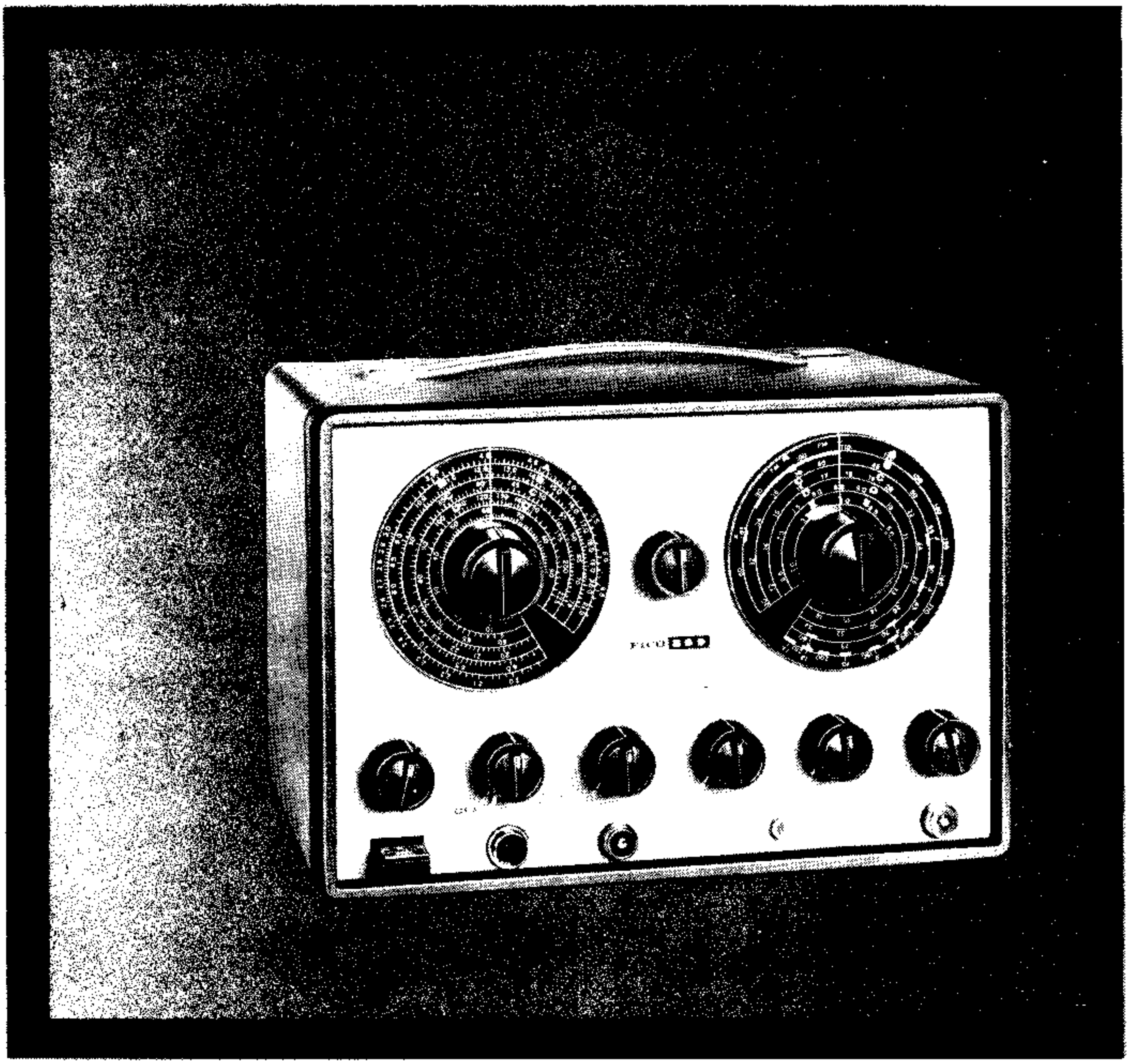
EICO

369/TV-FM Sweep and Post-Injection Marker Generator



OPERATING MANUAL

369 - Rev. I

GENERAL DESCRIPTION

The EICO Model 369 TV/FM Sweep & Post-Injection Marker Generator provides the greatest dependability, accuracy, and speed for service and factory alignment of color and black-and-white tv receivers and fm receivers.

With the EICO 369, circuit response is not affected by markers and markers are not affected by circuit response. The EICO 369 feeds only the required sweep signal to the input of the circuit being aligned or tested. At the output end of the circuit, a demodulator cable picks off the signal, and feeds the demodulated signal to a mixer stage inside the generator where the markers are added. Then this combined signal is fed to the oscilloscope. This means that circuitry under test of alignment is not affected by the marker signal, and that traps in the circuitry will not reduce or eliminate the marker.

The EICO 369 has a controllable inductor sweep circuit. This type of purely electronic sweep circuit has no mechanical parts to wear and give trouble later. The sweep generator is independent of the marker generator. It has five ranges: 3-7.5mc; 6-16mc; 16-42mc; 36-95mc and 75-220mc. All five ranges are fundamentals and tuning to the desired center frequency is simplified by a 6:1 vernier dial and a 350° scale. Output impedance is 50 ohms. Retrace blanking is obtained by both direct grid cut-off and indirect B+ cut-off (via the AGC chain) of the oscillator with a blanking tube that conducts during the negative excursion of the 60 cps sine sweep. A three-stage AGC circuit keeps the level of the swept signal constant over its entire frequency range, even when the widest sweep width of 20mc is being used. A phasing control at the rear of the EICO 369 adjusts permanently the horizontal sweep signal fed to the 'scope.

The marker generator in the EICO 369 has 4 ranges covering 2 - 225mc. The highest range, 60 - 225mc, is the third harmonic of the next lower range. All other ranges are fundamentals. Frequency setting is simplified by a 6:1 vernier dial and a 350° scale. For a rapid check of marker generator alignment, a 4.5mc crystal is supplied with each generator. When plugged into a front panel socket it automatically turns on a fixed frequency marker oscillator. The 4.5mc signal produced by this oscillator is mixed with the variable frequency marker. The 4.5mc crystal is used also for alignment of sound circuitry in tv receivers.

The demodulated wave form with post-injected marker is fed to the vertical input of the 'scope, and the horizontal sweep to the horizontal input of the 'scope, through a single, shielded, two-conductor cable. Separate level controls for trace size and marker size on the front panel can be used independently.

FEATURES

1. Entirely electronic sweep circuit (no moving parts, hum, or vibration) using controllable inductor, in which the oscillator coil inductance depends on the controlled excitation current in the primary windings of the unit. The controlled inductor provides a large and smoothly variable sweep width, and the sweep obtained is extremely linear and stable. The availability of a large sweep width renders operation of the instrument non-critical, since the band-pass region is easily located on the 'scope trace even when the tv set or generator are considerably off frequency. Once the band-pass waveform is located, it is only a matter of adjusting the sweep generator center frequency and the sweep width as required for the most satisfactory display.

2. Extremely flat sweep signal provided by the three-stage AGC circuit which automatically adjusts the oscillator for maximum output on each band with minimum amplitude variations. High output on all five bands permits "cold" alignment of all tuned circuits and filters.

3. The 60cps sine sweep fed to the horizontal input of the 'scope is obtained by bleeding and filtering a large voltage from the secondary winding of the power transformer to achieve both isolation from the line and low distortion. Positive action return trace blanking. Double pi line isolation filter.

4. Multiple marker system for easier alignment. A variable frequency marker oscillator covers from 2mc to 75mc on fundamentals in three ranges, and from 60mc to 225mc on harmonics of the highest fundamental range. (Note that the marker range includes the color burst frequency of 3.58mc). The fixed marker is a crystal-controlled oscillator employing a 4.5mc crystal supplied with the instrument. As the crystal plugs into a panel mount, other crystals may easily be substituted when desired. Variable and fixed markers are both fed to the post-injection mixer circuit. Note that when variable and fixed markers are mixed, pips appear on the 'scope trace at the fundamental and harmonic frequencies of both, and at the sum and difference frequencies. If the pips so obtained are not close enough for a particular job, a crystal of lower frequency can be used.

SPECIFICATIONS

Sweep Oscillator

	Range	Center Frequency	Output	Regulation
Frequency Ranges & Output:	A	75-220mc	.1V	±1db
	B	36-95mc	.2V	±1/2db
	C	16-42mc	.3V	±1/2db
	D	6-16mc	.3V	±1/2db
	E	3-7.5mc	.3V	±1/2db

Note 1: All frequency ranges are fundamental
Note 2: Three-stage AGC circuit
Note 3: 6:1 vernier tuning of center frequency sweep, 350 degrees scale

Output Impedance: 50Ω

Blanking: Negative excursion of power transformer sec. output applied through diode to cut off oscillator grid and osc. B+ through AGC circuit.

Output Attenuators: Four-step decade attenuator and continuously variable level adjustment

Sweep Width: Continuously variable up to 20mc depending on range. Minimum sweep width on all TV channels and IF frequencies 10mc.

Phasing: Narrow-range phasing control at rear of chassis permits permanent adjustment of horizontal deflection signal for accurate alignment.

Variable Frequency Marker Oscillator

	Range	Frequency
Frequency Ranges:	A	2-6mc
	B	6-20mc
	C	20-75mc
	D	60-225mc

Note 1: Range D is third harmonic of Range C
Note 2: 6:1 vernier tuning of variable marker frequency, 350 degrees scale

Fixed Frequency Marker Oscillator

Crystal-controlled oscillator using 4.5mc crystal included with instrument. Crystal socket on panel permits other crystals to be used. Insertion of crystal in socket automatically activates fixed frequency marker oscillator. Fixed marker is internally mixed with variable frequency marker.

Marker Post-Injection Circuit

Sweep signal only (independently attenuated) is fed to device under test via 50Ω shielded cable supplied. Demodulated output of device is returned via demodulator cable supplied (incorporating low-pass filter) through independent trace size attenuator to post-injection circuit. Variable and fixed markers (mixed) are also fed to post-injection circuit via independent marker size control. Demodulated signal and markers are mixed and amplified in post-injection circuit and fed to vertical input of 'scope via 'scope cable supplied. Horizontal deflection signal to 'scope is supplied via the same cable.

Tube Complement:		
	6BQ7A	sweep oscillator and RF output cathode follower
	12AT7	variable and crystal marker oscillator
	12AX7	blanking diode and first AGC amplifier
	6DR7	second AGC amplifier and AGC series regulator
	12AU7	post-injection mixer and amplifier
	6X4	full-wave rectifier
	Selenium rectifier for increductor bias voltage	

Cables: RF output cable - 50Ω termination
Demodulated Signal cable - incorporating low-pass RC filter
'Scope Cable - dual shielded cable carrying both vertical and horizontal 'scope input leads

Power Requirements: 105-125 VAC, 60 cps; 50 watts

Size (HWD): 8-1/2 x 12-1/2 x 7 inches

Weight: 16 lbs.

