Ron Nott

GROUP 1

1-A; TELEVISION TESTS MEASUREMENTS MAINTENANCE

(TEXT)

INSTRUCTIONS FOR USING THE BROADCAST WORKSHOP LECTURES

When you receive the Reference Text "Television System Maintenance", look thru the Table of Contents and review in particular those points under the subjects you consider you need the most help. You MUST be thoroughly grounded in the contents of Section 1; "Standards For Picture Signal Analysis" which are stressed throughout the series. When particular Study Assignments are given in the Lecture, BE CERTAIN you understand ALL the subject matter covered.

Note that the Illustrations are filed in a separate Notebook from the text. The Figure Number discussed is always visible regardless of change in text page.

When you come to the self-checking Exercises at the end of each Lecture, cover the answers with a sheet of paper and try to solve the question on your own. If you can't, review the Lecture carefully. In a few cases, the Exercise actually covers an ADDITION to the Lecture material, but inclusive within the framework of the subject covered.

If you do not understand any particular discussion in either the Lecture material or Reference Text, WRITE YOUR INSTRUCTOR AS FOLLOWS:

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Please confine your questions to those concerning the Lectures or the Reference Text.

BEST WISHES.

(GROUP 1; TESTS, MEASUREMENTS, MAINTENANCE)

LECTURE ONE

GETTING SQUARED AWAY

Excuse the pun, but the title of this first Lecture DOES mean what it says in any way you take it. The square wave generator, one of the most slighted pieces of test gear by many stations, is the solid ground upon which your foundation is built. Your foundation is TEST EQUIPMENT and TECHNIQUES in general, with the scope as THE major item. The scope is STANDARDIZED with a square wave. Square wave response analysis can reveal chinks or weak points in your basic understanding of television systems as no other signal can, with the possible exception of the Sin^2 signal.

METHOD OF ATTACK

The method of attack is first to consider the "system" as being from the Switcher inputs to transmitter output, including pulses and pulse distribution. The "system" must be made relatively linear in amplitude and frequency response. It is THEN time to consider the various signal sources which must incorporate special non-linear devices (gamma and aperture correctors, etc) so that the source signal fed INTO the "system" is linear. This Group One Training follows this method of attack; the "system" will be "Color-proofed", then monochrome signal sources placed in top-notch performance condition. Color signal sources are "coming up" under your Supplemental Color Training.

The NUMBER ONE step is establishing the STANDARDS upon which your techniques of measurements are based.

Study Assignment: Reference Text; all of Section 1,
pp 7-26.

YOUR STANDARD PREFIXES

The slope of the curve is ever upward, and recent years have added new prefixes to the old list of standard prefixes. We will be using these where applicable in this Course. Table 1-1 lists the new ones along with some of the old ones

TABLE 1-1

PREFIX	DEFINITION	POWER OF TEN MULTIPLIER
pico	millionth of one millionth part	10^{-12}
micromicro	millionth of one millionth part	10^{-12}
atto	millionth of millionth of millionth part	10^{-18}
nano	thousandth of a millionth	10^{-9}
micro	millionth of one part	10^{-6}
milli	thousandth of one part	10^{-3}
centi	hundredth of one part	10^{-2}
deci	tenth of one part	10^{-1}
deka	ten	10^{1}
hecto	one hundred	10^{2}
kilo	one thousand	10^{3}
mega	one million	10^{6}
giga	one billion	10^{9}
tera	one trillion	10^{12}

EXERCISE 1-1: An oscilloscope amplifier is specified as having a rise time of 35 nanoseconds. What is the rise time in microseconds?

EXERCISE 1-2: With the rise time specified in Exercise 1-1, what is the frequency response (to the 3 db points) (A) in megacycles, and (B) in gigacycles?

EXERCISE 1-3: Aschematic shows a coupling capacitor of 470 picofarads (470 pF). What is the value in (A) microfarads (uf), and (B) micro-microfarads (uuf)?

THE SQUARE WAVE AND YOUR SCOPE

Now you will lose edge sharpness (increased rise time) even through wide band amplifiers. Take two identical 10 mc stages:

$$RT = \sqrt{0.035^2 + 0.035^2} = \sqrt{0.002450} = 0.049^+ \text{ or approx } 0.05 \text{ us.}$$

This indicates a 40% increase in rise time due to passing a signal through two identical 10 mc stages, of a complete video system.

The POINT OF EMPHASIS right at this time is two-fold:

1. To insure that the square wave generator and the scope are performing per specifications.

2. To establish the back-to-back response of the square wave generator and the scope. Thus when the generator is feeding the system and the scope is looking at the system output, the STANDARD has been established against which the measurement is made.

You have a Tektronix Type 105 Square Wave Generator with specification of 20 nanosecond rise time. You have a Tektronix 524 scope which is specified as having 35 nanosecond rise time. (Incidently, this means that the scope RESPONSE switch must be in the NORMAL position, NOT on IRE position). What rise time should you measure with this combination? (See Fig. 1-1). Set the pulse repetition rate at 100 kc.

$$RT = \sqrt{20^2 + 35^2} = \sqrt{1625} = 40^+ \text{ nanoseconds} = 0.04 \text{ us.}$$

Now if your square wave generator-scope combination meets this specification WITH NO MORE THAN 3% OVERSHOOT, you are certain that both units are in proper operating condition.

Assume you do not have overshoot but your measurement indicates a rise time somewhat over the "hair above" 0.04 us.; which is at fault, the generator or the scope?

The "long way" to go about this is to run complete sweep-response checks on the scope as described in your Study Assignment above. I will elaborate on this later.

There is a "short cut" method if your square wave generator is capable of putting out at least 15 volts (peak-to-peak) amplitude in 75 ohms. The Tektronix 105 is capable of doing this. NOTE: per specifications, it may be necessary to use a 93 ohm cable with 93 ohm termination. Although this is manufacturers specifications, all of these units I have used will reach a 15 volt amplitude in 75 ohms. You do not lose rise time UNLESS you go to a HIGHER impedance than 93 ohms.

See Fig 1-2. In this Exercise I am going to make a direct connection from the generator to the top vertical deflection plate of the CRO on the 524 scope, bypassing the vertical amplifier. The resulting vertical deflection sensitivity is approximately 15v/cm.

1. If you have the original test cable which comes with the Type 105, you have a short piece of 93 ohm cable with a UHF connector on one end and a 93 ohm termination on the

other, which incorporates banana jacks. Use this cable.

2. Remove the jumper Y2 from the rear panel of the scope. Place the V. Amp. Switch on EXT position. This capacity-couples (with an internal blocking capacitor) to the CRO top deflection plate, and throws 1 megohm resistors to the vertical amplifier to retain function of the vertical position controls.

3. If you do not have the test cable described in Step 1, make up a cable as shown in Fig 1-2.

The above procedure provides a low-capacity connection direct from your generator to the CRO. With the generator amplitude control maximum clockwise, you should get 1 centimeter deflection on the CRO. Expand the time base to 0.05 us/cm or greater. You can now measure the EXACT rise time, which for the Type 105, should be 0.02 us.

Regardless of the type of square wave generator you have, you can use the above procedure by correlating your manufacturers specifications with the above techniques.

If you follow this procedure, you know in which unit (generator or scope) trouble exists. The tektronix scope itself is checked and aligned with a square wave generator. If changing tubes (in whichever unit is at fault) and going through the manufacturers instructions fails to right the wrong, NEVER HESITATE TO CALL UPON THE MANUFACTURERS FIELD SERVICE. Broadcast-type test equipment is HIGHLY SPECIALIZED item. Remember that broadcasting is a FEDERALLY REGULATED SERVICE, and the FCC DOES NOT EXCUSE FAULTY TEST EQUIPMENT IN PROOF-OF-PERFORMANCE FAILURES. YOUR BASIC TEST EQUIPMENT MUST BE STANDARDIZED!

Before leaving the subject of the square wave generator, let's be sure you know how to properly connect this generator into the amplifier (or system) to be tested. This is just as much a part of STANDARDIZING your technique as the back-to-back test equipment checks.

See Fig 1-3. This is based upon data supplied by Tektronix for the type 105 generator. The peak-to-peak (p-p) voltage output shown is per their specifications and turns out to be the MINIMUM that you can expect. Whenever you feed long lines with a fast rise-time square wave, use the method of double-termination shown in (4) and (5) of Fig 1-3.

CONFIRMING YOUR SCOPE RESPONSE

The procedures outlined in your Reference Text, pp 14-15 are extremely important in proper frequency-calibration of your scope.

1. When you use the detector probe to look at the sweep generator output, YOU ARE CHECKING THE SWEEP GENERATOR FLATNESS. This, of course, does not give you any indication of the scope amplifier response.

2. Make your sweep generator output as flat as possible to avoid cumbersome calculations in plotting the actual scope response. The Tel-Instrument Corporation Type 1105 generator is very popular in station use. I have found that this generator can be made perfectly flat to 10 mc (as indicated by detected sweep) by following this procedure:

(A). Adjust the SWEEP OSC LEVEL and SWEEP OSC BIAS controls for flattest output possible.

(B). Trim with peaking coils L4, L6, L8, L10, L11.

(C). Adjust L2 for maximum output.

If you do not have this specific sweep generator, you may find similar adjustments in your unit. Always follow any specific instructions for your unit. If you cannot get a flat output, never hesitate to contact the Manufacturer with your problem.

3. When your sweep generator is checked (as in Fig 1-5, p 14 of Reference Text), observe the UNDETECTED sweep on your scope as per Fig 1-6, A&B, p 15 of the Reference Text. This will indicate the actual scope amplifier response for the NORMAL and FLAT positions of the RESPONSE selector switch. Remember that the NORMAL position, with its more gradual roll-off characteristics, is used for all "quality" checks involving transient response, while the FLAT position is used (for one example) to adjust your individual burst amplitudes on the keyed burst generator. Review all of Section 1 in your Reference Text thoroughly until you are sure you understand the entire subject of Standards of Measurement.

4. Now to confirm your scope frequency response curve, you must employ single-frequency runs over the spectrum concerned; normally out to 10 mc. In the above steps, you have measured the flatness of the sweep generator itself, and made an initial observation of the scope amplifier response in the NORMAL and FLAT positions. The use of single-frequency sine waves will now confirm your video sweep response from a different source; i.e. the sine-wave generator.

The purpose here is to assure yourself that the scope will show identical frequency and transient response (roll-off characteristic) REGARDLESS OF THE SLIGHT DIFFERENCE IN THE COMPLEX SOURCE IMPEDANCE OF VARIOUS TEST GENERATORS.

Incidently, if your sine-wave signal generator employs a 600-ohm internal impedance, you must make special provisions to feed the normal 75-ohm inputs of the station gear. For example, the Hewlitt-Packard Model 650-A Test Oscillator is such a device. Now this particular unit is provided with a "low-impedance" voltage divider cable which supplies the signal across a 6-ohm resistor, and a 75-ohm load can be fed from this with no effect on frequency or transient response. However, it is often desireable to obtain a 1 volt peak-to-peak signal for test purposes, and it is not possible to obtain this amplitude across 6 ohms. (From the particular generator discussed).

The best way to modify this type of generator for video use is shown by Fig 1-4. Note that the total resistance is 600 ohms; the UHF connector (which can be mounted on the front panel) is across 75 ohms of this total. THE UHF CONNECTOR MUST FEED A 75-OHM TERMINATION.

5. Now when you plot the frequency response of your scope from this source, YOU SHOULD END UP WITH A CURVE WHICH INDICATES LESS THAN 2% difference of the video sweep response indication. If this is NOT true, YOUR SYSTEM ADJUSTMENTS WILL NOT AGREE BETWEEN VARIOUS SIGNAL SOURCES.

In my next Lecture, I will continue with this problem and show you the techniques of tracing the source of this trouble.

<u>EXERCISE 1-4</u>: Two types of video sweep detector probes are shown by Fig 1-4, p 14 of your Reference Text. How can you check your particular detector probe without dis-assembly to trace the circuitry?

<u>EXERCISE 1-5</u>: Your detector probe has a 25% attenuation factor. You desire to feed a peak-to-peak video sweep signal of 0.5 volt amplitude to an amplifier input. What detected amplitude should you read?

<u>EXERCISE 1-6</u>: Why is correct frequency calibration of your Test Oscillator particularly important in the region from 4.1 to 4.2 mc?

LECTURE ONE EXERCISE SOLUTIONS

1-1: One nanosecond under the old terminology would be called one milli-microsecond, or a thousandth of a microsecond. Therefore to convert nanoseconds to microseconds you divide by 1000. So 35 ns = 0.035 us.

1-2: (A) 10 mc. (Review Reference Text, pp 9-10, and Table 1-1).

(B) Since one gigacycle is a thousand megacycles, to convert from megacycles to gigacycles you divide by 1000. So 10 mc = 0.01 gigacycle..

1-3: A picofarad (pF) is simply an easier way to say a micro-microfarad (uuF).
(A): 470 pF = 0.00047 uF
(B): 470 pF = 470 uuF

1-4: You don't really care about the circuitry. The important thing to know is the attenuation of the detector probe. Observe the output of your video sweep generator wideband (UN-DETECTED) and adjust the generator amplitude to give you a convenient p-p signal, such as 1 volt. Use the 1 mc marker amplitude point. THEN install the detector probe on the scope without changing either the amplitude of the signal or the scope calibration, and read the p-p DETECTED signal at the 1 mc point. The amplitude will now normally be between 0.5 and 0.75 volts p-p with a 1 volt signal.

1-5: You should adjust your video sweep generator amplitude control to obtain 0.75 X 0.5 = 0.375 volts peak-to-peak.

1-6: Suppose this signal is being measured at the transmitter output. If your Test Osc frequency dial indicates 4.18 mc., but the actual frequency is 4.25 mc., the sharp roll-off above 4.18 mc will tell you that the proper FCC color specifications are NOT MET. This can cause the transmitter operator to attempt re-tuning, etc, WHICH IS ACTUALLY NOT REQUIRED, due to faulty calibration of the Test Oscillator.

LECTURE TWO

AFTER THIS ONE, YOU'RE READY FOR MEASUREMENTS

I will pick up in this session the problem of ASSURING that your scope doesn't care what the signal source is. It will give you essentially the same answer whether you use video sweep or single-frequency sine wave spot checks, as one example.

The input attenuator on your Tektronix 524 scope is a compensated network so that the input time constant is made equal for all positions of the VOLTS/CM switch to get the same frequency and transient response. There is also a small trimmer capacitor in later models (524AD) directly across INPUT #1, but none across INPUT #2.

See Fig. 2-1. Let C2 represent the stray capacitance across INPUT #2, which has a longer run to the input attenuator than does INPUT #1. The small trimmer across the number one input is adjusted in practice to equal C2. This is done as follows:

1. With the input selector set on number 2 position, and with the 10/1 attenuator probe connected to this input, (VOLTS/CM switch on 0.15-0.5 position), connect the probe to the terminated output of a fast rise-time square wave generator. Adjust the 10/1 probe compensating trimmer to get a flat top without overshoot, scope response switch set on NORMAL position.

2. Step 1 has correctly compensated the probe. Now connect this probe to INPUT #1 and set the selector switch to the number one position. Looking at the same square wave with the standardized probe, adjust the trimmer across INPUT #1 in the scope to get the same correct square wave response.

Actually the input capacity represented by C2 and matched by C1 serves as "swamping capacity" in conjunction with the compensating trimmers and resistors for each position of the input attenuator (VOLTS/CM switch). If your R-C networks are not correct, as could happen if any of the resistors should change value for any reason, the sending - end complex impedance will CONSIDERABLY influence what your scope tells you. For example, if your square wave transient response is different for different settings of the VOLTS/CM switch, the compensating circuits are definitely in need of adjustment. Follow your specific Instruction Manual religiously in the "front end" alignment.

However, IT IS POSSIBLE that you can arrive at what seems to be correct input attenuator compensation, and still not get close correlation between scope response as indicated by videc sweep, and that which is indicated by single-frequency sine-wave in the video spectrum (to 10 mc). This can be caused by either one or both of the following:

1. One or more resistors in the input attenuator may have changed just enough that adjustment of associated trimmers in the network for that particular position of the attenuator will appear to properly pass the square wave, but the R-C ratio is not optimum. This is usually indicated if it is necessary to REMOVE the small trimmer (usually 0.7 - 3 pF) across INPUT #1 to "match" INPUT #2; or conversely, if more capacity is needed across this trimmer.

2. The output level METER on the sine-wave generator may not be "flat" across the video spectrum to 10 mc.

Now very few stations own a wideband VTVM with known response to 10 mc with which to check the internal Output Level Meter of a signal generator. Actually, you don't need one. Fig. 2-2 shows the schematic of the conventional R.F. detector probe for use with VTVM's of 10 megohm input resistance. If you don't already have a commercial detector probe for your VTVM, build this one. It will extend the response of your meter to well over that required for the video spectrum of 10 or 20 mc. Use it as follows:

(A). Plug your regular VTVM probe into the tip jack of the detector probe, and set the probe AC-OHMS/DC switch to AC position. This bypasses the 1 meg resistor in the VTVM probe which is normally in series with the 10 meg input resistance of the meter, and gives you a "direct connection" to the VTVM. If desired, you can make the detector probe an entirely separate item.

