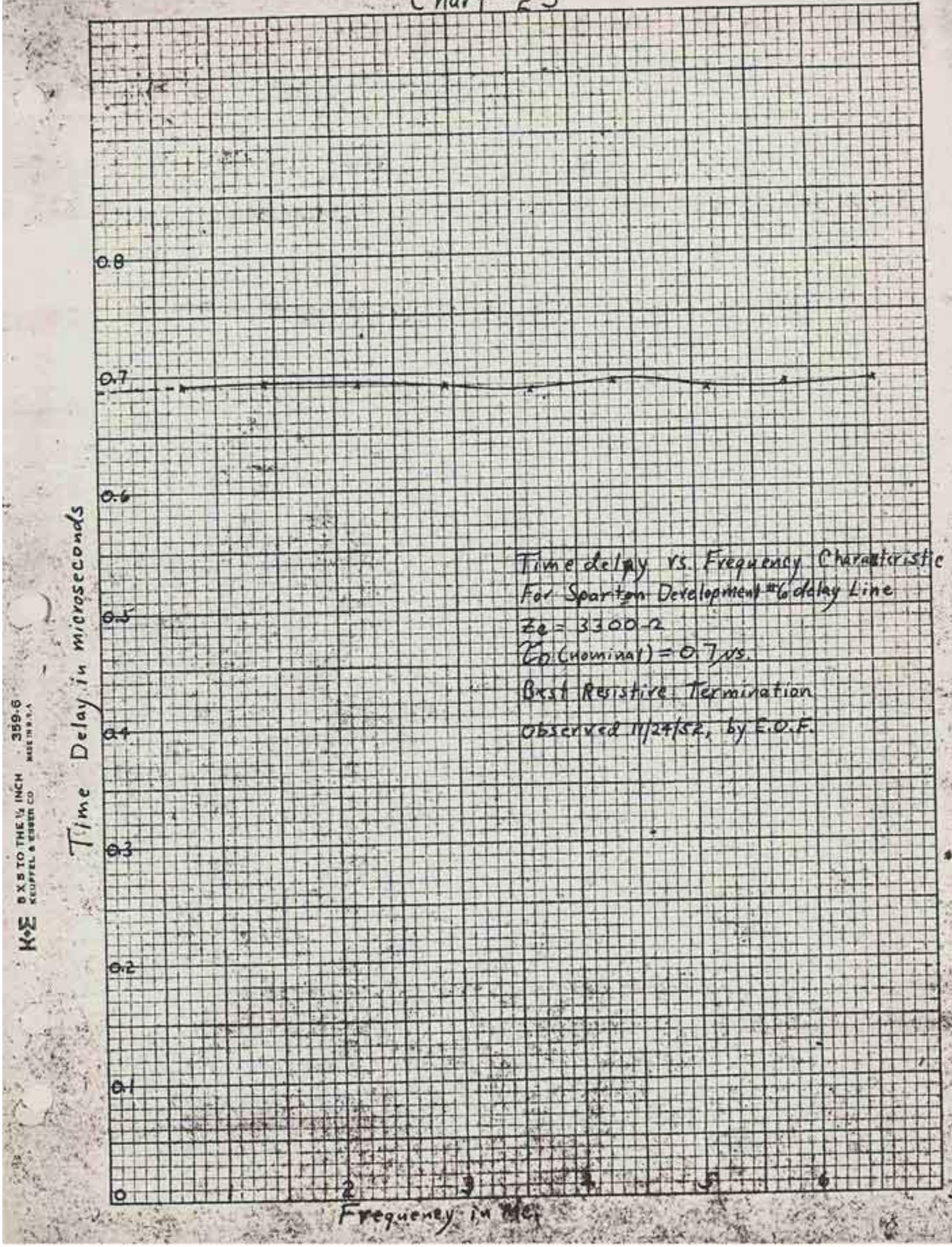
observed 2/23/54 by E.O.F

Chart #22



Amplitude Transfer Characteristic
of Sparton Development #6 Delay Line
[illegible] 3.0 [illegible]
Z₀ ([illegible]) = [illegible]
[illegible] Phase vs. Frequency
Base Resistance [illegible]
Observed [illegible]/58, by K.C.R.

Chart #23



Time delay vs. Frequency Characteristic
For Sparton Development #6 delay Line
$Z_e = 3300\,\Omega$
τ_0 (nominal) $= 0.7\,\mu s.$
Best Resistive Termination
observed 11/24/52, by E.O.F.

Courtesy of the estate of Dave Johnson