101 WAYS

to use your... OSCILLOSCOPE

by
ROBERT G. MIDDLETON

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101 ways to use your

OSCILLOSCOPE

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PREFACE

Books of the *101 Ways to use your Test Equipment* series are *working handbooks* with an emphasis on practice, not theory. The information is presented without frills or double talk; it is designed to show you how to do various jobs with your equipment as efficiently as possible.

Oscilloscopes have changed in the years since this book was first published. Wide-band scopes are now standard equipment, and the triggered-sweep scope (formerly almost a laboratory curiosity) can now be found in the better-equipped service shops. Consequently, material has been added on these instruments. Their unique features are demonstrated in several of the suggested uses.

Since the television set has the most involved electronic circuitry the average serviceman encounters, much of this book is related to testing the various sections of this type of receiver. Using square waves to evaluate circuits and components is also explained. Time-constant charts for some of the common circuits have been added to this revision.

This book has a twofold purpose: to help you understand how to make waveform tests with an oscilloscope, and to show you how to analyze the waveforms produced by defective circuits. A careful study of these pages should make your work easier and more effective.

ROBERT G. MIDDLETON

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INTRODUCTION

Most servicing is done with voltmeters.

An oscilloscope is a voltmeter. It is a more complete voltmeter than a VOM.

A scope gives more complete information than a VOM (or VTVM) because it shows how a voltage rises and falls in a receiver circuit. This rise and fall is called the waveform of the voltage.

It is sometimes supposed that a scope is difficult to operate. As a matter of fact, it is easier to learn how to use a scope than to learn how to ride a bicycle.

Just as we can go places faster on a bicycle than on foot, we can troubleshoot TV receivers faster with a scope than with a voltmeter. For example, a meter cannot show whether a voltage is "ringing"—a scope does. A meter cannot show whether a signal is undistorted, clipped, or noisy—but a scope does. A meter cannot indicate the occurrence of parasitics, cross talk, or phase shift—a scope shows these troubles at a glance.

Using a scope can be an interesting procedure, as well as a profitable one. The service technician who understands scope operation is worth more to himself and to his employer than one who is handicapped by ignorance of this important instrument.

Although this book is titled *101 Ways to Use Your Oscilloscope,* there are also many other ways to use a scope. Additional applications will be found in the companion volume, *101 Ways to Use Your Sweep Generator*.

This book is not intended to be used as a textbook. It is a practical working handbook for the professional service technician. However, if you have never used a scope before, you will find it helpful to read the next few pages carefully. Here you will find a practical discussion of peak-to-peak, instantaneous, effective, and average values of sine waves and how they tie in with the peak-to-peak values of complex TV waveforms.

Peak-to-Peak, Instantaneous, Effective, and Average Values

TV service literature frequently refers to "peak-to-peak" voltage values. The AC voltage scales of a volt-ohm-milliammeter indicate *rms* voltage values. The meter movement in a VOM responds to the *average* value of a rectified sine wave. What do these various terms mean?

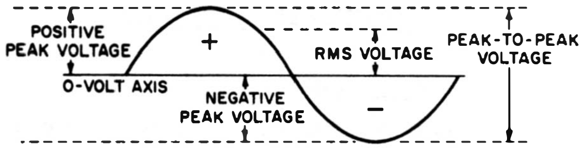


Fig. 1. A sine wave.

A sine wave, with its important component values indicated, is given in Fig. 1. The highest value reached in any one direction by a waveform is called the *peak* value. The *peak-to-peak* voltage is equal to the total excursion from the positive peak to the negative peak. The two peaks of the sine wave have the same value on both positive and negative half-cycles—that is, a sine wave is a *symmetrical* waveform. The peak voltage is equal to one-half the peak-to-peak voltage. The rms voltage is equal to 0.707 the peak voltage.

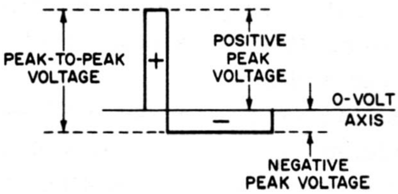
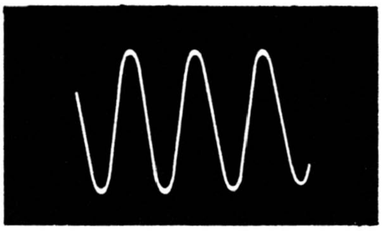


Fig. 2. A pulse waveform.

Of course, not all television waveforms are symmetrical. For example, consider a pulse waveform as shown in Fig. 2. Note that here the positive-peak voltage is not equal to the negative-peak voltage. However, the positive area of the waveform is equal to its negative area. The sum of the positive-peak and negative-peak voltages is equal to the peak-to-peak voltage.

Pulse waveforms are common in television receiver operation, as shown in Fig. 3. In Fig. 3A, the 3.58-mc color oscillator signal is shown. This waveform has a peak-to-peak voltage of 55 volts. Fig. 3B shows the waveform at the grid of the vertical output tube, and Fig. 3C shows the waveform at the plate of the same tube. The peak-to-peak voltage of the waveform shown



(A) 3.58-mc color oscillator signal.

(B) Vertical sweep voltage at grid of vertical output tube.

(C) Vertical sweep voltage at plate of vertical output tube.

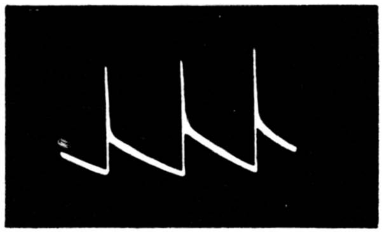


Fig. 3. Typical waveforms found in a TV receiver. *(Courtesy Motorola, Inc.)*

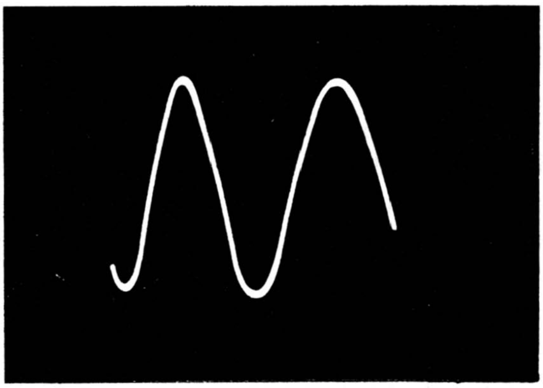
at B is approximately 150 volts, while the one shown at C is approximately 1,500 volts, depending upon the settings of the Vertical Size and Vertical Linearity controls.

The value of the voltage at any point on the waveform is called the *instantaneous* voltage at that point. Thus, the peak voltage of a waveform is an instantaneous value. A given point on a waveform can be identified in terms of time (such as the $\frac{1}{8}$-cycle point), or it can be identified in terms of an angle (such as 45°).

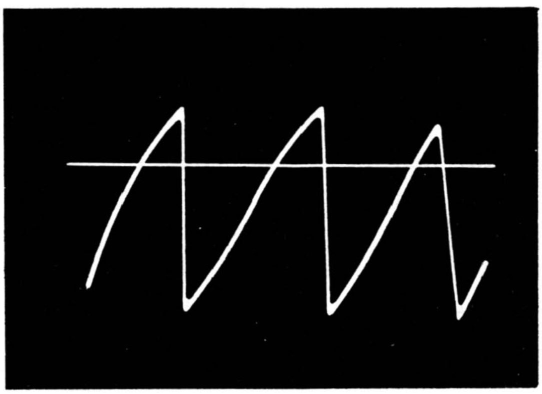
As seen in Fig. 1, the *average value* of a *sine wave* is *zero*—that is, the average value over one complete cycle is zero. It is sometimes puzzling to consider how we can speak of "10 milliamperes of alternating current," because the instantaneous value of the current is continuously changing and the average value of a complete cycle is zero. The puzzle is solved by first recognizing that, although the average value of an AC current is zero when tested with a DC meter, it does have some finite value when tested with an AC meter. Furthermore, when an alternating current is used for heating a soldering iron or for lighting the filament of a tube, for example, *both* the positive and the negative half-cycles of the waveform effectively produce heat or light and do *not* cancel out. Cancellation occurs only when the AC waveform is applied to a DC utilization device, such as a DC voltmeter.

Early in the development of the electrical industry, DC was used exclusively for heating, lighting, and power. Later, AC was found to be more economical to distribute and use, and AC power systems gradually displaced DC power systems. Now, the industry faced a new problem. A unit of voltage and current measurement was needed, whereby "110 volts" of AC would produce the same amount of heat, light, or power as "110 volts" of DC. What unit of AC measurement produces this equivalence?

Equivalence is realized when AC is measured in terms of "effective" values. In other words, the *effective* value of an AC current corresponds to a *DC value*. A soldering iron will get just as hot when energized by 110 volts of DC as it will by 110 effective volts of AC. Usually, we speak of an effective value as an rms value. As noted in Fig. 1, the rms value is equal to 0.707 the peak value. Service voltmeters are normally calibrated to read AC voltage and current in terms of rms values. The initials "rms" stand for "root mean square."



(A) Sine wave.



(B) Sawtooth wave.

Fig. 4. A sine wave and sawtooth wave with equal peak-to-peak voltage values.

Thus, we can compile the useful relations of *sine-wave* voltages:

PEAK-TO-PEAK VOLTAGE = 2 × PEAK VOLTAGE
PEAK VOLTAGE = ½ × PEAK-TO-PEAK VOLTAGE
RMS VOLTAGE = 0.707 × PEAK VOLTAGE
PEAK VOLTAGE = 1.414 × RMS VOLTAGE
PEAK-TO-PEAK VOLTAGE = 2.83 × RMS VOLTAGE

Furthermore, if you are using a DC scope, you need to know that when you apply a 1.5-volt battery across the vertical-input terminals of a DC scope, the trace will move the same vertical height as when a 1.5 peak-to-peak, sine-wave voltage is applied. (This is discussed and illustrated in detail in the text.)

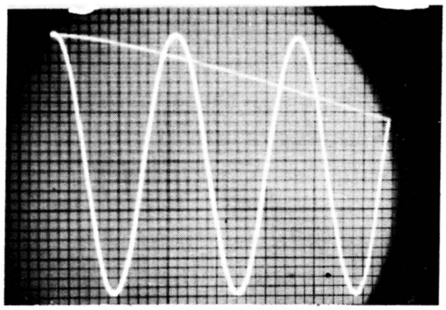


Fig. 5. Appearance of a graticule, used to measure peak-to-peak voltages.

The peak-to-peak voltages of the sine wave and sawtooth wave in Fig. 4 are equal. On the other hand, it is clear that the rms voltages of the two waveforms are *not* equal.

Of course, the relationships for AC *current* are the same as those for AC voltage, as given in the foregoing tabulation. Note very carefully: *rms relations are for sine waves only.*

When a scope is used to measure peak-to-peak voltage values, a ruled screen (graticule) is placed over the face of the CRT, as shown in Fig. 5. This screen permits accurate counting of vertical intervals of deflection when measuring peak-to-peak voltages.

Oscilloscope Specifications

Service scopes are commonly rated for vertical-amplifier sensitivity on the basis of rms volts-per-inch of deflection. In practice, the service technician is concerned with peak-to-peak volts, but manufacturers prefer to rate scopes in terms of rms volts because it makes the scope "look better." Thus, a scope having a sensitivity of 0.01 rms volt per inch has an equivalent sensitivity of 0.028 peak-to-peak volt per inch. It is apparent that, to the casual reader of specifications, the rms rating gives the superficial appearance of higher sensitivity. This practice is now so firmly entrenched that it is not likely to be changed in years to come. However, a minority of scope manufacturers rate the sensitivity of the vertical amplifier in a scope in terms of *both* rms volts per inch and peak-to-peak volts per inch.

A few service scopes are rated in terms of rms volts per centimeter, and this type of rating makes the scope appear still more sensitive to the casual specifications reader. An inch contains 2.54 centimeters, and hence a scope having a sensitivity of 0.01 rms volt per inch has an equivalent sensitivity of approximately 0.004 rms volt per cm.

To illustrate these points with a specific example, consider a scope having a sensitivity of 0.01 rms volt per inch. All of the following ratings are exactly equal to one another:

rms volts per inch	0.010
Peak-to-peak (or DC) volts per inch	0.028
rms volts per centimeter	0.004
Peak-to-peak (or DC) volts per centimeter	0.011

Service scopes vary in vertical-amplifier bandwidth from 500 kc to 5 mc. The uniformity of response (flatness) also varies greatly. The most important requirements for wide-band flat response arise in color TV tests. (Readers interested in vertical-amplifier response may refer to the companion volume, *101 Ways to Use Your Sweep Generator*.)

Triggered-Sweep Scopes

There is growing interest in triggered-sweep scopes that have wide-band response. This type of scope is used with fast-rise square-wave generators to make accurate checks of amplifiers, TV receivers, circuit sections, and components. A triggered-sweep scope is not so very different from an ordinary scope in many respects. However, the sweep oscillator of the scope is normally biased beyond cutoff so no horizontal deflection occurs until there is a sync (trigger) signal of sufficient amplitude to bring the sweep

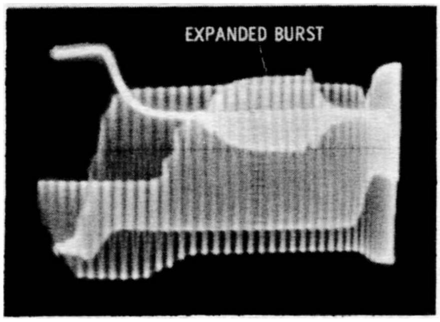


Fig. 6. Color burst expanded on an ordinary scope.

oscillator out of cutoff. Then the beam is deflected across the face of the scope once by a single sawtooth cycle. The beam rests after the one sweep until the sync signal rises once again to the triggering level.

This triggering function might seem to be a minor feature, but it actually has great utility. For example, if you try to expand a color burst on the screen of an ordinary scope, a confused and overlapping display is obtained (Fig. 6). On the other hand, a

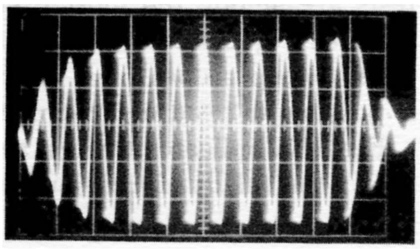


Fig. 7. Color burst expanded with a triggered-sweep scope.

triggered-sweep scope provides the expanded display seen in Fig. 7. Why is there no overlap in the pattern of Fig. 7? It is because the beam deflects only once for each horizontal sync pulse, regardless of sweep speed. Since the sweep speed can be set at any value, we choose a speed that fills the screen horizontally with only the burst display. Unlike a conventional scope, sync lock is unaffected by changing the horizontal sweep speed.

Again, when square-wave tests of receivers, amplifiers, or cir-

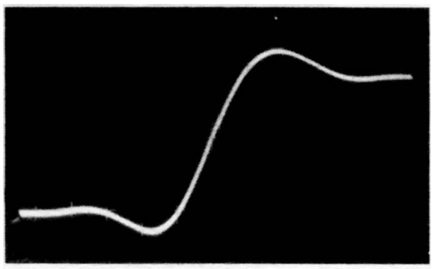


Fig. 8. Expanded leading edge of a square-wave display.

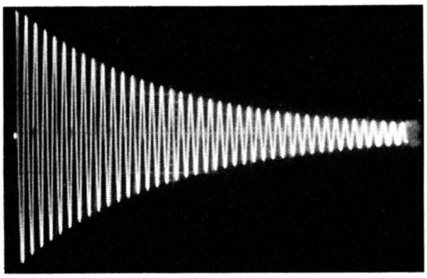
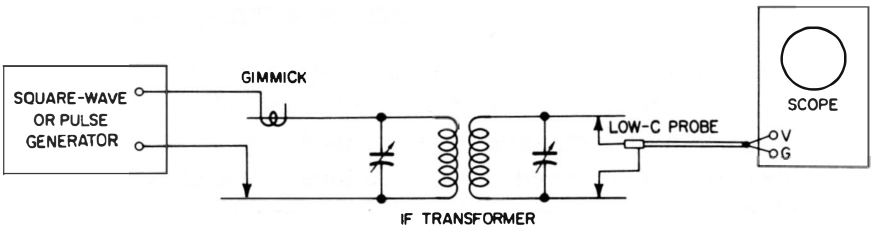


Fig. 9. Ringing test of a single coil.

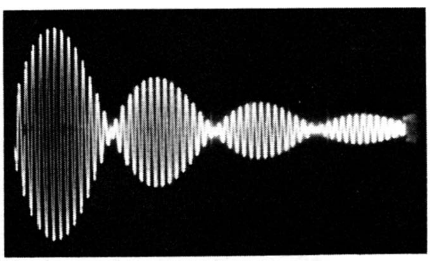
cuits are made, rise-time measurement provides essential test information. To measure rise time, the leading edge of the reproduced square wave must be expanded as illustrated in Fig. 8. A confused, overlapping pattern is avoided by employing triggered sweep.

Technicians know that modular construction of TV receivers has already begun. Printed components have been with us for years, and sealed, encapsulated blocks containing several ordinary components are in regular use. Square-wave testing is most suitable for analyzing these multiple component modules. Ringing tests are among the most useful methods of checking inductive circuits. Fig. 9 displays a ringing pattern from a single coil. Triggered-sweep scopes have calibrated horizontal controls, making it possible to read out complete information concerning the coil.

Fig. 10A indicates the test setup of the equipment, and Fig. 10B shows the result of a ringing test on an ordinary IF transformer.



(A) Test setup.



(B) Ringing pattern.

Fig. 10. Making ringing tests of transformers.

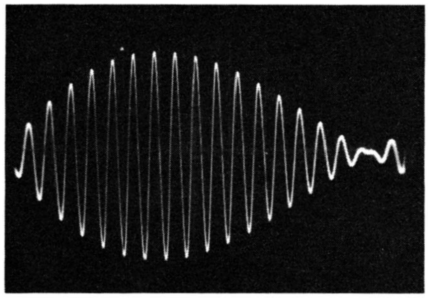
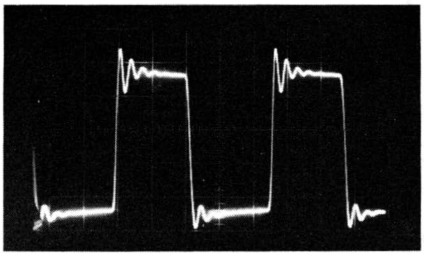
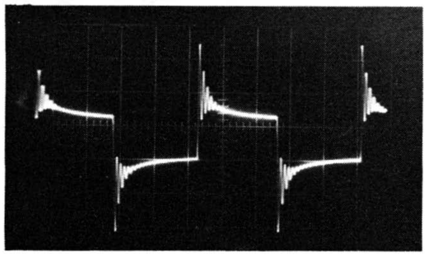


Fig. 11. Expansion of ringing pattern.

To the technician "in the know" this pattern provides complete information concerning the transformer; even the number of cycles in each ringing group is significant. A group display can be expanded when a triggered sweep is used as shown in Fig. 11. Amplifiers often ring when tested with a square-wave signal (Fig.



(A) 2-kc square-wave response with resistive load on the amplifier.



(B) 2-kc square-wave response with voice-coil load on the amplifier.

Fig. 12. Ringing in an amplifier.

12). The ringing interval is an important part of the waveform that is taken into consideration in square-wave analysis. Some of these characteristics are discussed further under specific tests described subsequently.

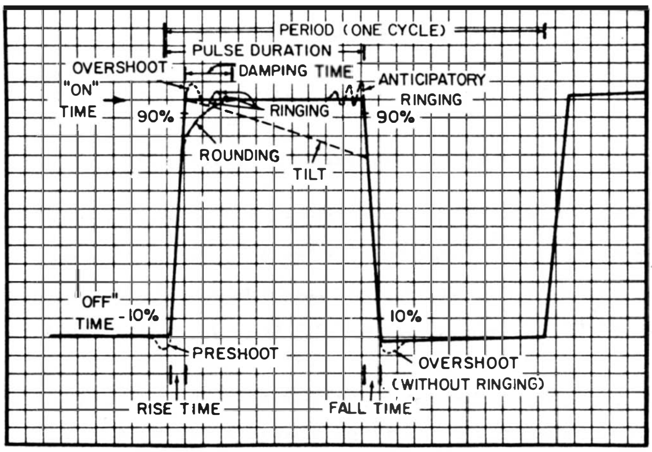
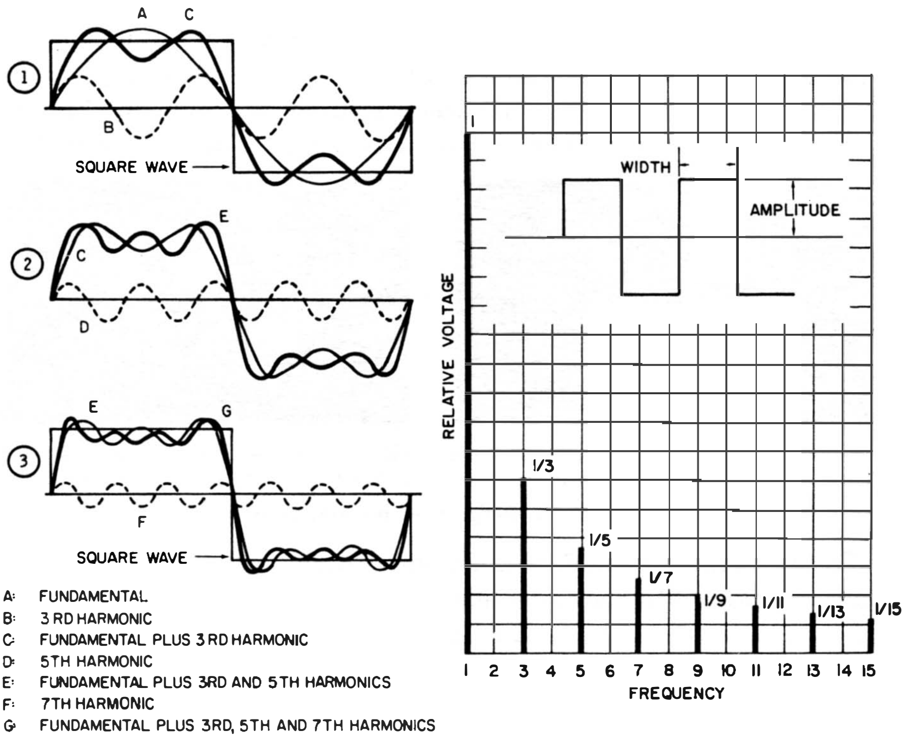


Fig. 13. Terminology of the square wave.

High-quality instruments (the only practical kind for accurate square-wave testing) provide square-wave signals and screen patterns having a rise time of approximately 25 nanoseconds (0.025 microsecond) or faster. The basic terminology of square waves is noted in Fig. 13. When the output from a square-wave generator is fed directly to a scope, preshoot, overshoot, ringing, rounding, and tilt should not be noticeable if the scope has a rise time at



(A) Building a square wave from sine waves.

(B) Harmonic amplitudes in a perfect square wave.

Fig. 14. Analyzing a square wave.

least twice as fast (12 nsec) as that of the square-wave generator. Generators of lesser quality can be used in square-wave tests, but the limitations of the generator have to be allowed for in evaluating, a reproduced waveform, and this is sometimes a confusing task.

There are two ways of regarding a square wave. The easiest way is to assume that a square wave is composed of a very large number of sine waves, as depicted in Fig. 14. This viewpoint is useful for rough checks, but it has two disadvantages. First, if you try to apply Ohm's law from this viewpoint, there are so many sine waves to contend with that the solution of Ohm's law becomes prohibitively difficult. Second, there are many situations in which the assumption of a very large number of sine waves (theoretically an infinite number) will actually give the wrong answer. This is because the sine-wave viewpoint assumes that the circuit has a very large bandwidth (theoretically an infinite bandwidth), and this is contrary to fact.

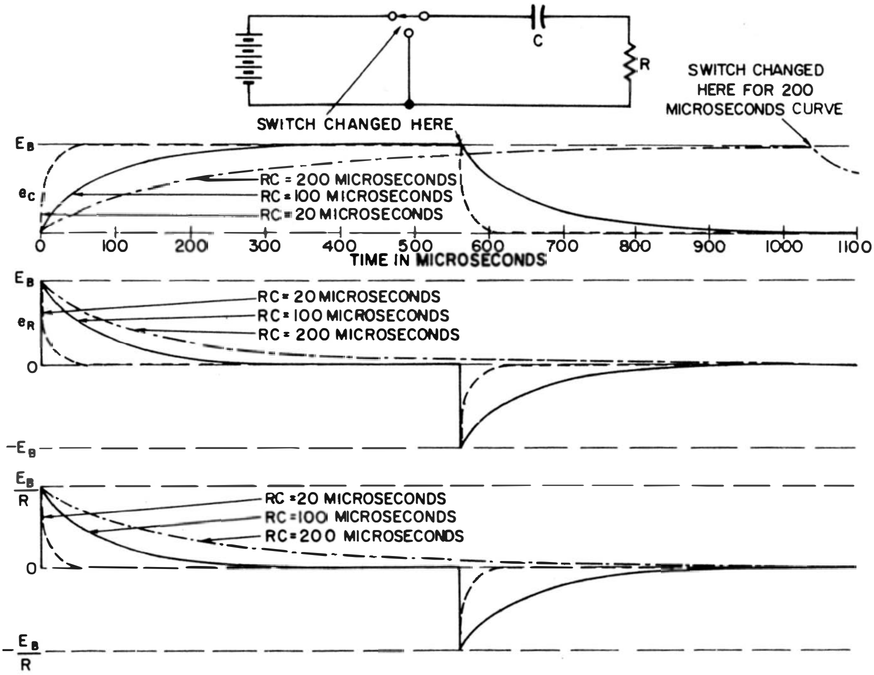


Fig. 15. Effect of varying R and C in an RC circuit.

Therefore, the better way to regard a square wave is to recognize that it is generated by switching a DC voltage off and on at regular intervals. This way we are concerned basically with exponential waveforms, such as are depicted in Fig. 15. Ohm's law can then be effectively applied to the circuit under test, and the correct waveform determined. Actually, it is not necessary to make step-by-step Ohm's law calculations in a circuit such as shown in Fig. 15. Instead, a universal RC time-constant chart can be used. From it values for voltage at any instant can be determined without going through any involved calculations.

EQUIPMENT CHECKS

U1

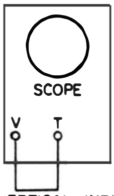
To Display a 60-Cycle Sine Wave on the Scope Screen

Equipment: None, if scope has a 60-cycle, test-voltage terminal on the front panel. If not, use a convenient voltage source, such as a heater line from a TV chassis.

Connections: Run a test lead from the 60-cycle, test-voltage terminal on the scope panel to the vertical-input terminal of the scope. (If external 60-cycle source is used, connect a test lead from the source to the vertical-input terminal of the scope. Also, connect a test lead from the ground point of the source to the ground terminal of the scope.)

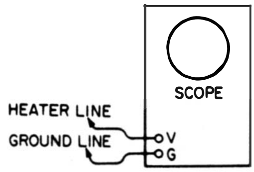
Procedure: Set the scope controls for sawtooth horizontal sweep at a rate from 15 to 60 cycles. Set intensity and focus controls for moderate brightness and good focus. Set vertical-gain controls for approximately ½ or ⅔ full-screen deflection. Adjust horizontal-gain control for about ½ to ⅔ full-screen deflection. Adjust synchronizing controls to lock pattern on screen. (Effect of control settings is illustrated on following pages.)

Evaluation of Results: The pattern should be linear (undistorted), both vertically and horizontally.



V= VERTICAL-INPUT TERMINAL
T= 60-CYCLE TEST-VOLTAGE TERMINAL

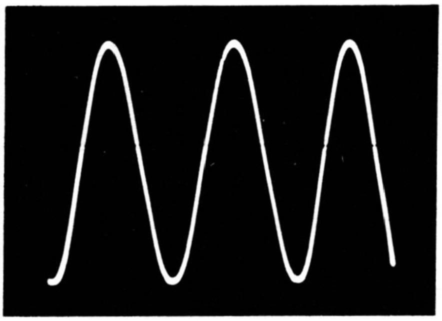
(A) Using internal 60-cycle voltage.



V=VERTICAL-INPUT TERMINAL
G=GROUND TERMINAL

(B) Using external 60-cycle voltage (heater line).

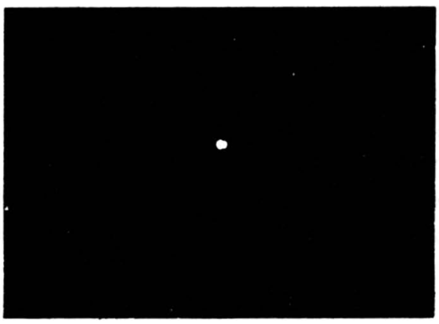
Connections for viewing a 60-cycle waveform on a scope screen.



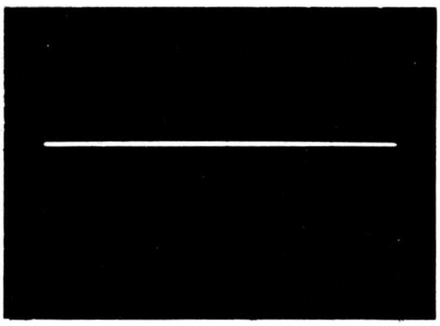
Waveform when a 60-cycle sine wave is viewed at a horizontal sweep rate of 20 cps. Three cycles are displayed. NOTE: A portion of one cycle is lost on retrace.

NOTE 1

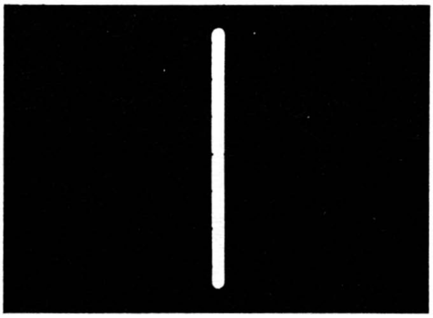
Zero Settings of Scope Gain Controls



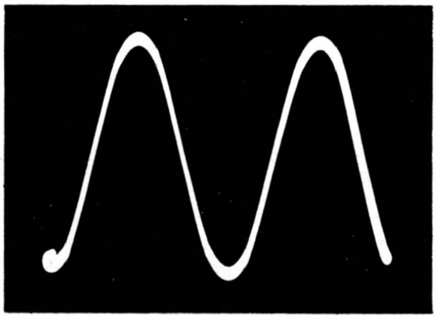
Both horizontal and vertical gain controls set to zero.



Horizontal gain advanced; vertical gain zero.



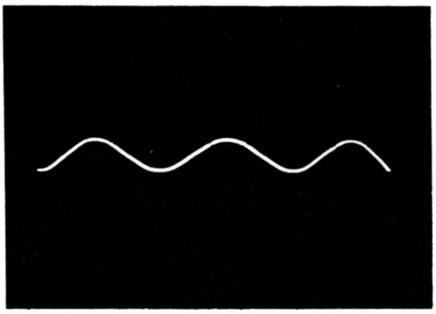
Vertical gain advanced; horizontal gain zero.



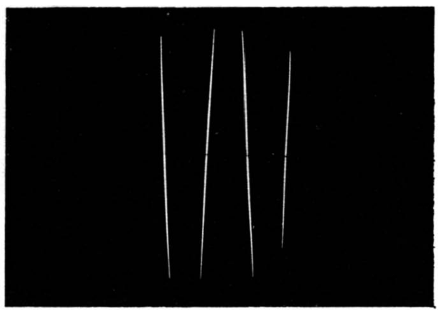
Both vertical and horizontal gain controls advanced.

NOTE 2

Checking the Operation of the Vertical Gain Controls

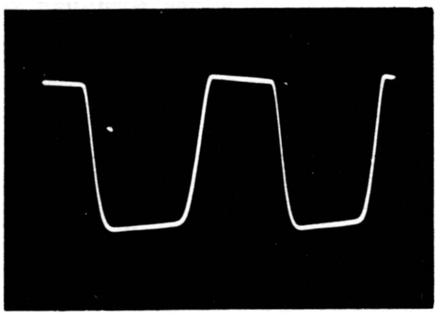


Vertical gain control set too low.



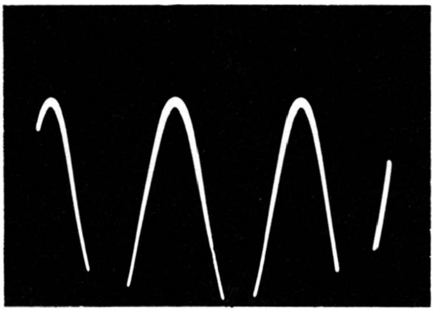
Vertical gain control set too high.

Vertical step attenuator set too high; vernier vertical gain control set too low. Vertical-input stage is overloaded and sine wave is clipped.

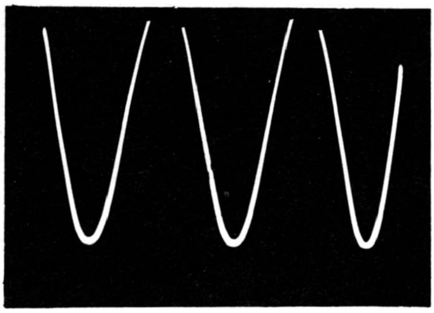


NOTE 3

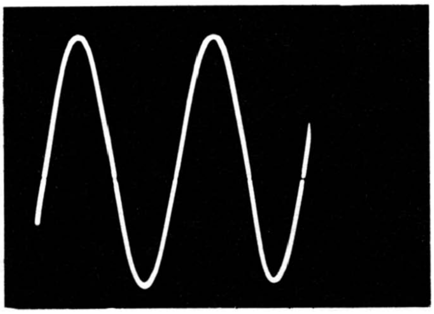
Checking the Operation of the Centering Controls



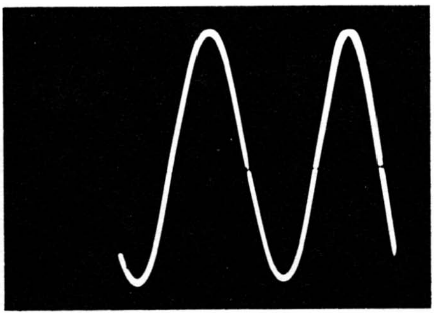
Vertical centering control set too low.



Vertical centering control set too high.



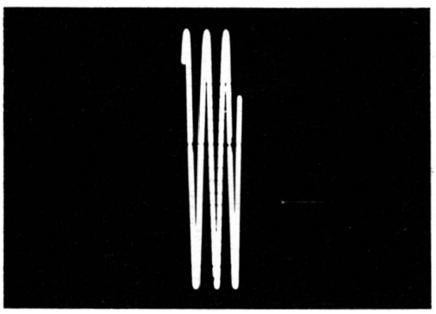
Horizontal centering control set too far left.



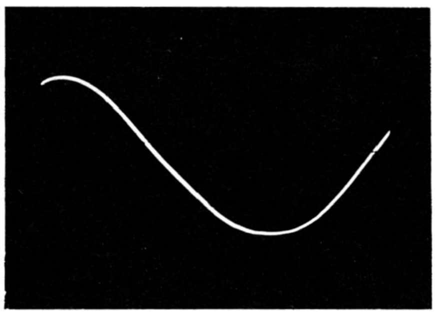
Horizontal centering control set too far right.

NOTE 4

Checking the Operation of the Horizontal Gain Control



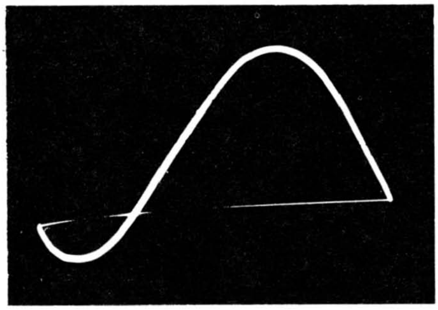
Horizontal gain control set too low.

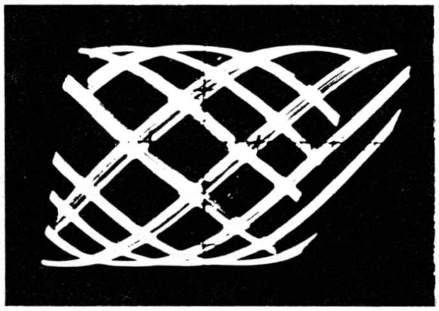


Horizontal gain control set too high.

NOTE 5

Checking the Operation of the Horizontal Sweep-Rate Control



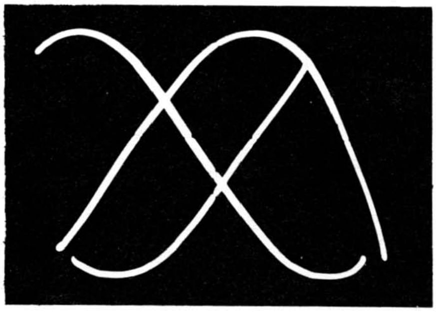


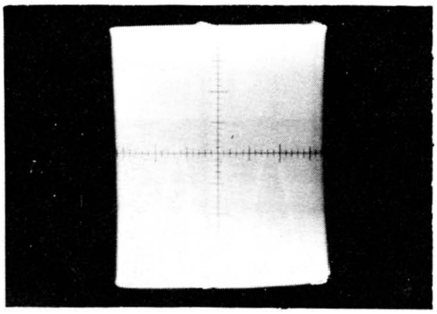
Horizontal sweep rate slightly high. Less than one cycle displayed.

Horizontal sweep rate set much too high.

NOTE 6

Checking the Operation of the Sync Amplitude Control





Sync amplitude control set too high. Multiple triggering of the sweep oscillator occurs.

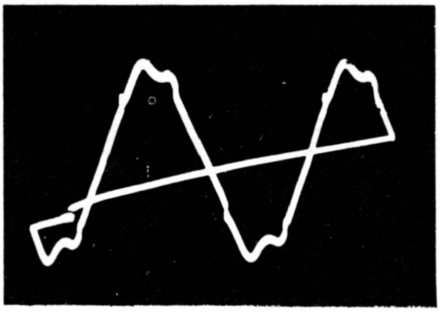
Sync amplitude control set too low. Pattern runs rapidly on screen and does not lock.

NOTE 7

Stray Field Pickup

A sine-wave pattern can also be displayed by leaving the vertical-input leads of the scope lying open on the bench. A distorted sine wave appears on the scope screen. This is a display of the stray 60-cycle field. Because the vertical-input circuit of the scope has a very high

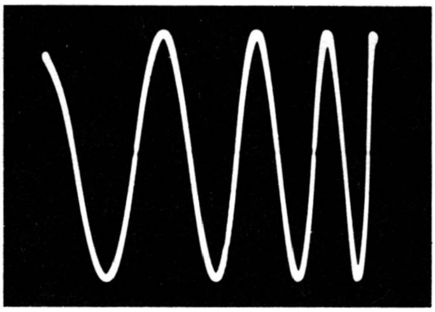
impedance,
field. A stray field is a high-impedance voltage source. The sine-wave pattern is distorted because the open test leads are coupled via a very small stray capacitance to the power wiring of the bench. A capacitance has lower impedance at higher frequencies. Hence,
the waveform are exaggerated. These harmonics show up as kinks in the waveform. If the vertical-input leads of the scope are connected across a 100K-resistor,
stray field pattern disappears,
cause the input impedance of the scope is then lowered to 100,
ohms.
low to couple effectively into the high-impedance,



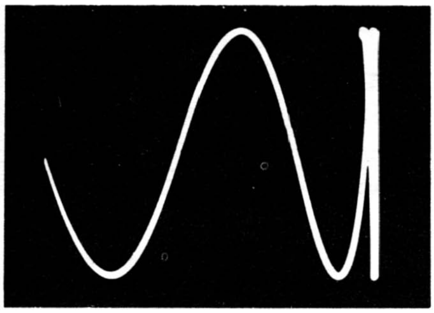
Stray-field pattern obtained with test leads lying open on bench.

NOTE 8

Recognition of Horizontal Nonlinearity



Sine wave cramped at right.

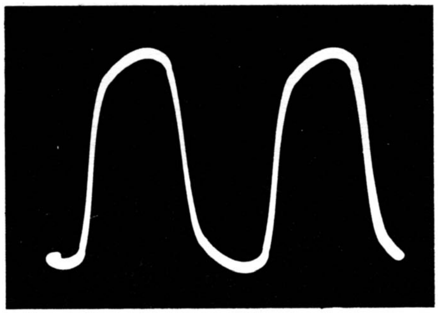


Sine wave folded over at right.

NOTE 9

Recognition of Vertical Nonlinearity

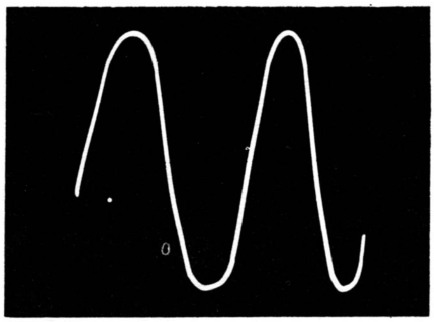
Sine wave compressed at top and bottom.



NOTE 10

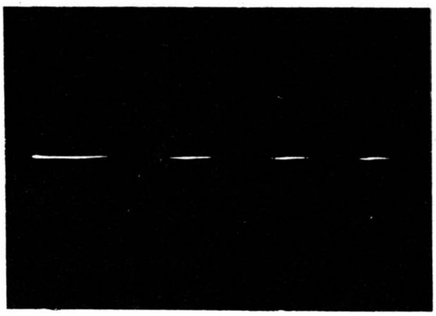
Recognition of Vertical and Horizontal Nonlinearity

Sine wave compressed at top and bottom, and at right side.

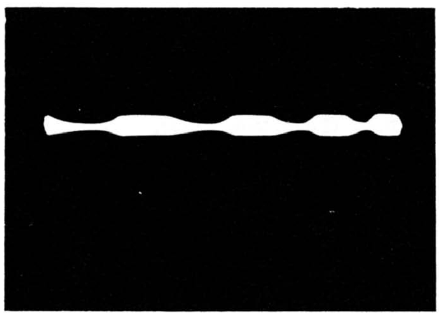


NOTE 11

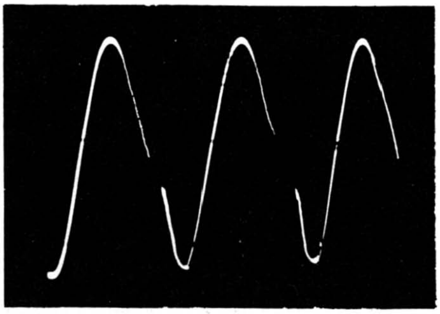
Recognition of Hum Modulation on Scope Trace



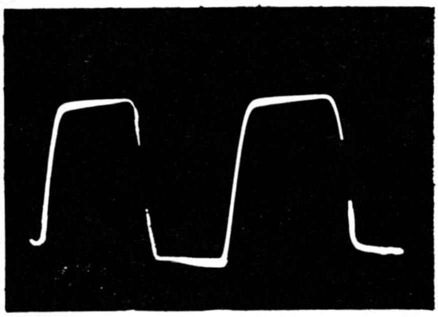
Hum modulation of beam at normal brightness setting.



Hum modulation of beam at high brightness setting.



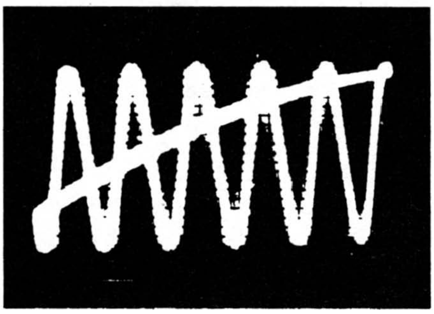
60-cycle hum modulation seen in display of 60-cycle sine wave.



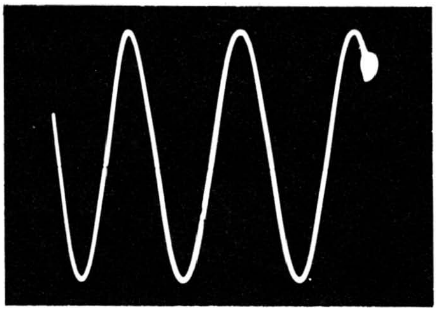
60-cycle hum modulation seen in an overloaded 60-cycle, sine-wave display. (Overloading due to setting step vertical-gain control too high and continuous vertical-gain control too low.)