(B). Set the VTVM meter switch to the -DC position. Connect the detector probe to the terminated output of your sine-wave generator.

(C). Adjust your signal generator amplitude to get 0.25 volts on the VTVM, with a frequency of 200 kc reference. Note the setting of the Output Level Meter on the generator. Now repeat this procedure at spot frequencies (those you will use, for example, on Proof-of-Performance runs), adjusting the generator amplitude (if necessary) to maintain the 0.25 volts. Compare this to the Output Level Meter reading at each frequency, and record any difference in reading. This is your correction factor to use when feeding equipment on tests.

(D). For example, if the generator meter is -0.5 db at 5 mc relative to the reference frequency "zero" db., then you know that at 5 mc, you must set the generator amplitude this 0.5 db lower than you did at 200 kc, to maintain the same actual output level.

(E). This also holds true when running the scope response with the spot-frequency sine waves to compare with the video sweep indication of response. NEVER TRY TO HAVE THE SCOPE CONNECTED TO THE GENERATOR OUTPUT AT THE SAME TIME AS THE VTVM, since the added capacity of the VTVM arrangement will upset scope response. ALWAYS calibrate the generator meter first. If your signal generator does not have an internal meter, you must set your level with the VTVM first for each frequency, then feed the scope and remove the meter. Generators which employ the built-in Output Level Meter isolate the meter from the output terminals by means of a known attenuator pad.

(F). If your generator has a means of calibrating the frequency response of the Output Level Meter, by all means follow your Instruction Manual and get it done. This will contribute immensely to your confidence in measurements when you have proven that the meter response MEANS WHAT IT SAYS, and it obviously is a great time-saver over the necessity to correlate correction factors.

Remember that the VTVM reading is in RMS volts. To get the peak-to-peak value, you multiply the RMS reading by 2.828; thus the 0.25 volts I used in the above procedure results in an actual p-p value of 0.7 volt. Conversely, to get the RMS value of a p-p voltage, you multiply the p-p reading by the reciprocal of 2.828, which is 0.3535.

When you get your scope and test generators standardized as we have been doing thus far, your scope will indicate to you a reliable story of system performance regardless of the signal source. You're ready for tests without the many pitfalls that so often occur due to lack of attention to these EXTREMELY IMPORTANT and NECESSARY details.

YOU WILL NEED VIDEO PADS

Video pads are a necessity in television system maintenance. You will note from Fig. 1-3 (Lecture One) that the Tektronix square wave generator does not go to zero output even with the Output Amplitude control in the maximum CCW position. For example, feeding a 75-ohm termination allows a MINIMUM amplitude of around 0.8 volt p-p. In addition to this, it is often desireable to feed a test signal into a low-level input such as a pickup tube preamp at a fairly precise p-p level, which is too low to measure on the scope.

You will find it VERY HELPFUL to build up a series of video pads customed to your individual needs. Now I could review the necessary formulas for pad design with you, but in line with keeping these Lectures on a PRACTICAL basis, I give you a TABLE OF VALUES along with the design computation of Fig. 2-3. When you construct a pad for video, the use of the "Pi" configuration will result in minimum capacitive effects (across 50 or 75 ohms) and optimum frequency response. Use a small metal box with coax connectors on each end. This shielding is very important for low-level signal insertion to the input of the unit or system to be checked. Space the resistors at least 1 inch from the metal box.

Assume you want to feed a test signal to the input of a camera control unit with a 0.1 volt p-p amplitude. Since this input is normally fed via the camera cable, its terminating impedance is 50 ohms. If you want to use a 1 volt p-p test signal and pad this down to 0.1 volt, your voltage ratio is 10 to 1 which is 20 db. Observe your TABLE and Fig. 2-3. You know that Z = 50 ohms. Then:

From Fig. 2-3, R1 = Z/A, or 50 divided by 0.818 (The 0.818 is found from the TABLE under column "A" for 20 db).

Thus R1 = 50/0.818 = 61.1 ohms
... and R2 = Z/B = 50/0.202 = 247 ohms

In practice, you use the nearest EIA values to the computed values. Thus you would need two 62 ohm (5%) resistors for the shunt arms, and a 240 ohm (5%) resistor for the series arm. Use ½ watt composition (non-inductive) type.

<u>EXERCISE 2-1</u>: You are observing the direct output of your terminated square-wave generator with your scope. What is the significance of waveforms (A) and (B), Fig. 2-4?

<u>EXERCISE 2-2</u>: What is the significance of waveform (C), Fig. 2-4? Define (a) to (d); (b) to (d); and (a) to (c).

<u>EXERCISE 2-3</u>: The detected output of your sweep generator direct is as shown by (A), Fig. 2-5. This is as flat as you can get it. The detected output of your equipment is shown by (B). What is the actual response (relative to 1 mc reference) at 5 mc? At 10 mc?

<u>EXERCISE 2-4</u>: You need to feed an 0.01 volt (p-p) test signal into a low level input of 75 ohms. You will adjust your test signal generator to a 1 volt (p-p) output. Design the necessary pad for doing this.

SOLUTIONS TO EXERCISES:

EXERCISE 2-1: Waveforms (A) and (B) or Fig. 2-4 show entirely different stories as covered in Section 1 of your Reference Text. The overshoot of (A) is caused either by an over-compensated scope probe, or by too-rapid cutoff in the scope amplifier. Waveform (B), since the overshoot is a considerable portion of the pulse duration, indicates "cathode interface" of a tube or tubes in the scope amplifier. When you see this, follow the instructions given on pages 16 and 17 of your Reference Text.

EXERCISE 2-2: Waveform (C) or Fig. 2-4 indicates "tilt" due to insufficient low-frequency response. (a) to (d) is the total peak-to-peak excursion of the square wave, which is greater than the original amplitude due to the resultant phase distortion. (b) to (d), or (a) to (c) is the actual amplitude of the UNDISTORTED pulse.

EXERCISE 2-3: You have adjusted your gain to place the 1 mc reference point at 5 major divisions which is 100%. Each major division is, then, 20%, and each minor division 10%. You have a 10% "hump" at 5 mc in your generator. You are reading -15% at 5 mc at your equipment output. Therefore your actual equipment response at 5 mc is -25%, or about 2.5 db down.

At 10 mc, your generator is 20% down. Your equipment response at 10 mc is down 40% from reference. Since the input was already 20% low, actual equipment response is -20% at 10 mc, or about 2 db down. Actual equipment response is therefore a half-db greater at 10 mc than at 5 mc.

EXERCISE 2-4: See your Table of Values and Fig. 2-3. You can see you will need a 40 db pad. Then:

R1 = Z/A = 75/0.98 = 75.6 ohms. (Use 75 ohm resistors).
R2 = Z/B = 75/0.02 = 3750 ohms. (Use a 3600 ohm resistor).

LECTURE THREE

LOW FREQUENCY RESPONSE MEASUREMENTS

In this lecture I will discuss all the facets of low frequency - phase measurements pertaining to the "system" as apart from signal sources (camera chains, etc.) which are covered later. We will consider also any characteristic that might "look like" a low-frequency problem but is actually something else.

STUDY ASSIGNMENT: The portions of your Reference Text which concern the points of discussion are: pp 138-149; 162-168; 181-192 and 193-208. Study these pages.

THE PULSE SYSTEM

The television system is a pulse system. Picture information is contained in the fundamental and harmonics of the 60-cycle field frequency and the 15,750 cycle line scanning frequency. If the system frequency-phase response is GOOD on pulses at these repetition rates and over the time-durations employed, it is capable of handling a GOOD picture. If the system has a POOR pulse response, it will degrade a GOOD picture to a POOR picture.

NOTE: Video monitor presentations are included in the Reference Text as guides only. You cannot trust ANY picture monitor to give you a proper test (except as a comparison between portions of a complete system or various signal sources) UNLESS its own amplifier and picture tube characteristics are definitely known as apart from the system checked. Therefore we will concern ourselves with the properly STANDARDIZED scope analysis of signals.

See Fig 3-1. The rise and decay times of a pulse depend upon high-frequency response and shape of the passband response curve and this is covered in future lectures. We are concerned now with the duration response (t_d) which depends upon t/RC, or time divided by the RC product. This, of course, is the low-frequency characteristic in practice.

The output voltage as a function of t/RC is shown by Fig 3-2. At the instant the pulse is applied (t=0) the output voltage is 1 times the input voltage or unity. As t increases, the factor t/RC increases and the output voltage decreases until at t/RC=1, the output voltage drops to 0.37 of the applied voltage. This is basic theory which you can see on any Universal Time-Constant Chart for RC or RL circuits in any basic text.

Since the pulse durations required in a TV system are known, it is most convenient to use the reciprocal of the above relationship in thinking of practical RC coupled circuits. Fig 3-3 plots the output voltage of a pulse in relation to the RC/t_d ratio. Note that it is necessary to have an RC product of 10 times the pulse duration (t_d) to avoid more than a 10% "tilt" over the duration of the pulse. It is obvious that the time constant problem becomes severe in any practical circuit when the duration of the field frequency is 16,666 us. (The reciprocal of 1/60th of a second).

To find the time constant (TC):

TC=seconds when R is in ohms and C is in farads
or: R is in megohms and C is in uF

TC=microseconds (us) when R is in ohms and C is in uF
or: R is in megohms and C is in pF

The second relationship above (us) is most useful for TV circuits.

For example, a 0.1 mfd coupling capacitor to a 1 megohm grid resistor results in a TC=100,000 us. You can see that this is not 10 times the value of the field duration. The TC value in practical circuits is limited by the stability factor (motorboating, large capacities to ground, etc.) and is the reason why either negative feedback to flatten the lows (as well as the highs) is used, or the "low-frequency boost" circuit (such as Fig 5-6, p 144 of the Reference Text) is employed. In amplifiers incorporating clamping circuits, the low-frequency characteristics are almost entirely dependent upon proper operation of the clamp pulse former and clamping circuit.

SINE WAVE RESPONSE VS PULSE RESPONSE

See Fig 3-4. This cathode-follower circuit has a sine wave frequency response that is only 3 db down (relative to 1 mc) at 5 cycles-per-second. But the time constant (in us) of this circuit is for all practical purposes 1000 X 12=12,000 us. This is a RC/t_d ratio of less than 1 for the field duration in a television signal.

Some of you may recognize this circuit. It is the CF-500 probe for the Tektronix 524 scope. Since capacitive loading of the circuit by the probe must be minimized, a small coupling capacitor must be used. The value of this probe lies in medium and high-frequency circuit checks without sacrificing gain such as results from a 10-1 capacity-divider probe. It is not intended to be used where low frequency duration checks are important. This is emphasized in Section 1 of your Reference Text.

This example is also intended to form a sharp demarcation line in your mind between the practical application of sine wave tests and pulse tests. For low frequency checks (fundamental and harmonics of the field frequency to about 900 cps) sinewaves are used only in unusual circumstances that will be considered in their proper place.

TERMINOLOGY IN LOW FREQUENCY PROBLEMS

It is actually very difficult to consider one end of the video passband at a time; viz low frequency or high frequency. This is because impairments are usually first noticed on a picture monitor, and the frequency-phase response must be adequate across the ENTIRE passband to obtain a good picture on a good monitor.

Is it "smear," or is it "streaking?" You can't always tell on a video monitor! Let's take the AT&T definitions below and try to tell the difference on a typical monitor:

SMEAR: A term used to describe a picture condition in which objects appear to be extended horizontally beyond their normal boundaries in a blurred or "smeared" manner.

STREAKING: A term used to describe a picture condition in which objects appear to be extended horizontally beyond their normal boundaries. This will be more apparent at vertical edges of objects when there is a large transition from black to white or white to black. The change in luminance is carried beyond the transition, and may be either negative or positive. For example, if the tonal degradation is an opposite shade to the original figure, (white following black), the streaking is called negative; however, if the shade is the same as the original figure, (white following white), the streaking is called positive. Streaking is usually expressed as short, medium or long streaking. Long streaking may extend to the right edge of the picture, and in extreme cases of low-frequency distortion, can extend over a whole line interval.

Now as far as the picture monitor is concerned, there can be little difference between "short streaking" and "smearing." But your CRO will show you the difference. In general, you must realize that "smearing" is caused by a loss in the middle-to-high frequency range, while "streaking" is caused by an impairment in the middle-to-low frequency spectrum. The "longer" the streaking, the lower is the frequency impairment.

INTERPRETING LOW FREQUENCY IMPAIRMENTS

Low frequency problems manifest themselves as follows:

1. Bad picture shading from top to bottom of the raster.
2. Loss of setup.

3. More-than-normal picture "bounce" on drastic scenic changes. (This can also be caused by phase-shift at the higher frequencies.)
4. Streaking. This is the most noticeable impairment. It will be found in practice to be a severe phase distortion below 200 kc down to 60 cps. In amplifiers employing PROPERLY OPERATING clamping circuits, the fault will lie in the spectrum from 15,750 cps to 200 kc.

On amplifiers not employing clampers (such as most distribution amps) run the 60-cycle square wave measurement for tilt. (Page 166 of your Reference Text) Remember that tilt indicates phase shift of the harmonics of the pulse fundamental frequency. Always compare the measured tilt to the manufacturers specifications. If this is exceeded, you have either a coupling-circuit time constant problem or, in negative feedback amplifiers, a reduction of feedback or a feedback phasing problem.

In such amplifiers, always measure the maximum gain you can get. If, for example, the specs say a gain of 2/1 is normal and you measure 4/1 gain, it is more than likely you have a changed component in the feedback path. Usually such troubles will not manifest themselves as high frequency impairments, since the associated peaking circuits are normally capable of bringing the higher frequencies within specifications. But you will find low-frequency square wave tilt to be out of specs. This may also show up as tilt on a square wave with a fundamental frequency at the line scanning rate of 15.75 kc.

I should point out here that "streaking" is more apt to take place in the camera chain itself as will be discussed in future lectures. At the moment, we are concerned with the case where the camera control monitor shows a "clean" picture, but you are ending up with an impaired picture thru the distribution system and/or the transmitter.

Most common in distribution systems and transmitters is the loss of low frequency gain with attendant phase shift that is not so severe as to cause streaking, but will reduce setup and also cause "short streaking" almost to the point of being interpreted as "smear." In case of clamping problems, severe streaking will occur.

Your CRO can tell you immediately whether the problem is one of clamping or simple low frequency gain loss. See Fig 3-5. Compare (A) of Fig 3-5 with (B) and (C) of Fig 5-32, p 168 in your Reference Text. The waveform in your Reference Text was NOT the result of clamping problems. Remember that the coupling capacitor into the clamped grid is a very small value, since it must charge and discharge quickly in the few microseconds of the clamp conduction interval. The clamper restores the

DC component by bringing this capacitor to a reference potential by the start of each scanning line. Obviously if clamping fails, you end up with a very short time constant, and severe phase shift below about 200 kc.

Partial clamping failure such as indicated by (B) of Fig 3-5 can be caused in a stabilizing amplifier or the transmitter by insufficient composite video input level, by excessive low frequency tilt (more than 10%) at the input, by faulty solder connections or clamp driver (pulse former) transformers which can cause "rounded off" pulses to be fed to the clamp diodes. Complete clamping failure almost invariably adds a slight sine wave to the top of the horizontal-rate CRO display as in (A). The horizontal-rate display under partial clamping failure reveals thickened pulse tips and bases as in (C), with visible retrace on the blacker-than-black region. Note that all of these impairments are absent in the photos in your Reference Text, which was not caused by clamping problems.

In case of suspected clamping problems, always check the clamp pulses themselves at the plate and cathode of the diode being driven by the pulses. (See Fig 5-52 on p 188 of your Reference Text.) In some circuits, the pulses are particularly critical in rise and fall times and the shape of the pulse tops. Any difference in rise and fall times between the two 180-degree polarity pulses can sometimes result in spikes appearing at the clamped grid. A marked difference in pulse top shapes will appear as a signal voltage at the clamped grid. In practice, A SIGNIFICANT DIFFERENCE IN AMPLITUDE can exist between the pulses <u>without</u> causing trouble. This is true up to the point where <u>the amplitude</u> IS NOT SUFFICIENT to drive the diode into conduction. As a rule-of-thumb, the clamping pulses are at least 4-times the amplitude of the video signal amplitude at the clamped grid.

(E) and (F) of Fig 3-5 shows you how your CRO distinguishes between "smear" and the lower-frequency impairments discussed above. Note the rounding off of the pulses in (E). Now note also that the vertical-rate display of (F) reveals a "displacement of porches" very similar to that of clamping troubles. However, an expanded time base on the vertical interval will NOT show the drastic downward slopes on the pulses as occurs with clamping difficulties. The base of the pulses may actually show an UPWARD tilt, indicating EXCESSIVE low frequency gain.

