# INSTRUCTION MANUAL

Serial Number ____________

# TYPE 1L60 SPECTRUM ANALYZER

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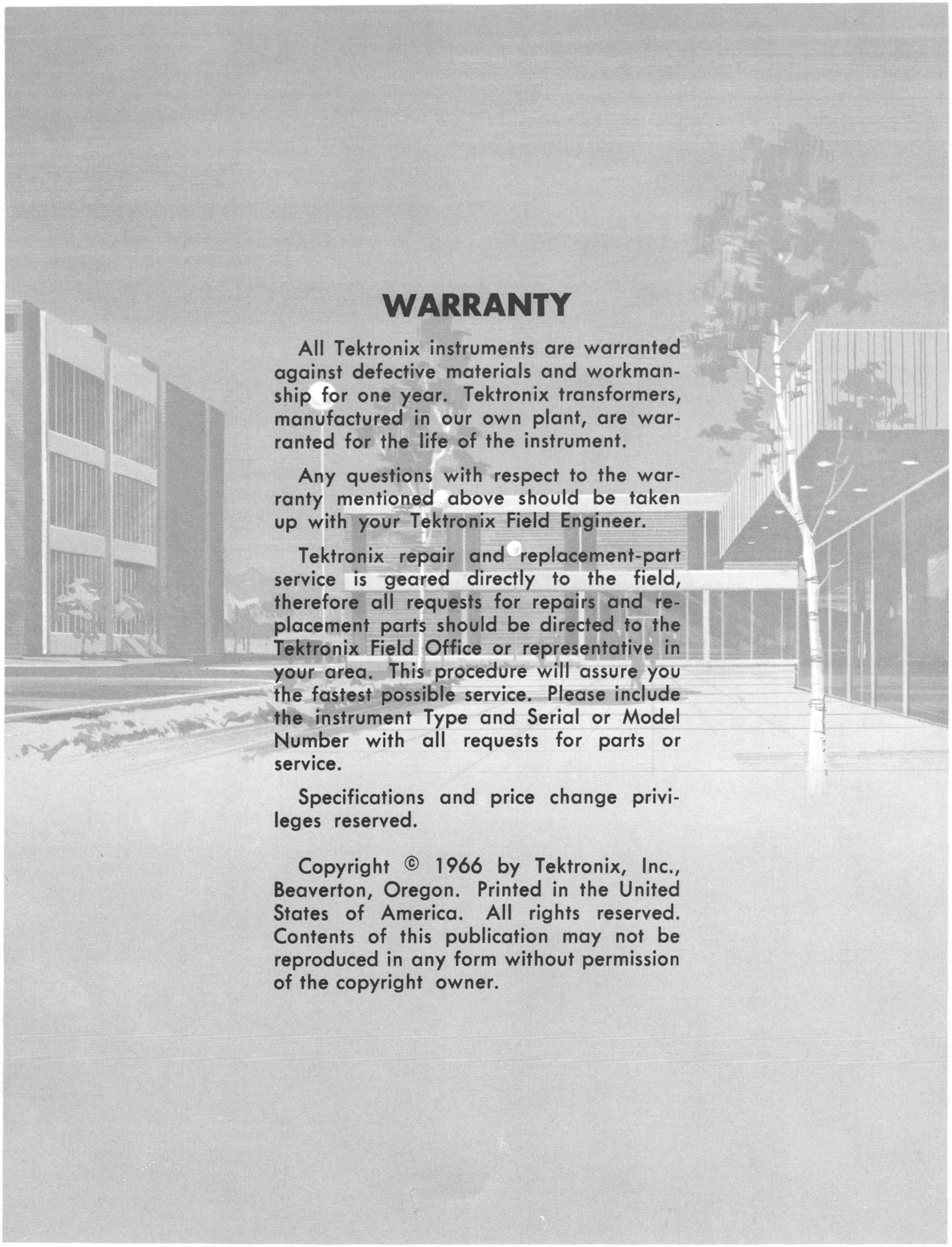

# WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

# CONTENTS



Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

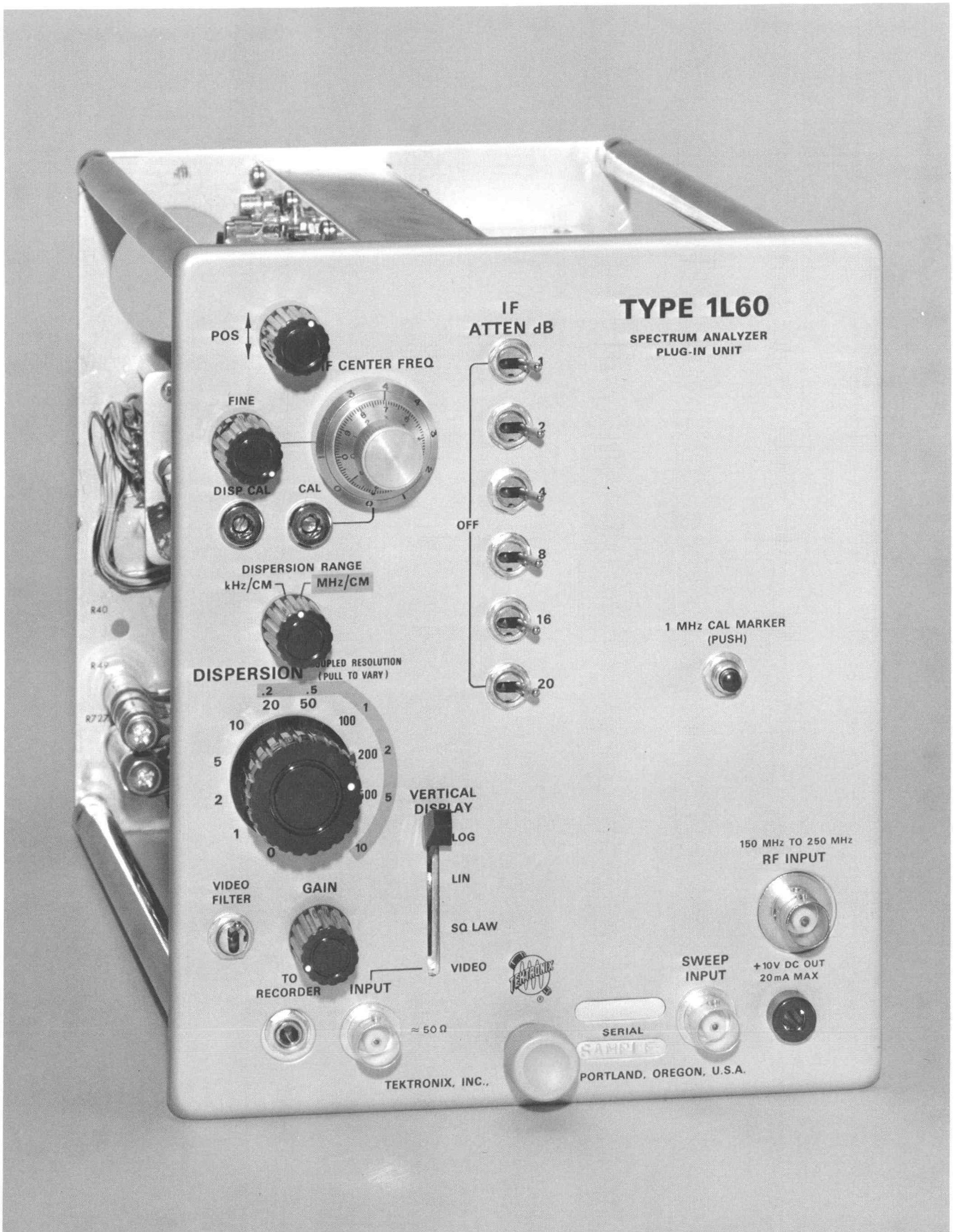


Fig. 1-1. Type 1L60 Spectrum Analyzer.



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# SECTION 1

# CHARACTERISTICS

## Introduction

The Type 1L60 Spectrum Analyzer described in this manual is designed for use in Tektronix oscilloscopes for the panoramic presentation of RF signals in the frequency range of 150 MHz to 250 MHz. The analyzer displays the frequency distribution of the applied signal along the horizontal axis of the oscilloscope CRT and displays the signal energy on the vertical axis.

The analyzer is designed for use in all Tektronix 530-, 540-, 550-, and 580-[1] Series Oscilloscopes. The analyzer plugs directly into the oscilloscope and derives all its power from the oscilloscope. The Type 1L60 can also be used in an external Plug-In Unit power supply such as the Tektronix Type 127 and Type 132 Power Supplies.

The following electrical characteristics apply at ambient temperature of 25° C (±5°C) after an initial warm-up period of 20 minutes.

**[1]A Tektronix Type 81 Plug-In Adapter must be used with 580-Series Oscilloscopes.**

## ELECTRICAL CHARACTERISTICS

| Characteristics | Performance Requirement | Supplementary Information |
|---|---|---|
| Input Frequency | | |
| Range (Fixed Tuned) | 150 MHz to 250 MHz | |
| Minimum Sensitivity[2] | 1 kHz Resolution—130 dBm (0.07 μV); 100 kHz Resolution—110 dBm (0.7 μV) | |
| Dial Accuracy | ± (2 MHz + 1% of dial reading) | |
| Dispersion, kHz/CM RANGE | | |
| Range | 1 kHz/cm to 500 kHz/cm and 0 dispersion | In 1-2-5 sequence |
| Accuracy | ±3% | |
| Linearity | ±3% | |
| Dispersion, MHz/CM RANGE | | |
| Range | 0.2 MHz/cm to 10 MHz/cm | In 1-2-5 sequence |
| Accuracy | See Table 1-1 | |
| Linearity | ±3% | |
| Resolution | | |
| Range | 1 kHz to 100 kHz; uncalibrated | Can be cross-coupled with DISPERSION control or switched separately |
| IF CENTER FREQ Range | Coarse control / FINE control | |
| 1-500 kHz/CM Dispersion | ≥(±2.5 MHz) / ≥(±50 kHz) | |
| .2-5 MHz/CM Dispersion | ≥(±25 MHz) / ≥(±1 MHz) | |
| 10 MHz/CM Dispersion | ≥(±10 MHz) / ≥(±1 MHz) | |
| IF GAIN Control Range | ≥50 dB | |
| IF ATTEN Control | | |
| Range | 0-51 dB | In 1 dB steps |
| Accuracy | ±.1 dB/dB | |
| Display Flatness (of a converted signal) | ±1.5 dB | + and —50 MHz from center frequency |
| Incidental FM | | |
| IF | ≤200 Hz | |
| Internal Marker Reference Signal | 1 MHz ±100 Hz | Crystal-controlled |

**[2]Signal + Noise = 2× Noise; 50 Ω load impedance; all voltages are RMS.**

| Characteristics | Performance Requirement | Supplementary Information |
|---|---|---|
| Dynamic Range | | |
| LOG | ≥40 dB; | |
| LIN | ≥26 dB | ≥6 centimeter display |
| SQ LAW | ≥13 dB | |
| VIDEO INPUT Response | ≤16 Hz to ≥10 MHz | |
| TO RECORDER Sensitivity | 24 mV to 40 mV | With 6 centimeter LIN display. ≈600 Ω impedance. |
| +10 V OUT (Front-Panel) | 10 V ±5% | 20 mA maximum load current. |

## Environmental Characteristics

The instrument will operate over a room-temperature range of 0°C to +50°C after 20 minutes warm-up time. Ventilation adequate for the main oscilloscope is adequate for this plug-in unit.

## Finish

Front-panel is anodized aluminum.

## Connectors

| | |
|---|---|
| SWEEP INPUT | BNC |
| VIDEO INPUT | BNC |
| RF INPUT | BNC |
| +10 V DC OUT | Banana Jack |
| TO RECORDER | Miniature Phone Jack |

**TABLE-1-1**

| DISPERSION/CM Position | Accuracy |
|---|---|
| 10 MHz | ±3% |
| 5 MHz | ±3% |
| 2 MHz | ±5%[3] |
| 1 MHz | ±7%[3] |
| .5 MHz | ±10%[3] |
| .2 MHz | ±15%[3] |

[3]Over the 50 MHz range of the IF CENTER FREQ control. The DISP CAL adjust can be reset to improve the accuracy of a specific IF CENTER FREQ control setting by using the front-panel 1 MHz CAL MARKER signal as a calibration signal.

# SECTION 2
# OPERATING INSTRUCTIONS

## General

To effectively use the Spectrum Analyzer, the operation and capabilities of the instrument must be known. This section describes the operation of the front-panel controls and connectors, gives first-time and general operating information, and lists some basic applications for the instrument.

## Controls and Connectors

A front panel view of the Analyzer is shown in Fig. 2-1. A brief functional description of the controls, connectors and securing latch is given on the illustration.

### FIRST-TIME OPERATION

The following procedure demonstrates the function of the various front-panel controls and is intended to help you become familiar with its operation.