NOTE 12

Recognition of Faulty Retrace Blanking

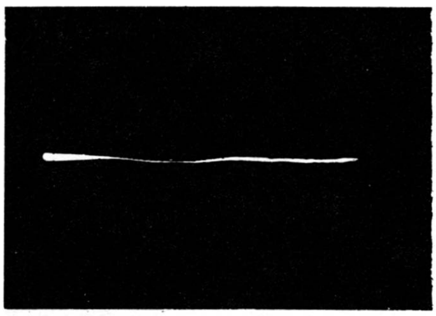


Retrace blanking ineffective; retrace plainly visible.



Retrace blanking pulse distorted, causing bright spot at end of pattern.

Retrace blanking pulse distorted; appearance of fault without sine-wave pattern (base line only).



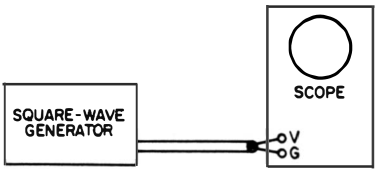
To Display a Square-Wave Pattern on the Scope Screen

Equipment: Square-wave generator.

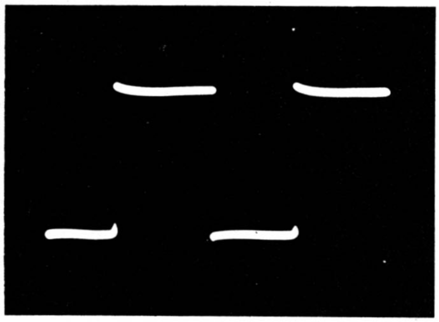
Connections Required: Connect the output cable from the square-wave generator to the vertical-input terminals of the scope.

Procedure: Adjust instrument controls for a suitable square-wave pattern.

Evaluation of Results: Within a certain range of square-wave frequencies (using a good generator), the scope should reproduce a good square waveform. At very low and very high square-wave frequencies, the vertical amplifier will reproduce a distorted square wave.



Test setup.

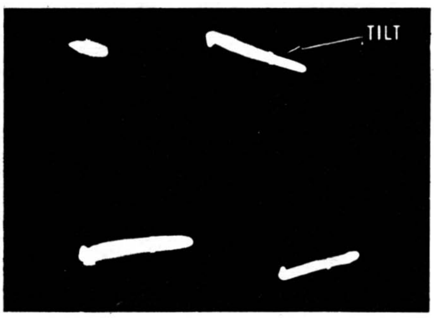


A reasonably good square-wave pattern.

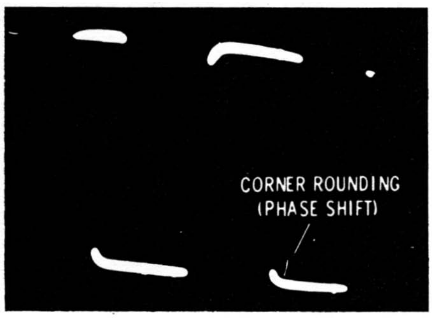
NOTE 13

Typical Square-Wave Distortions Produced by Inadequate Vertical Amplifier of Service Scope

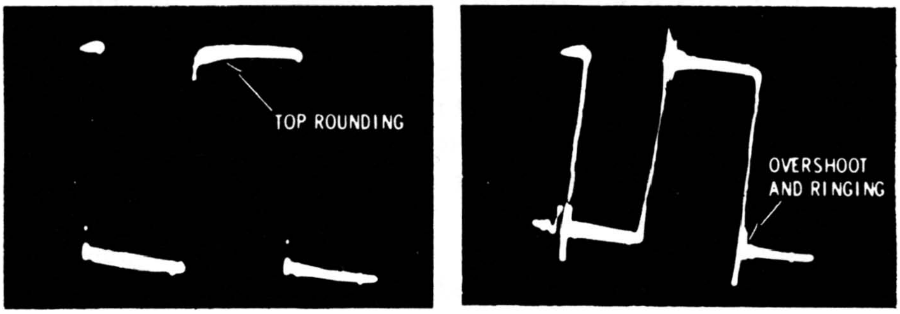
The following photos show typical distortions in reproductions of square-wave frequencies from 50 cps to 100 kc, caused by an inadequately compensated vertical amplifier. Although these scope distortions can be taken into account when making equipment checks, such procedure is somewhat difficult and not generally recommended.



(A) 50 pulses per second.



(B) 1,000 pulses per second.



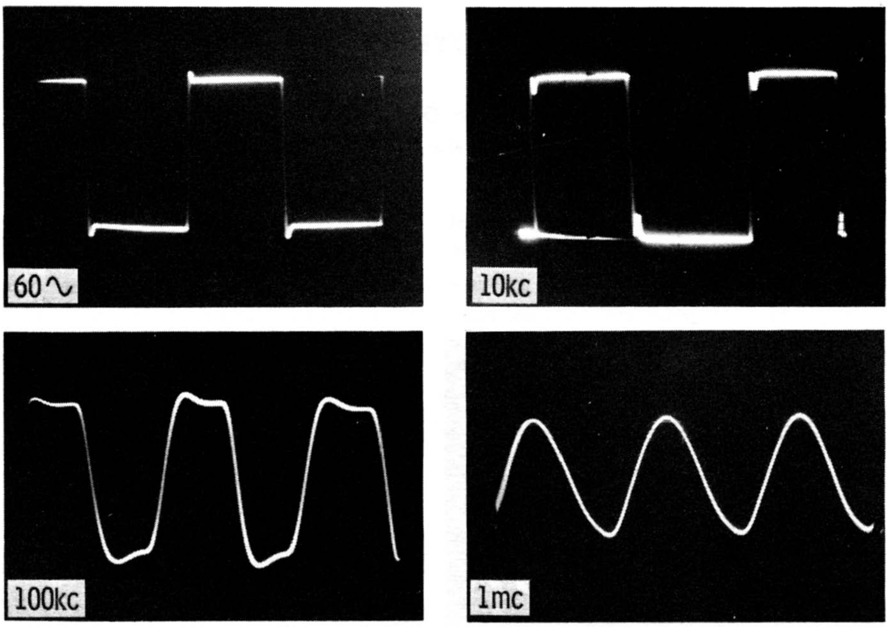
(C) 10,000 pulses per second. (D) 100,000 pulses per second.

Typical square-wave distortions.

NOTE 14

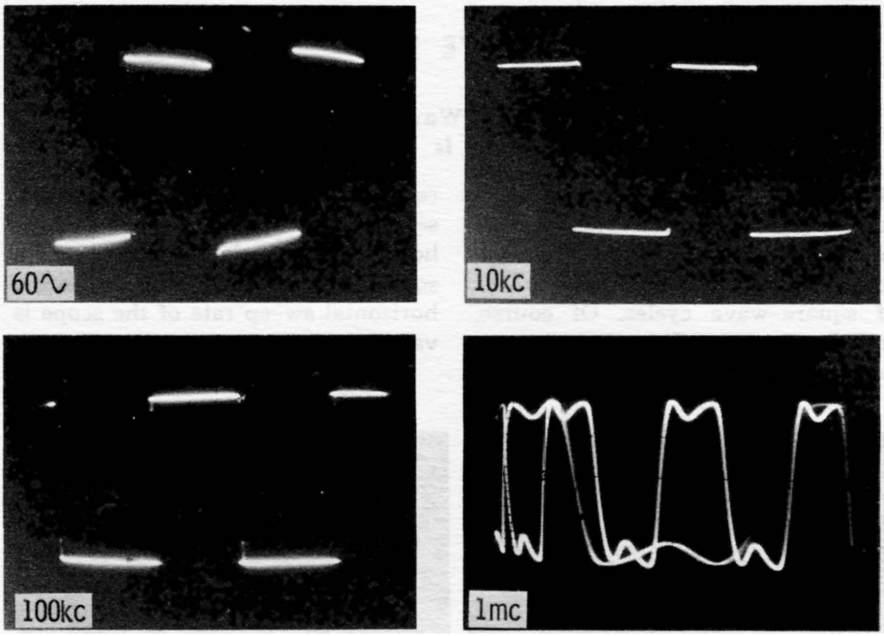
Typical Square-Wave Patterns Produced by Scopes

The following photos show typical reproductions of square waves from scopes of varying capabilities—a 100-kc (narrow band), a 4-mc (wide band), and a 15-mc (laboratory) instrument. Waveforms at four different frequencies are shown. There is some tilt at low frequencies and noticeable ringing at high frequencies in the 4-mc scope response. Note that scopes which are quite free from square-wave distortion are relatively high priced.

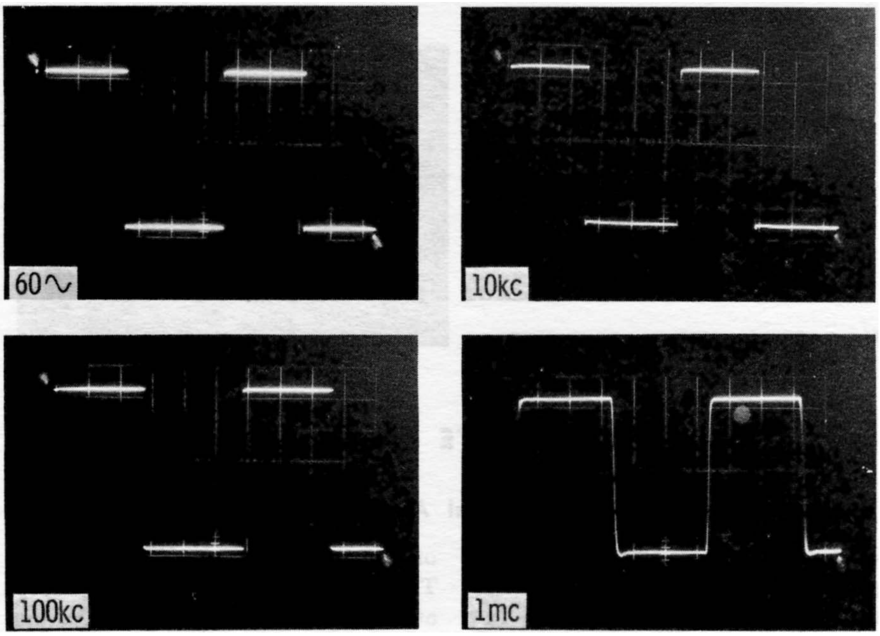


(A) Response of a service-type 100-kc scope.

Square-wave response of



(B) Response of a service-type 4-mc scope.



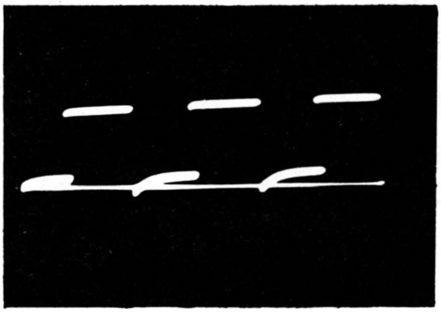
(C) Response of a lab-type 15-mc scope.

three different oscilloscopes.

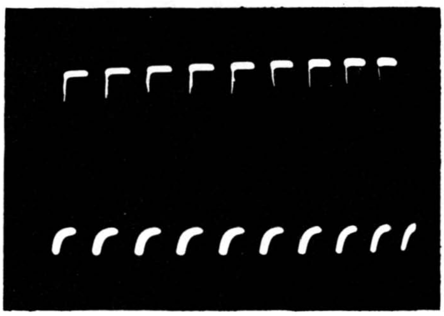
NOTE 15

Effect on Shape of Square Waveform When Sweep Rate of Scope Is Varied

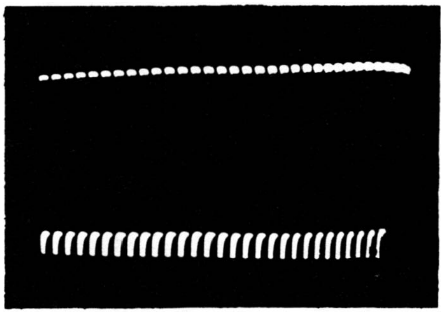
Beginners sometimes suppose that a square-wave generator can be used as a pulse generator by adjusting the scope controls to display a number of square-wave cycles. Of course, this is not so. The square-wave voltage remains the same in shape, regardless of its aspect on the scope screen. The following photos show how the superficial appearance of a square-wave voltage changes as the horizontal sweep rate of the scope is varied.



(A) High sweep rate.



(B) Medium sweep rate.



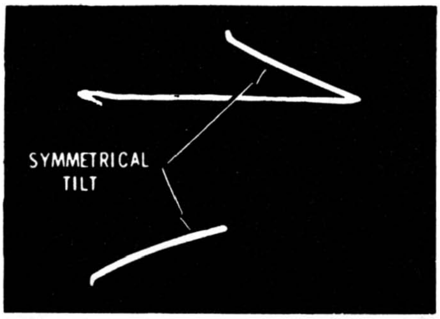
(C) Low sweep rate.

Effect of sweep rate on square wave.

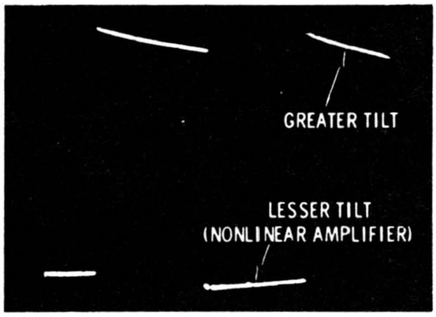
NOTE 16

Effect of Nonlinearity in Vertical Amplifier on Square Waveform

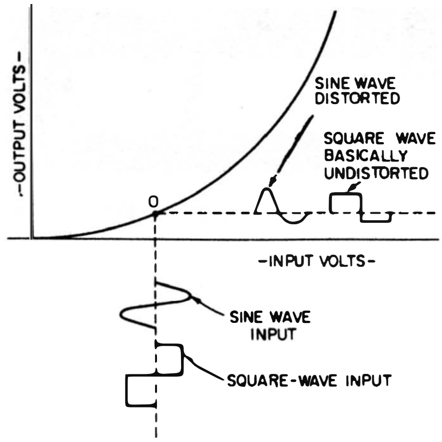
You will notice when making square-wave tests of scope response that the top and bottom of the reproduced square wave are sometimes unsymmetrical. When a vertical amplifier causes tilt in the square waveform, this tilt will be the same along the top and bottom of the wave if the amplifier is linear. This tilt is caused by low-frequency attenuation and phase shift. On the other hand, when tilt is unsymmetrical, as shown in the second photo, this tilt is caused by amplitude distortion (nonlinearity) in the vertical amplifier.



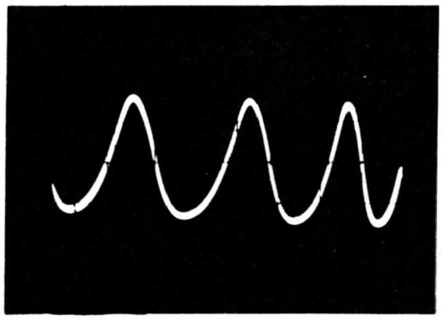
Tilt caused by low frequency attenuation and phase shift.



Tilt caused by amplitude distortion in vertical amplifier of scope.

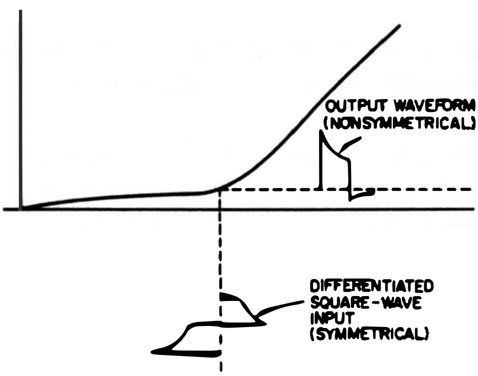


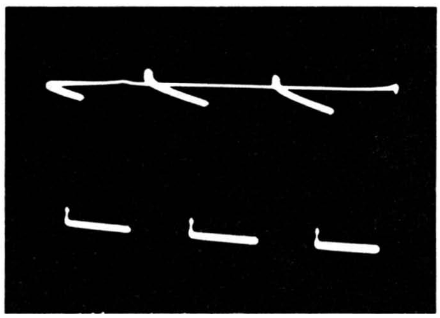
(A) Characteristic curve.



(B) Effect on sine wave.

Nonlinear vertical amplifier.





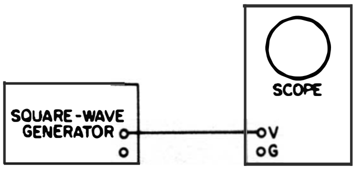
(A) Characteristic curve. (B) Effect on differentiated square wave.

Nonlinear vertical amplifier.

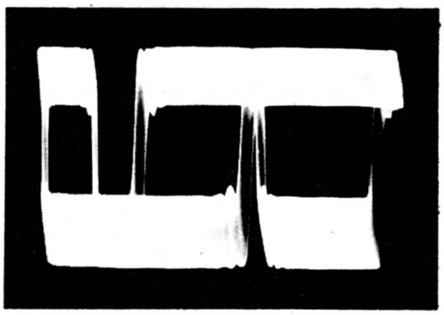
NOTE 17

Effect of 60-Cycle Hum Voltage on Square-Wave Pattern

The following photo shows the appearance of 60-cycle hum voltage in a reproduced square-wave pattern. This hum voltage is encountered, for example, when the "hot" output terminal from the square-wave generator is connected to the vertical-input terminals of the scope and the ground lead between the instruments is omitted.



Test setup.



60-cycle hum voltage in square wave.

U3

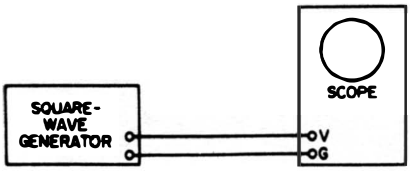
To Check a Scope for Cross Talk Between the Vertical and Horizontal Amplifiers

Equipment: Square-wave generator.

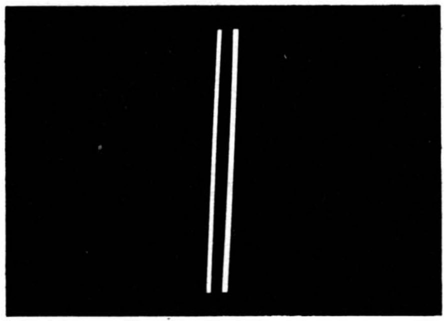
Connections Required: Apply output from square-wave generator to vertical-input terminals of scope. In second test, apply output from square-wave generator to horizontal-input terminals of scope.

Procedure: With drive applied to the vertical-input terminals, advance the vertical gain and reduce the horizontal gain to zero. In the second test, with drive applied to the horizontal-input terminals, advance the horizontal gain and reduce the vertical gain to zero.

Evaluation of Results: The first test should display a single vertical line. Two vertical lines show the occurrence of cross talk. In the second test, a single horizontal line should be displayed. Two horizontal lines show the presence of cross talk.

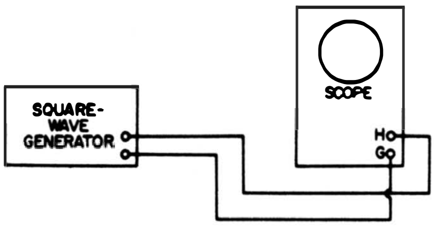


(A) Test setup.

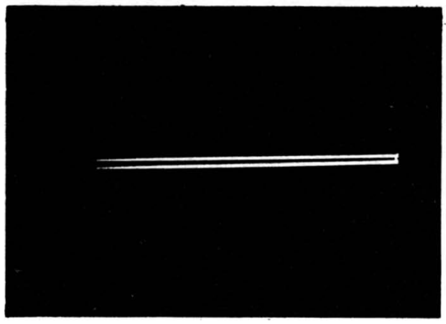


(B) Waveform showing the presence of cross talk.

First test.



(A) Test setup.



(B) Waveform showing the presence of cross talk.

Second test.

U4

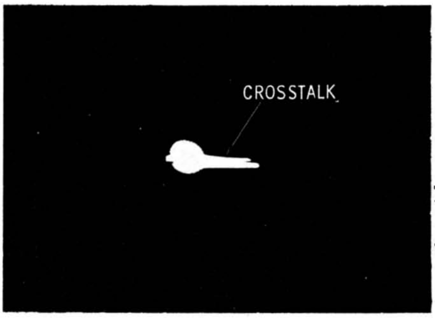
To Check a Scope for Cross Talk Between the Sawtooth Oscillator and the Amplifiers

Equipment: None.

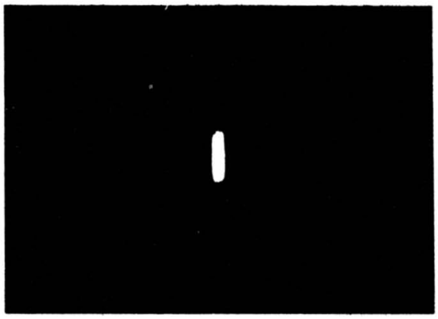
Connections Required: None.

Procedure: Switch horizontal-range switch (or horizontal-amplifier switch) to Off position. (Or, set horizontal-amplifier switch to Horizontal Input position.) Set vertical gain to zero.

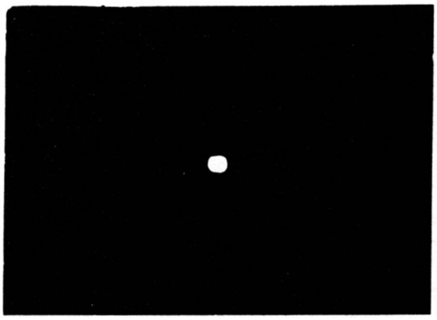
Evaluation of Results: A sharply focused round spot should appear at the center of the scope screen. Tailing or smearing of the spot indicates cross talk between the sawtooth oscillator and one or both amplifiers of the scope.



Cross talk between the sawtooth oscillator and the horizontal amplifier.



Cross talk between the sawtooth oscillator and the vertical amplifier.



Absence of cross talk between sawtooth oscillator and scope amplifiers.

U5

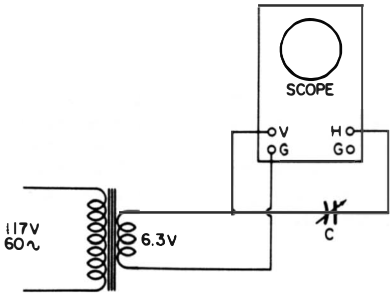
To Check a Scope for Astigmatism

Equipment: Trimmer capacitor and 60-cycle, sine-wave source.

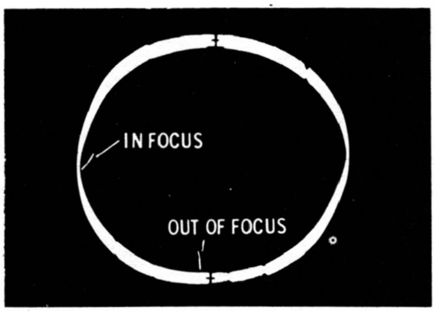
Connections Required: Apply the 60-cycle, sine-wave voltage directly to the vertical-input terminals of the scope. Apply the same voltage through a trimmer capacitor to the horizontal-input terminals of the scope.

Procedure: Adjust trimmer capacitor and scope gain controls for a circular pattern.

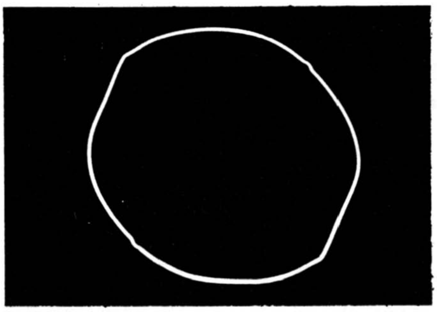
Evaluation of Results: Astigmatism causes poor focus at top and bottom, or at left and right, of circle.



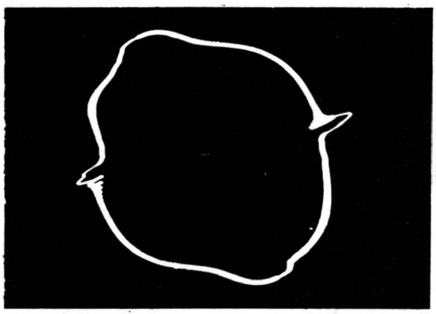
Test setup.



Severe astigmatism.



No astigmatism.

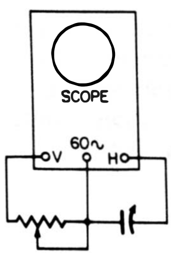


Exaggeration of harmonics in sine wave caused by using a small value of series capacitance.

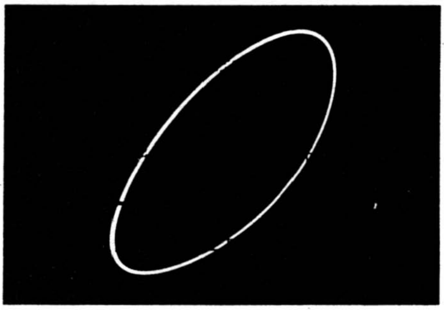
NOTE 18

Addition of Resistor When Circular Pattern Cannot Be Obtained

With some scopes, a resistor (potentiometer) is needed in addition to the trimmer capacitor to obtain a circular pattern. There must be a 90° phase difference between the vertical- and horizontal-input voltages to display a circle. Use a 1-meg pot and a 3-30 mmf trimmer, as shown in the following illustration.



Test setup.

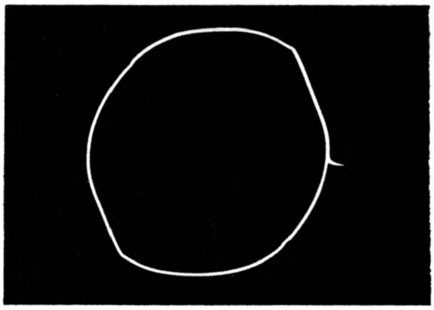


An ellipse, as shown above, is displayed unless R and C have suitable values. A circle is obtained only when R and C are of suitable values and the scope gain controls are suitably adjusted.

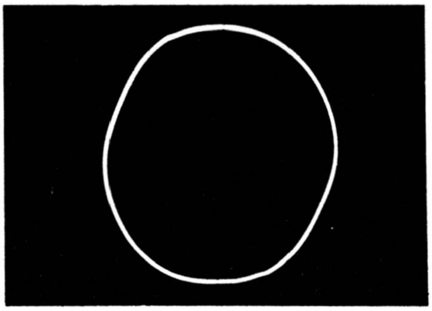
NOTE 19

Effect When There Is Cross Talk Between Sawtooth Oscillator and Horizontal Amplifier

When there is cross talk between the sawtooth oscillator and the horizontal amplifier, a pip appears on the circular pattern, as shown in the following illustrations.



Cross talk present.

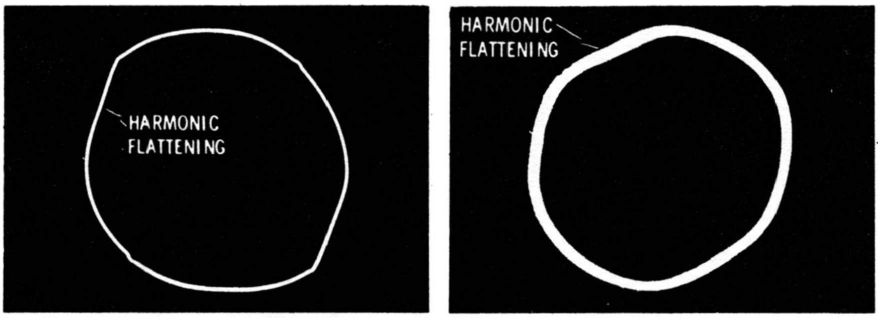


Pattern free of cross talk.

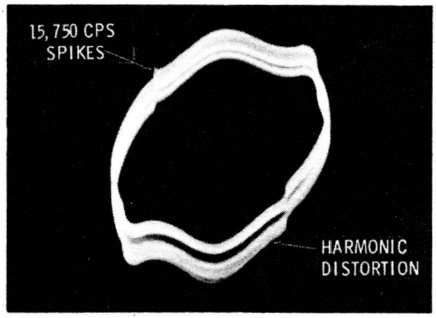
NOTE 20

Effect of Harmonics on Circular Pattern

When a small trimmer capacitor is used in a phase-shifting network, any harmonics in the source voltage are accentuated. This accentuation causes the pattern to display flatnesses or kinks, instead of appearing as a perfect circle or perfect ellipse. Typical examples are shown in the following illustrations.



Typical harmonic distortions in a circular pattern.



Stray field pickup from a sweep system of a TV receiver operating near the scope.

U6

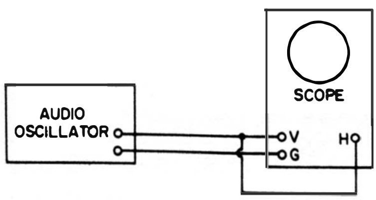
To Determine the Frequency Range Over Which a Scope Is Free from Phase Shift Between the Vertical and Horizontal Amplifiers

Equipment: Audio oscillator.

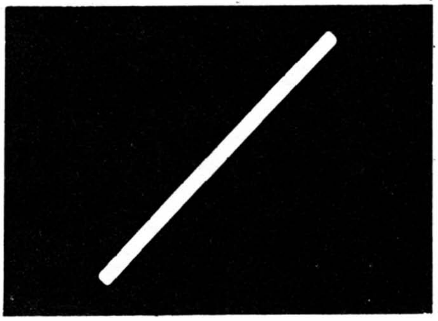
Connections Required: Apply output from audio oscillator to vertical- and horizontal-input terminals of scope, as shown in the following drawing.

Procedure: Adjust scope controls for diagonal line on screen.

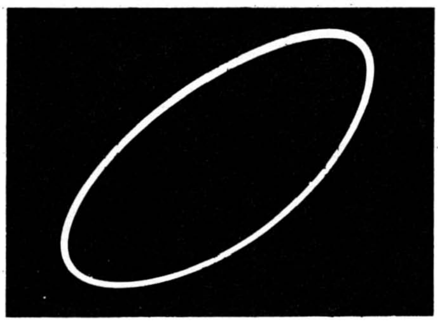
Evaluation of Results: Vary output frequency from audio oscillator while watching scope pattern. Limit of freedom from phase shift is reached when the diagonal line opens out into an ellipse.



Test setup.



No phase shift.



Severe phase shift.

U7

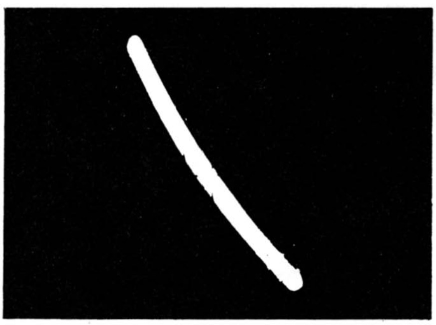
To Determine Whether the Scope Amplifiers Are Free from Amplitude Distortion Over Their Useful Frequency Range

Equipment: Audio oscillator.

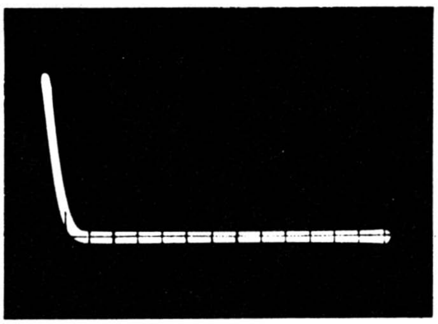
Connections Required: Apply output from audio oscillator to vertical- and horizontal-input terminals of the scope.

Procedure: Adjust scope controls for diagonal line on screen. Advance scope gain controls for full-screen deflection.

Evaluation of Results: Vary the audio oscillator frequency through the range over which the diagonal line does not open into an ellipse. Watch the line for departures from straightness. Curvature or kinks in the line show that amplitude distortion is occurring in one or both amplifiers. A scope can have a different amount of amplitude distortion at low frequencies than at high frequencies.



Noticeable amplitude distortion.



Severe amplitude distortion.

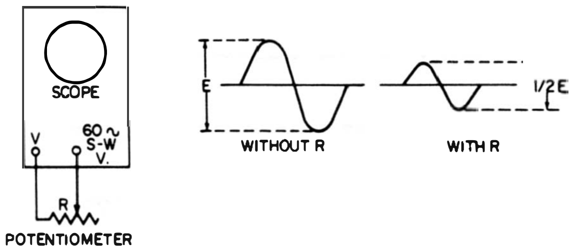
To Measure the Input Resistance of a Scope

Equipment: Potentiometer with several megohms maximum resistance.

Connections Required: Connect a potentiometer in series between the vertical-input terminal of the scope and a 60-cycle, sine-wave voltage source.

Procedure: Note the amount of vertical deflection of the sine-wave pattern with the potentiometer set for zero resistance. Then adjust the potentiometer for exactly one-half this deflection.

Evaluation of Results: Disconnect potentiometer and measure its resistance with an ohmmeter. This is the value of the input resistance of the scope.



Test setup.

U9

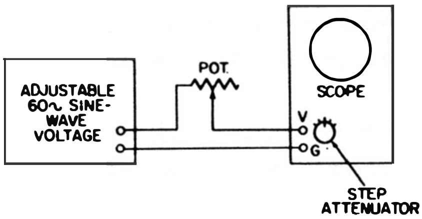
To Determine Whether a Scope Has a Constant Value of Input Resistance on Each Step of the Coarse Attenuator

Equipment: Potentiometer with several megohms maximum resistance.

Connections Required: Connect the potentiometer in series between the vertical-input terminals of the scope and an adjustable source of 60-cycle, sine-wave voltage. Sufficient voltage must be available to obtain adequate vertical deflection on the least sensitive step of the attenuator.

Procedure: Note the amount of vertical deflection of the sine-wave pattern with the potentiometer set for zero resistance. Then adjust the potentiometer for exactly one-half this deflection and measure the resistance with an ohmmeter. Repeat on each step of the coarse attenuator. Use sufficient output voltage from the 60-cycle source in each step to obtain convenient vertical deflection.

Evaluation of Results: The *same* amount of series resistance should reduce the vertical deflection to one-half on each step of the coarse attenuator.



Test setup.

U10

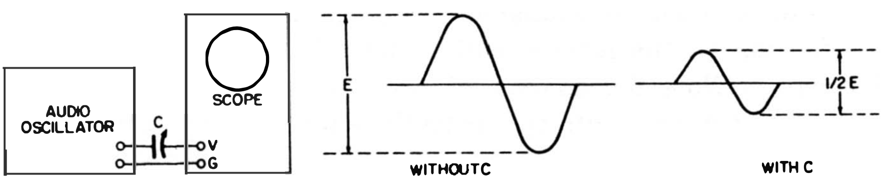
To Measure the Input Capacitance of a Scope

Equipment: Trimmer capacitor and audio oscillator.

Connections Required: Connect the trimmer capacitor in series between the vertical-input terminals of the scope and the audio oscillator.

Procedure: Set the audio oscillator to a relatively high-frequency output, such as 100 kc. Short-circuit the trimmer capacitor and note the vertical deflection obtained. Then remove the short and adjust trimmer for one-half the original deflection.

Evaluation of Results: Remove trimmer and measure its capacitance with a capacitance bridge or capacitance meter. This capacitance value is equal to the input capacitance of the scope.



Test setup.

To Determine Whether a Scope Has a Constant Value of Input Capacitance on Each Step of the Coarse Attenuator

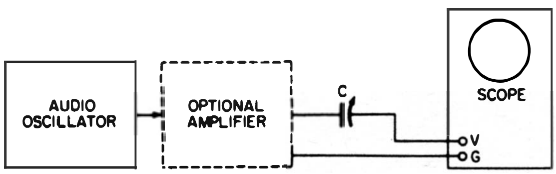
Equipment: Trimmer capacitor and audio oscillator.

Connections Required: Connect the trimmer capacitor in series between the vertical-input terminals of the scope and an audio amplifier.

Procedure: Set the audio oscillator to a relatively high frequency output, such as 100 kc. Short-circuit the trimmer capacitor. Note the vertical deflection obtained. Then remove the short, adjust the trimmer for one-half the original deflection, and measure the value of the trimmer capacitor. Repeat on each step of the coarse attenuator. (Use an audio amplifier, as shown in the illustration, if needed, to obtain adequate deflection on the least sensitive step of the coarse attenuator.) Adjust input voltage to vertical amplifier on each step, as required.

Evaluation of Results: The *same* value of series capacitance should reduce the vertical deflection to one-half on each step of the coarse attenuator.

Unless a scope has a constant value of input resistance and a constant value of input capacitance on each step of the coarse attenuator, a low-capacitance probe or capacitance-divider probe cannot be used satisfactorily.



Test setup.

To Measure the Rise Time of a Square Wave

Equipment: Square-wave generator and triggered-sweep scope.

Connections Required: Terminate the output cable from the square-wave generator correctly (see instruction manual), and feed the square-wave signal directly into the vertical-input terminals of the scope.

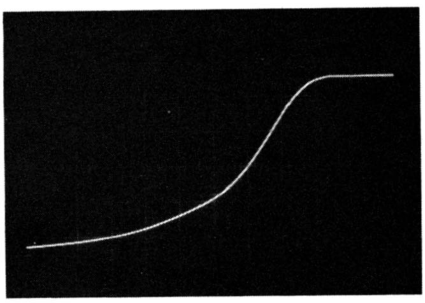
Procedure: Adjust the scope controls to expand the leading edge as required for easy measurement of rise time. The accompanying photo shows how the leading edge can be expanded.

Evaluation of Results: Rise time is measured from the 10% point to the 90% point on the leading edge of the reproduced square wave. The elapsed time is determined from the setting of the horizontal-sweep controls on the triggered-sweep scope and the width of the display on the screen. If the scope has a fast rise time and the square-wave generator has a slow rise time, you are essentially measuring the rise time of the square-wave generator. On the other hand, if the scope has a slow rise time, and the square-wave generator has a fast rise time, you are essentially measuring the rise time of the scope. In any case, the rise time displayed on the scope screen is equal to:

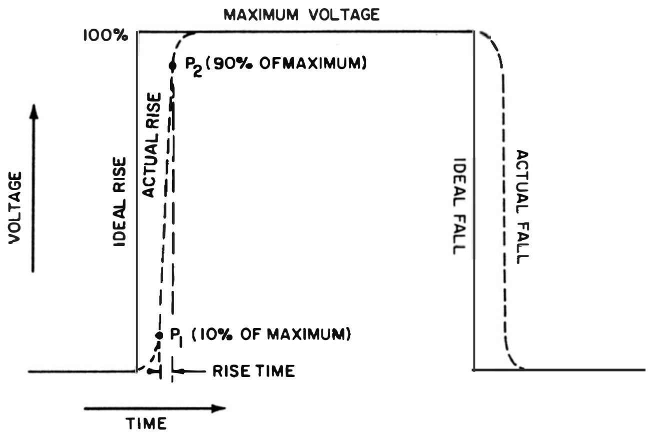
$$T_D = \sqrt{T_G^2 + T_S^2}$$

where,

T_D is the rise time displayed on the scope screen,
T_G is the rise time of the square-wave generator,
T_S is the rise time of the scope.



Expanded rise of a square wave.

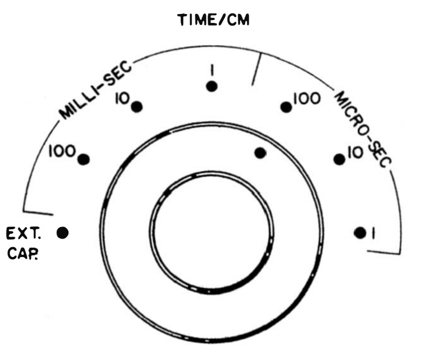


Rise time is measured from the 10% to the 90% point.

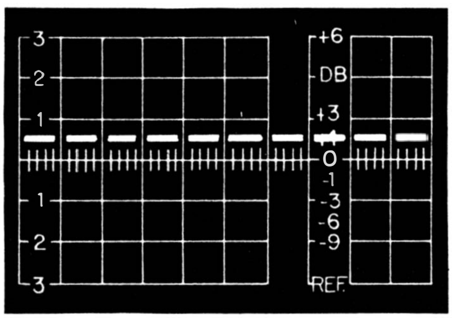
NOTE 21

Reading Elapsed Time on a Triggered-Sweep Scope

Triggered-sweep controls are calibrated to read milliseconds or microseconds per centimeter, as depicted in the diagram which follows. Each division on the graticule of a triggered-sweep scope is an interval of 1 centimeter. By noting the number of centimeters occupied by the waveform and the setting of the scope it is easy to calculate the elapsed time from one point to another on a waveform. Although the top sweep speed indicated in the diagram is 1 microsecond per centimeter, other triggered-sweep scopes have a much faster upper limit (0.04 microsecond per centimeter).



Typical sweep-speed control on triggered-sweep scope.



Triggered-sweep scope has its graticule stepped off in centimeter intervals.

U13

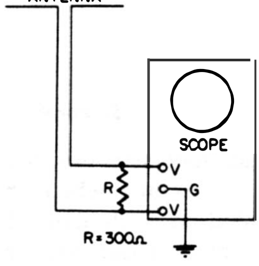
To Measure the Peak-to-Peak Voltage of AM Broadcast and Short-Wave Signals Picked Up by a TV Antenna

Equipment: Calibrated wide-band scope with double-ended input and 300-ohm resistor.

Connections Required: Terminate the lead-in with the 300-ohm resistor and apply signal to the vertical-input terminals of the scope.

Procedure: Adjust scope controls for suitable pattern height. Measure the peak-to-peak voltage of the maximum signal excursion.

Evaluation of Results: The signal voltage measured is the resultant of all signal voltages falling within the scope passband. This is the important measurement to be made when troubleshooting cross modulation of an RF tuner by AM broadcast signals. (Also see U14.)



Test setup.

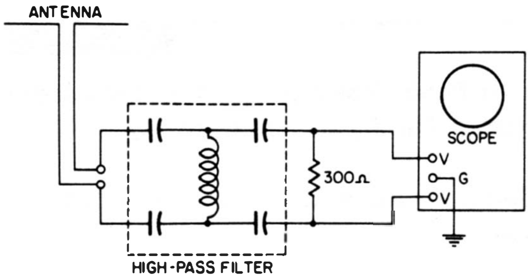
Typical waveform observed at the output of the antenna.

To Check the Effectiveness of a High-Pass Filter in Eliminating AM Broadcast Interference from a TV Antenna

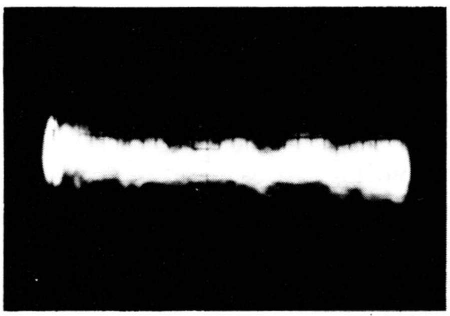
Equipment: High-pass filter; double-ended, wide-band scope; and 300-ohm resistor.

Connections Required: Connect lead-in to input terminals of high-pass filter. Terminate filter with 300-ohm resistor and apply filter output to vertical-input terminals of scope.

Evaluation of Results: Vertical deflection should be very small compared with deflection obtained without filter. Otherwise, filter is not operating satisfactorily.



Test setup.

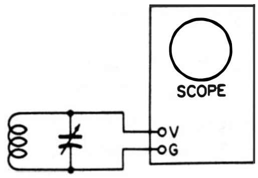


Waveform observed at output of filter connected to an antenna.

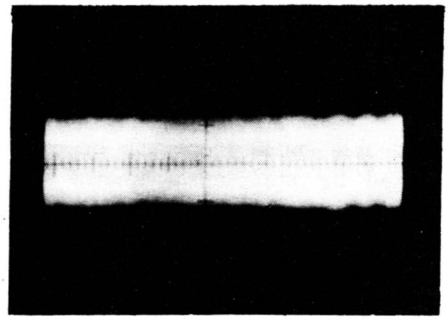
NOTE 22

Antenna Effect Causes Scope Interference When Field Strength Is High

When making tests with a coil connected across the vertical-input terminals of a wide-band scope, as shown in the following illustration, the base line will show rapidly changing modulation interference if working in an area of high AM broadcast field strength. The interference is greater when the scope is operated at high gain. The best remedy for this difficulty is to design the shop as a screen room (walls lined with grounded copper screening).



