# INSTRUCTION AND SERVICE MANUAL
# PHILCO PRECISION VISUAL ALIGNMENT GENERATOR FOR TELEVISION AND FM, MODEL 7008

**For the Radio and Television Serviceman — For the Experimenter — For the Radio Amateur — For the Radio-Electronics Engineer**

Philco Precision Visual Alignment Generator for Television and FM, Model 7008, is the only completely self-contained and moderately priced instrument for precision alignment of television and FM receivers that is at present available to the serviceman. It is housed in an attractive steel case equipped with a handle and a special storage compartment for test leads, probes, and aligning tools. See figure 1.

The instrument is of compact unit design, and weighs only 36-1/2 pounds complete; it is portable, and operates entirely from the 110—120-volt, 60-cycle, a-c line, consuming only 70 watts.

Model 7008 is a precision instrument which contains the following: an FM (master osc.) generator, covering ranges of appproximately 4—120 mc. and 144—260 mc., with a variable sweep width of 15-mc. maximum deviation; a crystal calibrator, to provide accurate check points every five megacycies (and at other calculable frequencies); an r-f (marker) generator, operating over a frequency range of 3.2—250 mc; an audio-frequency generator, operating at 400 cycles; a special oscilloscope; and a common power supply. This unique combination of circuits, with only one input and one output connection, has individual gain controls or attenuators to provide for control of the circuits. In addition to their use for the primary purpose of television or FM alignment, these circuits may be used separately when trouble shooting. For example, besides furnishing a marker "pip" for checking visual alignment, the r-f (marker) generator may also be used as a separate signal generator with 400-cycle amplitude modulation for checking continuity through the picture and video stages, through the sound stages or for checking and setting the sound traps. The audio generator can be used to modulate the r-f (marker) generator, or to supply a 400-cycle signal to the receiver for checking the continuity of the audio stages.

The crystal-calibrator feature is not available for external use, but makes the unit self-calibrating; it is not necessary to use an external signal to check calibration. The oscilloscope is connected internally to a detector, which allows the beat signal between the crystal oscillator and the marker generator to be observed, so that it is possible to set the generator for an exact zero beat. The generator can then be used to furnish a marker signal which is accurate at all times. The dial calibration of the unit itself may be checked quickly and easily, and with a minimum of error. A unique logging scale is engraved on the marker-generator dial, so that it is possible to make accurate resetting to a tenth of a division.

The cathode-ray tube is a 3MP1 type employing electrostatic deflection, and has a deflection sensitivity of better than 25 millivolts per inch at maximum vertical-amplifier gain. The screen is a medium-persistence, green-fluorescent type, providing high contrast; it is supplied with a crosshatch screen for easy calibration. The crosshatch screen is removable, and is specially constructed of laminated sheets of plastic, so that the markings are sandwiched in between two sheets, and cannot be damaged by handling. The cathode-ray tube is mounted in a separate swivelled housing which can be folded into the main housing, so that the unit may be conveniently stored in a small space, and carried with a minimum of interference from protruding parts. The metal light shield telescopes into the housing for compact storage when not in use, or may be removed entirely, if desired. The oscilloscope circuit is extremely stable; the trace does not move off screen with sudden changes in line voltage or input levels; furthermore, changing from one test point to another does not necessitate a long wait until the presentation is stabilized. A unique method of using compensating load resistors in the various circuits not in use provides a practically constant load on the power supply.

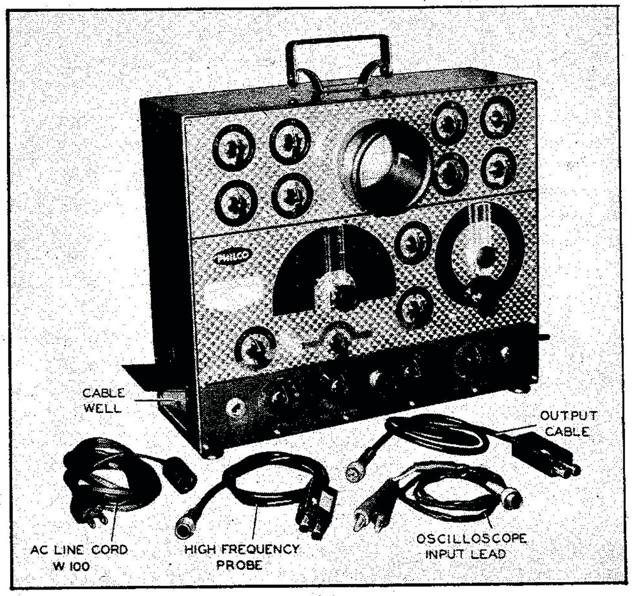


**Fig. 1.** TP-5977

**MODEL 7008**

With the variable SWEEP WIDTH control, the sweep width can be reduced to a low value (approximately 200 kc.) before its adjustment becomes critical, and can be expanded up to 15 mc., depending upon the frequency range in use. Thus the c-r-tube presentation may be expanded to include the full screen for wide-band FM or for television picture i-f channels.

Because the gain of most television receivers falls off on the high-frequency channels, the high-frequency output of Model 7008 is increased to about five times the output at low frequencies; more than enough output is available at all times to view the front-end alignment of a TV or FM receiver. This feature is only available in high-priced laboratory types of sweep generators.

The output of this instrument is controlled by a shielded multiplier attenuator, permitting absolute control of output from thousands of microvolts down to a few microvolts.

A crystal-diode high-frequency probe is included, for use in checking the continuity of individual stages by visual means, and for setting the 4.5-mc, video trap. Of importance to the design engineer, or for school demonstrations, is the use of this instrument for determining the correct termination for r-f transmission lines, for measuring transmission-line attenuation, for measuring the standing-wave ratio on transmission lines, and for determining the velocity-of-propagation constant of transmission lines.

A PHASING control is included, to obviate the neccessity of using an external phase shifter to provide a single trace.

A BLANKING control effectively provides a base line for zero reference level, so that the polarity and amplitude of the presentation can be accurately compared with known figures.

Since the various instruments comprising Model 7008 are all mounted in one case, only two cable connections are necessary; this feature minimizes the possibility of regeneration and feed-back troubles during alignment; the test connections are short and neat.

## SUGGESTED APPLICATIONS

Some of the applications of the Model 7008 are as follows:

- Servicing on the bench or in the customer's home
- Making complete alignment of TV receiver
- Making complete alignment of FM receiver
- Checking individual stage or over-all picture i.f.
- Checking individual stage or over-all sound i.f.
- Observing discriminator response
- Setting discriminator to exact center frequency
- Checking sound-trap adjustment
- Checking video-trap adjustment
- Measuring video detector output
- Checking oscillator setting
- Observing r-f-stage and mixer response for each channel
- Observing video response at 400 cycles, and from 3 mc. to cutoff point
- Determining relative strength of local TV stations at point of installation, for correct orientation of aerial
- Determining relative receiver sensitivity
- Determining relative stage gain (i-f, r-f, video, or audio)
- Checking impedance of r-f transmission lines
- Checking attenuation of r-f transmission-line cable
- Checking standing-wave ratio on r-f transmission lines
- Checking velocity of propagation constant of r-f transmission lines
- Checking continuity of r-f, i-f, and video stages
- Determining correct setting of a-v-c control

## SPECIFICATIONS

Over-all Dimensions: width, 16"; depth, 6½" (carrying), 12½" (operating); height, 16"

Weight: 36-½lbs. (including cables)

Operating Voltage: 110 to 120 volts, 60 cycles, a. c.

Power Consumption: 70 watts

Marker Generator Ranges:

- A Band — 3.2 to 7.5 mc. (fundamental), and 6.4 to 15 mc. (second harmonic)
- B Band — 14.5 to 36 mc. (fundamental), and 29 to 72 mc. (second harmonic)
- C Band — 69 to 125 mc. (fundamental), and 138 to 250 mc. (second harmonic)

FM (Master Osc.) Generator Ranges:

- A Band — 4 to 120 mc. (beat frequency)
- B Band — 144 to 260 mc. (fundamental)

Sweep Characteristics:

- Electro-mechanical type
- Variable up to a maximum of 15 mc.
- Flat to within .2 db per megacycle

Oscilloscope:

- 3-inch tube, green medium-persistance phosphor
- Electrostatic deflection
- Sine-wave sweep; sweep rate, 60 c. p. s.
- Better than 25 millivolts per inch sensitivity
- Crosshatch screen, 10 divisions per inch

Audio Generator: Sine wave, 400 cycles, ± 10%

Output Impedance: 75 ohms, constant

Input Impedance: High (.5-mf. blocking condenser and 500,000-ohm gain control)

High-Frequency Probe: Crystal-diode type (crystal type 1N34)

## TUBE COMPLEMENT

- 1—5Z4 Low-voltage rectifier
- 2—6X4 High-voltage rectifiers
- 1—6C4 Blanking tube
- 1—6C4 Fixed oscillator (140 mc.)
- 1—6C4 R-f oscillator (marker)
- 1—6C4 Audio oscillator
- 1—6J6 Crystal oscillator and cathode follower
- 1—6AK5 Master oscillator (FM)
- 1—6AK5 Mixer
- 2—7F7 Vertical amplifiers
- 1—3MP1 Cathode-ray tube

## CONTROL FUNCTIONS

Model 7008 consists essentially of four functional units, any or all of which may be used separately or simultaneously. A total of 18 controls are employed; for alignment purposes, however, some of these controls need only be adjusted at the beginning. Since the user is probably familiar with one or more of the four functional units in other forms, the controls are grouped under functional headings for ease of discussion.

### OSCILLOSCOPE

INTENSITY: Rotary knob control which adjusts the brilliance of the cathode-ray-tube trace.

FOCUS: Rotary knob control which adjusts the cathode-ray beam for a sharp trace line.

HORIZ. CENT.: Rotary knob control which moves the cathode-ray-tube trace horizontally in either direction.

VERT. CENT.: Rotary knob control which moves the cathode-ray-tube trace vertically in either direction.

HORIZ. GAIN: Rotary knob control which controls the amplitude of the sweep voltage applied to the horizontal deflection plates, thereby controlling the width of the screen presentation.

VERT. GAIN: Rotary knob control which determines the degree of amplification of the input signal, thereby controlling the height of the screen presentation.

PHASING: Rotary knob control, by means of which the forward and return sweep traces on the face of the oscilloscope tube are made to coincide. This adjustment must be made every time the SWEEP WIDTH control is changed.

BLANKING: Rotary switch and potentiometer which controls the application and phase of 60-cycle voltage to the blanking circuit. In the OFF position (normal operation) a double trace appears on the scope. These traces should *always* be adjusted to coincide by means of the PHASING control before the blanking is applied. To provide a base line, the BLANKING control is rotated until it snaps on. The potentiometer is then adjusted until a single trace and reference line exists on the scope. This line may be either above or below the curve, depending upon the polarity of the signal.

## R-F (MARKER) GENERATOR

MARKER FREQUENCY: Rotary knob control which determines the frequency of the marker oscillator.

MARKER BAND SW.: Rotary wafer switch which selects one of three ranges: Band A, B, or C.

## FM (MASTER OSC.) GENERATOR

MASTER OSC. APPROXIMATE CENTER FREQ.: Rotary knob control which determines the center frequency of the FM oscillator.

MASTER OSC. BAND SWITCH: Rotary wafer switch which selects one of two ranges (A or B), and in the OFF position, removes plate voltage from all the FM-generator tubes, and removes sweep voltage from the modulator unit.

SWEEP WIDTH: Rotary knob control which, when varied from 0 to 10, increases the sweep deviation from 200 kc. to a maximum of 15 mc. Any readjustment of this control must be followed by readjustment of the PHASING control, to bring the scope traces in to coincidence. This must, of course, be done with the BLANKING control at the OFF position.

## COMMON CONTROLS

FUNCTION ATTEN.: Rotary knob control which, when varied from 0 to 10, increases the output of the r-f generator, the AM RF output, or the audio generator from minimum to full output as determined by the settings of the OUTPUT MULTIPLIER control and the FUNCTION switch.

OUTPUT MULTIPLIER: Rotary wafer switch, decade multiplier. In position 1, minimum output is obtained, the setting advances in steps of ten until, at MAX position, full output is obtained. A constant output impedance of 75 ohms is maintained for all positions. Note that the output of the r-f generator, the AM RF output, or the audio generator, for any setting of the OUTPUT MULTIPLIER switch, is determined by the FUNCTION ATTEN. control; likewise, the output of the FM Generator for any setting of the OUTPUT MULTIPLIER switch is determined by the MASTER OSC. ATTEN. control.

FUNCTION: Rotary wafer switch which determines the type of output signal, as outlined below:

OFF position: The r-f (marker) generator, the crystal calibrator, and the audio generator are inoperative, while the FM generator and oscilloscope may be used.

MKR position: The crystal calibrator and the audio generator are inoperative, while the r-f (marker) generator can be used to furnish an unmodulated r-f signal which may be used as a marker pip. If the MASTER OSC. BAND SWITCH is placed in OFF position, the FM generator is made inoperative, and an unmodulated CW signal can be obtained from the OUTPUT terminal.

CAL position: The audio generator and the FM generator are made inoperative, and the oscilloscope is disconnected from the INPUT terminal and connected directly to a crystal diode; the diode rectifies the beat signal from the r-f (marker) generator and the crystal calibrator, thus furnishing a beat pattern every 5 mc. and at other calculable frequencies, for calibration purposes.

### NOTE

If the beat, as seen in the scope is weak, the scope gain should be increased. After zero beat is obtained, the scope gain may be returned to normal, and the FUNCTION switch turned to the MKR position.

AM RF position: All circuits except crystal oscillator operate; a 400-cycle modulated r-f signal can be obtained at the OUTPUT terminal if the FM generator is made inoperative by setting the MASTER OSC. BAND SWITCH to OFF.

400∼position: Only the audio generator and oscilloscope are operative.

### NOTE

The oscilloscope may be used externally in every position except CAL, and the separate output of unmodulated r.f., FM r.f., modulated (AM) r.f., or 400-cycle audio frequency may be obtained, if desired, by the proper setting of the FUNCTION switch and the MASTER OSC. BAND SWITCH, together with the FUNCTION ATTEN. and MASTER OSC. ATTEN. controls.

POWER: Rotary single-pole, single-throw switch; turns main power ON or OFF.

## CIRCUIT DESCRIPTION

The Philco Precision Visual Alignment Generator for Television and FM, Model 7008, consists functionally of an FM (master osc.) generator with a variable sweep width, an r-f (marker) generator (unmodulated r-f oscillator), a crystal oscillator for calibration purposes, an AM r-f generator, an audio generator, an oscilloscope with a sine-wave sweep and a special blanking circuit, and a common power supply. These functional units are discussed separately.

## FM (MASTER OSC.) GENERATOR

The FM generator employs a 6AK5 master oscillator operating at 144—260 mc., a 6C4 fixed oscillator operating at 140 mc., and a 6AK5 mixer, together with a special FM Modulator-and-Tuner assembly which produces a sweep that is variable up to a maximum of 15-mc. total deviation. See schematic, figure 57. The output frequency is variable continuously over two ranges, Band A, from 4 to 120 mc., and Band B, from 144 to 260 mc. The frequency range available on Band A is obtained by beating together the outputs of the master oscillator and the fixed oscillator. Therefore, on this band, the generator output is composed of four major components: the master-oscillator frequency, the fixed-oscillator frequency, and the sum and difference frequencies. In order to obtain a low-frequency range with a minimum of harmonically related beat frequencies, the difference frequency is used; while the other three frequencies exist in the output of the generator, they are not accepted by the tuned circuit under test. On Band B, the master oscillator operates alone, supplying fundamental frequencies to the mixer. Since the beat method is used for the low-frequency range, and the master-oscillator direct output for the high-frequency range, the high-frequency output is approximately five times that of the low-frequency output; this compensates for the lower receiver gain at high frequencies (a characteristic of present-day receivers). The mixer is inductively coupled to the fixed oscillator, and capacitively coupled to the master oscillator; the output is controlled by the MASTER OSC. ATTEN., which varies the mixer plate voltage from approximately 0 to 120 volts. The mixer output is fed into a decade multiplier-attenuator, which provides a constant output impedance of 75 ohms at all times.

The FM Modulator-and-Tuner assembly consists essentially of two parts, the tuner assembly and the FM modulator. The tuner assembly consists of a one-turn, silver-plated-ring coil, whose inductance is varied by a sliding contact, and whose low-frequency limit is determined by a shunt trimmer condenser; the condenser and coil comprise the tank circuit for the master oscillator. The FM modulator assembly consists of a special condenser connected in shunt across the tuner-assembly tank circuit; this condenser is made to vibrate at line frequency. The sweep width is determined by the amount of capacitance variation, the unit being designed to operate with a 15-mc. maximum sweep width at a travel of less than 5/32". The special condenser has a set of concentric plates connected to the tuner assembly; these plates mesh with another set of concentric plates which are secured to a coil form upon which a coil is wound. The coil form fits over a cylindrical permanent-magnet pole piece, and is supported by two flexible diaphragms, similar to the voice-coil arrangement in a loudspeaker. A maximum of approximately 2 volts, a.c., is applied to the coil, causing it to vibrate, and making the condenser vary sinusoidally in value at the line frequency. The amplitude of the voltage applied to the coil is determined by the SWEEP WIDTH control on the front panel, the maximum being determined by the DEVIATION LIMITER control inside the unit. Resistors R529 and R530 are employed as voltage dividers, to stabilize sweep-width operation. In later units, R530 is not used, and the supply voltage is changed to 3.2 volts, taken from a tap on the transformer. This control is adjusted for a maximum deviation of 15 mc. with the SWEEP WIDTH control set to maximum (position 10). Load compensating resistors are automatically switched into circuit, when the FM (master osc.) generator is turned off, by setting the FUNCTION switch to the CAL or 400-cycle positions, or when the MASTER OSC. BAND SWITCH is in OFF position, thereby maintaining a practically constant load on the power supply, to insure good regulation.

## R-F (MARKER) GENERATOR

The r-f (marker) generator consists of a 6C4 r-f oscillator, a 6J6 crystal oscillator-cathode follower, and a 1N34 crystal detector. The r-f oscillator covers a frequency range of 3.2 to 250 mc. in three bands, using both fundamental and second-harmonic outputs. A unique method of obtaining maximum output with a minimum of effect from switch-contact resistance on the high-frequency band (Band C) is achieved by using a modified Colpitts circuit, and by permanently connecting the coil (a 5.187" piece of copper wire) across the tuning condenser and to the grid of the r-f oscillator tube. On the lower frequency bands (Bands A and B), a Hartley circuit is employed, and is unaffected by the presence of the high-frequency tank in the grid circuit. Trimmers are provided for adjusting the dial calibration.

The grid of the r-f oscillator tube is capacitively coupled to the grid of the cathode-follower section of the 6J6 tube. The other section of the 6J6 tube is used as a conventional crystal oscillator employing a fixed-tuned plate circuit, and operating at a fundamental frequency of 5 mc., with an accuracy of ±.005%. Thus, any harmonically related frequency or combination thereof can be used for zero beating with the output of the marker generator, providing an accuracy of .005%. The outputs of the crystal oscillator and marker generator are combined through the common cathode resistor of the cathode-follower and crystal-oscillator tube. A 1N34 crystal diode is used to rectify the beat signal of the marker generator and crystal oscillator, in the CAL position of the FUNCTION switch, and to supply this beat signal through a contact on the FUNCTION switch to the vertical amplifier, so that the beat signal can be observed on the oscilloscope. In other positions of the FUNCTION switch, the crystal-oscillator plate voltage is removed, and the oscilloscope input is connected to INPUT jack J300 so that the oscilloscope can be used externally.

The output of the marker generator is controlled by the FUNCTION ATTEN. control, a dual potentiometer arranged to provide complete, smooth control of output, down to a very low value. This output is also subject to the setting of the OUTPUT MULTIPLIER control, so that from positions 1 to 1000, the output is increased in multiples of ten, and in MAX position, the maximum output of the marker generator is available, the output level for each step being under the control of the FUNCTION ATTEN. control. Thus, the FM (master osc.) generator and the r-f (marker) generator outputs are individually controllable, and the ratio of one to the other can be adjusted as desired.

Load-compensating resistors are also employed, so that, whether or not the marker generator and the crystal oscillator are operating, the same load is presented to the power supply.

## AUDIO GENERATOR

A 6C4 triode is connected as an audio oscillator, using a tapped audio transformer to supply grid-plate feedback. Circuit constants are such that the audio frequency is fixed at 400 cycles, $\pm 10\%$. The audio output is taken from a tap on the plate winding of the transformer; the output is applied through a .02-mf. condenser to the FUNCTION ATTEN. control in the 400~position of the FUNCTION switch (for separate audio output), and is applied directly to the plate of the cathode follower in the AM RF position of the FUNCTION switch (to modulate the output of the r-f (marker) generator). Although plate voltage is applied to the audio oscillator at all times, the grid of the tube is grounded in the first three positions of the FUNCTION switch, so that it can only oscillate in the AM RF and the 400~positions.

## OSCILLOSCOPE

The oscilloscope portion of this equipment employs two 7F7 tubes as vertical amplifiers, and a three-inch cathode-ray tube, type 3MP1 (electrostatic deflection), supplied with a sine-wave horizontal sweep and a phasing network. The input circuit consists of a .5-mf. condenser and 500,000-ohm VERT. GAIN control, using one half of a 7F7 as a resistance-coupled amplifier and the other half as a phase inverter, to supply push-pull inputs to the 7F7 output tube which supplies push-pull outputs to the vertical deflection plates of the c-r-tube. The output stage is capacitively coupled to the deflection plates; vertical centering voltage is applied through dual potentiometers (VERT. CENT. control).

Horizontal deflection voltage is applied through a separate phasing transformer and RC phasing network, supplying a 60-cycle sine-wave sweep. Horizontal centering voltages are also obtained through a dual-potentiometer arrangement (HORIZ. CENT. control) similar to the vertical centering arrangement. Clockwise rotation of the HORIZ. CENT. and VERT. CENT. controls causes the trace to move to the right, and upward, respectively. The HORIZ. GAIN control utilizes a dual potentiometer connected across the phasing transformer, so that the sweep voltage can be varied from approximately zero to 80 volts, thus expanding the horizontal trace at least four inches. The response of the vertical amplifiers is usable up to 100 kc., and the polarity is such that a positive input pulse will cause the trace to be deflected upward.

Since the vertical input varies at a 60-cycle rate, and the horizontal sweep also varies at the same rate, no distortion of the response curve occurs, and it appears (for a response curve only) exactly as if linear sweeps were used; the pattern is also more stable, and at least two controls are eliminated.

## BLANKING CIRCUIT

The blanking circuit establishes a reference base line on the cathode-ray-tube screen, together with the response curve of the unit under test. It can only be used with the FM (master osc.) generator. The base line is produced by periodically removing the swept signal applied to the output of the 7008 and allowing the horizontal sweep to trace a line across the screen during the absence of vertical deflection. This cycle of events occurs at a 60-cycle rate, and produces the optical illusion that the response curve and base line appear simultaneously.

A 60-cycle sine-wave voltage is applied to the grid of a 6C4 tube from the phasing transformer through a phase-shifting network consisting of a .02-mf. condenser and the 1-megohm BLANKING control. The flow of grid current through the 10-megohm grid-current-limiting resistor produces practically cutoff bias, so that no effect is obtained on the negative half-cycles; however, on the positive half-cycles, plate-current flow is increased, creating a negative-swinging gate in the plate circuit. This negative gate is applied through a .25-mf. condenser, through the ON-OFF switch attached to the BLANKING control, and through a filter and voltage-divider RC network, to the grid of the master-oscillator tube. When the negative gate appears at the grid of the master oscillator tube, it prevents the tube from operating. Thus, the trace on the oscilloscope collapses to a straight line during the gating period, and the alternate straight-line and response-curve presentations are combined, appearing as a response curve with a reference base line on the c-r-tube screen.

## POWER SUPPLY

The power supply contains two half-wave, high-voltage rectifiers and a full-wave, low-voltage rectifier. One 6X4 operating as a half-wave rectifier supplies a positive 400-volt output, and the other 6X4 supplies a negative 400-volt output. Capacitance-resistance filters are used, because of the low current drain, and appropriate voltage dividers are employed to supply the proper voltages for the c-r tube. The FOCUS and INTENSITY controls form a portion of a voltage divider across the –400-volt supply, while the HORIZ. CENT. and VERT. CENT. controls comprise a voltage-divider arrangement across the +400-volt supply. The low-voltage supply utilizes a 5Z4 full-wave rectifier with choke-input, supplying approximately 260 volts at high current for all circuits other than the c-r tube, and one 7F7.

The use of load-compensating resistors throughout the instrument (together with a choke-input filter) places a practically constant load on the low-voltage power supply, thus insuring good regulation, and providing exceptional operating stability.

# THEORY OF VISUAL ALIGNMENT

The use of sweep generator, together with an oscilloscope, to produce a visual response curve, and the various techniques for making visual alignments and checks, are used often in the engineering laboratories. The average serviceman, however, may not be too familiar with the proper techniques; the following paragraphs, therefore, will explain how the visual response curve is obtained in Model 7008, and will point out some precautions that should be observed for the most effective use of this instrument.

## HOW THE RESPONSE CURVE IS DEVELOPED

It is apparent that a graph of an amplifier response curve can be obtained by plotting frequency horizontally from left to right, and response amplitude vertically, if a sufficient number of points are determined. See figure 1A. However, it is easily seen that such a method of obtaining a response curve is laborious and time consuming; with such a method, alignment for a specified wave shape would be a long, drawn-out process.

Model 7008 produces the visual response curve by applying an FM signal to the circuit being checked and by employing an oscilloscope as an output indicator; the FM signal varies sinusoidally in frequency, at a 60-cycle rate, about a center frequency. The amount of frequency variation (deviation) about the center frequency is determined by the SWEEP WIDTH control. For a total deviation of 6 mc., the frequency varies above and below the center frequency by 3 mc. When this changing frequency is applied to the circuit under test, the instantaneous output amplitude is always proportional to the response of the circuit to the frequency at that instant. Thus, the original frequency-modulated input signal is changed in passing through the amplifier, so that the output signal from the amplifier now consists of an FM signal which is also amplitude modulated. See figure 1B. Since, for equal deviations, the positive and negative portions of this envelope are symmetrical, we need only observe one side of the envelope. Since the signal is also varying at an r-f rate, it cannot be seen on the oscilloscope without first being detected. The composite signal is therefore detected by either the second detector or discriminator of the receiver, or, in special instances, by the high-frequency probe. After detection, only the modulation remains, and this appears on the oscilloscope in the form of the response curve of the amplifier. Since the FM signal is swept at a 60-cycle rate, the presentation appears as a continuous curve, due to the persistence of vision. Note that the detector polarity determines whether a positive or negative output occurs, so that the response curve will appear inverted if the output is of negative polarity. However, the response curve may be used in whichever position it appears at the output of the detector.

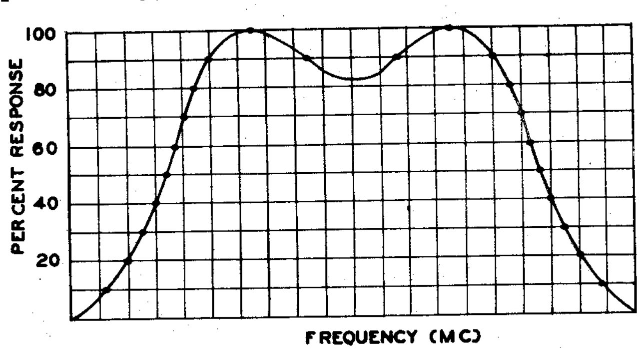


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**Figure 1A — Point-Plotted Response Curve**

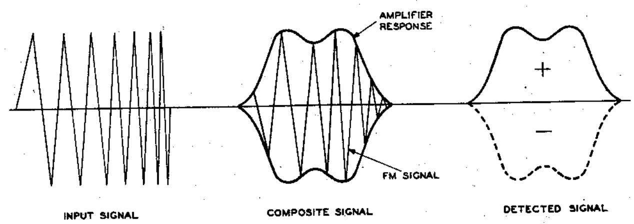


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**Figure 1B — Composite Wave Form, Showing Final Result**

Since a 60-cycle voltage is available from the power mains, the FM generator is swept at this frequency because this permits the use of the 60-cycle voltage for horizontal deflection of the oscilloscope, thus providing an inexpensive sweep. Since both the FM output of Model 7008 and the horizontal-sweep voltage are varying sinusoidally at the same rate, the presentation appears as though a linear sweep were used.

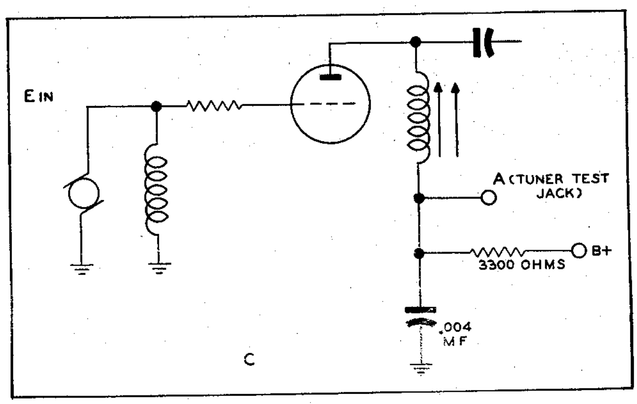


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**Figure 1C — Decoupling Network**

## HOW TO DETERMINE THE CORRECT DEVIATION

It is important to remember that a response curve can be more easily checked when it covers a large portion, rather than a small portion, of the oscilloscope screen, so the SWEEP WIDTH control should be operated at a position which produces only enough deviation to accommodate the band pass of the circuit being checked. It is poor practice to operate Model 7008 at maximum deviation at all times, or to use a sweep width much greater than required, except for some special objective. As a general rule, FM circuits should be operated with about 1-mc. deviation, TV i-f circuits with about 10-mc. deviation, and TV r-f circuits with full deviation.

## USE OF THE HIGH-FREQUENCY PROBE

Two sets of oscilloscope input leads are supplied with Model 7008. One set consists of a plain pair of shielded leads which are used for nearly all checks, and is referred to throughout the text as the low-frequency probe, or the scope input leads. The other set contains a crystal detector and r-f filter, and is referred to as the high-frequency-probe. The oscilloscope input circuits contain a blocking condenser, as does the high-frequency-probe, so that it is not necessary to use an isolating condenser with either of these leads. Note particularly, however, that the output cable of Model 7008 provides a 75-ohm d-c path to ground. It is, therefore, important to use a blocking condenser in the output lead for some applications.

It is not recommended that the high-frequency probe be used to determine the absolute response of i-f or r-f circuits, but only to visually determine the continuity of these stages. While the input capacitance of the high-frequency probe is as low as is practical, it must be noted that, at the i.f. used for Television receivers, even a capacitance of 1 mmf. can seriously detune the circuit. Thus, any shunting effects of leads, etc., may cause a noticeable change in the response curve.