CIRCUIT DESCRIPTION

SWEEP OSCILLATOR

The sweep oscillator is of the Colpitts type, using half of a 6BQ7A tube (V2B). The coils are built into the controllable inductor unit (L5) and are connected in series. All coils are used on the lowest band and one more coil is shorted out on each successively higher band, until only the straps and switch remain to act as the coil on the highest band.

The coil cores are made of a special ferrous composition, and are located between and make contact with the laminated pole piece of the inductor core. A control winding (primary) on the inductor core controls the magnetic flux density in the inductor core and the cores of the signal coils. Thus when current is supplied to the control winding, the permeability of the special core materials is reduced. This in turn causes the inductance of the signal windings to decrease.

The low frequency edge of each swept band occurs at zero control current and the high frequency edge at maximum control current. The center frequency of each swept band depends on the setting of the tuning capacitor (C9).

The inductor control and the horizontal sweep voltage fed to the horizontal axis of the 'scope are both sinusoidal variations at 60 cps and are derived from the 117 volt, 60 cps line. Thus the sweep display on the scope exhibits a linear variation of frequency versus horizontal displacement from the low edge to the high edge of the swept band.

The magnitude of the inductor control current, which sets the sweep width (overall frequency variation), is controlled by a potentiometer (R41) connected across the 117 volt line in series with a limiting resistor (R37) which prevents the overloading of the controllable inductor. The inductor unit is connected to one end and to the arm of the potentiometer through a blocking capacitor (C26). Capacitor C25, which is in parallel with the inductor primary, has been chosen to resonate with the inductor at 60 cycles in order to increase the available range of control current and therefore the available range of sweep width.

Center frequency sweep is achieved through the use of a DC bias current through the control winding of the inductor unit. The DC voltage that develops the bias current is obtained by rectifying (CR1) and filtering (C27) the 117 volt, 60 cps line voltage. The DC bias current is controlled by series resistors (R39 and R40), which are selected on each band so that, at zero sweep width, the operating frequency is mid-way between the zero current and saturation current points of the inductor to assure excellent linearity on all bands. As the stated ranges of the sweep oscillator are all fundamental ranges, the user is assured of entirely adequate output on all bands.

The 60 cps horizontal sweep voltage fed to the 'scope must be controllable as to phase, and also be a true sine wave to ensure a linear display. R22 is the variable phase control, and the network #29756 performs the functions of filtering and attenuating the 60 cycle voltage obtained from the high voltage secondary of the power transformer T1. This voltage is taken from the secondary of the transformer to provide isolation from the line, and filtering is required to eliminate distortion introduced by the transformer.

The second half of the 6BQ7A tube V2A is connected as a cathode follower. The swept RF voltage is coupled from the grid circuit of the oscillator section to the grid of the cathode follower section. As a cathode follower exhibits a high input impedance, the loading effect on the oscillator is very slight. The cathode follower provides a low impedance output and is connected to the attenuator network.

BLANKING

If the swept RF output is not blanked during the negative excursion of the horizontal 60 cps sine sweep, the return trace (mirror image of the forward trace) will be superimposed on the forward trace and difficulty in interpreting the pattern will result. The important blanking function is achieved in the 369 by driving the oscillator grid highly negative to cut-off, and simultaneously feeding a portion of the negative grid blanking voltage to the AGC circuit which results in a reduced B+ voltage to the oscillator tube. A more detailed description of the blanking process follows.

Plate and grid of one-half of the 12AX7 blanking and AGC amplifier tube (V3A) are tied together and connected to the oscillator grid through isolating resistor R12. One side of the high voltage secondary winding of the power transformer is connected to the cathode of the blanking tube through a voltage dividing network consisting of resistors R13 and R18 and capacitor C31. Throughout the positive excursion of the voltage applied to the cathode, the plate is negative with respect to the cathode and no current can flow. At this time, the oscillator operates with its own grid leak (R11) only. During the negative excursion of the voltage at the cathode, the grid and plate become effectively positive with respect to the cathode and the tube will conduct. As the plate follows the cathode, a high negative voltage is applied to the oscillator grid, thus cutting the oscillator tube off. Also, the negative voltage pulse is coupled to the grid of the second half of the 12AX7 tube (V3B), which is the 1st AGC amplifier, thus causing a positive pulse at the plate of this tube. The positive pulse is coupled to the grid of the first half of the 6DR7 end AGC amplifier (V4A), resulting in a large negative pulse at the plate of this tube. This negative pulse appears at the grid of the second half of the 6DR7 (V4B) acting as series regulator to cut this tube off, and consequently the B+ supply to the oscillator section of V2 is cut off. Therefore, the oscillator tube is cut off in two ways during the blanking period. L6 is an RF choke which prevents the oscillator RF output from getting back to the regulator circuit.

REGULATOR CIRCUIT

Automatic gain control of the RF output voltage is achieved by coupling part of the varying DC voltage developed at the oscillator grid to the control grid of the 1st AGC amplifier, one-half of the 12AX7 tube (V3A). To understand the operation, we utilize the well known fact that the negative voltage at the oscillator grid increases with the amplitude of the RF output. Supposing that instantaneously the RF output has increased, we can anticipate that the negative oscillator grid voltage will increase. By tracing the effect of this increase through the AGC chain, we can see the regulating action. The negative pulse results in a positive pulse at the plate of the 1st AGC amplifier, which is coupled to the control grid of the 6DR7 2nd AGC amplifier tube (V4A) and results in a negative pulse at the plate of this tube. This negative pulse is fed to the grid of the second half of the 6DR7 series regulator tube (V4B), which is in the path of the B+ voltage applied to the plate of the oscillator. The increase in the effective resistance of the regulator tube,as a result of the negative pulse on its control grid, provides the reduction in B+ voltage at the oscillator plate necessary to reduce the RF amplitude to the predetermined level. Similarly, an instantaneous drop in RF amplitude will produce effects opposite to those just described at each point in the AGC chain to increase the B+ voltage at the oscillator plate sufficiently to restore the RF amplitude to a predetermined level. Level control R17 (internal adjustment) is used to set the AGC circuit for maximum output on all bands with minimum amplitude variations.

MARKER OSCILLATOR, V5

One-half of the 12AT7 dual triode tube (V5B) is employed as a Colpitts variable frequency marker oscillator, and the other half (V5A) is used as a crystal marker oscillator. The variable marker oscillator covers the range from 2mc to 75mc in 3 fundamental bands and the range from 60mc to 225mc on the third harmonic of the highest fundamental band. The oscillator coils are slug-tuned so the oscillator can be trimmed for perfect tracking over the whole frequency range.

POST INJECTION MARKER CIRCUIT

The Model 369 employs a post-injection marker circuit in which the markers are added to the response curve after the demodulator circuit in the device under test. A swept RF sampling signal is fed to the grid of the mixer-amplifier tube (V1B), and the combined marker signals (variable and/or fixed) are fed to the cathode of the (V1B) tube. The beat signal (markers) are amplified in the plate circuit of V1B and fed through a Marker Size control to the second marker amplifier (V1A). The output of this amplifier is mixed in resistor R2 with the demodulated signal from the unit under test, which has been returned to the 369 through the demodulator cable. The combined signal is fed out through the 'scope cable to the vertical input of the oscilloscope. The demodulated trace is controlled by the Trace Size control.

POWER SUPPLY

A 6X4 full-wave rectifier tube (V6) is employed in the power supply, and the DC output is well-filtered by dual-section electrolytic C10 and resistor R16. Plate voltage for the rectifier and the required filament voltage for all tubes is supplied by power transformer T1, which also provides the voltages for the phasing and blanking circuits.

FUNCTION OF CONTROLS AND TERMINALS

RF RANGE switch – Permits selection from 5 fundamental sweep oscillator frequency ranges marked on panel.

RF 3-220Mc tuning control – Provides fine adjustment of sweep oscillator frequency. Approximate sweep center frequencies are all read on dial scale corresponding to the sweep range selected.

MARKER RANGE switch – Permits selection from 3 fundamental and 1 harmonic variable marker oscillator ranges marked on panel. At the MARKER OFF position, the variable marker oscillator is disabled. The crystal marker oscillator is operative at all positions, provided a crystal is inserted in the XTAL panel socket.

MARKER 2-225Mc tuning control – Provides a fine adjustment of marker oscillator frequency. Fundamental marker frequencies are read on dial scale corresponding to the sweep range selected. Range C (fundamental) and Range D (3rd harmonic) are both read at position C-D of the MARKER RANGE switch.

SWEEP WIDTH control – Provides adjustment of sweep width from zero to a maximum deviation depending on the selected center frequency.

MARKER SIZE control – Provides independent size adjustment of the markers obtained from the variable marker oscillator and/or crystal oscillator.

RF ATTENUATOR switch – Provides coarse amplitude adjustment of swept RF output in 20db steps.

RF LEVEL control – Provides fine adjustment of swept RF voltage amplitude.

TRACE SIZE CONTROL & ON-OFF switch – Permits adjustment of the amplitude of the demodulated signal. The ON-OFF power switch is actuated at the extreme counter-clockwise position to turn the instrument off.

RF OUTPUT connector – Output connection for swept RF output.

DEMOD IN connector – Input connection for demodulated signal.

SCOPE output jack – Take off terminal for the oscilloscope signals.

XTAL socket – Insertion of the 4.5mc crystal supplied with the instrument in this socket closes the crystal oscillator circuit and results in 4.5mc marker energy (and harmonics thereof) to be fed into the post-injection mixer. Broadband circuit permits other frequency crystals to be used if desired.

SCOPE cable – Dual cable providing a shielded vertical input cable and the horizontal 60 cycles phased signal cable.

OPERATION

The use of a sweep signal generator economizes on time and effort and also provides greater refinement of measurement in a very practical manner. For example, an adjustable frequency, adjustable output RF signal generator might be used to obtain output vs. input data for an IF amplifier at several discrete frequency points. This information can be plotted on a graph showing response vs. frequency to obtain the pass-band of the circuit. The procedure would have to be repeated after each circuit readjustment. While a plot for a narrow-band circuit would be laborious but possible, the time required for a broad-band circuit would make this procedure highly impractical.

A sweep signal generator in conjunction with a 'scope provides a simultaneous display of the response of a circuit at all frequencies within the swept band on the screen of the 'scope, in the form of a response vs. frequency curve. The immediate indication of changes caused by adjustments to the circuit under study expedites alignment work or circuit design enormously. Also, information is instantly obtained by sweep methods which might easily be missed using the point-by-point method. For example, regeneration effects and "suck-outs" may cause changes in the response curve over only a narrow range of frequencies. This effect might very easily be entirely within two adjacent discrete frequencies chosen for the point-by-point method. Obviously such effects will be missed, and a smooth response curve would be drawn which does not correspond in its entirety to the actual response.