Coil connected across scope vertical input.



Interference from AM broadcast stations.

U15

To Measure the Rejection of AM Broadcast Interference From a TV Antenna, Using a Tuned Trap

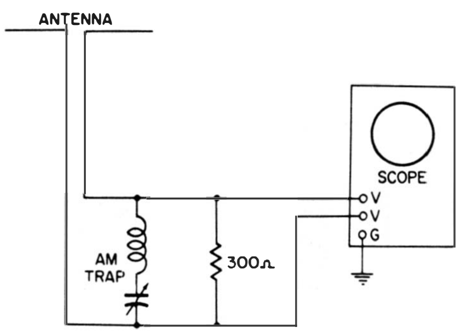
Equipment: AM trap and 300-ohm resistor.

Connections Required: Connect trap across lead-in. Terminate lead-in with 300-ohm resistor. Apply signal to vertical-input terminals of scope, as shown in the following diagram.

Procedure: Adjust trap tuning to minimize AM interference. Then disconnect trap and observe difference in vertical deflection.

Evaluation of Results: Rejection can be measured as a voltage ratio, but more advantageously as a decibel ratio. Decibels are proportional to eye and ear response. The relation between voltage ratios and decibels can be found in most standard handbooks.

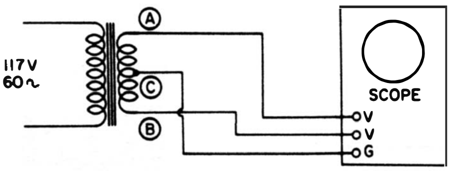
Test setup.



NOTE 23

How to Calibrate a Double-Ended Scope

A double-ended scope can be calibrated by applying a known 60-cycle, sine-wave voltage between both vertical-input terminals. Or, to obtain the most accurate calibration, use a step-down transformer with a center-tapped secondary, as shown in the following. Connect a VOM or VTVM between A and C, and read the voltage. Then connect the meter between B and C, and read the voltage between these points. Add the two voltages. This sum is the calibrating voltage.



Method of calibrating double-ended scope.

U16

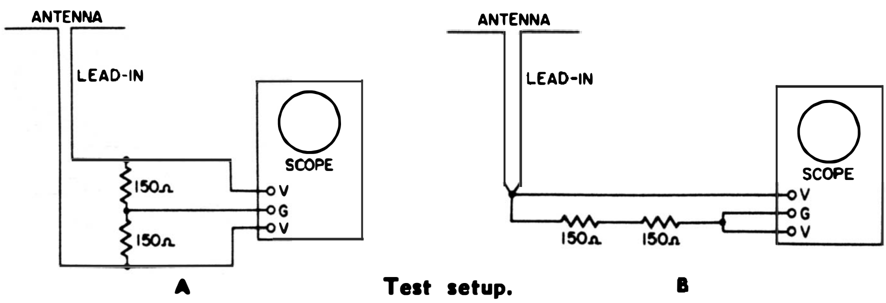
To Check a Lead-in for Electrical Balance (Rejection of Antenna Effect)

Equipment: Two 150-ohm resistors and a wide-band, double-ended scope.

Connections Required: Terminate lead-in with the two 150-ohm resistors series-connected. Connect to scope in first test as shown at A. Connect to scope in second test as shown at B.

Procedure: Note vertical deflections obtained in A and B. Scope may need to be operated at high gain, depending upon the prevailing AM broadcast field strength.

Evaluation of Results: The ratio of the two deflections is a measure of the electrical balance of the lead-in installation.



Test setup.

U17

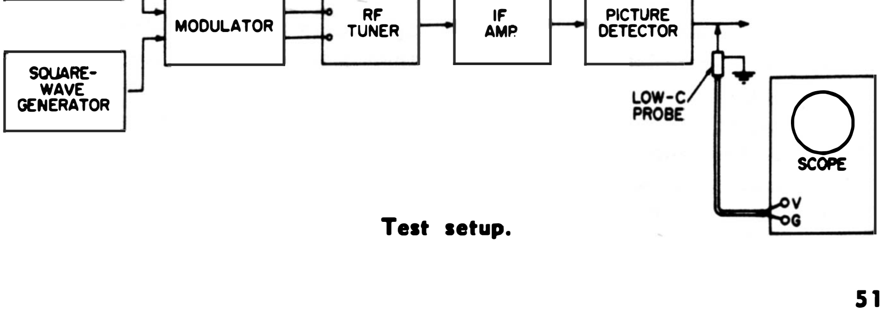
To Check the Modulated Square-Wave Response of the RF and IF Amplifiers

Equipment: Square-wave generator, signal generator, modulator, and low-capacitance probe.

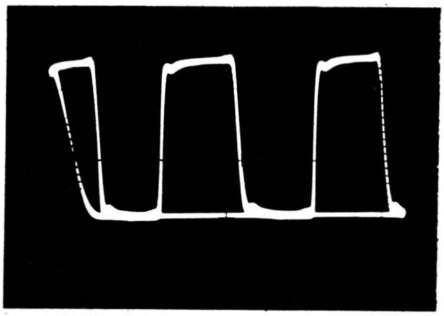
Connections Required: Apply generator outputs to modulator input. Apply modulator output to antenna-input terminals of receiver. Pull the first video-amplifier tube, and connect low-capacitance probe between video-amplifier grid terminal and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust instrument and receiver controls for square-wave display on scope screen. Carefully tune signal generator to picture-carrier frequency. Avoid overloading IF amplifier.

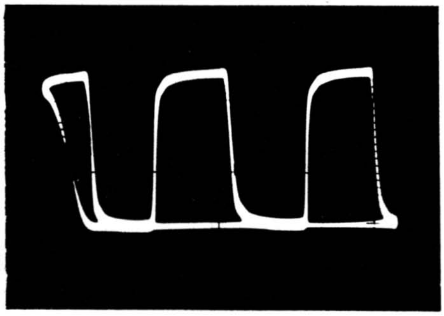
Evaluation of Results: A 60-cycle square wave should be reproduced with less than 15% tilt. A 100-kc square wave should not overshoot more than 10%. A 20-kc square wave should not have seriously rounded corners. (These are the factors determining picture quality.)



Test setup.



Corners of a 10-kc square wave are reasonably square when the picture carrier is correctly located halfway up the side of the over-all response curve.

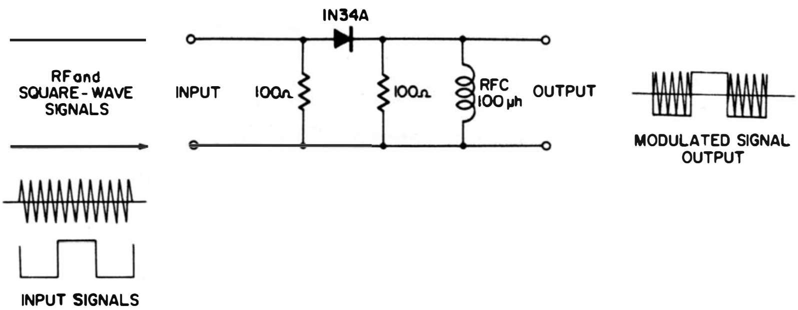


Corners of a 10-kc square wave are rounded when the picture carrier is tuned to the top of the over-all response curve.

NOTE 24

Construction of External Modulator

An effective external modulator can be easily constructed, as shown below. Its response is much better than that of built-in modulators in many signal generators.

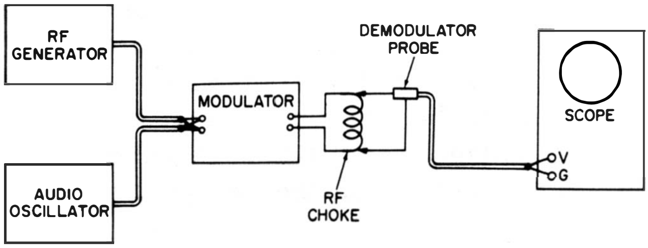


Modulator circuit.

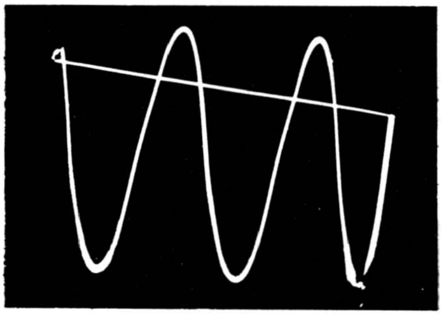
NOTE 25

Test for Modulator Linearity

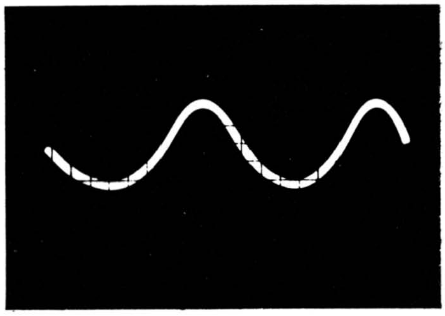
Misleading results can be obtained in tests if a modulator is operated in a nonlinear manner. Hence, a simple test for modulator linearity is described in the following. Outputs from an audio oscillator and RF generator are applied to the modulator input. The modulator output is applied to a demodulator probe and thence to a scope. The scope pattern should be essentially the same as observed directly from the audio oscillator. If distortion is observed in modulator operation, adjust the levels of the RF and AF signals to obtain satisfactory linear operation.



Test setup.



Waveform from audio oscillator.



Distorted output from modulator—Negative half-cycle of wave is flattened.

U18

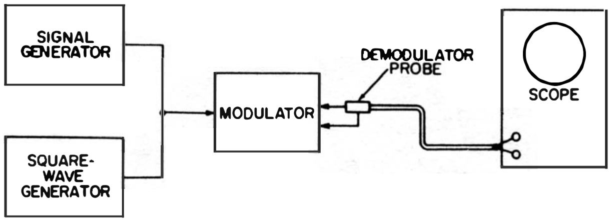
To Check the Percentage Modulation of the Output from a Diode Modulator

Equipment: Square-wave generator, signal generator, modulator (shown in Note 24), demodulator probe, and DC scope.

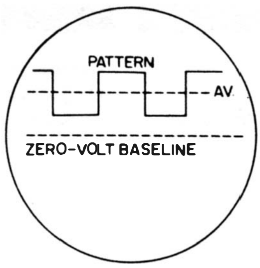
Connections Required: Apply signal-generator and square-wave generator outputs to modulator input. Connect demodulator probe at modulator output. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust square-wave generator for frequency within the capability of the demodulator probe, such as 100 cps. Set signal generator to any suitable frequency, such as 75 mc. Short scope input terminals and note resting position of the base line (zero-volt level). Remove short and observe position of square-wave pattern on screen.

Evaluation of Results: The excursion of the square wave with respect to the zero-volt level shows the percentage of modulation. If the negative peak of the square wave touches the zero-volt level, modulation is 100%. The following illustration shows 50% modulation. Receiver checks are usually made to best advantage at about 85% modulation. (The percentage modulation is determined by the relative output voltages from the two generators.)



Test setup.



Appearance of 50% modulation.

U19

To Check the Demodulating Capability of a Demodulator Probe

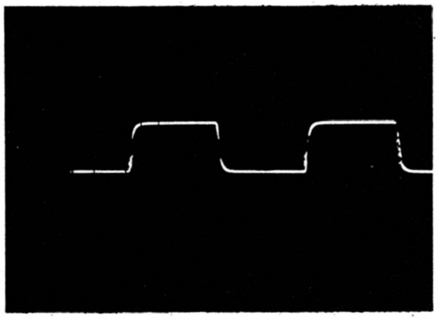
Equipment: Square-wave generator, signal generator, modulator (shown in Note 24), demodulator probe, and DC scope.

Connections Required: Apply signal-generator and square-wave generator outputs to modulator input. Connect demodulator probe at modulator output. Feed probe output to vertical-input terminals of scope.

Procedure: Vary square-wave generator frequency to determine the upper limit at which the reproduced square wave begins to show rounded corners.

Evaluation of Results: The demodulator probe will introduce distortion when used in square-wave tests at frequencies exceeding the limit determined by the foregoing procedure.

Rounded corners of square wave caused by square-wave frequencies exceeding the demodulating capabilities of the probe.



NOTE 26

Elimination of Line Bounce

In some heavily industrialized and rural areas, line voltage will fluctuate considerably. This fluctuation can cause line bounce in the scope pattern, as illustrated in the following. To correct this difficulty, use an automatic line-voltage regulating transformer to power the scope and other equipment used in tests.

Appearance of line bounce.

U20

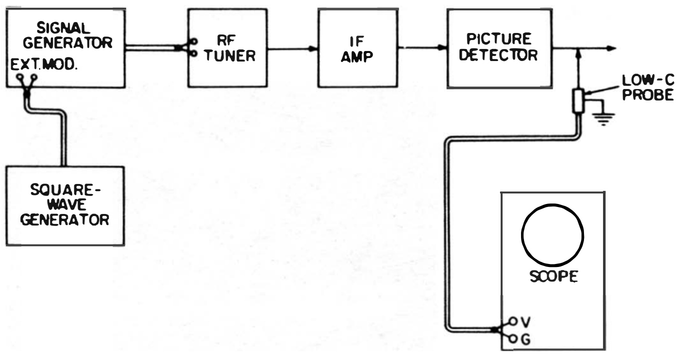
To Check the Modulated Square-Wave Response of the RF and IF Amplifiers, Using a Signal Generator with a Built-in Modulator

Equipment: Signal generator (with built-in modulator), square-wave generator, and low-capacitance probe.

Connections Required: Connect square-wave generator output cable to External Modulation terminals of signal generator. Connect signal-generator output cable to antenna-input terminals of receiver. Pull first video-amplifier tube. Connect low-capacitance probe between grid of first video-amplifier tube and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust instrument and receiver controls for square-wave display on scope screen. Carefully tune signal generator to picture-carrier frequency. Avoid overloading IF amplifier.

Evaluation of Results: A 60-cycle square wave should be reproduced with less than 15% tilt. A 100-kc square wave should not overshoot more than 10%. A 20-kc square wave should not have seriously rounded corners. These are the factors determining picture quality. (Note that the built-in modulator of some signal generators may distort the square-wave signal at higher frequencies of test.)



Test setup.

U21

To Check the Video Signal at the Picture-Detector Output

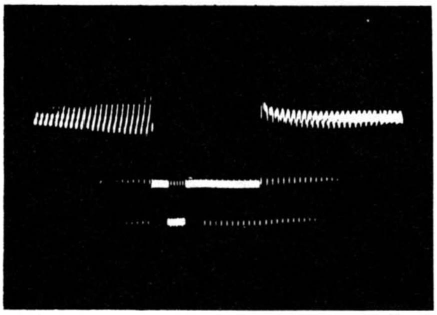
Equipment: Low-capacitance probe.

Connections Required: Connect probe output cable to vertical-input terminals of scope. Apply probe at grid of first video-amplifier tube.

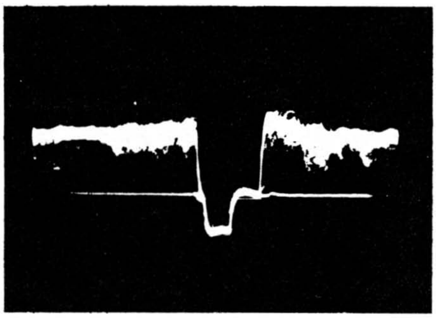
Procedure: Tune in TV station signal on receiver. Pull first video-amplifier tube. Adjust scope controls for desired waveform. Use either vertical or horizontal sweep rate.

Evaluation of Results: A wide-band scope will show all details of the composite video signal. However, a narrow-band scope will serve for many practical tests. Compare waveform and peak-to-peak voltage with data specified in receiver service literature.

Some service scopes have preset horizontal sweep rates for waveforms of this type. If so, the coarse sweep-rate control is merely set to either the "V" or "H" position.



Composite video signal—60-cps sweep.

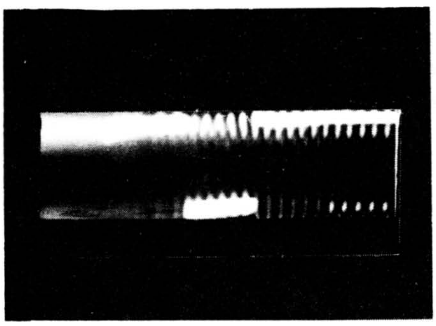


Composite video signal—15,750-cps sweep.

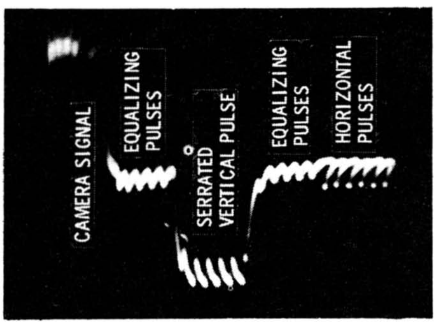
NOTE 27

Distortion of Composite Video Signal, Caused by Resistive Isolating Probe

Only a low-capacitance probe is suitable for display of the composite video signal. When a low-capacitance probe is used, the horizontal sync pulses have the same height as the vertical sync pulse. If a resistive isolating probe is used, the reproduced waveform becomes distorted, as illustrated in the following. Here, the horizontal sync pulses (high frequencies) are greatly attenuated and distorted to small sawteeth. Serrations in the vertical sync pulse are also distorted to a sawtooth form.



Waveform obtained with a low-capacitance probe.

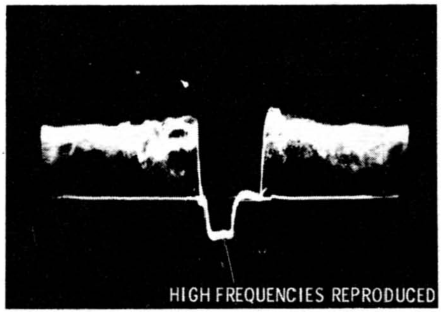


Waveform obtained with resistive probe.

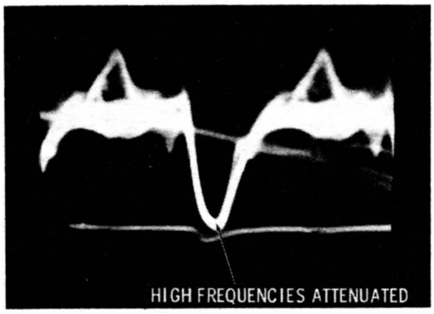
NOTE 28

Distortion of Composite Video Signal, Caused by Narrow-Band Oscilloscope

A scope having a narrow bandwidth attenuates the higher video frequencies and causes phase-shift distortion, in much the same manner as a resistive isolating probe. The following photographs show a comparison between the horizontal sync pulse as displayed by a narrow-band scope and by a wide-band scope.



Waveform obtained with a 4-mc scope.



Waveform obtained with audio-frequency scope.

NOTE 29

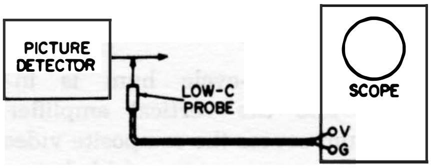
Locking the Composite Video Signal, When Scope Is Deflected at 60-Cycle Rate

Difficulty is sometimes experienced in obtaining tight sync lock when displaying the composite video signal at a 60-cycle (or 30-cycle) sweep rate. Scopes vary in their ability to lock this type of signal. In event of difficulty, internal 60-cycle line sync can be used. The pattern locks tightly. However, if a distant station signal, powered from another utility, is being displayed, the vertical sync pulse will drift slowly through the pattern, because various utilities do not operate on synchronized frequencies.

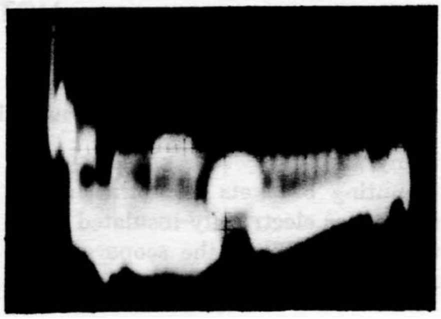
NOTE 30

Display of Video Signal Picture Pattern on Scope Screen, Caused by Stray Hum Pickup

When open test leads are used to the vertical-input terminals of the scope, 60-cycle hum will be picked up when the operator brings his hand near the leads. If the composite video signal is being displayed on the scope screen at a 15,750-cycle sweep rate, the presence of 60-cycle hum causes a vertical scanning that displays a picture pattern on the scope screen, as shown in the following illustration. This pattern is caused by beam displacement, not by intensity modulation, as in a picture tube.

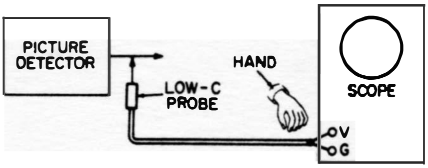


(A) Test setup.

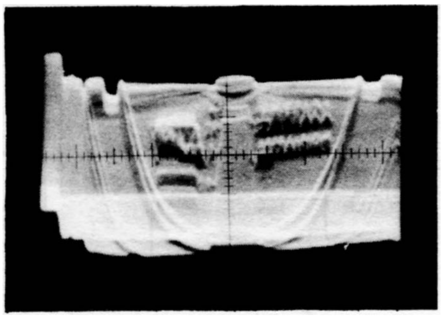


(B) Waveform.

Composite video signal without 60-cycle hum.



(A) Test setup. NOTE: Proximity of hand injects 60-cycle hum into exposed vertical-input terminals.



(B) Waveform.

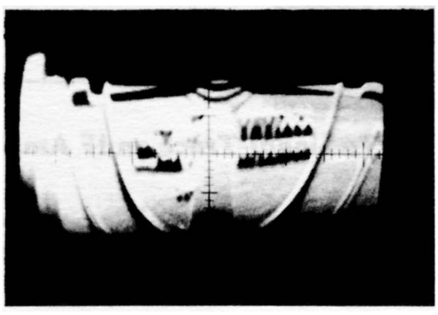
Composite video signal with 60-cycle hum.

NOTE 31

Foldover of Video Signal Picture Pattern, Caused by 60-Cycle Hum

When hum is introduced into the vertical amplifier while a composite video signal is being displayed at a 15,750-cycle sweep rate, the hum voltage produces vertical scanning. Because this is a 60-cycle scan, the pattern is folded over in half, as seen in Note 30. Some scopes have an internal 60-cycle blanking voltage. If this blanking voltage is turned on, the folded-over half of the picture pattern disappears, as shown in the following illustration.

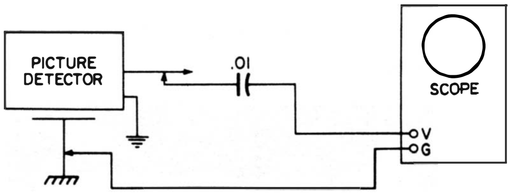
Appearance of video signal picture pattern with 60-cycle blanking voltage turned on.



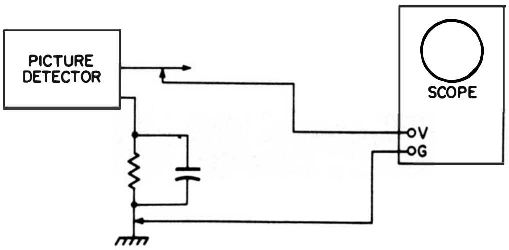
NOTE 32

Display of Video Signal Pattern on Scope Screen, Caused by Making Ground Return to Floating Metalwork

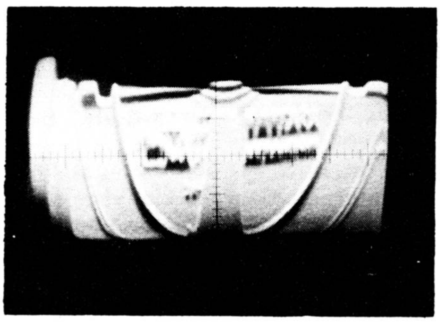
Many AC/DC TV chassis have mounting brackets and other metal structures electrically insulated from the chassis. When the scope ground return is made to such floating metalwork, 60-cycle hum is injected into the vertical amplifier. This hum causes the composite video signal to appear as a folded-over picture pattern on the scope screen.



Scope connected to floating mounting bracket.



Scope properly connected.



Waveform obtained when scope is connected to floating mounting bracket.

U22

To Signal-Trace an IF Amplifier

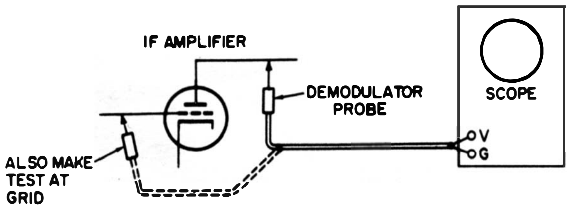
Equipment: Demodulator probe.

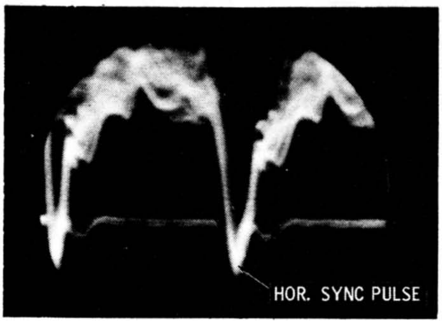
Connections Required: Connect probe output cable to vertical-input terminals of scope.

Procedure: Tune in a TV broadcast station (or use modulated output from a signal generator). Operate the scope at high gain to check the first and second IF stages. Either vertical or horizontal sweep rate can be used. Apply the probe consecutively to each plate and grid of the IF amplifier tubes.

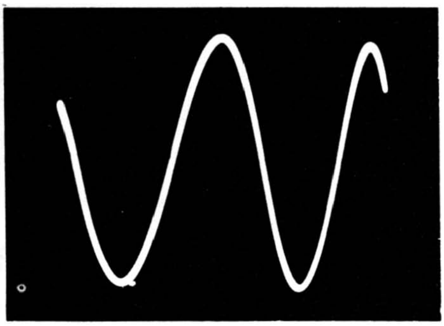
Evaluation of Results: This test is useful chiefly to determine the presence or absence of signal at a particular stage. The probe loads the IF circuits heavily, and accurate peak-to-peak voltage or gain measurements cannot be made. A dead IF stage can be quickly localized, and is indicated by absence of a video signal pattern on the scope screen.

Test setup.





Video signal waveform from a TV station.



Modulated signal waveform from a generator.

NOTE 33

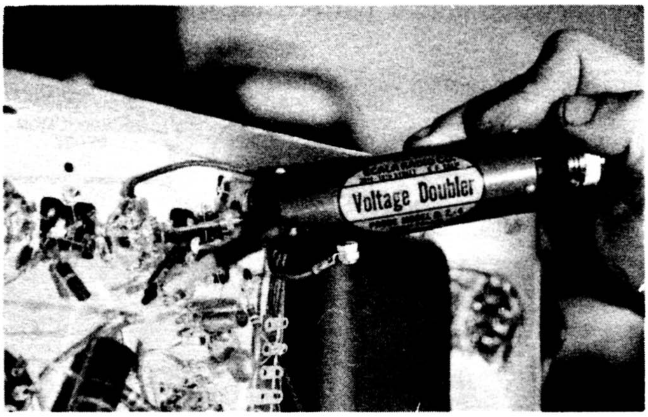
Oscillation in Video IF Amplifiers, Caused by Probe Capacitance

You will sometimes observe that the input capacitance of the probe detunes an IF stage in such a manner that the tube starts to oscillate. An IF stage generally oscillates if the grid and plate circuits happen to be peaked to the same frequency. When a stage oscillates, the video signal is "killed," and the scope screen displays a base line only. It could be falsely concluded that the stage is dead. However, if a test is made at both the grid and the plate of the tube, signal will be found at one point. If the probe capacitance should tune the grid circuit in the direction of oscillation, it will then tune the plate circuit away from the oscillation point.

NOTE 34

Use of Voltage Doubler Demodulator Probe

Service technicians often wish to signal-trace throughout the IF amplifier, from the picture detector back to the tuner output. This can be done if the scope has high sensitivity and a good demodulator probe is used. It is also helpful to tune in a strong TV station signal, to check at the tuner output. Several test-equipment manufacturers have voltage-doubler demodulator probes available. These are twice as sensitive as half-wave probes and assist in making useful checks at the tuner output.

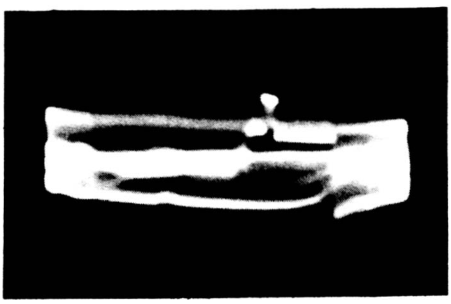


A voltage-doubler demodulator probe in use. (Courtesy of *Scala Radio* Co.)

NOTE 35

Attenuation of Horizontal Sync Pulse, Caused by Demodulator Probe

The usual demodulator probe has poor high-frequency response. As a result, the horizontal sync pulses are attenuated and rounded. When the pattern is displayed with 60-cycle sweep, the vertical sync pulse extends above the level of the horizontal sync pulses, as shown in the following photo. (For tests of probe frequency response, see the companion book, *101 Ways to Use Your Sweep Generator*.)

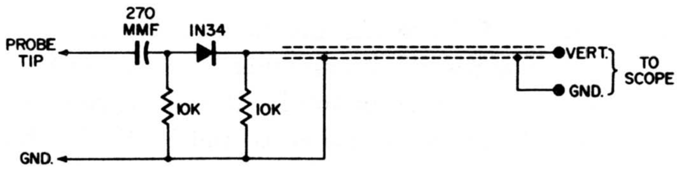


Waveform showing the attenuation of horizontal sync pulses by the demodulator probe.

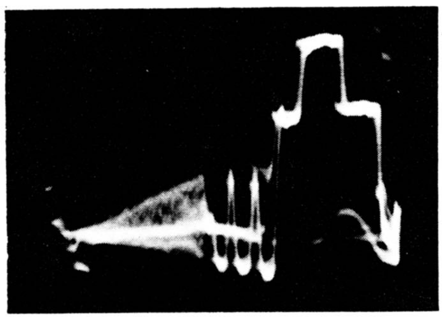
NOTE 36

Use of Medium-Impedance Demodulator to Eliminate Distortion

Service technicians occasionally wish to use a medium-impedance demodulator probe that does not appreciably distort the horizontal sync pulse. This can be done at the expense of sensitivity. The probe circuit shown in the following illustration can be used for this purpose. An output cable having relatively low capacitance must also be used. Best response is obtained by removing the center conductor from standard coax cable and replacing the center conductor with No. 30 wire. To do this, select the type of coax having a spiral-wound polystyrene insulation around the conductor; otherwise, removal is not practical. (To invert the direction of the sync pulse on the scope screen, reverse the diode polarity.)



Medium-impedance demodulator probe circuit.



Waveform obtained using the demodulator probe.

NOTE 37

Demodulator Probe Containing IF Amplifier Stage

Special demodulator probes containing a tunable IF amplifier stage are available for obtaining substantial screen deflection when signal tracing low-level stages. This type of probe has a small self-contained power supply and is powered from a 117-volt, 60-cycle outlet. A small tuning disc extending through the probe housing permits tuning over the 20- and 40-mc IF bands. It provides good waveform display, as well as high sensitivity. This type of probe is two to three times as expensive as nonamplifying demodulator probes.

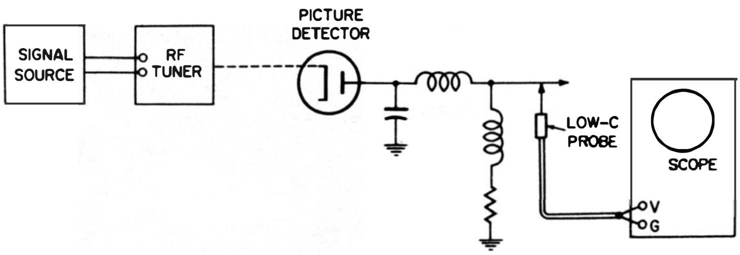
To Use the RF and IF Amplifiers to Check the Percentage Modulation of a Video Signal, Pattern-Generator Output, or Signal-Generator Output

Equipment: DC scope and low-capacitance probe. (Also a generator, if signal is to be checked from an equipment source.)

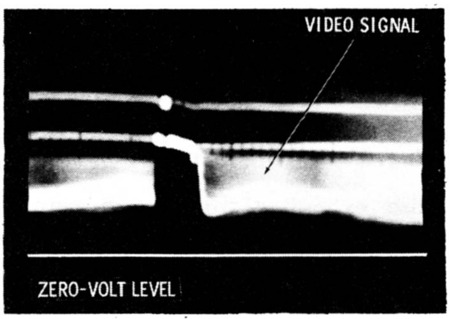
Connections Required: Connect low-capacitance probe at picture-detector output. Apply probe output to vertical-input terminals of DC scope. (If instrument is used as a signal source, apply output to antenna-input terminals of receiver.)

Procedure: Tune receiver to input signal frequency. Adjust scope controls for suitable waveform display. Then short the vertical-input terminals of the scope.

Evaluation of Results: Note the position of the waveform with respect to the zero-volt level when the vertical-input terminals are shorted. For example, if the waveform touches the zero-volt level, modulation is 100%. If the bottom of the waveform is clipped at the zero-volt level, the carrier is overmodulated.



Test setup.

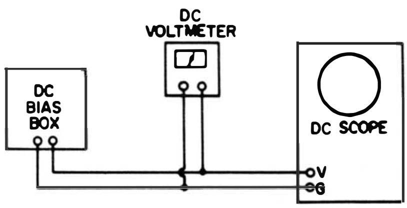


Waveform obtained when checking the percentage modulation of a video signal.

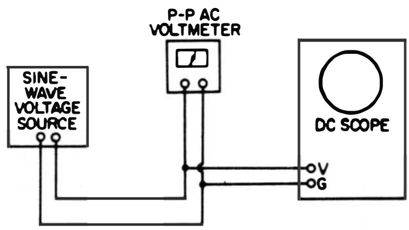
NOTE 38

Checking a DC Scope for Equality of AC and DC Response

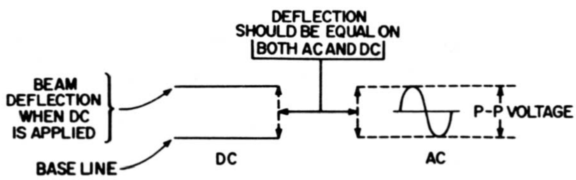
Most DC scopes give equal vertical deflections for equal values of DC and peak-to-peak voltages. That is, if a 1-volt, peak-to-peak, sine-wave source deflects the CRT beam one inch, a 1-volt DC source will also deflect the beam one inch. However, because of amplifier defects, this is not always true. The scope can be checked for equality of AC and DC response as shown in the following illustrations. First mark the base line of the scope, then apply a DC potential and note the amount the beam is deflected. Next, apply an AC voltage having a peak-to-peak voltage equal to the DC voltage. The peak-to-peak beam deflection of the AC voltage should equal the beam deflection of the DC potential. When AC and DC deflections are not equal, measurements of percentage modulation will be in error.



Test setup for DC response.



Test setup for AC response.



Comparison of DC and AC deflection.

U24

To Make a Quick Test of the Over-all Frequency Response of a TV Receiver

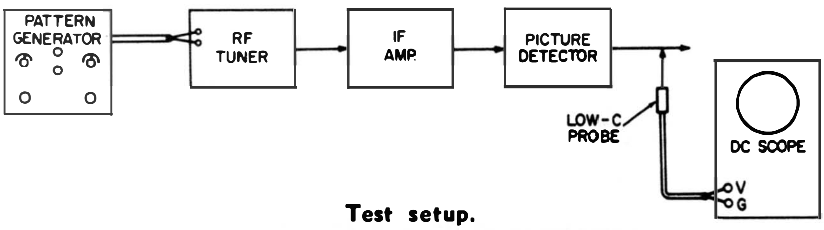
Equipment: Pattern generator and low-capacitance probe.

Connections Required: Apply modulated RF output from pattern generator to antenna-input terminals of receiver. Connect probe at picture-detector output. Feed probe output to vertical-input terminals of scope.

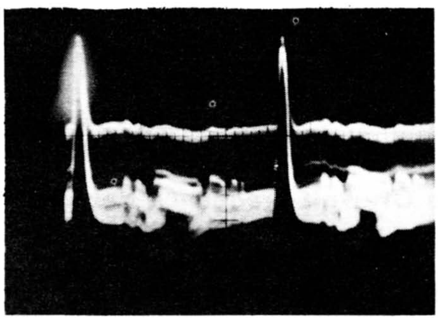
Procedure: Adjust instrument and receiver controls for suitable pattern. Then vary the RF carrier frequency of the pattern generator through the passband of the receiver while watching the vertical deflection on the scope screen. Operate the scope on 30-cycle sweep.

Evaluation of Results: The peak-to-peak voltage of the pattern depends chiefly upon the low video frequencies. These correspond to sidebands near the picture carrier. As the frequency of the pattern generator is varied through the passband of the receiver, the vertical deflection noted on the scope screen indicates the height of the over-all response curve at that frequency. If the pattern height "jumps" or "pops up," there is a sharp peak in the over-all response curve. If it "pops up" twice, there are two sharp peaks, etc. If the pattern suddenly disappears and then reappears, there is a "suck-out" in the over-all response curve.

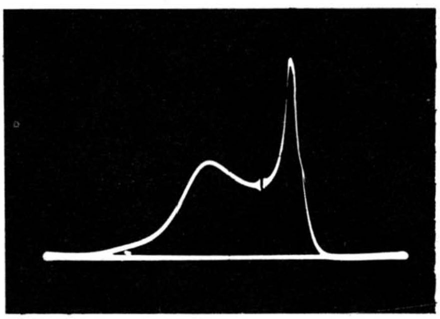
You will note from the photograph that the vertical sync pulse from a service pattern generator does not have standard shape. This is true of all but the most expensive pattern generators. However, useful service tests can still be made without a perfectly shaped vertical sync pulse.



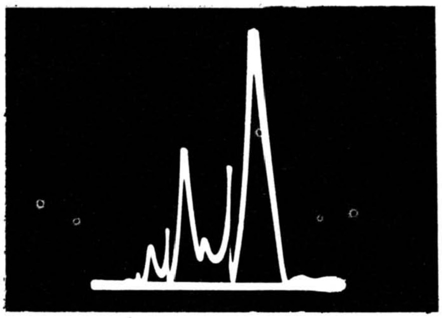
Test setup.



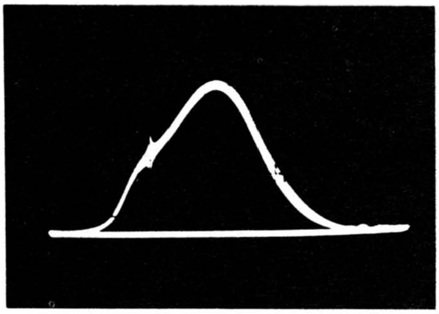
Typical display from a test pattern generator.



If a receiver has a response curve like this, the pattern will jump to double height when the generator carrier frequency is tuned to the sharp peak.



If the receiver has a response curve like this, the pattern will jump up and down rapidly when the pattern generator is tuned across the pass-band of the receiver.



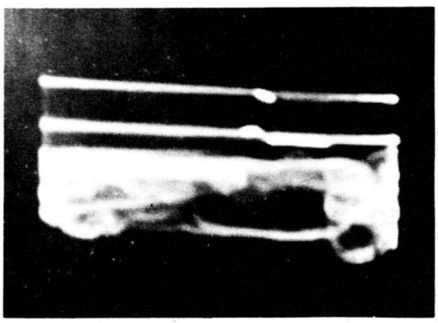
Pattern has half-height on scope screen when generator RF frequency is tuned to half-voltage point on curve; pattern has full height when RF frequency is tuned to top of curve.

NOTE 39

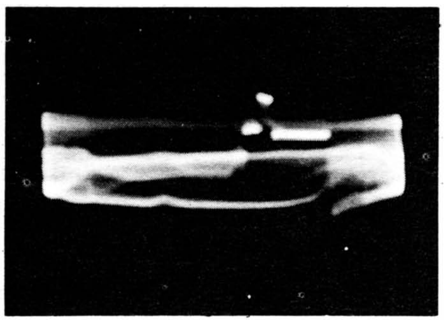
Checking the Over-all Frequency Response, Using the Signal from a TV Station

The same general type of over-all frequency response test can be made with a TV station signal if the local-oscillator frequency is varied. To obtain the necessary range of frequency variation, rotation of the fine-tuning control is usually insufficient and must be supplemented by turning the slug in the local-oscillator coil. A well-shaped vertical sync pulse is observed when a TV station signal is used.

If a wide-band scope is used, the horizontal sync pulses will have the same peak voltage as the vertical sync pulse. However, if a narrow-band scope is used, the horizontal sync pulses are attenuated and do not appear to have the same peak voltage as the vertical sync pulses. This is because the horizontal sync pulses are higher in frequency than the vertical sync pulses.



Pattern obtained with a wide-band scope.



Pattern obtained with a narrow-band scope.

To Measure the 4.5-Mc Intercarrier Sound-Signal Voltage at the Picture-Detector Output

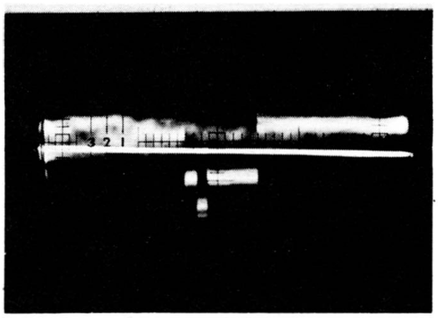
Equipment: Low-capacitance probe.

Connections Required: Remove first video-amplifier tube. Connect probe at grid terminal of video-amplifier socket. Feed probe output to vertical-input terminals of a wide-band (flat through 4.5 mc) scope.

Procedure: Tune in a TV station signal. Adjust scope controls for suitable video signal pattern. Use 60-cycle sweep rate.

Evaluation of Results: Observe the top and porches of the vertical sync pulse. The "fuzz" riding on the pulse is the 4.5-mc sound signal. Turn the fine-tuning control and observe the variation in the 4.5-mc voltage. If the scope is calibrated, the intercarrier sound voltage can be measured. It should not exceed 5% of the video-signal voltage. If it does, the IF amplifier is operating nonlinearly or the receiver passband is much too broad.

In the following illustration, the over-all passband is much too wide. The 4.5-mc intercarrier sound-signal voltage exceeds the allowable 5%. This is conducive to generation of sync buzz. (Note the horizontal line through the pattern. This line is the zero-volt reference level, obtained by shorting the vertical-input terminals of the scope. The average value or zero-volt level in any waveform can be quickly observed in this manner.)



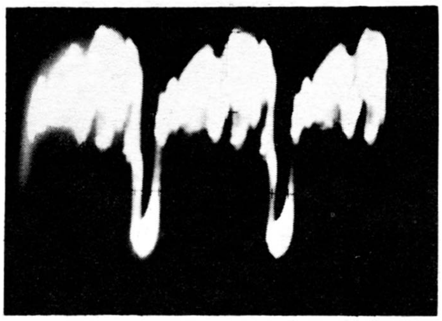
Waveform observed when 4.5-mc intercarrier sound signal exceeds 5%.

NOTE 40

Eliminating Cross Talk from Sweep Circuits in a Video Signal

Do not confuse the 4.5-mc intercarrier sound signal with possible cross talk from the sweep circuits of the receiver. The following illustration shows the appearance of 60-cycle hum and vertical-sweep cross talk in the composite video signal. The pattern shows simulated horizontal sync pulses, as commonly provided by service pattern generators. When in doubt whether cross talk or 4.5-mc intercarrier sound signal is being observed, remove the horizontal- and vertical-output tubes. Sometimes the horizontal- and vertical-oscillator tubes must also be removed to eliminate cross talk. A quick test is to turn the fine-tuning control of the receiver. Cross talk does not respond to the local-oscillator frequency.

60-cycle hum and vertical-sweep cross talk in composite video signal.

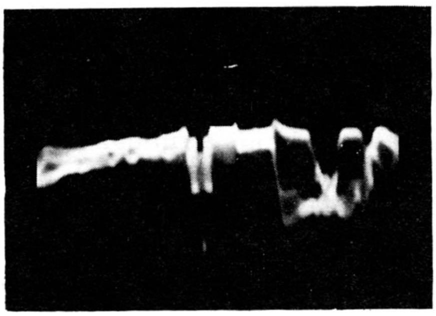


NOTE 41

Effect when Demodulator Probe Is Used

Erroneous use of a demodulator probe (instead of a low-capacitance probe) seriously distorts the composite video signal, which undergoes double demodulation.