1. Set the slide switch SW201 (mounted on the rear plate) to the appropriate sawtooth voltage as listed in Table 2-1. (If your oscilloscope is not listed, check the specifications given in its Instruction Manual for the front-panel SAWTOOTH OUT waveform.)

**TABLE 2-1**

| 100 Volt Sawtooth | 150 Volt Sawtooth |
|---|---|
| Type 544 | All Type 530-Series |
| Type 546 | Type 543 (A and B) |
| Type 547 | Type 545 (A and B) |
| Type 556 | Type 549 |
| | Type 555 |
| | All Type 580-Series |
| | Type T Plug-In Unit |

2. Insert the Spectrum Analyzer into the plug-in compartment and fasten the securing latch. Turn on the power.

3. Connect the oscilloscope Sawtooth Out (or Sawtooth A) connector to the Analyzer SWEEP INPUT connector.

WARNING

**Shock hazard exists at the oscilloscope Sawtooth Out connector.**

4. Set the oscilloscope for a free-running 5 ms/cm sweep. (In actual practice, the oscilloscope may be set to any desired sweep rate between 5 s/cm and 1 ms/cm.) Set the oscilloscope Mode (or Horizontal Display) switch to "A" or Normal.

5. Preset the following front-panel controls:

| | |
|---|---|
| POS | Midrange |
| IF CENTER FREQ | Midrange (000) |
| DISPERSION RANGE | MHz/CM |
| DISPERSION-COUPLED RESOLUTION | 10 |
| VIDEO FILTER | OFF (down) |
| GAIN | Midrange |
| VERTICAL DISPLAY | LIN |
| 1 MHz CAL MARKER | Button pushed in |

6. Connect a signal in the frequency range between 150 and 250 MHz to the INPUT connector. If the signal strength is greater than —30 dBm (7 mV RMS) an external attenuator should be used.

7. At this point, there should be a trace displayed on the CRT. If there is not, adjust the POSITION and INTENSITY controls. Once the trace is on the CRT, set the FOCUS, ASTIGMATISM, and INTENSITY controls for a well-defined display. The POSITION controls should be set so that the trace starts just outside the lower-left corner of the graticule.

8. Turn the GAIN control and/or the IF ATTEN switches so that the vertical deflection is at a convenient amplitude.

9. Move the spectrum display across the CRT, using the IF CENTER FREQ controls. Note that all the spikes move the same amount and in the same direction. Center the IF CENTER FREQ controls.

10. Change the oscilloscope sweep rate to 50 ms/cm and note the increased amplitude and detail in the display. Set the sweep rate to 10 ms/cm.

11. Change the DISPERSION RANGE switch to kHz/CM and set the DISPERSION-COUPLED RESOLUTION switch to 10 (inner ring).

12. Pull out on the COUPLED RESOLUTION knob and rotate it toward the clockwise end of its rotation without changing the DISPERSION setting. Note the broadening of the displayed signal.

### FRONT PANEL ADJUSTMENTS

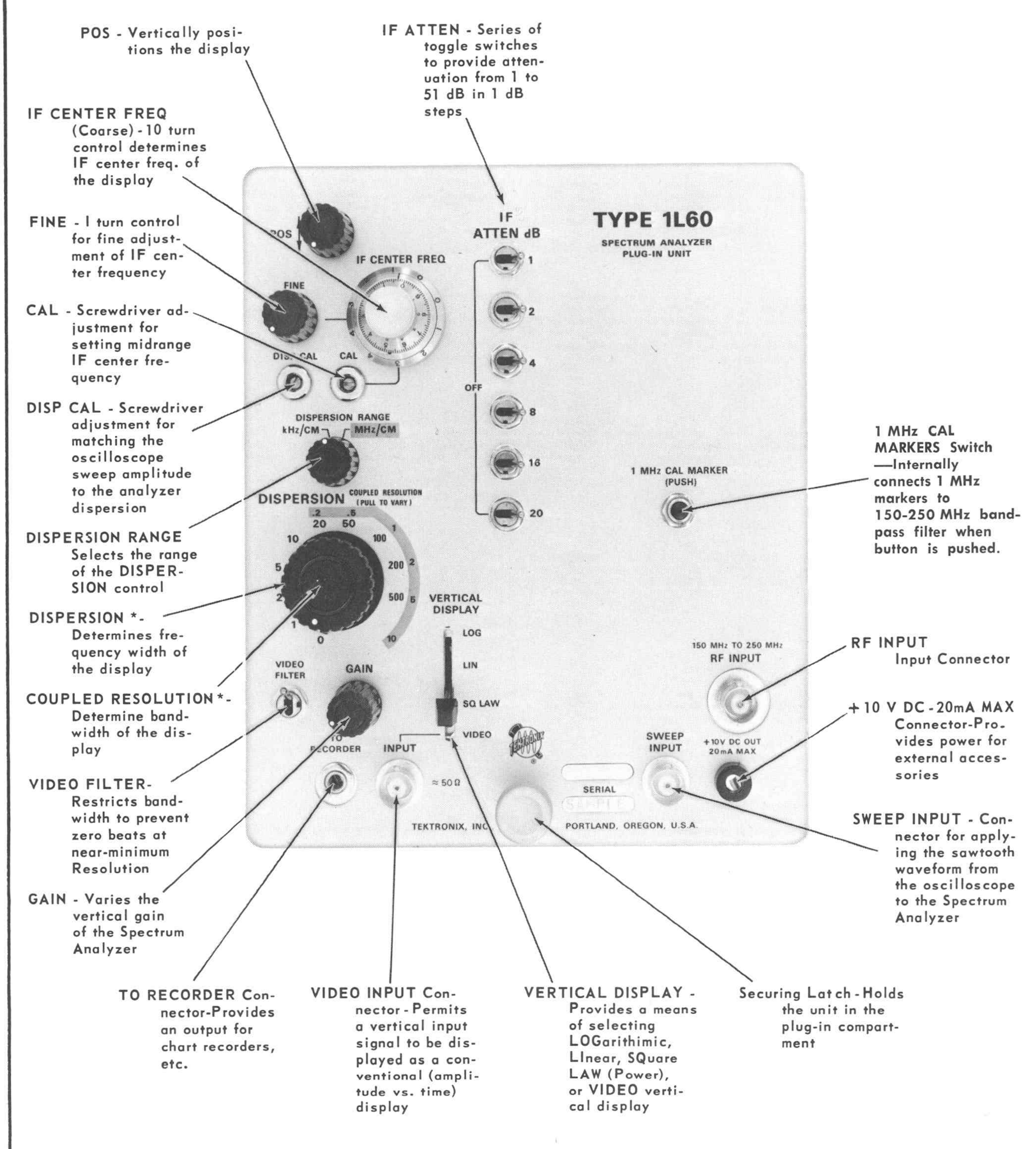
Any time the Specrtum Analyzer is moved from one oscilloscope to another, the front-panel IF CENTER FREQ CAL and DISP CAL adjustments must be recalibrated to compensate for differences in sawtooth amplitude and CRT sensitivity. These adjustments should also be checked occasionally during the regular use of the instrument.