Fig. 1 shows the Model 369, a broad band detector, and an oscilloscope interconnected. The resultant display on the 'scope screen is shown in Fig. 2. The pattern is a graph with abscissa (horizontal axis) proportional to frequency and the ordinate (vertical axis) proportional to the amplitude response of the detector circuit.

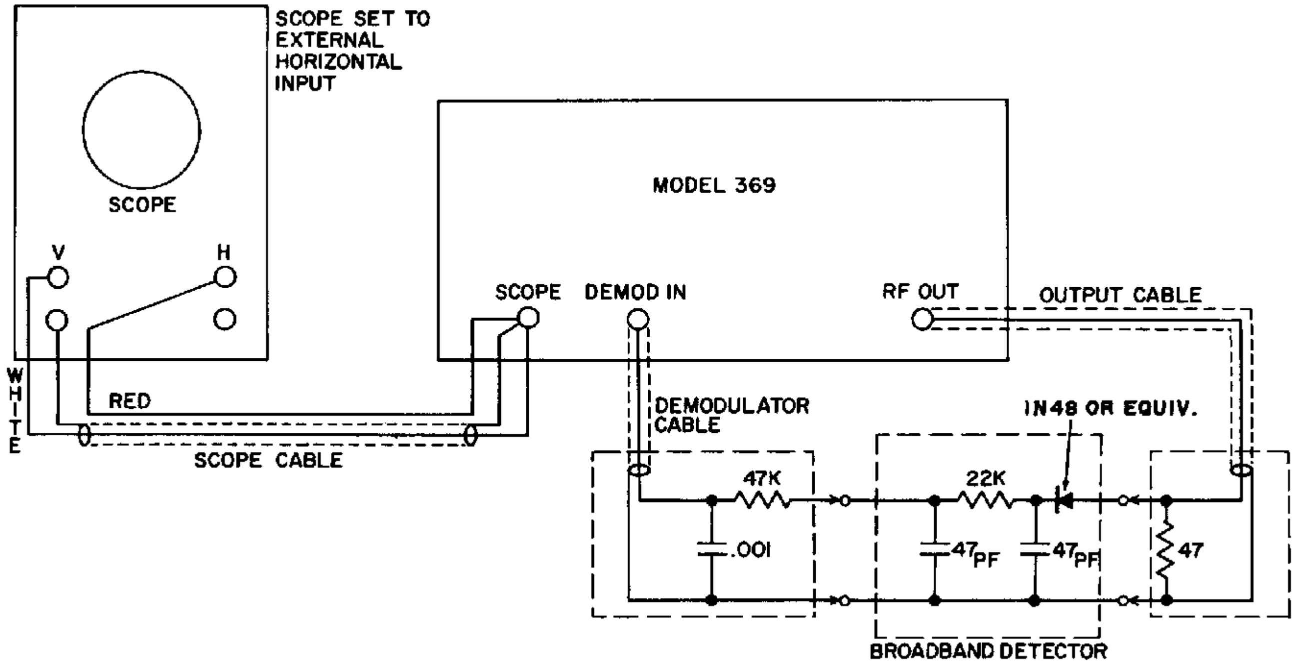


FIGURE 1

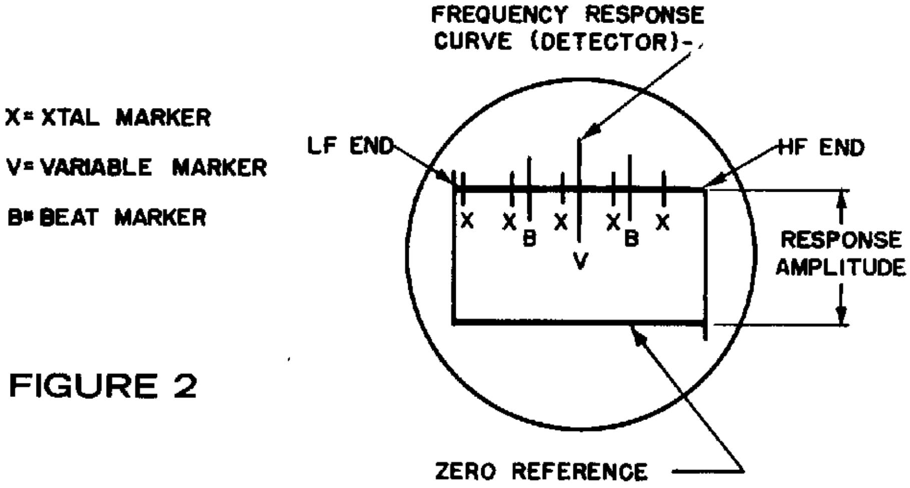


FIGURE 2

Of the two approximately parallel horizontal lines that appear on the screen, one is the reference line of zero input, signifying the blanking period that occurs during every other 1/120th of a second, and the other is the rectified RF output. The rectified RF output will be the upper trace if the detector provides a positive dc output (i.e., as shown in Fig. 2) and the 'scope beam is deflected upward by a positive voltage at the vertical input terminal that is not grounded. The left-hand end of the rectified RF output trace will represent the lower frequency edge of the swept band if the 60 cycle sine sweep is phased so that the start of the positive-going excursion of the 60 cps sine sweep (applied to the horizontal deflection plates of the 'scope) is synchronized with the start of the increasing-frequency excursion of the rectified swept RF band (applied to the vertical deflection plates of the 'scope), and the 'scope beam is deflected to the right by a positive voltage at the horizontal input terminal that is not grounded. It is not possible to interpose the low and high frequency edges of the swept band trace by use of the phasing control of the Model 369, since the latter provides a narrow range of adjustment for fine compensation of small phase shifts.

In this connection, note that tv receiver RF curves are shown deflecting downward, because, when RF response curves are observed, the 'scope is usually connected through an isolating resistor to the mixer grid circuit in the tuner, which goes increasingly negative as signal strength increases. As a result, these response curves deflect downward and are seen below the zero input reference trace. IF response curves are usually shown deflecting upward and are seen above the zero input reference trace. Of course, these curves may be upward or downward, depending on the connections to the rectifier or second detector.

Similarly, as regards to horizontal deflection, confusion will be avoided if the low frequency edge of RF response curves appear on the 'scope at the left side. With this connection, picture RF carriers will be to the left of associated sound RF carriers. Keep in mind that the low-frequency being placed on the left-hand side pertains to RF response curves only. When observing IF response curves, the opposite condition is obtained, and the low frequency is on the right-hand side because the heterodyning action causes a reversal of right and left so far as frequency direction is concerned. To avoid confusion on this subject, it is best to check the direction of frequency increase with an RF response curve obtained at the mixer grid, thereby establishing the left-hand side of the curve as the low-frequency side. The direction of frequency increase, on any response display, can always be determined by noting the direction of travel of the variable marker as its frequency is increased.

To interpret a response curve, facilities must exist for identifying frequencies along the abscissa. This is the function of the highly versatile marker circuits found in the Model 369. Single, dual, or multiple markers may be obtained as desired. High output levels on harmonics as well as fundamentals greatly increase the value of the marker facilities.

The marker appears on the RF response curve trace at a point along the frequency axis corresponding to its own frequency. This occurs because a portion of the marker oscillator output beats against the sweep oscillator output within the instrument. As the instantaneous frequency of the swept oscillator approaches the marker oscillator frequency, the beat frequency becomes visible on the 'scope. As the two frequencies near equivalence, the increasing response of the 'scope to the decreasing difference frequency causes the amplitude to increase correspondingly. The same phenomenon occurs in reverse when the swept oscillator frequency passes the marker oscillator frequency. Immediately adjacent to zero beat (frequency equivalence) the marker reaches its greatest amplitude, which serves to identify the frequency at the point on the RF response curve.

All of the specific uses of this instrument, interpretations of abnormal 'scope traces, and the variations in procedure appropriate to different types of receiver circuitry can not be covered in a brief instruction book. Many excellent books and magazine articles have appeared on the subject, and are easily obtainable. In any case, a detailed alignment procedure for each make and model of receiver is available as prepared by the manufacturer or from information supplied by the manufacturer. Wher aligning a receiver, it is imperative that you have access to the specific service and alignment notes for the particular model. The following description of operation, therefore, will be confined to general information on setting up the instrument for the specific alignment procedures given by the set manufacturers.

The Model 369 employs a center frequency sweep. This means that as the SWEEP WIDTH control is advanced clockwise, the sweep increases evenly on both sides of the center frequency read on the sweep oscillator dial. The sweep is blanked during half of the line cycle to provide a straight line zero input reference. The voltage response of the tuned circuit, at any frequency in the swept band, is proportional to the vertical distance from the corresponding frequency point on the response curve to the zero input reference line. To observe the response curve of a tuned circuit to be aligned with the Model 369, set the RF RANGE and RF 3-220mc controls to the nominal center frequency of the tuned circuit and advance the SWEEP WIDTH control clockwise until a satisfactory trace is obtained. If the left-hand edge (low frequency side) of the trace ends abruptly, instead of sloping down to a point on the zero input reference line, reduce the frequency setting of the RF 3-220mc dial until the start of the trace appears on the zero reference line. If the right-hand edge of the trace ends abruptly, increase the frequency setting of the RF 3-220mc dial. When both edges and abruptly, advance the SWEEP WIDTH control clockwise until both edges of the curve are on the zero reference line. See Fig. 3.

SWEEP OSC.
TOO HIGH

INSUFFICIENT
SWEEP WIDTH

CORRECT FREQ.
& SWEEP WIDTH

FIGURE 3

In connection with sweep width, it should be noted that the uppermost frequency of the sweep oscillator is not limited by the highest indicated frequency on the RF 3-220mc dial for the selected band, since the unit is capable of sweeping across bands. Furthermore, it is worth knowing that the maximum sweep width available on any band is obtained at a frequency setting near the high frequency end. This means that greater sweep width is available at the high end of band B than at the low end of band A at the same frequency.