Another use for the high-frequency probe for other than stage-by-stage continuity checks is for adjusting the 4.5-mc. video trap. In this instance, it is merely used to "strip off" the modulation, so that it can appear on the scope.

## USE OF DECOUPLING NETWORKS

The necessity for a high-frequency probe can be eliminated by the use of a decoupling network. See figure 1C. The decoupling network by-passes the r.f., and at point A we have the response-curve modulation component riding on the $B^+$ voltage, so that the scope input leads can be used to obtain the presentation. An unfortunate effect is that, since the signal is riding on $B^+$, if the receiver power-supply regulation is poor, the presentation will fluctuate upward and downward on the scope screen as the voltage varies with line-voltage changes; however, the accuracy of the response curve will not be affected.

## USE OF MARKER PIP

While the response curve shows the frequency discrimination of the circuit under test, some means of determining the actual frequency at any definite point along the curve is necessary. This could be accomplished, is some instances, by use of an absortion-type wave trap, which causes a reduction of amplitude at the point of resonance, placing a notch in the curve. In Model 7008, however, a separate marker generator is used to furnish a CW signal, which is combined with the FM sweep output signal. At the point on the response curve corresponding to the frequency to which the marker generator is tuned, a pip is produced which is the result of the beat between the marker generator and the sweeping generator at that frequency. It must be noted that the pip, if too strong in amplitude, has a tendency to change the response curve somewhat; therefore, it is recommended that the output of the marker generator be kept as low as possible at all times.

## HOW TO OPERATE MODEL 7008

In general, the following sequence of operations and procedures is recommended for obtaining the best possible performance from the instrument. However, after the user has become familiar with the operation of the controls and the use of the instrument, he will probably adopt methods and procedure of his own.

## PRELIMINARY ADJUSTMENTS

1. Insert the line cord into the a-c receptacle in the side of the unit, and plug into the nearest 110-volt, 60-cycle service receptacle.
2. Pull out, or remove the light shield, as desired, and swing the c-r tube into the operating position.
3. Turn the POWER switch to the ON position, and allow the unit to warm up for about 15 minutes before attempting any precise alignments.
4. Adjust the INTENSITY control until the c-r-tube beam becomes visible, setting the HORIZ. CENT. and VERT. CENT. controls so that the spot (or line) is centered on the screen.
5. Set the HORIZ. GAIN control so that the trace line covers about twenty crosshatch divisions, and adjust the FOCUS control for a sharp, clear sweep line, setting the INTENSITY control for the desired brilliance.
6. Set the VERT. GAIN control midway between positions 1 and 2, and touch the center conductor of the INPUT jack. Observe that an elliptical pattern appears on the screen, and adjust the PHASING control until the sides of the ellipse coincide to form a single trace line; this pattern indicates that the oscilloscope portion of the equipment is functioning properly.
7. Set the FUNCTION switch to CAL, and vary the MARKER FREQUENCY control over its entire range on Bands A, B and C, noting that a beat pattern is observed every 5 mc. and at other harmonically related frequencies of the r-f and crystal oscillators.
8. Connect the high-frequency probe to the INPUT jack, connect the output-cable plug (P500) to the OUTPUT jack, and connect output and input terminals together. Set the FUNCTION ATTEN. control to 10, and the OUTPUT MULTIPLIER to MAX.
9. Set the MASTER OSC. BAND SWITCH first to position A, then to position B. Set the FUNCTION switch to the MKR position, the MASTER OSC. ATTEN. control to position 10, and the SWEEP WIDTH control to 0. Adjust the MARKER FREQUENCY control to a frequency which corresponds to the frequency indicated by the MASTER OSC. APPROXIMATE CENTER FREQ. control, and observe that a beat pattern similar to figure 49 appears on the screen.
10. Turn the MASTER OSC. BAND SWITCH to OFF. Set the FUNCTION switch to AM RF, then 400~position, noting that a Lissajou figure (similar to figure 8) appears in each position.

### NOTE

Steps 7 through 10 of the above procedure are included as an operational check to determine for the first time, or after a period of disuse, whether all circuits are functioning properly. Steps 1 through 6, however, are always necessary, in order to set up the oscilloscope for proper operation.

## OBTAINING A RESPONSE CURVE

Connect the output-cable binding posts to the stage ahead of that for which the response curve is desired. See figure 2.

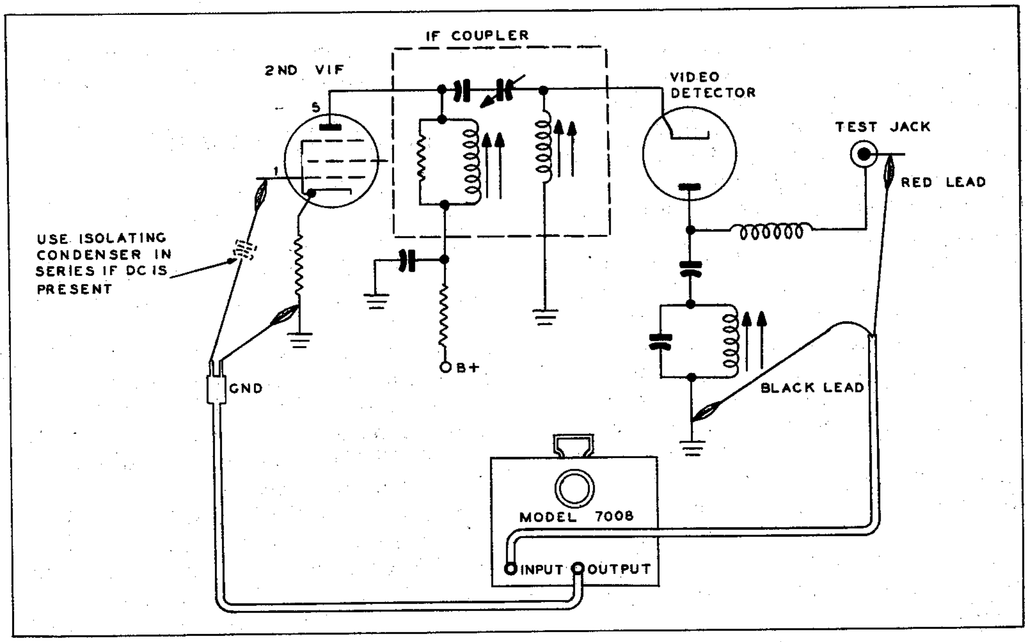


**Figure 2. — Input and Output Connections** TP-6929

## CAUTION

If connecting to a d-c bus, be sure to use an isolating condenser of at least .01 mf. in series with the output lead, otherwise a d-c path of 75 ohms to ground will exist.

Connect the INPUT jack through the scope input cable to the r-f test jack or to the second detector of the receiver being checked.

With the oscilloscope controls set as in the preceding paragraph, proceed as follows:

1. Set the MASTER OSC. BAND SWITCH to A or B, as required.
2. Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to the approximate center frequency of the amplifier under test. Set the FUNCTION switch to OFF or MKR, as desired.
3. Set the OUTPUT MULTIPLIER control to MAX., and the MASTER OSC. ATTEN. control to 10.
4. With the SWEEP WIDTH control at position 6, adjust the MASTER OSC. ATTEN. control until the vertical amplitude of the screen presentation covers 10 crosshatch marks (1 inch height). (When using the blanking circuit, if it is desired to use a larger pattern, adjust the HORIZ. CENT control until the bottom of the pattern is shifted a sufficient amount toward the bottom of the screen to provide for the desired height.) If the pattern is not of the desired vertical amplitude, it is necessary to either reduce the input to the receiver or reduce the oscilloscope vertical-amplifier gain. It is recommended that the oscilloscope gain be kept below 2 when possible, and that the output of Model 7008 be adjusted to give the desired height of screen presentation.
5. Adjust the SWEEP WIDTH control for a pattern which covers about twenty cross-hatch divisions horizontally, or as desired. Vary the PHASING control until only a single image is obtained.
6. Turn the BLANKING control clockwise until the switch clicks, and continue to rotate the control until a reference base line appears along the full width of the c-r-tube pattern. Adjustment of the BLANKING control should always be preceded by the PHASING adjustment.

## NOTE

It is not necessary to always use the blanking circuit, particularly if the response curve is of one polarity. It is, however, extremely valuable to have a reference line appear, especially where the response curve has both a positive and negative component (for example, a discriminator response curve), and also where the response curve is so broad that the skirts do not reach zero level within the sweep limits of the FM generator.

7. Adjust the MASTER OSC. ATTEN. control when aligning stage-by-stage to keep the pattern covering the same screen area, or to prevent it from going off the screen.

## OBTAINING A "MARKER" SIGNAL

The marker signal consists of an unmodulated r-f (CW) signal which is super-imposed on the FM (master oscillator) output signal, to furnish a "marker pip" at the point on the response curve corresponding to the frequency of the marker signal. With the controls set as directed in OBTAINING A RESPONSE CURVE, proceed as follows:

1. Set the FUNCTION switch to the MKR position.
2. Set the MARKER FREQUENCY control to the desired marker frequency, and the MARKER BAND SW. for the desired frequency band, as indicated by the letter at the end of the scale on which the desired frequency appears.
3. Adjust the FUNCTION ATTEN. control until a marker pip appears on the response curve. Should the marker pip appear too small, even with the FUNC-

TION ATTEN. control at maximum (position 10), increase the VERT. GAIN control setting and, since the response curve will increase in amplitude, adjust the MASTER OSC. ATTEN. control to bring the screen presentation back to its original size.

To make the "marker pip" as small as possible with respect to the presentation, the FUNCTION ATTEN. control should be set at minimum (position 0), the MASTER OSC. ATTEN. control set at maximum (position 10), and the over-all attenuation accomplished with the OUTPUT MULTIPLIER. Should the "marker pip" still appear too large, even with the FUNCTION ATTEN. control set at minimum (position 0), it may be desirable to use a lower frequency, of which the desired marker frequency is a harmonic and which will cause the marker to be considerably smaller. For example, if the marker on B band at 24.0 mc. is too large, turn the MARKER BAND SW. to A band and tune to 6.0 mc., whose fourth harmonic is the desired 24.0 mc. and which will give a comparatively diminished marker at that frequency.

An unmodulated r-f signal output can be obtained for external use, if the FM output is removed by turning the MASTER OSC. BAND SWITCH to OFF. In this special case, the output amplitude is determined by the setting of the FUNCTION ATTEN. and the OUTPUT MULTIPLIER controls.

## OBTAINING A MODULATED R-F OUTPUT SIGNAL

The r-f (marker) generator portion of this equipment can be used separately as a signal generator with 400-cycle modulation by setting the controls as follows:

1. Set the MASTER OSC. BAND SWITCH to OFF.
2. Set the FUNCTION switch to AM RF.
3. Set the MARKER FREQUENCY control to the desired frequency, with the MARKER BAND SW. set for the proper frequency band, as indicated by the letter at the end of the scale on which the desired frequency appears.
4. Adjust the output amplitude by using the FUNCTION ATTEN. and OUTPUT MULTIPLIER controls.

### NOTE

Connect the output cable to the unit under test, making certain to connect the post marked "GND" to chassis or ground, and the other post to the circuit under test through an isolating condenser, otherwise a d-c path of 75 ohms to ground will exist.

## OBTAINING A 400-CYCLE AUDIO OUTPUT SIGNAL

The Audio Generator of this instrument can be used separately to furnish a 400-cycle audio output signal by setting the controls as follows:

1. Set the FUNCTION switch to 400~.
2. Adjust the FUNCTION ATTEN. and OUTPUT MULTIPLIER controls for the desired output amplitude.

## HOW TO CHECK CALIBRATION

The crystal calibrator function of this instrument is provided to furnish a means of checking the direct-reading frequency dials, so that changes in calibration due to aging or other factors will not affect its use as a precision instrument, and for securing accurate marking points when interpolating to obtain a precise frequency setting. A 5-mc. crystal-calibrator signal is available for all ranges, and the beat between its harmonics and the marker-generator fundamental and harmonics is visible on the oscilloscope, so that the marker generator can be set to an exact zero beat; proceed as follows:

1. Set the FUNCTION switch to CAL.
2. Set the MARKER BAND SW. to the desired range, and vary the MARKER FREQUENCY control while observing the pattern on the oscilloscope.

At every 5-mc. point, a beat pattern will be observed. The pattern will vary from a Lissajou pattern, containing a great number of cycles, to a pattern of only a few cycles, and finally to zero beat, then back again to a great number of cycles, dropping off to a straight line between the 5-mc. points. The straight line observed between the 5-mc. points will be quite stable, whereas the line observed at the exact zero beat will be unstable and critical in adjustment. Since, for the high frequencies, a greater frequency change occurs for a given movement of the MARKER FREQUENCY control, adjustment to zero beat will appear more critical on the higher frequency ranges than on the lower frequency ranges.

It will be noted that beat patterns can also be obtained at points other than the 5-mc. harmonic frequencies (due to oscillator harmonic content). However, the 5-mc. beat points are easily determined, because their amplitudes are usually much greater. If, for example, a beat pattern should be observed somewhere between 15 and 20 mc., the amplitude of this pattern would be much lower than the patterns obtained at exactly 15 and 20 mc. (It is usually necessary to advance the setting of the VERT. GAIN control to observe most of the in-between harmonics). The existence of these in-between harmonic beat patterns increases the number of precise check points available to the user, provided that he exercises care in calculating the exact frequency. Since, in some cases, it requires considerable ingenuity to determine the actual frequencies of these harmonics, it is suggested that reliance be placed on the 5-mc. harmonically related points, and that direct dial calibration be used between the accurately determined 5-mc points. If necessary, frequency setting between dial markings can be determined, by interpolation. An example of interpolation is given in the paragraph following the use of the vernier scale.

## HOW TO USE THE VERNIER SCALE

The vernier scale is to be used for logging, so that the generator may be reset exactly to a specific frequency, and to determine the amount of pointer movement for use in interpolation when setting the generator to an exact frequency.

The vernier scale consists of two parts, a fixed logging scale, and a moving pointer vernier scale. The logging scale is divided into 200 equally spaced divisions, numbered from 0 to 20, in groups of ten. The pointer-vernier scale is constructed so that it will divide any one of the 200 equally spaced divisions into ten equal parts; thus the logging scale can be read to one part of 2000.

When determining the vernier-scale setting, always use the pointer-vernier index mark (the extreme left-hand pointer-vernier scale mark with a dot at the bottom) for determining the whole number of logging-scale divisions marked in blue on the dial. The remaining 10 pointer-vernier-scale divisions are then used to determine settings to a fractional part of the logging-scale division. Never use the central pointer index line with the vernier scale; it is to be used only when setting the dial to the directly calibrated points marked in red on the dial.

Assuming the pointer to be set as shown in figure 3, the vernier scale reading may be determined as follows:

1. Determine the number on the blue logging scale which lies immediately to the left of the pointer vernier-index mark; in the example shown, it is 3. Since this number indicates three groups of ten divisions, add a zero, making the logging scale value 30.

2. Count the number of logging-scale divisions to the right of the numeral 3, stopping at the pointer vernier-index mark. In the example shown, there are 7 divisions between the number 3 and the pointer vernier-index mark. Add this number to the logging-scale numeral previously determined, to complete the whole number portion of the logging-scale setting. In this example, 30 plus 7 equals 37.

3. Determine the fractional part of the logging number by counting the number of pointer-vernier-scale divisions to the right of the vernier-index mark, stopping when a pointer-vernier-scale division is reached which coincides with a division on the logging-scale. In the example given, both the pointer vernier-index mark and the last pointer-vernier-scale division coincide with a logging-scale division, indicating zero. Place a decimal point after the logging-scale number previously determined, and add the new figure. In the example, 37. plus 0 equals 37.0, the final logging-scale number.

Note that, in the above example, both the vernier-index mark and the 10th pointer-vernier-scale divisions coincide with a logging-scale division, and that they are exactly nine logging-scale divisions apart. Only in the case where the pointer vernier-index mark is set exactly to a logging-scale division does the preceding condition hold true. For all other cases, the pointer vernier-index mark never coincides with a logging-scale division, but one, and only one, of the pointer-vernier-scale divisions does. To illustrate this statement, refer to figure 4. In this example, it is evident that, following the above procedure, the whole-number portion of the logging numeral is again 37. The pointer vernier-index mark now does not coincide with any logging-scale division, but the first pointer-vernier-scale mark does; thus the complete logging number is 37.1.

If the pointer shown in figure 4 were progressively rotated until the second, third, fourth, and so on up to the 10th pointer-vernier-scale divisions coincided with a logging-scale division, the logging numbers would be 37.2, 37.3, 37.4, etc. When the 10th pointer-vernier-scale division coincided with a logging-scale division, it would be observed that the pointer vernier-index mark also coincided with 38, and the logging number would be exactly 38.0.

## HOW TO SET THE R-F (MARKER) GENERATOR TO AN EXACT FREQUENCY

Model 7008 marker-frequency dial is directly calibrated in megacycles, and is accurate to 1%. In addition, the crystal calibrator provides 5-mc check points which can be used for quick checks of dial calibration, and for spotting, exactly, any multiple of the crystal frequency. To determine as closely as possible the pointer setting which corresponds to a frequency located between two 5-mc. points, or the setting for specific frequency, it is necessary to use the vernier scale and to calculate by interpolating the correct vernier-scale setting (logging number).

Assume that it is desired to set the generator to 22.1 mc. (a sound i.f. used in television alignment) with crystal accuracy. First, determine the crystal calibrator frequencies closest to 22.1 mc., which in this example are 21.67 and 22.50 mc.; set the FUNCTION switch to the CAL postion, and the VERT. GAIN control to

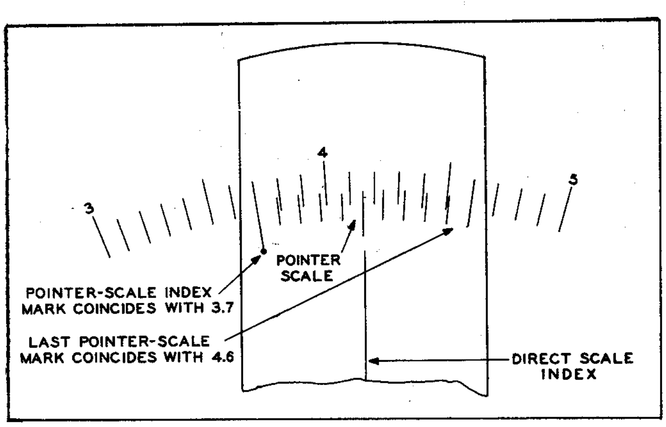


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**Figure 3. — Reading the Vernier Scale, Example 1**

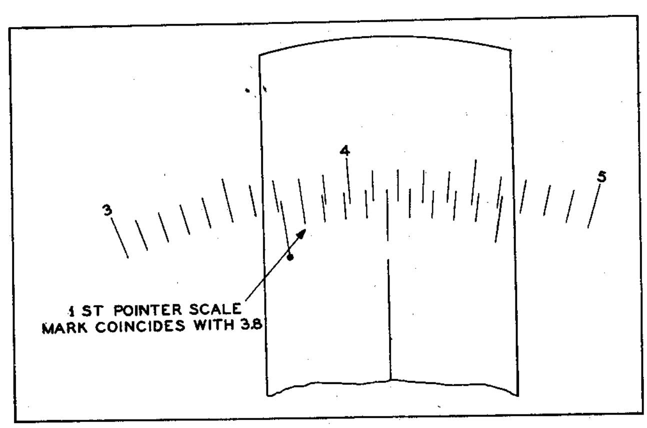


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**Figure 4. — Reading the Vernier Scale, Example 2**

position 2. Adjust the MARKER FREQUENCY control slightly about the 21.67-mc. calibration mark and watch the oscilloscope for a beat pattern, setting the control to zero beat. Read the logging number on the vernier-scale, say 89.9; then, in a similar manner, determine the vernier-scale setting for 22.5 mc., say 95.6. The difference between these logging numbers is 5.7, and represents a frequency change of .83 mc. The desired frequency is 22.10 mc., and is greater than 21.67 mc. by .43 mc. Therefore, assuming a linear frequency change between the 21.67 and 22.50-mc. points, it is evident that .43 is to .83 as the unknown number of divisions (x) is to 5.7, which, when calculated, gives the scale divisions we must add to the logging number found for the 21.67-mc. check point to obtain the desired dial setting.

| Logging Number | Frequency | |
|---|---|---|
| 95.6 | 22.50 mc. | 22.10 desired frequency |
| 89.9 | 21.67 mc. | 21.67 lowest check freq. |
| —— | —— | —— |
| 5.7 scale difference | .83 mc. frequency difference | .43 mc. difference |

.43: .83 as x :5.7; by crossmultiplying, .83 x = 2.451; now divide by .83; then x = 3.0.

| Logging Number | |
|---|---|
| 89.9 | (21.67 mc.) |
| 3.0 | ( .43 mc.) |
| —— | —— |
| 92.9 | (22.10 mc.) |

The logging number for 22.1 mc., once determined, can then be used for future generator settings. Spot checks should be made from time to time to make certain that dial calibration has not changed, if extreme accuracy is required.

While the points at 21.67 and 22.50 mc. were chosen for easy explanation in the above example, it must be noted that greater accuracy in interpolation can be obtained by using 22.00 and 22.50 mc. To see the higher harmonic beat patterns on the oscilloscope, it will be necessary to increase the setting of the VERT. GAIN control, and care must be used in determining these frequencies, since the minor beats may be so close together as to cause possible error in identification.

If the required accuracy is not so extreme as to require interpolation, but it is desired that the frequency be known closer than 1%, use the crystal calibration check points to determine the error in marker-frequency scale calibration.

The correction for the calibration error can then be applied mentally in setting the marker-frequency dial to the required frequencies. For example, if it is noted that the 20.00-mc., 22.00-mc., or the 22.50-mc. check points occur at 20.10 mc., 22.10 mc., and 22.60 mc. on the MARKER FREQUENCY dial, it may be assumed that all frequencies in this range require correction of .10 mc. so that, for 22.10 mc., the pointer would be set at 22.20 on the dial. This method is quick, and still gives very good accuracy, since all the check points have the same accuracy (.005%) as the crystal itself.

It might also be pointed out that many of these check points fall very close to certain fixed frequencies which are used quite often in alignment work. For example, the video carrier falls at 26.6 mc. in the i.f. of Philco TV receivers, and a check point occurs at 26.67 mc. Therefore, if the FUNCTION switch is set to CAL position and the pointer is set slightly to the left of absolute zero beat for the 26.67 mc. check point, switching back to the MKR position will provide a marker at an accuracy better than .2% without much effort.

The three tables of crystal check points which follow also indicate the order of the harmonics causing them. It should be noted that those beats which involve the lowest orders of harmonics will be the strongest, and they are indicated by the bold-face type. Many other beat points, of course, occur within these ranges. However, to avoid confusion, only the stronger ones are included in the tables. If there is ever any doubt about the weaker beats, reference should be made to the crystal check points in bold-face type.

## A BAND CRYSTAL CHECK POINTS

| Fundamental Frequency (mc.) | 2nd Harmonic Frequency (mc.) | Marker Osc. Harmonic | Crystal Osc. Harmonic |
|---|---|---|---|
| **3.333** | **6.667** | 3 | 2 |
| 3.462 | 6.923 | 13 | 9 |
| 3.500 | 7.000 | 10 | 7 |
| 3.571 | 7.143 | 7 | 5 |
| 3.636 | 7.273 | 11 | 8 |
| **3.750** | **7.500** | 4 | 3 |
| 3.889 | 7.777 | 9 | 7 |
| **4.000** | **8.000** | 5 | 4 |
| 4.091 | 8.182 | 11 | 9 |
| **4.167** | **8.333** | 6 | 5 |
| 4.286 | 8.571 | 7 | 6 |
| 4.375 | 8.750 | 8 | 7 |
| 4.444 | 8.889 | 9 | 8 |
| 4.500 | 9.000 | 10 | 9 |
| 4.545 | 9.091 | 11 | 10 |
| **5.000** | **10.000** | 1 | 1 |
| 5.625 | 11.250 | 8 | 9 |
| 5.714 | 11.428 | 7 | 8 |
| 5.833 | 11.667 | 6 | 7 |
| 6.000 | 12.000 | 5 | 6 |
| **6.250** | **12.500** | 4 | 5 |
| 6.429 | 12.857 | 7 | 9 |
| **6.667** | **13.333** | 3 | 4 |
| 7.000 | 14.000 | 5 | 7 |
| 7.143 | 14.286 | 7 | 10 |
| **7.500** | **15.000** | 2 | 3 |

## B BAND CRYSTAL CHECK POINTS

| Fundamental Frequency (mc.) | 2nd Harmonic Frequency (mc.) | Marker Osc. Harmonic | Crystal Osc. Harmonic |
|---|---|---|---|
| **15.000** | **30.000** | 1 | 3 |
| 15.833 | 31.667 | 6 | 19 |
| 16.000 | 32.000 | 5 | 16 |
| **16.250** | **32.500** | 4 | 11 |
| **16.667** | **33.333** | 3 | 10 |
| 17.000 | 34.000 | 5 | 17 |
| **17.500** | **35.000** | 2 | 35 |
| 18.000 | 36.000 | 5 | 18 |
| **18.333** | **36.667** | 3 | 11 |

### B BAND CRYSTAL CHECK POINTS (Cont.)

| Fundamental Frequency (mc.) | 2nd Harmonic Frequency (mc.) | Marker Osc. Harmonic | Crystal Osc. Harmonic |
|---|---|---|---|
| 18.750 | 37.500 | 4 | 15 |
| 19.000 | 38.000 | 5 | 19 |
| **20.000** | **40.000** | 1 | 4 |
| 21.000 | 42.000 | 5 | 33 |
| 21.250 | 42.500 | 4 | 17 |
| **21.667** | **43.333** | 3 | 13 |
| 22.000 | 44.000 | 5 | 22 |
| **22.500** | **45.000** | 2 | 9 |
| 23.000 | 46.000 | 5 | 23 |
| **23.333** | **46.667** | 3 | 14 |
| 23.750 | 47.500 | 4 | 19 |
| 24.000 | 48.000 | 5 | 24 |
| **25.000** | **50.000** | 1 | 5 |
| 26.250 | 52.500 | 4 | 21 |
| 26.667 | 53.333 | 3 | 16 |
| **27.500** | **55.000** | 2 | 11 |
| 28.333 | 56.667 | 3 | 17 |
| 28.750 | 57.500 | 4 | 23 |
| **30.000** | **60.000** | 1 | 6 |
| 31.667 | 63.333 | 3 | 19 |
| **32.500** | **65.000** | 2 | 13 |
| 33.333 | 66.667 | 3 | 20 |
| **35.000** | **70.000** | 1 | 7 |

### C BAND CRYSTAL CHECK POINTS

| Fundamental Frequency (mc.) | 2nd Harmonic Frequency (mc.) | Marker Osc. Harmonic | Crystal Osc. Harmonic |
|---|---|---|---|
| **70.00** | **140.00** | 1 | 14 |
| 72.50 | 145.00 | 2 | 29 |
| **75.00** | **150.00** | 1 | 15 |
| 77.50 | 155.00 | 2 | 31 |
| **80.00** | **160.00** | 1 | 16 |
| 82.50 | 165.00 | 2 | 33 |
| **85.00** | **170.00** | 1 | 17 |
| 87.50 | 175.00 | 2 | 35 |
| **90.00** | **180.00** | 1 | 18 |
| 92.50 | 185.00 | 2 | 37 |
| **95.00** | **190.00** | 1 | 19 |
| 97.50 | 195.00 | 2 | 39 |
| **100.00** | **200.00** | 1 | 20 |
| 102.50 | 205.00 | 2 | 41 |
| **105.00** | **210.00** | 1 | 21 |
| 107.50 | 215.00 | 2 | 43 |
| **110.00** | **220.00** | 1 | 22 |
| 112.50 | 225.00 | 2 | 45 |
| **115.00** | **230.00** | 1 | 23 |
| 117.50 | 235.00 | 2 | 47 |
| **120.00** | **240.00** | 1 | 24 |
| 122.50 | 245.00 | 2 | 49 |
| **125.00** | **250.00** | 1 | 25 |

NOTE: To avoid possible confusion or error in Band C, it might be mentioned that other weak beats exist on either side of 72.50 or 145.00 mc., 77.50 or 155.00 mc., etc. These beats occur at 71.67 or 143.33 mc., 73.33 or 146.67 mc., 76.67 or 153.33, 78.33 or 156.67 mc., etc. They occur when the 3rd harmonic of the C Band oscillator beats with the 43rd, 44th, 45th, 46th, and up to the 77th harmonic of the 5-mc. crystal oscillator. However, they will, in general, be so weak that they will probably not be noticed except in a few instances.

## PRACTICAL APPLICATIONS

Model 7008 is a versatile instrument, capable of performing many functions. The list of suggested applications appearing in the front part of this manual will give the user an idea of the many uses for which it can be employed, and will be explained in detail in the following paragraph. Other applications will probably occur to the user; meanwhile, the following procedures are submitted as a guide to the effective use of the instrument.

In some of the following applications, the oscilloscope is used as an a-c voltmeter. When employed in this manner, the HORIZ. GAIN control is kept at zero, or just enough gain is used to provide a desirable indicating line. See figure 5. The indicating line will vary in height as the input signal varies in amplitude. Thus, for a given setting of the VERT. GAIN control, an input voltage can be found which will create a definite height of line, and a calibration chart listing the equivalent voltage for each vertical crosshatch line may be compiled. The usual calibrating procedure is to apply a 60-cycle voltage through a voltage divider to the oscilloscope input, and note the trace height while reading the r.m.s. input voltage on a voltmeter. A chart can be made for each setting of the VERT. GAIN control, or a single chart listing the voltage at each position of the control may be made, for quick checks where the response amplitude is to be kept between certain values of voltage. Because of the high sensitivity of the oscilloscope used in Model 7008, any setting of the VERT. GAIN control above position 2 will require a millivoltmeter for calibration. Since the output level at the video detector of Philco Television Receivers is designed for a two-volt, peak-to-peak amplitude, it is important that the oscilloscope be calibrated for at least this one value of voltage, to avoid overloading during alignment. To convert r.m.s. voltage values (voltmeter readings) to peak-to-peak values, multiply the meter reading by 2.83.

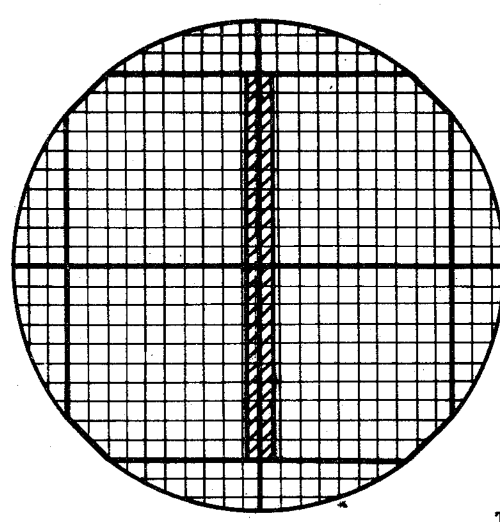

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**Figure 5.—Calibrating Oscilloscope (Horiz. Gain at 0)**

## NOTE

The following paragraphs contain many references to the oscilloscope of Model 7008. It is expected that the user will properly center, focus, and adjust the scope brilliance (intensity), and that the PHASING control will always be adjusted for each pattern. When the blanking circuit is also employed, the BLANKING control must be adjusted for each pattern. Occasional references to these controls are made to prevent possibility of error.