## 1. IF CENTER FREQ CAL Adjustment

a. Set the front-panel controls and connect the Spectrum Analyzer to the oscilloscope as directed in steps 1 through 6 of First Time Operation.

b. Apply an external 200 MHz signal to the RF INPUT connector.

c. Adjust the GAIN and IF ATTEN controls for a signal amplitude of about 5 centimeters.




*NOTE - The DISPERSION-COUPLED RESOLUTION switches are turned by a 2-piece knob with the indicator section (next to the front-panel) turning the DISPERSION switch, and the knurled section (away from the front-panel) turning the RESOLUTION switch.

If non-coupled operation is desired, the whole knob is turned to the position giving the desired DISPERSION setting, then the knurled section is pulled out about ¼" and set to the desired RESOLUTION setting. The two parts will be recoupled again whenever they are set to the same setting.

Fig. 2-1. Function of front panel controls and connectors.

d. Set the IF CENTER FREQ CAL adjustment for no signal shift as the DISPERSION-COUPLED RESOLUTION control is rotated.

e. Position the signal to the graticule center with the oscilloscope HORIZONTAL POSITION control. (With some oscilloscopes it can be necessary to readjust R204, the internal Swp Ctr adjustment.) See step 5 of the Calibration Procedure.

## 2. DISP CAL Adjustment

a. Set the Analyzer front-panel controls as follows:

| | |
|---|---|
| IF ATTEN | All OFF |
| IF CENTER FREQ | 000 (centered) |
| DISPERSION RANGE | kHz/CM |
| DISPERSION-COUPLED RESOLUTION | 500 (inner ring) |
| VERTICAL DISPLAY | SQ LAW |

b. Push 1 MHz CAL MARKER button.

c. Adjust the GAIN control for a marker display about 3 centimeters in height.

d. Use the FINE IF CENTER FREQ control to keep the markers aligned with the graticule lines while setting the DISP CAL adjustment for 1 marker/2 centimeters.

e. Check for 1 marker/centimeter ±7% with the DISPERSION and DISPERSION RANGE controls set for 1 MHz/CM.

f. Vary the IF CENTER FREQ control and check that the distance between markers remains 1 marker/centimeter ±7%.

## Applied Signal Precautions

Signals applied to the RF INPUT connectors should be connected through a 50-ohm coaxial cable, using a Type BNC connector. Unshielded connections will tend to pick up stray unwanted signals and cause a confusing display.

Reflections caused by mismatches between the signal source and the RF INPUT sometimes cause amplitude changes in the signal display on the CRT. When good conversion flatness is desired and sufficient signal strength is available, a 6 dB 50 Ω attenuator pad can be inserted between the source and the Analyzer to minimize these reflections.

The signal applied to the RF INPUT should not be stronger than —30 dBm (7 millivolts RMS) for an undistorted display. (See Fig. 2-2.) As a matter of practice, stay well away from the point where compression (no increase in height with an increase in signal strength) is noticed. Back off at least 10 dB from this point. Otherwise, the Spectrum Analyzer might be over-driven, resulting in the generation of spurious responses due to harmonic mixing at much higher level than normal.

CAUTION

**At no time should signals stronger than +15 dBm (1 volt RMS) be applied to the Spectrum Analyzer. Signals above this limit are apt to damage the RF INPUT circuit.**

## Sweep Latch-Up

Occasionally, when switching the DISPERSION RANGE switch from MHz/CM to kHz/CM, the sweep will "latch-up" as indicated by an apparent loss of the spectrum display. This condition is caused by the kHz/CM Discriminator oper-

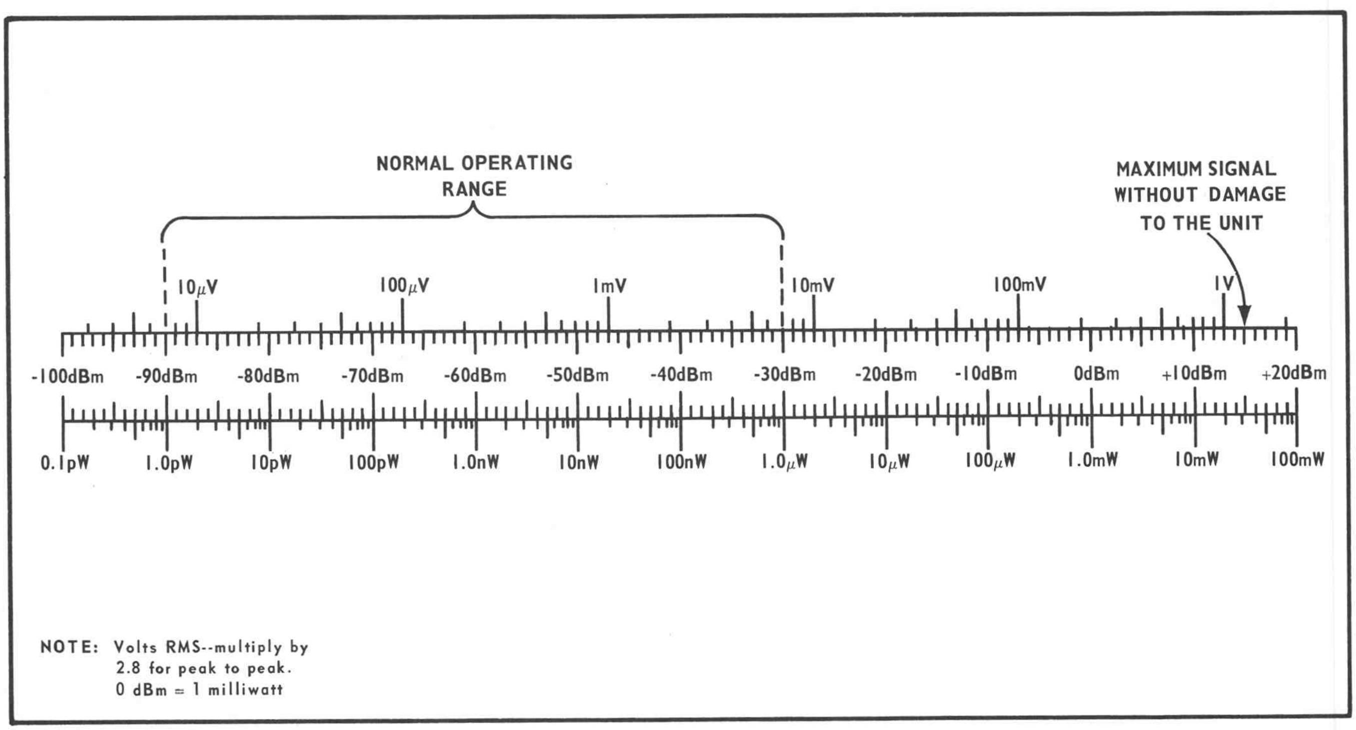



Fig. 2-2. Volts—dBm—Watts Conversion Chart for 50 Ω impedance.