Appearance of composite video signal when demodulator probe is used at picture-detector output.

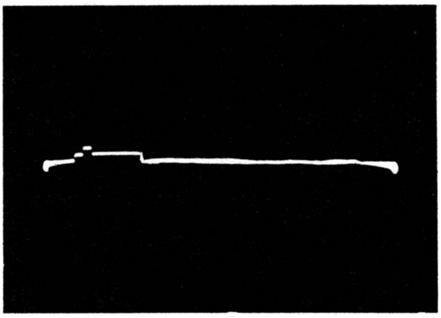


NOTE 42

Pickup of Signal from Local TV Station with Demodulator Probe

When a demodulator probe is connected to the vertical-input terminals of a scope and left on the bench, the operator sometimes observes a sync pulse when the scope is operated at a 60-cycle sweep rate and at high gain. This sync pulse is caused by probe pickup of a local

TV station having high field strength. The spurious signal disappears when the probe is connected across a circuit under test, because the input impedance of the probe is then sufficiently lowered that pickup is negligible.



Composite video signal picked up by demodulator probe from local TV station.

U26

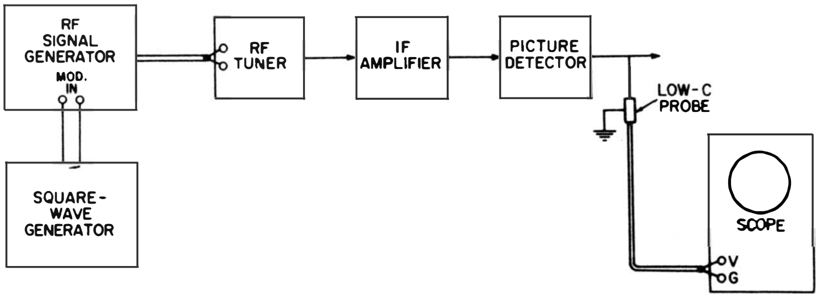
To Check the IF Amplifier for Amplitude Linearity

Equipment: RF signal generator, square-wave generator with built-in modulator (or external modulator), and low-capacitance probe.

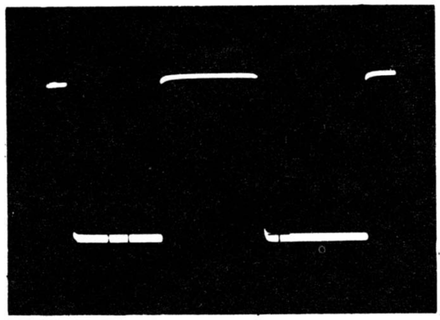
Connections Required: Apply square-wave signal to modulator-input terminals of signal generator. (If external modulator is used, apply both square-wave signal and RF signal to modulator input.) Connect modulated signal output to antenna-input terminals of receiver. Connect probe at picture-detector output. Feed probe output to vertical-input terminals of scope.

Procedure: Tune RF signal generator to channel frequency of receiver. Use a small percentage modulation on the RF generator signal. Tune square-wave generator to any medium frequency, such as 10 kc. Adjust scope controls for suitable square-wave pattern display.

Evaluation of Results: Vary the receiver signal input from a low level to where an output of 2 peak-to-peak volts is obtained from the picture detector. The reproduced square wave shows "fuzz" along the top and bottom. This "fuzz" is caused by the audio modulating voltage in the generator signal. If the IF amplifier is linear, the "fuzz" has equal voltages at both top and bottom of the square-wave display, even at full output from the picture detector. Otherwise, the IF amplifier is nonlinear. Nonlinear amplification is one of the important causes of sync buzz.



Test setup.



If the "fuzz" in the reproduced square wave has less peak-to-peak voltage at the top than at the bottom, IF amplifier amplitude nonlinearity is indicated.

NOTE 43

Determining if Signal Generator Modulator Is Operating Properly

Misleading results can be obtained in the linearity test if the signal generator has a poor modulator. If you find apparent IF-amplifier nonlinearity at low input to the receiver, the generator modulator should be suspected. Unless serious trouble is present in the IF amplifier, it will be linear at low RF signal input levels. On the other hand, any IF amplifier becomes nonlinear as the input signal level is increased past the normal capability of the IF strip.

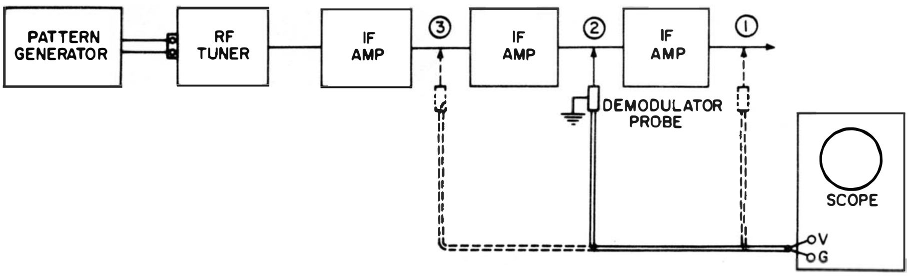
To Localize a Sync-Limiting Stage in the IF Amplifier

Equipment: Pattern generator and demodulator probe.

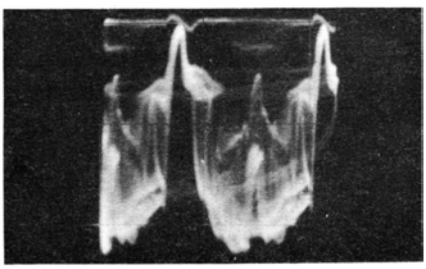
Connections Required: Connect modulated-RF output of generator to antenna-input terminals of receiver. Connect probe output cable to vertical-input terminals of scope.

Procedure: Adjust generator and receiver controls for approximately 1 volt peak-to-peak (or normal) output from the picture detector. Apply demodulator probe to the grid and plate of each IF stage, from the picture detector to the tuner. Adjust scope controls for pattern shown in the following illustration.

Evaluation of Results: The height of the vertical sync pulse is observed with respect to the video information. The limiting IF stage causes the vertical sync pulse to appear at less height in the video signal. The stages before the limiting stage show the sync pulse at normal height. The stages after the limiting stage show the sync pulse at subnormal height.



Test setup.



Appearance of normal signal from pattern generator at detector output.

NOTE 44

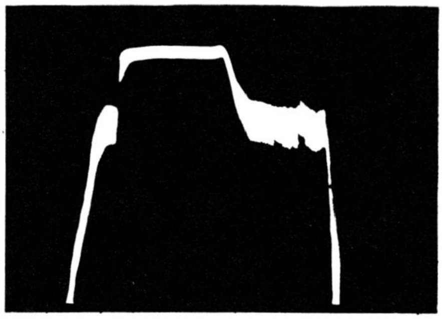
Reason for Using Pattern Generator to Localize Sync-Limiting Stage

A pattern generator is used in this test because it provides a constant signal as tests are made from stage to stage. A TV station signal is unsuitable unless the station is transmitting a test pattern. Sync limiting, if present, becomes more troublesome where pictures with white backgrounds are used. Most pattern generators permit using a plain white field. Sync limiting is a common cause of picture pulling and 60-cycle sync buzz.

NOTE 45

Method of Determining Whether Limiting of Sync Pulse Is Caused by Receiver or Scope

Sync limiting in receiver signal circuits should not be confused with limiting in the vertical amplifier of the scope. For example, the following photo shows a sync-pulse display in which the sync tip is seriously limited. However, the limiting is being caused by nonlinearity of the scope vertical amplifier. This is quickly shown by reducing the vertical gain to half-screen deflection or less. If the sync tip then resumes normal proportions, the limiting is occurring in the scope, not in the receiver under test.



Appearance of horizontal sync pulse when sync tip is compressed in the vertical amplifier of the scope.

VIDEO-AMPLIFIER TESTS

U28

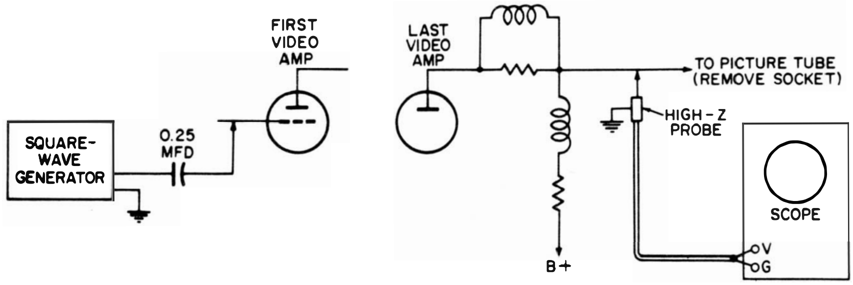
To Make a Square-Wave Test of a Video Amplifier

Equipment: Square-wave generator and low-capacitance probe.

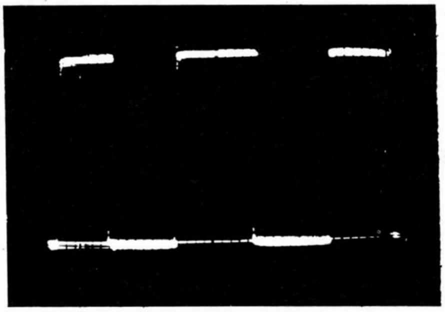
Connections Required: Connect a 0.25-mfd blocking capacitor in series with the "hot" lead from the generator. Apply square-wave voltage between grid and ground of the input video-amplifier tube. Remove socket from picture tube. Connect low-capacitance probe at video-amplifier output. Feed probe output to vertical-input terminals of wide-band scope. (Scope should have flat response through 4 mc.)

Procedure: Adjust square-wave generator for an output of approximately 1 volt peak-to-peak. Set contrast control to normal operating position. Adjust scope controls for suitable pattern. Make successive square-wave tests at approximately 60 cps, 10 kc, and 100 kc.

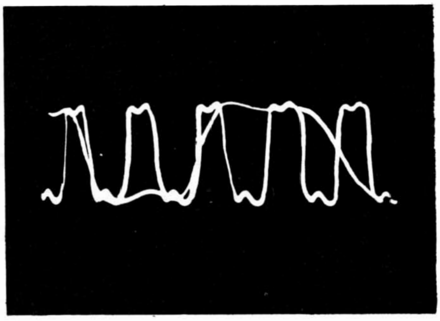
Evaluation of Results: Low-frequency square waves should not have more than 10% tilt. High-frequency square waves should not have more than 10% overshoot. Waveform should be reproduced symmetrically. Faults in a square-wave reproduction are caused by incorrect values of load resistors, damping resistors, peaking coils, or by incorrect operating point of video-amplifier tube(s). Component faults, such as leaky coupling capacitors, defective bypass capacitors, and off-value screen and cathode resistors also cause distorted square-wave reproduction.



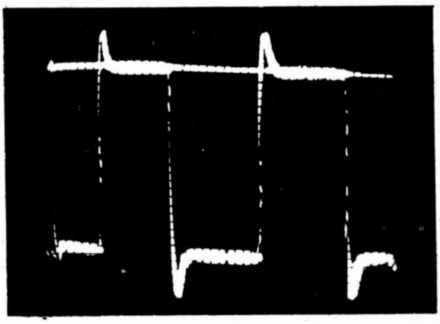
Test setup.



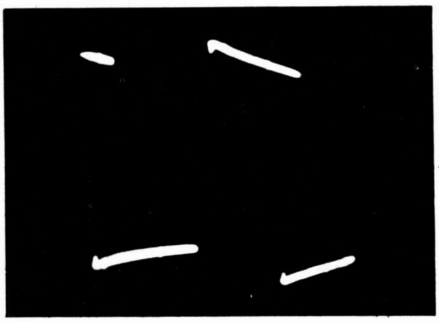
Good square-wave response.



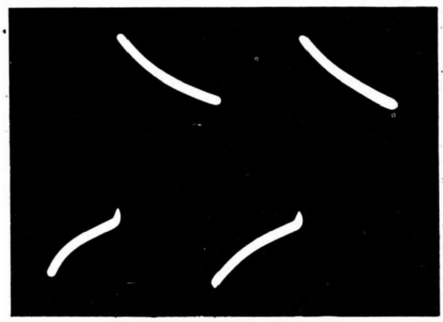
Corner rounding and ringing.



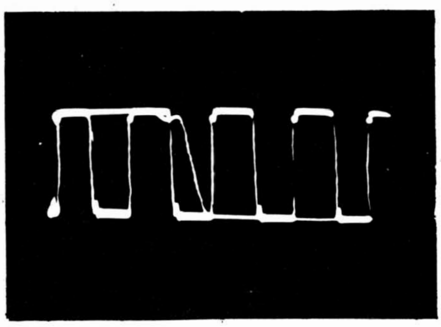
Overshoot.



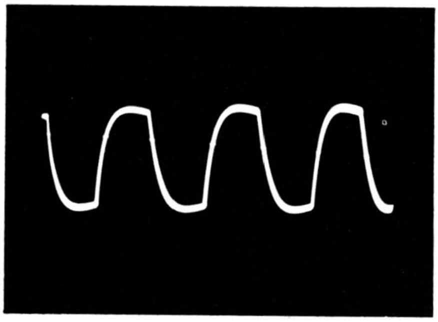
Tilt (some curvature).



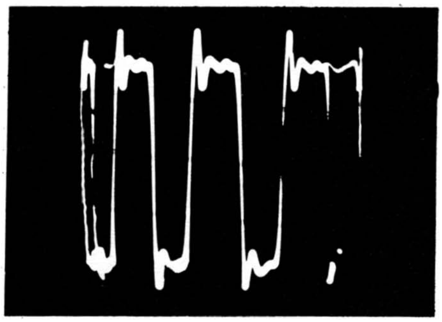
Severe tilt and curvature.



"Stepped" corner.



High-frequency attenuation and phase shift.

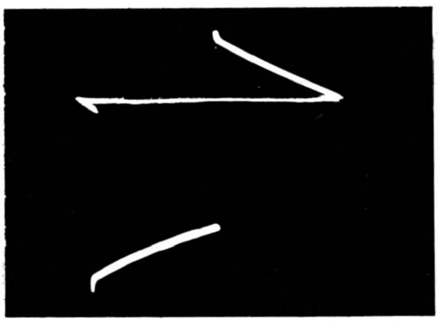


Overshoot and ringing.

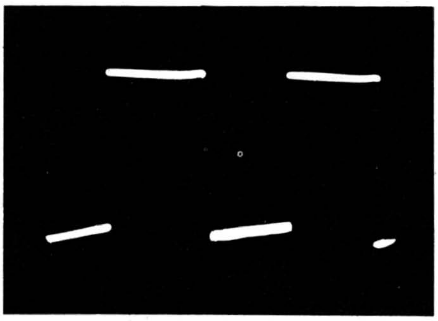
NOTE 46

Checking a Video Amplifier for Amplitude Linearity

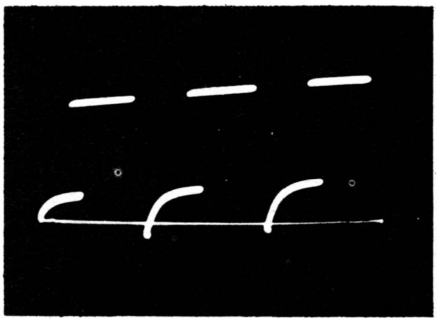
At low frequencies, all video amplifiers introduce substantial tilt into the reproduced square wave. Linearity of the video amplifier can be checked by following the procedure outlined in U28 and setting the square-wave generator to 30 cps. The tilt of the reproduced square wave is symmetrical if the video amplifier is linear. On the other hand, the tilt is unsymmetrical if the video amplifier introduces amplitude distortion. This is shown in the following illustrations. Nonlinear operation is caused by incorrect operating point of the video-amplifier tube, low plate or screen voltages, or inability of the tube type to handle the normal signal excursion (about 1-volt peak-to-peak input).



Tilt is reproduced symmetrically when amplitude distortion is absent.



Unsymmetrical reproduction of tilted square wave, caused by a nonlinear amplifier.

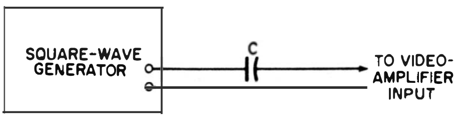


Severe dissymmetry of tilted square wave.

NOTE 47

Method of Differentiating the Square-Wave Signal in a Well-Designed DC Video Amplifier

The amplitude-distortion test described in Note 46 is easiest to make. Note, however, that with a well-designed DC video amplifier, differentiation of a square-wave signal does not take place, although the amplifier may operate in a nonlinear manner. If so, the square-wave signal must be tilted (differentiated) before it is applied to the video amplifier. This differentiation is conveniently done by inserting a small series capacitor in the generator output lead, as shown in the following.



Inserting a small value of capacitance in series with the generator output lead. NOTE: Choose a value for C that provides substantial differentiation of the square wave.

U29

To Make a Square-Wave Test of a Video Amplifier, Taking the Picture-Detector Circuit into Account

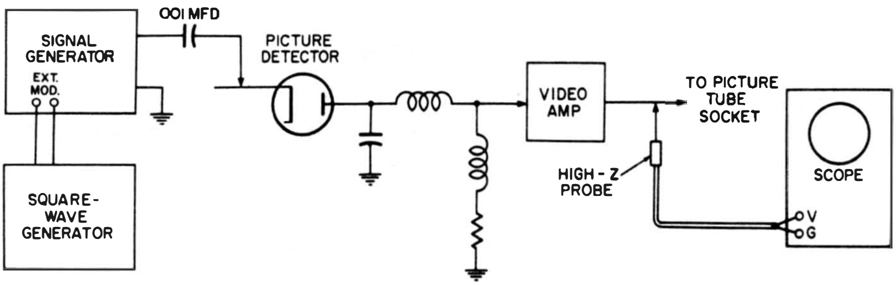
Equipment: Signal generator with built-in modulator (or use external modulator), square-wave generator, 0.001-mfd capacitor, and low-capacitance probe.

Connections Required: Connect output cable from square-wave generator to modulator input terminals (Ext. Mod. terminals of generator). Connect signal-generator output cable through a 0.001-mfd blocking capacitor to the picture-detector input.

Connect probe at video-amplifier output. Remove socket from picture tube.

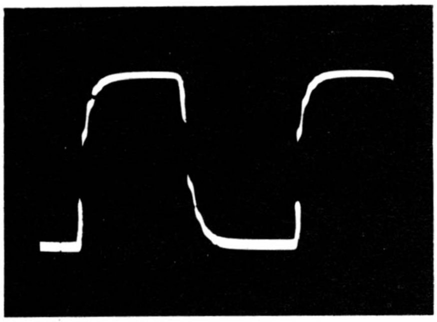
Procedure: Adjust square-wave generator output for 85% to 100% modulation of the RF voltage (see U18). Tune signal generator to midband frequency of receiver IF. Use maximum output from signal generator.

Evaluation of Results: Same as explained in U28. Note that the picture-detector circuit attenuates the high video frequencies somewhat. Since the picture detector processes the composite video signal, this test is more informative when investigating causes of poor picture quality than when checking the video-amplifier response alone.



Test setup.

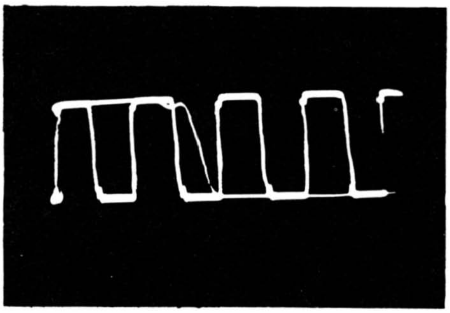
Typical corner rounding and ringing in a 100-kc, square-wave test.



NOTE 48

Effect of Over- and Undercompensated Circuits

Corner rounding and ringing in square-wave reproduction is caused by a combination of over- and undercompensated circuits. If a circuit with falling high-frequency response is followed by a circuit with rising high-frequency response, the first circuit introduces a rounded corner, while the second circuit introduces ringing. The over-all effect is to produce "sawtooth" or "stepped" corners in the reproduced high-frequency square wave.

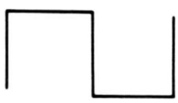


Stepped corner over a reproduced 100-kc square wave.

NOTE 49

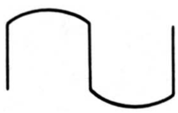
Square-Wave Distortion

The basic square-wave distortions and their causes are illustrated in the following. When troubleshooting circuits that cause square-wave distortion, it is helpful to keep these points in mind.

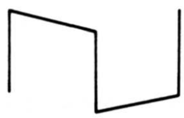


(A) Undistorted.

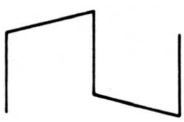
(B) Low-frequency attenuation.



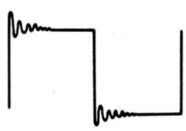
(C) High-frequency attenuation.



(D) Leading low-frequency phase shift.



(E) Lagging low-frequency phase shift.



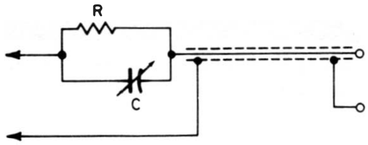
(F) Transient oscillation (ringing).

(G) Combination of low-frequency attenuation and leading low-frequency phase shift (differentiation).

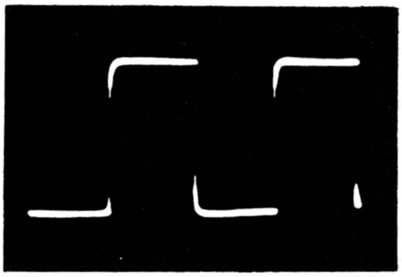
(H) Combination of high-frequency attenuation and lagging low-frequency phase shift.

Square-wave distortion by circuit under test.

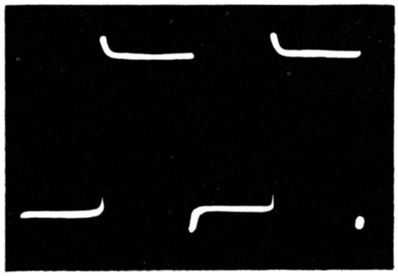
A low-capacitance probe contains a compensating capacitor, as shown in the following diagram. Unless the capacitor is correctly adjusted, the scope will display a distorted square wave. Undercompensation causes diagonal corner rounding (high-frequency attenuation and phase shift). Overcompensation causes diagonal overshoot (excessive high-frequency response and phase shift). The step attenuator in a scope also utilizes compensating capacitors. Unless these capacitors are correctly adjusted, similar square-wave distortion occurs.



Low-C probe contains a compensating capacitor.



Undercompensated probe.

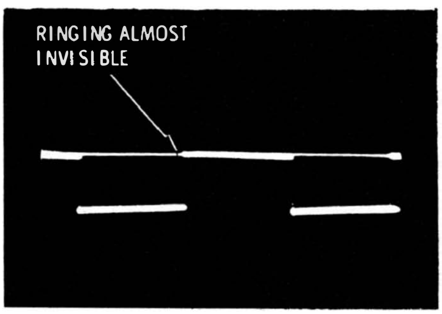


Overcompensated probe.

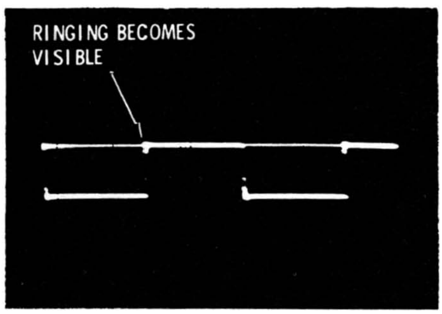
NOTE 50

Need for High-Frequency, Square-Wave Test in Video Amplifier

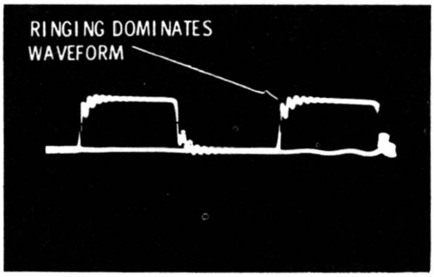
High-frequency ringing in a video amplifier can be properly observed with a high-frequency, square-wave test only, because the high-frequency harmonics in a low-frequency square wave are relatively weak. As shown in the following illustrations, high-frequency ringing, practically invisible in a 1,000-cycle square-wave test, becomes apparent in a 100,000- or 500,000-cycle square-wave test. Ringing in a video amplifier is a common cause of "outlines," "repeats," or "circuit ghosts" in the picture.



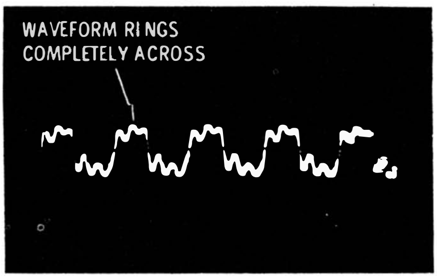
1,000-cycle square wave. High-frequency ringing is practically invisible.



10,000-cycle square wave. High-frequency ringing can be seen on leading and trailing edges.



100,000-cycle square wave. Ringing becomes evident.

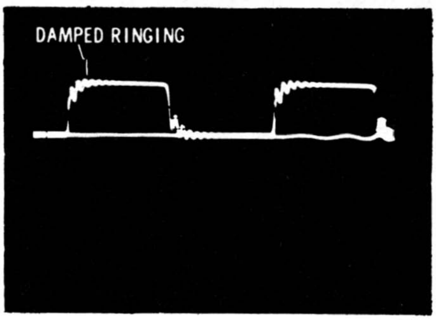


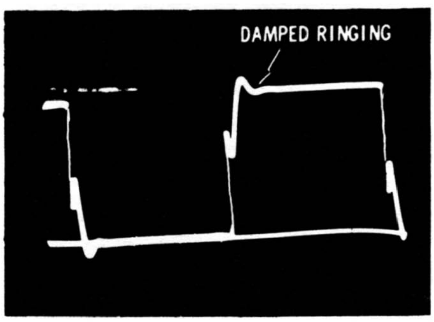
500,000-cycle square wave. Pattern shows ringing completely across the top and bottom.

NOTE 51

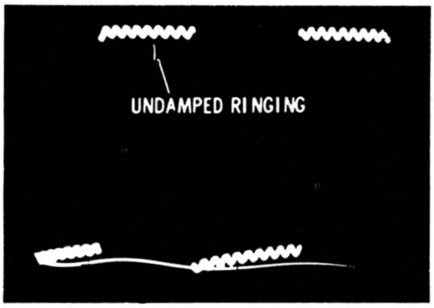
Checking for Ringing in Video Amplifier

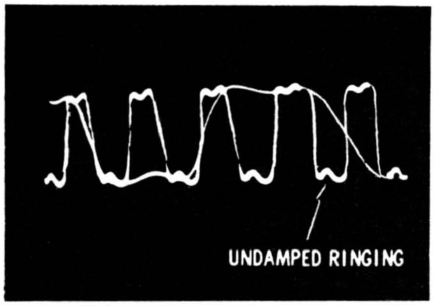
A basic distinction will be observed in ringing patterns from a video amplifier, depending upon whether the square wave rings only at the leading and trailing edges or whether it rings clear across the top of the square wave. When the ringing is damped and dies out between leading and trailing edges, the amplifier rings the same for all square-wave frequencies; i.e., you will observe that the peak-to-peak voltage of the ringing component remains the same when the tuning dial of the square-wave generator is varied. On the other hand, when the ringing is undamped and persists at practically the same peak-to-peak voltage completely across the top of the square wave, the amplifier rings strongly at one setting of the generator tuning dial, but the ringing disappears as the square-wave frequency is changed. Then the ringing appears again as the square-wave frequency is changed still more. This is caused by interference from ringing patterns, which aid or oppose at different frequencies. Therefore, ringing tests should not be made at "step frequencies," but should be observed as the tuning dial of the generator is rocked back and forth. Otherwise, a false conclusion might be made that the video amplifier does not ring at all, whereas it actually rings very strongly at reinforcing square-wave frequencies. (See the following illustrations.)





Square waveforms displaying damped ringing.





Square waveforms displaying essentially undamped ringing.

U30

To Check the Composite Video Signal at the Video-Amplifier Output

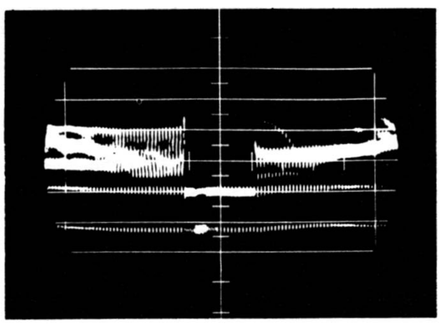
Equipment: Low-capacitance probe.

Connections Required: Connect probe between video-amplifier output terminal and chassis ground. Remove socket from picture tube. Feed probe output to vertical-input terminals of scope. (Scope should be flat through 4 mc.)

Procedure: Tune in a TV broadcast signal or drive receiver from a test-pattern generator. Adjust scope controls for suitable pattern display.

Evaluation of Results: Composite video signal should be undistorted, as shown in the following photo.

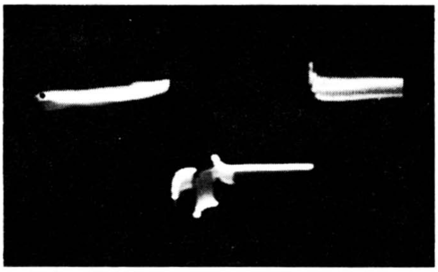
Appearance of composite video signal at output of video amplifier.

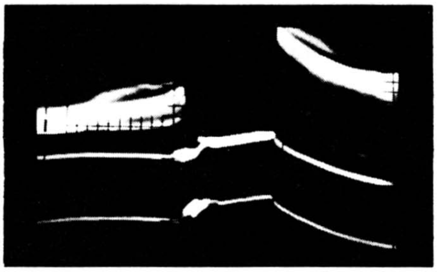


NOTE 52

Effect on Composite Video Signal When Video Amplifier Low-Frequency Response Is Poor

When the low-frequency response of the video amplifier is poor, a partial differentiation of the composite video signal, commonly called sync punching, can be seen. The vertical sync pulse is punched (depressed) below the level of the horizontal sync pulses. (See the following photos.)





Examples of sync punching.

NOTE 53

Effect of Poor Low-Frequency Response and 60-Cycle Hum Distortion on Composite Video Signal

A combination of poor low-frequency response and 60-cycle hum distortion in the video amplifier causes the composite video signal to appear as shown in the following photo. Poor low-frequency response is caused by faulty coupling or bypass capacitors, or by a load resistor too low in value. 60-cycle hum is caused by heater-cathode leakage in a tube.

Effect of poor low-frequency response and 60-cycle hum in video amplifier on composite video signal.

NOTE 54

Checking for Sync Punching in IF and RF Amplifiers

Sync punching (as well as 60-cycle hum) can enter the composite video signal in the IF or RF amplifier, as well as in the video amplifier. Hence, this type of distortion must sometimes be traced back into the high-frequency circuits. Sync punching causes unstable or lost vertical sync. If the distortion is found at the video amplifier *input*, it is next traced back through the IF amplifier. A demodulator probe is used. A probe as described in Note 36 is best. It normally displays horizontal and vertical sync pulses at equal height.

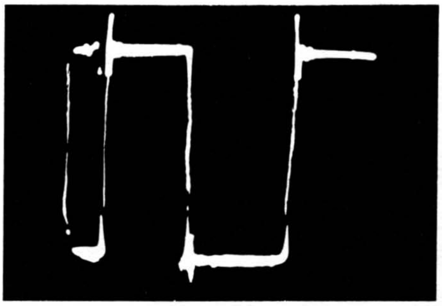
To Check the Operation of a Video-Peaking Contrast Control

Equipment: Signal generator with built-in modulator (or external modulator), square-wave generator, 0.001-mfd capacitor, and low-capacitance probe.

Connections Required: Connect output cable from square-wave generator to modulator input terminals (Ext. Mod. terminals of generator). Connect signal-generator output cable through a 0.001-mfd blocking capacitor to the picture-detector input terminal. Connect probe at video-amplifier output. Remove socket from picture tube.

Procedure: Adjust square-wave generator output for 85% to 100% modulation of the RF voltage (see U18). Tune signal generator to midband frequency of receiver IF. Use maximum output from signal generator. Vary the setting of the contrast control over the major portion of its range. (Increase scope gain as the contrast-control setting is reduced.)

Evaluation of Results: A video-peaking contrast control, when set at maximum, usually introduces noticeable overshoot and ringing into a 100-kc square wave. On the other hand, when the control is set to a low position, the corners of a 100-kc square wave are usually rounded.



Overshoot and ringing of square wave with video-peaking contrast control at high setting.

Corner rounding occurs when control is set to low level.

NOTE 55

Reason for Unsymmetrical Overshoot in Reproduced Waveform

When observing reproduced square waves for overshoot, note that the overshoot is sometimes unsymmetrical on positive and negative peaks of the waveform, even though the amplifier is linear. This unsymmetrical overshoot is caused by unequal rise and fall times of the square-wave generator signal. The faster the rise (or fall), the greater the overshoot produced by a given video-amplifier circuit. Good square-wave generators have equal rise and fall times.

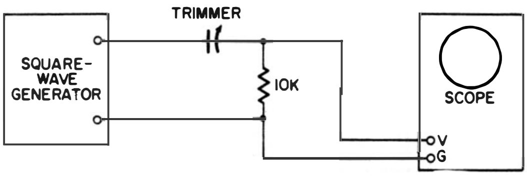
To Check a Square-Wave Signal for Equal Rise and Fall Times

Equipment: Trimmer capacitor, 10,000-ohm resistor, and square-wave generator.

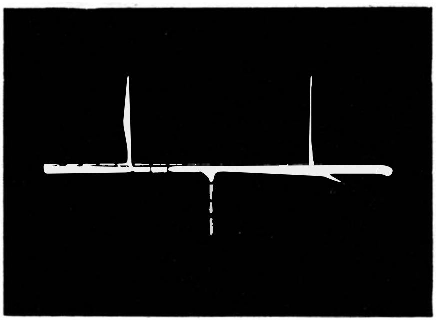
Connections Required: Feed generator signal through the small capacitor and into the resistor (differentiating circuit). Apply the voltage across the resistor to the vertical-input terminals of the scope.

Procedure: Adjust instrument controls for pattern as shown. Vary trimmer capacitance to obtain sharp pulses.

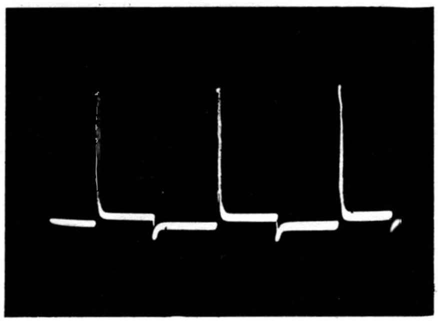
Evaluation of Results: If the square-wave voltage has equal rise and fall times, the pulses have equal positive and negative peak voltages. If pulses have unequal voltages, the differing rise and fall times thus indicated must be taken into account in evaluating amplifier linearity in terms of overshooting.



Test setup.



Rise time slightly faster than fall time.

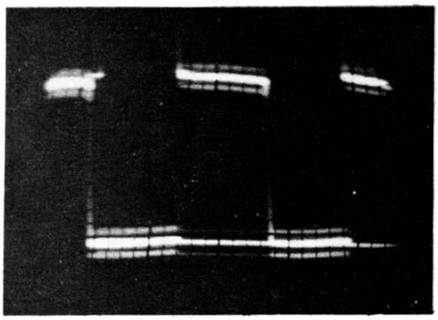


Rise time much faster than fall time.

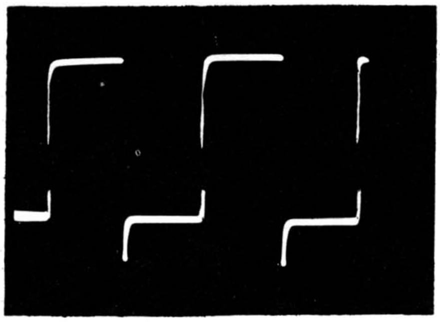
NOTE 56

Alternate Method of Checking Rise and Fall Time of Square-Wave Generator

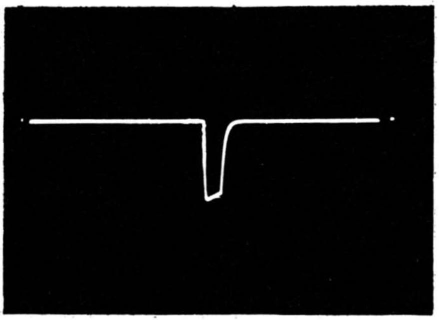
Another simple test for determining the equality or inequality of rise and fall times is to adjust the intensity control of the scope until either the rise or fall of the square-wave pattern is just visible. When rise and fall times are equal, their traces are equally visible. On the other hand, as shown in the next illustration, the fall trace, for example, may become visible before the rise trace. This shows that the rise is faster than the fall. This test is less informative than the test given in U32 because it is not quantitative. Furthermore, unless the scope itself is known to be in good operating condition, the square-wave generator could be unjustly blamed for a failure of the scope.



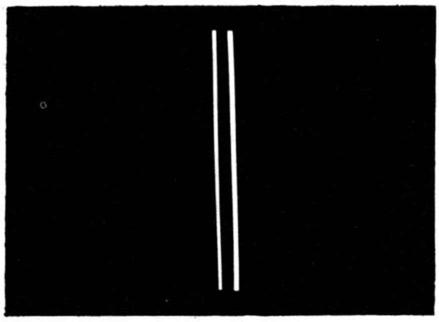
Leading edge is invisible at brightness level where trailing edge is visible. Rise time is faster than the fall time in this waveform.



Rise time is visible (slow). Fall time is invisible (fast). Rise edge causes no overshoot. Fall edge causes overshoot.



Sync-pulse waveform from generator shows faster leading edge than trailing edge. Leading edge will ring a video amplifier before the trailing edge does.

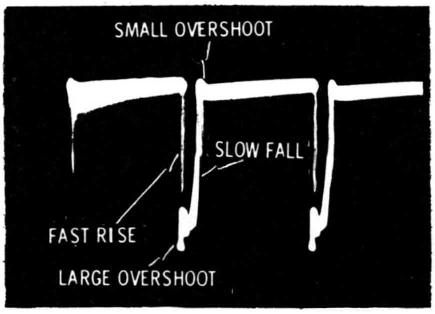


Same sync pulse with vertical-gain control advanced and horizontal-gain control setting reduced. This provides an easy comparison of the leading and trailing edge brightness.

NOTE 57

How a Horizontal Sync Pulse with Unequal Rise and Fall Times Causes Ringing in Video Amplifier

The following photo illustrates how a horizontal sync pulse with unequal rise and fall times rings a video amplifier. The pulse rise is fast, as shown by its small visibility. This fast rise causes considerable overshoot and ringing in underdamped video-frequency circuits. On the other hand, the pulse fall is slow, as shown by its plain visibility. This slow fall causes a comparatively small overshoot in the video circuits.



Horizontal sync pulse with unequal rise and fall times.

U33

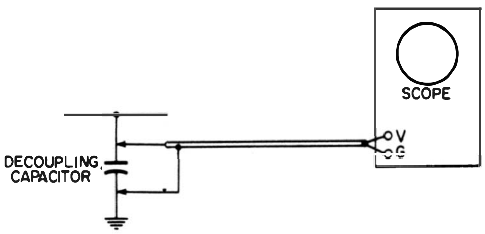
To Check the Decoupling Capacitors in a Video-Amplifier Circuit

Equipment: None.

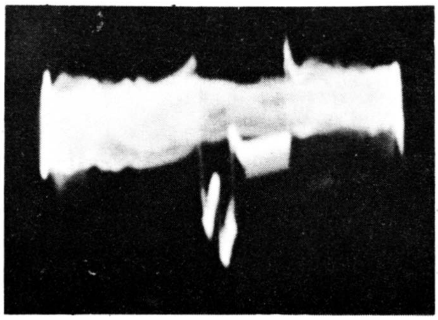
Connections Required: Connect vertical-input cable of scope across the decoupling capacitor under test.

Procedure: Tune in TV broadcast signal. Adjust scope controls for pattern, as shown in the following illustration.

Evaluation of Results: Maximum tolerable p-p voltage is not published in general service notes, but the observed p-p voltage can be compared with that found in a normally operating receiver of the same type. A higher than normal p-p voltage at this point indicates the decoupling capacitor is not functioning properly.



Test setup.



Typical waveform across a video amplifier decoupling capacitor (60-cycle sweep rate).

U34

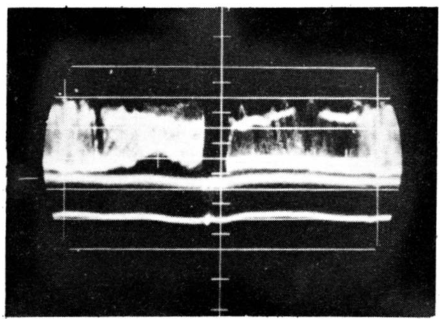
To Check the Action of a DC Restorer

Equipment: DC scope and low-capacitance probe.

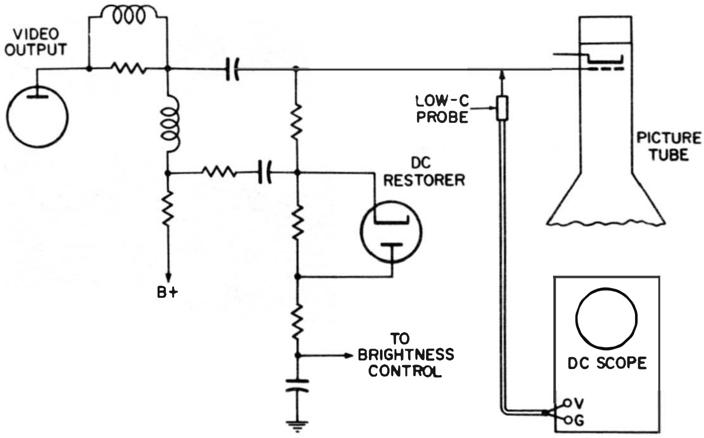
Connections Required: Connect probe at signal-input electrode of picture tube. Feed probe output to vertical-input terminals of scope.

Procedure: Tune in TV station signal (or use pattern-generator signal). Adjust scope controls for waveform as shown in the following illustration.

Evaluation of Results: DC scope must have good vertical balance to make a valid test. Note level of the horizontal sync pulses on the scope screen. If DC restorer is operating properly, the sync tips remain at the same level (or nearly so) as the background changes from light to dark or vice versa. If using a pattern generator, test is accomplished by varying the percentage modulation of the RF carrier by the test pattern. This generator control is identified as the Video control on some instruments.



Waveform at picture-tube input.



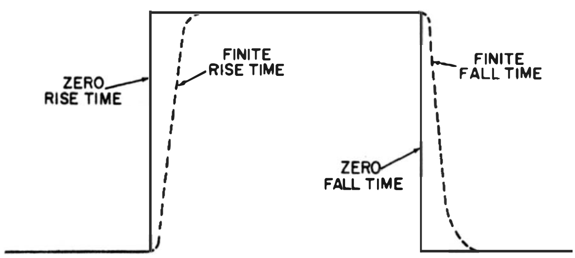
Test setup.

NOTE 58

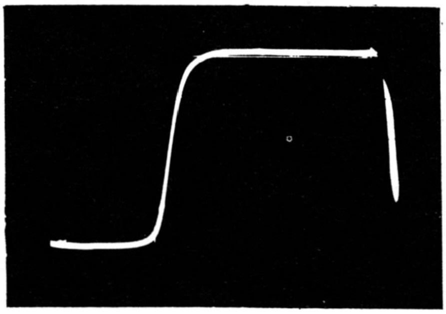
Checking the Rise Time of a Video Amplifier

According to a rule of thumb, the rise time of a video amplifier is considered to be one-third the period represented by the frequency at a point down 3 db (71%, or half-power point). For example, if the amplifier passes a 4-mc frequency at the 3-db point, then the period of the 4-mc frequency is 0.25 microsecond, and one-third of this period is approximately 0.08 microsecond. The rise time of the amplifier is then considered to be 0.08 microsecond.