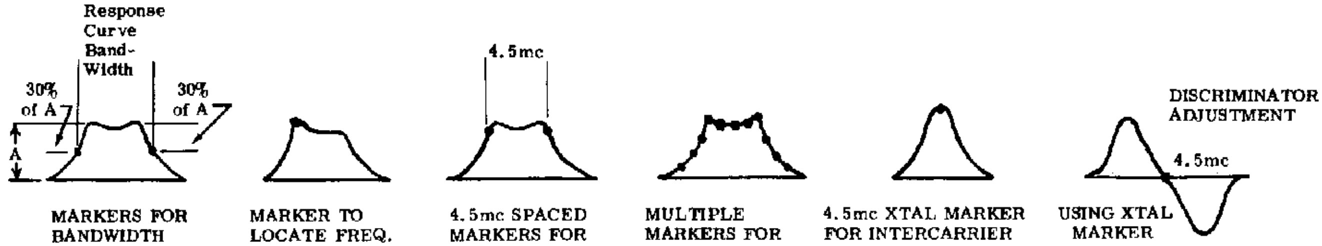
MARKER OSCILLATORS

To determine the bandwidth of a tuned circuit, the MARKER RANGE and MARKER 2-225mc controls are used to set the variable frequency marker pip to a point on the trace that is 30% down from the maximum voltage response on the slope of one side of the waveform. Having done so, the frequency on the marker dial is noted. Then the pip is set to the point on the trace that is 30% down from the maximum voltage on the slope on the other side of the waveform, and the frequency on the marker dial is noted again. The difference between the two frequencies is the bandwidth of the tuned circuit under test.

The outputs of both oscillators are mixed, so that the two oscillator frequencies, their harmonics, and the sum and difference of the fundamental frequencies and their harmonics, will all be present in the output. For example, if the 4.5mc crystal supplied is used, and the variable oscillator is set at 30mc, markers will be obtained 30mc, 34.5mc, 25.5mc, 39mc, 29mc; also at 22.5mc, 27mc, 31.5mc, and 36mc, which are direct harmonics of the crystal oscillator. Therefore, if the variable marker is set to one side of a broadband RF or IF response waveform, another marker will appear 4.5mc away on the opposite side of the waveform. Closer or further spacing of markers can be obtained by substituting crystals of lower or higher frequencies respectively.

Note that the markers produced by the higher harmonics of the 4.5mc crystal oscillator and the variable marker oscillator will be smaller in amplitude than the fundamental marker provided by the variable oscillator and the markers at the sum and difference frequencies of the fundamental variable and crystal marker frequencies (4.5mc on each side of the variable oscillator fundamental marker).

The crystal marker oscillator has many other uses. Using the 4.5mc crystal supplied, this oscillator can be used for alignment of the 4.5mc sound IF to be found in intercarrier sets. A 10.7mc or 5.35mc crystal can be used for FM alignment purposes, with the harmonics useful for FM RF alignment. In the same way, crystals having useful harmonics in the TV IF or RF regions may be used, if required.



MARKERS FOR BANDWIDTH MEASUREMENT

MARKER TO LOCATE FREQ. AT WHICH RESP. IS BEING PEAKED

4.5mc SPACED MARKERS FOR OVERALL RESP. CHECK

MULTIPLE MARKERS FOR SPOT CHECKING

4.5mc XTAL MARKER FOR INTERCARRIER SOUND I.F. ALIGNMENT

USING XTAL MARKER

FIGURE 4

It is of course essential that markers be easily identified. To quickly determine which marker is the fundamental or harmonic of the variable oscillator, remove the crystal from the panel socket. The signal marker pip remaining will be the fundamental or harmonic of the variable oscillator. Restoring the crystal oscillator will permit identification of all the other markers. A fixed marker that remains when all markers have been removed can be assumed to be generated by the local oscillator of the set under test. A pip of this type can be eliminated by connecting a shorting jumper between oscillator grid and chassis.

RF LEVEL AND RF ATTEN CONTROLS

The RF LEVEL control provides continuous adjustment of the amplitude of the swept RF signal, whereas the RF ATTEN switch provides decade step attenuation. Start an alignment job with the RF ATTEN control set at 1K (least attenuation) and the RF LEVEL control set at approximately 5. When the response curve is obtained on the 'scope screen, increase or decrease the attenuation as required. It can not be overly stressed that the generator output (input to the circuit under test) should be kept as low as possible, no higher than is necessary for a good indication of the response on the 'scope screen. Use fully the gain provided by the oscilloscope to assist in this practice. The reason for this is that too much output will result in serious distortion of the response curve, resulting in misleading information, and therefore misalignment. To ensure that overloading has not distorted the response curve, reduce the setting of the RF LEVEL control while observing the waveform. If, at a reduced RF LEVEL control setting, the response curve changes shape, you can be sure the tuned circuit under test was being overloaded previously. Should the original RF LEVEL setting be near or below 1 on the dial, the RF ATTEN control should be turned counter-clockwise one position (greater attenuation), and then the RF LEVEL control reset.

TRACE SIZE CONTROL

The TRACE SIZE control attenuates the demodulated signal, which is in turn fed to the vertical amplifier of the oscilloscope. It is provided for the convenience of not having to readjust the 'scope's vertical gain control at every step in alignment or testing.

MARKER SIZE CONTROL

The MARKER SIZE control should be used to set the marker to an amplitude no greater than that required for easy observation. (Too great a marker amplitude will cause objectionable trace distortion.)

NOTE: The TRACE SIZE and MARKER SIZE controls are independent of each other.

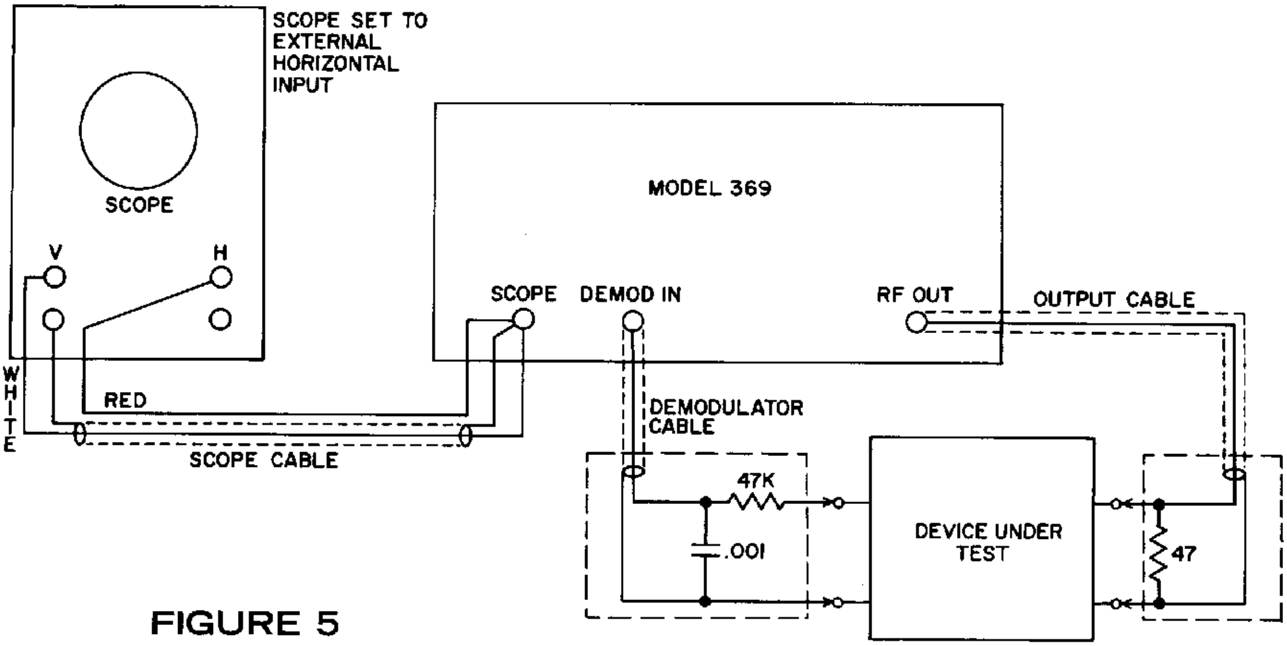


FIGURE 5

TV ALIGNMENT—GENERAL

Do not undertake re-alignment of a tv set unless there is evidence of misalignment. Many symptoms of incorrect alignment may also arise from other causes. Even an abnormal response curve is not certain evidence of misalignment and may sometimes be remedied by tube substitution. By connecting an oscilloscope and the Model 369 to a tv set as described below, gain checks may be made to locate a dead or weak stage. Tubes and other circuit components should be checked before making adjustments on tuned circuits.

It is unusual for RF re-alignment to be required unless the adjustments have been tampered with. Misalignment of the front end (RF, mixer, oscillator) is usually manifested by both picture and sound troubles, either on one channel, several channels, or all channels depending on the set design. Sound troubles only, on all channels, with picture and raster normal, is associated with sound section misalignment.

For all alignment except RF, it is required to render the local oscillator of the tv set inoperative. This may be done either by removing the oscillator tube or temporarily disconnecting the B+ lead going to its plate circuits. Also, render the AGC circuit inoperative by removing the AGC tube, if necessary, and apply a fixed negative dc potential to the AGC line as per manufacturer's instructions.

TRAP ALIGNMENT

In some tv receivers, adjacent channel sound and picture traps are provided in the early IF stages. These traps, if present, must be adjusted before IF alignment. Another type is the 4.5mc sound take-off trap, which is always located after the detector. This trap is more conveniently adjusted after IF alignment.

IF ALIGNMENT - GENERAL

There are two general types of picture IF amplifiers, the stagger-tuned type and the over-coupled type. The final response curve is the same in either case, but the alignment procedure is different. Note that if the trap adjustments are made after the IF alignment, the response curve will be destroyed. Keep in mind also that the correct bias must be applied to the IF tubes during the picture IF alignment (or on RF tubes during RF alignment) if the alignment is to be successful. The best procedure is to follow the manufacturer's instructions in this regard for the particular set being aligned.

IF ALIGNMENT - STAGGER-TUNED TYPE

To align stagger-tuned IF stages, feed the sweep generator output (from the RF OUT connector via the Output Cable) to the grid of the mixer tube through a small capacitor. Connect the Demodulator Cable (from the DEMOD IN connector) across the detector load resistor of the IF strip. Connect the Scope Cable to the V and H inputs of the oscilloscope. See Fig. 5 for a diagram of the connections. Refer to the set manufacturer's service notes during the alignment work.

Select the appropriate SWEEP RANGE and set the RF 3-220mc dial to the desired IF frequency. Adjust the SWEEP WIDTH control to obtain the entire frequency response curve. Reduce the sweep width if the response curve occupies too small a section of the trace and increase the sweep width if the response curve does not return to the zero input reference trace at both the left and right. Also readjust the RF 3-220mc dial setting, if necessary, to properly center the trace. Make sure that the response is not distorted due to overloading.

Select the appropriate MARKER RANGE position and then set the MARKER 2-225mc dial to the IF frequency of the first IF stage as given in the set manufacturer's service notes. Set the MARKER SIZE control to obtain a clearly visible pip. Adjust the first IF so that the marker coincides with the maximum on the trace. If recommended, the primary of the IF transformer preceding the stage being aligned should be shorted. The marker oscillator is then set at the frequency of the next stage and this stage is adjusted. It will be necessary to reduce the output of the generator as alignment proceeds, using the RF LEVEL and RF ATTEN controls. Do not reduce the 'scope vertical amplifier gain instead, but rather keep it at a maximum while holding the output from the generator to a minimum. After all the IF stages have been aligned in this manner, compare the overall response obtained with the curve recommended by the manufacturer in the service notes. The position on the curve of the sound and picture carriers can be checked with the dual markers. Small readjustments in the individual stages may be required to obtain the manufacturer's recommended curve.