The multi-burst test signal will also reveal immediately whether the problem is "smear" or a tendency to "streaking." See (G) of Fig 3-5. The waveform on the left reveals loss of low frequency gain by the reduced setup and the tilt on the white-reference pulse and sync tips. Note that if the problem was in the middle-to-high frequency range, the sine wave bursts would not be of equal amplitude, but might look as in (A) of Fig 5-39, p 172 of your Reference Text.

The waveform at the right of (G) indicates excessive low frequency gain. Again, the telltale points are the shape of the white reference pulse and sync tips. You don't need to know what the original setup level was to know that an increase has occurred. Remember that if you don't have the test signals mentioned here, you can similate them with the square wave set to the proper fundamental frequency. If you don't have a keyer, build the one on page 161 (Fig 5-22) of your Reference Text. It's very inexpensive.

Now we have arrived at the point where it is convenient to consider that a change in setup level can occur from other than low frequency loss or gain. It can occur from compression or clipping, as you studied in the Reference Text. It can also be caused by incorrect adjustment of a transient suppressor (clipper) circuit, or by the sync-strip adjustment in a stabilizing amplifier.

For example, the RCA TA-9 Stabilizing Amplifier separates sync and completely reforms the pulses to eliminate hum and noise degradation. A sync clipper eliminates any vestige of the old sync from the luminance amplifier. The clipper is supposed to be adjusted so that the blanking base line is perfectly flat, and the reformed sync is added in a later stage. If this clipper is turned just a bit too far, setup level is reduced a measurable amount. In fact, with proper adjustment for this particular amplifier, a very slight RISE occurs on the back porch in the region of the color burst. THIS IS NORMAL. If you adjust the clipper to flatten this slight rise, you will find you have cut into the setup level.

Let me illustrate the importance of proper adjustments as distinguished from actual circuit troubles. A new station which had just taken the air experienced a problem of pictures looking "black." This is to say that when the home receiver was adjusted in contrast and brightness to get a good picture from the other local stations, the new station's pictures were "dark." Film chains looked worse in this respect than live cameras. Here is what was found:

1. A stairstep signal with ten steps was fed into one film camera control unit. At the transmitter output, the first step (in the black region) was completely missing.

2. A check at the studio line output also showed the step missing. A transient suppressor adjustment on the control unit was found to be misadjusted and causing complete loss of the first step.

3. When this was restored to normal, the transmitter reported the step visible but only 2% setup level. The studio line output showed 7.5% setup. A check of the stabilizing amplifier at the transmitter

showed normal setup at the input, but only 2% at the output. You guessed it, the clipper circuit in this unit was over-adjusted.

Whenever you run into compression in any unit not employing such adjustments, check that the input level is not excessive, then check the voltages down thru the amplifier. The compression occurs either from excessive levels, low plate voltages or improper biasing, assuming the tubes and/or transistors are good. To tell the difference between loss of low frequency gain and compression (or clipping) in tracking down loss of setup problems, use the variable APL feature of your stairstep generator. (Section 6 of your Reference Text) An actual loss of low-frequency gain is not affected by varying the APL, but compression will normally be revealed by this procedure. This is true because your video amplifier will need to handle the maximum possible peak-to-peak signal excursions as the APL is varied from 10% to 90%. See Fig 6-2, page 197 of your Reference Text.

A fault which may "look like" a low frequency impairment is illustrated by the waveform of (H), Fig 3-5. Note the "notch" in the sync tip trace, and the leading-edge effect on the window signal. This type of window signal reproduction is the result of improper termination of the line being tested. See pp 87-90 in your Reference Text for the most convenient way to check coaxial lines for irregularities or faulty terminations.

EXERCISE 3-1: What is meant by the term phase shift in a video amplifier?

EXERCISE 3-2: What is primarily responsible for phase shift at low frequencies in video amplifiers?

EXERCISE 3-3: Name five factors that would account for low frequency losses in a video amplifier.

EXERCISE 3-4: What detrimental effects can result from trying to employ a coupling capacitor of too large a value between video amplifier stages?

EXERCISE 3-5: Why should you carefully check the level of a 60-cycle square wave input to the unit or system being tested?

ANSWERS TO EXERCISES

3-1: Phase shift is the additional phase angle between the input and output signal voltages over and above the normal 180-degree phase reversal of the stage. This is expressed:

$$\text{Phase shift} = \theta - 180 \text{ degrees}$$

where θ is the total displacement between input and output voltages expressed in degrees. The low-frequency phase shift can be calculated directly from circuit constants as follows:

$$\emptyset = + \text{arc tan} \frac{X_c}{R_g}$$

where X_c is the capacitive reactance of the coupling condenser and R_g is the grid resistor of the following tube. The formula simply states that the phase shift is an arc whose tangent is the ratio of the capacitive reactance to the grid resistance. The plus sign indicates a leading phase shift; this is true because capacitive reactance causes the current to LEAD the applied voltage, causing a leading voltage to be developed across the grid resistor. It can be seen that the larger the capacitance, (less reactance) the smaller will be the resultant phase shift.

3-2: The coupling capacitance.

3-3: Low frequency degeneration in the cathode bias circuit; insufficient time constant (RC) in the coupling circuit; degenerative feedback through the power supply; changed components in negative feedback circuits; faulty clamping in clamp type amplifiers.

3-4: Increased stray capacitance to ground (detrimental to high frequencies) and tendency to "motorboat" at a low frequency.

3-5: If the 60-cycle square wave signal level is excessive, the resultant clipping or compression will remove the "tilt" and a "poor" response may look "good."

IMPORTANT NOTE: In employing the 60-cycle square wave, always take into consideration the "back-to-back" response of the generator and the scope as emphasized in Section 1 of your Reference Text. Use the DC scope position whenever possible.

In my next Lecture I will elaborate on this problem of low-frequency response, and consider how "streaking" can occur at the transmitter even when the clampers are functioning properly. I will also delve further into transient response analysis at both studios and transmitters.

NOTE: **Between now and the next Lecture, study as much of pp 138-192 in your Reference Text as time permits. The next Lecture will cover in more detailed manner the makeup of the Sin^2 pulse and its basic application.**

LECTURE FOUR

TRANSIENT RESPONSE ANALYSIS

A square wave is used to measure TRANSIENT response of the system; this means the leading and trailing edges of the vertical transitions, and the time-constant effect on the flat portion (dc component) of the square wave.

For a system to pass a pulse with the same rise time and shape as the input pulse, it must have a bandwidth of:

$$BW = \frac{1}{2\ RT}$$

This says the bandwidth must be equal to half the inverse of the rise time. For a pulse with RT = 0.02 us:

$$BW = \frac{1}{2(0.02)} = \frac{1}{0.04} = 25 \text{ megacycles.}$$

(Since the rise time is in microseconds, the result is in megacycles.)

Now immediately you should note that I have used a different relationship for conversion of rise time (RT) to bandwidth (BW) than in your Reference Text, pages 9, 10. The relationship in your text is based upon an assumption that "overshoot" will be "under 3%". This is where the "K Factor" enters, and says that the bandwidth is 0.35 divided by the rise time. For RT = 0.02 us, this calls for a bandwidth of 17.5 mc. The rise time will still not be materially affected, but a slight amount of overshoot will occur, on a rise time of 0.02 us.

The relationship which states that the bandwidth must be equal to half the inverse of the rise time, is based upon Fourier analysis. The Fourier theorem says that any recurring non-sinusoidal waveform can be shown to be made up of a sum of sine waves or cosine waves or both, of various amplitudes, phases and frequencies.

Fig. 4-1A illustrates a fundamental sine wave combined with its third harmonic. Note that the resultant shows a tendency to start formation of a square wave, by the steepening of the sides. (The "dip" in the center is filled-in by higher frequency harmonics.) As odd-order harmonics are added, this effect increases. A PERFECT SQUARE WAVE WOULD BE COMPOSED OF AN INFINITE NUMBER OF ODD HARMONICS. The amplitudes of the added harmonics varies inversely with frequency; thus the higher the harmonic frequency, the less its amplitude in relation to the fundamental. Now provided the bandwidth is adequate, these harmonics are retained in the original amplitude (and phase) relationship, and the pulse is passed without distortion.

Now to maintain the harmonics of the square wave in the same original timing as the fundamental component, THE PHASE SHIFT MUST BE PROPORTIONAL TO FREQUENCY. Be sure you understand this by:

STUDY ASSIGNMENT: pp 146-148, Reference Text.

Suppose the third harmonic of Fig. 4-1A suffers a different time-delay than its fundamental. See Fig. 4-1B. Note that this results in a square wave response similar to a "tilt" across the top with an undershoot at the trailing edge. The edges of an image will now be dispersed by an amount proportional to the phase shift of the harmonics making up the signal.

I want to consider now how "streaking" can occur at the transmitter even with properly operating clamp circuits. Remember this: the fundamental and harmonics of a given pulse frequency are translated to the envelope of the carriers' sideband frequencies under amplitude modulation. Observe (A) of Fig 8-20 (page 273) of your Reference Text. The pronounced "dips" in the envelope will cause severe low-frequency phase distortion, since this is the region of low frequency video content. It will be even more pronounced when detected by a receiver if an inequality of upper and lower sidebands immediately adjacent to the carrier occurs simultaneously with the above characteristic.

It is equally important that NO severe dips occur ANYWHERE in the envelope of the radiated carrier. Think of it this way: in practice, we must hold the frequency-phase response of the system under pretty tight control up to the 15th harmonic of the fundamental square wave frequency. We know that any "tilt" of a square wave (or more accurately a "rectangular" wave) with a fundamental frequency at the line-scanning rate of 15.75 kc will result in picture streaking. This means that, at the moment, we are concerned only with frequencies up to 15.75 X 15 = 236.25 kc., or roughly to about 240 kc. Any severe disturbance in the carrier frequencies 240 kc each side of the actual quiescent carrier frequency will cause trouble with streaking, particularly noticeable as long horizontal lines which follow vertical image movement. Severe undulations of the carrier envelope will also cause effects in the picture similar to "echos".

Now here is a catch. We have considered the REPETITION RATE, ignoring the DURATION of the pulse. For example, H sync pulses have a REPETITION RATE of 15.75 kc., with a DURATION of only 0.08H. To put this in terms of H time (the duration of a television line) we have 1/0.08 = 12.5 pulses.

But to be square waves of equal spacing there would be 12.5/2 = 6.25 POSITIVE PULSES per H time. Hence the FUNDAMENTAL FREQUENCY of the square wave is:

15,750 X 6.25 = 98,438 cps or close to 100 kc, to simulate a wave of the same duration as H sync.

And to consider up to the 15th harmonic, we discover that a frequency spectrum up to 1.5 mc can influence the transmission of a "square wave" at the frequency of 100 kc.

STUDY ASSIGNMENT: Reference Text, bottom of p 163 to middle of p 173.

Now to continue with our present consideration of "square wave" response relative to "pulse" response. My purpose in the preceding discussion was to point up the fact that the leading edge and trailing edge response of horizontal sync pulses may show a different story than that of a 15.75 kc square wave thru the system being tested, particularly with DIFFERENT RISE TIMES concerned. If you use a square wave with a fast rise time of, say, 0.02 us., it will indicate MORE OVERSHOOT AND UNDERSHOOT than the sync pulse which is normally a rise time of around 0.19 us or slightly better. I want to emphasize right here in your mind the DIFFERENCE between "square wave" testing and, for example, the WINDOW test signal. THE LEADING EDGE AND TRAILING EDGE RESPONSE (WHICH IS THE MEASUREMENT FOR TRANSIENT RESPONSE) DEPENDS ENTIRELY UPON THE RESPECTIVE RISE TIMES FOR A GIVEN BANDWIDTH SYSTEM BEING CHECKED. The DURATION RESPONSE (top of the pulse, or DC component) WILL BE THE SAME REGARDLESS OF RISE TIMES, FOR A GIVEN LOW FREQUENCY RESPONSE IN THE SYSTEM CHECKED.

Here is another way to look at it to clarify the point. If you use a "square wave" with a fundamental frequency of 15,750 cps, one complete cycle occurs in one line duration, which means half of the raster is black, the other half white. (Two picture elements in the duration of one line.) Thus the width of half of this cycle is a half-line, or about 27 us. (The active line interval is 63.5 us minus at least 10.5 us blanking time, or about 53 us.) Now the duration of the window signal is just about this same amount. Provided there is no difference in rise times between the square wave generator and the Window generator, transient response indications will be the same. BUT IN ANY CASE, ANY "TILT" EXISTING IN THE SYSTEM AT THE LINE SCANNING FREQUENCY WILL SHOW THE SAME FOR BOTH TEST SIGNALS. A pulse with the duration of a half-line that has as much as 2% tilt will be evident as streaking in the picture.

This problem of pulse rise times not being related to the actual picture transmission spectrum is the reason why, sooner or later, you will be concerned with the Sin^2 pulse for system testing. Right now, review USING THE WINDOW SIGNAL AND SIN^2 PULSE, pp 167-171 of your Reference Text.

This is very important, because in my next Lecture I am going to cover practical system and transmitter adjustments made on the basis of both the square wave and the SIN^2 - WINDOW signal. So at this point I want to be sure you understand the SIN^2 test signal.

The conventional tutorial method of explaining the sine-squared (Sin^2) pulse is shown by Fig. 4-2. In (A) you note the conventional continuous sinewave at a frequency of 4 mc so that one cycle occurs in a duration of 0.250 us. Now you realize from fundamental theory that any phase shift of a continuous sinewave is measured only by laborious methods not suitable for routine testing of transmission facilities. Also the amplitude-frequency characteristic of a system simply affects the amplitude of the continuous sinewave relative to a reference frequency, UNLESS you are equipped to measure the phase relative to a known reference.

Observe (B) of Fig. 4-2. If you shift 90° you have ONE COMPLETE CYCLE OF A 4 MC COSINE WAVE, STARTING AND FINISHING AT ITS NEGATIVE PEAKS. Now with an added DC component of such value as to raise the negative peaks to the zero power line, you have the T pulse of a 4 mc system. (Fig. 5-34, p 170 of your Reference Text.) As shown by (C) of Fig 4-2, the h.a.d is 0.125 us, equivalent to one picture element for a 4 mc bandwidth. Fig. 4-3 shows that the significant energy spectrum of the T pulse is 50% down (6 db) at 4 mc with practically no energy beyond 8 mc. The 2T pulse (h.a.d of 0.250 us) is 50% (6 db) down at 2 mc with no significant energy beyond 4 mc. Thus the system can be checked with a pulse that essentially duplicates actual picture conditions and which provides known frequency content upon which to base your judgement of system performance. Please note that any similarity to the sinewave no longer exists; a pure sinewave has no harmonic content at all.

Fig. 4-4 illustrates the fundamentals of measuring your Sin^2-Window signal, such as you might receive from your Network via AT&T. The amplitude-frequency and amplitude-phase response at "higher frequencies" (over about 100 kc) will be most evident in the measurement of the Sin^2 pulse. Amplitude-phase response is most evidenced by measurement of the Window signal. NOTE: some generators place the Sin^2 pulse FOLLOWING the window rather than preceding the window. This has no effect on your basic understanding of measurement principles.

BASIC RULE: Distortions at low frequencies produce waveform distortion with a long time-constant as, for example, streaking. This is most evident by Window measurement. Distortions at higher frequencies produce waveform distortions with shorter time-constants as, for example, smearing, loss of resolution, or "edge effects" from bad transient response. This is most evident by Sin^2 pulse measurement.

BASIC RULES FOR SIN^2 MEASUREMENT: High frequency roll-off results in loss of amplitude. Loss of amplitude results in a widening of the pulse, since the AREA of the pulse represents a CONSTANT DC COMPONENT. A SLOW ROLL-OFF within the video band produces LARGE REDUCTION in amplitude (and pulse width increase) with little or no ringing. A RAPID ROLL-OFF close to the top of the band but still within the video bandwidth desired produces both a REDUCTION (perhaps slight) in amplitude, and RINGING. A rapid roll-off (almost a cutoff) just above the video bandwidth concerned results in PRACTICALLY NO EFFECT ON AMPLITUDE, but does produce RINGING. The SHAPE of the roll-off and whether the resulting phase shift is LEADING or LAGGING is revealed by the distribution of ringing BEFORE and AFTER the pulse.

BASIC RULES FOR WINDOW MEASUREMENT: The window detects low-frequency distortion which has practically no effect on the Sin^2 pulse. The study assignment given in your Reference Text presents the fundamentals pretty thoroughly. The window shows undershoot, overshoot, and horizontal tilt depending upon the time-constant of the impairement. As shown by Fig. 4-4, the window when used with the Sin^2 pulse has the same rise times as the pulse so that no higher frequencies are introduced that are beyond the system test reference.

EXERCISE 4-1: What is the fundamental frequency of the 2T pulse for a 4 mc system?

EXERCISE 4-2: What is the repetition rate of the Sin^2 pulse?