Of course, a square-wave generator used for testing a video amplifier must have a faster rise time than the video amplifier to obtain a meaningful test. If the rise time of a video amplifier is 0.08 microsecond, a generator with a rise time of 0.05 microsecond is quite satisfactory.



Comparison of zero rise and fall times to finite rise and fall times.



The leading edge of any square wave is sloping, not vertical, when displayed on a scope with expanded sweep.

U35

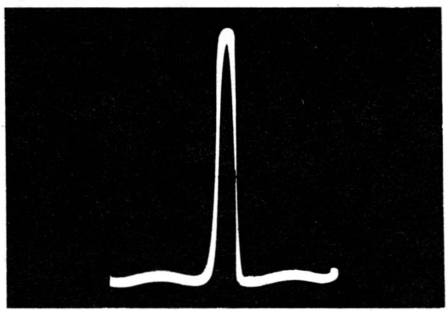
To Check the Vertical Retrace Blanking Pulse at the Picture Tube

Equipment: Low-capacitance probe.

Connections Required: Connect probe at blanking-pulse input point. This point is usually the grid or cathode of the picture tube. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for pattern as shown in the following.

Evaluation of Results: Check peak-to-peak voltage of pulse against value given in receiver service data.



Typical retrace blanking pulse.

To Check for AC in the Video-Amplifier B+ Supply Line

Equipment: None.

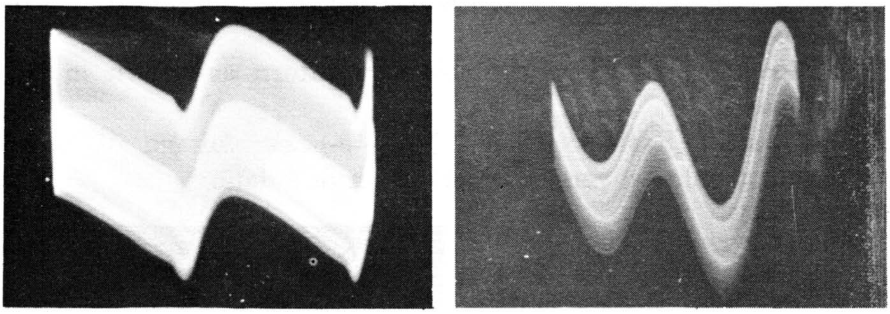
Connections Required: Connect cable directly from supply line to vertical-input terminals of scope.

Procedure: Use 60-cycle horizontal sweep. Adjust scope controls for pattern as shown in the following illustrations.

Evaluation of Results: Picture quality is impaired when excessive spurious AC voltage enters the video amplifier through the plate and screen supply lines. Maximum tolerable AC voltage is sometimes specified in the receiver service literature.

If maximum permissible ripple voltage is not given in receiver service literature, compare with value observed in a properly operating receiver of the same type.

Test setup.

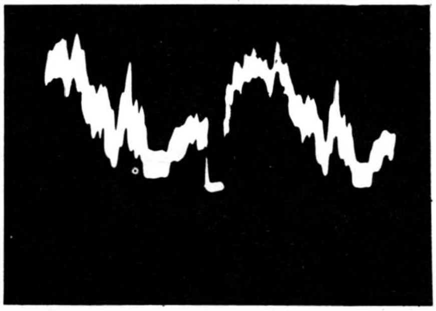


Typical ripple waveforms observed in B+ supply line.

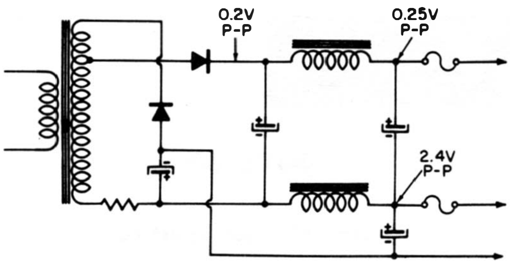
NOTE 59

Elimination of "Writhing," Caused by Difference in Supply Frequencies

AC waveforms in the power-supply system often "writhe." This "writhing" is caused by lack of identical frequencies between the vertical sweep rate and local utility frequency. To eliminate the "writhing," tune the receiver to a local TV station. Its sync is locked to the local utility frequency. In heavily industrialized and rural areas, rapid transients may also disturb the waveform, due to power-supply feedthrough. Transients can be eliminated with an automatic line-voltage regulating transformer.



Waveform disturbance caused by transients.



Typical maximum tolerable ripple voltages in a TV power supply.

U37

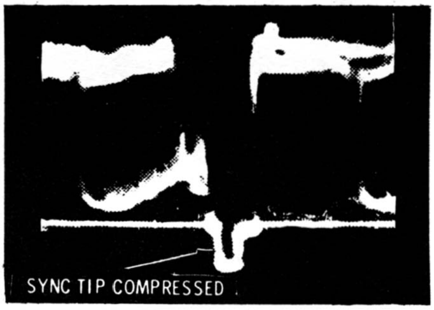
To Check the Output from a Video Amplifier for Sync Limiting

Equipment: Low-capacitance probe and pattern generator.

Connections Required: Connect output from pattern generator to antenna-input terminals of receiver. Connect probe, first to picture-detector output and then to video-amplifier output. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust generator and receiver controls for normal screen pattern (or specified p-p output from picture detector). Adjust scope controls for display as shown in the following illustration.

Evaluation of Results: With the probe applied at the picture-detector output, note the vertical deflection of the sync pulse with respect to the total deflection of the video signal. Next, with the probe applied at the video-amplifier output and scope gain reduced, check whether the ratio of sync-pulse deflection to total video-signal deflection is the same. If not the same, sync limiting is present in the video amplifier.

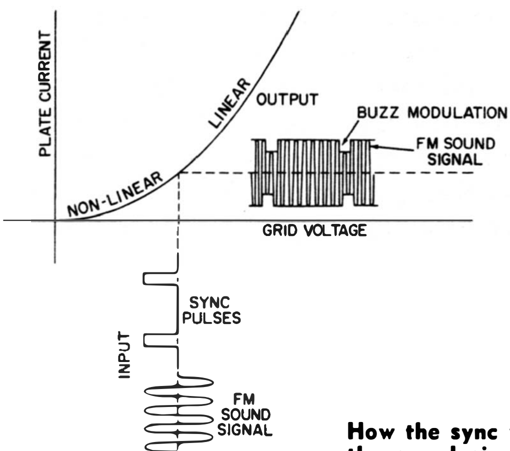


Horizontal sync pulse with amplitude limiting present.

NOTE 60

Effect of Sync Limiting

Sync limiting can cause picture pulling and sync buzz. Sync limiting can occur in the video amplifier as well as in the IF amplifier. This is the result of insufficient dynamic range. The most usual causes are incorrect tube operating points and low supply voltages. Picture pulling occurs when the sync pulses are so compressed that the phase detector no longer operates properly. Sync buzz occurs when the vertical sync pulse becomes deeply modulated into the 4.5-mc intercarrier sound signal. Buzz modulation does not occur when the video amplifier operates linearly. On the other hand, when the video amplifier limits sync (operates nonlinearly), the sync voltage becomes modulated into the 4.5-mc signal, as shown in the following illustration. The greater the curvature of the video-amplifier characteristic, the deeper the modulation of the sync pulses in the 4.5-mc FM signal.



How the sync voltage becomes modulated into the sound signal.

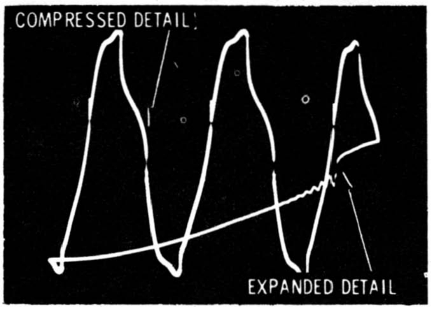
To Examine Waveform Detail by Use of Retrace Expansion

Equipment: As described under any selected Use.

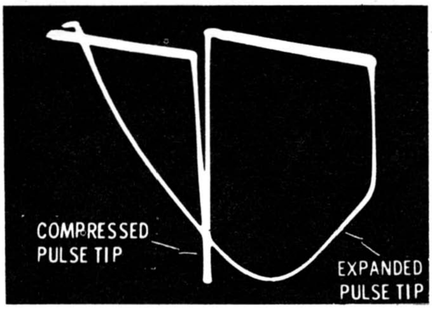
Connections Required: As described under that Use.

Procedure: Turn up intensity control of scope. Adjust sync amplitude, horizontal-sweep rate, and sync-polarity controls to display the desired waveform detail on retrace.

Evaluation of Results: Waveform detail at a given level in the forward trace will be displayed at the same level in the retrace. However, the display appears from right to left instead of left to right, and the detail is greatly expanded on retrace. Expansion is greater when the horizontal-sweep rate is greater. The expanded display appears with the forward-trace pattern.



Harmonic detail of a distorted sine wave expanded in retrace display.



Peak of narrow pulse expanded by display on retrace.

U39

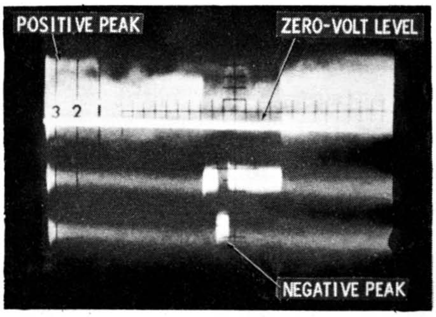
To Obtain the Zero-Volt Level in a Waveform (Measurement of Positive- and Negative-Peak Voltages)

Equipment: Same as described under selected Use (AC scopes only).

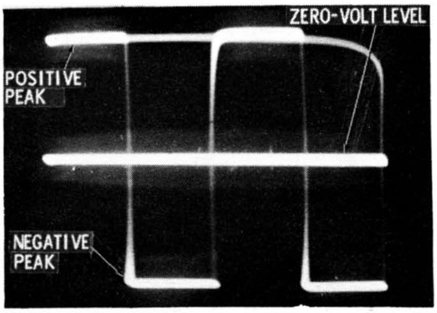
Connections Required: Same as described under that Use.

Procedure: Display waveform as in selected Use. Then short-circuit the vertical-input terminals of the scope. A base line appears on the scope screen.

Evaluation of Results: The base line indicates the zero-volt level in the waveform. Positive- and negative-peak voltages are measured from this zero-volt level. Peak volts are measured in the same units as peak-to-peak volts. Thus, if the scope has been calibrated for a sensitivity of one peak-to-peak volt per screen interval, its sensitivity is also one peak volt per screen interval when counting intervals from the zero-volt level to a waveform peak.



Appearance of the zero-volt line on a composite video waveform.



Appearance of the zero-volt line on a square wave.

U40

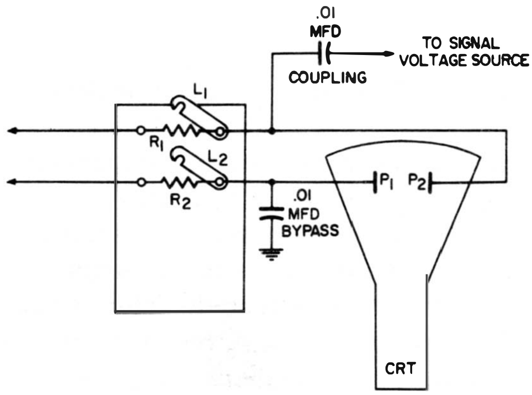
To Apply the Video Signal Voltage Directly to the Vertical-Deflection Plates of a Scope

Equipment: Two 0.1-mfd capacitors.

Connections Required: Open the links (or disconnect the busses) from the scope vertical amplifier to the CRT deflection plates. As shown in the following diagram, shunt a 0.1-mfd capacitor between the other plate and the video amplifier output.

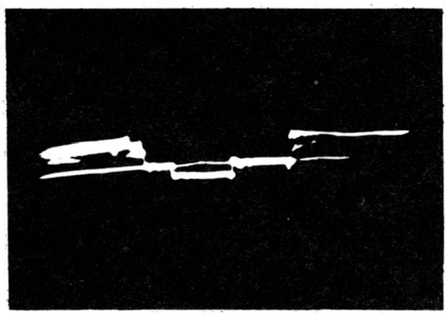
Procedure: Adjust the receiver for normal signal output. Adjust the horizontal-sweep controls of the scope for suitable CRT display, as shown in the following waveform. (Note that the vertical-gain controls of the scope do not work.) The centering controls operate, since R1 and R2 provide a DC path from the CRT plates to the centering controls of the scope. If the pattern is difficult to lock, use external sync. Run a test lead from the external-sync post of the scope and clip it to the insulation of the video-amplifier output lead.

Evaluation of Results: Note that the amount of vertical deflection obtained depends on the video-amplifier output voltage. About 400 peak-to-peak volts are needed to get full-screen deflection on the usual scope screen. Hence, a typical video amplifier gives only one-quarter screen deflection or less. This test shows extremely high frequencies, and parasitics or "spot" oscillatory voltages, which would escape the vertical amplifier in a service-type scope, can be seen.



Connections for applying video signal voltage directly to vertical-deflection plates of oscilloscope.

Horizontal sync pulse display obtained by applying video signal voltage directly to vertical-deflection plate of oscilloscope.



NOTE 61

Need for Bypass Capacitor When Viewing Video Signal Applied Directly to Deflection Plates of Scope

The bypass capacitor shown in the foregoing diagram is essential. If the bypass capacitor is not used and the link is closed, signal-voltage return is then made through the plate-load circuit of the vertical-amplifier circuit. The impedance of this return circuit distorts the waveform. On the other hand, if the bypass capacitor is not used and the link is left open, low sensitivity and severe frequency distortion occur. If a bypass capacitor is used and the link is left closed, a very large value of capacitance is required because of the resonant characteristics of the peaking coils shunting the bypass capacitor. Hence, open the link and use a relatively small value of bypass capacitance, such as 0.1 mfd. Because of the high value used for R1, this gives good frequency response.

U41

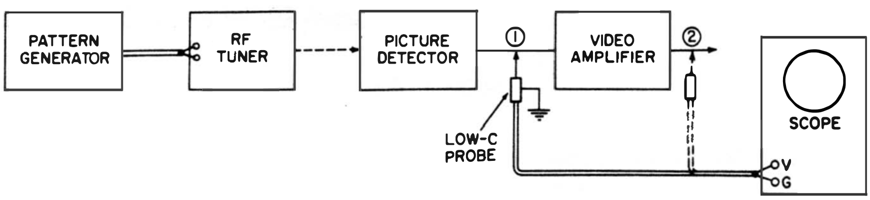
To Measure the Gain of a Video Amplifier

Equipment: Pattern generator and low-capacitance probe.

Connections Required: Connect output cable of generator to antenna-input terminals of receiver. Connect probe output cable to vertical-input terminals of scope.

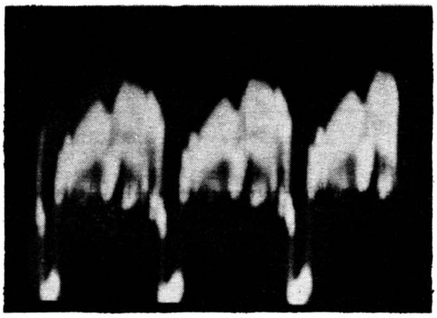
Procedure: Apply probe to picture-detector output and then to video-amplifier output. Adjust receiver controls for normal operation. Adjust scope controls for pattern as shown.

Evaluation of Results: The video-amplifier gain is measured by comparing vertical deflections in the two tests. A pattern generator insures a stable signal. If the step attenuator is dropped back from the X1 position to the X100 position and equal screen deflection is obtained at the amplifier output, the gain is 100 times. Check service data for normal gain. A variation of 20% is permissible. Low gain gives poor picture contrast and is usually caused by low-value load resistors, incorrect tube voltages, or defective bypass capacitors.



Test setup.

Waveform at video-amplifier tube.



U42

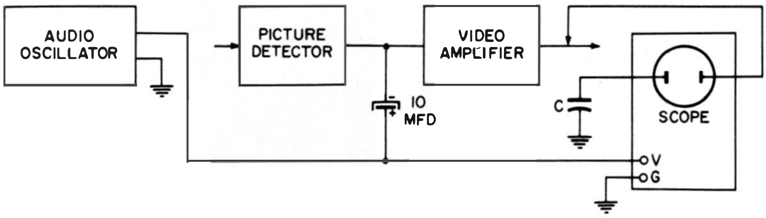
To Check a Video Amplifier for Low-Frequency and High-Frequency Phase Shift

Equipment: Audio oscillator and blocking capacitor (10 mfd).

Connections Required: Feed output from audio oscillator through blocking capacitor (connected in suitable polarity) to output terminal of picture detector. Also feed output from audio oscillator to vertical-input terminals of scope. Remove socket from picture tube and run lead from video-amplifier output to horizontal-deflection plate of scope. Horizontal amplifier is not used because its frequency response is inadequate in most service scopes. Hence, the video-amplifier output is applied directly to the horizontal-deflection plate of the CRT.

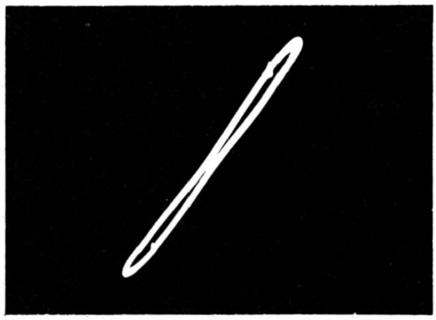
Procedure: Adjust audio generator output for maximum horizontal deflection on scope screen, without overload. Adjust vertical-gain control of scope for typical pattern, as shown.

Evaluation of Results: Negligible phase shift occurs in the mid-band range of the video amplifier, unless circuit faults are present. On the other hand, increasingly greater values of phase shift will be found at low video frequencies (such as 60 cycles) and at high video frequencies (such as 3 mc). Note that early low-frequency phase shift causes distortion of large areas in the picture, with poor background reproduction. Likewise, early high-frequency phase shift causes poor picture detail and displacement of picture elements. The pattern may appear inclined to the right or left, depending on the number of stages in the receiver video amplifier and in the vertical amplifier of the scope.

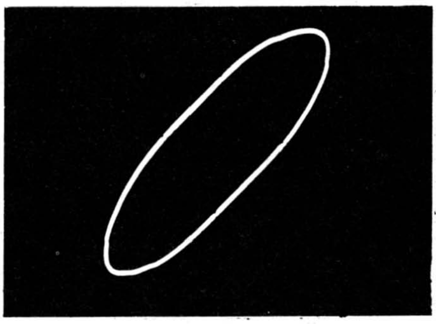


Test setup (see Note 61 for discussion of C).

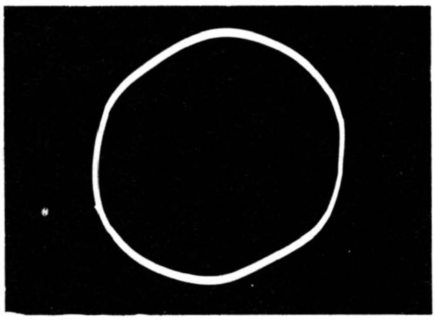
Negligible phase shift.



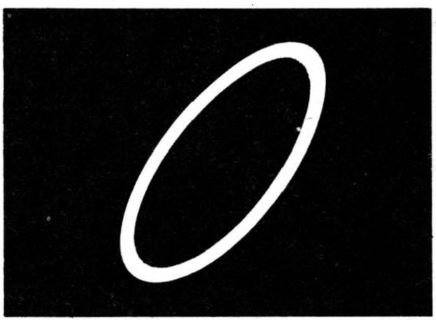
Small phase shift.



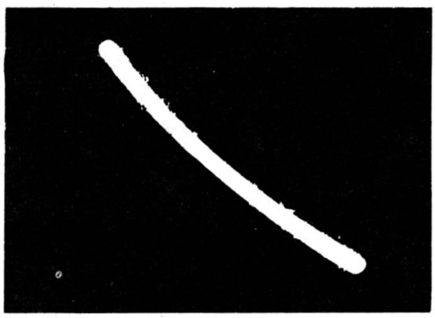
Greater phase shift.



Large phase shift.



Typical phase shift and loss of gain.



No phase shift, but amplitude non-linearity shows as a curvature of the diagonal line.

NOTE 62

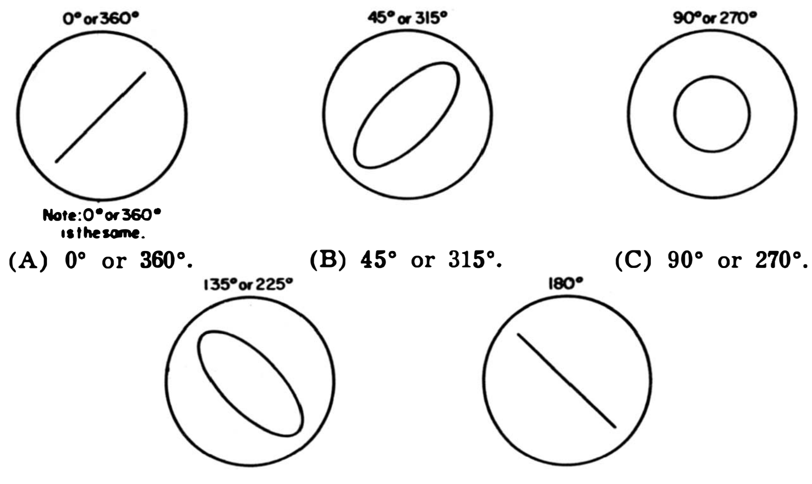
Phase Shift Introduced by Vertical Amplifier of Scope

The scope vertical amplifier should have a flat frequency response and a greater bandwidth than the receiver video amplifier. Otherwise, apparent phase shift in the patterns will be introduced by the scope. A DC scope is best for low-frequency checks, since the vertical amplifier introduces no phase shift at 60 cycles, for example. A 5-mc vertical amplifier is adequate for checking the 4-mc video amplifier of a receiver.

NOTE 63

Determining Degrees of Phase Shift

The pattern characteristics show the degrees of phase shift. For example, the following illustrations show five key patterns. Suppose that in the midband response where no phase shift is present, the screen pattern is a line inclined to the right. As either end of the band is approached, the line will open into a 45° ellipse, also inclined to the right, as seen in the second pattern. Closer approach to the band limits causes a circular pattern (when vertical and horizontal gains are properly adjusted), indicating 90° phase shift, as shown in the third illustration. At 135° the circle flattens to an ellipse, as shown in the fourth illustration, this ellipse being inclined to the left. At 180° a straight line inclined to the left is displayed, as seen in the fifth illustration. A phase shift of 225° next reproduces the 135° pattern. At 270° the 90° pattern is reproduced. At 315° the 45° pattern is reproduced. At 360° the 0° pattern reappears. Still greater amounts of phase shift cause the sequence to repeat.



(A) 0° or 360°. (B) 45° or 315°. (C) 90° or 270°.

(D) 135° or 225°. (E) 180°.

Waveforms obtained with different degrees of phase shift.

SYNC-CIRCUIT TESTS

U43

To Adjust the Ringing Coil in a Synchroguide Horizontal-Oscillator Circuit

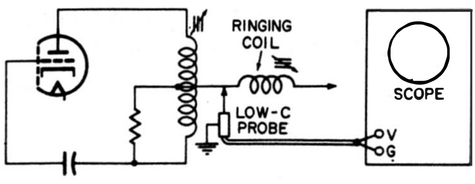
Equipment: Low-capacitance probe.

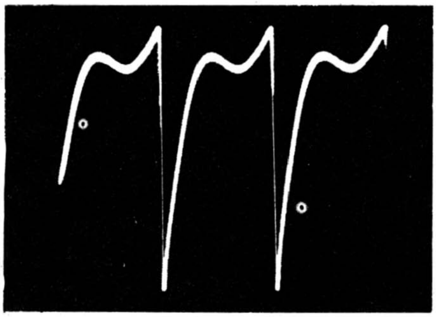
Connections Required: Connect probe between input of ringing coil and ground, as shown in the following diagram. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for pattern as shown in following photos. Receiver must be tuned to a TV broadcast station or energized from a pattern generator having horizontal sync output.

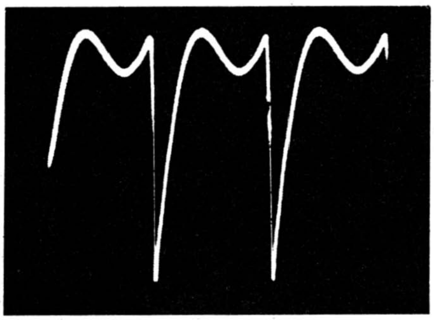
Evaluation of Results: Slug is adjusted in the ringing coil to bring the positive peaks of the pulse and sine wave to the same level.

Test setup.





Incorrect waveform.



Correct waveform.

U44

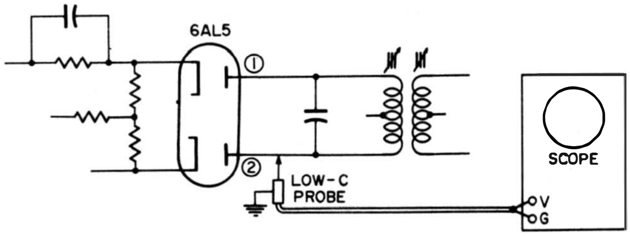
To Display Waveforms and Measure Peak-to-Peak Voltages In a Synchrolock Discriminator Circuit

Equipment: Low-capacitance probe.

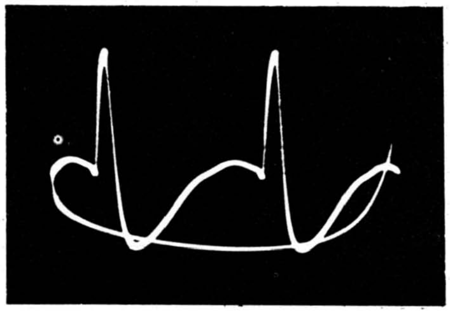
Connections Required: Apply probe from plate 1 to ground and then from plate 2 to ground, as shown in the following illustration. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern display as shown. Receiver must be tuned to TV station signal or driven by pattern generator having horizontal sync-pulse output.

Evaluation of Results: The normal waveform is a combined sine wave and sync pulse, as shown in the following waveform. (The sync pulse will normally show high-frequency attenuation.) Waveshapes and peak-to-peak voltages should be compared with data in receiver service literature.



Test setup.



Synchrolock discriminator waveform.

U45

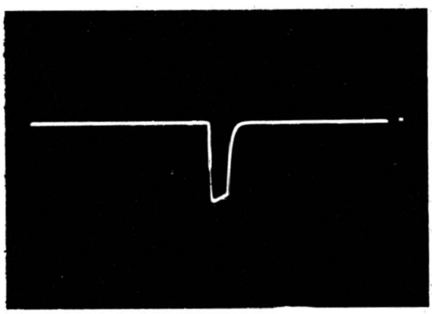
To Check the Action of a Sync Separator

Equipment: Low-capacitance probe.

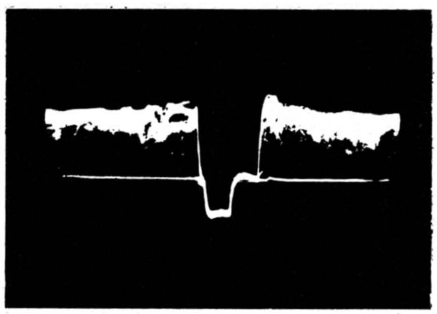
Connections Required: Apply probe at output of sync-separator tube. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical waveform as shown. Receiver must be tuned to TV station signal or energized from pattern generator having sync-pulse output.

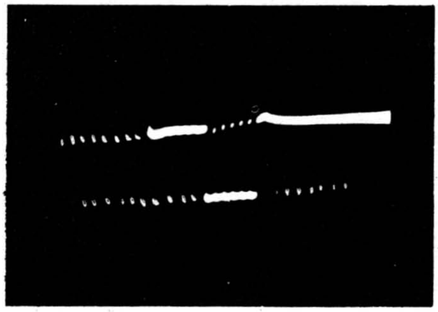
Evaluation of Results: Compare waveform (and peak-to-peak voltage) with data in receiver service literature. Good separation leaves all the camera signal behind. Poor separation is shown by passage of the camera signal. (See the following illustrations.)



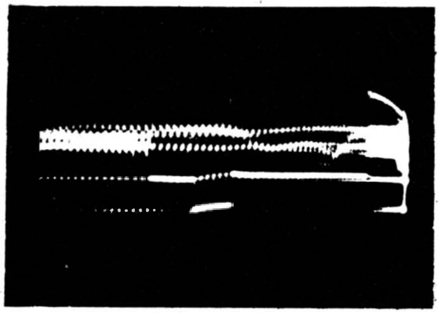
Good horizontal sync separation.



Poor horizontal sync separation.



Good vertical sync separation.

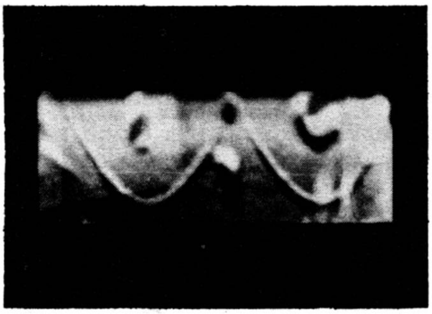


Poor vertical sync separation.

NOTE 64

Appearance of Pattern When 60-Cycle Hum Is Present

When sync separation is poor and substantial 60-cycle hum is present, no waveform will be seen. Instead, a picture appears on the scope screen, similar to a distorted image on a picture-tube screen. The reason for this display is similar to the one discussed in Note 30. (See the following photo.)



Beam displacement display, seen at output of faulty sync separator, with strong 60-cycle hum voltage in signal.

U46

To Check Waveforms and Peak-to-Peak Voltages Through the Vertical Sync Integrator

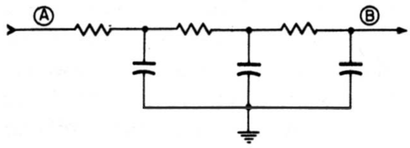
Equipment: Low-capacitance probe.

Connections Required: Apply probe at terminal points in the vertical-sync integrator network. Feed probe output to vertical-input terminals of scope.

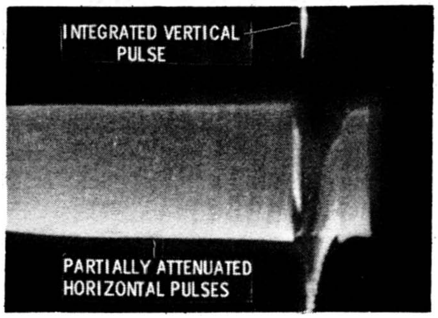
Procedure: Adjust scope controls for typical pattern as shown.

Receiver must be tuned to TV station signal or driven by pattern generator having sync-pulse output.

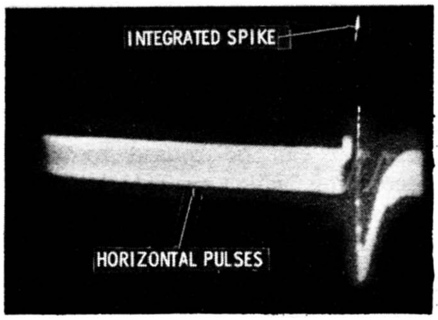
Evaluation of Results: Compare waveshapes and peak-to-peak voltages with data in receiver service literature. The merit of an integrator circuit is seen in its rejection of the horizontal sync pulses and development of the vertical sync pulse into a spike.



Integrator circuit.



Waveform viewed at A.



Waveform viewed at B.

NOTE 65

Need for Correct Setting of Receiver Controls

Integrator waveforms (like many other receiver waveforms) will appear distorted unless the receiver controls are correctly set and correct test conditions used. Hence, check the receiver service data. Quite often, it will state that the vertical oscillator be stopped and that vertical controls be set to specified positions.

NOTE 66

Apparent Failure of Integrator Network Due to Faults Outside of the Network

Apparent failure of the integrator network to eliminate horizontal pulses is sometimes caused by faults outside the network. For example, stray fields from the horizontal-sweep system may be reaching the integrator leads. To correct, dress the radiating leads away from the vertical-sync circuits, or investigate shielding conditions. In other cases, poor decoupling permits horizontal sweep or sync pulses to enter the vertical-oscillator circuit and mix with the integrator output waveform.

NOTE 67

Unstable Vertical-Integrator Output

Once in a while you will find an unstable vertical-integrator output. The picture remains in vertical sync for a short time, then starts to roll upward. When the picture rolls upward, the vertical oscillator is breaking sync lock. A scope check will show that the pulse output from the integrator varies in peak-to-peak voltage. When the voltage falls to a low value, the picture rolls. This variation can be caused by poor decoupling, which permits interfering voltages to enter the vertical-oscillator circuit. It can also be caused by faults anywhere in the signal or sync circuits which cause vertical sync punching. Poorly aligned IF amplifiers which are regenerative can cause this trouble. Gassy tubes in the high-frequency signal circuits can also be responsible. The scope is very useful in such cases for tracing the vertical sync waveform back through the circuits step-by-step to localize the defective circuit or component.

U47

To Observe the Waveform and Measure Its Peak-to-Peak Voltage at the Grid of the Horizontal AFC Tube

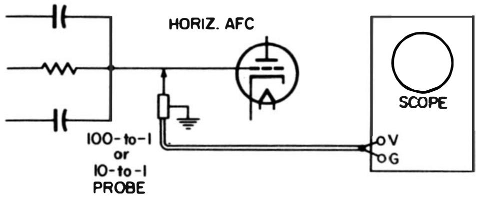
Equipment: 100-to-1 capacitance-divider probe or 10-to-1 low-capacitance probe.

Connections Required: Apply probe between grid of AFC tube and chassis ground. Feed probe output to vertical-input terminals of scope. 100-to-1 probe is preferred because of its lesser loading on the grid circuit.

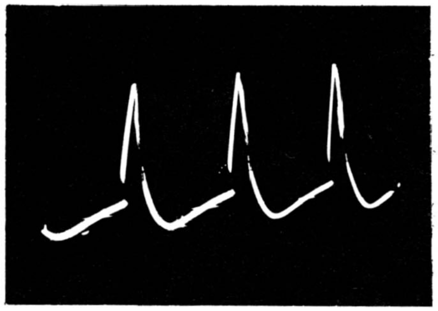
Procedure: Adjust scope controls for the following pattern.

Evaluation of Results: Check waveshape and peak-to-peak voltage against specified data in receiver service literature

Test setup.



Typical waveform at the grid of an AFC tube.



SWEEP-CIRCUIT TESTS

U48

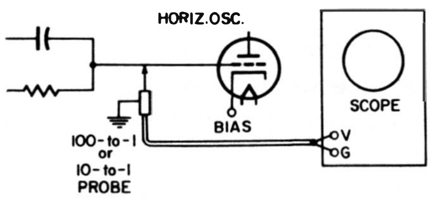
To Observe the Waveform and Measure the Peak-to-Peak Voltage at the Horizontal-Oscillator Grid

Equipment: 100-to-1 capacitance-divider probe or 10-to-1 low-capacitance probe.

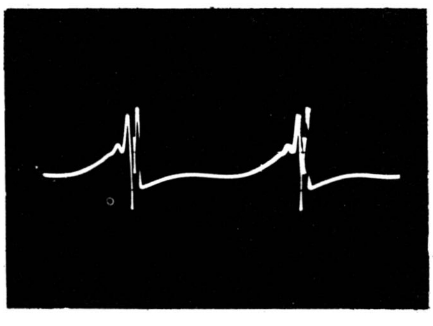
Connections Required: Apply probe between grid of horizontal-oscillator tube and ground. (100-to-1 probe is preferred because its lower input capacitance detunes circuit less than 10-to-1 probe.) Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for display shown in the following.

Evaluation of Results: Peak-to-peak voltage should be within 20% of value specified in receiver service literature. Waveform should be reasonably close to specified waveshape.



Test setup.



Typical waveform observed in test. (See receiver service literature for chassis under test.)

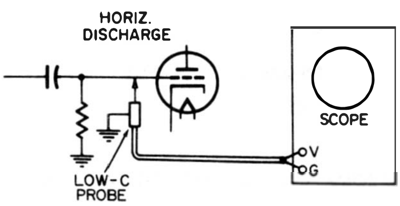
To Observe the Waveform and Measure Its Peak-to-Peak Voltage at the Grid of a Horizontal-Discharge Tube

Equipment: Low-capacitance probe.

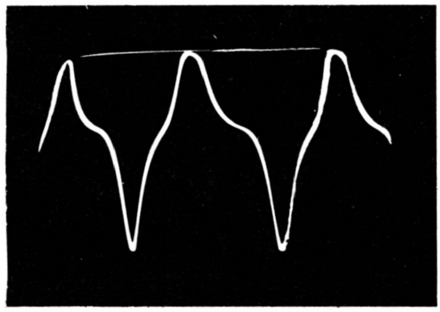
Connections Required: Apply probe between grid of horizontal-discharge tube and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern, as shown.

Evaluation of Results: Compare waveshape and peak-to-peak voltage with data in receiver service literature.



Test setup.



Typical waveform at grid of horizontal-discharge tube.

U50

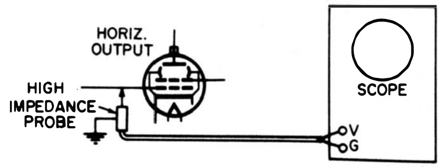
To Check the Waveform and Measure the Peak-to-Peak Voltage at the Grid of the Horizontal-Output Tube

Equipment: 10-to-1 high-impedance (compensated) probe.

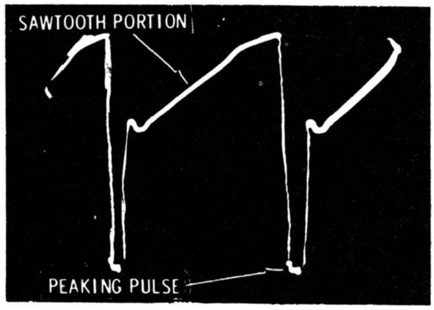
Connections Required: Apply probe between grid and ground of the horizontal-output tube. Connect probe cable to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern as shown.

Evaluation of Results: Observe waveform and compare with specified waveshape in receiver service data. Measure peak-to-peak voltage and compare with specified value. The observed peak-to-peak voltage will vary with the setting of the horizontal-drive control. Note that the test can be made with a direct cable to the scope in some instances. In others, a 10-to-1 probe is essential to avoid waveform distortion and voltage attenuation due to circuit loading.



Test setup.



Waveform at grid of horizontal-output tube.

U51

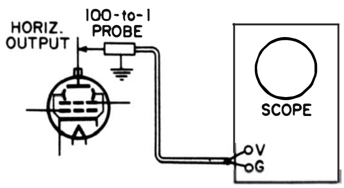
To Check the Waveform and Peak-to-Peak Voltage at the Plate of the Horizontal-Output Tube

Equipment: 100-to-1 high-voltage, capacitance-divider probe.

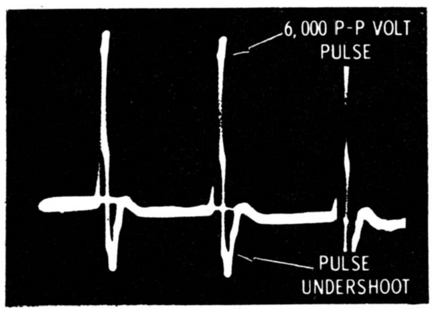
Connections Required: Apply probe between the plate terminals of the horizontal-output tube and ground. Connect probe cable to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern as shown.

Evaluation of Results: Observe waveshape and measure its peak-to-peak voltage. Compare with data in receiver service notes. Note that the setting of the drive adjustment will vary the peak-to-peak voltage.



Test setup.



Waveform at plate of horizontal-output tube.

NOTE 68

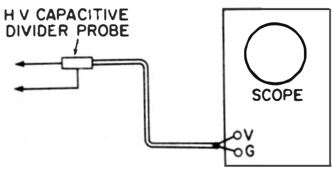
Voltage Rating of 100-to-1 Probe

A 100-to-1 capacitance-divider probe is generally rated for operation at voltages up to 10,000 peak-to-peak volts. Hence, it is adequate for testing at the plate of the horizontal-output tube. On the other hand, a 10-to-1 high-impedance compensated probe is usually rated to 600 peak-to-peak volts only. Therefore, a 10-to-1 probe must not be used in this test.

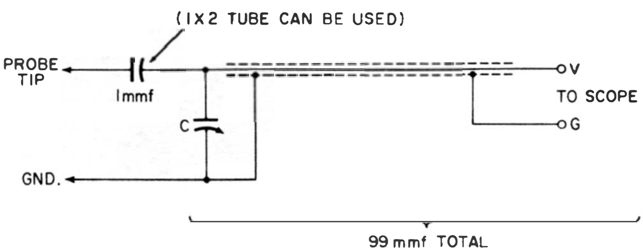
NOTE 69

Checking and Adjusting a 100-to-1 High-Voltage, Capacitance-Divider Probe for Attenuation Factor

Measure the peak-to-peak voltage of the waveform at a moderately high signal voltage point in the horizontal-sweep system, such as at the control grid of the horizontal-output tube, with the probe. Repeat the measurement with a direct cable to the vertical-input terminals of the scope. Observe the voltage value in the first test and compare with value obtained in the second test. Adjust trimmer capacitor of probe, if necessary, to obtain exactly 100-to-1 attenuation when the probe is used. Note that if the scope has a decade attenuator (10-to-1 steps), the same deflections should be obtained when the direct connection is used and the attenuator moved up two steps, as when the test is made with the divider probe.



Connection of a high-voltage, capacitor-divider probe.



Configuration of a typical high-voltage, capacitor-divider probe.

U52

To Check the Waveform and Peak-to-Peak Voltage at the Output of the Linearity-Coil Circuit

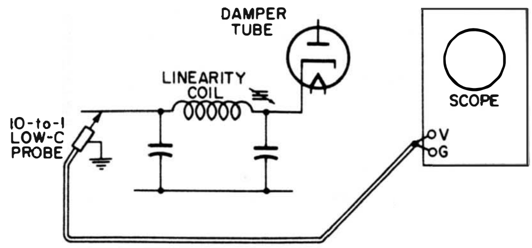
Equipment: 10-to-1 low-capacitance probe.

Connections Required: Apply probe between output terminal of linearity coil and chassis ground. Feed probe output to vertical-input terminals of scope.

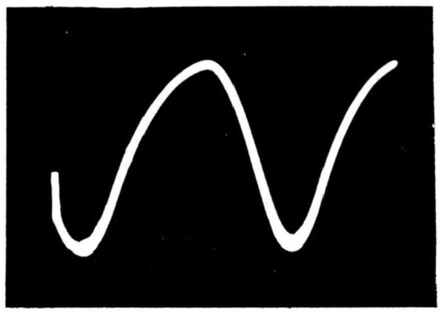
Procedure: Adjust scope controls for typical pattern as follows.

Evaluation of Results: Compare waveshape and peak-to-peak voltage with data specified in receiver service literature, or compare with pattern obtained from another chassis of the same type.

Test setup.



Typical waveform observed at output of linearity circuit.



U53

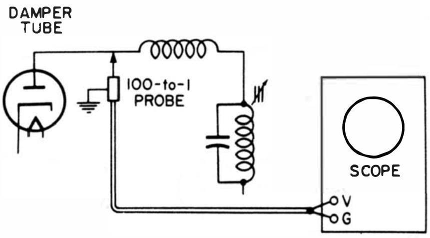
To Check the Waveform and Peak-to-Peak Voltage at the Plate of the Damper Tube

Equipment: 100-to-1 capacitance-divider probe.

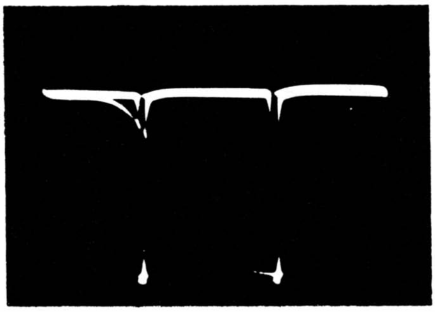
Connections Required: Apply probe between plate of damper tube and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for pattern as illustrated.

Evaluation of Results: Waveshape and peak-to-peak voltage should be compared with receiver service data or with pattern obtained from another receiver of the same type. NOTE: It is good practice to use a 100-to-1 probe in this test, since the peak-to-peak voltage at the damper plate is high in some receivers.



Test setup.



Typical waveform observed at damper tube plate.