NOTE: If the set has adjacent channel sound and picture traps, they should be adjusted before the IF alignment according to the following procedure. Using the crystal and/or variable marker facilities as required, obtain a marker at the nominal trap frequency and adjust the trap until a dip in the trace coincides with the marker pip. When the manufacturer specifies that a modulated signal be used for trap alignment, refer to the SPECIAL PROCEDURES section of the manual.

IF ALIGNMENT - OVER-COUPLED TYPE

To align over-coupled type IF stages, couple the sweep generator output (from the RF OUT connector via the Output Cable) to the grid of the final IF stage through a .001ufd capacitor. Connect the Demodulator Cable (from the DEMOD IN connector) across the detector load resistor of the IF strip. Connect the Scope Cable to the V and H inputs of the oscilloscope. (See Fig. 5). Then align the last IF stage as instructed in the set manufacturer's service notes. If recommended, shunt the primary of the transformer ahead of the control grid to which the signal is applied with a jumper or a 100-200uuf capacitor to prevent it from absorbing energy and causing a dip in the response curve. When alignment of the particular stage is completed, this shunt is removed. The proper trace to be obtained in each case will usually be found in the manufacturer's service notes and should be followed. Alignment proceeds stage by stage from the stage nearest the picture detector to the mixer tube. The overall response curve should be similar to the one shown in the manufacturer's instructions. Here too, the dual markers are used to locate the sound and picture carriers and to provide check points for determining whether the proper curve is being obtained.

NOTE: If the set has adjacent channel sound and picture traps, they should be adjusted before the IF alignment according to the following procedure. Using the crystal and/or variable marker facilities as required, obtain a marker at the nominal trap frequency and adjust the trap until a dip in the trace coincides with the marker pip. When the manufacturer specified that a modulated signal be used for trap alignment, refer to the SPECIAL PROCEDURES section of the manual.

SOUND IF ALIGNMENT

The common detector types found with tv sound IF systems are the discriminator, ratio detector, and gated-beam circuit. For the discriminator and ratio detector types, alignment procedures are similar except for the oscilloscope connection point. Adjustment of gated-beam detectors is usually performed using a transmitted tv signal according to procedures given in the manufacturer's service notes.

If the circuit uses a discriminator, connect the Demodulator Cable to the grid return of the last limiter tube, and adjust the generator's output for the lowest output that will give a satisfactory trace. Set the marker oscillator to the exact intermediate frequency of the sound IF strip, and perform adjustments maintaining a symmetrical wave-shape on each side of the marker. Then shift the Demodulator Cable to the volume control, or to the opposite side of the resistor going to the control, and adjust the discriminator transformer for the maximum amplitude and straightness of the slanted detecting curve. The adjustment is finished when the marker is at the center of the response curve. In intercarrier type sound systems, use the 4.5mc crystal oscillator to furnish the marker.

As for the ratio detector, note that in the output circuit of the two ratio detector diodes there are two capacitors, one connected to the plate of one diode and the other connected to the cathode of the other diode. Connect the Demodulator Cable to the junction of these two capacitors and ground. The i-f amplifiers and the detector transformer can then be aligned as described above for the case where a discriminator is employed.

VHF TUNER ALIGNMENT

Again it should be cautioned that oscillator and RF alignment should not be performed unless it is necessary. The general procedure is outlined below.

Restore the oscillator to operation, and feed the sweep generator output (from the RF OUT connector via the Output Cable) through an impedance matching device to the antenna input terminals. (For a 300 ohm antenna input, the impedance matching device will consist of 120 ohm resistors in series with both the "hot" and ground leads of the Output Cable.) Remove the first IF amplifier tube and shunt the grid resistor with another resistor (approximately 1000Ω). Connect the DEMOD IN cable to the test point at the tap of the mixer grid load (always available in tuners). The vertical amplifier of the 'scope must have good sensitivity for an adequate size display of the RF response at this point. Set the channel selector of the tv set and the sweep generator to channel 13. Sweep this band adequately to display the entire bandwidth. With the marker tuned to the video and/or sound frequency of channel 13, determine whether these frequencies are within the response curve and are in the relatively flat region. Consult the service notes on the tv set for location of the proper alignment points on the tuner to correct the response curve if required. On other channels, it might be required to compress or expand turns of the individual coils to adjust for proper response.

ALIGNMENT OF INTERCARRIER SETS

Use fixed frequency methods for video IF strip alignment with a VTVM connected across the video detector. The output from either the variable or crystal oscillator may be used. If sweep techniques are prescribed, the previously described methods can be employed.

On completion of fixed frequency alignment, check the overall response with sweep generator and 'scope. Connect the generator to the mixer stage and the 'scope to the video detector and touch up the IF adjustment screws to obtain the recommended response curve.

Alignment of the sound IF strip is performed as described previously, except that the 4.5 mc crystal oscillator is used as the signal source or marker, depending on which alignment method is employed. When this is done, adjust the 4.5mc trap (if any) using the 4.5mc output of the crystal marker oscillator and a VTVM with an RF probe at the cathode or grid of the picture tube. For some sets, the DC probe of a VTVM will instead be connected to a point in the sound detector circuit. Follow the set manufacturer's instructions in all cases.

The tuner in an intercarrier set is aligned according to the same general methods described previously.

FM RECEIVER ALIGNMENT

The procedure for aligning an FM receiver is similar to sound IF alignment in tv receivers. The usual IF frequency is 10.7mc, although higher IF frequencies are used in some receivers. The variable marker oscillator will supply the required 10.7mc signal. If extremely accurate alignment is desired, the crystal oscillator may be employed, using a 10.7mc or 5.35mc crystal inserted in the crystal socket on the panel. In the latter case, the variable marker oscillator may be set to a frequency 100kc above or below the crystal oscillator frequency to obtain additional bandwidth markers. If the variable marker oscillator is used to provide the 10.7mc or other IF frequency, an external signal generator set to a frequency 100kc above or below the IF frequency may be used to provide additional bandwidth markers.

SPECIAL PROCEDURES

If it is essential that a modulated signal be used for adjustment of traps, detectors, etc., a separate signal generator having modulation facilities may be used. If such a generator is not available, an unmodulated signal can often be used together with a VTVM set for DC voltage measurement connected to the video or audio detector. When a modulated signal is used, a VTVM set for AC voltage measurement, or a 'scope, is usually connected to the grid or cathode of the picture tube. In either case, the trap will be set for a minimum indication. If a modulated signal is required for sound IF alignment in a TV or FM set, it may be possible to substitute the procedure described under SOUND IF ALIGNMENT. Follow the recommended procedure, however, if there is doubt as to the efficacy of this method.

ACCESSORY INSTRUMENTS

For routine servicing of both monochrome and color tv sets without undue difficulty, a stable, sensitive, and wide-band scope (essentially flat to at least 3.58mc) is a necessity. For sweep alignment, however, wide-band response is not required, since all that is required is faithful reproduction of a 60 cycle square wave. For this purpose, the 'scope should be flat from 6 to 600 cycles, or preferably 3 to 1200 cycles, and introduce very little phase shift over the range. A scope having DC (direct-coupled) vertical amplifiers is ideal for this purpose. The EICO Model 460 Oscilloscope has both 5mc bandwidth and DC vertical amplifiers and is required if color tv servicing is to be done as well as monochrome tv and FM servicing. For monochrome tv only and FM servicing, the EICO Model 427 and 430 'scopes with .5mc bandwidth, are excellent.

Three EICO probes are available to increase the usefulness of your oscilloscope. These types of probes are available: Oscilloscope Demodulator Probe Model PSD for signal tracing and waveform checks in the RF and IF sections of tv and radio receivers, and also for stage gain measurements in low impedance RF circuits; Oscilloscope Low Capacity Probe Model PLC for accurate reproduction of sync signal waveforms, and generally for tracing high frequency, wide-band waveforms in high impedance circuits, since this probe effectively reduces the capacitive loading of the oscilloscope by a factor of ten; Oscilloscope Direct Probe Model PD for use in low frequency or low impedance test circuits, and where it is desired to eliminate stray pick-up and signal re-radiation.

Another essential instrument for alignment work and routine tv servicing is a high input impedance VTVM, preferably of the type with true peak-to-peak response such as the EICO Models 232 and 249. Both these models have an impedance of 11 megohms. This impedance is sufficiently high to make loading effects negligible, and to give true voltage readings in the circuits under investigation. A high voltage probe and an RF probe are available as accessories for use with the VTVM.

For horizontal and vertical linearity adjustments on a properly operating or completely serviced tv receiver, use the EICO Model 352 Bar Generator. This instrument produces an adjustable number of evenly spaced vertical or horizontal bars when connected to the antenna input terminals of a tv receiver to facilitate rapid and accurate linearity adjustments. This service will help gain the good will of your customers.

MAINTENANCE—GENERAL

Included in this section are instructions for mechanical adjustments, calibration, troubleshooting, and parts replacement. All adjustments and calibration procedures must be performed on completed kit instruments, in the order given, before they can be placed in use. The same procedures will serve for periodic re-adjustments in both kit and factory-wired instruments when required by component aging or replacement.

REMOVAL FROM CABINET

To remove the instrument from the cabinet, first disconnect it from the power line and remove the two screws at the cabinet rear. Then slide the chassis out of the front of the cabinet.

MECHANICAL ADJUSTMENTS

Both the MARKER 2-225mc and RF 3-220mc dials must be positioned so that the radial lines marking the low frequency end of all bands is brought exactly in front of the hairline on the panel when the variable capacitor plates are fully meshed. The procedure to make this adjustment is described below.

1. Turn the knob clockwise until the capacitor plates are fully meshed without forcing. NOTE: The knob can be turned slightly beyond this point with a little forcing, but doing this is undesirable because it would throw off the calibration. A sure way of avoiding this mistake is to watch the two thin adjacent gears on the capacitor shaft (both of which mesh with the thick brass gear on the driving shaft) while turning the knob clockwise. You are not forcing while the two thin adjacent gears move together; you are forcing when the gear nearest the capacitor frame is moved while the thin gear in front of it remains stationary. As forcing is possible only over a few degrees of rotation, you will have to observe closely.

2. Loosen the setscrews in the brass bushing which connects the ball drive to the variable capacitor shaft.

3. Position the dial (moving it clockwise) so that the radial line marking the low frequency end of all bands rests directly in front of the hairline on the panel. While the dial is in this position, retighten the setscrews on the bushing.