## DETERMINING CORRECT SETTING OF AGC CONTROL

Television receivers usually incorporate some form of automatic gain control (a.g.c.), to avoid overloading effects or undesirable changes in signal strength, so that, for signal inputs from a few microvolts to thousands of microvolts, the picture and sound remain substantially constant. Therefore, an a-g-c adjustment is usually required at the time of installation. In the Philco Television Receiver, the Automatic Level Control of Picture and Sound is adjusted for a 2-volt, peak-to-peak output from the video detector, while receiving the weakest local transmitting station.

Model 7008 should be used as an oscilloscope, with the input connected through the scope input cable from the output of the video detector (align test jack) to ground. Set the FUNCTION switch to the OFF position, set the VERT. GAIN control to the previously determined calibration point, and adjust the receiver a-g-c control for pattern height equivalent to the 2-volt, peak-to-peak signal. See figure 6.

Note that the video content of the pattern shown in figure 6 will change according to the program and test chart; however, the sync pulse and blanking pedestal will remain substantially the same for all stations, within limits fixed by the Federal Communications Commission. It will be necessary to adjust the PHASING control to obtain the same pattern as in the illustration; however, this control has no effect on the height of the pattern, so that for quick checks the phasing adjustment may be ignored.

## DETERMINING RELATIVE STRENGTH OF LOCAL TV STATIONS

Connect the oscilloscope input of Model 7008 through the scope input cable to the output of the video detector of a television receiver tuned to a local TV station. Disable the a-g-c system by removing the a-g-c tube. Note the height of the oscilloscope trace for each station, setting the VERT. GAIN control so that the strongest station covers at least 20 crosshatch marks. The relative height of each station pattern can be used for a comparison of signal strength at the particular receiving location for a particular aerial and for a particular orientation of the receiving aerial.

If the receiving aerial is rotated through 360 degrees while observing each station, it is easily possible to determine the optimum position for equal or satisfactory signal strength for all stations in a given locality.

## DETERMINING RELATIVE RECEIVER SENSITIVITY

Connect the output of Model 7008 to the aerial input circuit of a "standard" receiver, using an appropriate matching network if the input impedance of the receiver is other than 75 ohms. See figure 7. Disable the receiver a-g-c circuit by removing the a-g-c tube or grounding the a-g-c bus. Set the FM (master osc.) generator to the center of each television channel in turn, and the SWEEP WIDTH control for approximately 6-mc. deviation. Connect the input of Model 7008 to the video

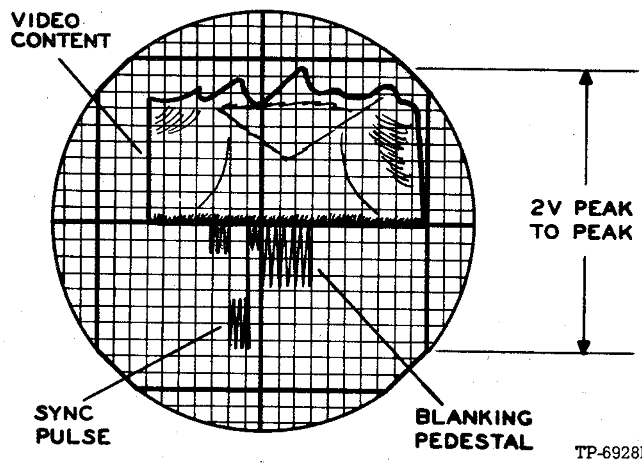


**Figure 6. — Typical Station Pattern at Video Detector**

detector output, through the scope input leads, and set the VERT. GAIN control for 2-volt peak-to-peak indication (adjust the PHASING control for a single image, and the BLANKING control for a single image with a base line), noting the position of the OUTPUT MULTIPLIER and MASTER OSC. ATTEN. controls for each channel.

Connect the receiver which is to be compared with the standard receiver to Model 7008 exactly as set forth for the standard receiver in the above paragraph. The change in the setting of the OUTPUT MULTIPLIER and MASTER OSC. ATTEN. controls necessary to produce the same output for each channel as compared with the standard receiver settings indicates the relative receiver over-all sensitivity.

While this sensitivity measurement is only a rough check, the serviceman can determine a loss in sensitivity which is not too apparent and which may not have been detected by the customer. After gaining experience by checking a number of sets, the serviceman will be able to adopt a standard of minimum sensitivity for each type of receiver, and avoid possible call-backs because of poor performance.

This check may also be performed by using a fixed output from Model 7008, and determining the video detector output voltage, using the oscilloscope portion as a voltmeter, provided that the check can be made without touching the VERT. GAIN control.

The above checks are also applicable to FM receivers, provided the amplitude of the discriminator response curve is checked instead of the video detector output, and that the sweep width is set for a total deviation of

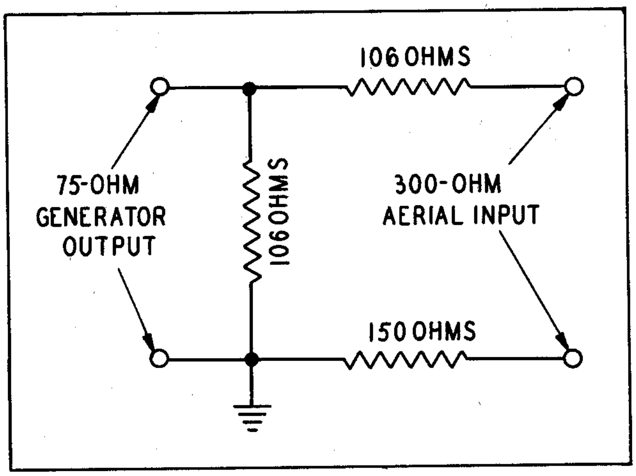


**Figure 7. — Aerial Matching Network**

no more than 200 kc. (be sure to ground the a-v-c bus). For the limiter-type FM receivers, the high-frequency probe can be used for the input cable, and should be connected to the plate of the i-f stage ahead of the limiter.

## DETERMINING APPROXIMATE STAGE GAIN (R.F., I.F., VIDEO, OR AUDIO)

Approximate stage gain can be checked in either a television or FM receiver by using the oscilloscope of Model 7008 as an output indicator, and selecting an arbitrary amplitude for reference, such as 10 crosshatch divisions. Connect the output of the discriminator (or second detector) to the oscilloscope input leads, and connect the output cable of Model 7008 to the grid of the stage ahead of the detector or discriminator. Set the OUTPUT MULTIPLIER and MASTER OSC. ATTEN. controls for sufficient output to obtain the arbitrary reference of 10 crosshatch divisions. Then proceed from the second detector or discriminator toward the aerial, connecting the output cable to the grid of each stage, and noting the setting of the OUTPUT MULTIPLIER and MASTER OSC. ATTEN. controls required to produce the arbitrary reference amplitude. The amount of attenuation necessary to produce the arbitrary reference is a relative measure of the gain of the stage being checked.

Note that the MASTER OSC. APPROXIMATE CENTER FREQ. control must be set to the center frequency of the stages under test, and that the SWEEP WIDTH control must be set for the proper deviation, say 1 mc. for FM, 10 mc. for TV i.f., and MAX for r-f input.

### NOTE

It is not recommended that a stage-by-stage check be made by utilizing the high-frequency probe as the detector, because of the effect of the probe upon response; refer to THEORY OF VISUAL ALIGNMENT for further particulars.

## CHECKING CONTINUITY OF R-F, I-F, AND VIDEO STAGES

Model 7008 can be used for checking the continuity of circuits when trouble shooting. Several different methods can be used, and either a block of circuits may be checked, or a stage-by-stage check may be made.

The r-f (marker) generator may be employed as a modulated r-f signal generator by setting the FUNCTION switch to AM RF and controlling the output by setting the FUNCTION ATTEN. and OUTPUT MULTIPLIER controls for the desired output level. Connect the oscilloscope input cable to the detector output. Place the output cable successively on the i-f stages to be checked, progressing from the detector toward the receiver input. A 400:60-cycle Lissajou pattern will appear on the oscilloscope. See figure 8 which illustrates a 420:60-cycle pattern. When an individual r-f or i-f stage is to be checked, use the high-frequency probe as a detector. Adjust the VERT. GAIN control for the desired height of c-r-tube pattern. Should the video circuit in a television receiver be found satisfactory, then the receiver picture tube may be used instead of the oscilloscope; however, this check is only approximate, since the output can only be determined by judging the change in brilliance of the bar pattern on the picture tube, whereas, when using the oscilloscope, a change in output is determined immediately by a change in the height of the oscilloscope pattern. The MARKER FREQUENCY control should be set for the proper r.f. or i.f. as the continuity check progresses.

The FM (master osc.) generator can be used similarly, a lack of response indicating loss of continuity. In this case, the output is controlled by the MASTER OSC. ATTEN. and the OUTPUT MULTIPLIER controls, and the SWEEP WIDTH control should be adjusted for sufficient deviation to cover the band pass of the stage under test. The FUNCTION switch should be set to the OFF position.

The scope input leads should be used for audio frequencies; for video, r.f., or i.f., use the high-frequency probe as a detector.

## CHECKING AUDIO STAGES

The continuity and gain of audio stages may be checked by employing Model 7008 as an audio generator, and using the oscilloscope as an output indicator.

Connect the output of Model 7008 to the grid of the audio stage under test, and the oscilloscope input through the scope input leads to the plate of the stage under test. Set the FUNCTION switch to the 400-cycle position. Use the FUNCTION ATTEN. and the OUTPUT MULTIPLIER controls to determine the output level, and set the VERT. GAIN control for a convenient height of c-r-tube pattern. A 400-cycle Lissajou pattern will appear on the screen if continuity exists.

## CHECKING SWEEP SECTION OF TELEVISION RECEIVER

Model 7008 contains a special oscilloscope which employs a 60-cycle-sine-wave sweep instead of a linear sweep. Therefore, the horizontal-sweep wave forms of television receivers cannot be adequately observed on the c-r-tube of Model 7008. A separate oscilloscope with a linear and variable-frequency horizontal sweep should be used to check these wave forms. However, it is possible to employ Model 7008 to determine whether the vertical and horizontal sweep circuits are operating. Vertical-sweep wave forms can be observed easily, since they occur at a 60-cycle rate, but the wave form will appear distorted as compared with the same wave form on a linear sweep. Horizontal wave forms generally appear as a brighter configuration within an r-f envelope. If it is desired to use Model 7008 for trouble-shooting by checking wave forms, it is suggested that the serviceman familiarize himself with the wave form to be expected by connecting to the test points indicated in the Philco Television Service Manuals and comparing the wave forms obtained from a normal set with those in the service manual. It is important that the PHASING control be set for a single image.

## CHECKING VIDEO GAIN AT 400 CYCLES

The video gain at 400 cycles may be checked to give an approximate indication of the response at this frequency. Connect the output of Model 7008 to the video detector output (align test jack on Philco receivers), and the input leads of the oscilloscope to the grid of the picture tube in the television receiver. Set the MASTER OSC. BAND SW. to OFF, and the FUNCTION switch to the 400-cycle position. Adjust the FUNCTION ATTEN. and OUTPUT MULTIPLIER controls so that, with the VERT. GAIN control set to 2, a convenient deflection is obtained on the oscilloscope. Note the exact number of crosshatch divisions covered by the Lissajou pattern (see figure 8). Repeat the above check using a video amplifier known to be in good operating condition, and to have the proper gain. The setting of the FUNCTION ATTEN. and OUTPUT MULTIPLIER controls for the good amplifier as compared with the amplifier under test is a relative measure of the response at this single frequency. If the oscilloscope is calibrated for these control settings, the comparison can be made in terms of voltage rather than relative indication.

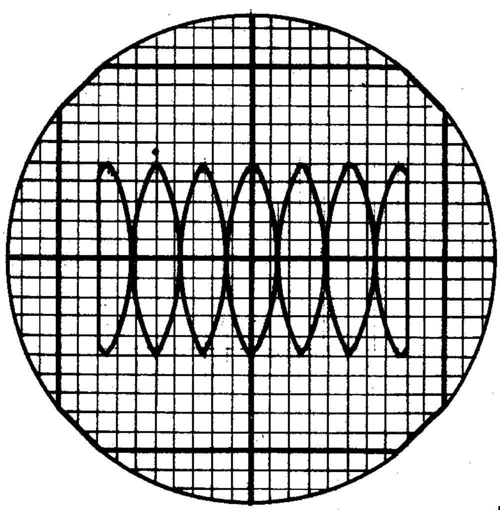

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**Figure 8. — 420:60-Cycle Lissajou Pattern**

## CHECKING VIDEO RESPONSE AT HIGH FREQUENCIES

The video amplifiers used in television receivers are required to pass frequencies up to 4 mc. equally and without discrimination. Model 7008 offers a means of checking the video response from 3.2 mc. upward and particularly for noting the effect of the 4.5-mc. trap. A graph of this response may be made, as shown in figure 9.

Connect the output of Model 7008 to the video detector output (align test jack in Philco receivers), and the oscilloscope input through the high-frequency probe to the grid of the picture tube in the receiver. Set the MARKER FREQUENCY control to 3.2 mc., then set the MASTER OSC. BAND SW. at OFF and the FUNCTION switch to the AM RF position. Adjust the FUNCTION ATTEN. and OUTPUT MULTIPLIER controls so that, with the VERT. GAIN set at 2, a convenient deflection is obtained on the oscilloscope. Note the exact number of crosshatch divisions covered by the Lissajou pattern. Now rotate the MARKER FREQUENCY control until the 5-mc. dial-calibration mark is reached, while carefully observing the height of the pattern on the c-r-tube. The height of the pattern will vary directly as the response of the amplifier, and appear as shown in the graph of figure 9.

The check points available on Model 7008 are sufficient to determine if the video amplifier under test is acceptable; however, if a more elaborate check is desired, substitute an audio generator and a modulated r-f generator in place of the output of Model 7008. Check at 100 cycles, and at every .25-mc. point there-

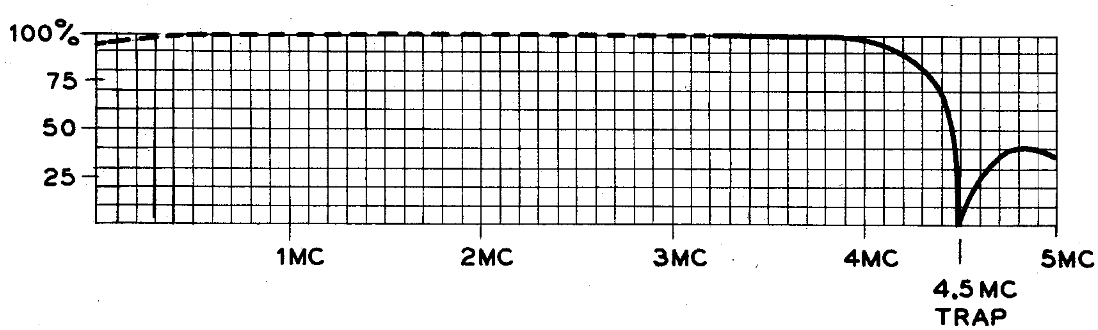


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**Figure 9. — Typical Video Response Curve**

after to 4.5 mc., using the oscilloscope of Model 7008 as in the preceding example, and connecting the scope leads or high-frequency probe, as required.

## CHECKING VIDEO-TRAP ADJUSTMENT

Television sound-and-picture carrier relationships are such that a constant difference of 4.5 mc. is maintained. In quality receivers, the i-f band pass is made to cover at least 4 mc., and reliance is placed on the accompanying-sound trap to eliminate sound interference. Since it is not desirable that the i-f band pass have perfectly sharp cutoff, strong signals have a tendency to produce a 4.5-mc. beat pattern, which consists of a series of fine, closely spaced vertical lines across the picture tube. A 4.5-mc. video trap is employed to eliminate the undesired beat interference. Model 7008 offers a means of adjusting the video trap to a true and observed minimum value, rather than a so-called zero value obtained by using a V.T.V.M.

Connect the output of Model 7008 to the video detector output (align test jack in Philco receivers), and the oscilloscope input through the high-frequency probe to the receiver picture-tube grid. Set the FUNCTION switch to the CAL position, and adjust the MARKER FREQUENCY control to exactly 4.5 mc. Set the MASTER OSC. BAND SWITCH to OFF, and, without touching the MARKER FREQUENCY control, set the FUNCTION switch to the AM RF position; set the FUNCTION ATTEN. control to 10, and adjust the VERT. GAIN control for a convenient pattern height on the c-r-tube.

Adjust the video trap to reduce the height of the c-r-tube pattern, continuing the trap adjustment while increasing the vertical gain until the pattern reaches a minimum value and then starts to increase. Leave the trap set at the exact minimum value.

## CHECKING SOUND-TRAP ADJUSTMENT

Modern television receivers usually contain two or more sound traps. The accompanying-sound trap is tuned to the receiver sound i.f. (22.1 mc. in Philco receivers), and rejects the sound which accompanies the picture, preventing it from appearing on the picture-tube grid. The adjacent-sound trap is usually set to a frequency of 6 mc. plus the accompanying-sound i.f. (28.1 mc. in Philco receivers). From a table of frequency allocation for TV channels, it can be seen that channels 1 and 7 require no adjacent-sound trap because no adjacent TV channel exists. Nor do channels 2 and 5 require these traps, since the i-f relationship is such that a 32.1-mc. beat interference is produced, which is well outside the picture i-f band pass. Adjacent channel interference is always caused by the station in the next lower frequency channel, since the adjacent channel on the high-frequency side produces a 16.1-mc. signal which is entirely outside the receiver band pass.

Connect Model 7008 output to the grid of the input i.f amplifier; connect the oscilloscope input to the video detector (align test jack), using the scope input leads. Set the FUNCTION switch to the AM RF position, the FUNCTION ATTEN. control to position 10, and the MASTER OSC. BAND SWITCH to OFF. Adjust the MARKER FREQUENCY control to 22.1 mc., and adjust the VERT. GAIN control for a convenient height of pattern on the c-r-tube. Adjust the accompanying-sound trap for a minimum height of pattern, as in the video-trap adjustment. Make certain that the marker generator is set to the exact discriminator center frequency (refer to SETTING DISCRIMINATOR TO EXACT CENTER FREQUENCY). If the discriminator is not set to the exact center frequency, the discriminator alignment should be rechecked, and the marker generator used to recheck the trap setting at the center frequency to which the discriminator is tuned, otherwise sound disturbances will appear in the picture.

The adjacent-sound trap should be adjusted in a similar manner, with the MARKER FREQUENCY control set to 28.1 mc. Generally speaking, it will be observed that the setting of the adjacent-channel sound trap is not as critical as that of the accompanying-sound trap, because it requires considerable signal strength to produce this interference.

If more than one accompanying-sound trap is employed, it is a good practice to adjust both traps before proceeding with the adjacent-sound-trap adjustment, to avoid any possibility of missetting the MARKER FREQUENCY control. Otherwise, the two accompanying-sound traps might be adjusted to two different frequencies, and lose their effectiveness.

## SETTING DISCRIMINATOR TO EXACT CENTER FREQUENCY

There are two methods of using Model 7008 to set the discriminator to its proper center frequency. The first method described is recommended, for its more accurate and easily observed results. It consists of applying a modulated r-f signal of the correct center-frequency to the discriminator, and adjusting the discriminator secondary until the modulation disappears. In this method the modulation disappears because the output of the discriminator is zero at the center frequency. In the second method, a marker pip is made to appear on the discriminator response curve, and is set for the crossover point at the center frequency. However, the second method is less effective, because the marker pip disappears at the center frequency so that the center frequency is actually determined by noting when the marker disappears and where it reappears, and, because of the difficulty in observing the exact points of appearance of this pip, it sometimes leads to inaccurate results.

To employ the first method, connect the output of Model 7008 to the grid of the last i-f tube, and the oscilloscope input through the scope input leads to the sound-detector output (a-f-c test jack in television receivers, FM test jack in FM receivers). Set the MARKER FREQUENCY control for the correct center frequency, and the MASTER OSC. APPROXIMATE CENTER FREQ. control to the center frequency (MASTER OSC. BAND SWITCH to Band A). Adjust the HORIZ. GAIN control for a horizontal trace of about 20 crosshatch divisions, with the SWEEP WIDTH control at 1. Turn the FUNCTION switch to the AM RF position. Set the OUTPUT MULTIPLIER and the MASTER OSC. ATTEN. controls for a response curve covering at least 10 vertical crosshatch divisions, with the VERT. GAIN at position 2. Set the FUNCTION

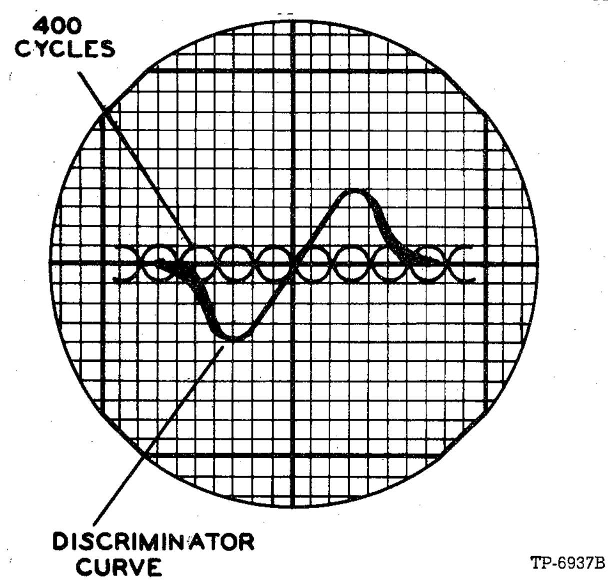


**Figure 10. — Discriminator Center-frequency Pattern**

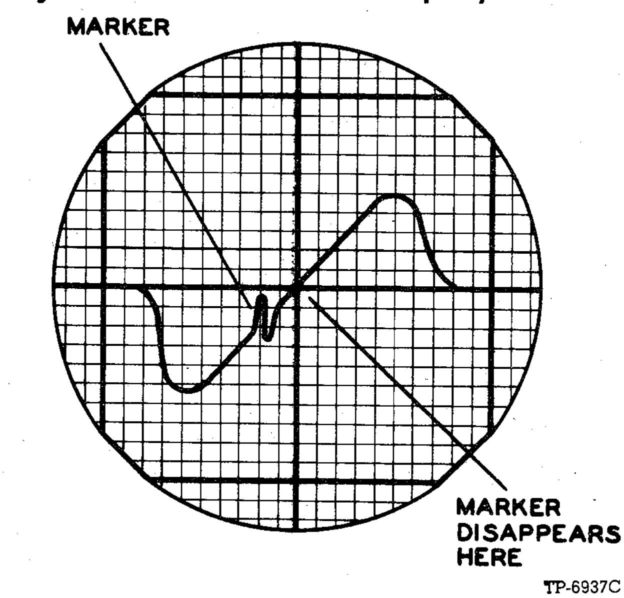


**Figure 11. — Use of Marker for Locating Discriminator Center Frequency**

ATTEN. control to position 10.

If the discriminator secondary trimmer is correctly adjusted to the proper center frequency, only a typical S-shaped curve will appear. If it is not adjusted to the correct frequency, but close to it, a pattern similar to that in figure 10 will appear. Regardless of which pattern appears, adjust the secondary trimmer until figure 10 pattern appears, then vary the trimmer slowly in one direction, and then in the other direction, until the 400-cycle portion of the pattern disappears and then reappears with a further movement of the trimmer. Set the trimmer to the point at which the 400-cycle portion disappears and will reappear if the trimmer is moved slightly in either direction.

NOTE: The setting of the FUNCTION ATTEN. control is critical in this application. Too much marker signal input will make the center frequency hard to find.

The user should note that the MASTER OSC. ATTEN. controls the height of the discriminator curve, while the FUNCTION ATTEN. controls the height of the 400-cycle pattern, and the OUTPUT MULTIPLIER and VERT. GAIN controls affect the height of both the curve and the 400-cycle pattern. This check should be performed a few times to enable the user to become familar with the setting of controls.

To employ the second method, using the marker pip on the response curve, connect Model 7008 as outlined above. Control settings are the same, except that the FUNCTION switch should be set to the MKR position. Set the MARKER FREQUENCY control slightly off the center frequency, and adjust the controls until the marker pip is visible on the discriminator response curve. See figure 11. Then set the marker pip for the correct center frequency, and set the discriminator secondary trimmer until the pip disappears at the crossover point in the center of the response curve.

It will be found helpful to use the blanking circuit in both of the above checks, so that the crossover point can be easily determined. To use the blanking circuit, first adjust the PHASING control for a single image, then turn the BLANKING control clockwise until a single image appears with a horizontal line through the full width of the pattern retuning the MASTER

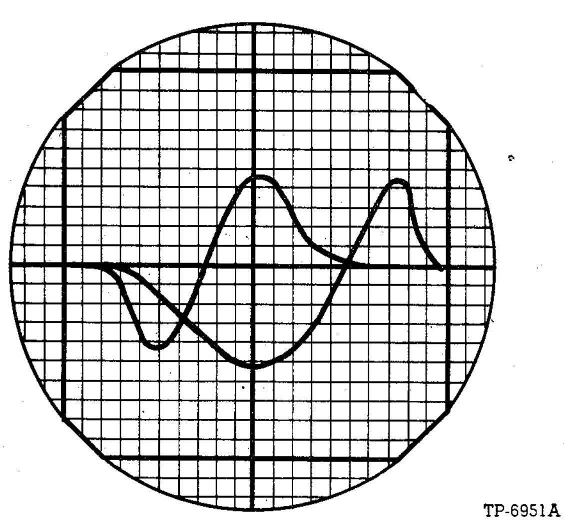


**Figure 12. — Discriminator Curve—PHASING Control Requires Adjustment**

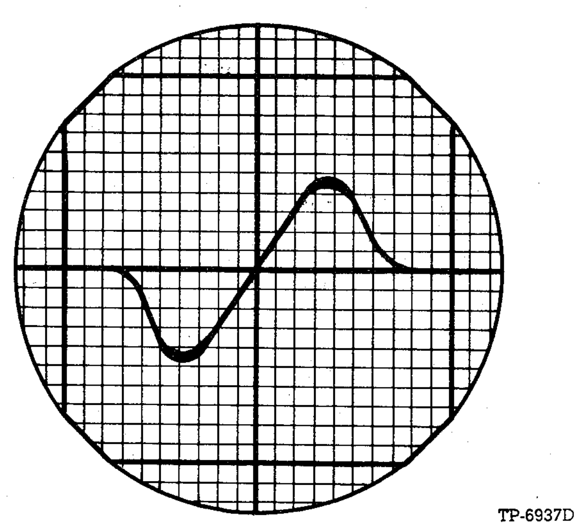


**Figure 13. — Discriminator Curve—PHASING Control Properly Set**

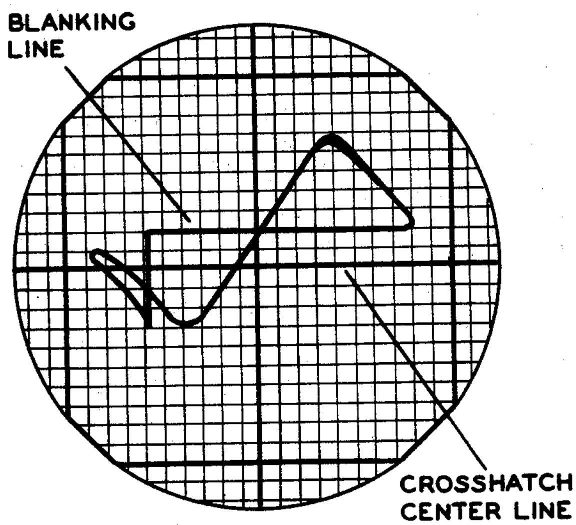


**Figure 14.—Discriminator Curve—BLANKING Control Requires Adjustment**

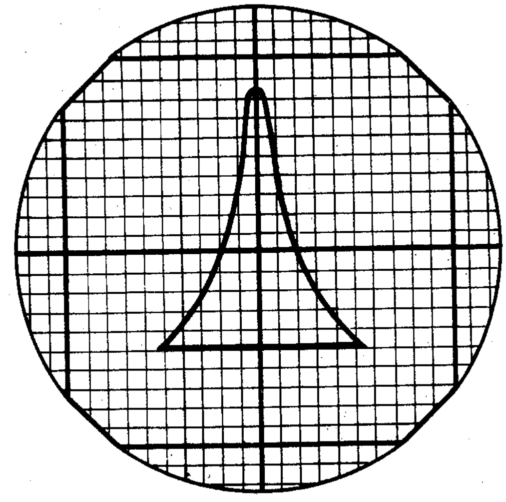


**Figure 16.—R-F and Mixer Response of FM Receiver**

OSC. APPROXIMATE CENTER FREQ. control slightly if necessary, to center the image on the scope. See figures 12, 13, 14 and 15.

## CHECKING R-F AND MIXER RESPONSE

The response of the r-f and mixer sections of either an FM or television receiver may be observed with Model 7008. Connect the output of Model 7008 to the receiver aerial input through an appropriate matching network, if the input impedance of the receiver is other than 75 ohms. Connect the oscilloscope input of Model 7008 through the scope input leads to the mixer plate decoupling filter (the tuner test jack in Philco receivers). Be sure to remove first i.f. tube. If a decoupling network is not supplied, connect the oscilloscope through the high-frequency probe to the plate of the mixer.

Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to the center-channel frequency, and the FUNCTION switch to the MKR position. Adjust the SWEEP WIDTH control for the desired deviation (position 6 to 10 for television receivers, and between 0 and 1 for FM receivers). Set the OUTPUT MULTIPLIER and MASTER OSC. ATTEN. controls for the desired pattern height, with the VERT. GAIN control at position 2. Use the MARKER FREQUENCY control to vary the marker pip along the response curve, to determine the cutoff points; the FUNCTION ATTEN. control determines the amplitude of the marker pip.

In some instances, it may be necessary to set the VERT. GAIN control to another position; it is generally good practice to keep this control near position 2, and adjust the output from Model 7008 so that the pattern is of a satisfactory height.