EXERCISE 4-3: Assuming the Window Signal has the same rise time as the pulse, what is the rise time of the Window Signal associated with:

(A). a T pulse for a 4 mc system
(B). a T pulse for an 8 mc system
(C). a 2T pulse for a 4 mc system

EXERCISE 4-4: If amplitude-frequency and frequency-phase response is flat to the top of the passband, will any impairments ABOVE the useful passband of a TV system affect the Sin^2 pulse response?

EXPERCISE 4-5: Sometimes a Sin^2 pulse as received from the Networks is fed originated at 70% of the window amplitude instead of 100%. How can you tell if the Sin^2 pulse has actually lost amplitude via transmission facilities?

ANSWERS TO EXERCISES

4-1: Since you know that the fundamental frequency for a T pulse (one pix element) for a 4 mc system is 4 mc., the duration of two pix elements would be ½ the T frequency, or 2 mc., and would contain one-half the harmonic spectrum of the T pulse.

4-2: The repetition rate is the line scanning frequency, 15.75 kc.

4-3: The rise-time is measured between the 10% and 90% amplitude point to eliminate measurement of the curvature at either end of the pulse. Thus the rise-time closely approximates the 80% value of half of the Sin^2 pulse width, so:

(A). the h.a.d. is 0.125 us.
80% of 0.125 = 0.1 us.

(B). the h.a.d. is 0.063 us.
80% of 0.063 = 0.05 us.

(C). the h.a.d. is 0.250 us.
80% of 0.250 = 0.2 us.

4-4: YES, and this is desireable. A serious phase shift above the useful passband will cause phase distortion within the useful passband. If the pulse transmitted is a T pulse for a 4 mc system, the nature of the impairement between 4 and 8 mc will determine the resulting pulse response. The amplitude of the ringing at the base line is determined by the rate (steepness) of roll-off. A fairly rapid roll-off with phase equalizers incorporated to correct the resulting phase distortion will result in the ringing amplitudes being equally distributed preceding and succeeding the pulse. The degree and nature of the high-frequency phase distortion is measured by the departure from this optimum response characteristic. (More details next Lecture.)

4-5: Regardless of the amplitude of the pulse received, adjust your scope gain to obtain 0-100 IRE units, base to peak. Increase the time-base (sweep rate) to conveniently measure the 50 IRE pulse width. If the width is greater than 0.125 us (for a T pulse) then the amplitude has been reduced, indicating roll-off in amplitude-frequency response characteristics.

STUDY ASSIGNMENT between now and the Next Lecture: pp 231-286 of your Reference Text.

LECTURE FIVE

TRANSIENT RESPONSE ANALYSIS CONTINUED

STUDY ASSIGNMENT: All of Section 5 (Frequency and Transient Response) in your Reference Text. It is also assumed you have completed your previous Study Assignment on Transmitter Proof-of-Performance, pp 231-286, and that you UNDERSTAND the content of this Section.

Following is a "Workshop Type" of outline required to put your transmitter in top-notch operating condition. We still have ample time in future Lectures to ELABORATE on specific troubles at the transmitter not covered here. Where you have the best possible "transient response" at both studio and transmitter, you are transmitting as good a picture as anyone in the business with assurance of good frequency-amplitude and frequency-phase response. The following outline is in the logical order of tests and adjustments as they should be performed in sequence.

1. FREQUENCY RESPONSE. This is a matter of proper tuning (broadbanding) of your transmitter. Remember that bandwidth (separation between humps in an "overcoupled" circuit) is largely affected by the DEGREE OF COUPLING, while flatness across the top of the response curve is largely affected by LOADING. In general, if your amplifier plate current is higher than specified in your I.B. for a specific power output, the bandwidth (degree of coupling) is too wide, and you might exceed the long-term power (plate) dissipation of the final tubes. If you are obtaining the proper power output with much less plate current than specified, chances are good that bandwidth is too narrow. Either of the above conditions alerts you to the fact that it is time to run complete frequency response checks by any of the methods outlined in your Reference Text, or as recommended by the manufacturer of your specific transmitter.

Incidently, Fig 8-25, p 276 of your Reference Text is not complete. This is shown by Fig 5-1 herewith. Your transmitter response should fall within the limits with which you, in particular, are concerned as shown by Fig 8-26 of your Text. Still more specifically, it should meet or better your manufacturers specifications. If these specs call for a response within +1, -1½ db., be sure you can obtain this response.

Another check that should be made if trouble is encountered in meeting FCC specifications, is a frequency response run at various brightness levels. This can be done by feeding video sweep thru the variable APL linearity checker (one-in-five-lines) and adjusting the BLANKING level to low, medium and high duty-cycles, noting any variation in frequency response. USE ONLY SUFFICIENT SWEEP SIGNAL AMPLITUDE TO PRODUCE

20% PEAK-TO-PEAK modulation at 50% APL. Then, maintaining the same video sweep amplitude, observe variations in response as the APL is varied. You can also use straight video sweep by placing the transmitter in AC operating position and varying the BLACK LEVEL control to correspond to 22.5%, 67.5% and mid-characteristic. If your frequency response varies more than 2 db with brightness level, chances are you cannot meet differential gain and differential phase specifications, or obtain optimum phase correction for color operation as covered later in this Lecture.

If you discover you have a problem here, you MAY have inherited a less-than-ideal installation! Variations in frequency response with power level (assuming proper tuning) is caused by a change in effective loads with power change. The electrical load must remain constant (within narrow limits) at all power levels (APL's) encountered under picture operation. The transmission line from your modulated amplifier to your power amplifier must be electrically a half-wavelength (or a multiple) at the operating frequency. The more it varies from this length, the greater your change in loading with power level changes. I am referring now to "frequency-selective" loading as contrasted to transmitter regulation from black-to-white covered in your Reference Text, 234-235. It is possible for your transmitter to meet regulation specifications black-to-white, but still exhibit variations in frequency response with power level due to poor transmission line regulation. Of course you may have loading adjustments and "line-stretchers" which are not optimized. Also, the transmission line between the RF driver and modulated stage cannot be ignored, since its length is usually critical. If you have this problem, contact your specific manufacturer for advice. If it is necessary to start cutting new lines, DO IT. Many of us have "inherited" problems. The "sin" is not doing anything about it.

2. AMPLITUDE AND PHASE LINEARITY. This is thoroughly covered in your Reference Text. It is normally your first introduction to "pre-distortion" techniques, where transmitter non-linearities are compensated in the video before modulation onto the carrier. Fig 5-2 herewith serves as a review of the basic principles. Linear video as in (A) normally results in white compression as in (B), particularly apparent on the superimposed 3.58 mc (color subcarrier) component. A waveform similar to (C) is necessary to result in a minimum of differential gain at 3.58 mc (waveform D) and a linear step response as in waveform (E). NOTE: Always use full modulation in this test. This means the top of the 3.58 component at the whitest step should be adjusted to full modulation as monitored with the chopper to an amplitude where 10% carrier remains. (Some stations use 15% minimum carrier, which is ok.) CAUTION: When adjusting degree of "white stretch", be sure to MAINTAIN reference "full modulation".

Then check your transmitter differential phase at 3.58 mc. It is usually necessary to employ pre-distortion here also. Differential phase results from "parallel impedance paths", which simply means that the loading of circuits (even in some distribution amplifiers) can vary somewhat depending upon amplitudes, particularly at the "higher" frequencies. This is pre-distorted by employing non-linear impedances prior to modulation which are opposite to transmitter characteristics, normally adjusted in the same Stabilizing Amplifier employing white stretch.

3. PHASE EQUALIZATION. Observe Fig 8-17, p 269, Reference Text. Due to the nature of VSB transmission, the transmitter and "standard receiver" must be considered as a system in relation to proper amplitude balance and phase characteristics of upper and lower sidebands. At best (as you are probably aware) the nature of this modulation-demodulation process is to cause slight leading white and trailing smear on a white-to-black transistion. In practice, you also note an "offset of porches" from an "uncompensated" transmitter.

The transmitter exhibits low and high frequency distortions due to the cutoff characteristics. The receiver exhibits low frequency distortion due to the vestigial sideband tuning. Also, due to the aural traps in the receiver, it exhibits considerable high frequency distortion in the frequency-phase relationship.

Observe Fig 8-28, p 279, Reference Text. This type of pre-distortion for envelope delay equalization consists of units as follows:

(A). A <u>variable</u> high frequency equalizer.
(B). A switcheable (IN-OUT) <u>fixed</u> high frequency delay.
(C). A switcheable (IN-OUT) <u>fixed</u> receiver equalizer.
(D). A <u>variable</u> low frequency phase equalizer.

When the antenna employs a filterplexer or notch diplexer, a fixed notch equalizer is switched into this path.

3-1 ENVELOPE DELAY ADJUSTED BY A SQUARE WAVE SIGNAL

(1) You must have a "standard demodulator" which has been accurately adjusted at the factory. This should be checked every few years. Very few stations find it economical to invest in specialized test equipment required to properly set "wing trap" and "sound trap" adjustments to complement the individual demodulator delay equalizer.

(2) Use a 100 kc square wave to modulate the transmitter ONLY about 20%, or roughly 25% power output. The faster the rise time, the more the "ringing" which facilitates the adjustments. In any event, the rise time should be AT LEAST 0.5 us or better. The low pass filter increases the rise time, so you must start with a sharp rise time pulse. Feed the square wave to the DA feeding the chain of phase equalizers.

(3) See Fig 5-3 herewith. Waveform (A) is the type of reproduction you get when the transmitter phase is not equalized.

Waveform (B) is the type of pre-distortion accomplished by the fixed receiver equalizer, which is an opposite "ring" to that caused by the typical receiver sound notch. Waveform (C) is the combined effect of low and high frequency phase equalization to obtain the properly equalized reproduction of waveform (D). The important characteristic to look for here is that the "rings" are SYMMETRICALLY DISTRIBUTED about the transitions.

(4) For your initial start in adjustments, (visual carrier only, with sound carrier OFF), you remove the demodulator sound notch and also the transmitter "receiver delay equalizer". This gives you the best modulator-demodulator combination and allows the greatest accuracy in setting low and high frequency delay adjustments. The waveform at (C) is the normal appearance at the transmitter input AND the modulator output IF the modulator itself needs no correction. The demodulator is fed from an rf pickup in the antenna line following the VSBF and harmonic filters thru a directional coupler so that only the "forward" wave is observed. The variable equalizers should be adjusted in conjunction with switching the fixed equalizers in and out to observe effect. When all frequency components of the pulse are delayed an equal time, the ringing about the transitions will be symmetrical and of MINIMUM AMPLITUDE. The ringing will increase and become non-symmetrical when you re-insert the demodulator sound notch, but this should be nullified by restoring the receiver delay equalizer to the pre-distortion circuits.

3-2 ENVELOPE DELAY ADJUSTED BY THE SIN^2 PULSE

(1) See Fig 5-4 herewith, waveform (A). This is a 2T pulse (Most convenient to adjust low frequency delay) with no transmitter compensation. The demodulator sound notch is OUT, and the receiver delay equalizer is OUT. Adjust the low frequency delay unit to minimize the anticipatory overshoot at the leading edge of the pulse as shown by waveform (B).

NOTE: The units along the bottom of the graticule are in unit intervals of T. This graticule along with coverage of the outer and inner limits of response will be discussed in my next Lecture.

(2) Waveform (C) is the T pulse (twice the frequency spectrum of the 2T pulse) without high frequency phase equalization. Adjust high frequency delay (variable) and switch the fixed unit IN and OUT to obtain best possible distribution of ringing and minimum amplitudes.

(3) Switching the demodulator aural notch back IN will result in the waveform of (e). Now switch the receiver delay equalizer (fixed) IN. Waveform (F) shows the result.

EXERCISE 5-1: If you find your transmitter frequency response varies with APL, what possible trouble could exist other than transmission line effective electrical length?

EXERCISE 5-2: Should your CRO monitor of the transmitter video output show 25% sync and 75% video, considering only video/sync ratio?

EXERCISE 5-3: What VERY IMPORTANT precaution must you observe when adjusting "white stretch" predistortion to obtain a linear transmitter video output?

EXERCISE 5-4: What should you do FIRST when you find you cannot meet differential gain or differential phase specifications?

ANSWERS TO EXERCISES

5-1: Assuming you have cleared vacuum tubes as possible contributing factors, run the same check ONLY TO THE MODULATOR OUTPUT. The modulator circuit must see a constant load impedance over the entire video band down to and including DC. Some modulator power supplies has the internal resistance designed into a matching network consisting of both high frequency and low frequency sections to make the load impedance independent of frequency. This check will tell you whether the trouble is at the point of modulation (and the trouble CAN be transmission line regulation between RF driver and modulated stage, as well as in the modulator circuit) or after this stage in final RF amplifiers.

5-2: If it does, you have sync compression. See Fig 8-5, p 240 of your Reference Text. This assumes, of course, that you have a "Reference White" signal content and that you are modulating with "full modulation".

5-3: Be sure to RECHECK DEPTH OF MODULATION when you increase or reduce "white stretch". The most obvious trouble is when you INCREASE white stretch and fail to recheck modulation, since you can be modulating to carrier cutoff. Always be sure to maintain a MINIMUM of 10% carrier on "white" as VERY FEW transmitters can be made linear beyond this point even though carrier cutoff is not reached.

5-4: Again assuming you have eliminated vacuum tubes (and power supplies) as possible contributing factors, run the frequency response vs power level check as discussed in 5-1 above. BOTH OF THESE TROUBLES ARE CAUSED BY THE SAME GENERAL CONDITION: a non-constant load at all frequencies within the intended passband. This CAN occur in straight video amplifiers AHEAD of the transmitter modulator, in which case the procedure discussed in your Reference Text and previous Lectures should be followed. If differential gain and phase specifications are GOOD up to the transmitter input, but the transmitter itself varies with APL, the most likely sources of trouble lie in the modulator, tuning procedures, or poor transmission line power regulation.

LECTURE SIX

MEASURING THE SIN^2 PULSE

The 2T pulse is used for direct ROUTINE measurements of television links and systems; the T-pulse is normally employed for ACCEPTANCE TESTS, altho certain features are considered for "routine-test".

In order to facilitate "routine-test" measurements, a special graticule may be employed as illustrated by Fig 6-1(A). This graticule, to be employed with the Tektronix 524 scope is outlined in "quality rating factor K" for 2% (dotted lines) and 4% (solid lines) limits. Bear in mind this percentage is in "K-factor" ratings, not in percent amplitude or width of the signal. In this Lecture, I will clear up this point so that you can measure with reasonable certainty your incoming Network signals, even though you do not employ this signal generator in your own system. The graticule shown is outlined for the 2T-pulse, although you can employ it for the T-pulse measurement as well. (The conventional IRE-scale marked in centimeters along the reference line is just as handy for the T-pulse measurement).

FIG 6-1(B). LIMITS FOR H WINDOW RESPONSE.

NOTE: Signal proportionments such as Fig 5-35, p 170 of your Reference Text are assumed.

Set your scope time base to 10 us/cm. Adjust horizontal centering so that the half-amplitude points on the Window transitions coincide with M1 and M2. Adjust vertical gain and vertical centering so that the black and white levels coincide with B and W respectively.

The H-Window response is read directly by the top of the window signal. Your studio system should fall well within the 2%K limits. As received from Network distribution facilities, or your transmitter output, the signal should be well within the 4%K rating.

CAUTION: Please note from (A) that the Window (top) graticule contains two sets of solid lines, since the same portion of the graticule is used for either H or V-Window measurement. The H-Window limits fall, on the IRE-scale, at 104 and 96 IRE units, relative to the center reference of 100 IRE units, for the 4%K rating.

IMPORTANT: You disregard the first microsecond of the response on either side of the Window transition in this measurement. Distortion of the rise and fall edges is more sensitively indicated by the Sin^2 pulse measurement.

FIG 6-1(C). LIMITS FOR V-WINDOW RESPONSE

Adjust your scope time base and horizontal positioning so that the half-amplitude points of the V-Window coincide with M1 and M2. Adjust vertical gain and vertical positioning so that the black and white levels coincide with B and W respectively. The top of the V-Window signal is measured by using the 2% and 4% response limits, or interpolating when necessary. If you want to report any departure from proper response to your Network or the local AT&T, take waveform photos and indicate on the back of the photo the date and time of measurement. The response should be VERY LITTLE beyond the 2%K rating. NOTE: You disregard the first 250 us of response either side of the transitions.

FIG 6-1(D). LIMITS FOR WINDOW-2T PULSE RATIO

The scope is adjusted as for Fig 6-1(B) above, and normally follows that measurement. If the amplitude of the 2T-pulse is lower or higher than the 4%K limits and you are receiving color originations from your Network, report the trouble immediately. CAUTION: You must know for a certainty that the 2T-pulse is transmitted AT THE SAME AMPLITUDE of the Window. Find this out from your Network Quality Control Engineer.

You should also realize that the Networks are transmitting different types of test signals; some arrangements have the Window placed AHEAD of the Sin^2 pulse and employ different spacings and time-constants for the Window. You should be able to measure any combination with the conventional IRE-scale, since obviously the graticule is not as handy for the different arrangements. You can, of course, use your scope positioning controls for one measurement at a time, providing the time-duration of the Window signal is the same.