TEST SET-UP FOR CALIBRATION AND ADJUSTMENT

1. For the calibration and adjustment of the Model 369, it is necessary to make up a broadband detector. The broadband detector simulates a device with flat frequency response over the entire frequency spectrum of the Model 369. The components for the detector are easily obtainable and should be wired as shown in Fig. 6. (The broadband detector is shown schematically in Fig. 7.

NOTE: In wiring the broadband detector, keep wires as short as possible to avoid resonances which will appear in the response curve on the 'scope. To minimize hum pickup, which distorts the response curve on the 'scope, it is most advisable to build the broadband detector into a shielding metal enclosure connected to ground.

BROAD BAND DETECTOR

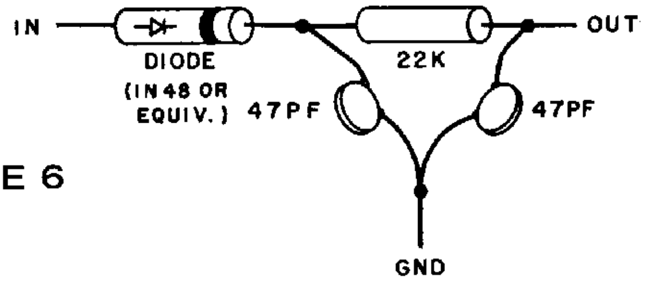


FIGURE 6

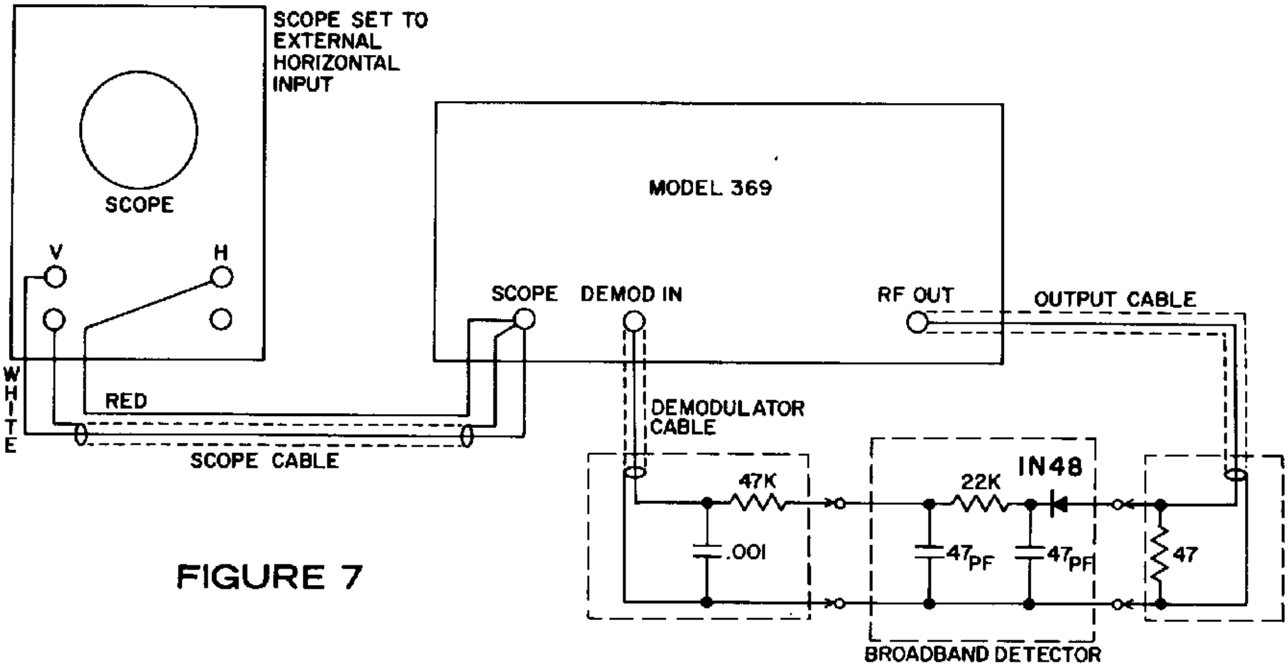


FIGURE 7

2. Connect the Model 369, the broadband detector, and an oscilloscope as shown in Fig. 7. This set-up is good for all calibration and adjustments.

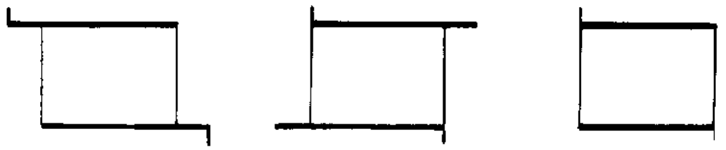
3. Connect the line cord to the 117VAC, 60 cps line, and turn the TRACE SIZE control clockwise from the OFF position to turn the power on. The unit is now operating and ready for calibration and adjustment. Allow the unit to warm up for half an hour before proceeding.

ADJUSTMENT OF SWEEP OSCILLATOR

NOTE: The SWEEP 3-220mc dial is not calibrated accurately because the marker oscillators serve to provide accurate identification of frequencies along the response curve.

1. Set the RF LEVEL and RF ATTEN controls to the furthest clockwise position (maximum output). Set the RF RANGE selector to position E, and the SWEEP WIDTH control at zero. Set the 'scope controls for a horizontal deflection of 1/2 to 2/3 the screen diameter, and the TRACE and 'scope vertical gain controls for a convenient pattern height.

2. A rectangular shaped trace should result from the preceding operations, as shown in Fig. 8.



IMPROPER PHASING

PROPER PHASING

FIGURE 8

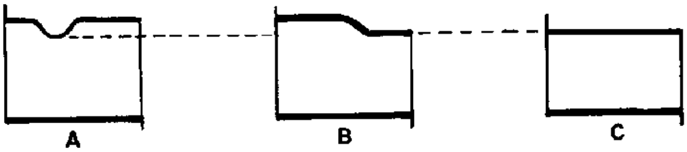
Note that the correct display consists of two bright, straight, and parallel horizontal lines connected by two light vertical lines at the extremities. A slight spike might be present at the extremities, caused by differentiation of the blanking pulse. This does not interfere with the operation of the unit. If the 'scope does not have good response below 60 cycles, the detected response line will be tilted. For this reason, it is preferable to use a 'scope with dc (direct-coupled) vertical amplifiers (such as the EICO Model 460 or Model 427). In the OPERATION section (page 5), information is given as to how to determine which of the horizontal lines is the detected sweep output, and which is the zero input reference; also, how to determine which is the high-frequency end, and which is the low-frequency end of the sweep.

If necessary, adjust the PHASE control located on the rear apron for correct phasing of the horizontal deflection voltage as shown in Fig. 8.

3. Now set the RF RANGE selector successively to each of the other ranges. At each position, wait for the AGC action to complete itself (finding the maximum output level with minimum amplitude variation). On each range the trace should consist of the same two straight horizontal parallel lines, although the vertical distance between the lines need not be the same on all ranges, and, in fact, will usually not be. On each range position, turn the RF 3-220mc dial through the full frequency range to determine whether there are any "dead" spots where the sweep oscillator does not function. The amplitude of the response curve will normally vary over any one sweep range, particularly on the two highest ranges. At one point at least, check the operation of the RF LEVEL and RF ATTEN controls by turning them fully counter-clockwise and then returning them to the furthest clockwise position.

4. Advance the SWEEP WIDTH control to maximum. The RF ATTEN should be set at X1K and the RF LEVEL at 10 (minimum attenuation). Rotate the AGC level adjust potentiometer R17 (on the chassis) maximum counter-clockwise. Set the RF RANGE selector at Range E, and turn the RF 3-220mc dial through the entire frequency range while observing the pattern on the 'scope. If a dip or break in response occurs, as shown in Fig. 9A, 9B, turn the AGC level control R17 clockwise just enough to bring the amplitude down to where the dip disappears, as shown in Fig. 9C. (Note that the ultimate effect of adjusting R17 is not evident instantaneously. Make the adjustment in small increments and allow time for AGC action). Then set the RF RANGE selector at Range D, and again turn the RF 3-220mc dial through the entire range while observing the pattern on the 'scope. If a dip or break occurs on this range, turn AGC level control R17 further clockwise until the dip disappears. Proceed successively to Range C and Range B, and turn R17 as far clockwise as is required to eliminate any dip in the output curve on every band. No further adjustment of the AGC level control should be attempted on Range A. (Note that adjustment of R17 can only correct dips or breaks in the output of the swept oscillator, not irregularities due to resonances or hum pickup in the broadband detector circuit. Therefore, be sure that the broadband detector is wired correctly as described previously, and preferably shielded by a grounded metal enclosure. In any case there will always be some residual hum pickup which will cause distortion of the response curve on the 'scope, particularly evident on the high end of Band A because of the reduced output level. Note that the response curves depicted in Fig. 9 are idealized and do not show the irregular tilt that would be introduced by hum pickup.

FIGURE 9



CALIBRATION OF MARKER GENERATOR

1. Insert the 4.5mc crystal in the XTAL socket on the panel and advance the MARKER SIZE control to 10 and the TRACE SIZE control to 0. Set RF RANGE switch to band A and the RF 3-220mc dial at 220mc. This will eliminate possible interference from the sweep generator in the marker calibration procedure.

2. Set the MARKER RANGE selector at position C-D and the MARKER 2-225mc dial to 22.5mc (5th harmonic of the crystal). Adjust the marker oscillator coil slug for Band C-D (see Fig. 10 for location) for zero beat between the crystal and variable marker oscillators. (The approach of zero beat will be indicated by an increased trace amplitude. Exactly at zero beat, the amplitude of the trace will drop to zero. Increased trace amplitude will be visible again on the other size of zero beat.) As there are strong crystal harmonics every 4.5mc, you can not be sure that the variable oscillator is zero beating against the selected harmonic without checking. For this reason, the coil slugs have been pre-set in production at approximately the correct position, so that the zero beat between the variable marker oscillator set to 22.5mc and the 5th harmonic of the 4.5mc crystal occurs when the coil slug is adjusted not more than a few turns either way from the pre-set position. To make certain that the coil slug adjustment is correct, it must be checked by setting the MARKER 2-225mc dial at 27mc (6th harmonic), 31.5mc (7th harmonic), and 36mc (8th harmonic), at all of which frequencies zero beat should occur again. If these checks do not confirm the correctness of the coil slug adjustment, reset the dial to 22.5mc and readjust the coil slug for zero beat at a different point. In all these adjustments, it may be necessary to re-adjust the MARKER SIZE control for a beat signal display of convenient amplitude on the 'scope.