FM receivers will have a front-end response similar to figure 16. It will be found, generally, that the width of this front-end response curve will be from 150 to 200 kc., since it is more or less fixed by the "Q" of the circuit; that is, while alignment may change the shape of the response curve, it can vary considerably in ampli-

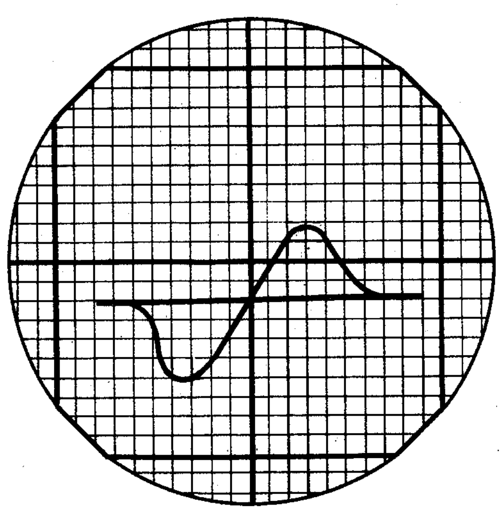


**Figure 15.—Discriminator Curve—BLANKING Control Properly Set**

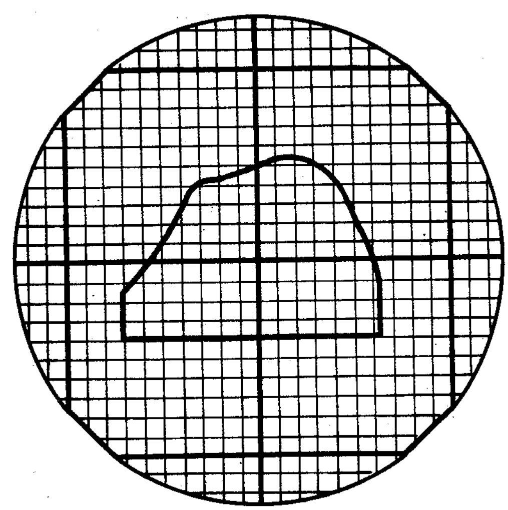


**Figure 17.—Typical TV Front-End Response, Curve 1**

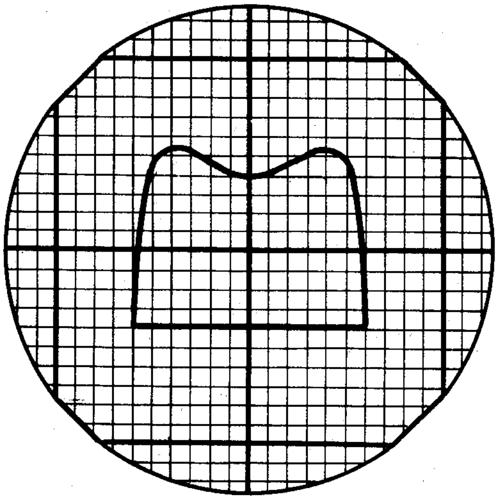

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**Figure 18. — Typical TV Front-End Response, Curve 2**

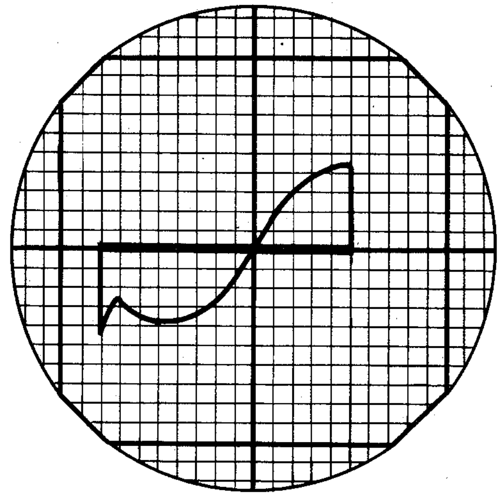

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**Figure 20. — SWEEP WIDTH Control Set Too Low**

tude and appear as a high, narrow, peaked curve, and yet retain the band width for which it was designed.

Some typical television receiver front-end response curves are shown in figures 17 and 18. From a theoretical standpoint, the most desirable response would be a rectangular-shaped curve which is flat over each channel and drops off sharply at each end, allowing the i-f selectivity to determine the final shape at the detector. However, at the present time, production tolerances permit quite a range over which the response is acceptable; see figure 19. It is evident, therefore, that for each type of receiver, while the ideal response is desired, variation therefrom is not uncommon. Therefore, any adjustments of front-end response should be attempted with due consideration for both the r-f and i-f over-all response, rather than that of the r-f response alone, since it is only necessary for a good picture, that the frequencies within the i-f band pass are passed. The main purpose of the r-f stage is to provide good image rejection and to minimize any spurious responses which can occur. It is important, however, that the r-f response be wide enough to prevent chopping off any picture or sound signal; this can be easily checked by observing the front-end response curve, and running the marker along the curve to determine the cutoff points.

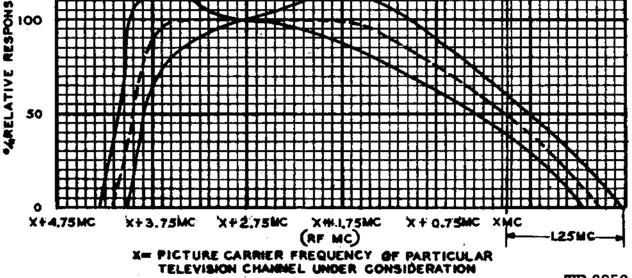


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**Figure 19. — Over-All R-F and I-F Response, Showing Tolerance**

## FM RECEIVER ALIGNMENT

The preceding paragraphs have discussed various methods of checking and adjusting particular portions of television and FM receivers. A complete alignment of FM receivers will now be discussed, to indicate the sequence of operations which should be followed.

There are three types of FM detectors that are in general use; other special types which are not generally used will not be discussed. The three general types are the limiter-type detector, the ratio detector, and the Philco Advanced FM Detector; the type of detector determines the procedure to be followed.

Model 7008 possesses high signal output and unusual oscilloscope sensitivity, together with more than sufficient sweep deviation. Therefore, it is not necessary in most cases to align the i-f stages before aligning the discriminator; instead, the discriminator may be aligned first, and the remainder of the set aligned to the discriminator. Since the effect of the adjustments are

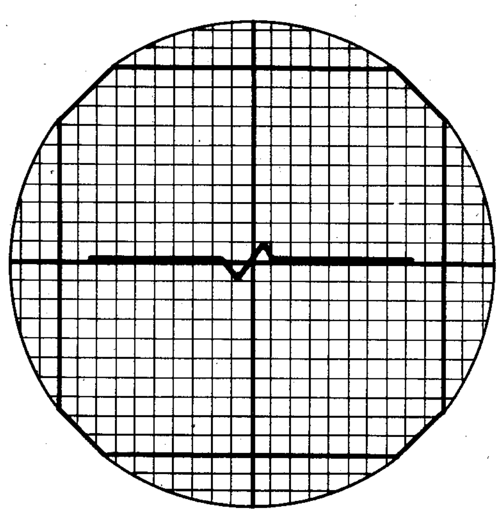

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**Figure 21. — SWEEP WIDTH Control Set Too High**

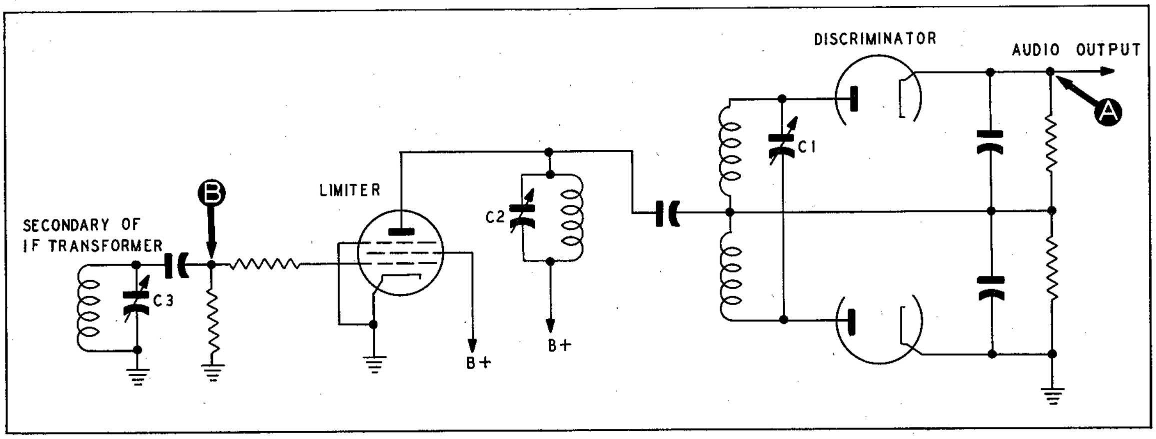


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**Figure 22. — Limiter-Type Detector Schematic**

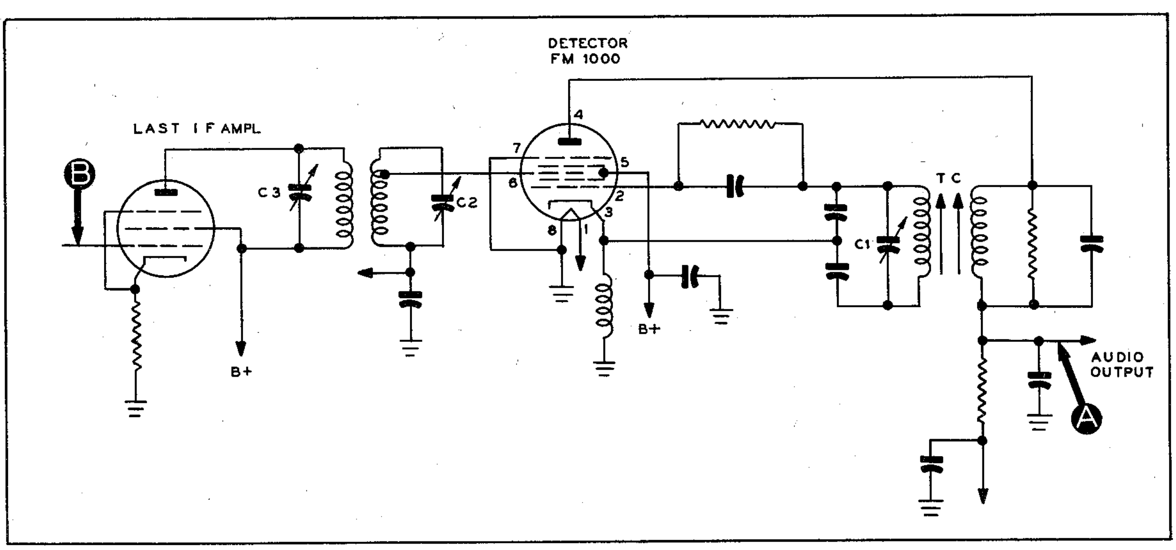
visible at all times, no guess work is involved. Regardless of whether the stages are single or double peaked, the adjustments are easily made for symmetrical response. While it may be found that the visual alignment produces less audio output than other previously employed methods of alignment, it will also be found that, after visual alignment for true symmetry, better sound quality and noise reduction are obtained.

The r-f (marker) generator should be used to check the maximum and minimum points of the response curve, but it is not good practice to leave it set to one of these points, because insertion of the marker signal produces some distortion of the response curve. Use the crosshatch screen as a graph, locating the desired change points at some easily determined crosshatch line. For example, the center or crossover point may be located at the intersection of the heavy horizontal and vertical crosshatch lines in the middle of the screen, and the peaks of discriminator response can be located 5 divisions either side of center. Thus true symmetry can be determined by counting the number of divisions to the right and left and above and below the center lines.

Use the blanking circuit to furnish a reference line, being certain to first adjust the PHASING control for a single image with the BLANKING control in the OFF position, and to turn the BLANKING control clockwise until a single image with base line appears.

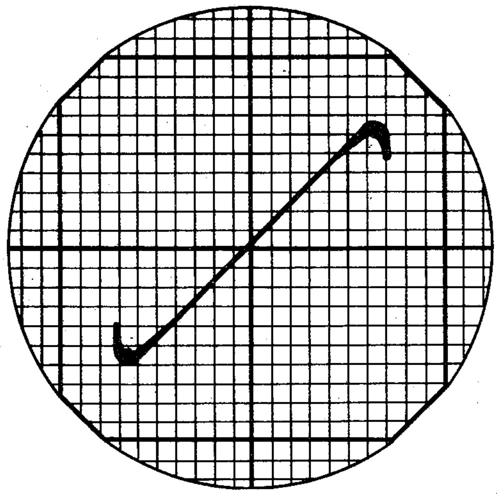
Adjust the SWEEP WIDTH and VERT. GAIN controls to keep the image on the c-r tube at a convenient size. Figure 20 shows insufficient sweep width, while figure 21 shows too great a sweep width. As a general rule, changes in symmetry may be more easily determined when the response curve is large than when it is small. Once proper sweep setting is obtained, blanking must be removed and the PHASING control reset for curve coincidence.

Connect the output cable of Model 7008 to the stage ahead of the one being checked, through a .01-mf. blocking condenser, and connect the input through the scope leads to the detector audio output (FM test jack in Philco receivers). Where it is desired to check indivi-




TP-6930

**Figure 23. — Philco Advanced FM Detector Schematic**



TP-6952A

**Figure 24. — Primary Set To Center Frequency**

dual stages ahead of the detector, connect the input of Model 7008 through the high-frequency probe to the grid of the stage following the one being checked.

## NOTE

Before starting the actual alignment, allow Model 7008 and the FM receiver to warm up for a period of at least 15 minutes.

## Limiter-Type Detector

1. Referring to figure 22, connect the output cable of Model 7008 between test point B and ground; connect the input through the scope input leads between test point A and ground.

2. Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to the desired center frequency; set the MASTER OSC. BAND SWITCH to position A.

3. Set the SWEEP WIDTH control for approximately 200 kc. total deviation, and adjust the discriminator primary condenser C2 for a curve of maximum amplitude, which will appear somewhat S-shaped if the secondary is not too far detuned. It will be necessary to keep the OUTPUT MULTIPLIER and MASTER OSC. ATTEN. controls set for an output below that at which limiting occurs.

4. Adjust the discriminator secondary trimmer condenser C1 for an S-shaped symmetrical response curve set to exact center frequency (see SETTING DISCRIMINATOR TO EXACT CENTER FREQUENCY).

5. Retune C2 for a symmetrical response curve with greater amplitude than in step 4, if possible.

6. Connect the output cable of Model 7008 to the grid of the last i-f stage preceding the limiter stage, and adjust trimmer C3 for a symmetrical response curve of maximum amplitude.

7. Connect the output cable of Model 7008 between the grid of the mixer tube and ground, and, if the output can be kept below the receiver limiting point, adjust each i-f secondary and primary in order, proceeding from the last i-f back to the first i-f stage, for a symmetrical response curve of maximum amplitude. Should limiting occur, that is, no change in amplitude occur as trimmers are adjusted, connect the input of Model 7008 through the high-frequency probe between test point B and ground, and adjust each i-f stage as stated. Then, when C3 is reached, connect the scope input leads to test point A, move the output cable of Model 7008 to the grid of the stage preceding C3, and adjust C3 and the discriminator as directed in steps 1 through 5 above.

## NOTE

As each i-f trimmer is adjusted, the MASTER OSC. ATTEN., OUTPUT MULTIPLIER and VERT. GAIN controls should be retarded to keep the pattern within the limits of the screen.

8. Align the r-f and oscillator circuits as explained in the last paragraph of this section (r-f alignment is similar for all types of detectors).

## Philco Advanced FM Detector

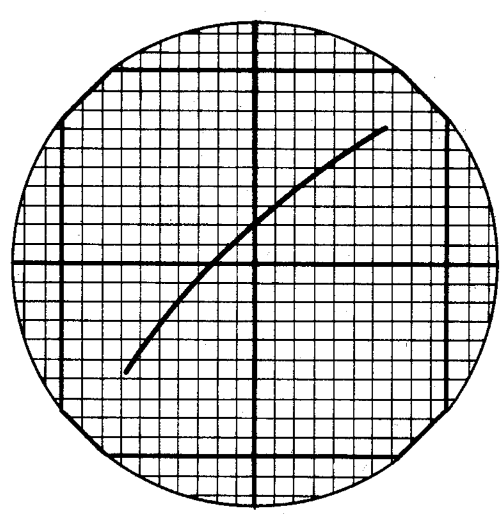
This type of FM detector requires that the i-f stages be adjusted first; then the detector is adjusted to the i-f center frequency. Any other procedure is not recommended.

1. Referring to figure 23, connect the output cable of Model 7008 to the grid of the last i-f stage, test point B; connect the oscilloscope input through the scope input leads to the detector output (FM test jack) test point A.

2. Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to 9.1 mc., the MASTER OSC. BAND SWITCH to Band A, and the FUNCTION switch to the MKR position.

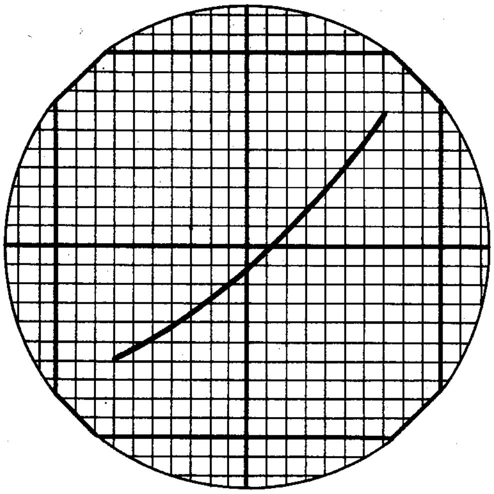
3. Short pin 2 of the FM1000 tube to ground, to render the oscillator inoperative. Set the SWEEP WIDTH control for approximately 200 kc. total deviation, and the OUTPUT MULTIPLIER, MASTER OSC. ATTEN., and VERT. GAIN controls for a pattern of desired height on the c-r tube.

4. Adjust the last i-f secondary trimmer C2 for a symmetrical i-f response curve of maximum amplitude and then adjust the last i-f primary trimmer C3 for a similar response. Move the output cable to the grid of



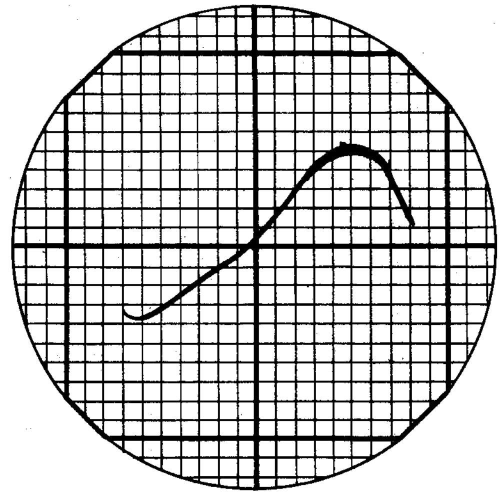
TP-6952B

**Figure 25. — Tuning Core Requires Turning In**



TP-6952C

**Figure 26. — Tuning Core Requires Turning Out**



TP-6936C

**Figure 28. — Primary Set Above Center Frequency**

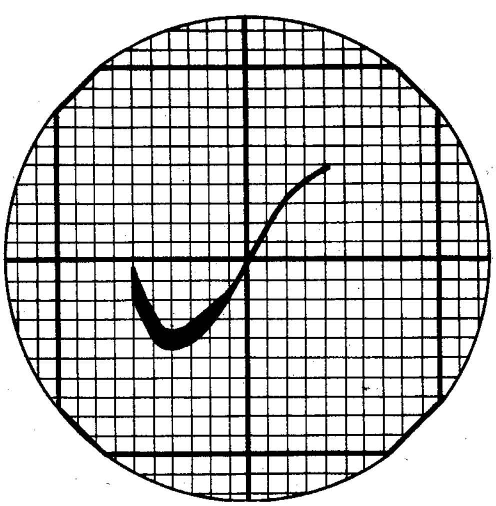
the preceding i-f stage, and adjust the secondary and primary trimmers in order. Continue to move the output cable to the preceding stage and adjust each i-f transformer until all i-f transformers have been aligned.

5. Remove the short from pin 2 of the oscillator tube, and adjust trimmer condenser C1 for a hooked curve, as shown in figure 24.

### NOTE

It will be necessary to decrease the receiver input to threshold value to secure the hooked curve. Be certain that the curve is symmetrical about the center.

6. Increase the output of Model 7008 until the hooked curve straightens out and becomes an almost straight line (see figure 25 and 26), then adjust the secondary tuning core TC (figure 23) for a straight line. Figures 27 and 28 indicate incorrect primary adjustments, while figures 25 and 26 indicate incorrect secondary adjustments.



TP-6952D

**Figure 27. — Primary Set Below Center Frequency**

### NOTE

If the c-r tube pattern is not observed directly from the front of the oscilloscope, it is possible to adjust for what appears to be a straight line, which when checked with a straight-edge is found to be bowed.

If the blanking circuit is used, be sure to first adjust the PHASING control for a single image with the blanking circuit off, and then adjust the BLANKING control for a base line along the full width of the pattern.

## Ratio Detector

1. Referring to figure 29, connect the output cable of Model 7008 between test point B and ground; connect oscilloscope input through the scope input leads between test point A and ground.

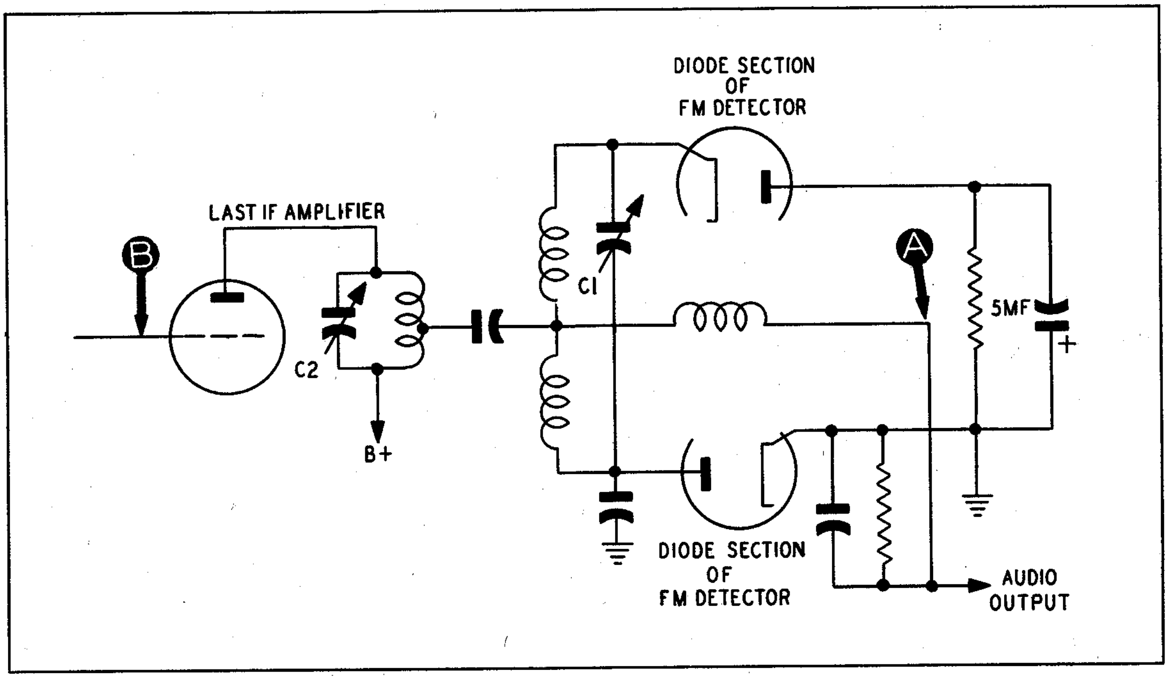
2. Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to the desired center frequency (9.1 mc. for Philco FM receivers, and 22.1 mc. for Philco television receivers); set the MASTER OSC. BAND SWITCH to position A.

3. Set the SWEEP WIDTH control for approximately 600 kc. deviation for TV receivers. Adjust the discriminator primary trimmer condenser C2 for a response curve of maximum amplitude; the curve will be S-shaped if the secondary trimmer is near the proper adjustment.

4. Adjust the discriminator secondary trimmer condenser C1 for an S-shaped symmetrical response curve set to the exact center frequency (see SETTING DISCRIMINATOR TO EXACT CENTER FREQUENCY).

5. Remove the output cable from test point B, and advance it one stage toward the mixer, tuning the secondary and then the primary of the last i-f transformer for a symmetrical S-shaped response curve of greater amplitude than in step 4.

6. Proceed to adjust each i-f stage in order until the mixer is reached, adjusting the OUTPUT MULTIPLIER, MASTER OSC. ATTEN., and VERT. GAIN controls to retain the pattern on the screen.




TP-6942A

**Figure 29.—Ratio Detector Schematic**

7. Align the r-f and oscillator stages as explained in the following paragraph.

## Aligning R-F and Oscillator Stages

1. Connect the output cable of Model 7008 to the aerial terminals of the FM receiver, using an appropriate matching network if the input impedance is other than 75 ohms. Leave the oscilloscope input cable connected to the output of the detector (FM test jack).

### NOTE

If the radio is equipped with an external, all-purpose aerial-matching transformer, remove this transformer and feed the signal directly into the ANT. coil.

2. Set the MASTER OSC. APPROXIMATE CENTER FREQ. control and the FM radio dial for 105 mc., and set the SWEEP WIDTH control for a total deviation of approximately 200 kc.

3. Adjust the shunt (high-frequency) trimmer of the oscillator circuit for maximum output.

4. Set the FM radio dial to 88 mc., and adjust the MASTER OSC. APPROXIMATE CENTER FREQ. control to 88 mc. Use a tuning wand and observe the oscilloscope pattern. If the signal amplitude decreases when either end of the wand is inserted in the oscillator coil, the tracking is satisfactory. If the output increases with the brass end of the wand inserted, spread the turns of the oscillator coil; if the output increases with the iron end of the wand inserted, compress the turns of the coil.

### NOTE

Do not bend the coil excessively, as only a slight physical change is necessary at this frequency.

5. Repeat steps 3 and 4 until no further change is noted. The last adjustment made should be that of the shunt (high-frequency) trimmer,

6. Set the radio dial and Model 7008 to 105 mc., and adjust the shunt trimmer of the mixer grid circuit for maximum output. If an r-f stage is employed, also adjust the shunt trimmer of the r-f stage for maximum output.

7. Set the radio dial and Model 7008 to 92 mc., and check the tracking of the mixer and r-f grid circuits with the tuning wand. If the output increases with the brass end inserted in the coil, spread the coil turns; if the output increases with the iron end inserted, compress the coil turns. If the output decreases when either end is inserted, the tracking is correct. Do this for both the mixer and r-f coils.

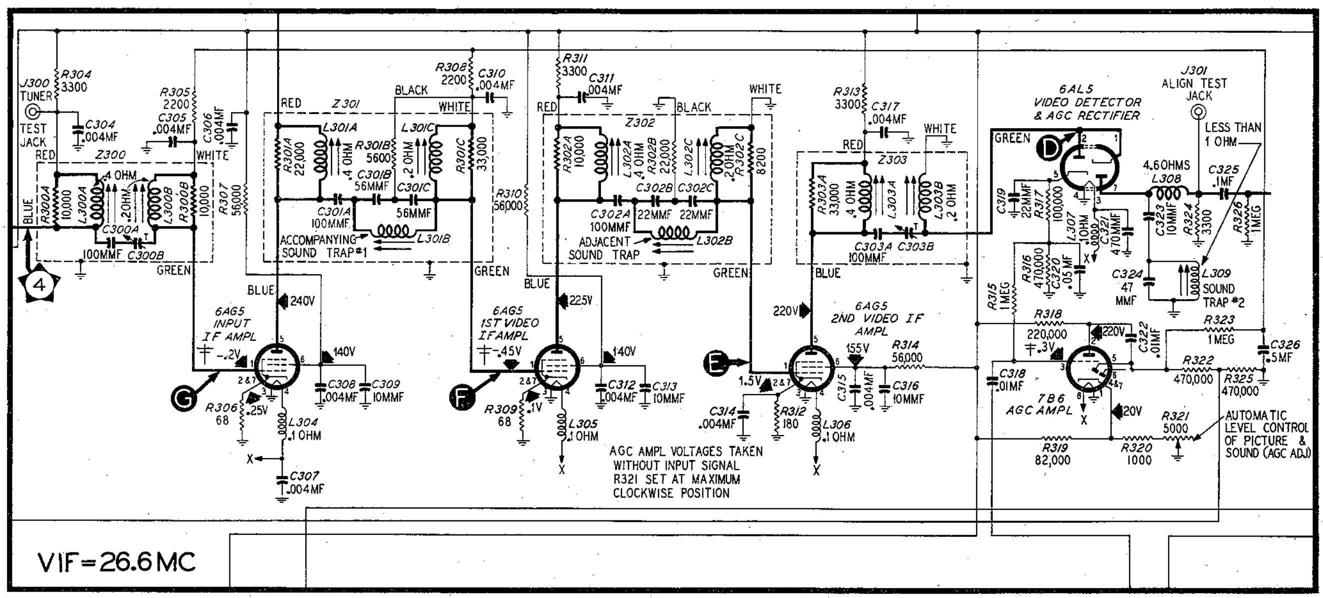
8. Repeat the foregoing adjustments of the r-f and mixer circuits, both at 105 mc. and 92 mc., until no further improvement is noted. Make the 105-mc. adjustments last.

### NOTE

See CHECKING R-F AND MIXER RESPONSE.

## TELEVISION RECEIVER ALIGNMENT

The television receiver chassis and the test equipment should be placed on a grounded metal plate in order that both chassis be at the same r-f potential. Model 7008 mounting feet are insulated; therefore, a grounding strap should be attached to the generator and




TP-6939

**Figure 30. — Typical Picture I-F (Band-Pass Type) Schematic**

ground plate. It is a good practice to check for proper grounding by connecting leads from the chassis under test to Model 7008, and noting if the response curve changes shape. With proper grounding no change should be noted; improper grounding produces regenerative effects which result in improper alignment. In many cases these effects are responsible for the so-called perfect alignments which produce poor pictures when tuned to a station.

A common defect in alignment is evidenced by a good picture with poor sound, or a poor picture with good sound. This results from not setting the sound and picture i-f stages to the correct frequencies, or from poor band pass in the r-f and mixer stages. If the manufacturer's alignment procedures are followed correctly, no trouble should be experienced.

The following paragraphs contain a discussion of alignment and the procedure to be followed with Model 7008 which also applies generally to other test equipment. A popular model of Philco television receiver is used as an example. Two methods of obtaining the proper video-i-f band pass are used; one in which each i-f stage is tuned to a specific curve to obtain the proper over-all response; the other in which each stage is stagger-tuned to obtain the same over-all response. The first method requires more careful adjustment than does the second method.

Alignment of the picture and sound i-f stages will be treated separately. The sound i-f alignment depends upon the type of detector used, and can be made either before or after the picture-i-f alignment. The picture alignment is usually made first as a matter of convenience, since sound-trap adjustments can be checked with the generator set for the sound-frequency alignment. It is of importance, therefore, that the sound i-f and adjacent-sound generator setting be accurately logged, to avoid any possibility of setting the traps to the wrong frequency, regardless of the alignment procedure that is followed.