FIG 6-1(E). LIMITS FOR 2T-PULSE RESPONSE

Adjust your scope time base to 0.250 us/cm by placing your sweep time control to 1, the sweep time multiplier to 2.5, (this gives 2.5 us/cm), then use the 10X Magnifier to arrive at 0.250 us/cm. For accuracy in setting the fractional part of the sweep multiplier, you know that 1 us/markers should occur at 4 cm apart.

Adjust the vertical positioning so that the pulse base coincides with the horizontal reference line graduated in centimeters. Adjust vertical gain so that the top of the 2T-pulse coincides with the top of the mask. Adjust horizontal positioning so that the half-amplitude points of the pulse are symmetrically placed about the vertical axis. Fig 6-2(A) is a photo of a 2T-pulse response outside the 4%K limits as most evident by the Second Lobe (positive) ringing amplitude.

Note that the K Graticule places the reference line at Black Level Reference rather than Blanking Level Reference as exists on the conventional IRE Scale.

TABLE 6-1

2T-PULSE LIMITS		
TEST	K RATING FACTOR	
	2%	4%
First lobe (negative) max %	10	12
Second lobe (positive) max %	6	8
h.a.d. max (us)	0.3	0.375

You can use Table 6-1 as a guide in measuring the 2T-pulse response without the graticule described above. Use the IRE scale to get your measurement directly in percent.

NOTE: Modern studio systems should pass both a 2T-pulse and T-pulse with practically NO DISTORTION.

MEASURING T-PULSE RESPONSE

When measuring without the graticule described, it is MUCH MORE CONVENIENT (in measuring ringing amplitude) the measure the OVERALL negative-positive swing. See Table 6-2 for T-pulse limits. Note that the OVERALL swing of a COMPLETE CYCLE (negative-positive swing) for a 2%K rating is 12% plus 8% for a total of 20%. Follow this procedure:

Adjust the vertical positioning and vertical gain so that the PRECEDING pulse base line is at 0 IRE units, and the top of the pulse is at 100 IRE units. THEN USE VERTICAL POSITIONING TO PLACE THE BOTTOM OF THE FIRST LOBE (NEGATIVE SWING) ON 0 IRE UNITS AND MEASURE IRE UNITS TO THE TOP OF THE POSITIVE SWING.

TABLE 6-2

LIMITS FOR T-PULSE RESPONSE		
TEST	K RATING FACTOR	
	2%	4%
Period of ringing (maximum) in us.	0.25	0.25
First lobe (negative) Max %	12	16
Second lobe (positive) Max %	8	10
h.a.d. max (us)	0.18	0.20

Note that the overall ring for a 4% rating of a T-pulse transmission is 16 plus 10 for a total of 26%. Most AT&T video distribution facilities now equal or better this rating for T-pulse tests.

In measuring the T-pulse response, the scope time base is adjusted to 0.125 us/cm. Thus the "period of ringing" (see Fig 6-2(B)) should be no more than 2 centimeters. Note that this is exceeded in the photo of Fig 6-2(B). Also note that the period of ringing is assuming that the minimum ringing frequency is at 4 mc. Ringing occurs at the frequency at which the gain-dip occurs in the system being tested. The initial amplitude and the damping factor are determined mainly by the WIDTH of the dip in response. If the MAGNITUDE of the dip is large, such as occurs in transmitters beyond 4.18 mc and in AT&T transmission facilities, most of the "ringing" is on the base line FOLLOWING the pulse. This is a normal condition at the present state of the art. Note that the response of Fig 6-2(B) indicates a "ring" at slightly lower frequency than 4 mc.

To measure the h.a.d. of the T-pulse, (see Fig 6-2(C)), follow this procedure:

With the sweep velocity at 0.125 us/cm, set the black level of the pulse at 0 IRE units and adjust scope gain so that the top of the pulse falls at 100 IRE units. THEN SHIFT THE VERTICAL POSITIONING SO THAT THE PULSE BLACK LEVEL IS AT -40 IRE units for the K GRATICULE, or at -50 for the conventional IRE scale. From Table 6-2, note that the 2% rating allows a maximum of 0.18 us h.a.d. which is 1.4 cm on the time base you are using. For a

4%K rating (0.2 us) the h.a.d. should be no more than 1.6 cm wide. The photo of Fig 6-2(C) shows a response exceeding the 4%K rating for this test.

EXERCISE 6-1: What is the main system fault indicated by the response shown in Fig 6-2(A) for a 2T-pulse?

EXERCISE 6-2: For any given system, (A), should the "period of ringing" be different for the 2T-pulse than the T-pulse? (B) Should the "amplitude of ringing" be different?

EXERCISE 6-3: If you employ a SIN^2 generator to feed your studio system input, and measure a ringing period of 0.15 us., what does this indicate?

EXERCISE 6-4: At what "line number" on your EIA resolution chart would you expect to see "ringing" from your studio output under the conditions of Exercise 6-3?

SOLUTIONS TO EXERCISES

6-1: The main fault indicated here is too sharp roll-off, increasing the amplitude of the "ring". Phase compensation must be employed, or the rapidity of roll-off reduced to a more gradual slope.

6-2: For any given system with a certain cutoff frequency, the "period of ringing" will be exactly the same for either the 2T-pulse or the T-pulse. This of course must assume THAT THE CUTOFF FREQUENCY IS WITHIN THE FREQUENCY SPECTRUM OF THE 2T-PULSE, so that a "ring" will occur. The AMPLITUDE of the "ring" will be greater for a given cutoff frequency for the T-pulse than it will for the 2T-pulse.

6-3: The ringing period (R_p) has the following relationship:

$$R_p = \frac{1}{f_c} \quad \text{where } f_c = \text{cutoff frequency.}$$

Thus you can see that the ringing period of a 4mc cutoff is:

$$R_p = \frac{1}{4(10^6)} = 0.250 \text{ us}$$

Now for convenience, re-arrange your formula to obtain the cutoff frequency (f_c) in terms of the measured ringing period:

$$f_c \text{ (mc)} = \frac{1}{R_p} \quad \text{where } R_p \text{ is in microseconds.}$$

Since you are measuring an R_p of 0.15 us:

$$f_c \text{ (mc)} = \frac{1}{0.15} = 6.6 \text{ mc}$$

This indicates a cutoff frequency at 6.6 mc., the SEVERITY of which is indicated by the AMPLITUDE of the "ring", and the total number of "ringing" cycles.

6-4: Since 1mc=80 TV lines (remember studying this in your Reference Text?) then:

6.6 X 80 = 528 TV lines.

This would appear as ringing between the 500 and 600 line wedges on your test chart. Actually, as I pointed out earlier in this Lecture, your "system" (switcher input to line output) should pass a T-pulse with NO DISTORTION. Any slight amount of ringing in this region should NOT be contributed by the studio "system".

LECTURE 7

Q & A ON YOUR TELEVISION SYSTEM

In this Lecture, I want to summarize your "system" techniques, because starting with my next Lecture, we are going to cover maintenance techniques of various signal sources.

"Q" designates the question which is immediately followed by the answer "A".

Q 7-1: What is the most rapid test you can make to tell whether regulated power supplies need servicing before actual trouble occurs?

A 7-1: Put a scope on your B-plus output with a fixed load to provide a current drain near the top of the maximum rated output. If the p-p ripple voltage exceeds specifications of the particular supply used (normally 2 to 3 millivolts on a 280-volt output) the series regulator tubes or transistors have excessive resistance. This might also require change of the voltage adjust tube (or transistor) or shunt regulator. See your Reference Text, pp 37-43 for more exhaustive tests.

NOTE: Sometimes loss of regulation (severe video bouncing) will occur when the line voltage drops beyond minimum range, or near that point. For a complete story of your regulation safety margin, use a variac to supply the AC to the power supply. Note any marked increase in ripple level at lower AC supply voltages. Check that a change of tubes (or transistors) helps. If not, is your power supply primary line tap on the proper position for your "average" line voltage?

Q 7-2: You have "swept out" all individual amplifiers (DA's, switcher amps, etc.) and adjusted for proper frequency response. Then you run an overall sweep and find a problem. What is your procedure now?

A 7-2: It's probably interconnecting coax or terminations. Place your scope with detector probe at the LINE OUTPUT and your sweep generator at the input of the LAST AMPLIFIER in the chain. Leave the scope at the LINE OUTPUT and move back thru the system with the sweep generator. See pp 86-91 of your Reference Text for most convenient method of checking coax cables.

Q 7-3: You have "swept out" all amplifiers and interconnecting coax in your "system" (Switcher input to Line Output) and have good overall sweep response. You feed a square wave or

Sin^2 pulse thru the system and discover bad transient response. Now what?

A 7-3: Every individual amplifier has a fixed gain-bandwidth product. You should adjust each amplifier for a "flat response" ONLY out to a frequency which will still allow proper square wave (or Sin^2 pulse) response. It is better to have a slow roll-off within the passband than a "flat" response with sharp cut-off in studio gear. (From Switcher input to Line Output). Be sure ALL TERMINATIONS are of proper value. Review your Reference Text; pp 8-11 and 138-192.

Q 7-4: Why do we say that certain Test Signal Generators should be "double-terminated" (terminated sending and receiving ends) when feeding a TV System Input?

A 7-4: Most TV Broadcast Terminal Gear built after the earliest type of equipment, employs a "sending end" impedance which matches the characteristic impedance (Z_o) of the properly terminated coax cable. (Normally 75-ohms). This is true whether considering pulse or video distribution. For example, see Fig 5-10, page 150 of your Reference Text. When multiple outlets are used, an "isolation network" is built-in to avoid exhorbitant interaction between outputs, but each output "sees" 75-ohms (or 124-ohms in "balanced" line outputs) which is again terminated at the receiving end of the coax line. In effect, this means that modern equipment is "double-terminated" for minimum effects of long coaxial cable feeds.

Many test signal generators still employ an internal output impedance of 600-ohms, and therefore must be modified for a 75-ohm output, or the "double-termination" method employed. Capacitive, inductive and series resistance effects of long coax lines across a higher sending end Z_o upsets frequency and transient response.

Q 7-5: What is the most troublesome aspect of the conventional 75-ohm "unbalanced" distribution in TV systems?

A 7-5: Crosstalk (Reference Text, pp 86-90) and voltage gradient ("glitching") problems. In cases of definite faulty grounding, picture "hum" can also result.

Q 7-6: How do you isolate "glitching" sources?

A 7-6: A glitch results from a voltage built up across a common impedance of the system. It normally occurs only upon operation of such mechanisms as slide changers or in certain types of video switching systems. There is always a small transient occuring in ANY SYSTEM with long unbalanced coax lines; the problem is to minimize such transients (white flashes in the picture when the switch or slide change occurs) to a negligeable amount. Some cases are actually so severe as to cause picture "rolls" in home receivers upon actuation of the troublesome device.

The first thing to do is to electrically suppress the offending equipment as much as possible by shielding the control box and by coil and contact surge suppressors. (Diodes or R-C suppressor arrangements). If the Manufacturer of the particular equipment is out of ideas for any further help, you must go further into your own system.

One factor is the tally-light system. First, disable the tally lamp power. Is the "glitching" reduced? Then disable the tally relay control voltage. Be sure ANY relays in the system are properly "arc suppressed" as called for by the Manufacturer. Glitching has been known to occur when a certain camera chain was switched "On-Air" by the tally light relay in the camera head. Try different suppressor combinations across these coils and/or contacts.

"Ground loops" MAY exist only when certain pieces of equipment are connected into the system. Even a faulty ground on a viewfinder was known in one case to cause glitching when a slide-changer operated! When the viewfinder was removed from the camera, the glitch practically disappeared. (The particular camera-chain routing happened to be nearest to the offending slide change control box). Even though it "doesn't make sense", try disconnecting any equipment that can be spared during tests for this condition. ALL COAX MUST HAVE SOLID SHIELD CONNECTION AT BOTH ENDS. When you isolate any line or sections of units which seem to emphasize the glitch problem, examine these for "clean" grounds, shielding, solid interconnecting harness, etc.

When the trouble is in a video switcher, even tube conditions can cause excessive switching transients. "Cathode interface" of tubes (Reference Text, pp 16-17) will do this. In case of relay type switchers (as well as straight mechanical contacts on pushbuttons) be sure an "overlap" interval occurs rather than "break-before-make" operation. The usual overlap interval is 200 to 300 milliseconds.

Problems of this nature can be minimized by going to 124-ohm "balanced" video distribution systems. Many of the latest transistorized distribution amps provide such an arrangement.

Q 7-7: You feed either a square wave or rectangular pulse into your system input. You measure the output pulse at some later point (see Fig 7-1 herein) and have the following values for A and B:

A = 0.1 us
B = 0.2 us

What does this tell you about the system (or unit) checked?

A 7-7: "A" is the rise time (RT) of the pulse. This is equivalent to:

$$RT = \frac{1}{2f_c}$$

that is, the inverse of twice the cutoff frequency. To re-arrange this in terms of finding the cutoff frequency (f_c) for the rise time measured:

$$2f_c = \frac{1}{RT}$$

and since the rise time is in microseconds (us) the frequency (f_c) is in megacycles (mc).

Thus: $$2f_c = \frac{1}{0.1} = 10$$

and $$f_c = \frac{10}{2} = 5 \text{ mc}$$

Therefore the measurement of the rise time has shown us that the passband to the cutoff frequency is 5 mc.

Now the ringing cycle (B) is 0.2 us. This period has the relationship:

$$R_p = \frac{1}{f_c}$$

where R_p is the ringing cycle and f_c is the cutoff frequency. Review Lecture Six.

To re-arrange in terms of finding the f_c for the measured "ring":

$$f_c = \frac{1}{R_p}$$

and since R_p is in us., f_c will be in mc.

Thus: $$f_c = \frac{1}{0.2} = 5 \text{ mc.}$$

and either measurement tells us the same thing. The SHARPNESS of cutoff (rapidity of reduction of gain, or the slope of the response curve) WILL affect the DEGREE OF OVERSHOOT and the NUMBER OF RINGING CYCLES.

Q 7-8: The "ringing cycle" as shown by B of Fig 7-1 is a complete cycle. Yet on Fig 6-2(B) (Lecture Six) it APPEARS to be only one alternation or a "half-cycle". Why?

A 7-8: See Fig 7-2 herein. Remember the formation of the Sin^2 pulse as outlined in Lecture Four. The pulse is a complete cycle as reviewed by (A) and (B) of Fig. 7-2. The "period of ring" shown by (C) is the first (negative) lobe of the transient.

Q 7-9: You want to check your system amplitude linearity. Lacking a variable APL test generator, why can't you simply increase the test signal amplitude to cover the AC range of variable picture levels as shown by Fig 6-2, page 197 of your Reference Text?

A 7-9: A 50% APL signal is simulated by a reference level PERFECTLY SYMMETRICAL square wave, or a stairstep signal repeated every line, or a sine wave, etc. Now if you are concerned ONLY with amplifiers employing AC coupled stages (no DC restoration or line-to-line clampers) you can increase your amplitude of the test signal to 1.5 volts peak-to-peak for a 1-volt composite system; or to 2.1 volts peak-to-peak for a 1.4 volt composite system. This simulates the AC variation of 201 IRE units for a normal 140 IRE unit signal over the gamut of picutre APL's.

However, YOU CAN'T DO THIS for amplifiers employing clampers. The clamped stage FIXES the operating point relative to blanking or sync tips. Stages following clampers (particularly at the transmitter) are not normally capable of handling the full AC excursion of unclamped video without running into compression or clipping.

LECTURE EIGHT

SIGNAL SOURCE CHARACTERISTICS

Up to this point we have been discussing the portion of Fig 8-1 concerned with strictly linear amplitude-frequency-phase response. Consider this the "intermediate link" in the complete system so that the individual pickup chain may be corrected for its own peculiarities. In one case (video transfer characteristic) the receiving end terminal characteristic (picture tube) must be considered in the correction to be applied in the sending end terminal.

In general, the corrections you are faced with are:

Signal Transfer. As you know, the "ideal" situation is where the light output of the kinescope is directly proportional to the light input from the televised scene. But the kinescope is non-linear in the direction of compressing blacks and stretching whites. The I.O. tube is non-linear in the direction of stretching blacks and compressing whites. Also this transfer characteristic of the I.O. is dependent in a complex manner with whether the scene is "high-key" or "low-key", which is another way of saying that the transfer curve (dynamic) varies somewhat with APL.

The resultant overall characteristic of an uncompensated system is black compression because the kinescope is more non-linear than the I.O. tube. This is just as true for the Vidicon or Plumbicon.