U54

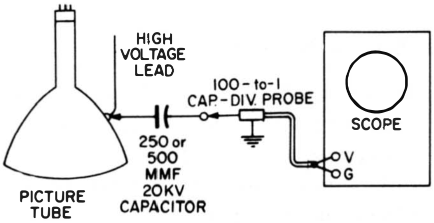
To Check the Waveform and Peak-to-Peak Voltage of the High-Voltage Ripple

Equipment: 100-to-1 high-voltage, capacitance-divider probe and high-voltage filter capacitor.

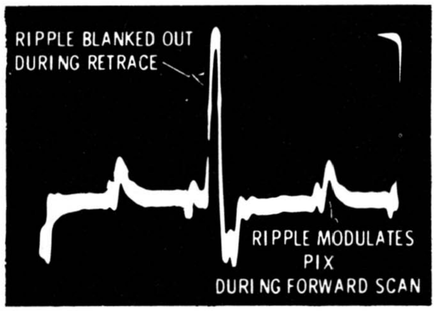
Connections Required: Connect the high-voltage filter capacitor (may be any convenient value, such as 250 and 500 mmf) in series with probe. Connect at second-anode terminal of picture tube, as shown. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for pattern shown in the following.

Evaluation of Results: Peak-to-peak voltage is a measure of the effectiveness of the high-voltage filter. Insufficient filtering can cause variation in shading across the screen. Compare observed voltage with value found in known good receiver using the same size picture tube.



Test setup.



Typical ripple waveform in a high-voltage, power-supply circuit.

U55

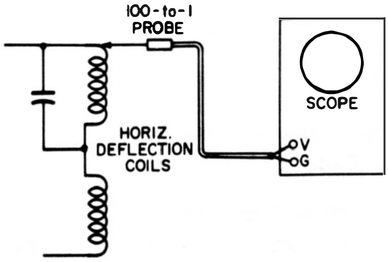
To Obtain the Waveform and Measure Its Peak-to-Peak Voltage Across the Horizontal-Deflection Coils

Equipment: 100-to-1 high-voltage, capacitor-divider probe.

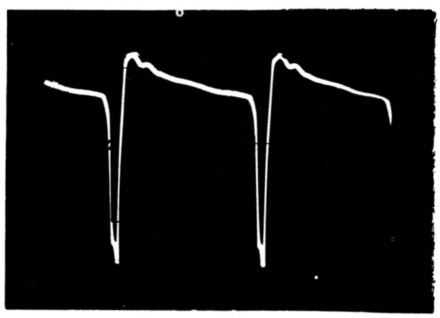
Connections Required: Apply probe between "high" side of deflection coils and ground. Connect probe cable to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern as shown.

Evaluation of Results: Compare waveform and peak-to-peak voltage value with data in receiver service literature. The peak-to-peak voltage varies with the setting of the horizontal-drive control.



Test setup.



Waveform across horizontal-deflection coils.

NOTE 70

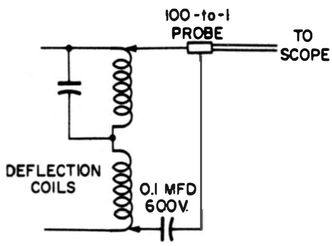
Interference in Sweep Circuit Waveforms

Typical interference in a sweep-circuit waveform is observed in the foregoing illustration. Such interference is usually caused by stray fields reaching the vertical-input terminals of the scope. In such cases, the interference can be eliminated by using a scope having a shielded vertical-input connector instead of exposed binding posts.

NOTE 71

Connecting Scope Ground to Low Side of Deflection Coils

In most instances, the 100-to-1 probe can be grounded to chassis, and the observed waveform will be practically the same as the actual waveform across the horizontal-deflection coils. In some instances, however, there is sufficient impedance between the return lead of the coil and chassis ground for substantial distortion to occur. The true waveform can be obtained by connecting the ground lead of the probe to the "low" side of the coils via a blocking capacitor, as shown in the following illustration. Do not use a direct connection between the probe and the coil return lead, because this may make the scope case "hot" and can give the operator a B+ "bite."

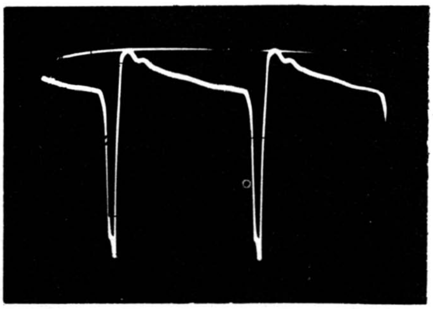


Method of connecting scope ground lead to the return lead of the deflection coils.

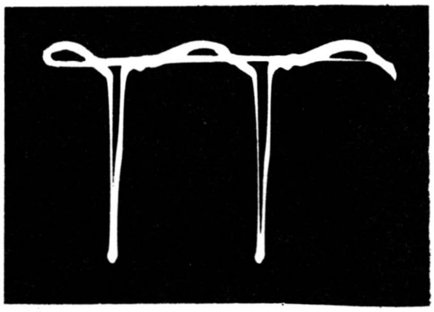
NOTE 72

Need for Using Correct Probe When Viewing Waveform Across Deflection Coils

A 10-to-1 high-impedance compensated probe should not be used to check the waveform across the horizontal-deflection coils. Its input voltage rating is inadequate, and the probe may be damaged. For the same reason, a direct cable to the scope should not be used. Even if the scope input circuit will withstand the peak-to-peak voltage applied, many scopes overload badly under this condition. Severe waveform distortion results, as shown in the following photos.



Waveform observed across horizontal-deflection coil, with a 100-to-1 capacitance-divider probe.



Distortion of the waveform which occurs when the scope is used with a direct probe.

U56

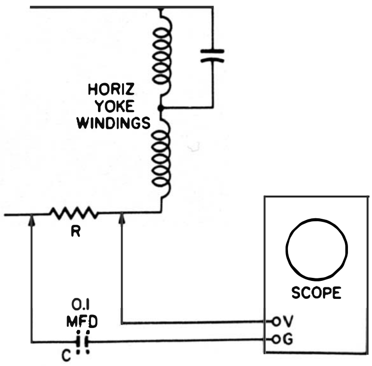
To Display the Sweep Current Waveform

Equipment: 5-ohm resistor.

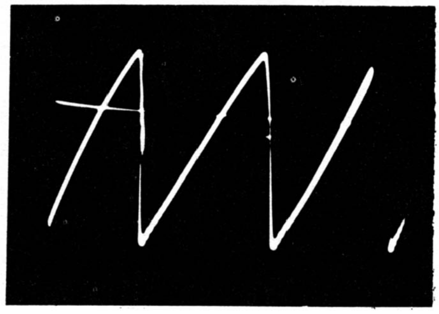
Connections Required: Insert the resistor in series with the return lead from the horizontal-deflection coils. Connect a direct cable across the resistor. Feed cable output to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical waveform, as shown in the following illustration.

Evaluation of Results: Waveform should have a linear sawtooth shape and be reasonably free from ringing or other transient distortion. Peak-to-peak current of waveform can be measured, if desired, with a scope calibrated in peak-to-peak volts per inch. With a 5-ohm resistor, a peak-to-peak current flow of 0.5 ampere will drop 2.5 peak-to-peak volts across the resistor. Because of the B+ voltage in the horizontal-deflection coils, the scope case becomes "hot" when the foregoing tests are being made unless the blocking capacitor C is added in series with the ground lead of the scope.



Test setup.

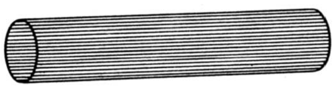


Horizontal sweep current waveform.

NOTE 73

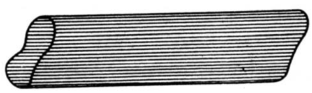
Value of Blocking Capacitor

When blocking capacitors are used in series with the ground lead of the scope, the capacitor must have a sufficiently high value to avoid 60-cycle hum interference in the pattern. The value should be at least 0.1 mfd; however, a higher value may be required in some tests.

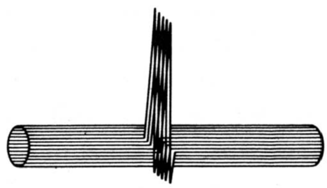


Base-line distortion from a 60-cycle, sine-wave voltage.

Normal appearance of a pulse voltage on base line.



Base-line distortion from a 60-cycle voltage with harmonics.

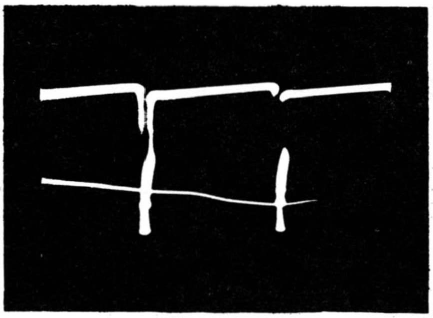


Distortion in pulse display, caused by lack of conductive ground return.

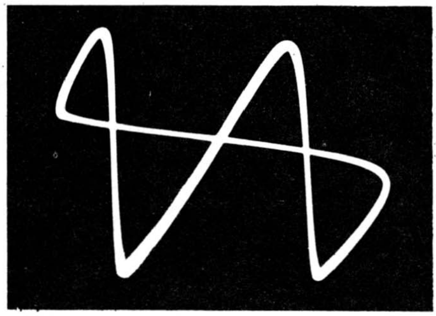
NOTE 74

Reason for Difference in Voltage and Current Waveforms

The horizontal sweep system has reactive circuits and operates upon the basis of tuned retrace. Hence, voltage and current waveforms in a circuit will always have different shapes. The same waveshape for voltage and current is found in purely resistive circuits only.



(A) Voltage waveform.



(B) Current waveform.

Comparison of voltage and current waveforms in a typical sweep circuit.

U57

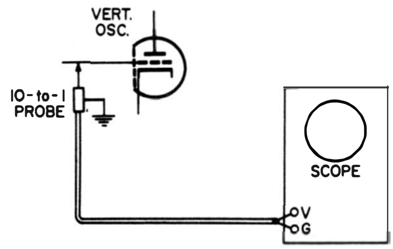
To Check the Waveform and Peak-to-Peak Voltage at the Grid of the Vertical-Oscillator Tube

Equipment: 10-to-1 (or special) high-impedance compensated probe.

Connections Required: Apply probe between grid of vertical-oscillator tube and chassis ground. Connect probe cable to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern, as illustrated in the following.

Evaluation of Results: Compare waveform and peak-to-peak voltage value with data in receiver service literature. In some receivers the pulse portion of the waveform is narrow and dim; reducing the vertical gain and advancing the intensity controls of the scope helps to improve its visibility.



Test setup.

Waveform at grid of typical vertical-oscillator tube.

NOTE 75

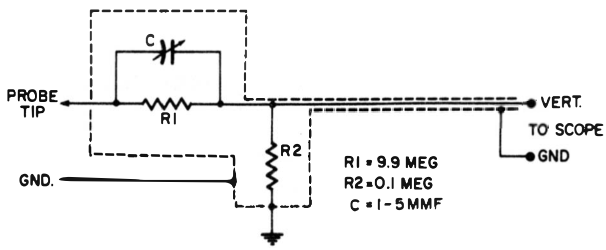
Type of Probes Used in Vertical Circuits

A 100-to-1 capacitor-divider probe must not be used in vertical-circuit tests. The 60-cycle waveforms have too low a fundamental frequency to operate a capacitor-divider probe properly. The vertical-frequency waveforms will be distorted badly. Use only compensated types of probes in vertical-circuit tests.

NOTE 76

100-to-1 High-Impedance Compensated Probe

The vertical oscillator grid in many receivers is a very high-impedance circuit. Waveform distortion often occurs because of loading by a 10-to-1 probe. In such cases, use a 100-to-1 high-impedance compensated probe, as shown in the following illustration. This type of 100-to-1 probe is not available at the time of writing and must be constructed by the technician.



Configuration for a 100-to-1 high-impedance compensated probe. (Adjust C for 100-to-1 attenuation at 60 cycles and 100 kc.)

NOTE 77

Cathode-Follower Type Probes

A few scope manufacturers have cathode-follower probes available for high-impedance circuit tests. These probes are better suited for tests at the grid of a vertical blocking oscillator than 10-to-1 RC high-impedance probes.

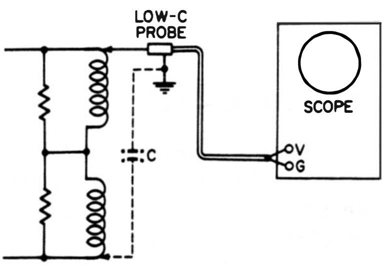
To Display the Voltage Waveform Across the Vertical-Deflection Coils

Equipment: 10-to-1 compensated probe.

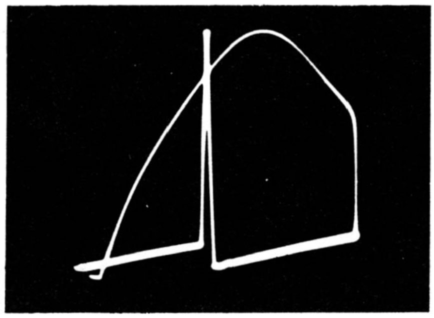
Connections Required: Apply probe across vertical-deflection coils. Use a large series-blocking capacitor if "low" side is above ground. In many instances, probe can be returned to chassis ground, with little waveform distortion.

Procedure: Adjust scope controls for typical waveform, as shown in the following illustrations.

Evaluation of Results: Compare waveform and peak-to-peak voltage with data in receiver service literature.



Test setup.



A typical voltage waveform across the vertical-deflection coils.

U59

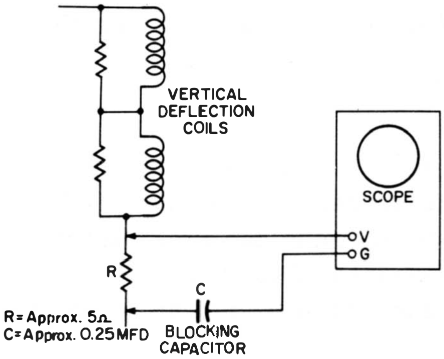
To Display the Current Waveform Through the Vertical-Deflection Coils

Equipment: 5-ohm resistor.

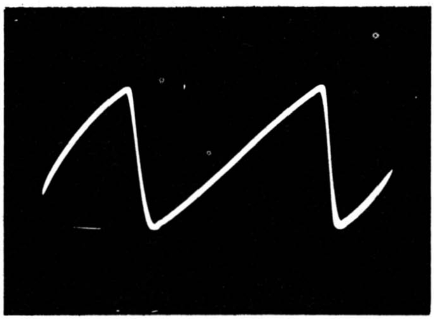
Connections Required: Insert resistor in return lead from the vertical-deflection coils. Connect direct cable across resistor. Feed cable output to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern display, as shown in the following.

Evaluation of Results: A linear sawtooth display, without spurious transients or ringing components, should be observed. Peak-to-peak current can be measured with a calibrated scope, by applying Ohm's law to relate current and voltage in the resistor.



Test setup.

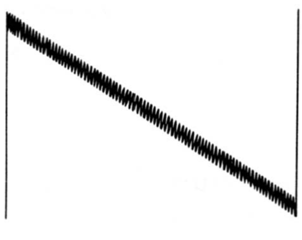


Current waveform of a typical vertical-deflection voltage.

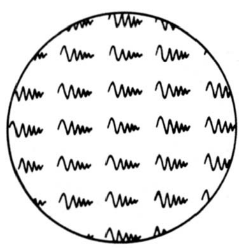
NOTE 78

Observing Cross Talk in Vertical-Deflection Coils

A defective yoke or other faults in the yoke circuit will sometimes cause a thickening of the sloping portion in the current sawtooth. This thickening is caused by cross talk with the horizontal-deflection coils. In such cases, the details of the cross talk can be observed by changing the horizontal-sweep rate to 15,750 cycles and applying external sync from the horizontal circuit to the Ext. Mod. post of the scope. When the vertical-gain control and horizontal-gain control are advanced, we see a raster-type display on the scope screen, with successive damped sine-wave patterns, as shown. Each horizontal-circuit pulse shock-excites the circuits and cross talks into the vertical-deflection coils. There are 262½ shock-excited waveforms in each vertical-scan interval.



Display at 60-cycle horizontal sweep in scope.



Display at 15,750-cycle horizontal sweep in scope.

U60

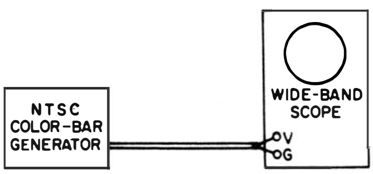
To Check the Output from an NTSC-Type Color-Bar Generator

Equipment: NTSC color-bar generator. Scope with vertical amplifier having flat frequency response through 3.58 mc.

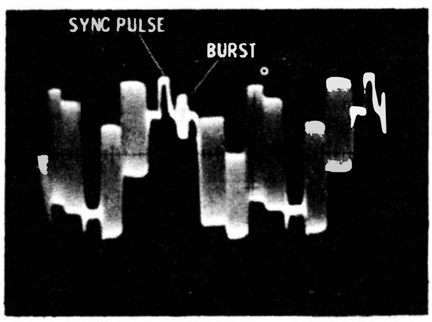
Connections Required: Connect generator output cable to vertical-input terminals of scope.

Procedure: Set generator controls for video-frequency output. Adjust scope controls for typical pattern, as shown in the following.

Evaluation of Results: Burst should have the same peak-to-peak voltage as the horizontal sync tip. Top of green bar should be approximately even with the back porch of the horizontal sync pulse. Bottom of the magenta bar should be approximately even with the white-bar level.



Test setup.

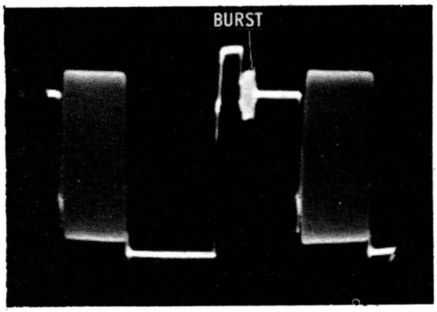


Waveform obtained from color-bar generator.

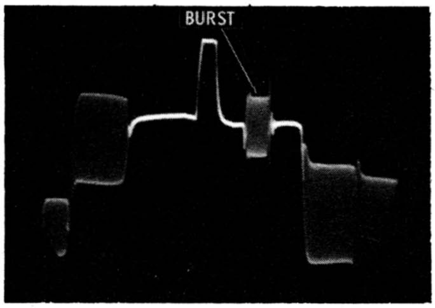
NOTE 79

Burst Position on Horizontal Sync Pulse

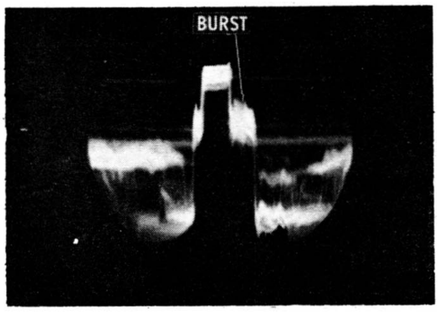
The position of the burst on the back porch of the horizontal sync pulse varies appreciably in some service color-bar generators. The following illustrations show two examples of burst positioning. Also shown is the burst position in a typical color-TV broadcast signal. According to FCC standards, there is a small interval between the sync pulse trailing edge and the burst leading edge. This interval is established as 0.006H, where H is the total horizontal-scanning interval. Although the burst position is not critical, a more accurate test of burst-gate timing is obtained when the burst position is standard.



Color-bar waveform with burst spaced close to sync pulse.



Color-bar waveform with burst spaced farther from the sync pulse.



Burst position in a typical color TV broadcast.

U61

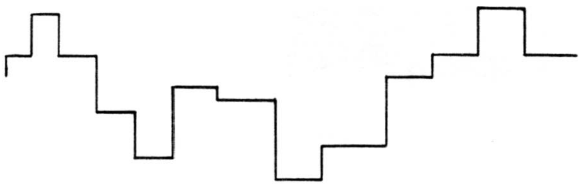
To Check the Y and Chroma Components in an NTSC Color-Bar Signal

Equipment: NTSC color-bar generator. Scope with vertical amplifier having flat frequency response through 3.58 mc.

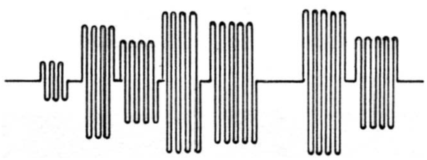
Connections Required: Connect generator output cable to vertical-input terminals of scope.

Procedure: Switch generator successively from "Color Bar" to "Y" and "Chroma" outputs.

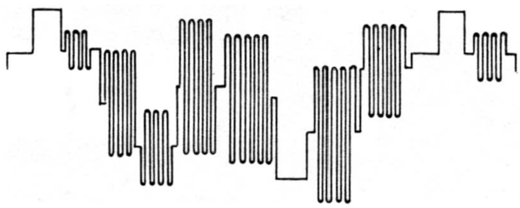
Evaluation of Results: See the following illustration for correct proportions of 100% saturated color-bar waveforms.



(A) Y signal.



(B) Chroma signal.



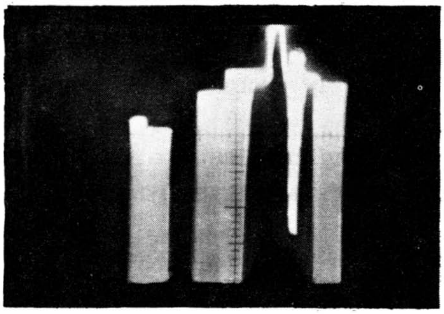
(C) Saturated color-bar signal.

Components of NTSC color-bar signal.

NOTE 80

Waveform Distortion When Scope Is Operated at High Gain

Some wide-band scopes distort a chroma waveform when the vertical-gain control is set for full-screen deflection. This distortion is caused by vertical-amplifier overloading. In such cases, operate the scope at lower deflection, e.g., at half-screen vertical deflection, to avoid waveform distortion.

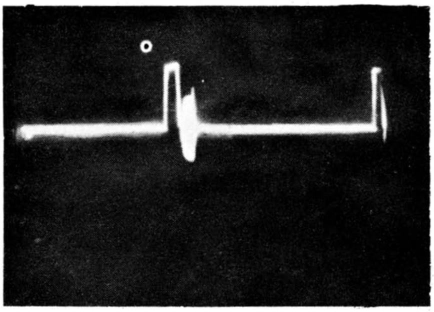


Severe overloading of vertical amplifier by chroma waveform.

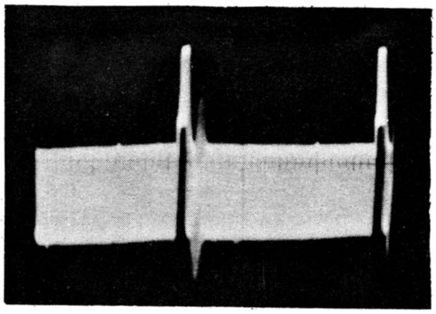
NOTE 81

60-Cycle Hum in Chroma Waveform

A poor ground connection or heater-cathode leakage in a generator tube sometimes causes 60-cycle hum distortion of a chroma waveform, as illustrated.



Undistorted sync and burst waveform.

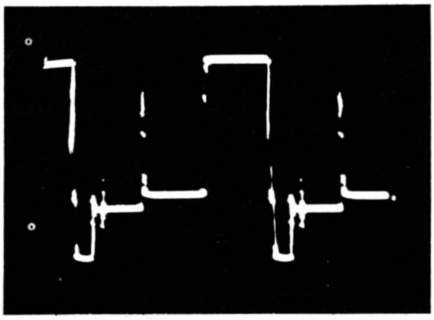


Waveform distorted by 60-cycle hum voltage.

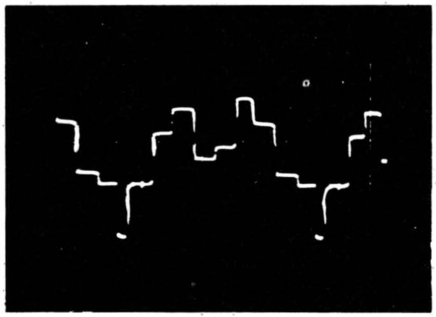
NOTE 82

Overshoot in Y Signal

The Y signal supplied by a color-bar generator sometimes displays noticeable overshoot and traces of ringing, as shown in the following. This is usually of no concern in practical test work. However, overshoot caused by a generator should not be confused with overshoot introduced by misaligned or misadjusted receiver circuits.



Y signal display with overshoot and ringing.



Y signal display without overshoot and ringing.

U62

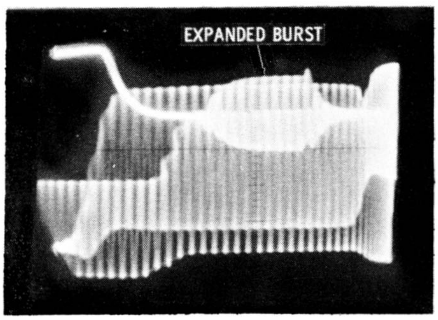
To Expand the Color Burst Display

Equipment: NTSC color-bar generator. Scope with vertical amplifier having flat frequency response through 3.58 mc.

Connections Required: Connect generator output cable to vertical-input terminals of scope.

Procedure: Carefully adjust the scope sync controls to display the burst on retrace.

Evaluation of Results: The expanded burst appears superimposed on the chroma information. However, details of burst waveform and number of cycles are made apparent.



Expanded color burst display.

NOTE 83

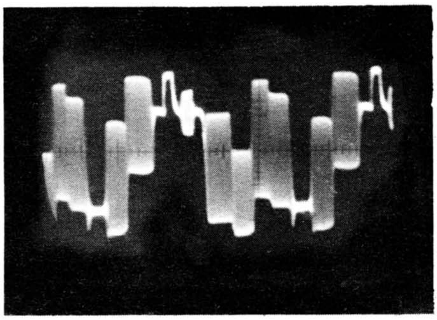
Scope with Triggered Sweep

A few service scopes of the wide-band type have triggered sweep. In such cases, the expanded burst can be further expanded without displaying the burst waveform on a background of chroma information. Expanded burst displays are useful in checking the adjustments of a color-bar generator. However, an expanded display is not particularly useful for making receiver waveform tests.

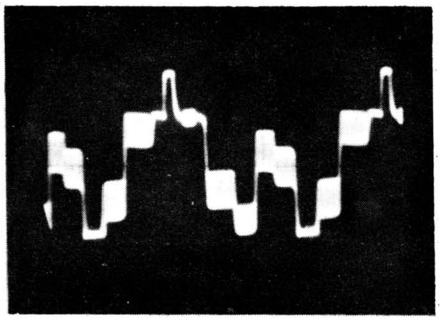
NOTE 84

Need for Wide-Band Scope

In some scopes the high-frequency response is not flat through 3.58 mc. In this case, the burst frequency may be 3 db, or 6 db down. In such cases, chroma waveforms are distorted, and the subcarrier component is attenuated, as shown. For details concerning scope vertical-amplifier response, see the companion volume *101 Ways to Use Your Sweep Generator.*



Wide-band scope pattern.

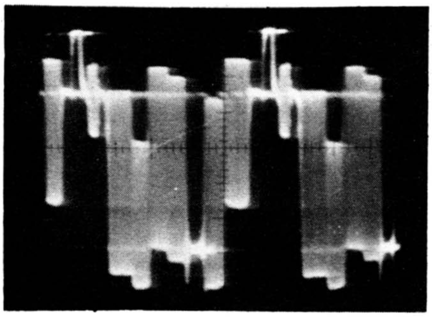


Narrow-band scope pattern.

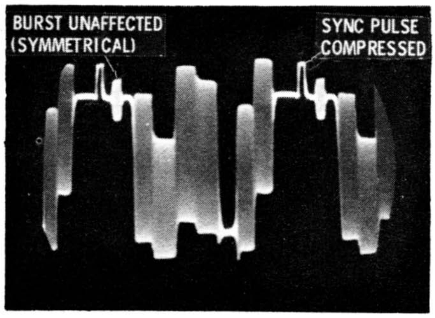
NOTE 85

Stagger-Peaked Scopes

Some wide-band scopes are stagger-peaked, with limited vertical-amplifier output capability (limited dynamic range). This causes either the low-frequency component of the chroma waveform to show compression or limiting before the high-frequency component is affected, or vice versa. In such cases, the vertical amplifier should be operated below the distortion point in either the LF or HF portion of the waveform. (See the following photos.)

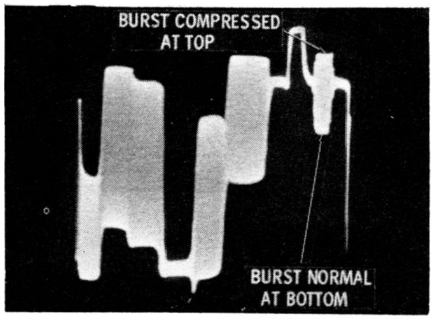


Normal proportions of color-bar waveform.



Sync pulse compressed before compression of chroma signal.

Chroma signal compressed before compression of sync pulse.



U63

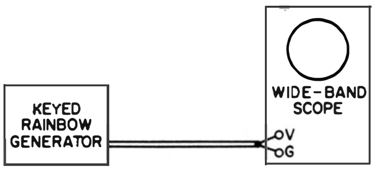
To Check the Output from a Keyed Rainbow Color-Bar Generator

Equipment: Keyed rainbow generator and wide-band scope.

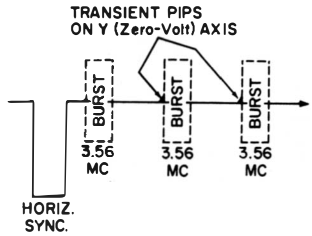
Connections Required: Apply generator video-frequency output to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern as illustrated in the following. (Generator is adjusted to display a pattern with 11 bursts between horizontal sync pulses.)

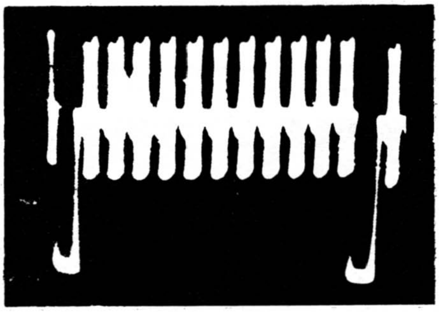
Evaluation of Results: Standard generators have 11 bursts between sync pulses. The first burst is for color sync lock. The remaining 10 bursts produce 10 color bars on the picture-tube screen of the receiver. The peak-to-peak voltage of the bursts is normally equal to the peak-to-peak voltage of the horizontal sync pulse. Generator adjustments are provided to obtain the correct waveform.



Test setup.



Composition of rainbow waveform.



Waveform obtained from rainbow generator.

U64

To Display the Color Signal at the Picture Detector Output (Either Black and White or Color Receivers)

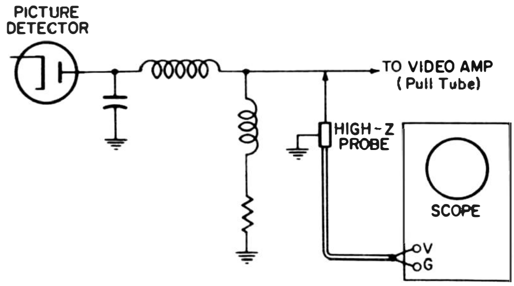
Equipment: 10-to-1 compensated probe and wide-band scope.

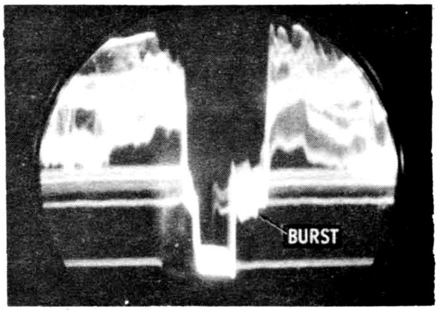
Connections Required: Apply probe at signal-output point of picture detector. Connect probe cable to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern display, as shown.

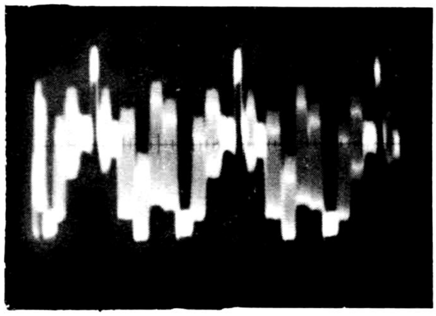
Evaluation of Results: The burst voltage (peak-to-peak) should be equal to the peak-to-peak voltage of the sync-pulse tip. This test depends upon the availability of an undistorted signal. Properly adjusted generators provide undistorted signals. The color burst from a TV station is sometimes attenuated because of the receiving antenna characteristic or because of technical difficulties in network transmissions. Therefore, it is preferable to use a color-bar generator in this test. Note also that some color receivers have vestigial color-sideband IF circuits. This type of IF amplifier normally attenuates the chroma 6 db (50%).

Test setup.





Burst waveform observed at picture detector from color TV broadcast.



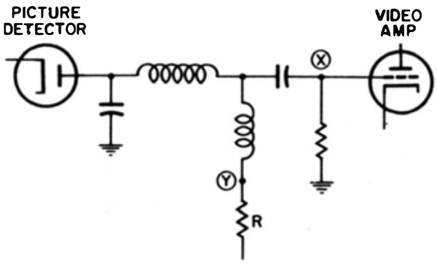
Cross talk in the color-bar signal at the picture-detector output.

NOTE 86

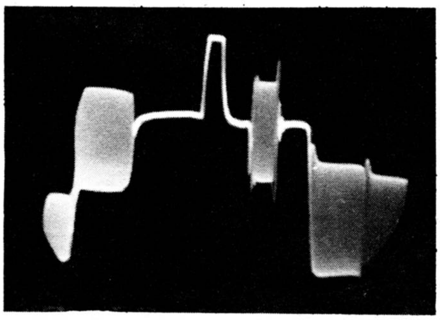
Precautions When Observing the Burst Signal

When checking the burst, scope connection must be made at point X. It is impossible to observe the burst across the picture-detector load resistor R (at point Y) because the low video frequencies only are developed across the load resistor. The high video frequencies are developed across the shunt peaking coil. Connection can be made across the load resistor for low-frequency tests only, as in sweep alignment procedures.

Note that the burst never appears as sharp and clean at the picture-detector output as it does when the scope is fed directly from a color-bar generator. Moreover, the burst appears sharper at the picture detector when the receiver is driven from a color-bar generator than when it is driven by an antenna signal. Lack of sharpness is caused by interference components from other circuits and from noise. Compare the following illustration with preceding one.



Video detector load circuit.

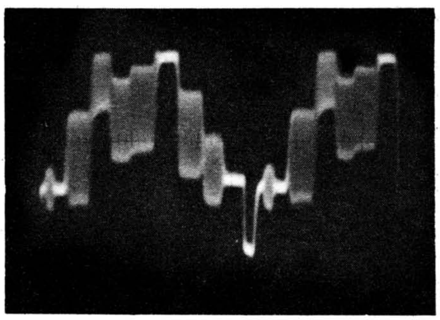


Burst waveform observed when color-bar generator is connected directly to scope.

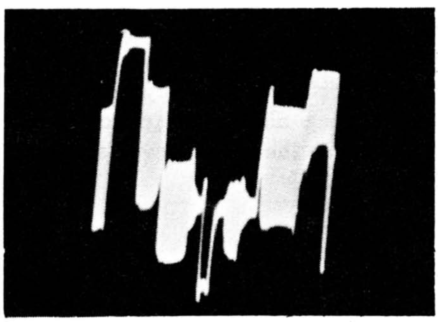
NOTE 87

Nonlinearity Caused by Receiver Circuits

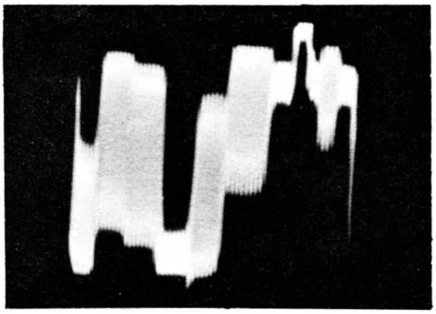
Color receiver circuits may introduce nonlinearity into waveforms, just as scope amplifiers may. The following illustrations show typical examples of amplitude distortion in a color-bar waveform caused by nonlinear IF amplifiers. Although distortion is present, most viewers do not complain about the resulting picture. Hence, the color-TV technician should determine whether or not certain waveform distortions are tolerable. In the first of the accompanying illustrations, a waveform processed through a linear IF amplifier strip is shown. The second illustration shows the waveform of the color-bar signal after passing through an IF amplifier strip having considerable amplitude distortion. The burst is a handy guide to distortion of this type. In the third waveform, the opposite type of amplitude distortion appears. Here the sync pulse (and top of the burst) is compressed instead of expanded. Also note the ragged edges of the waveform, which show appreciable 920-kc beat voltage is present.



Color-bar waveform processed through a linear IF amplifier strip.



Color-bar waveform showing amplitude distortion in the IF amplifier.



Amplitude distortion with compression of the sync pulse.

U65

To Check the Signal Output from the Y Amplifier

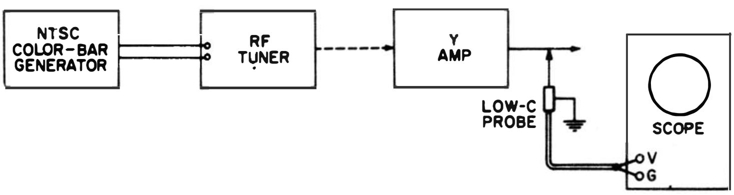
Equipment: 10-to-1 compensated probe. Color-bar generator optional, but gives a steady signal for test, compared with color-TV broadcast signal.

Connections Required: Apply color signal input to antenna-input terminals of receiver. Apply probe at Y-amplifier output. Connect probe cable to vertical-input terminals of scope.

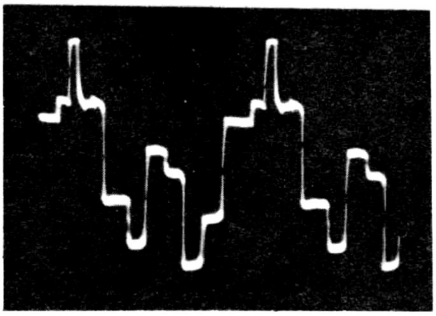
Procedure: Adjust receiver and scope controls for typical pattern, as shown.

Evaluation of Results: The waveform should appear essentially the same as the Y output taken directly from the generator. The corners should not be seriously rounded off, and compression should not appear at top or bottom of the pattern. If the color-subcarrier trap is correctly adjusted, little or no chroma signal will appear in the waveform.

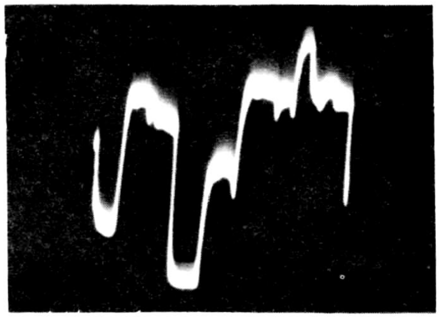
A wide-band scope is not required in this test. In most cases, there will be some waveform interference from other receiver circuits (principally the vertical-sweep circuit). Severe interference often occurs if open test leads are used to the scope.



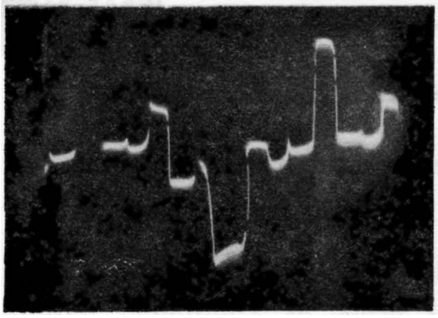
Test setup.



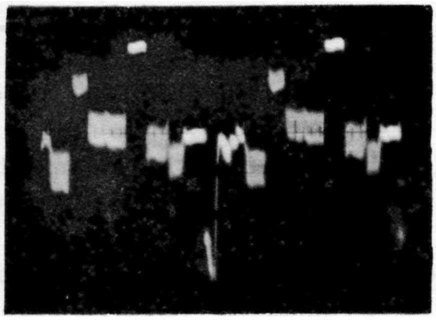
Y signal waveform.



Interference from vertical sweep circuit.



Y amplifier nonlinear; gray levels incorrect.

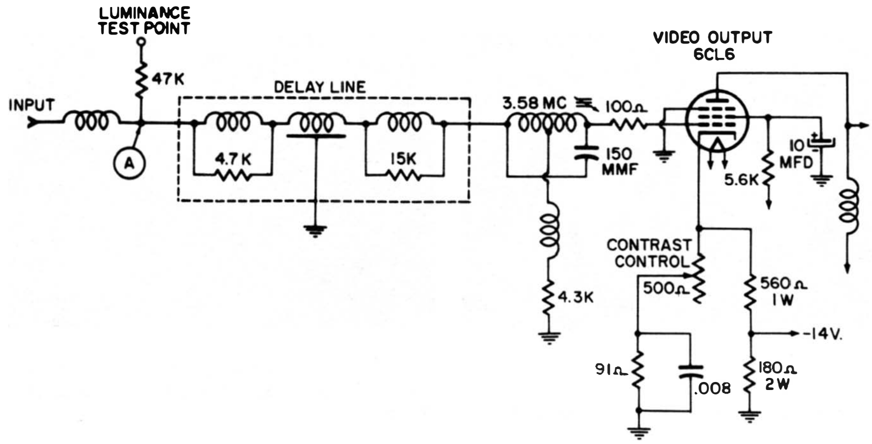


Y amplifier nonlinear; color-subcarrier trap misadjusted; gray levels incorrect; chroma signal passing through; waveform compressed at top; sync pulse distorted.

NOTE 88

Luminance Test Point

Some color receivers have a luminance test point, which is basically a VTVM test point. The series-isolating resistor causes high-frequency attenuation when making scope tests. Make scope check on input side of the 47K-ohm resistor (point A) in the following diagram.

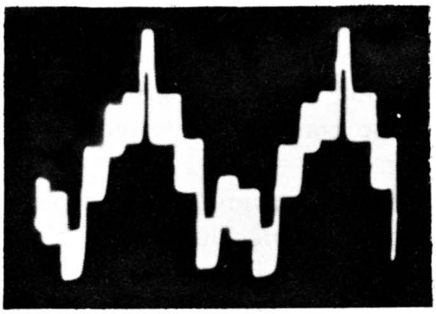


Video output circuit.

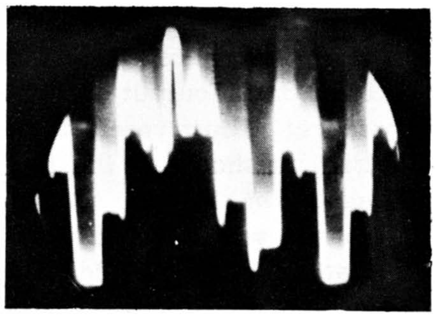
NOTE 89

60-Cycle Hum and Cross Talk Interference

The waveform at the Y-amplifier output can be greatly thickened, either by cross talk with other receiver circuits or occasionally by 60-cycle hum. Hum voltage usually is caused by heater-cathode leakage in a tube. The following illustrations show the difference in appearance between the two types of interference.



60-cycle hum interference.

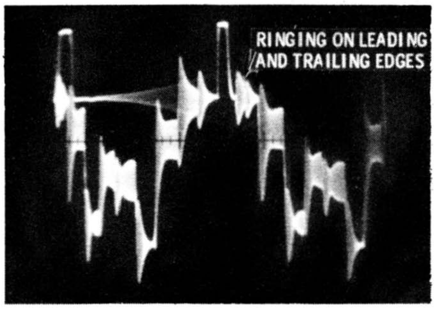


Interference from cross talk.

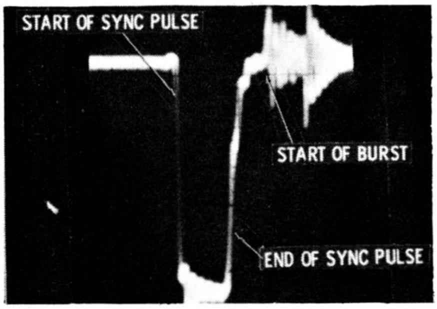
NOTE 90

Ringing Caused by Insufficiently Damped Color-Subcarrier Trap

The color-subcarrier trap must be suitably damped with resistance, or it rings excessively on the burst and chroma bars. A trap with very little damping will also ring the sync pulse. (See following illustrations.)