It is more or less general practice in alignment to stand the chassis on end and connect the test equipment under the chassis. In television alignment, where a number of low-gain band-pass stages are employed, it is easily possible to have a feed-back loop, through unshielded test leads, which produces regeneration when the first (input) i-f stage is reached. An easy method of avoiding this trouble is to place the chassis on the ground plate and reach the signal-input points through holes in the i-f cans. Such a procedure is followed in the factory, and results in trouble-free alignment. Special jigs are used to reach the signal-input points, and may be constructed more or less elaborately if the serviceman desires. However, the ordinary test prod will suffice for reaching through the holes in the i-f cans if its shank is insulated to prevent grounding to the can. The mixer grid can be reached by using a dummy coil with the grid lead brought out from the proper terminal for easy connections; since jacks are provided at the proper receiver output points, it is possible to avoid any underchassis connections. And to make the alignment with the chassis flat on the bench, the alignment may be made quickly, and with a mimimum of feed-back troubles.

## Picture I.F. (Band-Pass Type)

1. Connect the oscilloscope input of Model 7008 through the scope input leads to the output of the video detector (align test jack). Connect the output cable to the grid of the last i-f stage, test point E, figure 30 (accessible through top of v-i-f can #3).

2. Set the a-g-c control for maximum sensitivity, or remove the a-g-c amplifier tube.

## NOTE

By using maximum sensitivity for alignment, and with a-g-c operating, better fringe-area performance will be obtained. If the receiver is to be used only in an area of strong signals, the a-g-c bus can be biased with -3 volts, from two dry cells.

3. Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to 25 mc., MASTER OSC. BAND SWITCH to Band A, FUNCTION switch to the MKR position, SWEEP WIDTH control to position 6, OUTPUT MULTIPLIER to MAX. and adjust the MASTER OSC. ATTEN. and VERT. GAIN controls for the desired height of c-r tube pattern. Adjust the PHASING and BLANKING controls for a single image and reference base line.

4. Adjust the last i-f primary and secondary tuning cores (L303A and L303B) for a single peak, centered at 27.1 mc. (coupling condenser C303B open). Then adjust the coupling condenser for a peak at 23.25 mc. The response curve should appear similar to curve 1 in figure 31 with the dip in the center not more than 30%. If necessary, readjust L303A and L303B for the proper curve. Use a marker pip to check the response curve.

5. Connect the output cable of Model 7008 to the grid of the 1st v-i-f amplifier, test point F (accessible through top of v-i-f can #2), and turn the MASTER OSC. BAND SWITCH to the OFF position. Set the MARKER FREQUENCY control for 28.1 mc. (Band B), turn the FUNCTION switch to the AM RF position, and set the FUNCTION ATTEN. control to position 10.

6. Adjust the adjacent-sound trap, L302B, for a minimum of 400-cycle Lissajou pattern (see CHECKING SOUND-TRAP ADJUSTMENT).

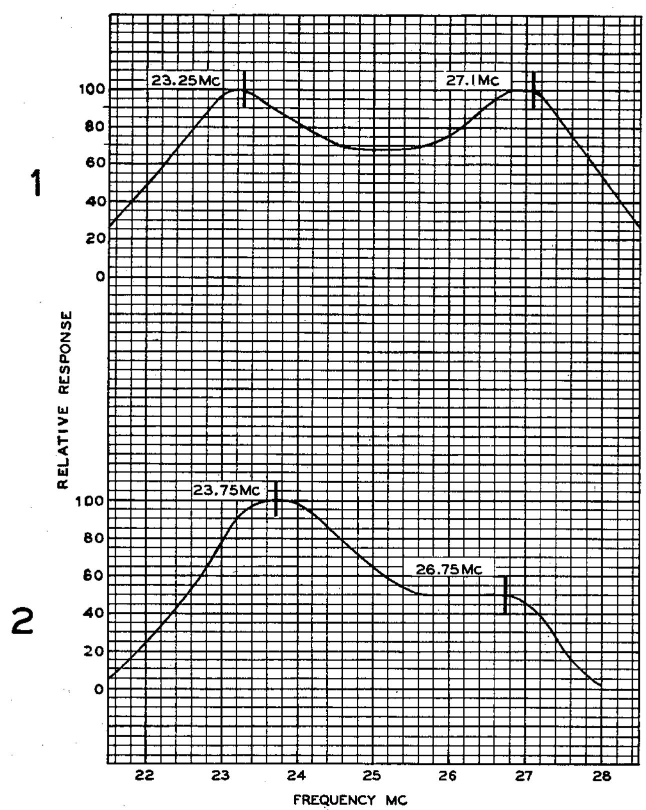
7. Turn the FUNCTION switch to the MKR position, and the MASTER OSC. BAND SWITCH to Band A. Adjust the first v-i-f secondary, L302C, for a peak at 23.75 mc., and the primary, L302A, for a peak at 26.75 mc., to obtain a response curve similar to curve 2 in figure 31.

## NOTE

Adjust the MASTER OSC. ATTEN. and OUTPUT MULTIPLIER controls for sufficient output with the VERT. GAIN set at position 2 to provide a c-r-tube pattern of proper height as the alignment progresses from stage to stage, but do not exceed 2 volts, peak-to-peak, at the detector.

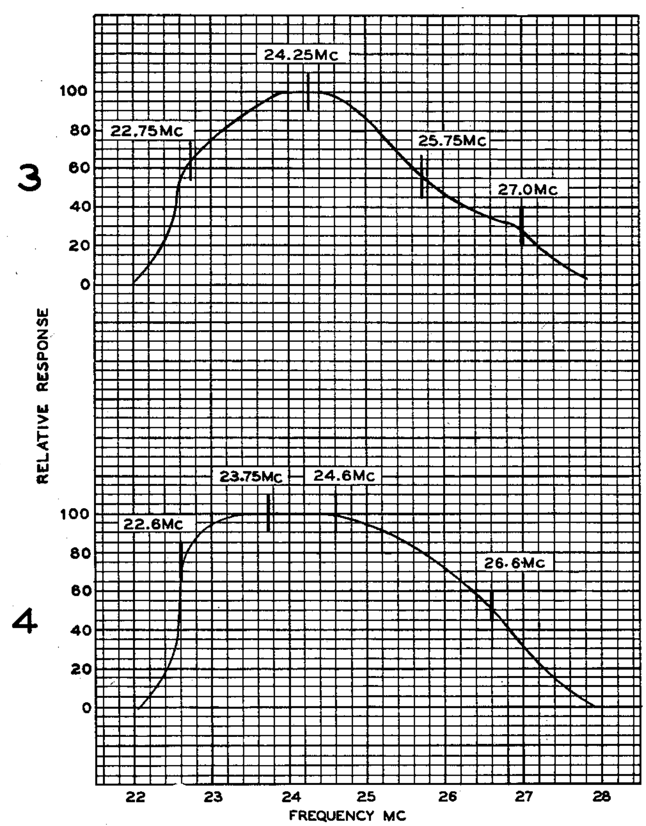
8. Connect the ouput cable of Model 7008 to the grid of the input amplifier, test point G (accessible through top of v-i-f can #1), and turn the MASTER OSC. BAND SWITCH to the OFF position. Set the MARKER FREQUENCY control for 22.1 mc. (Band B), and turn the FUNCTION switch to the AM RF position (FUNCTION ATTEN. at 10).

9. Adjust accompanying-sound trap L301B for a minimum of 400-cycle Lissajou pattern (see CHECKING SOUND-TRAP ADJUSTMENT).




TP-4725

**Figure 31.— Video I-F Curves 1 and 2**




TP-4726

**Figure 32.—Video I-F Curves 3 and 4**

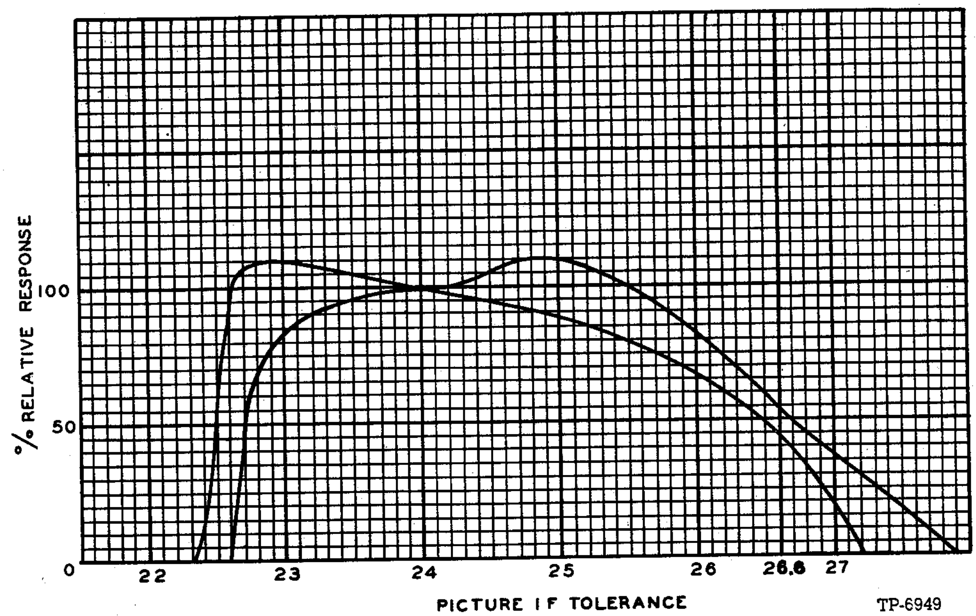



**Figure 33.—Picture I-F Tolerance**

10. Turn the FUNCTION switch to the MKR position, and the MASTER OSC. BAND SWITCH to Band A. Adjust the input i-f primary and secondary, L301A and L301C, for a response curve having the same shape and amplitude as curve 3 in figure 32.

11. Connect the output cable of Model 7008 to the grid of the mixer tube (fourth pin from front of oscillator coil section of Philco Precision Channel Selector). Adjust L300A and L300B, the primary and secondary of the input i-f stage, and C300B, the input i-f coupling condenser, for a response curve similar to curve 4 in figure 32.

## NOTE

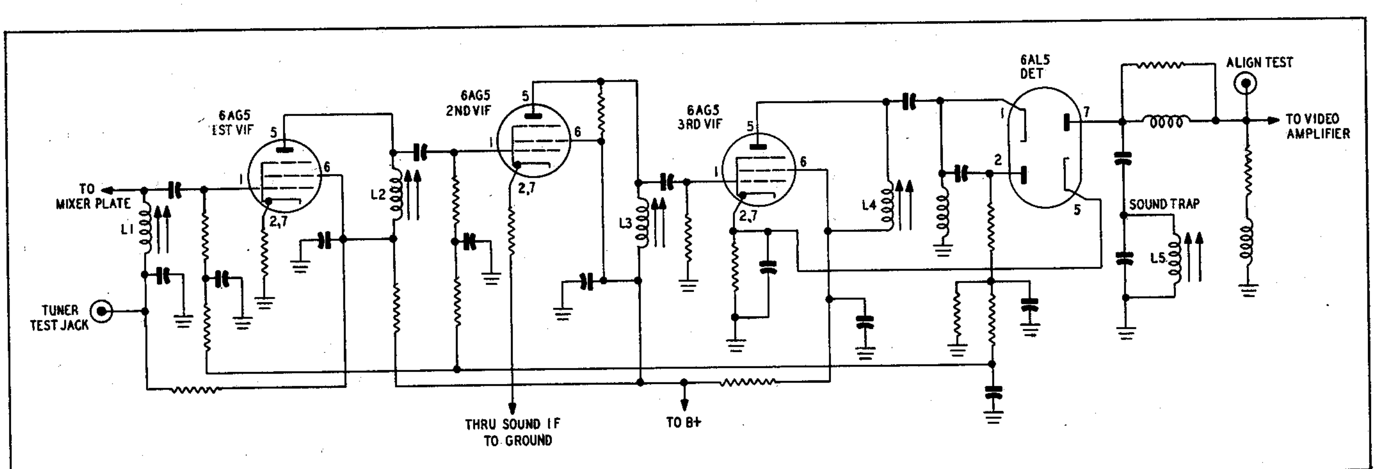
Band width and sound output are determined by coupling condenser C300B. On some receivers, it may be necessary to adjust this trimmer for maximum sound and leave it set at that position and to obtain the correct picture response curve by using only the i-f primary and secondary adjustments.

It may also be necessary to slightly adjust the primary and secondary slugs of the first and second v-i-f couplers to secure the proper over-all response curve, but *do not* adjust the accompanying-sound or adjacent-sound traps, or the last v-i-f coupler. Curve 4 of figure 32 shows the ideal response; the curves in figure 33 show the extremes of variation which are acceptable; adjust for a curve within these limits.

The remainder of the alignment consists of adjusting the sound-i-f stages, and the sound and video traps, also checking r-f alignment and the local-oscillator setting.

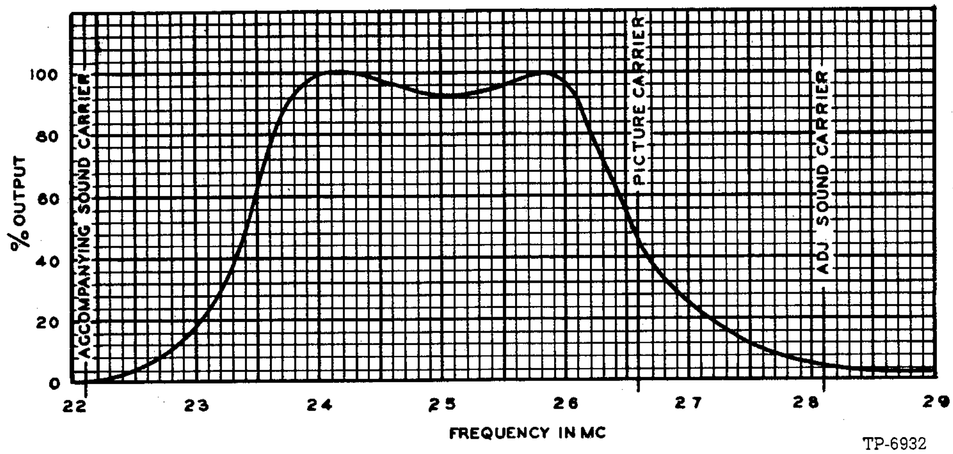
## Picture I.F. (Stagger-Tuned)

1. Connect the oscilloscope input of Model 7008, through the scope input leads between the detector output (align test jack) and ground. Connect the output cable of Model 7008 to the grid of the mixer tube.




TP-6942B

**Figure 34.—Typical Stagger-Tuned Picture I-F Schematic**




TP-6932

**Figure 35. — Typical Stagger-Tuned I-F Response Curve**

2. Adjust the accompanying-sound traps for a minimum of 400-cycle Lissajou pattern (see CHECKING SOUND TRAP ADJUSTMENT) at 22.1 mc.

3. Set the MARKER FREQUENCY control to 22.75 mc., and the FUNCTION switch to the AM RF position. Set the MASTER OSC. BAND SWITCH to OFF, and adjust the FUNCTION ATTEN. and VERT. GAIN controls as required, while trimming L1 and L4, in figure 34, for a peaked response of maximum amplitude (keep output to approximately .6 volt peak-to-peak for 30% modulation, or 2 volts peak-to-peak for 100% modulation).

4. Set the MARKER FREQUENCY control to 25.75 mc., and adjust L2 and L3 for maximum response.

5. Set the FUNCTION switch to MKR, and the MASTER OSC. BAND SWITCH to position A; adjust the MASTER OSC. APPROXIMATE CENTER FREQ. control to 25 mc., and set the SWEEP WIDTH control to position 7. Readjust L1, L2, L3, and L4, if necessary, to obtain a response curve similar to figure 35.

## NOTE

L2 and L3 shape the high-frequency slope and the video carrier position, while L1 and L4 control the band width and the flatness of the top.

It will be necessary to adjust the MASTER OSC. ATTEN. and the OUTPUT MULTIPLIER controls so as not to exceed the 2-volt peak-to-peak output during all the above adjustments, and to use the VERT. GAIN control to determine the amplitude of the c-r-tube presentation. Use the MARKER FREQUENCY control to check the points of change on the curve, adjusting the FUNCTION ATTEN. and VERT. GAIN controls to obtain a satisfactory marker signal. Do not leave the marker on the response curve when adjusting for proper shape, as it might cause some distortion of the response curve.

The sound-i-f alignment for either band pass or stagger-tuned picture receivers is similar, if not identical. Follow the general procedure as outlined in the example given in the next paragraph.

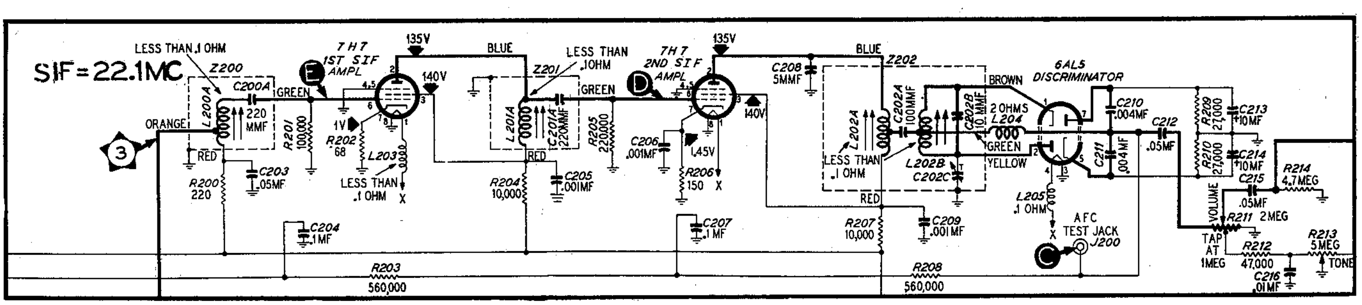
## Sound I.F.

1. Connect the output of Model 7008 to the grid of the mixer, as in the last step of the picture alignment. Connect the oscilloscope input through the low-frequency probe to the audio output of the sound detector (a-f-c test jack).

2. Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to 22.1 mc. (MASTER OSC. BAND SWITCH at A), and set the FUNCTION switch to the MKR position. Set the OUTPUT MULTIPLIER to MAX, and the MASTER OSC. ATTEN. control to position 10.

3. Adjust the discriminator secondary, L202B (see figure 36), until a signal appears on the c-r tube.

4. Set the balancing condenser, C202C, all the way in, and adjust L200A, L201A, and L202A, in order, for maximum signal on the c-r tube.




TP-6940

**Figure 36. — Sound I-F Schematic**

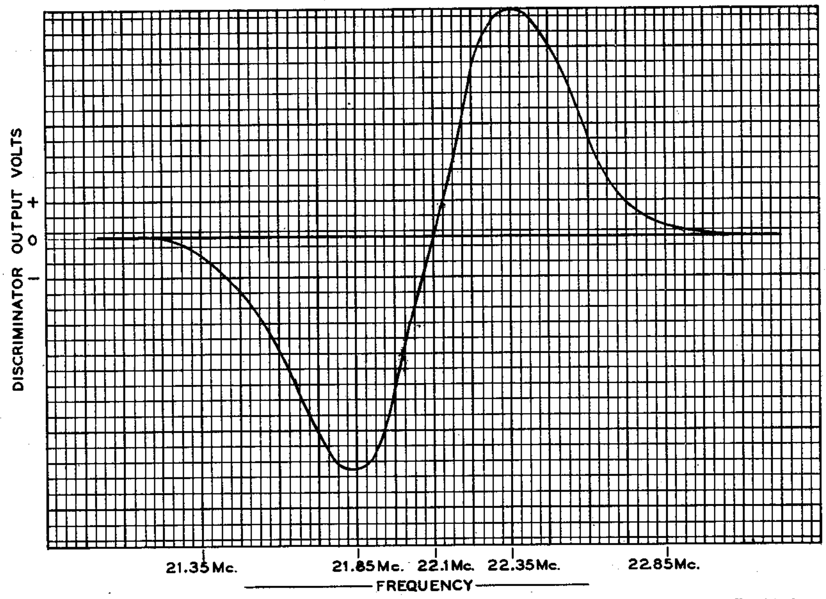



**Figure 37. — Discriminator Curve**

5. Adjust the discriminator secondary, L202B, and the balancing condenser, C202C, for a symmetrical response curve. Check for correct center frequency (see SETTING DISCRIMINATOR TO EXACT CENTER FREQUENCY). Retrim L200A, L201A, and L202A for a symmetrical response curve of maximum amplitude, similar to figure 37.

### NOTE

Balancing condenser C202C controls the phasing of the discriminator response. The polarity of response should be negative below the center frequency, and positive above the center frequency, for proper a-f-c operation; otherwise, the a-f-c will not lock in, and the receiver local oscillator cannot be set to hold the station.

6. Set the r-f (marker) generator to 22.1 mc. (use same method as for setting discriminator to exact center frequency) and connect Model 7008 output cable to test point F, figure 30; connect the input cable through the scope input leads to the align test jack (video detector output). Adjust accompanying-sound trap #2 (L309) for minimum signal.

### NOTE

Step 6 need only be made in those receivers containing two accompanying-sound traps.

## Final I.F. Check

To make certain that the discriminator and accompanying-sound traps are tuned to the same frequency (22.1 mc.), turn the FUNCTION switch to the AM RF position, and the FUNCTION ATTEN. control to position 10; connect a 20,000-ohms-per-volt meter to the a-f-c test jack. Connect the oscilloscope input to the align test jack, and the output cable to the input i-f grid (test point G, figure 30). Adjust the MARKER FREQUENCY control for minimum signal on the c-r tube; at this point the output of the discriminator should be zero.

## Video Trap

1. Connect the output cable of Model 7008 to the video detector output (align test jack), and the input cable through the high-frequency probe to the grid of the picture tube.

2. Adjust the video trap, L310 (see figure 38), for a minimum c-r tube response (see CHECKING VIDEO-TRAP ADJUSTMENT).

## Correct Oscillator Setting

The oscillator adjustment is repeated at the time of installation, being set for optimum conditions on the local television station. This adjustment should be set at the time of alignment, so that no trouble is experienced at the time of installation.

Connect the output of Model 7008 to the aerial terminals of the receiver through a matching network; connect the oscilloscope input through the scope input leads to the a-f-c test jack (output of discriminator), and set the FUNCTION switch to AM RF. Set the MARKER FREQUENCY control to the sound-carrier frequency of the television station for each channel for which coils are provided, and adjust the core of each oscillator coil to the correct sound carrier by tuning it for a minimum of 400-cycle Lissajou pattern on the c-r tube.

### NOTE

The picture-i-f response curve should be viewed and checked to see that the picture-i-f carrier is set to the 50% response point. If the response at the picture-carrier frequency is less, or more, than 50%, the alignment should be corrected until the proper response is obtained. The exact picture-

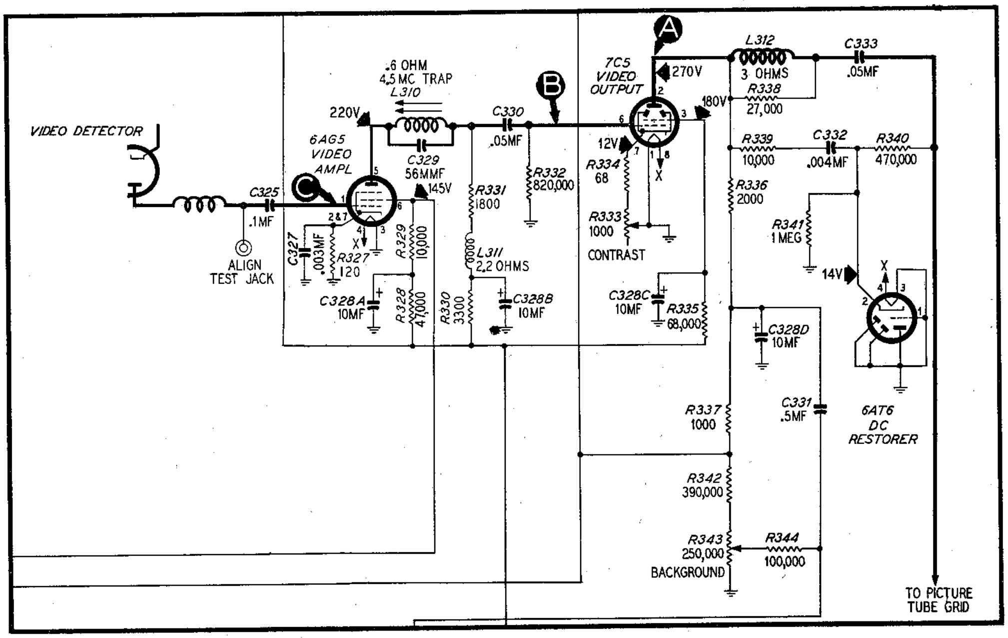



**Figure 38. — Video Amplifier Schematic**

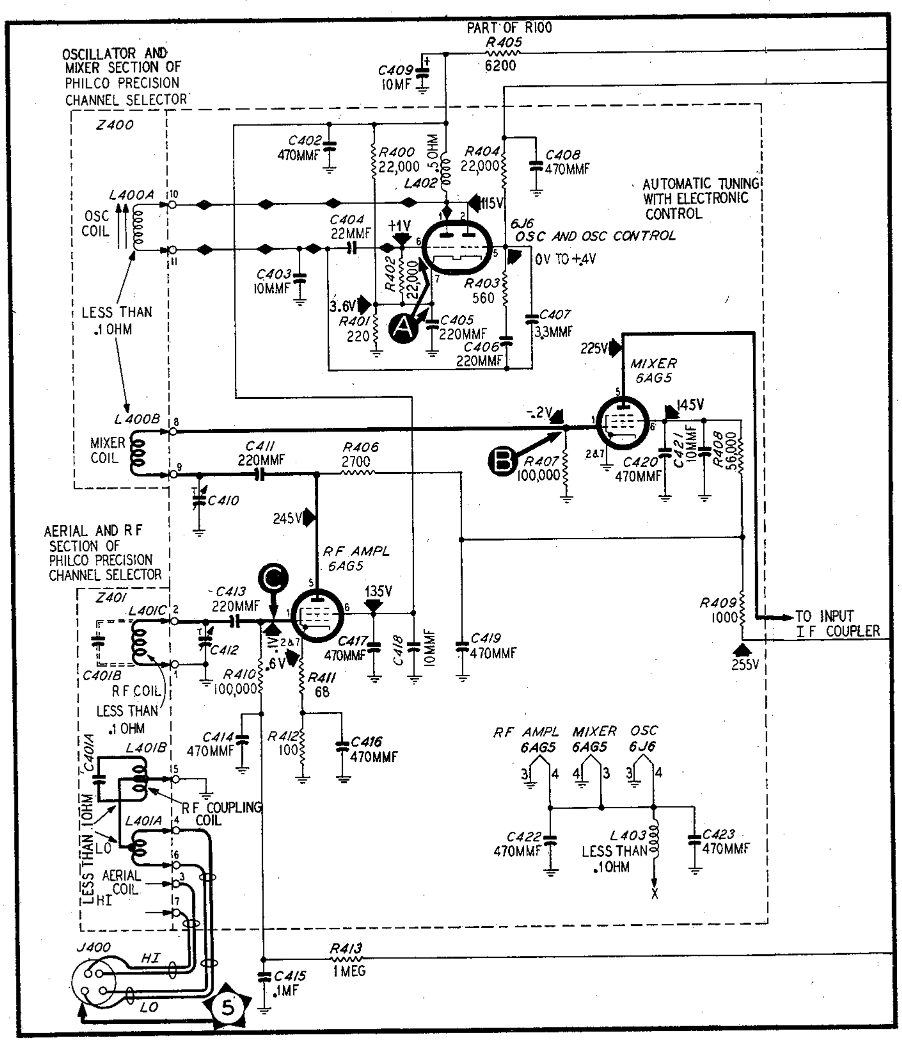



**Figure 39. — R-F and Mixer Schematic**

carrier location can be determined with the station on the air (provided the signal is of the proper strength) by coupling the receiver aerial very loosely to Model 7008; the beat between the station and Model 7008 will appear as a marker on the response curve.

The setting of the a-g-c adjustment should be left until the time of installation; the control should be temporarily set for maximum sensitivity at completion of the alignment.

## R.F. and Mixer

1. Connect the output cable of Model 7008 to the low-frequency aerial connections with a matching network, shown in figure 7.
2. Connect the input of Model 7008 through the scope input leads to the tuner test jack. Remove the first i-f tube and the horizontal-sweep and vertical-sweep generator tubes.
3. Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to the middle of channel 3 (63 mc.); set the SWEEP WIDTH control at about 10 megacycles, the OUTPUT MULTIPLIER at MAX, and the MASTER OSC. ATTEN. and VERT. GAIN controls as required for the desired height of the c-r-tube pattern.
4. Adjust the mixer trimmer, C410 (see figure 39), for double-peak response similar to curve 1 in figure 31, except that the peaks should occur at 60 and 66 megacycles.
5. Adjust r-f trimmer C412 for flat response (within 25%). Check each channel for which coils are provided. See also CHECKING R-F AND MIXER RESPONSE.

### NOTE

Should the discrepancy in response be greater than the specified 25%, it is possible to select coils which will be within the tolerance. It is normal for the response amplitude to decrease as the channels increase in number, channel 13 being least responsive. When checking the h-f channels, be certain to connect Model 7008 output cable to the high-frequency aerial terminals.

## Checking Transmission Lines

Model 7008 may be employed to measure various properties of transmission lines, such as standing-wave ratios, line impedance, line attenuation, velocity of propagation, and also the impedance match of r-f circuits.

It is important that the user thoroughly understand the methods of using Model 7008 for the above checks, and also that he understand the theory upon which the methods are based, to avoid possible misconceptions and the extreme errors which can easily be made. As an aid to this understanding, a few basic principles of transmission-line theory will be considered. For ease of presentation, and because of their present popularity, parallel-wire transmission lines will be discussed; however, the following also applies to the coaxial type, the inner conductor being considered as one wire, and the outer conductor as the other parallel wire.