Now be sure of your terminology. Amplitude linearity is a measurement of the shape of the transfer curve. It is a function of output-vs-input luminance levels of the system. GAMMA is the exponent of the transfer characteristic. This is the slope of the transfer characteristic plotted on a log-log scale. As shown by the simple transfer blocks of Fig 8-1, a gamma of unity (dotted lines) is a strictly linear transfer slope. If the slope is greater than unity, (kinescope), blacks are compressed, whites are stretched. If the slope is less than unity, (pickup tube), blacks are stretched and whites are compressed. Overall system gamma is the product of the individual gammas.

For example, the Vidicon has a relatively constant gamma of 0.65 over the normal beam current operating range. The average kinescope gamma is around 2 (color standards assume an exponent of 2.2) which means that the pix tube highlight brightness increases approximately as the square of the applied video voltage above cutoff. Then assuming all other units of the system are unity gamma, the overall system gamma is:

$$(0.65)(2.2) = 1.43$$

or greater than unity. The amount of gamma correction necessary to obtain a unity exponent is:

$$1/1.43 = 0.7$$

so that the product of the system gamma (1.43) and the gamma correction (0.7) = 1 or unity.

Amplitude vs Frequency Response. Review "What To Expect In Picture Resolution", pp 157-160 of your Reference Text. Now observe Fig 8-2 herewith. This curve shows the typical uncompensated response of the three most commonly employed pickup tubes in use today. The camera is focused on a square wave test pattern and the signal is measured with an amplifier of 10 mc bandwidth.

The "aperture effect" is similar to passing the signal thru a low-pass filter WITH NO PHASE DISTORTION. Thus the "aperture correction" is ideally made with a device that produces a rise in response at the higher frequencies corresponding to the slope of the aperture loss, without introducing phase shifts. This is normally achieved by an "open-ended delay line" technique which boosts the highs without phase distortion. The input capacity to the preamplifier stage DOES produce some phase shift. Thus you will always find some means of correcting the phase of the video signal. These circuits are variously termed "hi-peakers" or "phase correction", and there is no sharp line of demarcation between the two terminologies.

"RESOLUTION" AND "SHARPNESS"

Curve B of Fig 8-2 is typical of the very popular type 5820 I.O. The amplitude response increase at low line numbers (below approximately 250 lines) relative to the initial 100% broad-area black and white signal, results from signal re-distribution effects on the target when the lens is operated one or two stops above the knee of the transfer curve. The field-mesh 3-inch tube and the newer 4½-inch tube exhibit this characteristic to a much lesser extent because of the improved beam landing and lowered spurious response. However, many practicing engineers are at a loss as to why the image appears "sharper" from the non-field mesh tube (such as the 5820) than it does from the field mesh type (such as the 7293) even tho they can "see" the same horizontal resolution on the test pattern from either tube.

The "sharpness" and "snappiness" of a properly set up type 5820 I.O. due to the over-emphasized outlines of the picture elements cannot be denied. However, it is this very spurious response characteristic that is hard to control on "glints" from sequins on a dress at the studio, or when panning across unexpected light sources on remotes. You are all familiar with the resultant black halos that result, sometimes sending the entire scene into an unlighted coal mine.

LIMITATIONS OF APERTURE CORRECTION

The detail response of a system is its relative amplitude response to black and white lines from broad to narrow; this is to say from low to high frequency information. Broad lines (low line numbers, low frequency) are normally reproduced with full contrast. (Amplitude equal to broad area information). As the lines become skinnier (increasing line numbers, higher frequencies) the contrast between black and white lines decreases until they can no longer be distinguished. The "line number" where this occurs is the resolution of the system; this normally occurs at the contrast range which is approximately equal to the brightness fluctuation due to noise.

Now the degree of aperture correction that can be used with a given pickup tube and amplifier, and the line number at which this "boost" can be peaked, is dependent upon the noise level existent. See Fig 8-3. If it is desired to obtain 100% detail response at 300 lines, aperture correction is peaked at 3.75 mc and ideally has the same slope of "boost" as the slope of "roll-off" due to pickup tube aperture response. Note that the noise level is boosted by a corresponding amount, and is the limiting factor in amount of correction that can be used.

In general, noise will be evident in the picture when the signal-to-noise ratio deteriorates to less than 24 db on a peak-to-peak video to peak-to-peak noise basis. The Image Orthicon tube has maximum noise level in black due to the fact that maximum beam current occurs at this time. Thus an attempt to use too much aperture correction results in a "noisy" picture occuring first in low-lights (dark areas) of the picture.

BASIC CIRCUITS INVOLVED

In practice, the camera amplifiers are made "flat" in amplitude-frequency response by conventional video sweep techniques, adjusting peaking coils and feedback frequency-compensation circuits for proper response. Inevitable phase distortions occuring in video signal circuits require correction circuitry normally taking the form of incomplete cathode resistance bypassing (small capacitance) as shown by Fig 8-4(A). Since the lower frequencies are degenerated by the un-bypassed cathode resistance while the higher frequencies are NOT degenerated, you can see that phase shift CANNOT be proportional to frequency, and "phase distortion" occurs. It is obvious that such circuits MUST BE BYPASSED WITH A LARGE CAPACITANCE when using video sweep, even though you are using keyed sweep with sync pulses present. Adjustment of "Hi-Peakers" or "Phase" controls MUST finally be made ONLY WITH PICKUP TUBE SIGNALS to eliminate "smear" or "streaking" in the picture.

If such circuits are not bypassed with a capacitance of around 0.47 mfd., the video sweep thru the amplifier is distorted as shown by (B) of Fig 8-4 and is meaningless. You will have practically no response below about 2 mc. This is where the term "hi-peaker" originates, but it is a mis-leading terminology. To see the actual effect on frequency response you need to feed the video sweep signal thru an Image-Orthicon circuit simulator, an example of which is illustrated by (C) of Fig 8-4. Note that the so-called "hi-peaker" affects only the very low end of the video sweep, while the "phase" control in this instance affects a higher-frequency range up to around 5 mc. The main purpose of such controls is phase correction caused by the image orthicon input resistance-capacitance network. Obviously, vidicons or any other known type of pickup tube requires the same type of correction.

You can get a rough idea of intended range of effect on length of smear (or streaking) by noting the maximum time-constant of such correction networks as in Fig 8-4(A). For example, the maximum time constant of the "phase" network (R1, R2, C1) is 0.12 us. Consider the active line interval to be 53 us. (H is 63.5 us., minus horizontal blanking time is about equal to 53 us). Now 0.12 us is approximately equal to 0.00226 of 53 us. Assume now an 18-inch wide raster.

Then: 0.00226 X 18 = 0.04" or about 3/64" on an 18" raster.

This type of circuit with the associated time-constant corrects smears of short trailing edges.

The maximum time constant of the "hi-peaker" (R3-R4-C2) is about 2.5 us. This is approximately 0.047 of the raster width. Then on the 18" wide raster: 0.047 X 18 is approximately 0.846" or close to 13/16" on the 18" width. Thus this time-constant corrects streaking of long trailing edges.

How to measure detail response, gamma correction, smearing and streaking will be detailed in Lectures to follow. Corrective measures, and means of obtaining maximum detail while maintaining highest practical signal-noise ratios will be discussed. Because of the differences in setup techniques necessary in recently available pickup tubes (due to super-dynodes, field mesh, etc.) it will be necessary for us to discuss adjustments normally applicable only to operations as contrasted to maintenance.

EXERCISE 8-1. The uncompensated amplitude response of a typical 5820 I.O. is about 80% at 300 TV-lines compared to flat-field response. The uncompensated response of a typical 7038 vidicon at 300 lines is about 45%. Does this mean the I.O. is capable of transmitting a higher <u>resolution</u> picture than the vidicon?

EXERCISE 8-2. See Fig 8-5. Curve (A) has a much broader amplitude response thru the entire system than curve (B). Which of these response curves will give the maximum "sharpness" in the picture assuming the same type of pickup tube is used?

EXERCISE 8-3. List the main factors that are responsible for noise (masking) voltages in the complete TV broadcast system.

EXERCISE 8-4. Give two reasons why the video signal representing sudden changes (as when the camera is looking at a square-wave pattern) is never the ideal waveform.

EXERCISE 8-5. Define (a) Transfer curve, and (b) Gamma.

ANSWERS TO EXERCISES

<u>8-1</u>: No. The limiting resolution of the typical 5820 I.O. is 625 lines. The limiting resolution of the 7038 vidicon is 750 lines. In practice, resolution is dependent primarily on amount of "aperture correction" that can be used before the thin lines to be resolved are covered by noise. It is usually impossible to bring the amplitude response at 300 lines up to 100% in the type 5820 without excessive noise level. But the 7038 vidicon (or any other broadcast-type vidicon) has sufficiently low noise level that response at 300 lines can be boosted to 100%.

<u>8-2</u>: Curve (B) will result in more "snap" than curve (A). Although the resolution capability of system (A) is greater than that of system (B), the picture will appear less sharp because of its lower response at lower line numbers where most of the picture energy lies. The complete specification of a television system must specify not only the resolution but also the horizontal detail response at some lower line number, usually at about 300 lines.

<u>8-3</u>:
1. Shot-effect noises in the beam current of the Image Orthicon.
2. Thermal agitation in amplifier resistors.
3. Shot-effect noises in amplifier tubes.
4. Natural external disturbances and man-made electrical interference.

<u>8-4</u>: (1) The scanning spot (aperture) that analyzes the scene in the pickup tube of the camera is essentially circular in shape and, when scanning elements that have sharp demarcations, results in a signal changing gradually rather than changing

suddenly. You can grasp this most clearly by considering the scanning spot sweeping across a checkerboard pattern in which the sides of the square are just equal to the diameter of the spot. This results in a gradual rise and fall of the signal waveform rather than the infinite rise and fall that the changes of such a scene demand. This effect is termed aperture distortion. And (2), amplifier circuits cannot be designed to respond to signal voltages having infinite changes. Hence the waveform departs from the ideal when the scene being transmitted is composed of such changes.

8-5: (a). A transfer curve is graphically illustrated by the system response to a stairstep signal as shown in your Reference Text. Such a curve might be strictly linear in all but one extreme end, such as black or white. (b). The term "gamma" in photography refers to the maximum slope of a density vs log-exposure characteristic. The term gamma in television usage (and this term is abused by many engineers) should refer to the over-all transfer characteristic of the system on a log-log scale plot. Although an over-simplification, the over-all transfer characteristic is given an exponent which relates the relative reproduced output luminance to input luminance. Although gamma is NOT a constant in a television system, but varies over the contrast range from lowlights to highlights, the fundamental relationship may be mathematically expressed as:

$$\text{gamma} = \frac{d \log b}{d \log B} = \frac{db/b}{dB/B}$$

where B is the relative scenic (input) luminance and b is the relative reproduced (output) luminance. You will grasp this more clearly from future Lecture projects in checking gamma.

LECTURE NINE

CHECKING THE VIDICON FILM CAMERA CHAIN

In the image orthicon camera, white stretch is used to compensate non-linearity in the IO when the tube is operated above the "knee" of the transfer curve. (Resulting in white compression). For a "low-key" scene (mostly black) the IO operates on a relatively linear portion of the transfer curve, but the picture tube operates in a non-linear region which compresses blacks. Black stretch is used to overcome this problem.

The stretch controls of an IO camera are normally adjusted for the most pleasing reproduction on the studio monitor, and most IO instruction books are quite thorough in explanation of such adjustments.

However, in the vidicon film camera chain, fixed values of "gamma correction" are normally switcheable in or out on the control chassis. Most units employ a switch with three positions: unity, 0.7 and 0.5. The 0.5 gamma is often necessary when telecasting films originally processed for theater in order to fit the wide dynamic range of the gray scale into that capable of transmission without severe compression of low grays and blacks. The vidicon has no "knee", hence will not compress whites. (Assuming sufficient beam current to discharge highest highlight).

HOW TO CHECK GAMMA

Regardless of the type of circuitry employed, the amplifier containing gamma correction is most conveniently checked by the stairstep generator. I will outline here a complete step-by-step procedure which you can use regardless of manufacturers type or method of obtaining gamma correction.

1. Observe directly the Linearity Generator output on the scope for proper linearity of steps. If steps are not perfectly linear from generator, take this into account when checking the amplifiers. (See Reference Text, p 203 and Fig 6-9 for best method of checking linearity).

2. Remove the camera signal input from the control chassis and feed the stairsteps into this point. Increase the amplitude of the stairstep signal until clipping starts to show at the output. This tells you the maximum p-p signal the control (processing) amplifiers will handle without compression. You should keep a record of this amplitude for future reference. BE SURE GAMMA SWITCH IS ON UNITY (no gamma correction). Remove any "aperture correction" employed.

3. For accuracy in checking linearity without danger of excessive levels affecting the measurement, reduce this input level to one-half the level recorded in Step 2.

4. When observing linearity of steps at the output of the control chassis, assure that PEDESTAL control is adjusted with sufficient setup that bottom (black) step is not compressed. If your black steps are still "pulled down", check any "transient suppressor" controls for incorrect adjustment. These circuits affect the "black" region.

5. Now place your black-stretch (gamma) switch on the position to be checked. Fig 9-1 shows the values of output steps you should get (with linear input) for the two most common values of correction used. To see it mathematically, assume you are using a gamma of 0.5 and to figure where the 0.1 volt input step should be: $(0.1)^{1/2} = \sqrt{0.1} = 0.316$. And for the 0.2 volt input step: $(0.2)^{1/2} = \sqrt{0.2} = 0.447$ etc.

To see the 0.7 gamma correction mathematically, you will need to use logarithms. For the 0.1 step $(0.1)^{0.7}$:

$\text{Log } N = \text{Log } 0.1\ (0.7)$
$\quad = (-1)(0.7) = -0.7$
This is $-1 + 0.3$
Antilog = 0.1995 or (in practice) 0.2

6. If your step-voltage response is distorted or more than a few percent off with the gamma correction IN, the reference diodes (when used) are the most likely source of trouble. See pp 43-44 of your Reference Text for best dynamic means of checking diodes. A slight departure from theoretical step-response is normal in circuits employing diodes which are biased to conduct at various levels of video, since the resulting response is in incremental steps from black to white rather than a smooth curve.

NOTE: I pointed out in the previous Lecture that your camera chain employs HI-Peakers and Phase-Correction circuits with small trimming capacities across a cathode (or emitter) resistance. These circuits may cause some "tilt" on the stair-steps, but will normally not prevent an accurate measurement. If excessive distortion is present, it is a simple matter to bypass such a cathode-correction circuit with a capacitance of around 0.47 mfd.

7. Now run the gray-scale slide or test loop through your complete film chain. This will give you a good indication of the camera head as it responds to the black-to-white pattern viewed by the vidicon. If any compression (with gamma correction removed) is now present, the trouble is either in the camera head itself, OR THE PEAK TO PEAK VIDEO LEVEL FROM THE CAMERA IS EXCESSIVE. Check this level at the input to your camera control chassis. You must always keep this input level below that found in Step 2 above. How to check the camera head is more fully described below.

STEPS IN OBTAINING MAXIMUM FILM CAMERA RESOLUTION

The problem here is to get maximum detail contrast (by means of aperture correction on a properly adjusted camera chain) while maintaining lowest possible noise level. You should perform the following steps before undertaking the longer procedure of a complete video-sweep alignment. It may not be necessary.

(A). Use open gate on your projector at normal lamp voltage and lens settings. Adjust your target voltage to obtain 0.3 uA beam current.

(B). See Fig 9-2. Turn any manual video gain control to maximum gain. Scope at T.P. #1. You should know what the normal p-p level your camera head should deliver at 0.3 uA beam current, and this is usually indicated on your schematic or in your I.B. Usually this level is around 0.4 to 0.5 volts p-p. If this p-p level is low under the above conditions, replace camera head tubes one at a time until proper gain is restored.

NOTE: If you do not know what this level should be, and/or if your camera chain does not employ either a beam current meter or "calibration pulse", proceed as follows:

Assume your target load resistor is 47K. (This is very near the value you will find in your equipment). For 0.3 uA current, the voltage swing is: $0.3(10^{-6})(47{,}000) = 0.014$ p-p (white to black). Now see Fig 9-3. Temporarily disconnect the vidicon target lead, (with target voltage OFF), and substitute the signal as shown. If you adjust your signal generator (which can be a 15.75 kc square wave, pulse, or stairstep generator) to 1.4 volts p-p output and use a 40 db pad, your input level to the pre-amp will be the required 0.014 volt signal to simulate 0.3 uA target current. (Again it may be necessary to temporarily bypass the camera head "Hi-Peaker" cathode circuitry with a 0.47 mfd cap). Now measure the p-p level at the input to your control chassis. Restore the camera head to normal operation and (with open projector gate) adjust your target voltage to get the same p-p level as measured with the signal generator. This target voltage is that which is required to obtain 0.3 uA target current. Even if your equipment employs a metering circuit, if you are in doubt as to its accuracy, check it by the above procedure.

(C). Readjust any Manual Gain Control to obtain 0.1 to 0.15 volt (p-p) video with test pattern signal. Or to the SAFE maximum value of p-p video found by the previous Linearity Test before compression occurs.