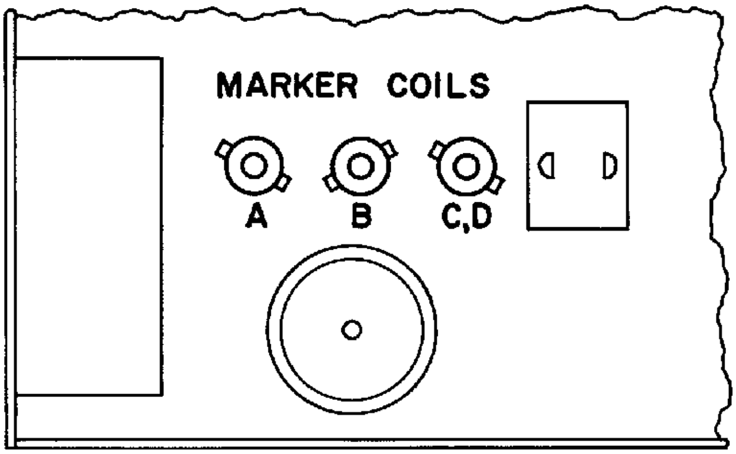


FIGURE 10

3. Set the MARKER RANGE selector at Range B. Set the MARKER 2-225mc dial at 9mc. Adjust the slug in the Band B coil for zero beat. To confirm the correctness of the coil adjustment, check for zero beat at dial settings of 13.5mc and 18mc on the Range B scale. Re-do the coil adjustment if confirmation is not obtained.

4. Set the MARKER RANGE selector at Range A. Set the MARKER 2-225mc dial at 2.25mc. Adjust the slug in the Range A coil for zero beat. To confirm the correctness of the coil adjustment, check for zero beat at a dial setting of 4.5mc. This completes the calibration of generator. Adjustment of the instrument is now completed.

TROUBLE-SHOOTING

The schematic diagram of the Model 369 plus the information given in the CIRCUIT DESCRIPTION section should aid in isolating the circuit in which the trouble is located. The next step is to localize the trouble in the particular section to the tube circuit involved and then to try a replacement tube. If the trouble is not eliminated, voltage and resistance checks should be made and compared with the data provided in the voltage and resistance chart (Fig. 11). Note that the sweep oscillator section consists of the oscillator, cathode follower, blanking, and AGC circuits, and that the voltages in these circuits are interdependent. Because of this voltage interdependence, first attempt to locate the defect by making wiring and cold resistance checks on each of these stages individually.

As an aid in localizing trouble, common symptoms together with their possible causes and remedies have been listed in groups corresponding to the major sections of the instrument (Fig. 13). Of course, all possible troubles could not be included in the chart and the make-up of the chart has been based on the assumption that the instrument has worked properly at some previous time. Keep in mind that in trouble-shooting, the main endeavor is to find and eliminate the source of the trouble. Recurrence of a trouble usually indicates that the effect, not the cause has been remedied.

RESISTANCE CHART

	V1 12AU7	V2 6BQ7A	V3 12AX7	V4 6DR7	V5 12AT7	V6 6X4
1	Above 330KΩ	Above 1M	20KΩ	Above 1M	INF.	170Ω
2	4.7K	100KΩ	20KΩ	Above 1M	22K	
3	680Ω	250Ω	15KΩ	Above 1M	470Ω	"N.S."
4	"N.S."	"N.S."	"N.S."	"N.S."	"N.S."	0
5	"N.S."	"N.S."	"N.S."	0	"N.S."	
6	Above 330KΩ	Above 1M	1.5MΩ	Above 1M	Above 1M	170Ω
7	100K	10KΩ	4.7MΩ	3M	47K	Above 300K
8	0	0	0	270Ω	470Ω	
9	0	—	0	Above 1M	0	

FIGURE 11A

REFERENCES FOR VOLTAGE & RESISTANCE CHART

*Voltages will change with MARKER RANGE positions.

**Voltages will vary with setting of AGC control, R17, and with RF RANGE and RF 3-220mc tuning dial positions. Sweep Circuit Voltages: Across C27, 150VDC; across C25, 0 to 68VAC varies with Sweep Width setting, R41. For this measurement use a blocking capacitor of at least .1uf. Unless otherwise noted, all voltage and resistance values may normally vary by ±10%.

***N.S. stands for "Not Significant".

CONTROL SETTINGS

TUNING KNOBS fully clockwise
RF RANGE at E
SWEEP WIDTH at 0
RF LEVEL at 10
RF ATTEN X1K
MARKER SIZE at 10
MARKER RANGE at A
TRACE SIZE at 10
XTAL IN

VOLTAGE CHART

	V1 12AU7	V2 6BQ7A	V3 12AX7	V4 6DR7	V5 12AT7	V6 6X4
1	14.4 VDC	160 VDC	-64VDC	350 VDC	140 to 170*	290 VAC
2	-.33 VDC	-12VDC	-64VDC	40 to 96VDC**	-3.5 to -9VDC*	NC
3	.4VDC	4VDC	148 AC	40 to 96VDC**	3.5VDC	6.3VAC
4	6.3VAC	6.3VAC	6.3VAC	6.3VAC	0	0
5	6.3VAC	0	6.3VAC	0	0	NC
6	14VDC	95 to 150 VDC**	24 to 40 VDC**	40 to 96 VDC**	120 VDC	290 VAC
7	-.4	-38 VDC**	-42 VDC	-.2 to -.7VDC**	-3 VDC	350 VDC
8	0	0	0	.22 to -.32VDC**	3.5 VDC	
9	0	0	0		6.3 VAC	

FIGURE 11B

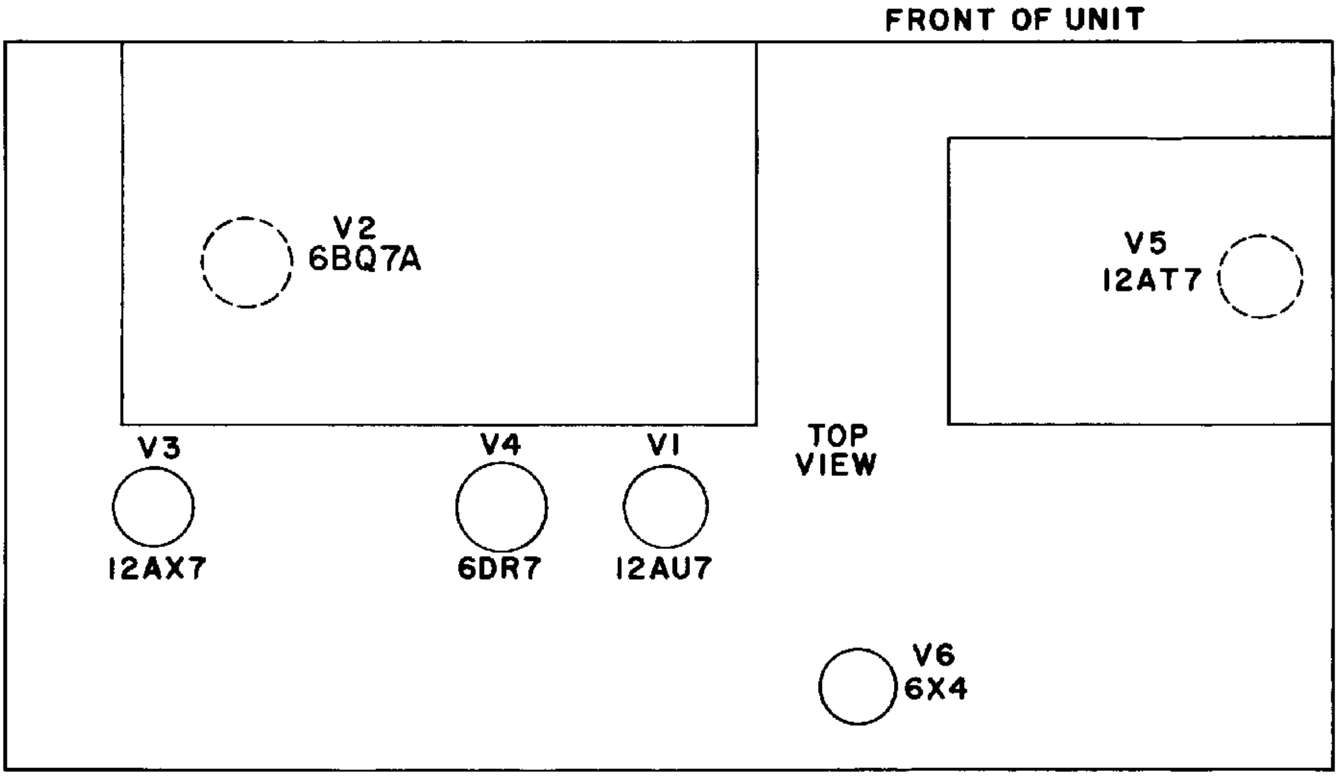


FIGURE 12 TUBE LAYOUT—TOP VIEW

TROUBLE-SHOOTING CHART

SYMPTOM	DEFECT	REMEDY
Pilot lamp I1 does not light.	I1 defective	Replace
	ON-OFF switch S4 defective.	Replace
	Line cord defective	Replace
	Transformer T1 defective.	Replace
	B+ short	Check for shorted filter electrolytic, tuning capacitor, B+ wiring.
Some or all tube filaments not lit.	Defective tube or tubes.	Replace
	Defective filament wiring.	Repair
	Transformer T1 defective.	Replace
No output from sweep osc.	Defective V2	Replace
	AGC level control R17 misadjusted.	Re-adjust
	Oscillator coil or coils of L5 open.	Replace L5
	Defective wiring	Repair
Poor or no regulation (AGC action)	R17 misadjusted	Re-adjust
	V3 or V4 defective	Replace
	R12, R15, R36 open	Replace
	C13, C24 defective	Replace
	Defective wiring to switch S3	Repair
No blanking	Defective V3	Replace
	R12, R22 open	Replace
	C11 shorted	Replace
No sweep	Control coil of L5 defective.	Replace L5
	C26 defective	Replace
	R39, R40, R41 open	Replace
	Defective CR1	Replace
No variable markers	Defective V1, V5	Replace
	L1, L2, L3, L4 open	Replace
	Defective R25, R26 (check if no negative voltage present at pin 2 of V5)	Replace
	Defective R4	Replace
	C1, C2 open	Replace
	C3 shorted	Replace
No crystal markers	Crystal defective	Replace
	PC3 defective	Replace
	C17 shorted	Replace
Trace Size control inoperative	R1 defective	Replace