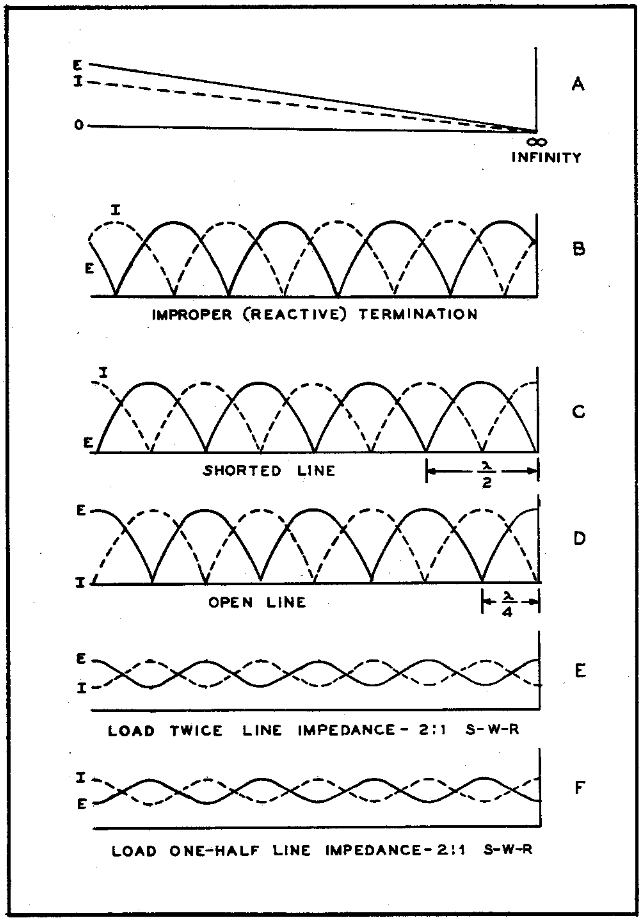
It is evident that a two-wire parallel transmission line possesses capacitance (between the conductors) and inductance, depending upon the length of the conductors. Since the spacing between the conductors is fixed, the inductance and capacitance can be considered as being equally distributed along the line. The formula for determining the characteristic impedance of a transmission line is $Z \text{ ohms} = \sqrt{\frac{L \text{ henries}}{C \text{ farads}}}$. If the line is connected to an r-f generator and terminated by a resistive load which is equal to the characteristic impedance of the line, the entire generator output is absorbed by the load (neglecting losses, and provided the input end of the line is matched to the generator). In this instance, the energy that leaves the generator never returns.

If the line were terminated in a resistive load not equal to the characteristic impedance of the line, or in a reactive load, or were unterminated, or shorted, some energy would be reflected back, and would return to the signal source.

Since there is no such thing as a perfect dielectric or a resistanceless conductor, it is evident that every type of line has a definite attenuation characteristic, depending upon the frequency and the length of the line. Thus, if the voltage could be measured at various points on an infinite line, it would be found to decrease progressively, and would eventually reach zero, the entire signal being absorbed by the losses in the line. See figure 40A.

Now consider a line which is not properly terminated in its characteristic impedance, and which is connected to an r-f generator. It can easily be seen that when the out-going signal reaches the end of the line, it will be reflected, either partially or totally (depending upon the degree of mismatch), back toward the source. The combination of outgoing and reflected signal produces "standing wave" of voltage along the line. See figure 40B. If the end of the line is shorted, the voltage at the short is low and the current is high, and the first voltage minimum occurs at a point which is, electrically, one-half wave back from the end of the line. See figure 40C. If the end of the line is open, the voltage at the end is high and the current is low, and the first voltage minimum occurs at a point which is one-quarter wave back from the end of the line. See figure 40D. In the above illustrations, the voltage minimums reach zero, which is due to the fact that the effect of attenuation has been disregarded, and the reflection is assumed to be complete. If there is a load impedance mismatch other than an open or a short, the standing-wave ratio of $\frac{\text{maximum voltage}}{\text{minimum voltage}}$ indicates the ratio of mismatch of the load. That is, a 2:1 standing-wave ratio (s.w.r.) would indicate a terminating impedance of either ½, or 2 times, the characteristic impedance of the line. See figures 40E and 40F. If the load has an appreciable reactive component, the standing-wave ratio is only an approximate indication of the impedance mismatch.

Ordinarily, in order to measure the standing waves for any particular frequency, one must move along the line with an r-f voltage detecting device, but this method requires special and complicated apparatus. The same results can be achieved by changing the frequency progressively (to effectively change the electrical length




TP-6934

**Figure 40. — Effects of Line Termination**

of the line) and causing the alternate points of maximum and minimum voltage to appear at the input end of the line. Thus, if the frequency is sufficiently high, and the line is long enough, a detector placed at the input end of the line will indicate this effect, and a very good approximation of the standing-wave ratio may be obtained. The picture appearing on the oscilloscope of Model 7008 *is not,* of course, the standing wave existing along the line; it is, however, a representation of the voltage existing at the input end of the line as the frequency of the applied voltage is changed.

## Determining Standing-Wave Ratio

By means of the base line, obtained by using the blanking circuit of Model 7008, an absolute value of the ratio of maximum to minimum voltage may be obtained. This ratio is known as the standing-wave ratio

$$\left(\text{s.w.r.} = \frac{\text{E max}}{\text{E min}}\right).$$

Strictly speaking, E max and E min should be measured at the same frequency; if the frequency separation of E max from that of E min is not too great, however, the error introduced will be small. Since the number of cycles visible on Model 7008 c-r tube depends upon the length of the line as well as the frequency deviation, the line should be made as long as possible between the input and the load whose matching characteristics are being observed. The frequency at which the s.w.r. indication is a minimum, as checked by means of the marker, is that at which the load is a better match for that particular line, because more of the energy is being absorbed by the load, and less reflected back to the input.

Note particularly that both the line attenuation and the degree of mismatch determine E min, and thus affect the s.w.r. That is, a line having great losses would reduce the amount of voltage available at the end of the line, so that the reflected signal could be so greatly at-

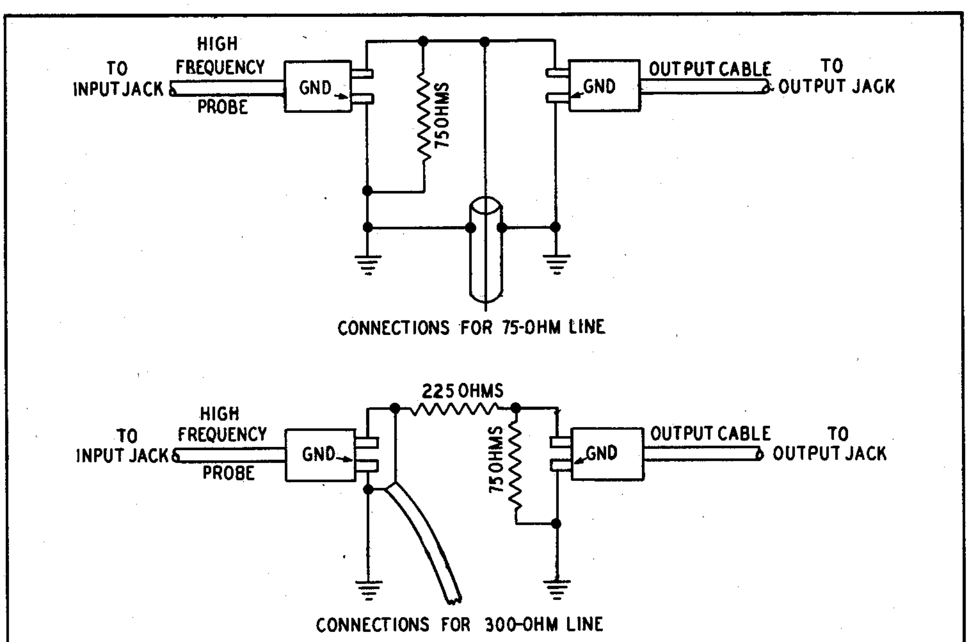



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**Figure 41. — Connections for 75-Ohm and 300-Ohm Lines**

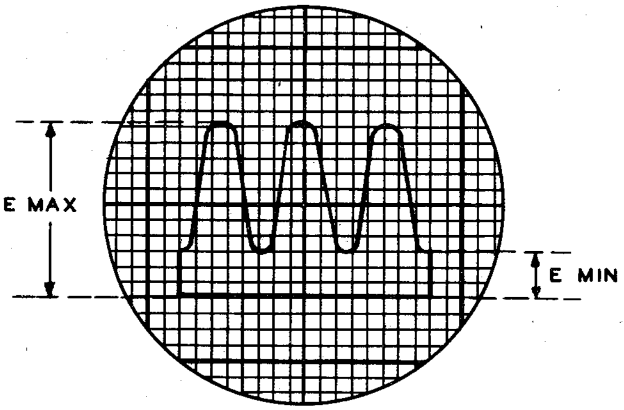


**Figure 42. — Checking Standing-Wave Ratio**

tenuated that it would have little or no effect on the input signal. Thus the s.w.r might appear to indicate an almost perfect match, due to the great attenuation, even though the line were badly mismatched. For example, with 1 volt at the input, assume that this is attenuated to ½ volt at the end of the line; further assume a mismatch of load which reflects 10% of the ½-volt signal. Then 10% of the ½ volt would be returned to the input, meanwhile being reduced again by line attenuation, to one-half its value, so that the reflected-signal amplitude would be only .025 volt at the input end, and the amplitude of the combined signal would appear as .975 volt as compared with the original 1.000 volt. Even with a 100% mismatch, the reflected voltage at the input would only be changed by 25%, or 4:1, so that "lossy" lines can introduce quite an appreciable error.

High second-harmonic content of the signal can also cause an appreciable error by distorting the apparent waveform seen on the c-r tube so that true maximum and minimum peaks are not obtained.

To determine the s.w.r. with Model 7008, connect the output cable to the oscilloscope input through the high-frequency probe, as shown in figure 41, and connect the transmission line through an appropriate matching network to the junction of these cables. The transmisson line should be terminated by the matching network to be checked. Use the blanking circuit, being certain to adjust the PHASING and BLANKING controls for a single image. Set the OUTPUT MULTIPLIER to MAX, and the MASTER OSC. ATTEN. and SWEEP WIDTH controls to position 10, and use the VERT. GAIN control to obtain a pattern of the desired height. Count the number of crosshatch division between the base line and E max and between the base line and E min, and divide the first number by the second to obtain the s.w.r. See figure 42.

## NOTE

It is recommended that this check be performed only on Band B of the master oscillator, where only fundamental frequencies are present.

## Determining Characteristic Impedance of Transmission Lines

If the transmission line is terminated in a load equal to its characteristic impedance, all the energy (except that lost in the line) will be absorbed by the load, and nothing will be reflected back to the input.

Connect Model 7008 as shown in figure 41. Set the FUNCTION switch to the OFF position. Set the OUTPUT MULTIPLIER control to MAX, and MASTER OSC. ATTEN. control to position 10; set the VERT. GAIN control for a desirable height of presentation. Adjust the MASTER OSC. APPROXIMATE CENTER FREQ. control to the center of the band over which the line is to be used, and make the check with the SWEEP WIDTH control set as high as necessary.

To find the characteristic impedance, place different non-inductive resistance units across the end of the line until a minimum standing-wave ratio indication is obtained, which is very nearly a straight line. See figure 43. To make this measurement a rapid one, a small carbon (non-inductive potentiometer may be placed across the end of the line, and its resistance varied until a minimum s.w.r. indication is obtained. Then measure the resistance with an ohmmeter. Care must be taken at all times to maintain very short and positive connections.

It is also possible to determine at what frequencies an r-f impedance with a frequency characteristic matches a given transmission line. Assume that it is desired to determine the frequency or frequencies at which a particular impedance matches a 300-ohm line. Place the impedance across the far end of the transmission line, and connect Model 7008 to the line as shown in figure 41. Set the FUNCTION switch to OFF, the OUTPUT MULTIPLIER to MAX, and the MASTER OSC. ATTEN. control to position 10. Adjust the VERT. GAIN control for a desirable height of presentation, with the SWEEP WIDTH control set as high as necessary; vary the MASTER OSC. APPROXIMATE CENTER FREQ. control over its complete range on Band B. It will be found that, if the impedance match takes place within

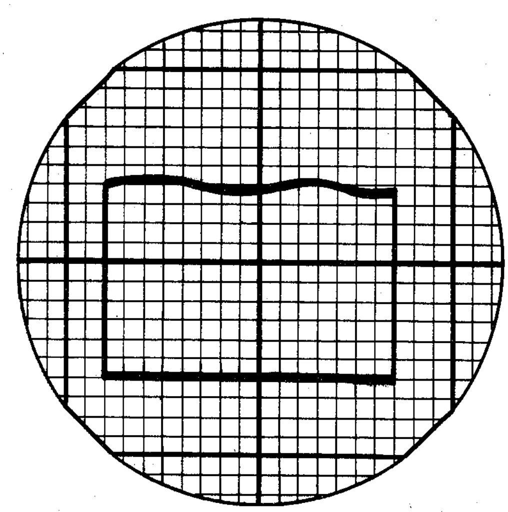


**Figure 43. — Correct Line Termination**

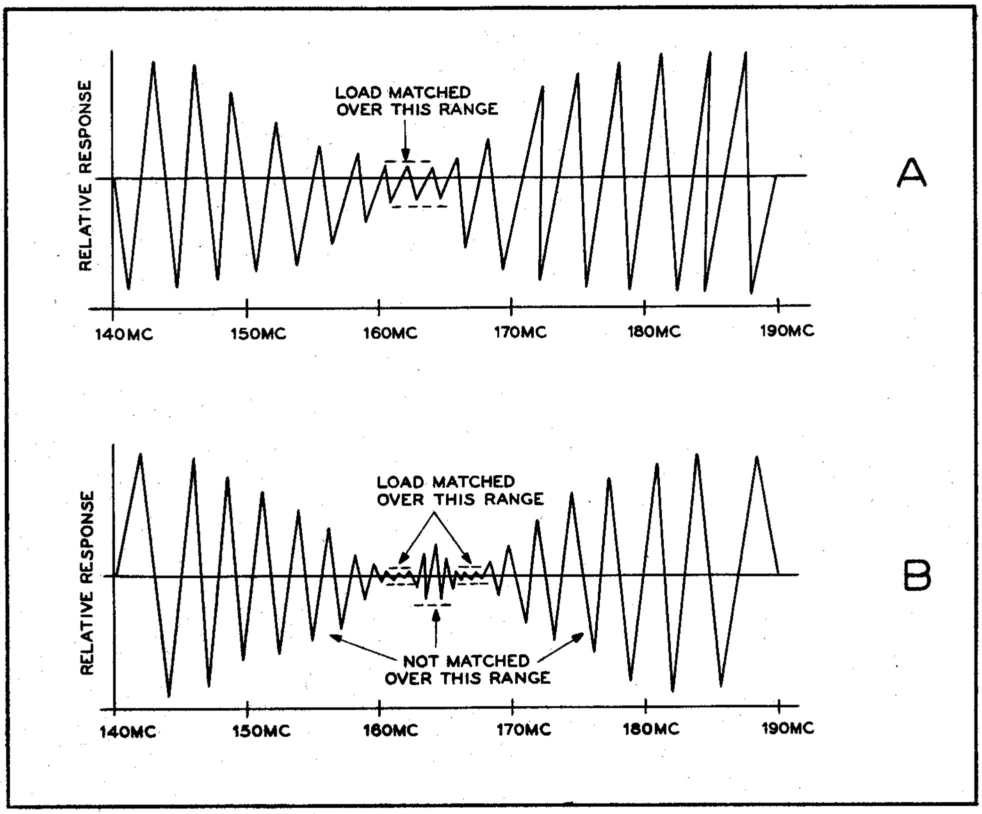


**Figure 44. — Impedance Variation With Frequency**

the range of the master oscillator, the standing-wave ratio will vary as the master oscillator center frequency is changed, and will be a minimum at the frequency for which the impedance equals 300 ohms. Figure 44A shows the condition where a match occurs at only one frequency, while figure 44B shows the condition where a match occurs at two different frequencies.

## Determining Transmission-Line Attenuation

The attenuation of a line will not only cause the output signal to be decreased in amplitude as it advances down the line, but will also decrease the amplitude of the reflected wave, if present. If the end of the line is left open, or is short-circuited, so that *all* the energy that reaches the end of the line is reflected back, the s.w.r. existing at the input end will be a measure of the line attenuation. The attenuation in db per foot is given by the following formula:

$$\text{Atten.} = \frac{20 \log_{10} \dfrac{(E\ max + E\ min)}{(E\ max - E\ min)}}{2\ L}$$

where E max is the number of crosshatch divisions above the base line at voltage maximum

E min is the number of crosshatch divisions above the base line at voltage minimum

L is the length of the line in feet

Extreme care should be taken to make all connections as short as possible.

## Determining the Velocity of Propagation

The speed with which an r-f wave travels along the line will, in general, be different from its velocity in air, so that the wavelength along the line will also be different in the same ratio. This ratio, or *velocity constant,* may be obtained by measuring the frequency from peak to peak, or valley to valley, by means of the marker circuit, and applying the following formula (see figure 45):

$$\text{Vel. Prop. constant} = \frac{L \times \triangle f}{492}$$

where L is the length of the line in feet

$\triangle$ f is the frequency difference from peak to peak, or valley to valley, in megacycles

To increase the accuracy of measurement, the frequency difference between several cycles on the c-r tube may be obtained, and divided by the number of cycles, to obtain an average.

Multiplying the Vel. Prop constant by 100 gives the velocity of propagation in percent of the speed in air.

Conversely, if the velocity-of-propagation constant is known for a particular transmission line, its actual length in feet may be determined by noting the frequency difference between cycles on the oscilloscope of Model 7008 by means of the marker, and applying the following formula:

$$L\ (\text{ft.}) = \frac{492 \times \text{Vel. Prop. constant}}{\triangle f}$$

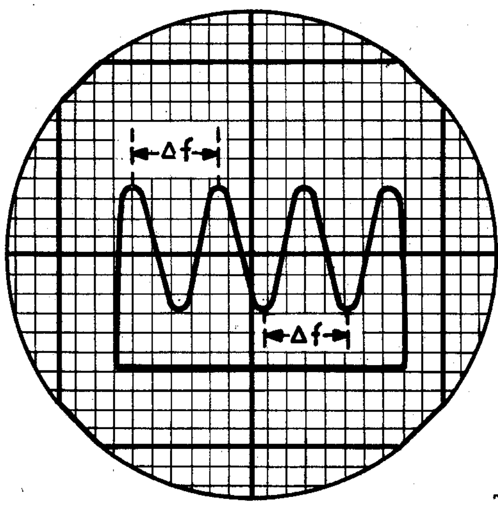


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**Figure 45. — Checking Velocity of Propagation**

## TUBE REPLACEMENT

If the tubes (other than the c-r tube) require replacement, it will be necessary to remove the front-panel screws, and take the instrument from its case. Before removing the instrument from its case, be certain to remove the power cord. When replacing tubes in the FM and AM generators, it will be necessary to recheck the calibration, as outlined below.

It is not necessary to remove the instrument from its cabinet when replacing the c-r tube. Remove the six screws holding the side cover on the c-r tube housing (tube in carrying position). See figure 46. Then loosen the clamp screws inside the housing, and loosen the two mounting-bracket screws. Turn the housing to the operating position and remove the two screws on the side opposite that from which the cover was removed. Turn the housing to the carrying position, and remove the tube and bracket assembly, pushing the c-r tube toward its socket, if necessary, to clear the front edge of the housing. When the tube and bracket assembly are removed from the housing, pull the c-r tube from its socket. Upon replacing, be certain that the c-r tube face presses against the rubber shock mounts; check for horizontal alignment of the tube, and then tighten the c-r tube clamp screw.

## REMOVING CROSSHATCH SCREEN

Should it be desired to operate the instrument without the crosshatch screen, it may be grasped with a pair of flat-head pliers from the rear of cabinet, with the housing in the carrying position, and removed.

## CALIBRATION ADJUSTMENTS

Model 7008 contains a crystal calibrator which is convenient and easy to use, and offers a quick means of checking calibration. Both the AM generator and the FM generator will require calibration if parts are removed or replaced. The AM (marker) generator should be calibrated by using an external signal, as outlined below, and the FM generator can then be calibrated by comparison with the r-f (marker) generator.

A separate trimmer condenser is provided for each r-f band, for correcting the dial calibration of Model 7008. Remove the generator from its case, as for replacement of tubes; the adjusting trimmers are located as shown in figure 47. It is necessary to use a calibrated signal source for obtaining a "standard" signal against which the marker-signal frequency of Model 7008 can be compared. Any one of the following combinations may be used, according to the equipment available.

1. A crystal-controlled heterodyne frequency meter. Connect as shown in figure 48A.

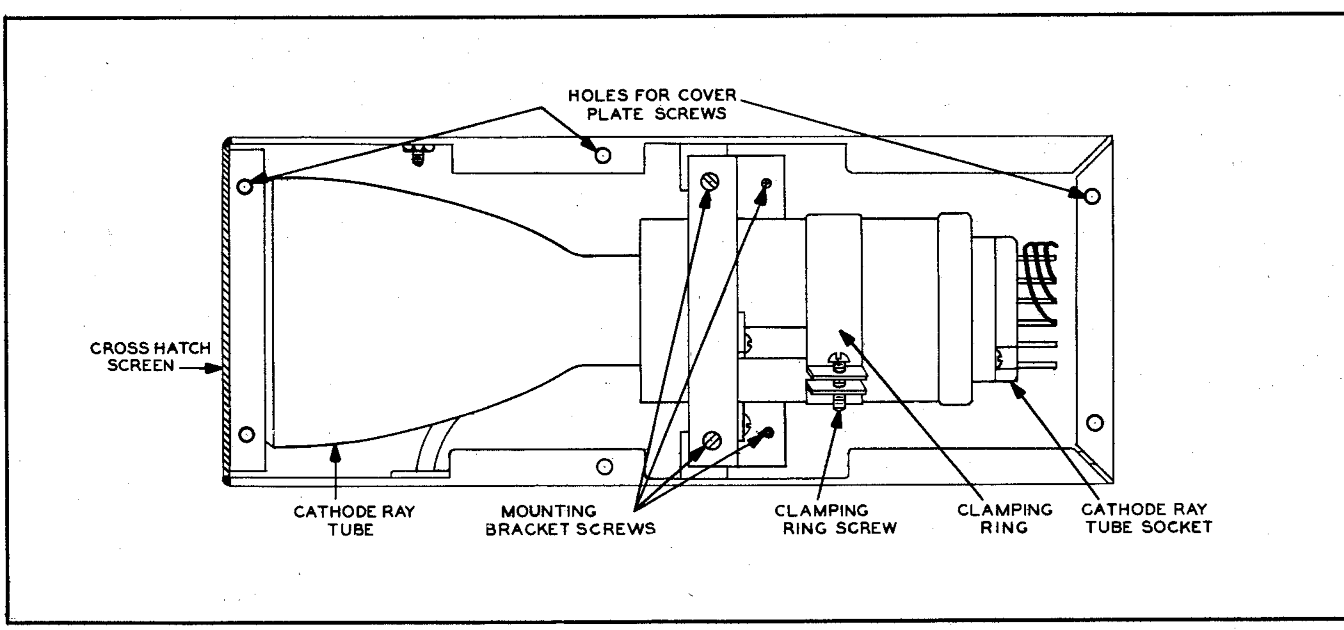


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**Figure 46. — C-R-Tube Mounting Details**

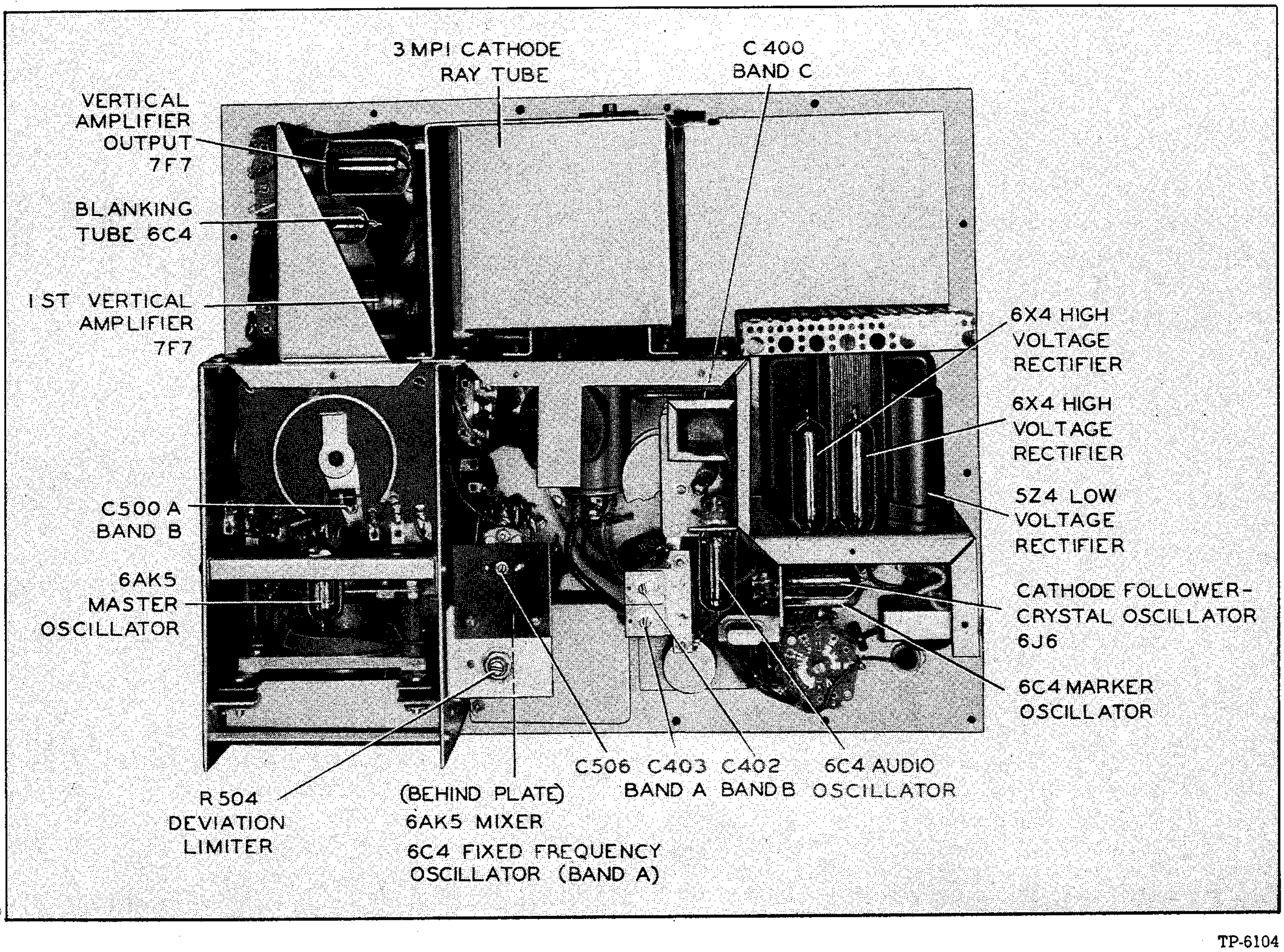


**Figure 47. — Rear View of Model 7008, Showing Calibration Adjustments**

2. Another r-f signal generator, known to be accurately calibrated, and a radio capable of tuning to the frequencies used. Connect as shown in figure 48B.
3. Another r-f signal generator, known to be accurately calibrated and the high-frequency probe and oscilloscope portion of Model 7008. Connect as shown in figure 48C.
4. If the calibration is only off by very slight amount, the trimmers may be adjusted by using the signal of the internal 5-mc. crystal calibrator; set the FUNCTION SWITCH to CAL, and adjust while observing the beat pattern on the c-r tube.

No special sequence of adjustments need be observed, since each trimmer and coil circuit is independent of the others; calibration points are as follows:

R-F (Marker) Generator

| | |
|---|---|
| Band A | 7.5 mc. |
| Band B | 36 mc. |
| Band C | 125 mc. |

Allow the signal generator, Model 7008, and associated equipment to warm up for at least 15 minutes. Turn off the audio modulation, set the standard signal generator to the desired point, and tune in the signal on the radio or listen on the heterodyne frequency meter while adjusting Model 7008 for zero beat against the standard signal.

Set the MARKER FREQUENCY control of Model 7008 to the correct calibration point (use the central pointer index line) with the MARKER BAND SW. set to the proper band. Turn the correct calibrating trimmer until the beat signal is heard in the radio or the heterodyne frequency meter; then carefully adjust the trimmer for zero beat. Make these adjustments for each band.

When using the high-frequency probe and oscilloscope of Model 7008 a visual beat pattern will be observed on the screen of the c-r tube; the adjustment should be made as close to zero beat as possible.

The FM (master osc.) generator should be calibrated as follows:

Connect the high-frequency probe to the INPUT jack on Model 7008, and connect the output cable to the high-frequency probe. Set the FUNCTION ATTEN. and MASTER OSC. ATTEN. controls to position 10. Set the OUTPUT MULTIPLIER control to MAX, the SWEEP WIDTH control to zero, and the MASTER OSC. BAND SWITCH to position B. Oscilloscope controls should be set in their normal operating positions and the POWER switch turned ON.

Adjust the MARKER FREQUENCY control to exactly 145 mc., checking this frequency in the CAL position of the FUNCTION switch. Set the MASTER OSC.

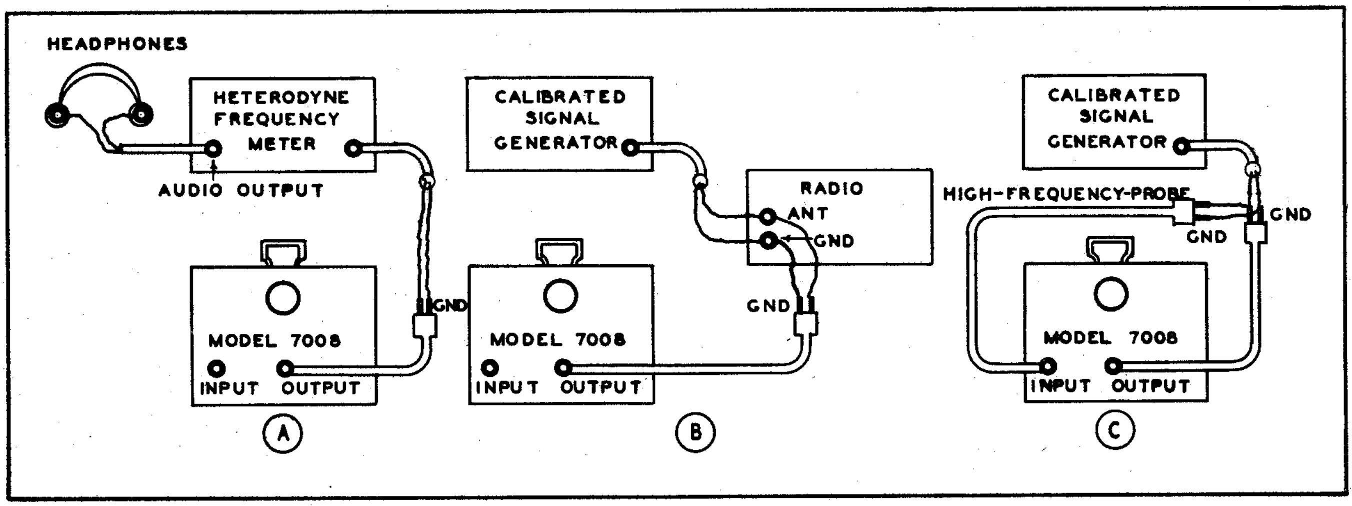


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**Figure 48.—Combinations of Equipment for Calibrating Model 7008**

APPROXIMATE CENTER FREQ. control to 145 mc., and turn the FUNCTION switch to MKR. Adjust trimmer C500A slowly for a zero-beat pattern on the oscilloscope. See figure 49. When adjusted correctly, the FUNCTION switch may be turned from MKR to CAL position with little or no change in the pattern. Should the trimmer not be set within 100 kc. of the marker frequency, the pattern will disappear when switching from MKR to CAL positions.

Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to 250 mc. Then adjust the MARKER FREQUENCY control for exactly 250 mc., using the CAL position of the FUNCTION switch to determine the exact setting, and adjust the MASTER OSC APPROXIMATE CENTER FREQ. control for zero beat, as observed on the oscilloscope. If the pointer central index line of the master oscillator is no longer set at 250 mc., loosen the pointer setscrews, adjust the pointer for 250 mc., and tighten the setscrews (be certain the zero-beat pattern still remains). Then set the pointer for 145 mc., and the marker generator to 145 mc., and adjust trimmer C500A for a zero-beat pattern. Recheck the 250-mc. setting and the 145-mc setting, if necessary.

Turn the MASTER OSC. BAND SWITCH to Band A. Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to 145 mc. Adjust the MARKER FREQUENCY control to exactly 140 mc., using the CAL position of the FUNCTION switch. Turn the FUNCTION switch to the MKR position. Now adjust trimmer C506 to zero beat with the marker circuit. Should this trimmer not be set within 100 kc. of the marker frequency, the pattern will disappear from the screen when the FUNCTION switch is turned from the MKR to the CAL position. This 140-mc. beat should disappear in the MKR position when the MASTER OSC. BAND SWITCH is switched from Band A to Band B.

A complete recheck of the above three frequencies (140 mc., 145 mc., 250 mc.) should be made, as the above adjustments are interlocking to a small extent, and appropriate readjustment made if necessary.

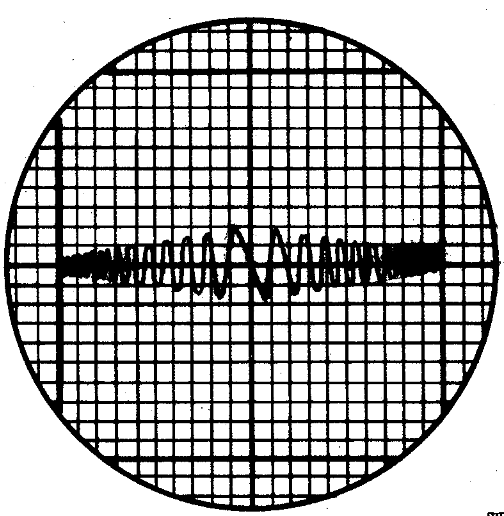

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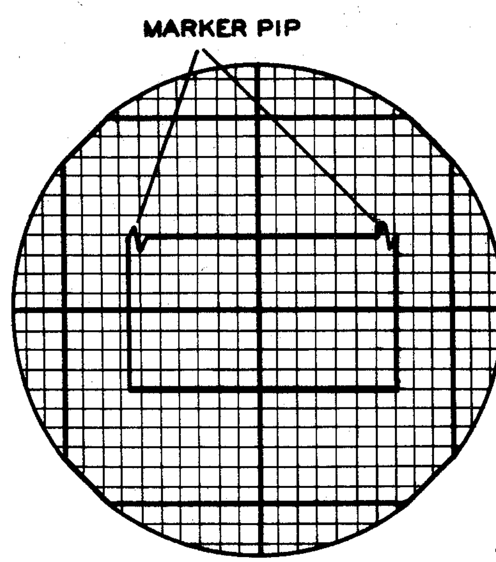
**Figure 49.—Zero-Beat Pattern**




TP-6928C

**Figure 50.—Checking Sweep Width**

## CHECKING SWEEP WIDTH

Maximum sweep width is determined by the setting of the internal Deviation Limiter control, which fixes the maximum voltage applied to the sweep coil. Connect the high-frequency probe to the output of Model 7008, set the MASTER OSC. BAND SWITCH to B, the OUTPUT MULTIPLIER control to MAX., the MASTER OSC. ATTEN. control to 10, the FUNCTION ATTEN. control to 10, the MARKER BAND SW. to C, the SWEEP WIDTH control to 10, the FUNCTION switch to MKR, and the VERT. GAIN to 2. Leave the BLANKING control OFF.

Set the MASTER OSC. APPROXIMATE CENTER FREQ. control to 160 mc., and vary the MARKER FREQUENCY control until the marker pips appear on the c-r-tube presentation. Adjust the PHASING control until the marker pips coincide. Then determine the points at each edge of the pattern where the marker disappears, by varying the marker frequency. See figure 50. The difference in frequency between these points is the measure of sweep deviation. The deviation Limiter control should be adjusted for a maximum of 15 mc. sweep deviation at 160 mc., and the visible movement of the sweep coil should be observed, to see that it does not exceed 5/32″.

It may be observed that greater deviation can be obtained by exceeding the 5/32-inch sweep-coil movement; however, such excessive vibration will tend to reduce the life of the sweep assembly, and is not recommended.

## THE PHILCO TROUBLE-SHOOTING PROCEDURE FOR MODEL 7008

The Philco trouble-shooting procedure for Model 7008 is logical, thorough, and easy to follow; it conforms generally to the Philco trouble-shooting procedure employed in servicing other types of electronic equipment. The basis of the Philco procedure is:

First, localization of the trouble to a functional section or block of circuits.

Second, isolation of the faulty circuit, or stage, within that section.

Third, location of the defective part within that circuit.

The instrument is divided into six functional sections or blocks of circuits, as follows.

Section 1—the power-supply circuits
Section 2—the audio circuits
Section 3—the vertical amplifier circuits
Section 4—the r-f (marker) generator circuits
Section 5—the FM generator circuits
Section 6—the sweep and blanking circuits

In the Philco trouble-shooting procedure, localization of the trouble to a functional section is accomplished, if possible, by the OPERATIONAL CHECKS. Charts are given to help the serviceman make this check quickly and accurately. Practically all the troubles that occur in the instrument will result in abnormal presentation or loss of a given pattern. By simply adjusting the controls and observing the resulting patterns on the cathode-ray tube as directed, the trouble can often be localized to a functional section without the need of extensive testing.

If the trouble cannot be localized by the OPERATIONAL CHECK, it can be localized by the TEST POINT ANALYSIS. To aid in this analysis, the parts in the schematic diagram, chassis views, and replacement parts list are symbolized according to the section numbers, and a trouble-shooting chart is given for each section. Each sectional chart refers to one or more "major" test points (numbers within stars) and a subordinate group of "key" test points (letters within circles), which are indicated on the schematic diagram and chassis views. A few tests at the major test points throughout the instrument, as directed in trouble-shooting charts, will definitely localize the trouble to a particular section and eliminate other sections from suspicion.

After the trouble has been localized to a section, either by the OPERATIONAL CHECK or the TEST POINT ANALYSIS, a few additional tests at the key test points, specified in the chart for that section, will isolate the faulty circuit. The defective part can then be located by simple voltage and resistance measurements, and in some cases by wave-form checks. Trouble revealed by any test should be corrected before testing further.

### IMPORTANT

To insure proper operation, all repairs should be made with exact replacement parts, and the new part should be located in the same position from which the original part was removed. If it is necessary to temporarily move parts or wiring to make a repair, be sure to restore the parts and wiring to the original positions after the repair has been made.

### OPERATIONAL CHECK

NOTE: Do not make an operational check if the symptoms indicate that the instrument may be further damaged by the application of power—proceed with the TEST POINT ANALYSIS, page 39.

If the unit can be safely turned on, connect the power cord to the a-c jack in the left side of the cabinet and to a convenient a-c power outlet. Place the cathode-ray-tube housing in its operating position, connect the output cable to the OUTPUT jack, and connect the scope input leads to the INPUT jack. Turn the POWER switch to the ON position, and set other controls as follows:

| CONTROL | POSITION |
|---|---|
| *Horiz. Cent.* | Center |
| *Focus* | Center |
| *Vert. Cent.* | Center |
| *Horiz. Cent.* | Center |
| *Intensity* | Three-fourths clockwise |
| *Phasing* | Center |
| *Blanking* | OFF |
| *Horiz. Gain* | 4 |

| | |
|---|---|
| *Vert. Gain* | 2 |
| *Marker Band Sw.* | A |
| *Master Osc. Band Switch* | OFF |
| *Sweep Width* | 0 |
| *Function* | OFF |
| *Function Atten.* | 10 |
| *Output Multiplier* | MAX. |
| *Master Osc. Atten.* | 10 |

After any control is varied according to the instructions in the chart, it should be returned to the position indicated above.

## OPERATIONAL CHECKS

Steps 1 through 6 clear the power supply, oscilloscope, and vertical amplifier of suspicion of trouble. After these steps are completed, the vertical amplifier and oscilloscope can be used to check the operation of the remaining circuits in the instrument.

| STEP | INSTRUCTIONS | NORMAL INDICATION | REFERENCE |
|---|---|---|---|
| 1 | Vary FOCUS control over complete range. | Trace becomes clear, sharp line at approximate center of control range. | If normal indication is not obtained, refer to Section 1 trouble-shooting chart. |
| 2 | Vary INTENSITY control over complete range. | Trace becomes visible at center of control range, and progressively brighter toward clockwise limit of control. | If normal indication is not obtained, refer to Section 1 trouble-shooting chart. |
| 3 | Vary HORIZ. CENT. and VERT. CENT. controls over complete range. | Trace moves screen from one extremity to other. | If normal indication is not obtained, refer to Section 1 trouble-shooting chart. |
| 4 | See Note 1. Vary VERT. GAIN control toward position 10. | Pattern on screen increases in amplitude vertically. | If normal indication is not obtained, refer to Section 3 trouble-shooting chart. |
| 5 | Vary HORIZ. GAIN control from 0 to 10. | Trace increases in amplitude horizontally from a bright spot to a line across screen. | If normal indication is not obtained, refer to Section 6 trouble-shooting chart. |
| 6 | See Note 1. Vary PHASING control over its complete range. | Elliptical pattern collapses into a single diagonal trace and opens up again when control is advanced further. | If normal indication is not obtained, refer to Section 6 trouble-shooting chart. |
| Step 7 clears the marker oscillator, the crystal oscillator, and the cathode follower. | | | |
| 7 | Place FUNCTION switch in CAL position, and adjust MARKER FREQUENCY control over complete range (all bands). | Zero-beat patterns are obtained at 5-mc. points (and other harmonically related combinations) over complete range of marker oscillator. | If normal indication is not obtained, refer to Section 4 trouble-shooting chart. |
| Step 8 clears the audio oscillator | | | |
| 8 | See Note 2. Place FUNCTION switch in 400-cycle position. | Lissajou pattern, 400:60, appears on screen. | If normal indication is not obtained, refer to Section 2 trouble-shooting chart. |
| 9 | With connections as indicated in step 8, vary FUNCTION ATTEN. control. | Pattern decreases in amplitude gradually, becoming zero at 0 position of control. | If normal indication is not obtained, refer to Section 4 trouble-shooting charts. |
| 10 | See Note 3. Place FUNCTION switch in AM RF position. Vary MARKER FREQUENCY control over complete range. | The 400-cycle modulation appears on screen as 400:60 Lissajou pattern. | If normal indication is not obtained, refer to Sections 2 and 4 trouble-shooting charts. Check high-frequency probe. |
| Step 11 determines whether the master oscillator is operating on both frequency bands. | | | |
| 11 | See Note 3. Set master oscillator to several different frequencies on each band and adjust marker oscillator to same frequencies. | Zero-beat pattern (beat between master oscillator and marker oscillator) appears on screen. | If normal indication is not obtained, refer to Section 5 trouble-shooting chart. |

## OPERATIONAL CHECKS (Cont.)

| STEP | INSTRUCTIONS | NORMAL INDICATION | REFERENCE |
|---|---|---|---|
| 12 | See note 3. Place MASTER OSC. BAND SWITCH in position B, turn BLANKING control on, and adjust for normal indication. | At some setting of BLANKING control, a rectangular pattern composed of two bright horizontal traces with two thin vertical lines (retrace) at either end appears on the screen. (See Note 4.) | If normal indication is not obtained, refer to Section 6 trouble-shooting chart. |
| Step 13 determines whether the FM oscillator is being modulated sufficiently. | | | |
| 13 | See note 3. Place FUNCTION switch in MKR position, SWEEP WIDTH to 10, MASTER OSC. BAND SWITCH to first A, and then B. Adjust PHASING control for marker-pip coincidence. Select a center frequency on the high and low end of each band; check frequency swing with marker generator. | The MARKER FREQUENCY control should require a change of at least 10 mc. to move the marker pip from beginning to end of the response curve. | If normal indication is not obtained, refer to Section 5 trouble-shooting chart. |
| 14 | With connections for checking blanking circuits as indicated in step 12, vary MASTER OSC. ATTEN. and OUTPUT MULTIPLIER. | As Master OSC. ATTEN. is varied, the two horizontal lines on screen approach each other gradually. As OUTPUT MULTIPLIER is varied, separation between lines changes in steps of 10. | If normal indication is not obtained, refer to Section 5 troubleshooting chart. |

Note 1: Grasp the alligator clip at the end of the red input lead, in order to provide an a-c signal input to the vertical amplifier and obtain a pattern on the cathode-ray-tube screen.

Note 2: Connect the scope input (low frequency) lead to the terminals of the output cable, and set the FUNCTION ATTEN. control to position 5.

Note 3: Connect the high-frequency probe to the input jack and connect it to the output cable with short pieces of wire; set the FUNCTION ATTEN. control to position 10.

Note 4: The spacing between the two bright traces will change as the MASTER OSC. APPROXIMATE CENTER FREQ. control is varied.

## TEST POINT ANALYSIS
### Trouble-Shooting Chart for Section 1

Use a 20,000-ohms-per-volt voltmeter for all checks in this section. (Line voltage, 117v.)

| +400v SUPPLY | | | |
|---|---|---|---|
| STEP | TEST POINT | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
| 1 | 1 | +170 volts, d.c. | If normal, proceed with step 6.<br>If abnormal, proceed with step 2. |
| 2 | A | 117 volts, a.c. | Incorrect line voltage. Defective: S100, J100, W100, C101, C102. |
| 3 | B | 640 volts, a.c. | Defective: T100, 5Z4. |
| 4 | C | +400 volts, d.c. | Defective: C100A, 6X4, R107. |
| 5 | 1 | +170 volts, d.c. | Defective: R105, R106, R107, R108, R109, R110, R111, R112, R113. |
| —400v SUPPLY | | | |
| 6 | 2 | —435 volts, d.c. | If normal, proceed with step 9.<br>If abnormal, proceed with step 7. |
| 7 | D | 310 volts, a.c. | Defective: R114. |
| 8 | 2 | —435 volts, d.c. | Defective: 6X4, C103, R100, R101, R102, R103, R104. |

## TEST POINT ANALYSIS (Cont.)

### Trouble-Shooting Chart for Section 1 (Cont.)

| +250v SUPPLY | | | |
|---|---|---|---|
| STEP | TEST POINT | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
| 9 | 3 | +255 volts, d.c. | If abnormal, proceed with step 10. |
| 10 | E | +255 volts, d.c. | Defective: 5Z4. |
| 11 | 3 | +255 volts, d.c. | Defective: L100, C100B. |

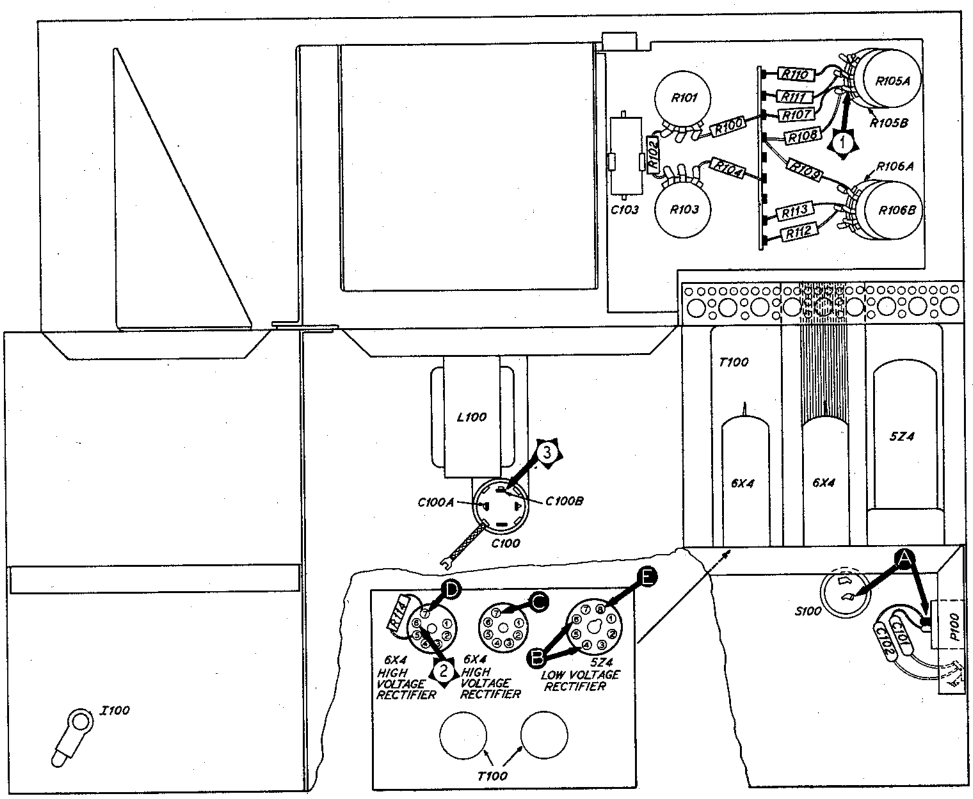



**Figure 51.—Rear View, Showing Section 1 Test Points**

### Trouble-Shooting Chart for Section 2

Set the FUNCTION switch to the 400-cycle position. Use a 20,000-ohms-per-volt, d-c voltmeter (1000 ohms-per-volt a-c voltmeter) for all checks in this section. (Line voltage, 117v.)

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 1 | 4 | | 60 volts, a.c., 400 cycles (on 250v a-c range). | If normal, trouble is not in this section. If abnormal, proceed with step 2. |
| 2 | A | Use .1-mf. blocking condenser in series with test lead. | 125 volts, a.c., 400 cycles (235 volts, d.c.). | Defective: T200. Shorted: C202. Open: R201. |
| 3 | B | | 13 volts, d.c. | Defective: 6C4. Open: R200. |

## TEST POINT ANALYSIS (Cont.)
## Trouble-Shooting Chart for Section 2 (Cont.)

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 4 | C | | 60 volts, a.c., 400 cycles (on 250v a-c range). | Defective: C200. |
| 5 | 4 | | 60 volts, a.c., 400 cycles (on 250v a-c range.) | Defective: Contact on WS3-2 (F). Shorted: C200. |

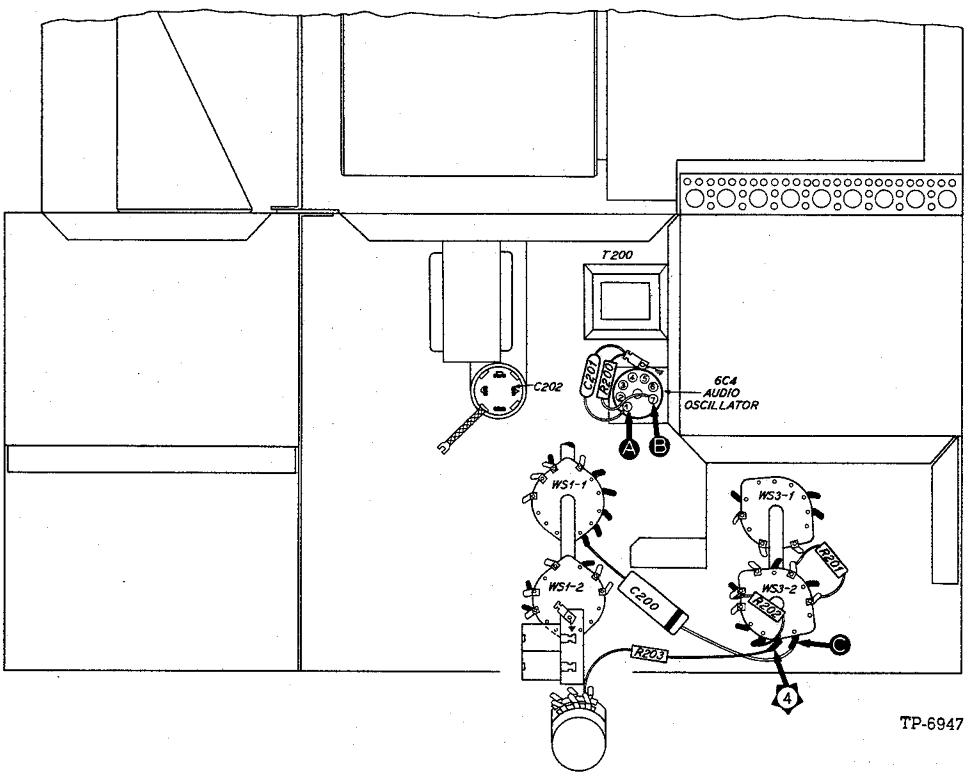



**Figure 52. — Rear View, Showing Section 2 Test Points**

## Trouble-Shooting Chart for Section 3

Set the FUNCTION switch to the 400-cycle position and the FUNCTION ATTEN. control to 10; connect the output cable to the input cable (black lead to GND). (Line voltage, 117v.)

Use a 20,000-ohms-per-volt, d-c voltmeter (10,000-ohms-per-volt a.c.) for all checks in this section.

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 1 | 5 | Set VERT. GAIN for 2" deflection on scope. | 65 volts, a.c., 400 cycles. | If normal, trouble is not in this section. If abnormal, proceed with step 2. |
| 2 | A | Voltage measured on 2.5-volt scale of meter. Set VERT. GAIN. to 10. | .45 volt, a.c., 400 cycles. | Open: R300, contact on WD3-1(F). |
| 3 | B | Voltage measured on 2.5-volt scale of meter. | 1.5 volts, d.c. | Defective: 7F7. Open: R302, R301, R312. Shorted: C308. |
| 4 | C | Voltage measured on 50-volt scale of meter. | 36 volts, d.c. | Defective: 7F7. Open: R306, R304, R305. Shorted: C301. |

## TEST POINT ANALYSIS (Cont.)

### Trouble-Shooting Chart for Section 3 (Cont.)

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 5 | D | Voltage measured on 10-volt scale of meter. | 3.3 volts, d.c. | Defective: 7F7. Open: R307, R308, R309, R310, R311. Shorted: C302, C303. |
| 6 | 5 | Set VERT. GAIN for 2″ deflection on scope. | 65 volts, a.c., 400 cycles. | Defective: C304, C305. |

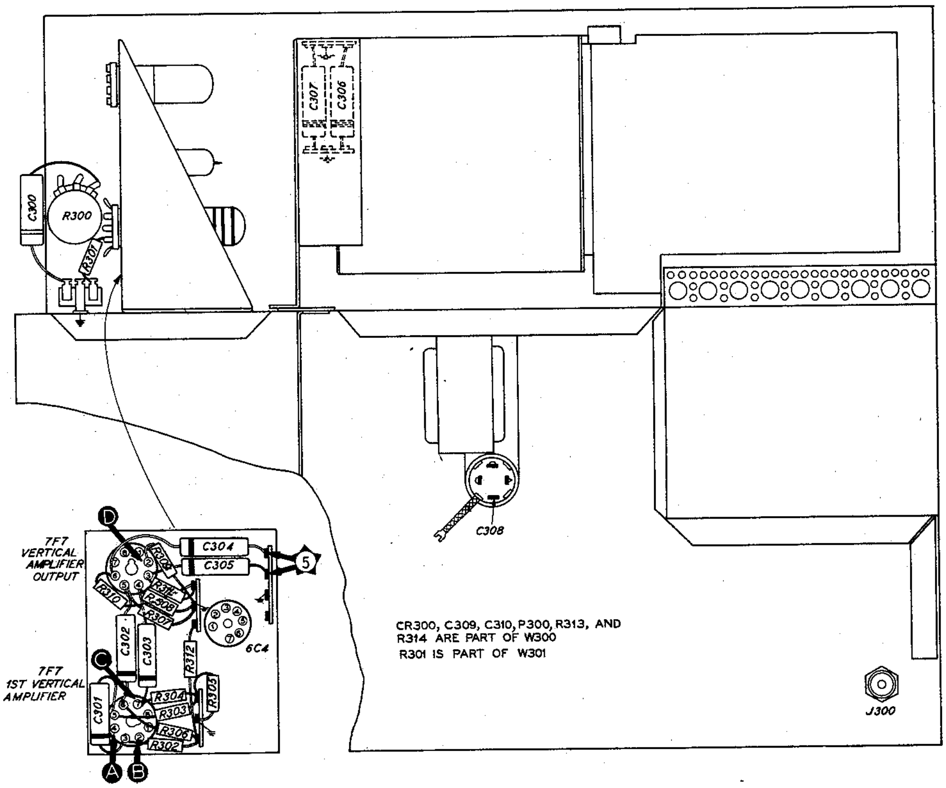



**Figure 53. — Rear View, Showing Section 3 Test Points**

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### Trouble-Shooting Chart for Section 4
### AM (MARKER) Generator

Use a 20,000-ohms-per-volt voltmeter for all voltage checks in this section. (Line voltage, 117v.) Set the FUNCTION switch to the AM RF position.

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 1 | 6 | See Note 1. Tune MARKER FREQUENCY control through its complete range on all bands. | 400:60-cycle Lissajou pattern. | If normal, proceed with Note 3. If abnormal, proceed with step 2. |
| 2 | A | Check on all bands. | 60, 80, 135 volts, d.c., depending upon band in use. | Shorted: C405, C406. Defective: Contact on WS3-2(F). |
| 3 | B | | 3, 1.7, 1.2 volts, d.c., depending upon band in use. | Open: R401. Shorted: C404. Defective: Contact on WS1-1(R), 6C4. |

# TEST POINT ANALYSIS (Cont.)

## Trouble-Shooting Chart for Section 4 (Cont.)

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATON | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 4 | C | | 130 volts, d.c. | Open: R405. Shorted: C408. Defective: T200. See Section 2 trouble-shooting chart. |
| 5 | D | Voltage varies with frequency. Use 10-volt scale. See Note 2. | -7.5, -6, -2 volts, d.c., depending upon band in use. | Defective: R405, C407. Defective: 6J6. |
| 6 | E | None | 1 volt, d.c. | Defective: 6J6, R407, R408, C410. |
| 7 | 6 | Same as step 1. | 400:60-cycle Lissajou pattern. | Defective: R410. |
| | | | | |
| 8 | F | | 40, 60, 120 volts, d.c., depending upon band in use. | Shorted: C409. Open: L403, R413. Defective: Contact on WS3-2 (F), WS1-2(F). |
| 9 | G | See Note 2. Voltage measured on 50 volt scale of meter. | -10, -23, -50 volts, d.c., depending upon band in use. | Defective: Y400, R412, 6J6. |
| 10 | | See Note 3. | See Note 3. | Defective: CR400, contact on WS3-1(F). |

Note 1: Connect the high-frequency probe to the INPUT jack. Use a short piece of wire in the binding post as a test prod, and connect the GND binding post to the chassis with a short length of wire.

Note 2: Use a 100,000-ohm isolating resistor at the test point, in series with the prod end of the meter lead.

Note 3: Set the FUNCTION switch to the CAL position, and rotate the MARKER FREQUENCY control through its complete range on all bands while observing the screen of the cathode-ray tube. A zero-beat pattern should appear at every 5-mc. point. If the beat pattern is present, the trouble is not located in this section. If the beat pattern is not present, proceed with step 8 in the chart below.

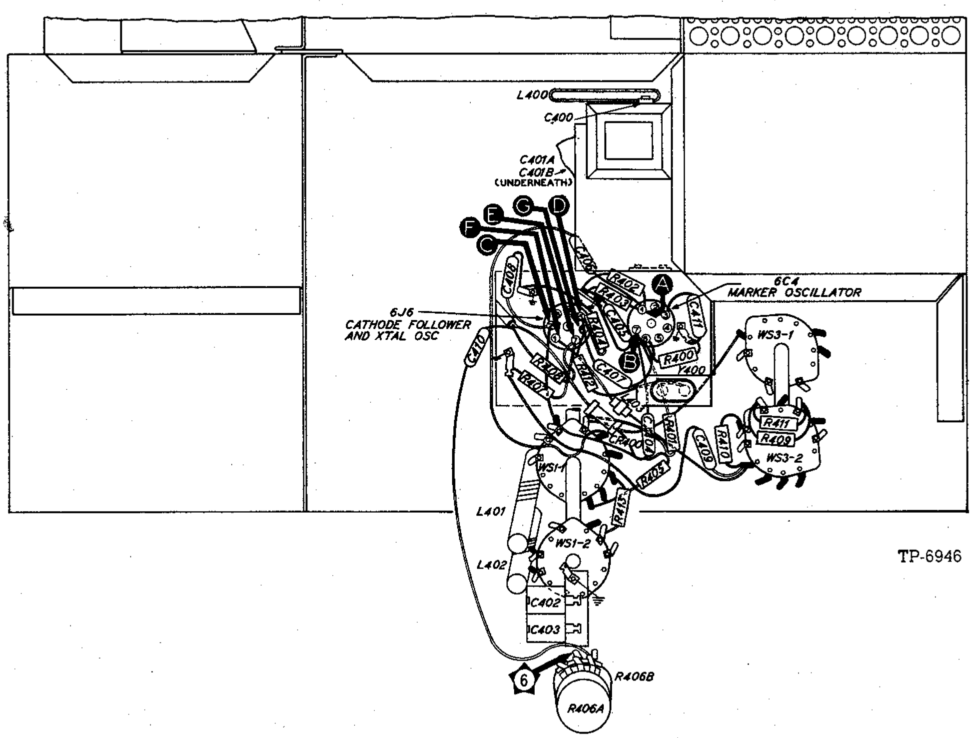


Figure 54. — Rear View, Showing Section 4 Test Points

# TEST POINT ANALYSIS (Cont.)
## Trouble-Shooting Chart for Section 5
## FM GENERATOR

Set the controls in the following positions: FUNCTION switch to OFF; SWEEP WIDTH control to 0; OUTPUT MULTIPLIER to MAX; MASTER OSC. ATTEN. to 10.

Use a 20,000-ohms-per-volt voltmeter for all checks in this section. (Line voltage, 117v.).