(D). With test pattern slide or film loop, adjust all HI-Peaker controls for minimum smear or streaking. Aperture compensation SHOULD BE REMOVED for setting these controls to observe only medium and low frequency response.

(E). Throw Aperture Compensation IN, and go to maximum boost required to get 600-line response with good detail contrast as observed on a GOOD master monitor. (See Reference Text page 163 to check response of your video monitor amplifier and picture tube). If noise is apparent when Aperture Compensation is adjusted to just obtain 600-lines horizontal resolution, do the following:

(1) Check for EXCESSIVE BEAM CURRENT. Reduce Beam until highlights are just resolved.

(2) Be certain of camera physical and electrical focusing.

(3) Check that camera output is normal per Step B above.

(4) Replace video amplifier tubes in Control Chassis one at a time for reduction of noise without loss of resolution.

(5) If still no improvement, your camera chain needs a complete video alignment procedure.

NOTE: A "bad" vidicon will show excessive "Target lag" before it deteriorates in "resolution" as a general rule. "Target lag" is image retention under movement of the images vertically or horizontally. You can "retire" such a vidicon to a slide (only) camera if you have one, since no movement is involved except slide change. After considerable extended use in the slide camera, the vidicon will go "soft" and lose resolving power.

Excessive "overpeaking" (either by video alignment or use of "Hi-Peak" controls to get white-following-black for "apparent" sharpness) will result in video bounce (excessive on drastic scenic changes) and white or black compression. In case of excessive "bounce" on scenic changes, check both Hi-Peak and "low-frequency compensation" controls. Adjust the low-frequency compensation control (where used) for a FLAT vertical interval at the output of the Control Chassis AS OBSERVED ON AN EXTERNAL CRO. Remember that most Master Monitors incorporate their own "tilt" controls which is a separate adjustment, for the Master Monitor CRO circuitry.

EXERCISE 9-1. Why is it important to have a 40-DB video pad available to the maintenance department?

EXERCISE 9-2. If your vidicon camera target load is 68K, how would you modify the data of Fig 9-3?

EXERCISE 9-3. What could cause "white compression" in the vidicon pickup tube even though associated amplifiers are linear?

EXERCISE 9-4. What is the result in using excessive beam current in the vidicon pickup tube?

ANSWERS TO EXERCISES

EXERCISE 9-1: 40-DB is a voltage ratio of 100/1. You will find this attenuation most convenient in feeding video preamps of pickup tubes, since it allows normal output levels from test equipment.

EXERCISE 9-2: The p-p voltage developed at 0.3 uA target current is:

$$0.3(10^{-6})(68,000) = 0.02 \text{ volts}$$

Therefore: 100 X 0.02 = 2 volts (p-p) from signal generator feeding the 40-DB pad.

EXERCISE 9-3: Insufficient beam current to discharge highest highlights.

EXERCISE 9-4: Excessive beam current will cause loss of resolution and, under some conditions, a "splitting" of image. In some cases, an effect similar to "target flutter" in an IO will result in the corner of the picture. This can also be caused by improper beam alignment of the vidicon.

LECTURE TEN

CAMERA FOCUS, ALIGNMENT, AND SHADING PROBLEMS

A surprisingly large percentage of "maintenance" time is spent needlessly when optimum adjustment procedures are not followed to begin with. I want to be sure you understand such procedures (normally considered under "operations" rather than "maintenance") so that you KNOW when actual maintenance is required.

THE VIDICON FILM CHAIN

My previous Lecture on the Vidicon film camera serves only as the "starting point" in obtaining good film telecasts. In that coverage it was "assumed" that projector lamp voltage and lens f:stop were "properly set". Also we still have to consider focus current, beam alignment and possible shading problems.

Here are some "fine points" in squeezing everything possible from the vidicon film setup:

1. Block all light from the vidicon faceplate, set the target voltage at 20 volts as a start, BEAM control OFF (maximum bias).

2. With your TARGET VOLTS-CURRENT meter in the I (current position) rotate ZERO ADJ control so that meter indicates upward on the scale. You do not want zero reading because you are going to take a DIFFERENCE measurement.

3. While watching the CRO or the monitor kinescope, bring up BEAM current until the information at black level is "wiped-in" (dark current information is discharged). This will be quite evident if you watch closely.

4. Measure the DIFFERENCE in meter readings between (2) and (3) above. For finest overall picture quality, this difference (actually a measurement of dark current) should be no more than 0.01 uA. Use maximum Target volts possible while maintaining dark current no more than 0.01 uA. This is for film application ONLY, not studio use for "live" pickups.

5. Now zero your target meter with beam control off, and remove light block from vidicon faceplate. Project a resolution slide into the vidicon. THE CAMERA LENS SHOULD ALWAYS BE WIDE OPEN. Adjust the projector lens WIDE OPEN (minimum depth of field) to obtain sharpest mechanical focus with BEAM adjusted to just discharge the highest highlight. Then STOP THE PROJECTOR LENS DOWN JUST TWO STOPS FROM WIDE OPEN. This will provide adequate depth of field for warped or buckled film.

6. Now adjust your projector lamp voltage to obtain 0.3 uA open gate at the target voltage you arrived at in Step (4) above. (Light wheel, or neutral density disc at center of rotation if used).

You have now arrived at the optimum settings of Target, Lens Aperture and Lamp Voltage. NOTE: If your film chain incorporates a color camera, YOU MUST OPERATE PROJECTOR LAMP VOLTAGE AT ITS NORMAL OPERATING VOLTAGE TO PRESERVE COLOR TEMPERATURE. We are currently discussing Monochrome operation only. If your monochrome camera is on a multiplexed basis with a color camera, you should use an additional neutral density filter on the monochrome camera axis to obtain proper operation and light balance.

If your vidicon camera chain does not employ a target current meter, or the metering circuit is not dependable in reading very small values of current as is required in dark current readings, keep the following in mind:

As target voltage is increased, you reach a point where "edge flare" (excessive dark current) is reached. When the target voltage is reduced below a certain value (depending upon the individual vidicon) a point is reached where "portholing" (darker around edges than at center) occurs. You can adjust your target voltage above the point where "portholing" just occurs, and where an entirely "flat" raster (as to shading) results. This can then be varied slightly if an unrealistic projector lamp voltage is required to obtain 0.3 uA target current (refer to my last Lecture for how to measure this without a meter) at the target voltage being used.

NOTE: If you attempt to use TOO LOW a target voltage, a condition known as "target bounce" can occur on drastic scenic changes. A small amount of dark current (up to 0.01 uA for a film camera) stabilizes voltage excursions caused by target current variations thru the load resistor in accordance with the charge on the photo-cathode under scanning. As a broad general rule, you will find optimum results are obtained in a monochrome film camera with a target voltage somewhere between 18 and 25 volts.

FOCUS CURRENT VS FOCUS VOLTAGE

The field strength at the center of the focus coil for a vidicon should normally be 40 gausses (produced by 40 ma of focus current), and 75 gausses (produced by 75 ma focus current) for an Image Orthicon. Therefore the Manufacturer usually recommends this focus current adjustment as a fixed value. However, you will find that with some tubes (either vids or I.O'S) you can vary the ratio of focus current to focus electrode voltage slightly and obtain sharper delineation of the high-frequency wedges on the test pattern. The focus electrode voltage is, of course, what you are varying when you adjust your BEAM FOCUS (or ORTH FOCUS in RCA Image Orthicon terminology). This assumes that the beam current has been properly aligned for optimum conditions, and on the proper "mode" for an Image Orthicon. (More on this later).

You must remember that when you vary your focus current, the scanning size varies. More current (greater focus field) "stiffens" the beam and the photocathode or target area is UNDERSCANNED (image increases in size). As the focus field is reduced, the scanning beam travels farther for the given deflection voltage, hence OVERSCANS (image decreases in size). Therefore remember to readjust your scanning for normal area upon change of focus current, before judging "resolution" on the test pattern. You must, of course, re-adjust BEAM FOCUS (voltage) control for optimum electrical focus each time you vary the current.

LINEARITY AND SHADING

The light output of a photoconductive device such as the Vidicon is directly proportional to velocity of scan. SO LONG AS THE SCANNING WAVEFORM IS LINEAR, NO INHERENT SHADING TAKES PLACE IN THE VIDICON. If the waveform is non-linear, the velocity or rate of scan is different for different areas of the target, and shading occurs.

The best way to check your film camera is to REMOVE THE LENS and swing the camera to one side so that a "flat light" source (such as a 40-watt bulb placed about 4 to 6 feet away) can be used. With a new vidicon (or an old one which has not been abused) you can actually adjust your LINEARITY controls for ABSOLUTELY FLAT SHADING. In 99 cases out of a hundred, you will find your image linearity well within 2% by this method. (How to check this is described shortly). If, upon replacement of the camera to its normal film chain path you have shading, you know the shading is the result of optics, NOT the camera. The above procedure assumes you have already set your target voltage for optimum operation as I described earlier.

It is also assumed that you are already familiar with the conventional method of checking camera sweep linearity; first getting the monitor linear by the grating generator, then adjusting the camera sweeps (and LINEARITY controls) to obtain a linear presentation of the test pattern image on the same monitor.

A far better method of exactly measuring "geometric distortion" (non-linearity of camera sweeps) is provided by the use of the "ball chart" (RETMA Linearity Chart) shown by Fig 10-1(A). This can be obtained in slide form for your film camera, or in chart form for studio camera use. The pattern is designed so that the black outlines of the circles are within 2% linearity, and the inner portions of the circles describe a linearity within 1%.

To use this method, you mix your grating signal either in the camera chain itself or to the monitor displaying the camera chain output. Fig 10-1(B) shows the kinescope display with excessive geometric distortion from the camera. Fig 10-1(C) is the output of the same camera chain with sweeps adjusted to 1% geometric distortion. With zero geometric distortion, the dots, circles or intersections of the ball chart (or slide) can be made to coincide with the intersections on the grating pattern. Some of the grating pattern lines will be on the outer edges of the circles when the linearity is within 2%. Distortion is measured in distance units (for picture elements) and time and distance figures (for scanning velocities).

NOTE THAT THE MONITOR LINEARITY HAS NO BEARING ON THIS MEASUREMENT. If the monitor is non-linear, camera sweeps can still be adjusted to obtain camera linearity, then the monitor adjusted for its own linearity independently.

If you use a fixed grating signal as obtained from some sync generators (such as the RCA TG-2) you will not be able to exactly "phase" the grating pattern with the ball chart intersections. (External grating signal generators normally employ a "phasing" control). For the studio camera, you can simply shift the camera or chart position slightly to one side to obtain superimposition. The slide can be shifted slightly in the holder on film setups.

Your grating generator must, of course, be adjusted to operate at the proper frequency to obtain the standard number of horizontal and vertical lines in the pattern to fit the ball chart intersections. This should be 900 cps for the horizontal bars (to check vertical linearity) and 315 KC for the vertical bars (to check horizontal linearity).

I will continue with the general subject of problems of linearity and shading, yokes, etc in the next Lecture. I will also show you how to measure "detail contrast" so that you can put "resolution" on a definite basis of measurement just as you have learned to do with geometric distortion in this Lecture.

EXERCISE 10-1: How can you tell whether "shading" is introduced by the pickup tube, or by the amplifiers and/or shading controls?

EXERCISE 10-2: What is the most common cause of shading in the vidicon film camera, other than "optics"?

EXERCISE 10-3: How many adjustments affect shading in the Image Orthicon camera in addition to the shading controls?

EXERCISE 10-4: Why should nearly all adjustments affecting shading in the Image Orthicon camera be made with the lens capped?

EXERCISE 10-5: You feed a 900 KC sine-wave signal to a monitor. What is the result?

EXERCISE 10-6: You feed a 315 KC sine-wave signal to a monitor. What is the result?

EXERCISE 10-7: Why can't you use sinewaves of the proper frequency for mixing with the ball chart signal in lieu of a grating generator?

ANSWERS TO EXERCISES

10-1: Any shading component originating in the pickup tube (particularly in the I.O.) will vary as a function of the light amplitude, which becomes video amplitude at the output. The shading generator signal remains fixed at any light level or video amplitude.

10-2: Non-linear sweeps. A perfect sawtooth current waveform thru the deflection yoke has a constant rate-of-change, hence the same velocity of scan across the target. Any departure from a sawtooth current waveform means the rate-of-change is not constant, and shading will result.

10-3: Assuming proper mode of focus (which I will discuss in more detail in the next Lecture), G-3 (multiplier focus) and G-5 (decelerator grid) are the most critical. (Adjust G-3 with lens capped). Proper use of the alignment controls may also improve shading characteristics.

10-4: Good shading characteristics depend primarily upon uniform collection of the secondary electrons as the return beam scans a small area (about ¼ inch) of the first dynode. Variations of the secondary emission ratio over the first dynode are amplified in the remaining dynode sections. The most severe case of shading is represented with the lens capped, since the beam is completely returned to the first dynode. Since the shading component amplitude is a function of the return beam, it is greatest in dark areas where return beam is maximum.

10-5: Look at it this way; if you feed a 60 cps sinewave to the grid of the kinescope, raster brightness is increased on the positive half-cycle, and decreased on the negative alternation. So you have a raster which is split vertically into one white-one black halves. This is ONE PAIR of bars. The number of pairs of bars placed upon the raster is equal to the applied frequency divided by the scanning frequency (in this case the vertical scanning frequency), minus any pairs that would be produced during vertical retrace time.

If 900 cps is applied, the number of bars produced is 900/60 = 15 pairs of bars. However, if the vertical retrace time (actually vertical blanking time) is 7.5% of the total scanning cycle, then 7.5% of the above number of bars are "covered up". Since 15 PAIRS of bars are produced for a total of 30 black and white bars, and 7.5% of 30 is 2.25; then

30-2.25 is 27.75 bars visible horizontally across the raster top-to-bottom. Since this is the total of black and white "stripes", there will be either 13 or 14 visible blacks or whites, depending upon the "phasing" of the sinewave to station blanking.

10-6: This is a multiple of the line scanning rate(15.75kc) hence will produce VERTICAL pairs of bars. The number of pairs is 315,000/15,750 = 20. If the horizontal blanking is 17.5%, then 17.5% of 20 = 3.5 and 20-3.5 is equal to 16.5 PAIRS of vertical lines. So there will be 16 vertical black or white bars on the raster.

10-7: The lines are too thick. A commercial grating generator narrows these to sharp pulses to give extremely thin black (or white) lines as shown by Fig 10-1 (B) and (C).

LECTURE ELEVEN

MORE ON SWEEP LINEARITY
PROPER BEAM ALIGNMENT
MEASURING DETAIL CONTRAST

The five general types of geometric distortion (in addition to those discussed in my last Lecture) are demonstrated by Fig 11-1.

(A). "S" distortion. You are probably familiar with this type of distortion in conjunction with G6 voltage (image accelerator) control on your camera. You pan the camera along horizontal lines and observe the departure from straight lines in the reproduction. It is the result of a non-uniform axial field in the pickup tube causing non-uniform rotation to the electrons in the scanning pattern. In practice, it is improper adjustment of pickup tube potentials, or the result of stray magnetic fields, or magnetized yoke.

(B). Pin-cushion. Normally results from improper distribution of windings in a picture tube (monitor) deflection yoke. Quite common in low-cost yokes, or an attempt to substitute a different yoke than intended for the particular kinescope.

(C). Same as (B) above; termed "barreling".

(D). Skewing can result in either pickup tube or monitor kinescope. It is the result of horizontal and vertical deflection coils not being perpendicular to each other. Color cameras employ "skew" controls either mechanical or electrical. In a monochrome camera, it can result from a magnetized yoke, or stray magnetic fields.

(E). Trapezoiding. Can be introduced either into the pickup tube or the display monitor. It is the result of one set of deflection coils not being equidistant about the axes of the other. The axes of the H and V deflection coils should effectively bisect each other. It can also be caused by a defective capacitor or resistor network used as built-in compensation for the difference in effective capacity of the two sides of the coil.

YOKE MAGNETIZATION. If you encounter a bothersome degree of geometric distortion typified by (A), (D), or (E) of Fig 11-1, you may have a magnetized yoke. First, note if the type or shape of distortion changes with change of location of the camera or monitor. If it DOES CHANGE with location, you have a stray magnetic field, either from power lines, transformers, rotating machinery, etc. If it DOES NOT CHANGE with location, you have a magnetized yoke, or something is strongly magnetized in the camera or monitor.

The most convenient way to demagnetize a camera deflection yoke is as follows:

(1). Disconnect the focus coil leads (please note I DID NOT SAY DEFLECTION COIL) from the terminal board. If no terminal board is used for the FOCUS COIL leads, simply disconnect the camera cable and locate where these leads go on the camera cable receptacle.

(2). Attach the output of a variac (with switch OFF) across the focus coil leads.

(3). Set the variac arm on 115 volts and plug into line.

(4). Turn variac ON. Reduce voltage to zero in about 5 seconds rotation.

(5). Turn variac OFF, remove variac leads and restore focus coil to normal operation. The YOKE should be de-magnetized.