Ringing in burst and chroma bars.



Ringing of sync pulse and burst, caused by sharply-tuned subcarrier trap.

U66

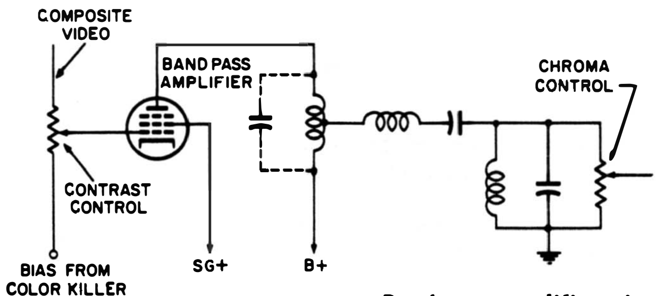
To Display the Waveform at the Bandpass-Amplifier Circuit

Equipment: 10-to-1 compensated probe and color-bar generator (for steady signal).

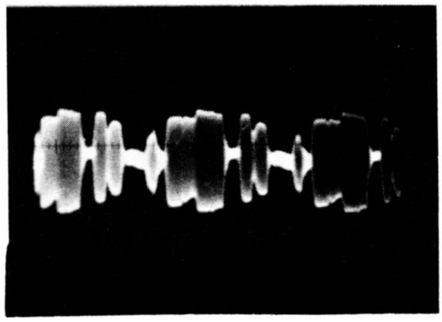
Connections Required: Apply generator output to antenna-input terminals of receiver. Connect probe at bandpass-amplifier output (arm of chroma control in following illustration). Feed probe output to vertical-input terminals of scope.

Procedure: Adjust receiver and scope controls for typical pattern, as shown in the following.

Evaluation of Results: Compare waveform and peak-to-peak voltage value with data in receiver service literature. Note that waveform should be symmetrical, without compression at top or bottom. Correct levels should appear for each chroma bar.



Bandpass amplifier circuit.

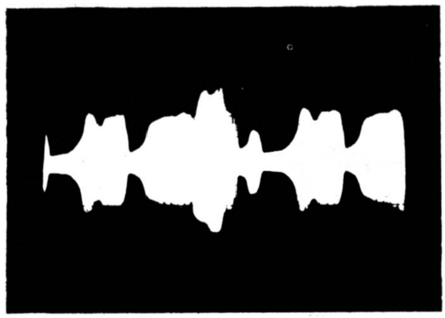


Waveform observed at arm of chroma control.

NOTE 91

Noisy Signal Circuits

Noisy signal circuits cause ragged and irregular edges to become quite apparent at the edges of the waveform, as shown in the following illustration.



Appearance of noise voltages in chroma signal.

U67

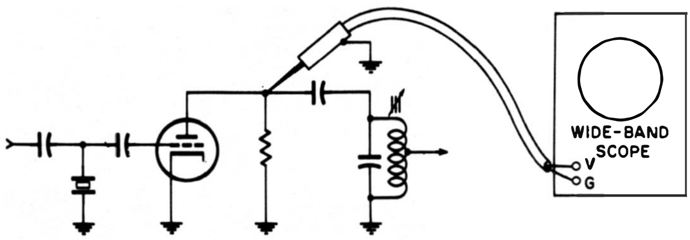
To Display the Color-Subcarrier Oscillator Voltage and to Measure Its Peak-to-Peak Value

Equipment: Low-capacitance probe and wide-band scope.

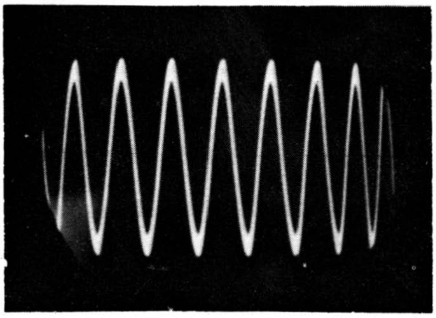
Connections Required: Apply probe between plate of subcarrier-oscillator tube and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure. Adjust scope controls for display, as shown.

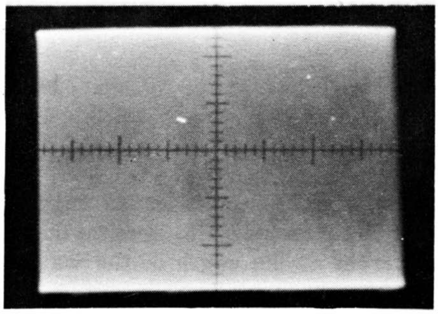
Evaluation of Results: If oscillator is dead, no waveform is obtained. A sine waveform shows the oscillator is operating. Peak-to-peak voltage value should be within 20% of value specified in receiver service literature.



Test setup.



Pattern displayed at high-speed horizontal sweep.



Pattern displayed at lower horizontal sweep speed.

U68

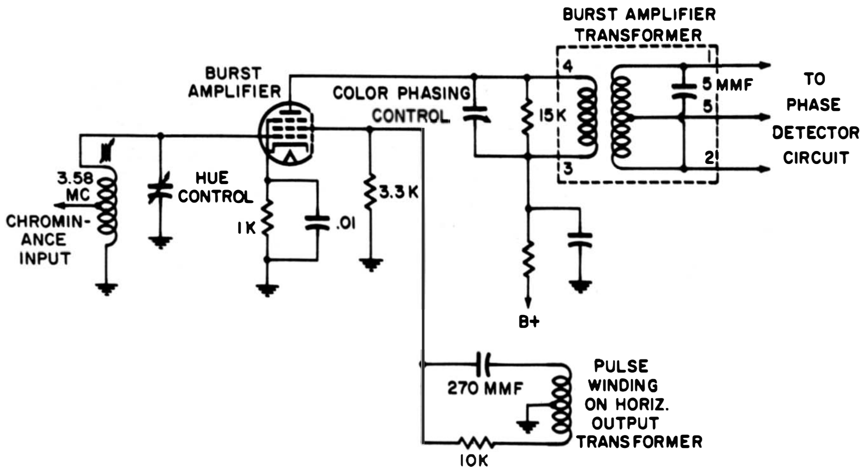
To Check the Burst-Gating Pulse and to Measure Its Peak-to-Peak Voltage

Equipment: Low-capacitance probe.

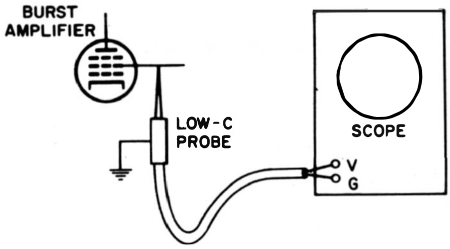
Connections Required: Apply probe between gated electrode of burst-amplifier tube and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for typical pattern shown in the following illustration.

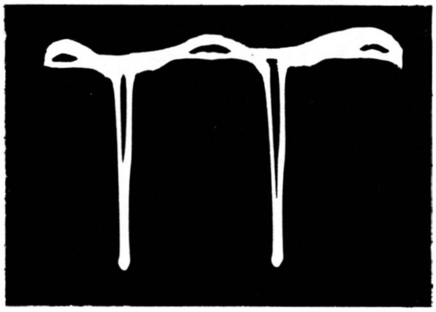
Evaluation of Results: Check waveform and peak-to-peak voltage against data in receiver service literature. In some receivers, the gating pulse is applied to the cathode instead of to the screen, as shown in the following schematic. NOTE: A wide-band scope is not necessary for this test.



A burst-amplifier circuit.



Test setup.



Appearance of the burst gating pulse.

U69

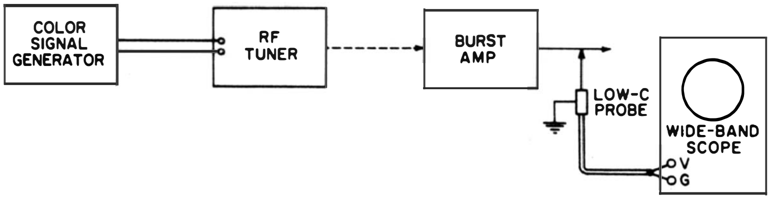
To Display the Waveform at the Output of the Burst Amplifier and to Measure Its Peak-to-Peak Voltage

Equipment: Low-capacitance probe and wide-band scope. Color-bar generator will supply a steady signal for test.

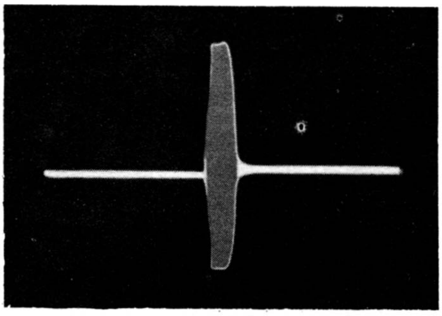
Connections Required: Apply color-bar generator output to antenna-input terminals of receiver. Connect probe between output terminal of burst amplifier and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust receiver controls and generator for normal color-bar signal display. Adjust scope controls for typical burst pattern, as shown.

Evaluation of Results: The burst should appear free from chroma signal. The top should not be clipped diagonally. Amplitude nonlinearity is often apparent, but is not a cause for concern. Peak-to-peak voltage of the waveform should be within 20% of value specified in receiver service literature.



Test setup.



Typical gated burst waveform.

U70

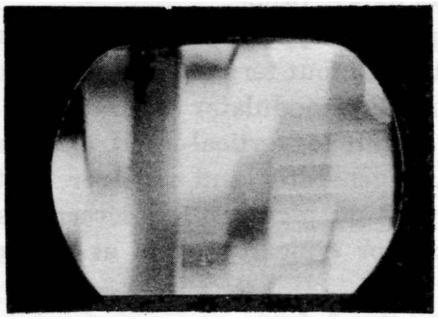
To Check the AC Waveform at the Arm of the Burst-AFC Balance Control

Equipment: Low-capacitance probe. Rainbow or color-bar generator will supply a steady signal.

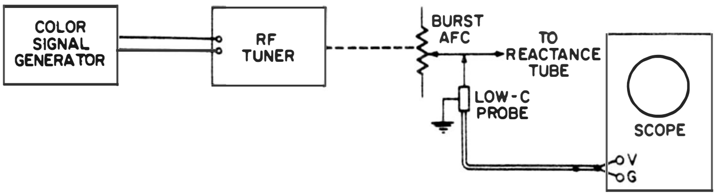
Connections Required: Apply generator output to antenna-input terminals of receiver. Connect probe between potentiometer arm and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust generator and receiver controls for screen pattern on color picture tube as shown in the following. AC waveform is found in this test when receiver is out of color sync. Adjust scope controls for typical pattern, as shown.

Evaluation of Results: Waveform must be evaluated on the basis of experience. Waveform can be subsequently checked through the burst-AFC output network to analyze certain faults causing loss of color sync.

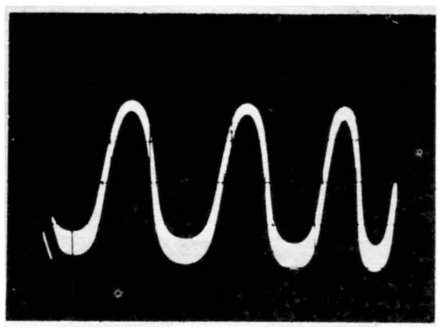


Appearance of a color-bar pattern when receiver is out of color sync.



Test setup.

Typical AFC waveform.



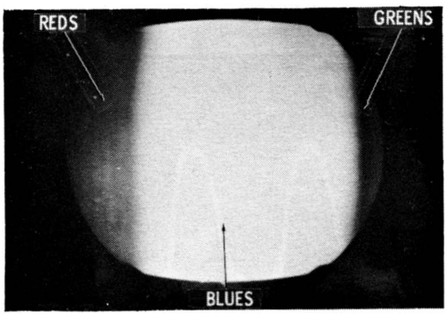
To Check the Output from a Chroma Demodulator with a Rainbow Signal Generator

Equipment: Rainbow generator (preferably crystal controlled) and low-capacitance probe.

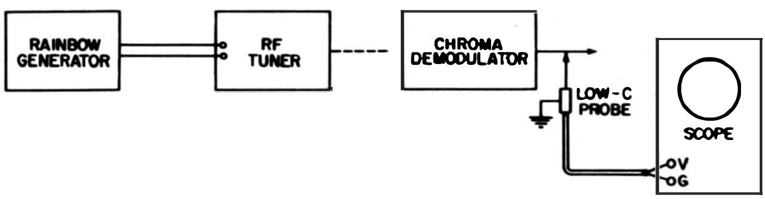
Connections Required: Apply modulated RF output from generator to antenna-input terminals of receiver. Connect probe between chroma-demodulator output and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust generator and receiver controls for normal rainbow display on picture-tube screen, as shown. Adjust scope controls for typical pattern, as illustrated in the following.

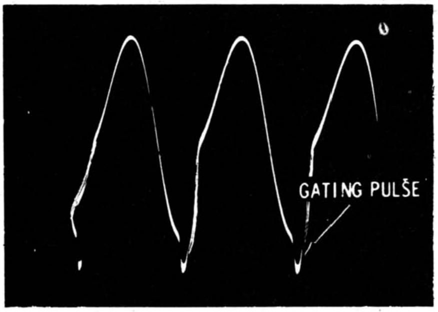
Evaluation of Results: A basic sine waveform is displayed, with either a blanking pulse or a boost pulse, depending upon the receiver design. The pulse marks the sync and burst interval and indicates the phasing of the demodulator axis. The relative heights of the sine-wave patterns from the two demodulators show the chroma-channel gains. Check against receiver service data. The same test method applies to R—Y, B—Y; R—Y, G—Y; IQ; R—Y, Q; or XZ demodulators.



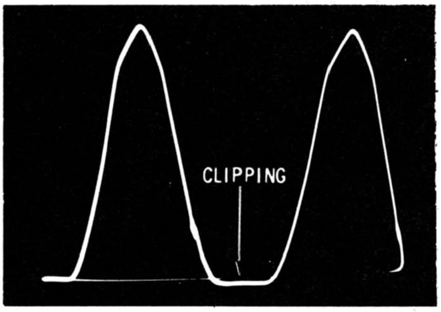
Normal picture-tube pattern.



Test setup.



Correct rainbow signal output from a B—Y chroma demodulator.
NOTE: The gating pulse appears properly at the —(B—Y) phase.



Flattened (clipped) pattern which results if receiver signal circuits are overloaded.

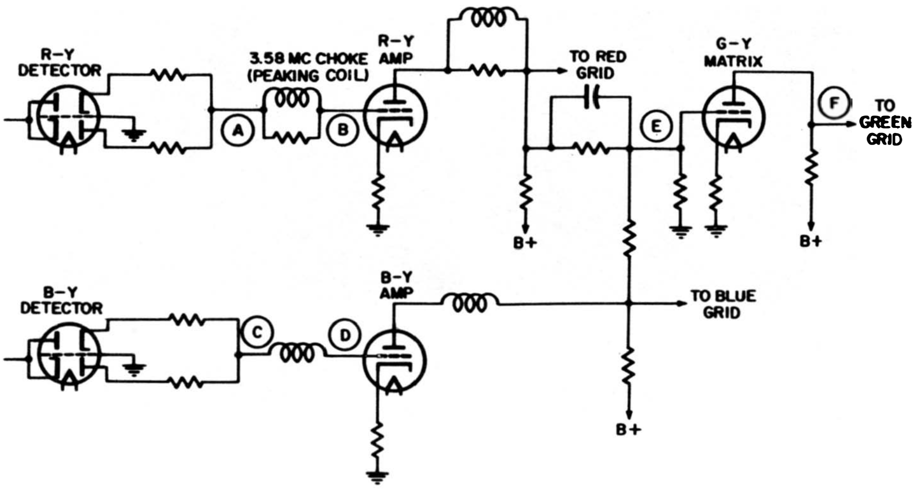
NOTE 92

Connecting Probe at Output of Chroma Demodulator Circuits

Peaking coils in the chroma demodulator output circuits serve a filtering function, as well as maintaining the frequency response at the high end of the chroma response. If a wide-band scope is applied at the input side of the peaking coils, a large amount of 3.58-mc voltage will be present. On the other hand, a clean demodulated waveform is found on the output side of the peaking coils.

If the probe is connected to point A in the following schematic, a suitable signal output for a narrow-band scope is obtained. However, if a wide-band scope is connected to this point, excessive 3.58-mc interference will appear in the waveform. A wide-band scope should be connected to point B for checking the R—Y signal. At point B the 3.58-mc signal has been filtered out by the choke coil. For the same reason, a narrow-band scope should be connected to point C and a wide-band scope should be connected to point D when checking the B—Y signal.

When checking the G—Y signal, the scope can be connected to either point E or point F, using either a narrow-band or a wide-band scope.



Chroma demodulator output circuit.

U72

To Check Adjustment of the Quadrature (Subcarrier Phasing) Transformer with a Rainbow Generator

Equipment: Rainbow generator (preferably crystal controlled).

Connections Required: Apply modulated RF output from generator to antenna-input terminals of receiver. Connect vertical-input terminals of scope to output of R—Y channel in receiver. Connect scope horizontal-input terminals to output of B—Y channel in receiver.

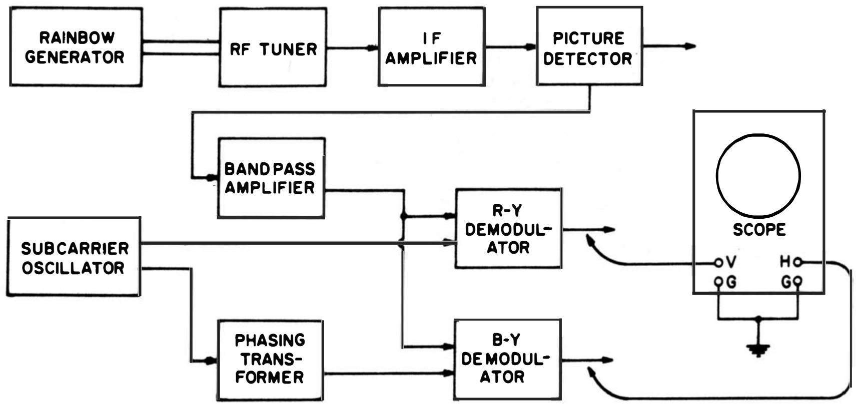
Procedure: Adjust generator and receiver controls for normal rainbow pattern on screen of color picture tube. Adjust vertical- and horizontal-gain controls of scope to obtain a circular pattern, as shown in the first illustration.

Evaluation of Results: If inclined ellipse is displayed, adjust slugs in subcarrier phasing transformer until a nearly perfect circle can be obtained. Note that small distortions in the receiver circuits prevent display of a perfect circle, but distortion should not be excessive.

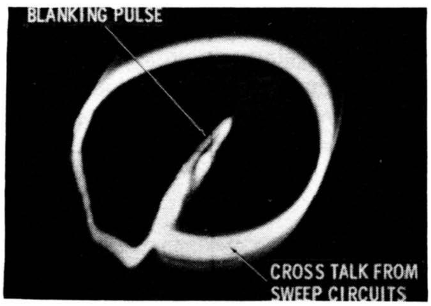
If the receiver is out of color sync, the pattern whirls and appears as shown in the second waveform. However, the pattern has the same contour and is equally as useful as a pattern in color sync for checking quadrature.

Overload of the signal circuits should be avoided. If the receiver signal circuits are overloaded, the pattern becomes distorted, as shown in the third illustration. This is a typical display obtained when the chroma circuits are overloaded and color sync is lost.

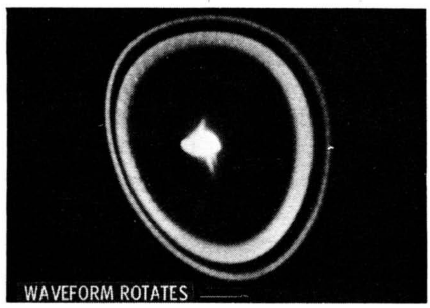
Receivers using a G—Y detector must be checked through the B—Y matrix. For this type of receiver, connect horizontal-input terminals of scope to the output of the B—Y matrix.



Test setup.

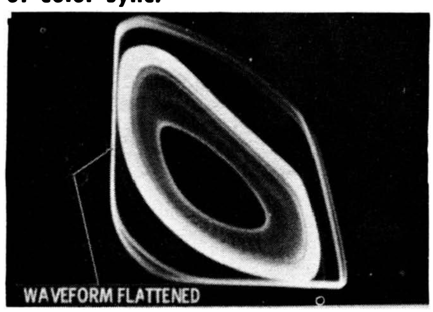


Correct waveform.



Pattern obtained when receiver is out of color sync.

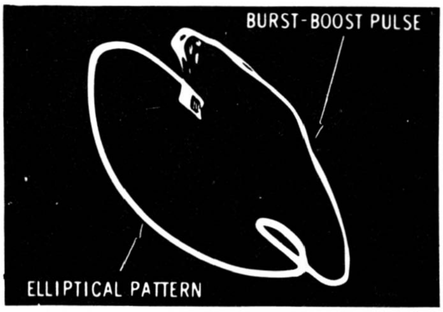
Pattern obtained when receiver signal circuits are overloaded.



NOTE 93

Appearance of a Burst-Boost Pulse

In some color receivers, a burst-blanking pulse does not appear in the patterns displayed at the outputs of the chroma demodulators. Instead, a burst-boost pulse appears. The burst-boost pulse has the appearance of a "blowout" from the circular or elliptical pattern, as shown in the following waveform.

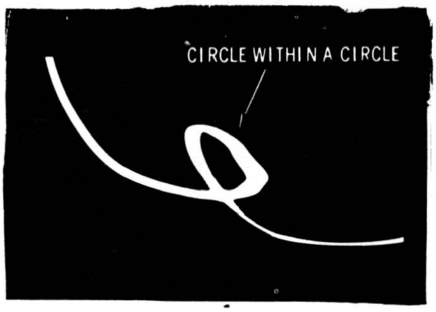


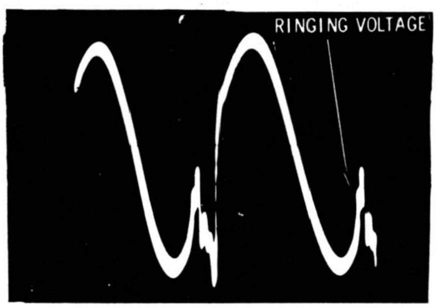
Burst-boost pulse.

NOTE 94

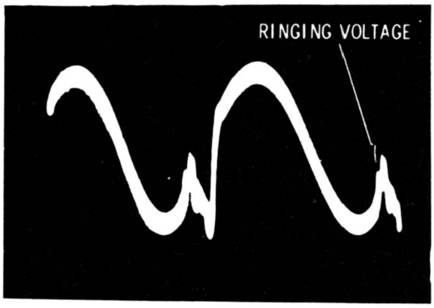
Ringing in Circle Pattern Tests

When making circle-pattern tests of chroma-demodulator output, circles within circles can sometimes be seen, as illustrated. The small circle or closed loop in the waveform is caused by ringing in the demodulator output signals. The ringing voltages are relatively small and, hence, form small circles or closed loops. These voltages form perfect circles if their phase difference is exactly 90°.





Appearance of ringing in circle-pattern tests.



U73

To Check the Adjustment of the Quadrature (Subcarrier Phasing) Transformer with an NTSC Color-Bar Generator

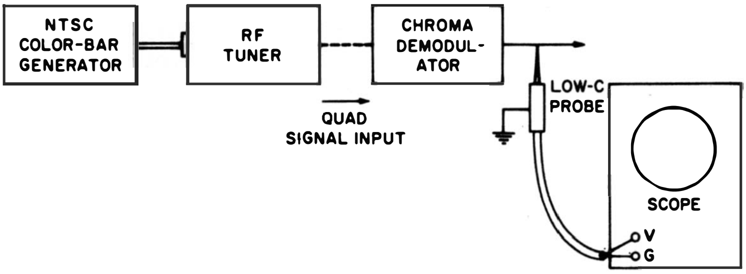
Equipment: NTSC color-bar generator and low-capacitance probe.

Connections Required: Apply modulated RF output from generator to antenna-input terminals of receiver. Connect probe at chroma demodulator output. Feed probe output to vertical-input terminals of scope.

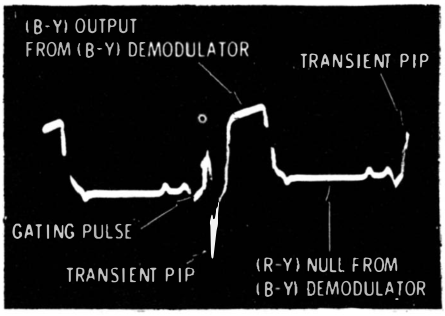
Procedure: Adjust generator and receiver controls for normal color-bar display on screen of color picture tube. An R—Y or B—Y demodulator can be checked with simultaneous R—Y B—Y bar output from generator. A G—Y demodulator is checked with a G—Y/90° signal. I and Q demodulators are checked with a simultaneous IQ bar output. R—Y and Q demodulators are checked with B—Y and I signals. X and Z demodulators must be checked indirectly.

Evaluation of Results: A chroma demodulator should null on a quadrature signal. Perfect nulls are not obtained. There is a transient disturbance at the beginning and at the end of the null signal.

Either positive or negative R—Y, B—Y, or G—Y/90° signals from the generator may be used for the null test.



Test setup.

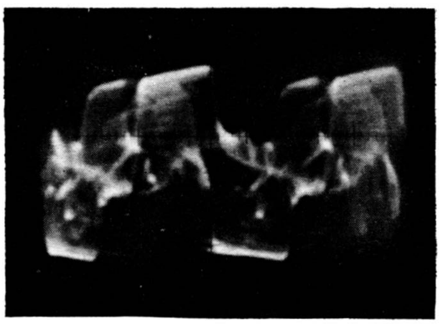


B—Y demodulator output signal waveform.

NOTE 95

Lost Color Sync Gives Faulty Null Test with NTSC Signal

The receiver must be in color sync to obtain a useful null test when an NTSC-type generator signal is used. On the other hand, the receiver can be out of color sync and a useful test will be obtained when a rainbow signal is used. The following illustration shows the blurred and confusing pattern obtained with an NTSC signal when color sync is lost.

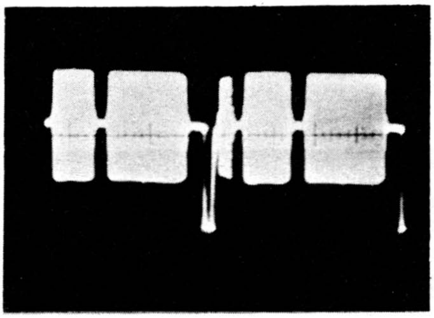


Pattern obtained with an NTSC signal when color sync is lost.

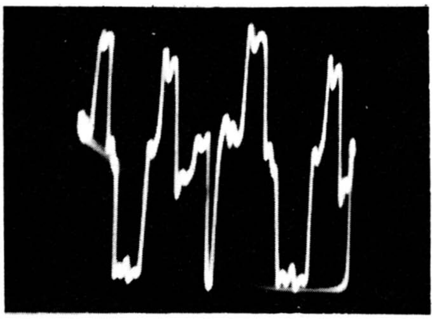
NOTE 96

Clue to Signal-Circuit Alignment

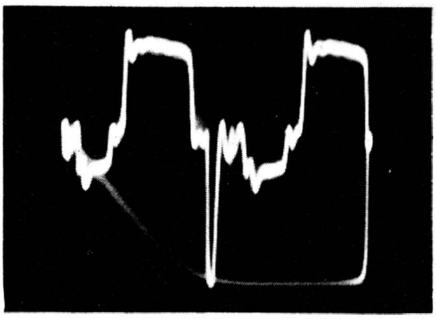
The shape of the output waveform from the chroma demodulator often gives a clue concerning signal-circuit alignment. As shown in the following illustration, the chroma-bar output from an NTSC generator has flat tops and square corners, without overshoot or ringing. When the receiver signal circuits are properly aligned, the output waveform from a chroma demodulator is flat-topped. The corners of the waveform are somewhat rounded, but there is no ringing or overshoot. On the other hand, peaked signal circuits cause ringing and overshoot, as shown in the following illustration. When the chroma signal falls on a steeply sloped response curve, the resulting phase shift causes a tilt in the top of the demodulated waveform, as illustrated.



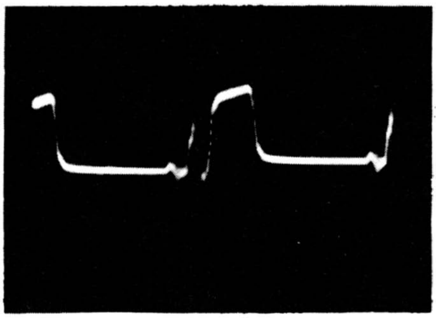
Waveform from color-bar generator.



Ringing in demodulator output waveform, caused by sharply peaked signal circuits.



Overshoot and ringing, caused by sharply peaked signal circuits.



Tilt in chroma demodulator waveform, caused by phase shift resulting from inaccurate alignment of signal circuits.

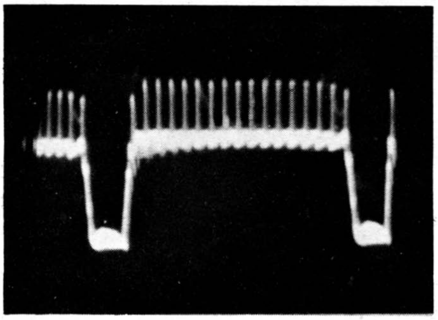
To Mark the Output from a Chroma Demodulator with a Rainbow-Crosshatch Generator

Equipment: Combination rainbow and crosshatch generator (such as Hickok 660) and low-capacitance probe.

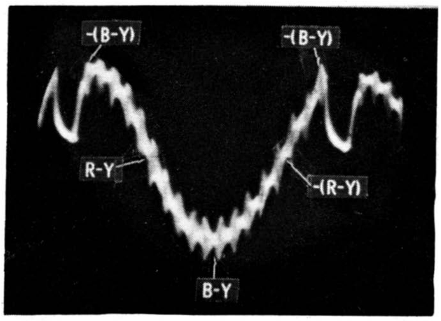
Connections Required: Apply simultaneous rainbow and crosshatch from generator to antenna-input terminals of receiver. Connect probe at chroma demodulator output. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust generator and receiver controls for display of rainbow and crosshatch pattern on picture-tube screen. Adjust scope controls for typical pattern, as shown in the accompanying waveforms.

Evaluation of Results: The crosshatch vertical bars feed through the bandpass amplifier as marker pips. The pips are useful landmarks for identification of basic chroma axes, as shown in the following illustration.



Pattern when color intensity control is turned down.



Effect on pattern when color intensity control is turned up.

NOTE 97

Checking the Output from the Chroma Matrix

The output from the matrix can be checked in the same manner as the tests outlined in U71, U73, and U74. Connect the scope to the matrix output instead of to the demodulator. The waveform observed will be the same as the corresponding waveform in the demodulator circuit.

NOTE 98

Keyed-Rainbow Signal Used to Check Matrix Operation

A keyed-rainbow signal is used to check matrix operation in the same manner as for chroma demodulators. Thus, the patterns shown in U75 apply to a G—Y matrix as well as to a G—Y demodulator. Likewise, the patterns apply to a B—Y matrix as well as to a B—Y demodulator.

U75

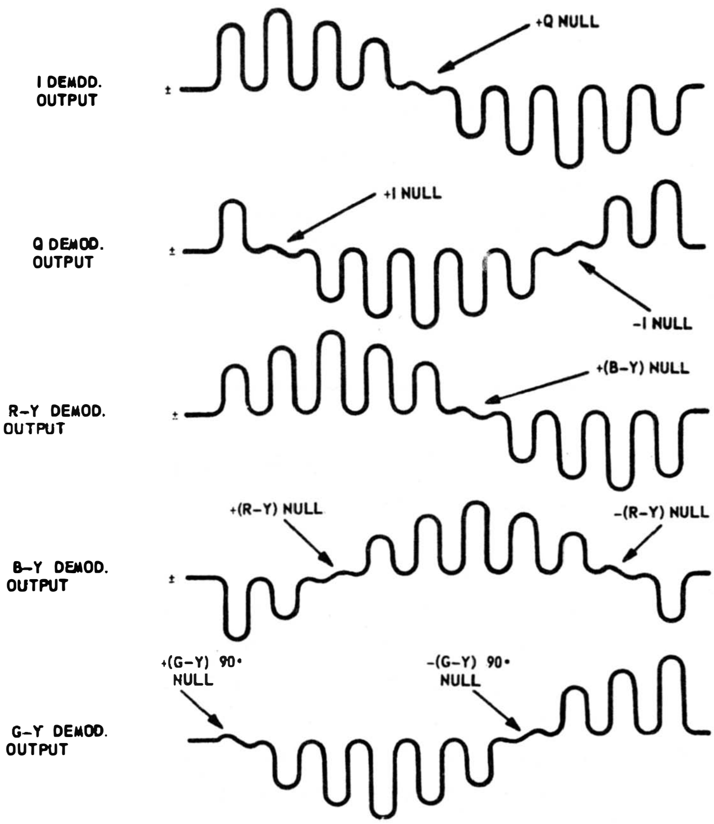
To Check the Output from a Chroma Demodulator with a Keyed-Rainbow Signal

Equipment: Keyed-rainbow generator and low-capacitance probe.

Connections Required: Apply output from generator to antenna-input terminals of receiver. Connect probe at chroma demodulator output. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust generator and receiver controls for normal chroma-bar display on picture-tube screen. Adjust scope controls for keyed sine-wave pattern, as shown in the following diagram.

Evaluation of Results: Null points for the various types of chroma demodulators are indicated. If null is correct from one demodulator, but is incorrect from the other demodulator, the quadrature (or subcarrier phasing) transformer requires adjustment. The relative heights of the keyed sine waveforms indicate the relative output levels of the two demodulators. Compare levels with data in receiver service literature.

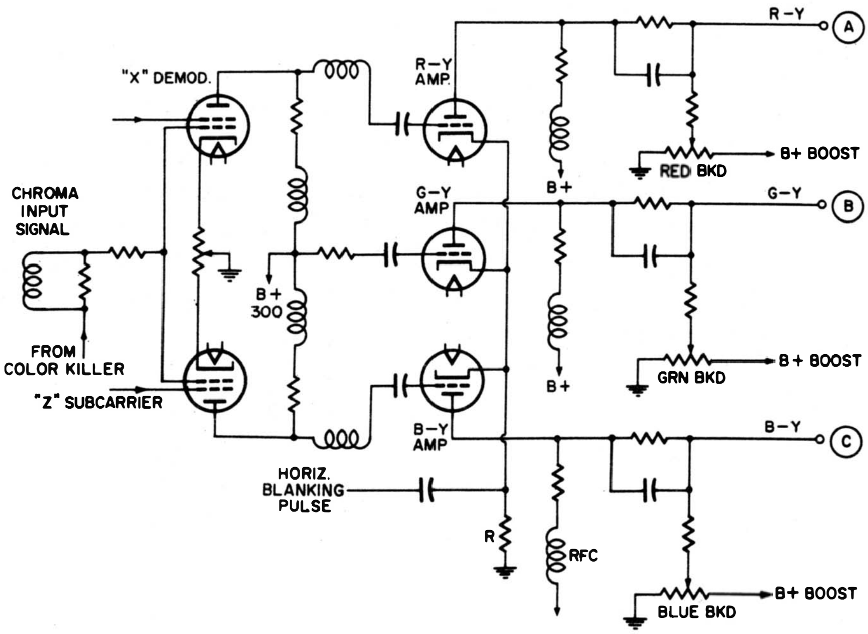


Correct nulls for a standard 10-bar keyed rainbow signal.

NOTE 99

Null Checks of X and Z Demodulators

When making null checks of X and Z demodulators, proceed as for R—Y, B—Y, G—Y, I, or Q demodulators. However, do not apply probe to the output of the X or Z demodulator. Connect probe at output of R—Y, G—Y, or B—Y amplifier as shown in the following illustration (points A, B, and C).



X and Z demodulator circuit.

NOTE 100

Checking the Chroma Circuits by Themselves

To check operation of the chroma circuits by themselves without taking the RF and IF circuits into account, inject the video-frequency output from the generator at the picture-detector output. NOTE: Correct polarity of video signal must be used; otherwise, bar patterns will have incorrect hues, and horizontal sync will be poor or absent. Some receivers, such as the Silvertone models, have separate Y and chroma detectors. In such cases, chroma tests are made by injecting the signal at the "chroma test point" provided in the chroma-detector output circuit. On the other hand, luminance tests are made by injecting a signal at the "luminance test point" provided in the picture-detector output circuit. Where both chroma and luminance information are required, these two test points are connected, as specified in the receiver service literature. Hence, unless you know the receiver, consult the service literature before making video-frequency tests.

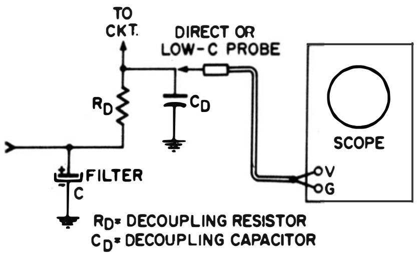
To Check the Chroma Decoupling Circuits

Equipment: Low-capacitance probe and color signal generator.

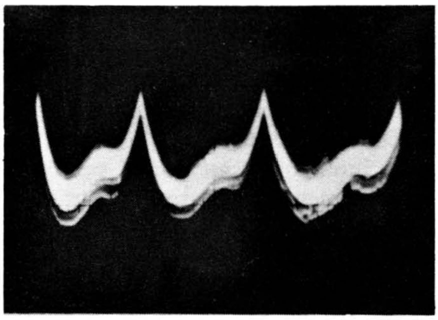
Connections Required: Apply modulated RF output from generator to antenna-input terminals of receiver. Connect probe across decoupling capacitor in chroma circuit. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust generator and receiver controls for normal display on picture-tube screen. Adjust scope controls for typical patterns, as shown.

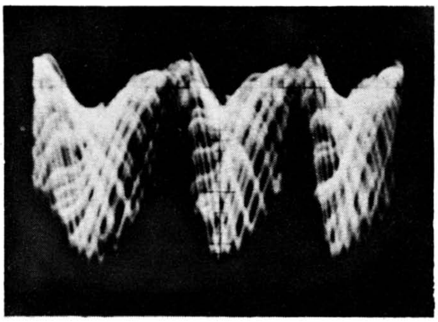
Evaluation of Results: The peak-to-peak AC voltage across the decoupling capacitor should not exceed a maximum tolerable value. Values are not given in receiver service notes, but may be determined by comparison tests in a receiver of the same type and in good operating condition.



Test setup.



Ripple on B+ lead to chroma section of a color-TV receiver.



Change in ripple waveform on B+ lead to chroma section when receiver is out of color sync.

CONVERGENCE-CIRCUIT TESTS

U77

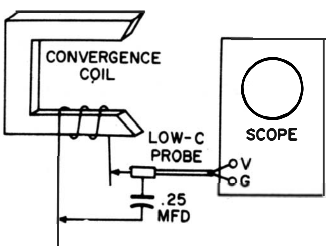
To Display the Vertical Waveform and Measure the Peak-to-Peak Voltage Across a Dynamic Convergence Coil

Equipment: Low-capacitance probe and 0.25-mfd blocking capacitor.

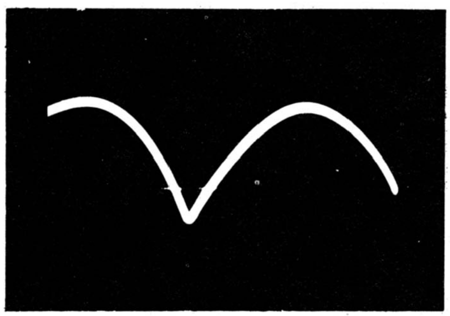
Connections Required: Connect capacitor in series with ground lead of probe (to prevent scope case from being "hot"). Apply probe tip and capacitor across convergence coil. Feed probe output to vertical-input terminals of scope.

Procedure: To view vertical dynamic convergence waveform, check service notes concerning control settings and disabling of horizontal sweep circuit. Adjust scope controls for typical pattern, as shown in the following.

Evaluation of Results: Compare waveshape and peak-to-peak voltage with data in receiver service literature. (Convergence yoke has separate coils for red, green, and blue guns.)



Test setup.



Typical vertical dynamic convergence waveform.

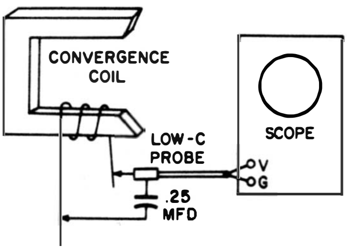
To Display the Horizontal Waveform and Measure the Peak-to-Peak Voltage Across a Dynamic Convergence Coil

Equipment: Low-capacitance probe and 0.25-mfd blocking capacitor.

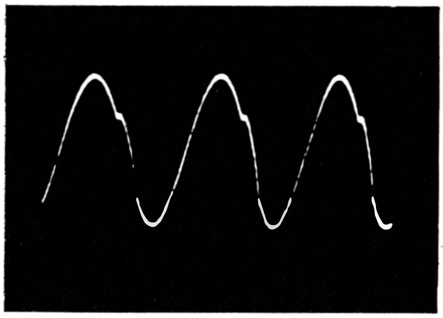
Connections Required: Connect capacitor in series with ground lead of probe (to prevent scope case from being "hot"). Apply probe tip and capacitor across convergence coil. Feed probe output to vertical-input terminals of scope.

Procedure: To view horizontal dynamic waveform, check service literature concerning receiver control settings. Adjust scope controls for typical pattern, as shown.

Evaluation of Results: Compare waveshape and peak-to-peak voltage with data in receiver service notes. (Convergence yoke has separate coils for red, green, and blue guns.)



Test setup.



Typical horizontal dynamic convergence waveform.

U79

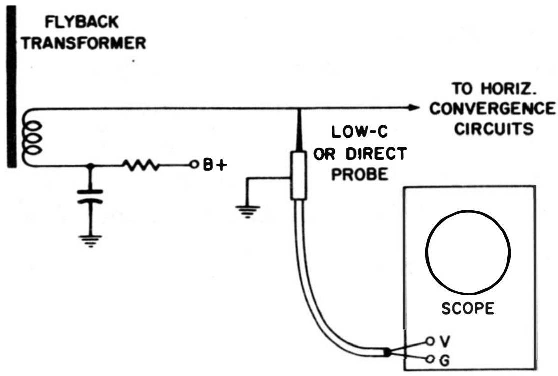
To Check the Waveform and Measure the Peak-to-Peak Voltage of the Drive Voltage to the Horizontal Dynamic Convergence System

Equipment: Low-capacitance or direct probe.

Connections Required: Apply probe between "hot" side of convergence-voltage winding (on flyback transformer) and chassis ground. Feed probe output to vertical-input terminals of scope.

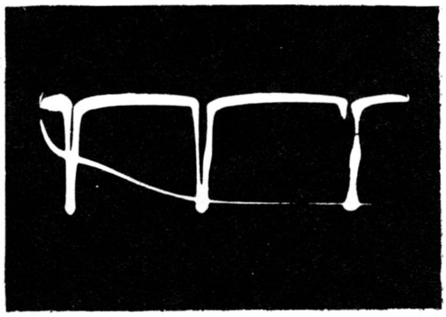
Procedure: Adjust scope controls for typical waveform, as shown.

Evaluation of Results: Compare waveform and peak-to-peak voltage value with data in receiver service literature.



Test setup.

Waveform of drive voltage to horizontal dynamic convergence system.



U80

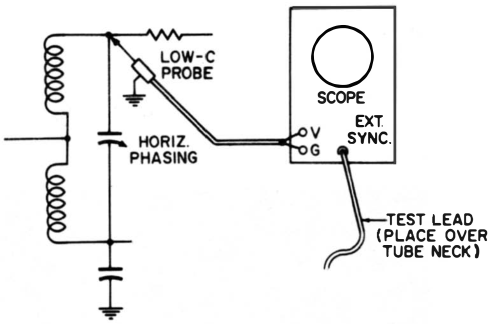
To Check the Action of a Horizontal Dynamic Convergence Phasing Control

Equipment: Low-capacitance probe and test lead.