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 1 | 7 | See Note 1. Set MASTER OSC. BAND SWITCH to position B; remove 6AK5 master oscillator tube. | Meter indication decreases to 0. | If normal indication is obtained, proceed with step 8. If abnormal indication is obtained, proceed with step 2. |
| 2 | A | Replace 6AK5 tube removed in step 1. | 120 to 145 volts, d.c. | Open: R500, R501. Defective: Contact on WS2-1(R), WS3-1(R). Shorted: C501. |
| 3 | B | | 1 volt, d.c. | Open: R503. Defective: 6AK5. |
| 4 | C | See Note 2. | -4 to -1.4 volts, d.c. (on 10-volt scale). | Open: R502, R503. Defective component in Z500. |
| 5 | D | | 0 to 120 volts, d.c., depending upon setting of MASTER OSC. ATTEN. | Open: R511, R512, R513. Defective: R506. Shorted: C509. |
| 6 | E | | .5 to 2.5 volts, d.c., depending upon setting of MASTER OSC. ATTEN. | Defective: 6AK5 (mixer). Open: R510, L502. Shorted: C512. |
| 7 | 7 | See Note 1. Set MASTER OSC. BAND SWITCH to position B. | .3 to .85 volt. | Defective: C510, contact on WS4-1(R). Check multiplier resistors. |

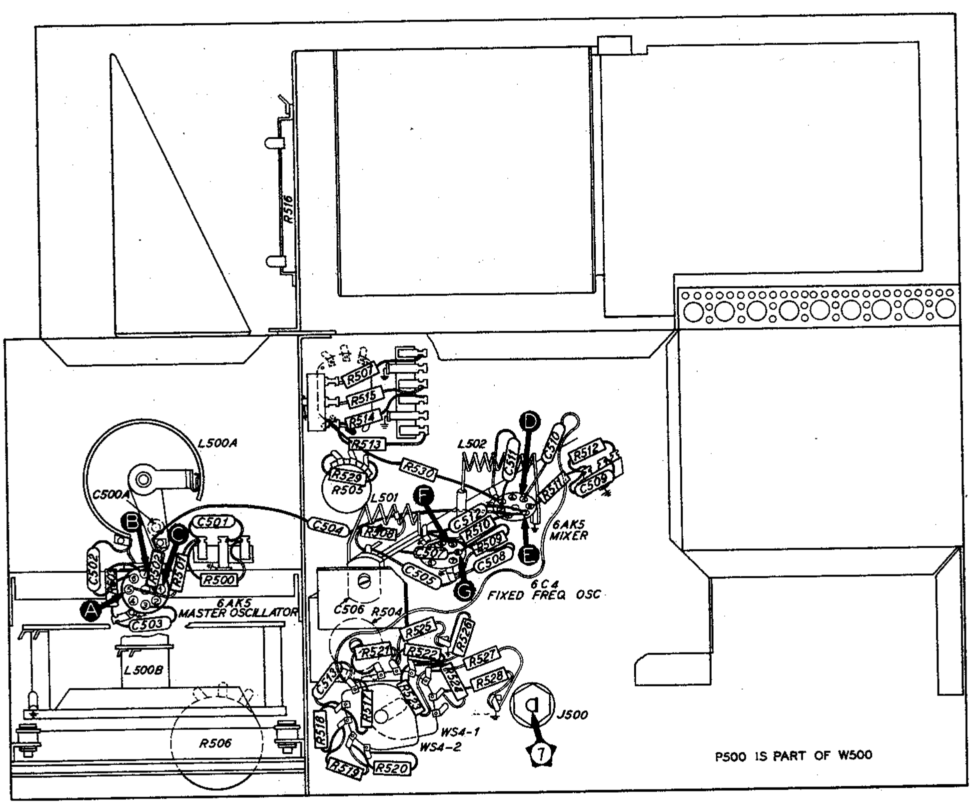


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Figure 55. — Rear View, Showing Section 5 Test Points

## TEST POINT ANALYSIS (Cont.)

### Trouble-Shooting Chart for Section 5 (Cont.)

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 8 | 7 | See Note 1. Remove 6AK5 master oscillator tube; set MASTER OSC. BAND SWITCH to position A. | 0 to .6 volt, d.c. (on 2.5-volt scale), depending upon setting of MASTER OSC ATTEN. | If normal indication is obtained, trouble is not in this section. If abnormal indication is obtained, proceed with step 9. |
| 9 | F | | 60 volts, d.c. | Defective: Contact on WS2-1(R). Open: R507, R508. Shorted: C505. |
| 10 | G | See Note 2. | -2 to -6 volts, d.c., depending upon setting of MASTER OSC. ATTEN. | Defective: 6C4, R509, R507. |
| 11 | | Observe modulating condenser as SWEEP WIDTH control is varied. | Condenser oscillates more violently as SWEEP WIDTH control is turned clockwise. | Defective: Contact on WS2-1(F). Open: R504, R505, L500B. Check for voltage across R505. |

Note 1: Connect the terminals of the OUTPUT cable to the terminals of the high-frequency probe; connect the meter leads between the chassis and the center conductor of the female connector on the end of the high-frequency-probe cable. The meter should read .3 to .85 volt, on the 2.5-volt scale.

Note 2: Use a 100,000-ohm isolating resistor at the test point, in series with the prod end of the meter lead.

### Trouble-Shooting Chart for Section 6

Use a 20,000-ohms-per-volt, d-c voltmeter (1,000-ohms-per-volt, a-c voltmeter) for all voltage checks in this section.

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 1 | 8 | Connect a-c voltmeter between each arm of dual potentiometer. | 0 to 160 volts, a.c., as HORIZ. GAIN control is varied over its complete range. | If normal indication is obtained, proceed with step 5. If abnormal indication is obtained, proceed with step 2. |
| 2 | A | | 160 volts, a.c. | Defective: T600. |

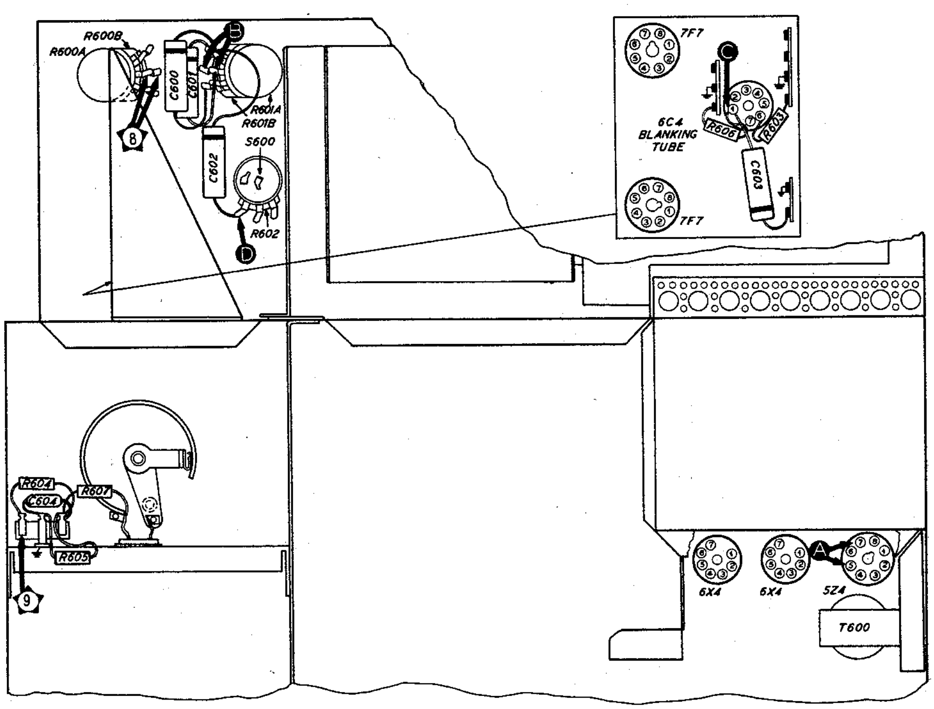


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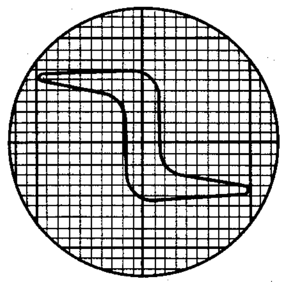
**Figure 56.— Rear View, Showing Section 6 Test Points**

## TEST POINT ANALYSIS (Cont.)

### Trouble-Shooting Chart for Section 6 (Cont.)

| STEP | TEST POINT | SPECIAL INSTRUCTIONS | NORMAL INDICATION | POSSIBLE CAUSE OF ABNORMAL INDICATION |
|---|---|---|---|---|
| 3 | B | Same as step 1. | 120 to 160 volts, a.c., depending upon setting of PHASING control. | Defective: R601, C600, C601. |
| 4 | 8 | Same as step 1. | 0 to 160 volts, a.c. as HORIZ. GAIN control is varied over its complete range. | Defective: R600. |
| 5 | 9 | Connect low-frequency probe from test point 9 to input jack J300. Set BLANKING control to ON. |  TP-6961 Adjust VERT. GAIN and PHASING controls to obtain this pattern. | If normal indication is obtained, trouble is not in this section. If abnormal indication is obtained, proceed with step 6. |
| 6 | C | | 100 volts, d.c. | Open R606. |
| 7 | D | Vary BLANKING control over its complete range. | 66 to 77 volts, a.c. | Defective: R602, R603, C602. |
| 8 | 9 | | 70 volts, a.c. | Defective: 6C4 blanking tube, C603, S600, R604, R605, C604. |

## REPLACEMENT PARTS LIST

### SECTION 1 — POWER SUPPLY

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| C100 | Condenser, electrolytic, 4-section | 30-2570-26 |
| C100A | Condenser, B+ filter, 15 mf., 475v | Part of C100 |
| C100B | Condenser, B+ filter, 40 mf., 350v | Part of C100 |
| C101 | Condenser, line filter, 8200 mmf. | 60-20823404 |
| C102 | Condenser, line filter, 8200 mmf. | 60-20823404 |
| C103 | Condenser, electrolytic, B-filter, 15 mf. | 30-2577 |
| I100 | Lamp, pilot | 34-2040 |
| J100 | Receptacle, a-c input | Part of W100 |
| P100 | Receptacle, a-c input | 76-3859 |
| L100 | Choke, filter, 5 henries | 32-8355 |
| R100 | Resistor, voltage divider, 100,000 ohms | 66-4103340 |
| R101 | FOCUS control, 100,000 ohms | 33-5550-11 |
| R102 | Resistor, voltage divider, 56,000 ohms | 66-3563340 |
| R103 | INTENSITY control, 10,000 ohms | 33-5550-10 |
| R104 | Resistor, voltage divider, 6800 ohms | 66-2683340 |
| R105 | HORIZ. CENT. control | 33-5550-7 |
| R105A | Potentiometer, 500,000 ohms | Part of R105 |
| R105B | Potentiometer, 500,000 ohms | Part of R105 |
| R106 | VERT. CENT. Control | 33-5550-7 |
| R106A | Potentiometer, 500,000 ohms | Part of R106 |
| R106B | Potentiometer, 500,000 ohms | Part of R106 |
| R107 | Resistor, voltage divider, 75,000 ohms | 66-3753240 |
| R108 | Resistor, voltage divider, 510,000 ohms | 66-4513240 |
| R109 | Resistor, voltage divider, 510,000 ohms | 66-4513240 |
| R110 | Resistor, isolating, 3.3 megohms | 66-5333340 |
| R111 | Resistor, isolating, 3.3 megohms | 66-5333340 |

### SECTION 1 — POWER SUPPLY (Cont.)

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| R112 | Resistor, isolating, 3.3 megohms | 66-5333340 |
| R113 | Resistor, isolating, 3.3 megohms | 66-5333340 |
| R114 | Resistor, voltage dropping, 2200 ohms | 66-2223340 |
| S100 | Switch, POWER ON-OFF | 42-1837-2 |
| T100 | Transformer, power | |
| | (Used in first 300 units) | 32-8354 |
| | (Used after first 300 units) | 32-8354-1 |
| W100 | Power cord | 76-3596 |

### SECTION 2 — AUDIO CIRCUIT

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| C200 | Condenser, output coupling, .02 mf. | 61-0108 |
| C201 | Condenser, plate by-pass, .015 mf. | 30-1226-16 |
| C202 | Condenser, B+ filter, 10 mf., 350v | Part of C100 |
| R200 | Resistor, cathode bias, 2200 ohms | 66-2223240 |
| R201 | Resistor, decoupling, 680 ohms | 66-1683340 |
| R202 | Resistor, output compensating, 33,000 ohms | 66-3333340 |
| R203 | Resistor, output compensating, 33,000 ohms | 66-3333340 |
| T200 | Transformer, audio oscillator | 32-8365 |

(Continued on Page 49)

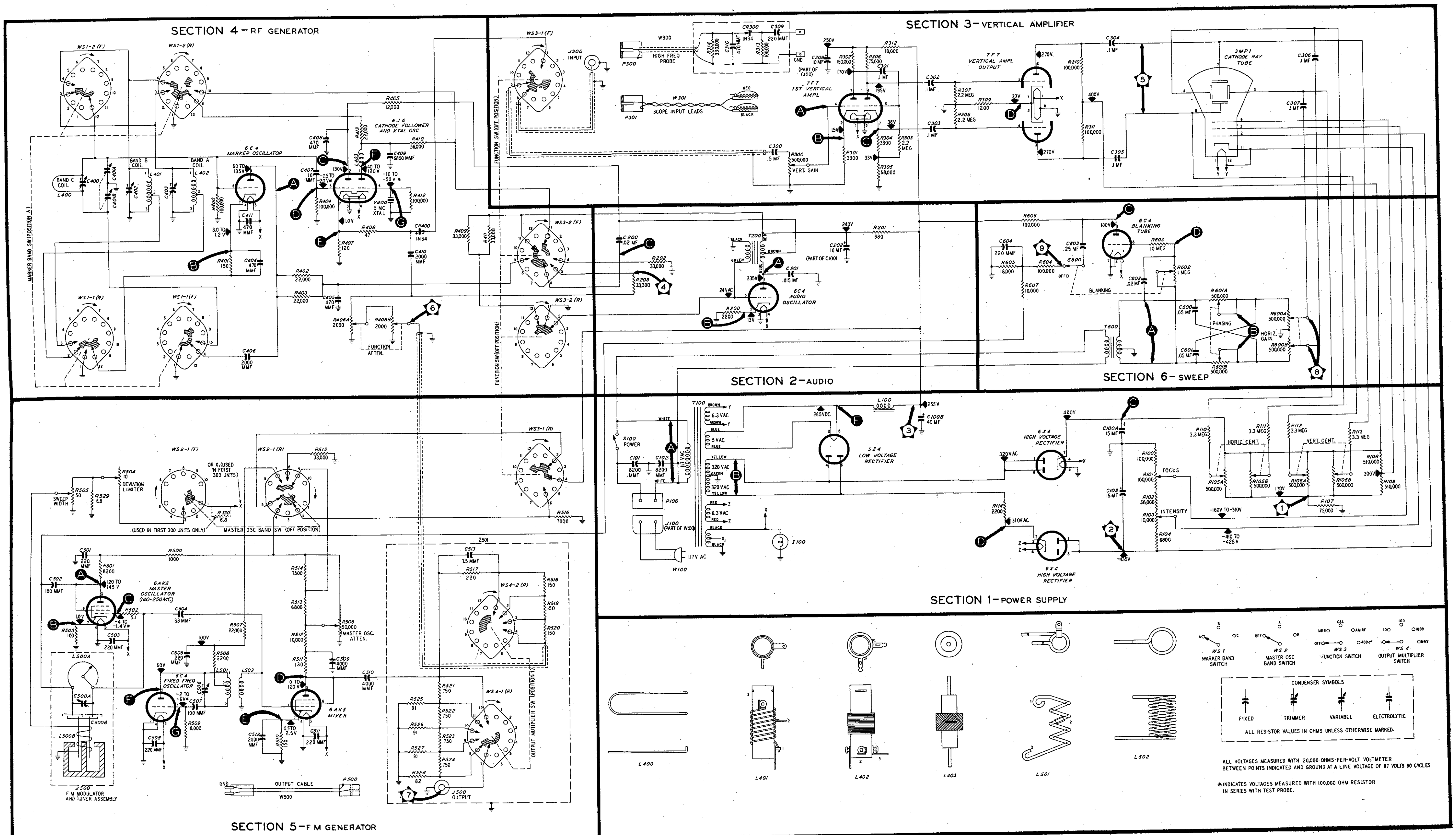



Figure 57. — Model 7008 Schematic

## REPLACEMENT PARTS LIST (Continued)

### SECTION 3 — VERTICAL AMPLIFIER CIRCUIT

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| C300 | Condenser, input, .5 mf. | 45-3500-4 |
| C301 | Condenser, coupling, .1 mf. | 61-0113 |
| C302 | Condenser, coupling, .1 mf. | 61-0113 |
| C303 | Condenser, coupling, .1 mf. | 61-0113 |
| C304 | Condenser, coupling, .1 mf. | 61-0113 |
| C305 | Condenser, coupling, .1 mf. | 61-0113 |
| C306 | Condenser, blocking, .1 mf. | 61-0113 |
| C307 | Condenser, blocking, .1 mf. | 61-0113 |
| C308 | Condenser, B+ filter, 10 mf., 350v | Part of C100 |
| C309 | Condenser, blocking, 220 mmf. (part of W300) | 30-1225-15 |
| C310 | Condenser, r-f filter, 470 mmf. (part of W300) | 30-1225-16 |
| CR300 | Crystal, type 1N34 (part of W300) | 54-6001 |
| J300 | Jack, INPUT | 76-3601 |
| R300 | VERT. GAIN control, 500,000 ohms | 33-5550-8 |
| R301 | Resistor, cathode bias, 3300 ohms | 66-2333340 |
| R302 | Resistor, plate load, 150,000 ohms | 66-4153340 |
| R303 | Resistor, grid return, 2.2 megohms | 66-5223340 |
| R304 | Resistor, cathode bias, 3300 ohms | 66-2333340 |
| R305 | Resistor, cathode load, 68,000 ohms | 66-3683240 |
| R306 | Resistor, plate load, 75,000 ohms | 66-3753240 |
| R307 | Resistor, grid return, 2.2 megohms | 66-5223340 |
| R308 | Resistor, grid return, 2.2 megohms | 66-5223340 |
| R309 | Resistor, cathode bias, 1200 ohms | 66-2123340 |
| R310 | Resistor, plate, 100,000 ohms | 66-4103340 |
| R311 | Resistor, plate load, 100,000 ohms | 66-4103340 |
| R312 | Resistor, decoupling, 18,000 ohms | 66-3183340 |
| R313 | Resistor, diode load, 100,000 ohms (part of W300) | 66-4103340 |
| R314 | Resistor, r-f filter, 330,000 ohms (part of W300) | 66-4333340 |
| W300 | High-frequency-probe assembly | 76-3595 |
| W301 | Scope leads | 76-3624 |
| WS3-1(F) | Switch-wafer section | Part of 42-1842† |

### SECTION 4 — R-F (MARKER) GENERATOR CIRCUIT

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| C400 | Condenser, trimmer, Band C, 3—12 mmf. | 31-6480-9 |
| C401 | Condenser, marker-oscillator tuning | 31-2642-1 |
| C401A | Condenser, marker-oscillator tuning | Part of C401 |
| C401B | Condenser, marker-oscillator tuning | Part of C401 |
| C402 | Condenser, trimmer, Band B, 2.2—20 mmf. | 31-6476-17 |
| C403 | Condenser, trimmer, Band A, 2.2—20 mmf. | 31-6476-17 |
| C404 | Condenser, cathode by-pass, 470 mmf. | 62-147001001 |
| C405 | Condenser, plate by-pass, 470 mmf. | 62-147009001 |
| C406 | Condenser, coupling, 2000 mmf. | 30-1225-6 |
| C407 | Condenser, coupling, 10 mmf. | 62-010409001 |
| C408 | Condenser, plate by-pass, 470 mmf. | 62-147001001 |
| C409 | Condenser plate by-pass, 6800 mmf. | 62-268001013 |
| C410 | Condenser, coupling, 2000 mmf. | 30-1225-6 |
| C411 | Condenser, by-pass, 470 mmf. | 62-147001001 |
| CR400 | Crystal, rectifier, type 1N34 | 54-6001 |
| L400 | Coil, AM oscillator, Band C | 32-4295 |
| L401 | Coil, AM oscillator, Band B | 32-4299 |
| L402 | Coil, AM oscillator, Band A | 32-4298 |
| L403 | Coil, crystal-oscillator plate | 32-4297 |
| R400 | Resistor, grid, 100,000 ohms | 66-4103340 |
| R401 | Resistor, cathode bias, 150 ohms | 66-1153350 |
| R402 | Resistor, plate-voltage dropping, 22,000 ohms | 66-3225351 |
| R403 | Resistor, plate-voltage dropping, 22,000 ohms | 66-3225351 |
| R404 | Resistor, grid, 100,000 ohms | 66-4103340 |

### SECTION 4 — R-F (MARKER) GENERATOR CIRCUIT (Cont.)

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| R405 | Resistor, plate-voltage dropping, 12,000 ohms | 66-3125340 |
| R406 | FUNCTION ATTEN. control | 33-5533-1 |
| R406A | Potentiometer, 2000 ohms | Part of R406 |
| R406B | Potentiometer, 2000 ohms | Part of R406 |
| R407 | Resistor, cathode load, 120 ohms | 66-1123350 |
| R408 | Resistor, voltage divider, 47 ohms | 66-0473350 |
| R409 | Resistor, load compensating, | |
| R410 | Resistor plate-voltage dropping, 56,000 ohms | 66-3564340 |
| R411 | Resistor, load compensating, 33,000 ohms | 66-3335351 |
| R412 | Resistor, grid, 100,000 ohms | 66-4103340 |
| R413 | Resistor, plate-voltage dropping, 22,000 ohms | 66-3225351 |
| WS1 | Wafer switch, 2-section, MARKER BAND SW. | 42-1843 |
| WS3-2(F) | Switch-wafer section | Part of 42-1842† |
| WS3-2(R) | Switch-wafer section | Part of 42-1842† |
| Y400 | Crystal, quartz, 5 mc. | 34-8014 |
| †42-1842 | 4-section wafer (FUNCTION) switch | |

### SECTION 5 — FM GENERATOR CIRCUIT

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| C500A | Condenser, trimmer | Part of Z500 |
| C500B | Condenser, variable modulating | Part of Z500 |
| C501 | Condenser, by-pass, 220 mmf. | 62-122001001 |
| C502 | Condenser, blocking, 100 mmf. | 30-1225-13 |
| C503 | Condenser, by-pass, 220 mmf. | 62-122001001 |
| C504 | Condenser, coupling, 3.3 mmf. | 30-1221 |
| C505 | Condenser, by-pass, 220 mmf. | 62-122001001 |
| C506 | Condenser, variable, 3.5—15 mmf. | 31-6497-4 |
| C507 | Condenser, grid, 100 mmf. | 30-1225-13 |
| C508 | Condenser, by-pass, 220 mmf. | 62-122001001 |
| C509 | Condenser, by-pass, 4000 mmf. | 30-1225-14 |
| C510 | Condenser, coupling, 4000 mmf. | 30-1225-14 |
| C511 | Condenser, by-pass, 220 mmf. | 62-122001001 |
| C512 | Condenser, by-pass, 2000 mmf. | 30-1225-6 |
| C513 | Condenser, coupling, 7.5 mmf. (part of Z501) | 30-1224-37 |
| J500 | Jack, output | 76-2003-1 |
| L500A | Inductive-tuning assembly (part of Z501) | 76-3621 |
| L500B | Modulator sweep coil | Part of Z500 |
| L501 | Coil, fixed-frequency oscillator | 32-4300 |
| L502 | Coil, pickup | 32-4301 |
| R500 | Resistor, decoupling, 1000 ohms | 66-2103340 |
| R501 | Resistor, plate-voltage dropping, 8200 ohms | 66-2825351 |
| R502 | Resistor, current limiting, 5.1 ohms | 66-9513250 |
| R503 | Resistor, cathode bias, 100 ohms | 66-1108350 |
| R504 | Internal Deviation Limiter control, 10 ohms | 33-5546-17 |
| R505 | SWEEP WIDTH control, 50 ohms | 33-5546-15 |
| R506 | MASTER OSC. ATTEN. control, 50,000 ohms | 33-5546-16 |
| R507 | Resistor, decoupling, 22,000 ohms | 66-3225340 |
| R508 | Resistor, plate-voltage dropping, 2200 ohms | 66-2228350 |
| R509 | Resistor, grid leak, 18,000 ohms | 66-3183340 |
| R510 | Resistor, cathode bias, 150 ohms | 66-1158350 |
| R511 | Resistor, plate-voltage dropping, 130 ohms | 66-1138250 |
| R512 | Resistor, voltage divider, 10,000 ohms | 66-3105351 |
| R513 | Resistor, stabilizing, 6800 ohms | 66-2685340 |
| R514 | Resistor, stabilizing, 7500 ohms | 33-1335-20 |
| R515 | Resistor, load compensating, 33,000 ohms | 66-3335340 |
| R516 | Resistor, load compensating, 7000 ohms | 33-3435-14 |
| R517 | Resistor, isolating, 220 ohms (part of Z501) | 66-1228250 |

## REPLACEMENT PARTS LIST (Continued)

### SECTION 5 — FM GENERATOR CIRCUIT (Cont.)

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| R518 | Resistor, attenuator, 150 ohms (part of Z501) | 66-1158250 |
| R519 | Resistor, attenuator, 150 ohms (part of Z501) | 66-1158250 |
| R520 | Resistor, attenuator, 150 ohms (part of Z501) | 66-1158250 |
| R521 | Resistor, attenuator, 750 ohms (part of Z501) | 66-1758250 |
| R522 | Resistor, attenuator, 750 ohms (part of Z501) | 66-1758250 |
| R523 | Resistor, attenuator, 750 ohms (part of Z501) | 66-1758250 |
| R524 | Resistor, attenuator, 750 ohms (part of Z501) | 66-1758250 |
| R525 | Resistor, attenuator, 91 ohms (part of Z501) | 66-0918250 |
| R526 | Resistor, attenuator, 91 ohms (part of Z501) | 66-0918250 |
| R527 | Resistor, attenuator, 91 ohms (part of Z501) | 66-0918250 |
| R528 | Resistor, attenuator, 82 ohms (part of Z501) | 66-0828250 |
| R529 | Resistor, voltage divider, 6.8 ohms | 66-9685360 |
| R530 | Resistor, voltage divider, 6.8 ohms (not used after first 300 units) | 66-9685360 |
| W500 | Output cable | 41-3730 |
| WS2 | Wafer switch, 2-section, MASTER OSC. BAND SWITCH | 42-1857 |
| WS3-1(R) | Switch-wafer section | Part of 42-1842† |
| WS4 | Wafer switch, 2-section, OUTPUT MULTIPLIER (part of Z501) | 42-1861 |
| Z500 | Master-oscillator-modulator assembly | 76-3616 |
| Z501 | OUTPUT MULTIPLIER assembly | 76-3606 |
| †42-1842 | 4-section wafer (FUNCTION) switch | |

### SECTION 6 — SWEEP CIRCUIT

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| C600 | Condenser, phasing, .05 mf. | 61-0122 |
| C601 | Condenser, phasing, .05 mf. | 61-0122 |
| C602 | Condenser, coupling, .02 mf. | 61-0108 |
| C603 | Condenser, coupling, .25 mf. | 61-0125 |
| C604 | Condenser, by-pass, 220 mmf. | 62-122001001 |
| R600 | HORIZ. GAIN control | 33-5550-12 |
| R600A | Potentiometer, 500,000 ohms | Part of R600 |
| R600B | Potentiometer, 500,000 ohms | Part of R600 |
| R601 | PHASING control | 33-5550-7 |
| R601A | Potentiometer, 500,000 ohms | Part of R601 |
| R601B | Potentiometer, 500,000 ohms | Part of R601 |
| R602 | BLANKING control, 1 megohm | 33-5550-9 |
| R603 | Resistor, current limiting, 10 megohms | 66-6103340 |
| R604 | Resistor, voltage divider, 100,000 ohms | 66-4103340 |
| R605 | Resistor, voltage divider, 18,000 ohms | 66-3183340 |

### SECTION 6 — SWEEP CIRCUIT (Cont.)

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| R606 | Resistor, plate load, 100,000 ohms | 66-4103340 |
| R607 | Resistor, isolating, 10,000 ohms | 66-3103340 |
| S600 | Switch, BLANKING control | Part of R602 |
| T600 | Transformer, phasing | 32-8368 |

### MISCELLANEOUS

| Reference Symbol | Description | Service Part No. |
|---|---|---|
| | Cathode-ray-tube housing assembly | 76-3603 |
| | Crystal holder | 54-4532 |
| | Crosshatch screen | 54-4545 |
| | Coupling, friction drive | 56-3183 |
| | Drive shaft | 31-2700-1 |
| | Front-plate assembly | 76-3602 |
| | Foot assembly | 76-3600 |
| | Friction-drive assembly | 76-3619 |
| | Handle assembly | 76-1979 |
| | High-Frequency-Probe Assembly, W300 (complete) | 76-3595 |
| C309 | Condenser, 220 mmf. (part of 76-3595) | 30-1225-15 |
| C310 | Condenser, 470 mmf. (part of 76-3595) | 30-1225-16 |
| CR300 | Crystal, type 1N34 (part of 76-3595) | 54-6001 |
| | Binding post (part of 76-3595) | 76-2896 |
| R313 | Resistor, 100,000 ohms (part of 76-3595) | 66-4103351 |
| R314 | Resistor, 330,000 ohms (part of 76-3595) | 66-4338350 |
| | Terminal box (part of 76-3595) | 54-4438 |
| | Terminal-box cover (part of 76-3595) | 76-4333 |
| | Knob | |
| | MARKER FREQUENCY and MASTER OSC. APPROX. CENTER FREQ. controls | 54-4542 |
| | Other controls | 54-4281 |
| | Light Shield | 56-5341 |
| | Oscilloscope input cable W301 (complete) | 76-3624 |
| | Marker-oscillator-cable assembly (internal) | 41-3842 |
| | Output-Cable Assembly | 41-3730 |
| | Binding post (part of 41-3730) | 76-2896 |
| | Retaining-cord sleeve (part of 41-3730) | 56-4559 |
| | Terminal box (part of 41-3730) | 54-4438 |
| | Terminal-box cover (part of 41-3730) | 54-4437 |
| | Panel, etched | 56-5338 |
| | Pilot-lamp assembly | 76-1658 |
| | Pointer (marker oscillator) | 54-4543 |
| | Pointer (master oscillator) | 54-4544 |
| | Socket-and-cable assembly, cathode-ray Tube | 76-3612 |
| | Socket, miniature (6 required) | 27-6203-1 |
| | Socket, miniature (3 required) | 27-6203 |
| | Socket, octal (1 required) | 27-6174 |
| | Socket, loktal (2 required) | 27-6177 |

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