If the above method doesn't work, it will be necessary to use the longer procedure of removing the entire yoke from the surrounding shield, and demagnetizing with a degaussing coil such as used for color picture tubes and receivers. Use the same coil on the entire camera. The very small hand-type degaussers such as used for magnetic audio heads are not effective in this procedure.

FIELD MESH IMAGE ORTHICONS. Many of you are faced with changing over from the non-field mesh I.O. (such as the 5820) to a field mesh tube (such as the 7293). For the field mesh tube, NEVER HAVE THE LENS CAPPED WITH YOU FIRST APPLY D.C. VOLTAGES TO THE CAMERA. The lens should be uncapped with some light falling on the photocathode, with the beam control UP to allow some beam current to flow. This prevents formation of static charges between the field mesh and target which can cause "sagging" of elements and consequent damage or shortened tube life.

The field mesh tube is more critical in beam alignment than the non-field mesh type. It will usually operate at top performance ONLY AT ONE PARTICULAR MODE OF FOCUS. For the 3-inch field mesh tube, grid 4 voltage will normally be in the range of 140 to 170 volts. Now look at Fig 11-2 which is the ORTH FOCUS circuit in the RCA TK-11 camera. This particular circuit has maximum voltage occuring at MAXIMUM COUNTER-CLOCKWISE rotation of the control. As the control is turned clockwise, voltage on grid 4 is reduced. The lowest voltage obtained is about 130 volts as shown. Thus in this particular camera, the "first mode" hit when starting from MAXIMUM CW position of the ORTH FOCUS control is usually the optimum mode of focus. On any other mode of focus, you may wind up with a coarse-mesh background in picture lowlights, also noticeable with the lens capped.

Now the field mesh type I.O. has no "white dynode spot" by which beam alignment is judged. Therefore the tube can be aligned just the same as the vidicon. Alignment current is adjusted so that the center of the picture does not change position as grid 4 voltage is varied.

A much quicker and more accurate method of beam alignment for these tubes is the "wobbulator" method. If you feed a synchronized 30-cps square wave to grid 4, beam mis-alignment will result in a split image of the entire pattern. It is then only necessary to adjust the alignment controls to converge the pattern into one well-defined image.

I am presenting to you herewith Fig 11-3(A) which is the schematic of a device I have used for several years, which really works. It has only two tubes, since you can "borrow" a plus-280 volts from a regulated supply in your existing installation. The 30 cps square wave output can be "looped-thru" all of your camera control units as shown by (B); thus only one "wobbulator" is capable of handling all cameras. Note that this line SHOULD NOT BE TERMINATEI This system requires adding the necessary "loop-thru" coax connectors to each control unit, and the addition of a switch as shown.

Now some of you may have built other "wobbulator" circuits that have appeared in various publications in the past, and found they didn't work. THE TROUBLE MAY NOT HAVE BEEN IN THE WOBBULATOR, but simply a result of the author(s) ignoring other aspects. For example, see Fig 11-3(C). If your camera happens to be similar to the RCA TK-11, the camera focus circuit has a resistor and bypass capacitor incorporated as shown. When this exists, very little of the "wobbulator" signal is transferred to the I.O. The drawing shows the necessary modification required for use of the wobbulator signal.

In practice, both the camera control and camera switch is thrown to "Align ON" position, and the beam is quickly aligned. (Remember to get G4 on the "optimum mode" of focus). Then both switches are thrown to the OFF, or normal operate position.

MEASURING DETAIL CONTRAST

The fact that you can "see" 600 lines horizontal resolution while someone else can "see" only 500 lines on the same test pattern reproduction is not meaningfull. There are too many variables here, including eyesight, psychology, and the condition of the display device used. There is only one way to put this on an absolute and measureable basis; the use of the line-selected sweep such as provided on your 524-AD scope, or other "strobe-line" devices.

Review pp 25-26 of your Reference Text for use of the 524 scope delayed selected-line sweep and the Line-Indicating-Video Output jack. Fig 11-4 herewith shows typical monitor and CRO displays. You adjust the DELAY control to move the gated indicating line (on the monitor) to the position desired for measurement. The relative amplitudes of the test pattern wedges on your CRO provides a direct and reliable measurement of the detail contrast. Normally the 100-line wedges will be the same amplitude as the reference (flat-field) amplitude. The 300-line response of the 3-inch I.O. will be something less than this, but should be around 80% when the lens is operated one or two stops above the knee.

A better type of test chart to use is shown by Fig 11-5(A). Fig 11-5(B) shows a typical trace for a "good" I.O. and optimum system. Note that with this pattern you can measure detail contrast at "top" and "bottom" of the scanning pattern relative to "center response" with identical information. Fig 11-6 illustrates a very useful type of "burst test chart" for the live I.O. camera, or in slide form for the vidicon camera. This type of measurement tells you DEFINITELY the resolution capability of the I.O. or vidicon tube as it compares to other tubes used in the same camera head. It leaves nothing to human judgement.

Special test patterns I have discussed in this Lecture are obtainable from a number of sources, among whom are:

Tele-Measurements, Inc., 72 N. Mitchell Ave., Livingston, N.J.
Marconi, distributed by Ampex Corp.

I am deleting the usual "Exercises" from this Lecture. The next (and Final) Lecture will be new material in Q&A form along with a complete "final exam" covering all the problems we have discussed.

LECTURE TWELVE

FINAL EXAM IN Q&A FORM

Q1. You notice a random type of interference running along the blanking level on your scope when viewing the vertical-rate sweep of an incoming video signal. Expanded sweep gives you 1 cycle in 1000 us. What is the frequency of the interference?

A1. The frequency is:

$$f = \frac{\text{cycles/cm}}{\text{sweep time/cm}} = \frac{1}{0.001} = 1{,}000 \text{ cps}$$

Q2. You want to quickly set a 5mc oscillator frequency by using the scope, and can accept the tolerable error of this method of adjustment. To get one cycle in one centimeter, what time base do you use?

A2. You use the following fundamental relationship:

$$\text{sweep time/cm} = \frac{\text{cycles/cm}}{\text{freq}} = \frac{1}{5(10^6)} = 0.2 \text{ us/cm}$$

so you adjust the oscillator frequency to get one cycle in one centimeter with a sweep time base set on 0.2 us/cm.

Q3. What is your "primary standard" for amplitude calibration of the scope, and checking AC and DC meters?

A3. The most convenient method not requiring "laboratory type" standards is described in your Reference Text, page 22. "Unloaded" mercury cells used for this type of service would be replaced about every 24 to 30 months with "fresh" cells.

Q4. Is it normal for video AGC amplifiers to pass short-duration video peaks outside the normal tolerances of gain control?

A4. Yes! Remember that AGC action depends upon deriving a control voltage relative to the amplitude of the video signal. Therefore a time constant is involved, and AGC action actually will be influenced by the duty-cycle (APL) of the video signal. It is possible that a "line-to-line" AGC action could be designed, but then lines that are actually in black would be raised into the noise region. White clipper circuits are necessary to prevent excessive amplitude excursions of very short-duration "spikes" in the picture waveform. See your Reference Text, pp 36-37 for general discussion of AGC amplifier testing, and remember that this does not consider extremely short-duration (high-frequency) excursions, which can be noted on the scope in wideband response position at horizontal rate time base.

Q5. What type of tube checker should you use for preventive maintenance tube-check schedules, and what should you check for?

A5. Use a reliable dynamic-transconductance type with provisions for checking high-resistance inter-electrode shorts, and provision to measure voltage-regulator tubes. In spite of what the I.B.'s say, it is not necessary to keep a record of measured transconductance. Use the GOOD-BAD scales which automatically allow manufacturers' tolerance (even on new tubes). Run the shorts check, and test all voltage regulator tubes for firing voltage and regulation within the specified current range. This type of tube testing should be done about every 90 days. After tube replacements, remember to run a complete performance analysis on the units involved, making any necessary adjustments. RE-CHECK after a four-day run-in time.

Q6. You have built the mercury-vapor rectifier checker on page 261 of your Reference Text, and find that it is suitable for certain types of gas rectifiers but not for others. What is wrong?

A6. It should have been stated on page 260 that this type of simple check is possible only for gas tubes (such as the 866 and 8008) where the filament directly faces the plate. Certain types of tubes (such as the 673) employ an indirect (cathode) heater which provides an extra element between filament and plate. This projection acts similar to a grid since it is connected to one side of the filament, and will be either positive or negative with respect to the plate, depending upon which way the filament transformer is connected. The best way to field-test this type of tube is described in an RCA Bulletin: "Pulse Method of Testing Hot-Cathode Gas Tubes", Application Note AN-157. If this Bulletin is not included in your I.B., write to RCA Tube Dept., Harrison, N.J. and request same. The circuitry is more involved, but is worth your time.

Q7. You measure a video Signal-to-Noise ratio of the overall STL as 38 db. Would you expect this same S/N ratio measured at the transmitter output?

A7. Depends upon how you measured this. "Wide-band" noise level as measured on the scope without bandwidth limiting will be GREATER directly off the STL than the same signal thru the transmitter, due to the bandwidth limiting (to 4.2mc) of the transmitter. The most accurate method of taking video S/N measurements is by a wideband (to 6mc) VTVM such as the Ballantine meter. Never use the detector normally employed for AM noise measurement of an FM aural measurement fed into the Noise and Distortion meter for video S/N measurement. The audio N-D meter only includes measurements to about 30 kc which is useless for video.

Q8. Should S/N measurement of an STL system include the hum component?

A8. No. The two measurements should be made separately. See your Reference Text, pp 225-227 for details.

Q9. How can you tell where sync compression is occuring in the video transmitter? What do you do to minimize this compression?

A9. If you are feeding, for example, a 50-50 ratio of video-to-sync INTO the modulator, you should get substantially this same ratio OUT. If ok here, the compression is occuring in the modulated stage or following linear amplifiers. For the MODULATED STAGE, adjust the RF drive and DC modulator current (bias) for optimum linearity, being careful not to exceed plate dissipation ratings of tubes. For any following LINEAR RF AMPLIFIERS, if the bias is insufficient and RF drive excessive, sync compression will occur. Remember that since sync is maximum carrier power, when modulator or RF tubes start to lose emission, sync drive must be increased. Also there is a limit as to how far the grid circuit can be tuned above carrier frequency without excessive SWR or sync drive requirements. Try moving the first linear amplifier grid closer to carrier frequency, then tune following linear amplifiers for proper operating point above the carrier to get required lower sideband suppression.

Q10. How do you check a sync generator for proper "interlace"?

A10. This is very simple if you have an "interlaced" pulse cross monitor. (Reference Text: pp 81-84). If your pulse cross monitor simply employs half-rate sweeps, a single field only is displayed, such as on the RCA TM-6A-B-C Master Monitors. In this case you employ the Tektronix 524 scope using delayed sweep per Reference Text page 85. See waveforms, Fig 3-1, page 52 of your Text. (Waveforms N and P). If your scope displays waveform N, note that a full line occurs between the last H sync pulse of field 1 and the first equalizing pulse. Note also that a half-line occurs between the last trailing equalizing pulse and the first H sync pulse. Operating the "field shift" button on your 524 scope will now display waveform P. On this display note that you have a half-line interval between the last H sync pulse of field 2 and the first equalizing pulse, and a full-line interval between the last trailing equalizer pulse and the first H sync pulse. This indicates your sync is properly interlaced with the half-line difference between fields.

Q11. If a slightly excessive beam current is used on a vidicon and a "split image" results, what are the two most likely sources of trouble?

A11. This is a result of low filament emission caused either by low vidicon filament voltage, or a weak vidicon tube.

Q12. If you are given the project of working up your own chart similar to Fig 11-5 (last Lecture) for studio use, how would you procede?

A12. A good overall dimension to use with proper aspect ratio is 18-inches high by 24-inches wide. Now the width of a line to represent a given TV-line number is:

$$\text{Width of line} = \frac{1}{N} \times \text{picture height.}$$

where N represents the given line number to be represented. For example, for a TV line number of 100: 1/100 = 0.01 and this times the pix height (18 inches) = 0.01 X 18 = 0.18" (or about 3/16"). For 300 lines:

1/300 X 18 = 0.0033 X 18 = 0.0594" (about 1/16").

Q13. You have noticed that when setting up I.O. cameras out-of-doors with long camera cable runs, you seem to be continually running out of Image Focus (photocathode focus) range, particularly after the cables heat up from direct sunlight. Can you do anything about this?

A13. The first thing you can do is to lower the FOCUS CURRENT for the duration of the remote telecast in order to get a reasonable picture. For example, if you normally use 75 ma focus current, reduce this to between 70 and 72 ma and readjust sizes and alignment, etc. Picture sharpness might suffer a little, but not as much as running out of range on Image Focus. The problem occurs as a result of drop in insulation resistance in some camera cables when heated. The critical conductors are the two leads going to one side and the arm of the photocathode voltage potentiometer, variously termed "Image Focus" or "P.C. Focus" on the camera control unit. For instance, this is pins 15 and 21 on the RCA TK-11 camera chain. Each of these conductors are one of two groups of seven conductors which are arranged in a circle of six with the seventh in the center. If you have this problem, remove the protective bell cover at each end of the camera cable, and check to make sure that a CENTER conductor is used for one pin in one group and for the other pin in the other group. IF NOT, simply interchange the conductor with whatever pin is connected to the center conductor. This will increase conductor-to-ground resistance.

Q14. What are the problems most likely to be associated with the Image Orthicon tube itself, rather than amplifiers?

A14. These can be outlined as follows:

SPOTS

(A). Those that defocus when the photocathode focus (Image Focus) is varied. This can be dirt on the faceplate. Open the lens iris. If the spots grow in size and contrast decreases, clean tube faceplate and/or other optical components in the system. If no change in size occurs, the photocathode itself is blemished. Adjust for best point to minimize.

(B). Those that remain UNCHANGED when P.C. focus is varied, but defocus when beam focus (Orth Focus) is varied. This is defects on the target or field mesh. You might be able to return the tube to the factory for possible correction. Check with the Manufacturer.

(C). Large white spot near center of raster, if observed with lens capped, and does not change with focus control, you have an ion spot. You must return the tube to the factory for reprocessing. This sometimes occurs in tubes THAT HAVE NOT BEEN OPERATED PERIODICALLY. Be sure to rotate your I.O.'s at least once a month, with all spare tubes.

PORTHOLING (DARK CORNERS IN PICTURE)

Usually improper adjustment. Open lens to operate over "knee" of transfer curve. Then adjust G-5 (decelerator grid) for best beam landing (best corner brightness). You might need to align the beam on a different loop (mode) of focus and readjust G-5. You also may need to slightly readjust G-3 (multiplier focus) to provide maximum uniform signal output. This should normally be adjusted with lens capped.

If the above procedure fails to affect portholing, change the lens and note whether pix improves. If it does, you have a vignetting lens. (Highly improbable). You might also have a magnetized yoke, which you should handle per instructions from previous Lectures.

NOISE IN PICTURE

First, kill the beam and check for amplifier noise with GAIN control on Control Unit at reference operating level. If no noise is apparent you will observe that turning the beam up will bring in the noise. This is a noisy I.O. If there IS some noise present (with beam OFF), you can sometimes temporarily handle this situation by increasing the ORTH GAIN control (dynode voltage) when provided on the camera, to override amplifier noise. This is only a temporary solution where time does not permit servicing the amplifier.

If the noise is definitely coming from the I.O., check target voltage adjustment, and see if adjustment of G-3 (multiplier focus) for maximum signal output will minimize noise. Be sure you are using sufficiently high lighting level to allow operation over the knee at normal lens f:stops.

COARSE MESH PATTERN IN PICTURE (Field-mesh types)

This is caused by alignment of the beam on the wrong loop (mode) of focus. I have discussed this in a previous Lecture. If you are unable to obtain proper voltage mode of operation, try using a different focus coil current, within 4 or 5 ma of your normal current. Remember that a field-mesh type I.O. will "align" properly on only one mode of operation which is near center to minimum operable G-4 volts.

SOFT PICTURE (POOR RESOLUTION)

The only way you can be sure of whether this is caused by the I.O. or by the associated amplifiers (unless lengthy video sweep procedures are used) is to interchange the tube with one giving a good picture in another camera. ALWAYS BE SURE THAT THE LENS AND FACEPLATE ARE SCRUPOUSLY CLEAN. Check that the blower motor and filters are in good shape so that the tube is not running too hot. Also be sure you don't have magnetic field problems by turning OFF the blower motor and other adjacent electrical machinery temporarily and noting effect. If your resolution changes with location of camera, this is almost certainly a clue. NEVER FORGET to double-check settings of such controls as filament voltage switches (usually in the camera) and cable-length switches (usually in the camera control or processing unit). Whenever you go to longer camera cables or to shorter camera cables, these should be properly reset. Otherwise resolution can suffer, along with encouragement of other problems.

Q15. What should you do if any part of the Reference Text or this Lecture Material is not clear to you, or you feel uncertain as to whether you understand it?

A15. Write Your Instructor.