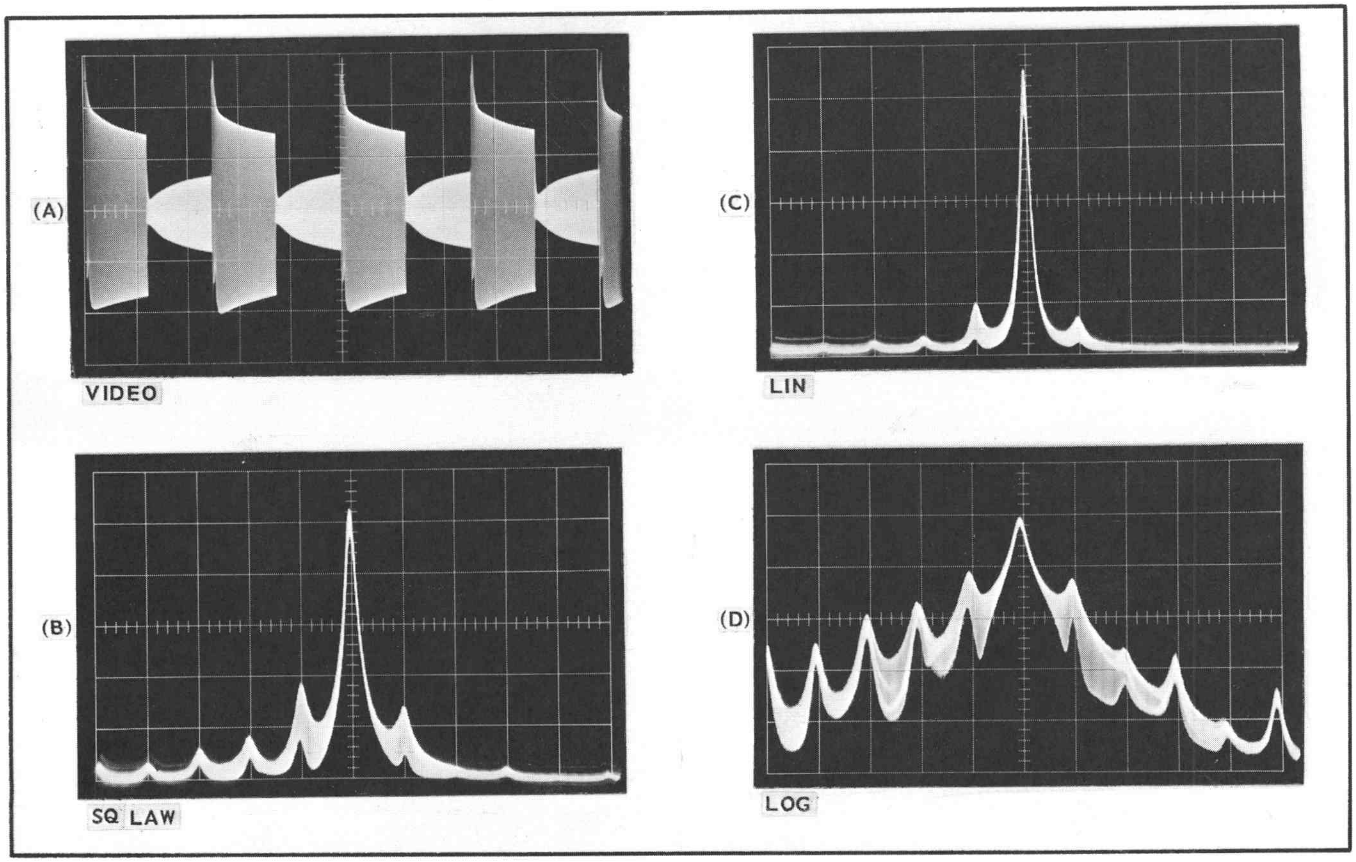



**Fig. 2-3. VERTICAL DISPLAY Modes. (A) shows a modulated 10 MHz signal; (B), (C), and (D) show the same modulation applied to a 1000 MHz carrier.**

ating on the wrong part of the frequency discriminator curve. To restore the unit to normal operation, either turn the IF CENTER FREQ control to a position nearer center or momentarily set the DISPERSION control to a clockwise position.

## Vertical Display

An RF signal is displayed on the screen of a spectrum analyzer as a pip, with the amplitude of the pip representing the signal strength and the horizontal position representing the frequency of the signal. The shape of the pip is a function of the IF response of the Analyzer. In this Analyzer, the response can be adjusted by the front panel RESOLUTION control in ten steps from 1 kHz (fully counterclockwise) to 100 kHz (fully clockwise).

The appearance of the signal display depends to a great extent on the setting of the VERTICAL DISPLAY switch.

Fig. 2-3 shows a signal being displayed in all four VERTICAL DISPLAY MODES:

**LINear Mode.** The Linear mode will be used for most applications, and where the relative differences between the signal amplitudes are not too great.

**LOGarithmic.** The Logarithmic mode increases the dynamic range of the display by attenuating large signals more than small signals, following an approximate logarithmic curve. This is basically a compression circuit and will be used when there are large differences between signal amplitudes.

**SQuare LAW Mode.** The output of this circuit is approximately proportional to the square of the input voltage; therefore the vertical deflection of the beam will be approximately proportional to the power of the signal. This is basically an expansion circuit and will be used when the differences between the signal amplitudes are very slight.

**VIDEO Mode.** In this mode, the spectrum display is grounded and a signal connected to the front-panel VIDEO INPUT connector will be displayed as a conventional analog (time versus signal-amplitude) display. An uncalibrated GAIN control provides a variable sensitivity. Maximum sensitivity is 0.1 V/cm.