FIGURE 13

PARTS LIST

CAPACITORS

SYM. #	STOCK#	DESCRIPTION
C1, 2	22556	disc, 68uuf, 500V
C3	22550	disc, 600uuf, 500V
C4, 5, 6, 7, 15, 20	22533	disc, 47uuf
C17	22551	disc, 22uuf
C8, 11, 28	22515	disc, 500uuf
C9	29006	tuning, sweep
C10	24001	elect., 2 x 20ufd, 450V
C12	20501	tubular, 2ufd, 150V
C13	20056	tubular, 1ufd, 200V
C14	22522	disc, 330uuf, 500V
C16	22503	disc, .01, 1500V
C22, 30,	22521	disc, .001ufd, 500V
C18, 21	22023	tubular, 2uuf
C19	29007	tuning, marker
C23, 29	22528	disc, 2 x .005ufd
C24	22526	disc, .005ufd
C25	20067	tubular, .25ufd, 200V
C26	23010	elect., 10ufd, 150V
C27	23015	elect., 50ufd, 150V
C31	20026	tubular, .047ufd, 600V

COILS

SYM. #	STOCK#	DESCRIPTION
L1	36011	variable
L2	36012	variable
L3	36013	variable
L4	35021	25uh, plain core
L5	37010	controllable inductor
L6	35052	100uh, plain core - 3 pi
L7, 8	35020	25uh, iron core

RESISTORS

(All resistors are 1/2 watt, 10% unless noted otherwise)

SYM. #	STOCK#	DESCRIPTION
R1	18111	potentiometer, 2MΩ, w/SPST
R2, 19, 35	10410	100KΩ
R3, 6	10412	330KΩ
R4	18113	potentiometer, 100KΩ
R5	10406	680Ω
R7, 25	10430	4700Ω
R8	10438	330Ω
R9	10857	2200Ω, 1W
R10, 31, 43	10436	47Ω
R11, 12	10400	10KΩ
R13	10851	22KΩ, 1W
R14	10418	4.7MΩ
R15	10407	1MΩ
R16	14309	7000Ω, 10W
R17	18017	potentiometer, 2MΩ
R18	10849	47KΩ, 1W
R20	10844	330KΩ, 1W
R21	10446	270Ω
R22	18112	potentiometer, 100KΩ
R23, 32, 33, 34	10429	470Ω
R24, 42	10428	47KΩ
R26	10424	22KΩ
R27	18115	potentiometer, 200Ω
R28, 29, 30	10437	56Ω
R36	10450	3900Ω
R37	10855	4700Ω, 1W
R38	10426	33KΩ
R39	10956	10KΩ, 2W
R40	10852	15KΩ, 1W
R41	18114	potentiometer, 10KΩ

SWITCHES

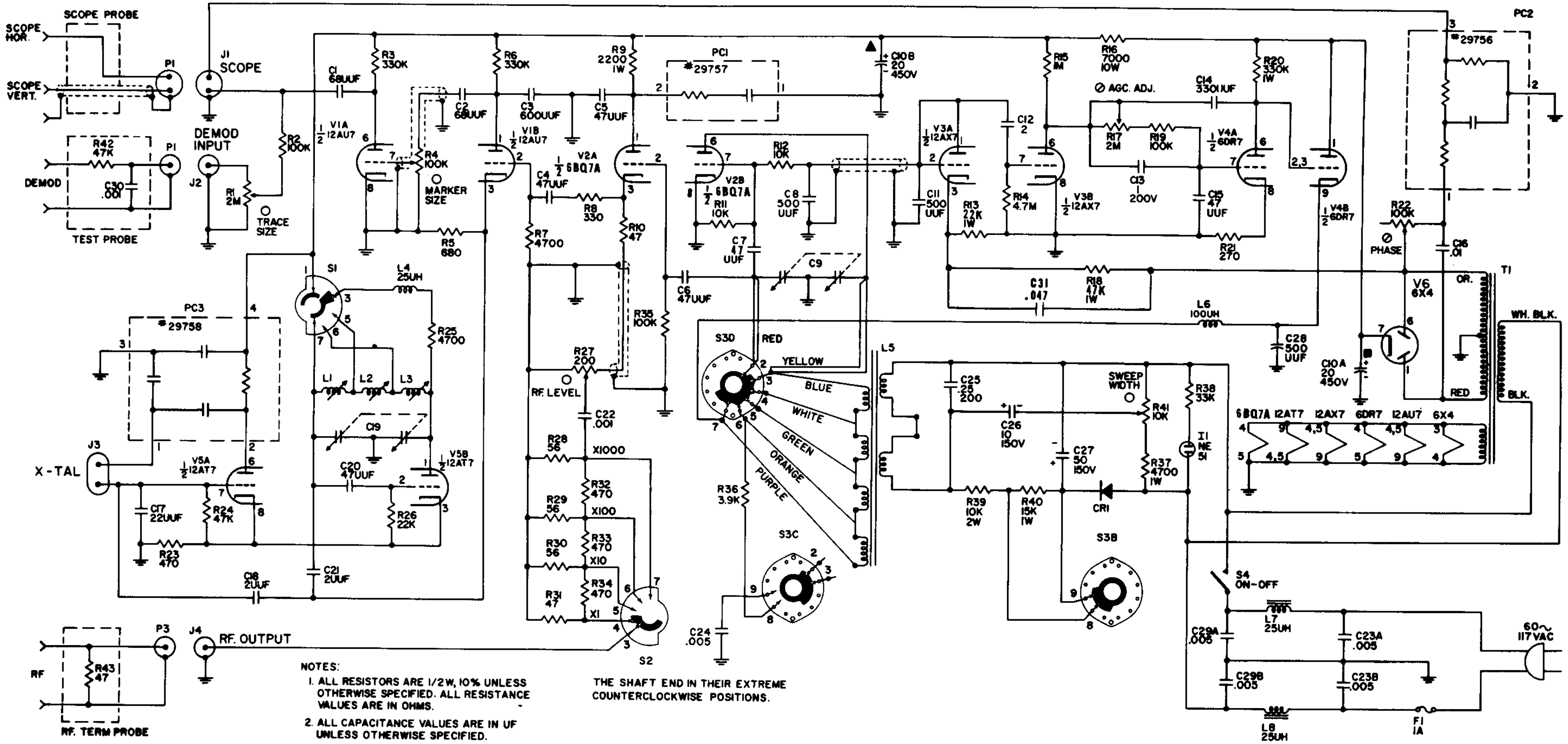
SYM#.	STOCK#	DESCRIPTION
S1	60122	rotary, marker
S2	60123	rotary, attenuator
S3	60124	rotary, range
S4	18111	ON-OFF on R1

TUBES

SYM#.	STOCK#	DESCRIPTION
V1	90013	12AU7
V2	90052	6BQ7A
V3	90034	12AX7
V4	90088	6DR7
V5	90012	12AT7
V6	90036	6X4

SYM. #	STOCK#	DESCRIPTION
	TUBE SOCKETS	
XV1, 3, 4, 5	97081	9 pin miniature
XV2	97005	9 pin wafer
XV6	97022	7 pin miniature
	TERMINAL STRIPS	
TB1, 10	54004	2 post w/gnd.
TB2, 4, 8	54006	3 post, 2 right
TB3	54008	4 post
TB5, 7, 14	54002	1 post right w/gnd.
TB6	54000	1 post left
TB9, 13	54015	3 post, 2 left w/gnd.
TB11	54060	3 post left
TB12	54005	2 post right w/gnd.
TB15, 16	54016	3 post upright, left
	MISCELLANEOUS	
CR1	93003	rectifier, 50mA
F1	91002	fuse, 1 Amp
I1	97715	neon indicator
J1	50036	connector, female, 2-cond.
J2, 4	50002	connector, male
J3	97500	socket, crystal
P1	50037	connector, male, 2-cond.
P2, 3	51000	connector, female
PC1	29757	printed circuit
PC2	29756	printed circuit
PC3	29758	printed circuit
T1	30002	transformer, power
XF1	97805	fuseholder
	46016	foot, plastic (4)
	49000	crystal, 4.5mc (1)
	51502	clip, alligator (4)
	53036	knob, 1-1/16 dia. (7)
	53052	knob, 1-1/2 dia. (2)
	54512	board, probe (2)
	57004	line cord
	58444	cable, 2-cond. one w/shield (1)
	66151	manual of instructions (1)
	66391	manual of construction (steps) (1)
		manual of construction (figures) (1)
	82101	strain relief, line cord (1)
	84000	drive, vernier (2)
	87007	handle, plastic (1)
	89525	sleeve, red (2)
	89320	label, nomenclature (1)

SYM. #	STOCK#	DESCRIPTION
	89526	sleeve, black (2)
	89564	nosepiece probe (2)
	89672	sleeve, small, black (1)
	89679	bracket, handle mtg. (2)
	89680	plate, handle mtg. (2)
	89741	dial, plastic sweep (1)
	89742	dial, plastic marker (1)
	89747	housing, probe demod. (1)
	89748	housing, probe RF out (1)
	HARDWARE	
	40000	nut, hex, #6-32 (20)
	40001	nut, hex, 3/8" (8)
	40007	nut, hex, #4-40 (17)
	40016	nut, hex, 1/2" (1)
	40017	nut, Tinnerman #8 (2)
	40022	nut, hex, #4-40 (5)
	40045	nut, hex, #8-32 (4)
	41003	screw, #8-32 x 3/8 (6)
	41069	screw, set # 6-32 x 1/8 (4)
	41063	screw, #6-32 x 1/4, Fl. Hd. (3)
	41086	screw, #6-32 x 5/16 (35)
	41089	screw, #6-32 x 3/16, Rd. Hd. (1)
	41090	screw, #4-40 x 5/16 (16)
	41095	screw, #2-56 x 1/4 (4)
	41125	screw, #4-40 x 5/8, Rd. Hd. (1)
	41140	screw, #6-32 x 1/4, self-tapping, Ph. Rd. Hd. (10)
	42000	washer, lock, 3/8" (9)
	42001	washer, flat, 3/8" (8)
	42002	washer, lock, #6 (42)
	42007	washer, lock, #4 (16)
	42008	washer, lock, #8 (4)
	42019	washer, rubber probe (2)
	42020	washer, fibre (8)
	42029	washer, rubber 1/2" (1)
	42511	retainer, neon indicator (1)
	43000	lug, #6 (1)
	43001	lug, pot., 3/8" (3)
	43005	lug, spade for probe (3)
	44009	standoff (8)
	47001	spring, spade for probe (2)
	SHEET METAL	
	80096	panel, front (1)
	81251	chassis, main (1)
	81252	chassis, sweep sub (1)
	81253	chassis, marker sub (1)
	81254	shield w/lugs (1)
	81984	bracket, Xtal socket (1)
	86007	frame (1)
	88114	cabinet (1)



NOTES:

1. ALL RESISTORS ARE 1/2W, 10% UNLESS OTHERWISE SPECIFIED. ALL RESISTANCE VALUES ARE IN OHMS.
2. ALL CAPACITANCE VALUES ARE IN UF UNLESS OTHERWISE SPECIFIED.
3. SWITCHES ARE SHOWN VIEWED FROM THE SHAFT END IN THEIR EXTREME COUNTERCLOCKWISE POSITIONS.

SCHEMATIC DIAGRAM