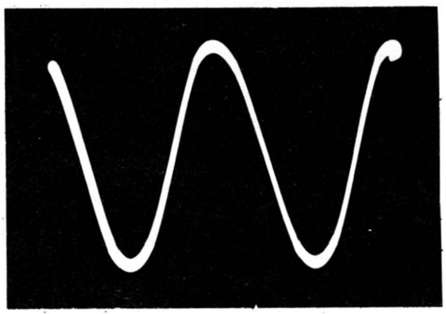
Connections Required: Apply low-capacitance probe from "high" side of phasing coil to chassis ground. Feed probe output to vertical-input terminals of scope. Connect test lead to Ext Sync post on scope panel. Drape test lead over picture-tube neck near yoke to pick up stray horizontal-sweep pulses.

Procedure: Operate scope on Ext. Sync. Adjust scope controls for typical pattern as shown in the following.

Evaluation of Results: The external sync voltage provides a reference phase point for the displayed waveform. Tune the phasing coil through resonance (with slug or trimmer capacitor provided) and observe pattern for horizontal shift along base line. If phasing control is operating properly, 90° or more phase shift will be observed. If pattern does not shift, coil cannot be tuned through resonance because of a circuit fault. Note that the associated horizontal-amplitude control must be turned up from its zero point, or no voltage will be applied across the phasing coil.



Test setup.



Waveform observed across the horizontal phasing control.

INTERCARRIER SOUND TESTS

U81

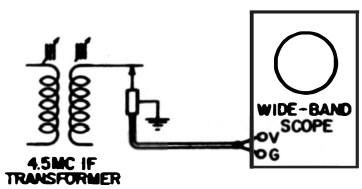
To Display the Undemodulated 4.5-Mc FM Sound Signal

Equipment: Low-capacitance probe and scope flat to 4.5 mc.

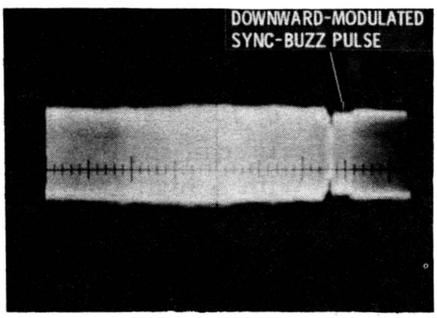
Connections Required: Apply probe between "hot" side of 4.5-mc circuit and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Use 60-cycle sawtooth or sine-wave sweep in scope. Tune in a TV broadcast station. Adjust receiver controls for normal reception. Adjust scope controls for pattern shown in the following.

Evaluation of Results: In theory, a 4.5-mc FM carrier with constant voltage is present in the 4.5-mc IF circuits. In practice, however, receiver-circuit nonlinearities usually cause amplitude modulation to appear on the envelope of the 4.5-mc waveform, as shown.



Test setup.



Typical 4.5-mc IF signal, showing AM modulation and a vertical sync-buzz pulse present on the FM envelope.

NOTE 101

Resonating the Coil Under Test

A probe has a certain amount of input capacitance. When applied across a tuned circuit, such as a 4.5-mc IF coil, it detunes the coil to some extent. To view the true waveform at that point, the slug in the coil must be turned farther out of the winding to restore 4.5-mc resonance. The most accurate method of resonating the coil under test is to apply a sweep signal to the receiver with a scope connected at the ratio-detector output. View the resulting S curve, first without the low-capacitance probe applied in the 4.5-mc circuit; then observe the change in curve height and shape when the probe is applied at the desired test point Retune the coil with the low-capacitance probe connected to restore the original height and shape of the S curve. Then disconnect the sweep generator and make the test described in U81. For details of sweep-generator application, see the companion volume, *101 Ways to Use Your Sweep Generator.*

U82

To Check the Undemodulated 4.5-Mc FM Sound Signal, Using a Pickup Loop

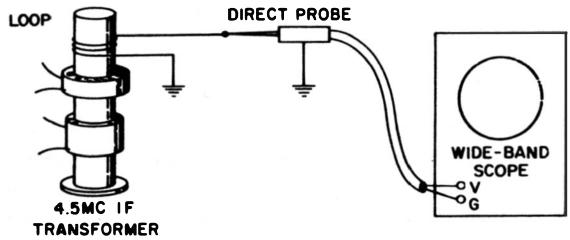
Equipment: Direct probe, several inches of insulated wire, and wide-band scope flat to 4.5 mc.

Connections Required: Connect one end of wire to chassis ground. Loop two or three turns of wire around end of 4.5-mc IF coil form. Connect direct probe between other end of wire and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust scope controls for pattern shown in U81. Receiver must be tuned to TV broadcast station.

Evaluation of Results: The pickup loop has less detuning effect on the IF coil than the conductive connection described in U81. With a high-gain scope, the 4.5-mc FM signal can be observed when loop is loosely coupled to the IF coil. AM modulation and sync buzz can be observed with minimum disturbance of the circuit.

Test setup.



U83

To Check Percentage Modulation of 4.5-Mc FM Signal by the Sync-Buzz Pulse, Using Narrow-Band DC Scope

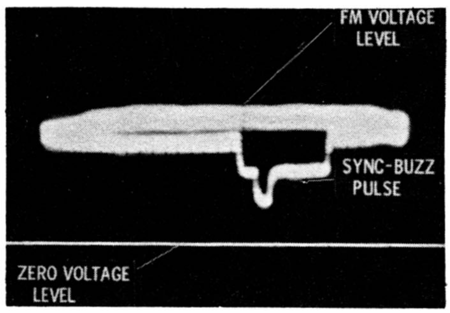
Equipment: Demodulator probe, several inches of insulated wire, and DC scope (scope can have narrow-band response).

Connections Required: Arrange pickup loop as in U82. Connect demodulator probe between loop output and chassis ground. Feed probe output to vertical-input terminals of scope.

Procedure: Make sure DC scope is balanced. Receiver must be tuned to TV broadcast station. Short vertical-input terminals of scope to locate the zero-volt level on the screen. Remove short and observe pattern with respect to zero-volt level.

Evaluation of Results: The buzz pulse usually extends downward. The amount it extends downward is a measure of its percentage modulation of the FM IF signal. A ratio detector in normal operating condition can eliminate up to 30% of downward modulation. Higher percentages of downward modulation will pass through the ratio detector and appear in the audio signal as 60-cycle sync buzz.

A sync-buzz pulse downward modulating the FM signal. Scope is swept with a 60-cycle, sine-wave voltage.



NOTE 102

Effect of Horizontal Sync Buzz

When vertical sync buzz is present, horizontal sync buzz is also present. However, only the vertical sync buzz is audible. The 15,750-cycle horizontal sync buzz is practically out of range of audibility and becomes choked out in the audio amplifier. A conventional service demodulator probe also greatly attenuates the horizontal sync-buzz pulses. Hence, operate the scope at 60 cycles sweep when making sync buzz checks.

NOTE 103

Sync-Buzz Pulses Formed in the IF Amplifier

Sync-buzz pulses can be formed in the IF amplifier because of misadjustment of the sound trap(s). This misadjustment permits the sound carrier to ride too high on the response curve. Sync buzz can also be generated in the IF amplifier when a stage is overloaded. Overload cross-modulates the vertical sync pulse into the FM sound signal. Sync buzz also occurs when the video amplifier is overloaded, causing the video signal to modulate the 4.5-mc FM signal. When sync buzz is generated in the video amplifier, its waveform and voltage change markedly with the setting of the contrast control. Often, this latter type of sync buzz extends upward from the FM envelope, instead of downward.

NOTE 104

Using a Pattern Generator Instead of a TV Signal for Sync Buzz Analysis

A pattern generator can be used instead of a TV broadcast signal to drive a receiver for sync-buzz analysis. The generator signal is steadier than a station signal. The generator must provide normal sync pulses and must have a standard 4.5-mc tone signal. Adjustable percentage of video modulation is desirable. Sync buzz is most troublesome when the video modulation percentage is high (pattern with white background). This is because the vertical sync pulse then produces the greatest amplitude modulation of the picture carrier.

U84

To Check the Action of a 4.5-Mc Limiter

Equipment: Low-capacitance probe and scope flat to 4.5 mc; or direct probe, several inches of insulated wire, and wide-band scope flat to 4.5 mc; or demodulator probe, several inches of insulated wire, and DC scope (scope can have narrow-band response).

Connections Required: First, connect loop and/or probe to limiter driving circuit; then connect to limiter output circuit.

Procedure: Observe percentage modulation of 4.5-mc signal by buzz pulse in first test and compare with results of second test.

Evaluation of Results: The limiter in normal operation prevents downward modulation of more than 30% from reaching the ratio detector. Note that low-priced receivers usually dispense with a limiter stage.

U85

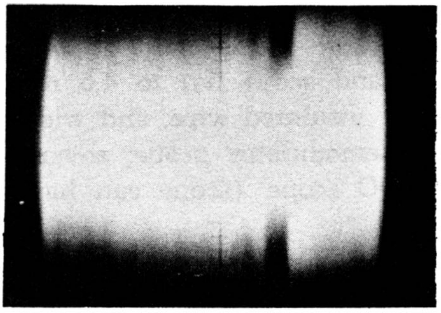
To Test for Vertical-Sweep Buzz

Equipment: Same as in U81, U82, or U83.

Connections Required: Same as in U81, U82, or U83.

Procedure: Display pattern using 60-cycle, sine-wave sweep to obtain deflection frequency reference. Turn vertical-hold control.

Evaluation of Results: If buzz pulse remains stationary in the pattern as picture rolls, the buzz pulse is being generated in the IF amplifier or video amplifier. On the other hand, if the buzz pulse moves through the pattern, it is caused by entry of spurious vertical-sweep voltages into the signal circuits. In this event, follow up with scope checks across decoupling capacitors at possible points of buzz-pulse entry to localize the faulty capacitor.



A typical vertical-sweep buzz pulse, caused by entry of vertical sweep voltage into the signal circuits, modulating the 4.5-mc IF signal.

U86

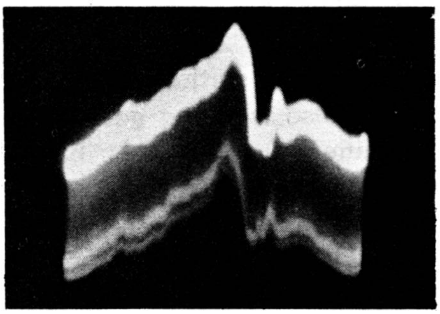
To Check for Vertical-Blanking Buzz

Equipment: Same as in U81, U82, or U83.

Connections Required: Same as in U81, U82, or U83.

Procedure: Turn brightness control through its range while watching the buzz pulse for change in height and shape.

Evaluation of Results: If the buzz pulse is responsive to picture-tube brightness changes, stray fields from the high-voltage system are entering the signal circuits. Blanking buzz is caused basically by rise and fall of the high-voltage output as the vertical blanking pulse is applied to the picture-tube cathode or grid. In such case, the signal circuits must be better shielded from the high-voltage stray fields.



A buzz pulse in the 4.5-mc FM sound signal, caused by signal-circuit pickup of strong stray fields from picture tube radiation.

To Check for Blanking Buzz at the Ratio-Detector Output

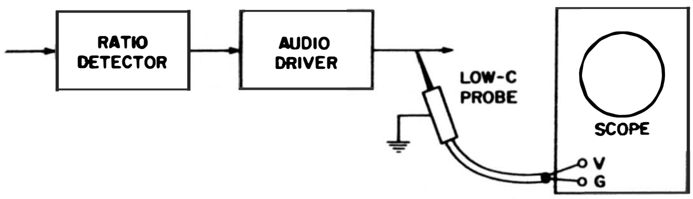
Equipment: Low-capacitance probe.

Connections Required: Apply probe at any point in the audio channel following the ratio detector. Feed probe output to vertical-input terminals of scope.

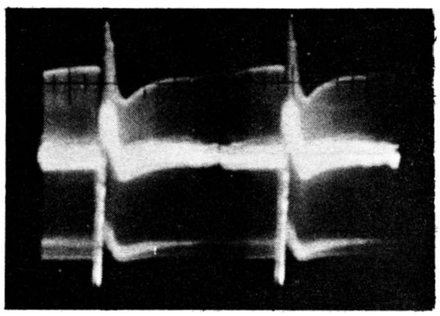
Procedure: Receiver must be driven by TV broadcast signal or suitable pattern generator. Adjust receiver (and generator, if used) for normal reception. Adjust scope controls for audio pattern, using 60-cycle sweep.

Evaluation of Results: This test should be made if U86 does not show the presence of blanking buzz. Turn brightness control through its range. If blanking buzz pulse is now displayed when brightness control is advanced, stray fields from the high-voltage system are entering the ratio-detector output circuit (audio input circuit). Better shielding will eliminate the blanking buzz.

Test setup.



Typical blanking buzz pulse, caused by audio circuit pickup of strong fields from the picture tube.



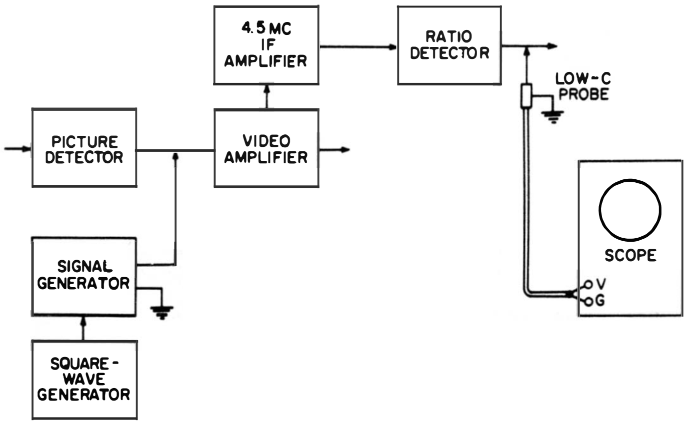
To Test a Ratio Detector for AM Rejection

Equipment: Square-wave generator, signal generator with built-in modulator (or external modulator unit), and low-capacitance probe.

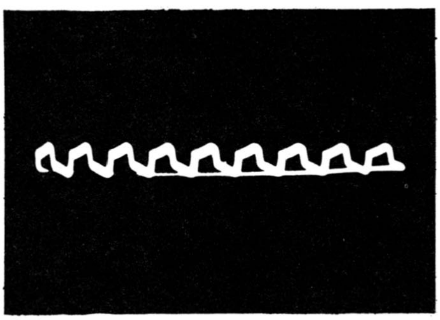
Connections Required: Connect square-wave generator and signal generator (with external modulator, if used) for modulated 4.5-mc output (see U17 and U18). Apply the signal voltage to the picture-detector output circuit. Connect probe at ratio-detector output. Feed probe output to vertical-input terminals of scope.

Procedure: Adjust square-wave generator output for 30% modulation of the 4.5-mc CW voltage from the signal generator. Operate the square-wave generator at approximately 60 cycles. Set signal-generator output for about 0.1 volt.

Evaluation of Results: Scope should display little or no square-wave output from the ratio detector.



Test setup.



Example of poor 60-cycle, square-wave rejection by ratio detector.

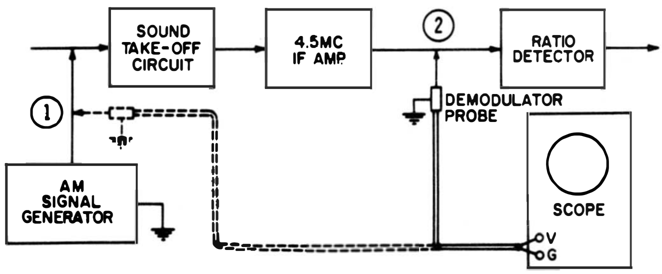
To Measure the Gain of the 4.5-Mc IF Amplifier

Equipment: AM signal generator and demodulator probe.

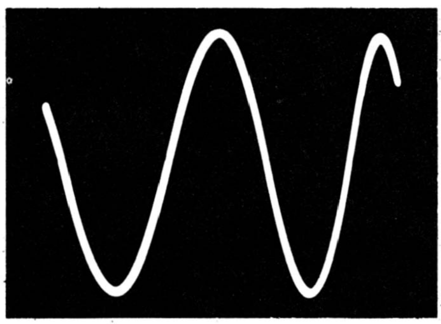
Connections Required: Connect generator output cable between 4.5-mc sound take-off coil and chassis ground. Connect probe output cable to vertical-input terminals of scope.

Procedure: Adjust signal generator for 4.5-mc output and approximately 30% modulation. Turn contrast control to minimum to eliminate noise interference from receiver signal circuits. Make first test by applying demodulator probe across generator output cable (point 1). Make second test by applying probe across ratio-detector input circuit (point 2). Note that this detunes the input circuit; for the most accurate measurement, retune to 4.5 mc (see Note 101).

Evaluation of Results: Make both tests with calibrated scope. The ratio of the output sine-wave voltage to the input sine-wave voltage gives the gain of the 4.5-mc IF amplifier.



Test setup.



Output signal from AM signal generator.

AUDIO-AMPLIFIER TESTS

U90

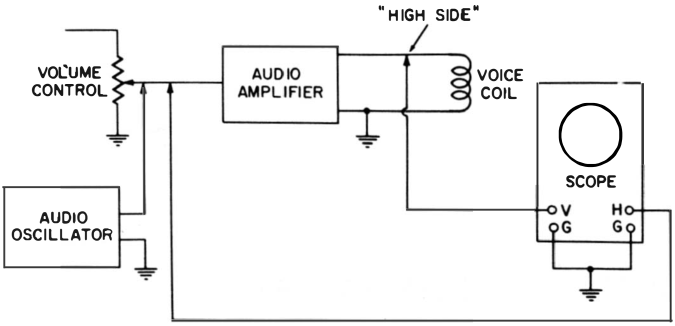
To Check the Audio Amplifier System for Amplitude Distortion

Equipment: Audio oscillator and scope having horizontal amplifier with flat frequency response through the audio-frequency range.

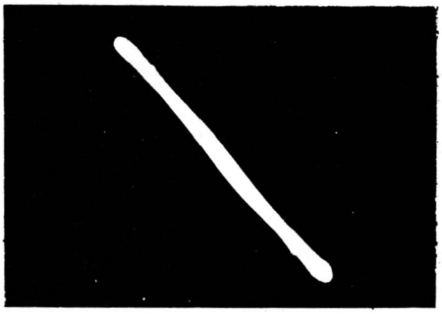
Connections Required: Connect output cable from audio oscillator to audio-amplifier input. Connect vertical-input cable of scope across voice-coil terminals of speaker. Connect horizontal-input terminals of scope to audio-oscillator output cable.

Procedure: Adjust scope controls for diagonal line or Lissajous pattern, as shown in the following. Set audio-oscillator output below overload point of amplifier. Check pattern over audio-frequency range.

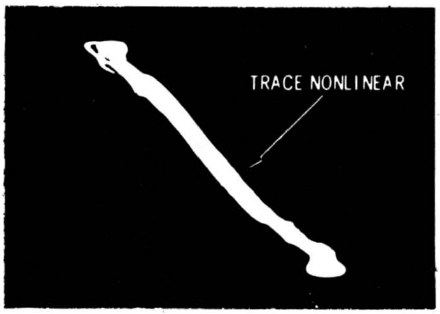
Evaluation of Results: When audio system is free from amplitude distortion, the diagonal line, ellipse, or circle displayed on the scope screen will be free from geometrical irregularities. Curvature or kinks in a line display, or flattened regions in an elliptical or circular display, show the occurrence of amplitude distortion.



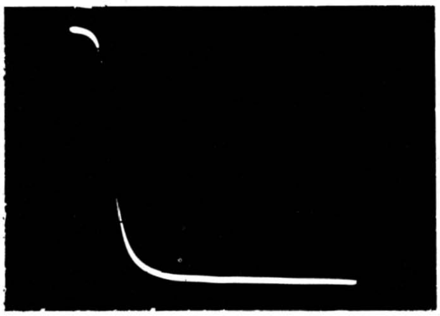
Test setup.



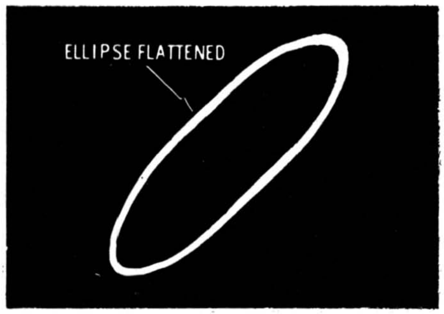
Negligible amplitude distortion.



Moderate amplitude distortion (audio oscillator frequency varied).



Severe amplitude distortion (overload).



Moderate amplitude distortion and phase shift.

NOTE 105

Floating Voice Coil

Inspect the receiver circuit diagram to determine whether the voice coil is grounded on one side or is "floating." If the coil is "floating," ground one side or use a double-ended scope. (See U94.)

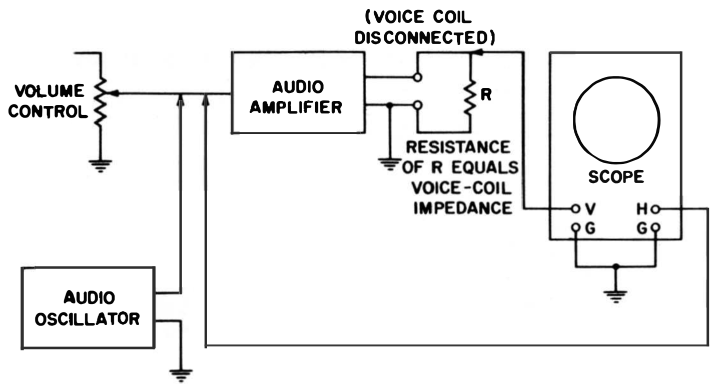
To Check the Audio Amplifier for Amplitude Distortion (Motional Impedance of Speaker Eliminated from Pattern)

Equipment: Audio oscillator, load resistor, and scope having horizontal amplifier with flat frequency response through the audio-frequency range (DC scope preferred for very low frequency tests).

Connections Required: Connect output cable from audio oscillator to audio-amplifier input. Disconnect voice coil and substitute 2-watt resistor having a value equal to voice-coil impedance. Connect vertical-input cable of scope across resistor. Connect horizontal-input terminals of scope to audio-oscillator output.

Procedure: Adjust scope controls for diagonal line or Lissajous pattern, as shown in U90. Set audio-oscillator output below overload point of amplifier. Check pattern over audio-frequency range.

Evaluation of Results: When audio system is free from amplitude distortion, the diagonal line, ellipse, or circle displayed on the scope screen will be free from geometrical irregularities. Curvature or kinks in a line display, or flattened regions in an elliptical or circular display, show the occurrence of amplitude distortion.



Test setup.

NOTE 106

Motional Impedance Characteristic of Speaker

The difference in patterns observed in U90 and U91 gives the motional impedance characteristic of the speaker. The better the speaker, the more constant is its motional impedance over a wide audio-frequency range.

NOTE 107

Use of Double-Ended Scope

If one side of the voice coil is not grounded or if circuit configuration prevents grounding one side for audio-output tests, use a double-ended scope. Ground scope case to receiver chassis. Connect vertical-input terminals of scope across the double-ended circuit, as shown in U94.

U92

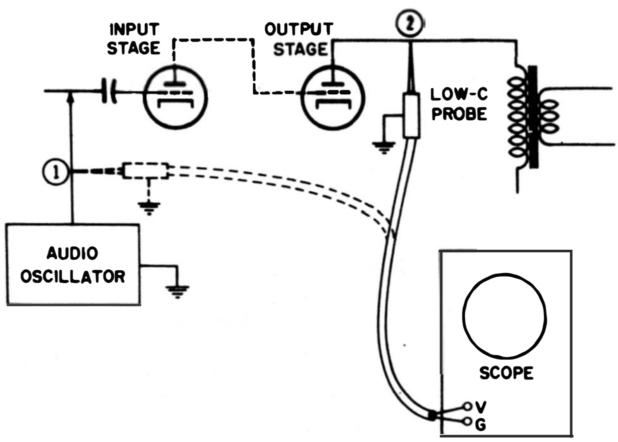
To Measure the Voltage Gain of the Audio Amplifier

Equipment: Audio oscillator and low-capacitance probe.

Connections Required: Apply audio-oscillator output to amplifier input. Connect probe output to vertical-input terminals of scope.

Procedure: Set audio-oscillator output below amplifier overload point. First, connect probe across the amplifier input and then connect probe across amplifier output.

Evaluation of Results: The ratio of vertical deflections at points 1 and 2 in the following illustration gives the voltage gain from the grid of the input stage to the plate of the output stage. Note that this test provides no data on power gain, since input and output impedances are not taken into account in this test.



Test setup.

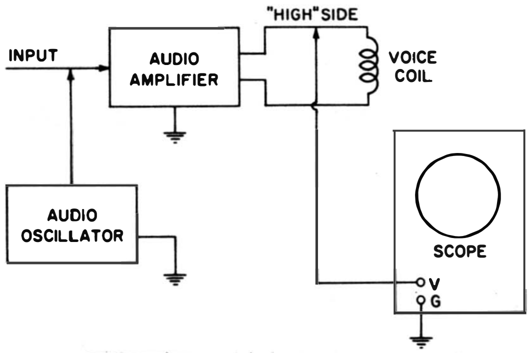
To Check the Frequency Response of the Audio System

Equipment: Audio oscillator with uniform output over the audio range and scope with flat frequency response (DC scope preferred).

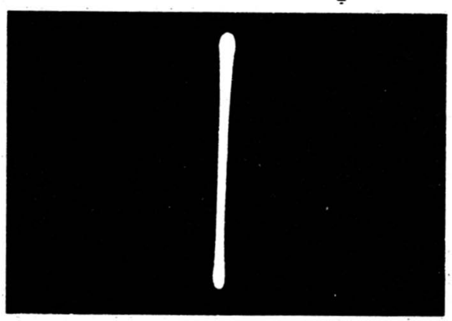
Connections Required: Connect audio-oscillator output cable to amplifier input. Connect vertical-input terminals of scope across voice-coil circuit.

Procedure: Operate audio oscillator below amplifier overload point. Adjust scope controls for usual sine-wave display. Vary audio-oscillator frequency while watching scope deflection.

Evaluation of Results: Disregard phase shift and observe only the amount of vertical deflection; horizontal-gain control may be turned to zero. Considerable variation of response is often observed in low-priced receivers.



Test setup.



Pattern obtained in frequency response check (horizontal gain reduced to zero).

NOTE 108

Effect of Tone Control in Audio-Amplifier Network

Some receivers have a tone control in the audio-amplifier network. The tone control setting affects the frequency response and phase shift over the audio-frequency range. Hence, this factor must be considered in evaluating amplifier performance.

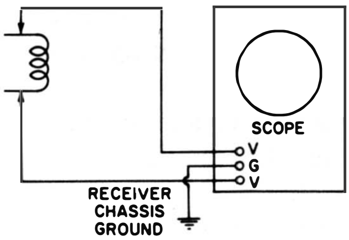
To Observe Waveforms in Double-Ended Audio Circuits

Equipment: Scope with double-ended vertical input.

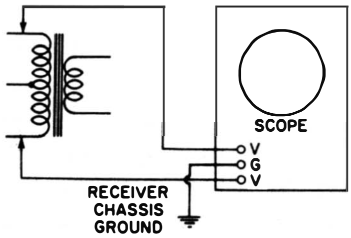
Connections Required: Ground scope case to receiver chassis. Connect vertical-input terminals of scope across the double-ended circuit, as shown in the following typical circuit.

Procedure: Same as in single-ended tests.

Evaluation of Results: Same as in single-ended tests.



(A) Across floating voice coil.



(B) Across push-pull audio output transformer.

Test setup for observing double-ended audio circuits.

MISCELLANEOUS TESTS

U95

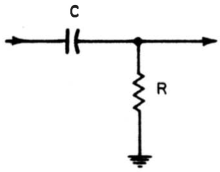
To Measure the Rise Time of a Square Wave with a Differentiating Circuit

Equipment: Resistor (75 ohm), assortment of small capacitors (or trimmer capacitor), and square-wave generator.

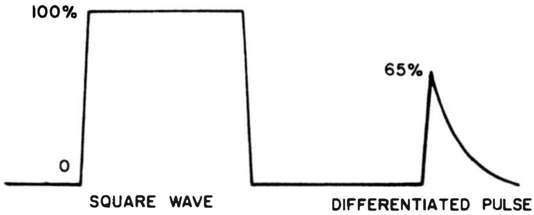
Connections Required: Connect the resistor and a capacitor in a differentiating circuit as shown. Connect the square-wave generator to the input of the differentiating circuit, and connect the scope via a low-capacitance probe to the output. A 75-ohm resistor is suitable for most tests.

Procedure: Using a measured output voltage from the generator (such as 1 volt peak-to-peak), change the value of C by using different capacitors until the output pulse is 65% of the square-wave amplitude. (In this example the pulse would have an amplitude of 0.65 volt peak-to-peak.)

Evaluation of Results: When the capacitor in the differentiating circuit has a suitable value, the differentiated pulse is 65% of the amplitude of the applied square wave. The time constant of the differentiating circuit is then equal to the rise time of the square wave, within the limits of practical accuracy. For example, suppose that you find that a 0.001-mfd capacitor must be used with a 75-ohm resistor. The time constant of this combination is 0.075 microsecond, so the rise time of the square wave is approximately 0.075 microsecond. This test is based on the fact that the charge on capacitor C (see the following illustration) is decaying while the square wave is rising. Thus the amplitude of the differentiated pulse is related to the rise time of the square wave.



Test setup.



Input and output of test circuit.

U96

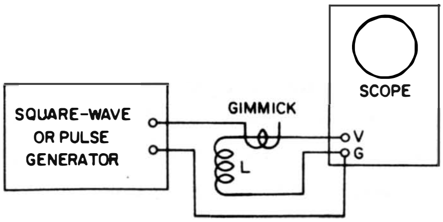
To Make a Ringing Test of an Inductor or Winding of a Transformer

Equipment: Square-wave generator, pulse generator, or scope that provides a fast-rise test pulse.

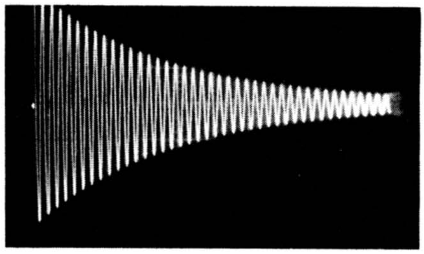
Connections Required: Connect coil winding under test to the vertical-input terminals of the scope, as shown in the following sketch. Couple the square-wave or pulse voltage to the coil via a gimmick or a small (fixed or trimmer) capacitor.

Procedure: Advance scope gain and apply sufficient drive voltage to display a convenient pattern height. Set the time base of the scope to obtain the desired waveform expansion. The pattern is automatically synchronized if you use a test pulse from the scope itself.

Evaluation of Results: Count the number of peaks in the ringing waveform from the 100% to the 37% amplitude point; this is the number of cycles. Multiply this number by pi (3.14). The product is equal to the Q value of the coil at its ringing frequency. If you are using a triggered-sweep scope, you can determine the ringing frequency by noting the setting of the time base. For example, if one cycle of the ringing waveform occupies one centimeter and the time base is set for a sweep speed of one microsecond per centimeter, the ringing frequency is one megacycle/second.



Ringing test setup.



Typical pattern.

NOTE 109

Lack of Adequate Amplitude in Ringing Pattern

Beginners sometimes have difficulty in obtaining a ringing pattern with adequate vertical amplitude. The cause of this is that the driving square wave or pulse has too slow a rise time. Use a better source if difficulty is encountered. It is not good practice to connect the square-wave or pulse generator directly to the inductor under test because the output resistance of the generator is then shunted across the inductor. This reduces the Q of the inductor and gives a misleading measurement. It is best practice to use a gimmick for coupling; the gimmick insures that the inductor is only slightly loaded by the generator. The use of a gimmick reduces the drive voltage to the inductor, so the square-wave or pulse source must have a fast rise.

U97

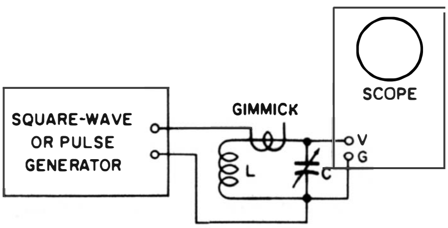
To Measure the Bandwidth of an LC Circuit with a Ringing Test

Equipment: Square-wave generator, pulse generator, or scope that provides a fast-rise test pulse; coil, and capacitor (fixed or variable).

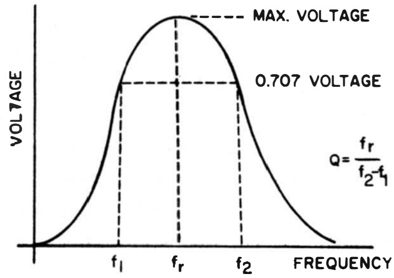
Connections Required: Connect equipment as shown in the follow illustration.

Procedure: Display the ringing waveform obtained with a chosen value of C, and count the number of peaks (cycles) in the ringing waveform from the 100% to the 37% amplitude point. Compute the ringing frequency (see U96).

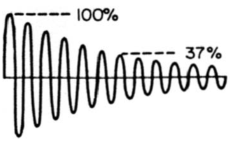
Evaluation of Results: Multiply the number of cycles observed by pi (3.14). This gives the Q value of the LC circuit. Divide the ringing frequency (given bv the time-base setting) by the Q value. This gives the bandwidth of the LC circuit with acceptable accuracy. For example, suppose that the Q value of the coil is 50, and the ringing frequency is 1 mc.; the bandwidth is approximately 20 kc. Note that the bandwidth of a coil and capacitor combination changes when the capacitor is tuned to a different frequency. As shown in the illustration which follows, the bandwidth is equal to the number of cycles between the 0.707 voltage points on the frequency response curve. The 0.707 voltage points are also called the half-power points, or the —3 db points.



Test setup.



Computing Q.



Bandwidth of a coil-capacitor combination.

U98

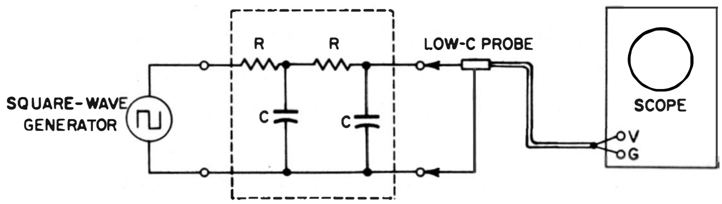
To Make a Square-Wave Test of a Two-Section RC Integrator

Equipment: Square-wave generator.

Connections Required: Connect output from square-wave generator to input of two-section integrator as shown in the following diagram. Connect the scope via a low-capacitance probe to the output of the two-section integrator.

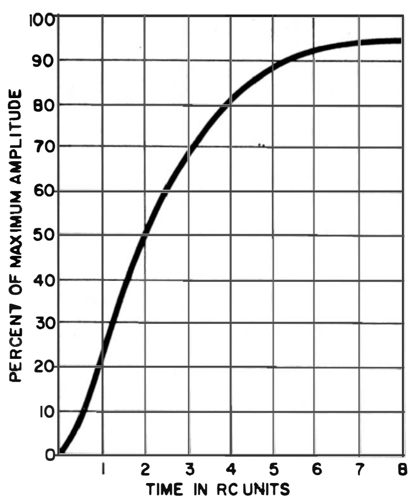
Procedure: Set the square-wave generator and scope controls to obtain a display of the leading edge of the output waveform. Compare this with the curve in the following chart.

Evaluation of Results: The universal time-constant chart shows the characteristic waveform of a two-section integrator. The waveform normally rises to 50% of maximum amplitude in 2 time constants, and rises to 95% of maximum amplitude in 8 time constants. Note that this assumes a symmetrical circuit, in which both resistors have the same value and both capacitors have the same value. For example, if R of an integrator unit is 10K and C is 0.1 mfd, RC is equal to 0.001 second, or 1 millisecond. If the integrator unit is good the output waveform should rise to 50% of maximum amplitude in 2 RC time constants, which in this case is 2 milliseconds. This is the most practical method of testing a "package" integrator, because the individual components are not accessible for test.



Test setup.

Universal RC time-constant chart for two-section integrator.



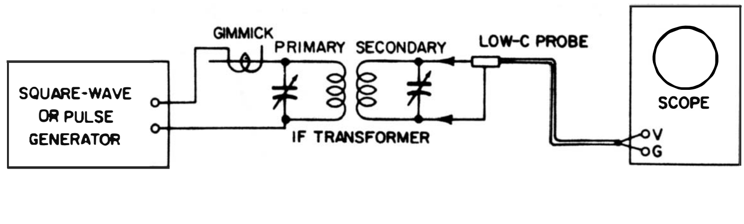
To Make a Ringing Test of an IF Transformer

Equipment: Square-wave generator, pulse generator, or scope with test-pulse output.

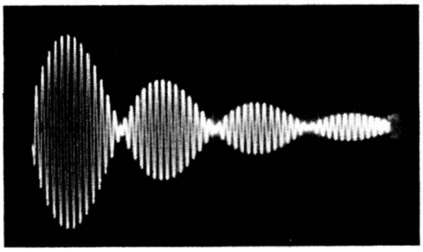
Connections Required: Connect the test setup as shown in the following diagram.

Procedure: Advance the scope gain and apply sufficient drive voltage to obtain a convenient pattern height on the scope screen. Use a square-wave frequency and a horizontal sweep rate that produce several beat intervals, as shown in the following photo. (If you use a test-pulse output from the scope, the pattern will be automatically synchronized.) Adjust the trimmer capacitors of the IF transformer for (1) maximum pattern amplitude and (2) well-defined zero-beat points, as shown in the photo.

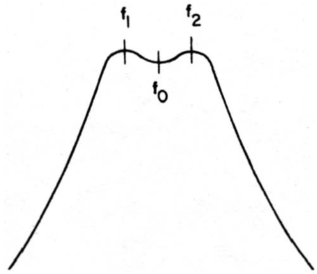
Evaluation of Results: Beginners are advised to limit themselves to comparative ringing tests of IF transformers. However, a few of the pattern characteristics may be noted. An IF transformer has two resonant frequencies, which result from the mutual inductance indicated in the equivalent circuit; these two frequencies beat together to produce the ringing pattern. If we call these ringing frequencies f_1 and f_2, the beat frequency is equal to $f_2 - f_1$. The center frequency of the IF transformer is equal to the ringing frequency of the pattern, $(f_1 + f_2)/2$. If a sweep-frequency generator signal is applied, you will see f_1 and f_2 as the hump frequencies indicated. The ringing frequency in the pattern corresponds to f_0. The ringing pattern decays because of the AC resistances of the primary and secondary. The rate of decay is determined by the Q values of the windings. Note that you must employ a fast-rise square wave or pulse to obtain the ringing pattern illustrated.



Test setup.

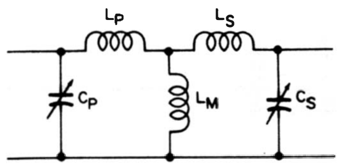


Typical ringing pattern.



The two resonant frequencies are f_1 and f_2, and the ringing frequency is f_0.

Equivolent circuit, showing mutual inductance L_M.



U100

To Display a Waveform on Expanded Sweep

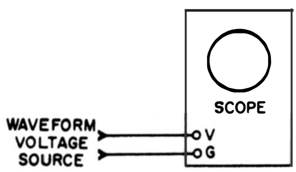
Equipment: Scope with expanded sweep function.

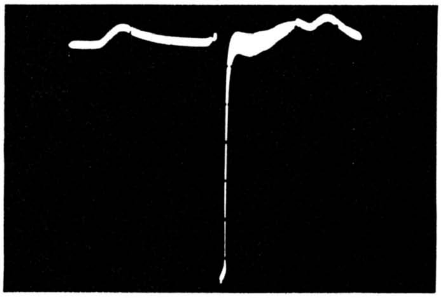
Connections Required: Apply waveform voltage under test to vertical-input terminals of scope.

Procedure: Set scope controls for expanded-sweep display, as shown.

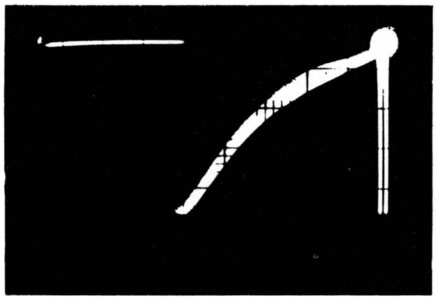
Evaluation of Results: Waveform details become apparent on expanded sweep. For example, in the following photo, expanded sweep gives a useful evaluation of the noise voltage on the trailing edge of the pulse. Note that the rise is so fast, it is invisible.

Test setup.





A pulse waveform displayed using conventional sawtooth sweep.



The same waveform displayed using the expanded sweep function.

U101

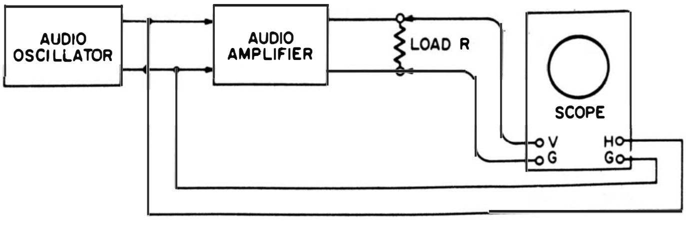
To Measure the Phase Angle Between Two Sine-Wave Voltages, Such As the Input and Output of an Amplifier

Equipment: Audio oscillator and load resistor.

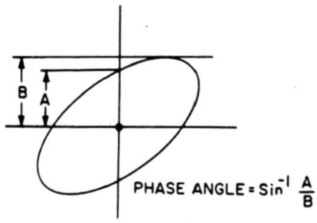
Connections Required: Drive amplifier with audio oscillator. Terminate amplifier in correct load with resistor. Feed amplifier input voltage to horizontal-input terminals of scope. Feed amplifier output voltage to vertical-input terminals of scope.

Procedure: Make tests at frequencies within flat frequency response range of scope amplifiers. Operate scope on horizontal-input function. Adjust gain controls for suitable pattern size.

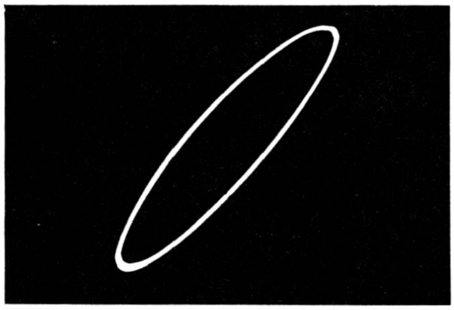
Evaluation of Results: An inclined line, ellipse, or circle appears on the scope screen. The ratio of dimensions shown gives the sine of the phase angle.



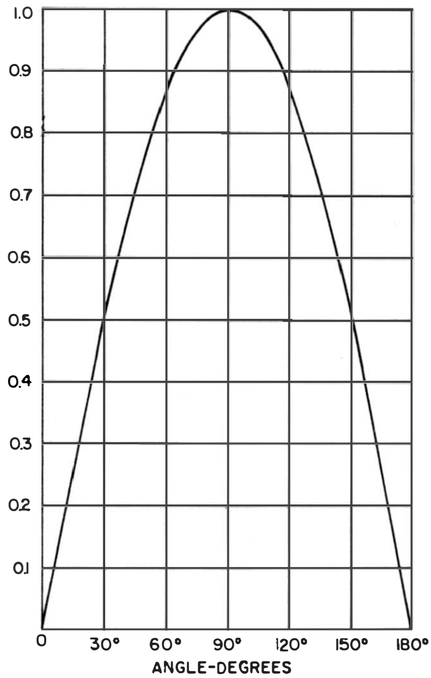
Test setup.



Method of computing phase angle.



Waveform observed on scope in foregoing test.



Values of the sine for angles from 0° to 180°.

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ABOUT THE AUTHOR

BOB MIDDLETON was born in Watsonville, Calif., in 1908. He spent his early years on a farm in the Bay region. Becoming interested in wireless in 1919, he operated a "bootleg" spark transmitter until he was old enough to become a licensed operator. In 1921, he held the state record for long-distance reception on a catswhisker detector. Bob operated his own radio service business for a number of years and later entered design engineering. In 1948, he moved into field engineering and technical lecturing. He has become well known also for his writing on service problems and instrumentation. Bob is a senior member in the I. R. E., and his biography appears in "Who's Who in the Midwest."

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