The impedance of the VIDEO INPUT circuit is approximately 50 ohms; therefore high-impedance probes cannot be used to couple signals to the VIDEO circuit.

## VIDEO FILTER Operation

The video filter is switched in to restrict the video bandwidth so as to prevent zero beats when observing signals separated by the minimum resolution of the unit. The filter also has the effect of suppressing the noise level and thereby improving the sensitivity in the narrow resolution positions. This filter action is obtained at the cost of usable sweep speed—to avoid a distorted display, the sweep rate must be reduced to about 50 ms/cm or slower.

The video filter will be useful in the following cases.

a. When attempting to observe two or more signals separated in frequency by the minimum resolution (1 kHz) of the unit.

b. When it is desired to observe only the envelope of a pulsed signal as opposed to observing the repetition rate lines.

c. When it is desired to obtain a clean, crisp display eliminating all high frequency phenomena such as baseline noise and beats between signals, and transient responses when observing pulsed signals.

## Obtaining Maximum Dispersion Accuracy

The dispersion accuracy of the MHz/CM ranges may vary considerably as the setting of the IF CENTER FREQ control is changed. This will be especially evident when using the .2 MHz/CM and .5 MHz/CM dispersion displays. Since the same dispersion/cm displays are available at 200 kHz/CM and 500 kHz/CM, but with a considerable increase in accuracy, it is recommended that the kHz/CM settings be used when precise measurements are needed and when the decreased IF CENTER FREQ control range (+ and —2.5 MHz versus + and —25 MHz) is acceptable.

The front-panel DISP CAL adjustment can be reset to improve the dispersion accuracy for a specific setting of the IF CENTER FREQ control.

This is accomplished as follows:

1. Set the front-panel controls for the desired signal display.

2. Push the 1 MHz CAL MARKERS button and set the DISP CAL adjustment to give the correct maker/division display.

3. Connect the external signal to the RF INPUT connector and make the desired measurements.

4. Be sure to recalibrate the DISP CAL adjustment when finished with step 3; center the IF CENTER FREQ controls, set the DISPERSION/CM to 500 kHz/CM, push the 1 MHz MARKER button, and reset the DISP CAL adjustment for 1 marker/2 centimeters.

## Obtaining Optimum Resolution

The resolution of a Spectrum Analyzer is the measure of the instrument's ability to separate individual signals. The resolution is a function of the IF bandwidth, sweep frequency rate, and dispersion. At very slow sweep rates, the effective resolution of the analyzer is determined by the —6 dB bandwidth of its IF circuits and will closely resemble the IF response curve.

The effective resolution at a specific sweep rate and dispersion is given by:

$$R = B\left[1 + 0.195\left(\frac{D}{TB^2}\right)^2\right]^{1/2}$$

where:

R = Resolution

B = Bandwidth in hertz

D = Dispersion in hertz

T = Sweep time in seconds

The sensitivity of the instrument is also dependent on the same factors. The sensitivity to be expected can be calculated mathematically as:

$$S = S_O\left[1 + 0.195\left(\frac{D}{TB^2}\right)^2\right]^{1/4}$$

where:

S = Sensitivity

$S_O$ = Sensitivity at very slow sweep speeds and zero dispersion

D = Dispersion in hertz

T = Sweep time in seconds

B = Bandwidth in hertz

Usually, the resolution of the Spectrum Analyzer will be near optimum at a given setting of the DISPERSION control when the DISPERSION and COUPLED RESOLUTION controls are coupled together (both switches set to the same position), although the RESOLUTION control can be turned separately if desired by pulling out on the knurled section of the knob.

The time base of the oscilloscope should be set for the fastest sweep rate at which no distortion or amplitude loss is noticed in the display. If the Spectrum Analyzer is being used in combination with a Type 549 Storage Oscilloscope, the slow-sweep display may be easier to analyze if the oscilloscope is operated in one of the Storage Modes.

Sensitivity of the Spectrum Analyzer to pulse signals is a function of the bandwidth of the instrument as stated above. However, if the bandwidth is too large, the minima of the spectrum are no longer zero. To adjust the RESOLUTION for a pulse signal, set the oscilloscope sweep rate for a pulse repetition frequency of about 40 lines in the principal lobe of the spectrum. Then, adjust the RESOLUTION control for well-defined lobe zeros without ringing (see Fig. 2-4). This setting corresponds to a bandwidth-pulse width product of 0.1 or less.

## Relative Amplitude Measurements

The relative amplitudes of two signals can be measured as follows:

1. Center the IF CENTER FREQ controls.

2. With all of the IF ATTEN switches OFF, adjust the GAIN control for exactly 4 centimeters of vertical deflection of the smallest signal.

3. Now observing the larger signal, switch in as many IF ATTEN switches as are required to make the larger-amplitude signal exactly 4 centimeters high.

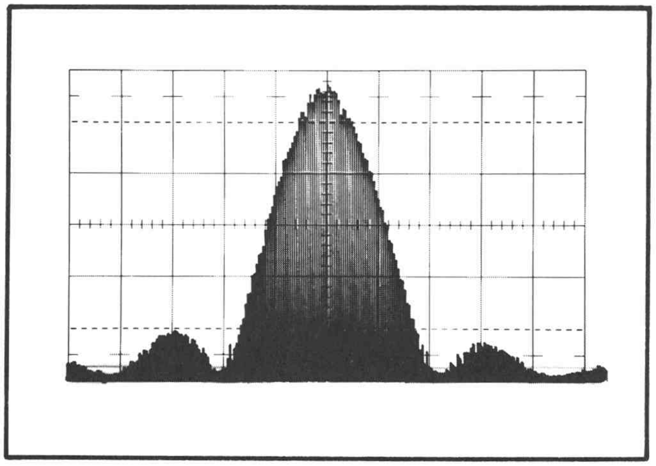


Fig. 2-4. Display of the frequency sprecta of a pulsed CW signal.

4. Add the settings of the IF ATTEN switches that were switched in. The total is the relative amplitude difference, in dB, between the two signals.

## Frequency Difference Measurements

Frequency separation measurements can be made between signals that are up to 100 MHz apart. The measurement is made as follows:

1. With the two signals displayed on the screen, set the DISPERSION RANGE and DISPERSION switches so that the signals are spaced as far apart on the screen as possible. (Center the two signals on the screen each time the DISPERSION switch is set to a lower position.)

2. Set the sweep rate of the oscilloscope and the RESOLUTION control of the Type 1L60 for the best defined signal peaks.

3. Measure the distance in graticule divisions between the two signals (see Fig. 2-5).

4. Multiply the distance measured in step 3 by the DISPERSION/CM setting to determine the frequency separation. As in the example shown in Fig. 2-5.

$$f_s = (7\ \text{cm})\ (2\ \text{MHz/CM}) = 14\ \text{MHz}$$

5. Accuracy of the measurement will vary according to the DISPERSION and DISPERSION RANGE settings. See Table 1-1.

## Frequency Spectra Measurements of Pulsed Signals

The main frequency lobe and side lobes of a pulse-modulated signal can be displayed and used to measure the pulse width as follows:

1. Adjust the DISPERSION RANGE and DISPERSION-COUPLED RESOLUTION controls and the IF CENTER FREQ control so that the main frequency lobe of the displayed signal is in the approximate center of the graticule and the side lobes of interest are visible.

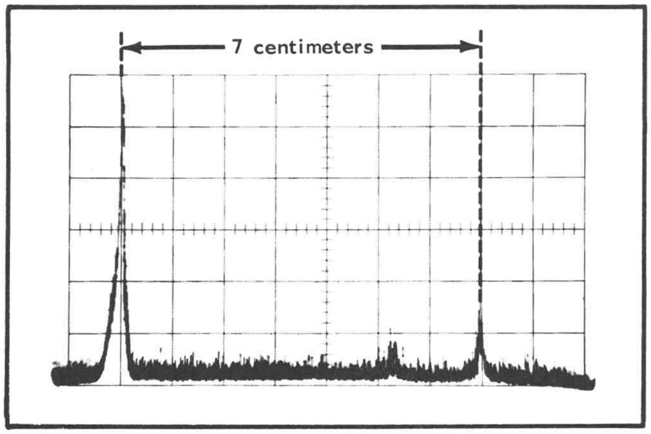



Fig. 2-5. Frequency difference measurement between two signals.

2. Set the GAIN control and the IF ATTEN switches so that the main lobe fills the screen vertically and the side lobes are of sufficient amplitude for viewing.

3. Set the sweep rate of the oscilloscope so the spectrum is well defined (Sweep Rate $\approx$ 1/50 pulse repetition rate).

4. Set the RESOLUTION control so that the low points in the spectrum are easily descernible without excessive loss of sensitivity. (Changing the VERTICAL DISPLAY Mode (LOG, LIN, or SQ LAW) may make these points easier to see.)

5. The equivalent pulse width of the modulation signal can now be determined by measuring the frequency width (see Fig. 2-6) of either the main lobe (of $\Delta f_{main}$) or a side lobe ($\Delta f_{side}$) as directed in Frequency Difference Measurements and calculating for pulse width.

$$t = \frac{2}{\Delta f_{main}} \text{ or } \frac{1}{\Delta f_{side}}$$

where:

$t$ = pulse width in microseconds

$\Delta f_{main}$ = frequency width of main lobe in MHz

$\Delta f_{side}$ = frequency width of side lobe in MHz

## Repetition Rate Measurements of Pulsed Signals

The spectrum analyzer can also be used to measure the repetition frequency of the pulsed signal. Note in Fig. 2-6 that the frequency distribution of the pulsed signal is a series of vertical lines. Each line represents one sampling (interception) of a pulse during the sweep interval. Thus, at zero dispersion, the line spacing will correspond directly to the sweep time.

The pulse rate can therefore be determined directly from the number of lines per division when the sweep speed is known. The procedure to be followed is given below:

1. Set the IF CENTER FREQ controls so that the signal appears at the center of the screen.

2. Set the DISPERSION switch to 0 and set the DISPERSION RANGE switch to kHz/CM. The oscilloscope is now operating as a time-base oscilloscope, and each line on the

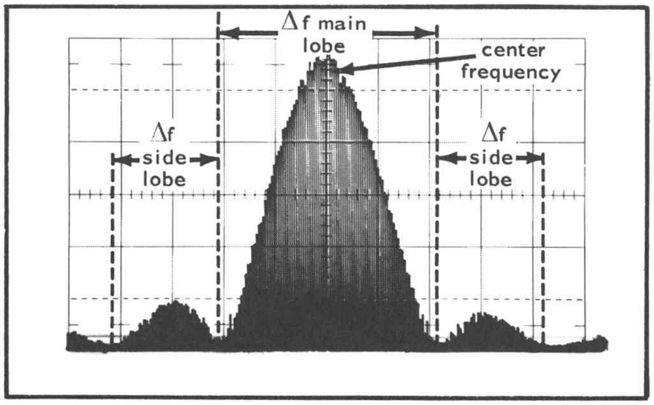



Fig. 2-6. Measuring the frequency spectra of a pulsed CW signal.

screen is equivalent to one pulse. (It might be helpful if the RESOLUTION control is uncoupled and reset for better resolution.)

3. Set the sweep controls of the oscilloscope for +INT triggering and set the Stability and Trig Level controls for a stable trace.

4. Set the Time/Cm switch of the oscilloscope to display several pulses of the applied signal (see Fig. 2-7). Be sure the Variable Time/cm control of the oscilloscope is in the Calibrated position.

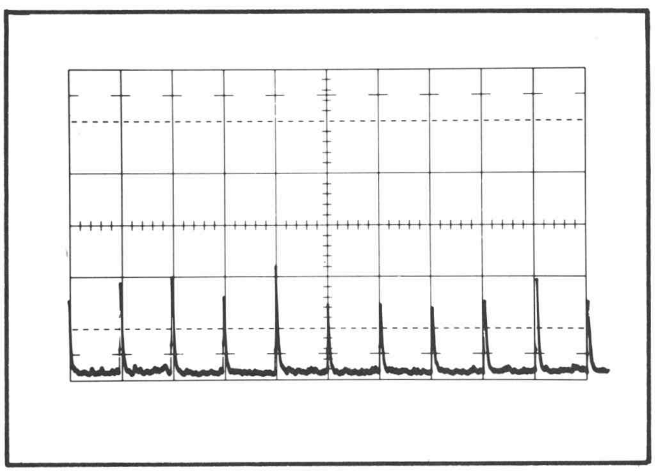


Fig. 2-7. Measuring pulse repetition rate (50 μs/cm sweep).

5. Count the number of lines (pulses) in one or more divisions and use the oscilloscope sweep rate to compute the time between each pulse. In the example of Fig. 2-7, the pulse repetition rate is:

$$\frac{(1\ \text{cm})\ (50\ \mu\text{s/cm})}{1\ \text{pulse}} = \frac{50\ \mu\text{s}}{\text{pulse}} = 20\ \text{kHz}$$

## Use of Expanded Sweep

The expanded (magnified) sweep can be used to advantage in certain spectrum analyzer measurements. It is often desired to examine a very small portion of the display in more detail. Theoretically, such an examination could be performed by changing the DISPERSION-COUPLED RESOLUTION control to give the desired display. A faster and easier method may be to set that part of the display to be examined to the center of the screen and expand the sweep.

Fig. 2-8 shows an expanded display of the pulsed RF signal that was shown before in Fig. 2-6. The spectrum is being examined in detail in the vicinity of one of the nulls.

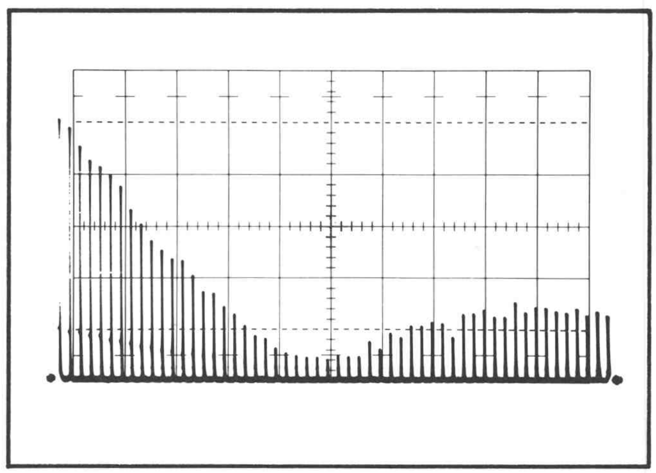


Fig. 2-8. ×5 magnification applied to the display shown in Fig. 2-6.

## NOTES

# SECTION 3
# CIRCUIT DESCRIPTION

## General Description

This Spectrum Analyzer is a superheterodyne receiver that is electronically tuned over a portion of the frequency spectrum at a rate synchronized with the horizontal sweep of the oscilloscope. In the resulting display, horizontal sweep of the CRT is proportional to frequency, with the vertical deflection proportional to the signal strength.

## BLOCK-DIAGRAM DESCRIPTION

Figure 3-1 is a block diagram of the Spectrum Analyzer.

A signal connected to the RF INPUT connector is sent through filter networks, to eliminate spurious signals generated between the INPUT connector. This signal and the Sweeper Oscillator is amplified in the Wide-Band IF Amplifier and mixed with the Swept Oscillator signal. The Swept Oscillator signal is centered at 275 MHz, but is swept in synchronism with the time base of the oscilloscope.

The resulting 75 MHz signal is further amplified in the second IF amplifier stage, converted to a 5 MHz third IF, and amplified in a variable bandwidth (1-100 kHz) 5 MHz IF Amplifier which determines the system's resolution. After amplification and detection, the signal is applied to the vertical amplifier of the oscilloscope.

### Low Pass Filter

The Low Pass Filter attenuates any frequency above 265 MHz. This attenuation, along with that supplied by the following 150-250 MHz Bandpass Filter, suppresses signals in the image frequency band of the 200 MHz IF amplifier (300 MHz to 400 MHz).

### Resistive T Coupler

The resistive T coupler permits the 1 MHz Calibrator Marker signal to gain access to the Wide-Band Amplifier and Mixer circuit via the 150-250 MHz Bandpass Filter.

### Wide-Band (200 MHz) Amplifier and Mixer

The output from the Resistive T Coupler is passed through the 150 MHz-250 MHz Bandpass Filter mentioned above and amplified by the Wide-Band Amplifier Q120-Q130, a two-stage common emitter IF amplifier tuned for a wide-band response centered around 200 MHz.

The signal from Q130 is combined in the amplifier-mixer stage of Q140 with the Swept-Frequency Oscillator signal coming from the Sweeper circuit to develop the difference frequency centered at 75 MHz. This signal is coupled through C147 and L147 to the IF Attenuator. C147-L147 for a 65 MHz trap to suppress signals in the image band of the 75 MHz intermediate frequency.

### Sweeper Circuit

The Sweeper generates a signal centered at 275 MHz but varying in frequency in step with the movement of the electron beam across the CRT. This swept-frequency signal is fed to the Wide-Band Mixer where it is mixed with the 150-250 MHz first IF signal as described above.

The sawtooth voltage from the oscilloscope is connected to the Analyzer SWEEP INPUT connector by an external jumper cable. This sawtooth voltage is attenuated by an amount determined by the setting of the Sawtooth Selector switch SW201 and applied to the attenuation network of the DISPERSION switch SW220. The front-panel DISP CAL adjust sets the amplitude of the sawtooth voltage appearing across the DISPERSION range. The internal Swp Ctr adjustment R204 sets the DC level of the sawtooth to center the sweep at 0 volts. The DISPERSION switch selects (in a 1-2-4 sequence) the amplitude of the sweep sawtooth applied to the input of the Sweep Comparator circuit at Q230.

The Sweep Comparator circuit compares this sawtooth signal with a feedback signal coming from the output of the Swept-Frequency Oscillator circuit. An error signal is sensed, amplified, and sent on to bias D314, a variable-capacitor diode forming the major part of the capacitance of the resonant circuit of the Swept-Frequency Oscillator. This error signal will be of such a nature that its non-linear characteristics will cancel the effect of the non-linear characteristics of the diode. As a result, the output of the Swept-Frequency Amplifier will be a signal that changes in frequency at a very nearly linear rate.

The capacitance change in D314 is not directly proportional to the voltage change across it, but instead varies more or less as an exponential function of the applied voltage. The frequency - discriminator feedback loop has been added to correct for this non-linearity.

A separate frequency descriminator circuit is provided for each dispersion range. In the kHz/CM circuit, the two resonant circuits (L384-C384 and L385-C385) are tuned to slightly different frequencies, centered at 275 MHz, as shown in Figures 3-2A and 3-2B. When the output of the detectors (D373 and D376) is applied to the Discriminator Comparator circuit of Q260, the result is a voltage versus frequency curve similar to Fig. 3-2C. The circuit operates on the centeral linear portion of the curve.

The MHz/CM Discriminator is a transmission-line type. One line is open circuited and thus has the capacitive characteristic of a tuned circuit operating above its resonant frequency. The other is shorted and thus has the inductive characteristic of a tuned circuit operating below its resonant frequency. Each transmission line is $\frac{1}{8}$ wavelength long at the center of the operating range (275 MHz). This type of discriminator is used because of the wide (100 MHz) frequency coverage needed. The kHz/CM Discriminator has better stability than the line type, but covers only 10 MHz.

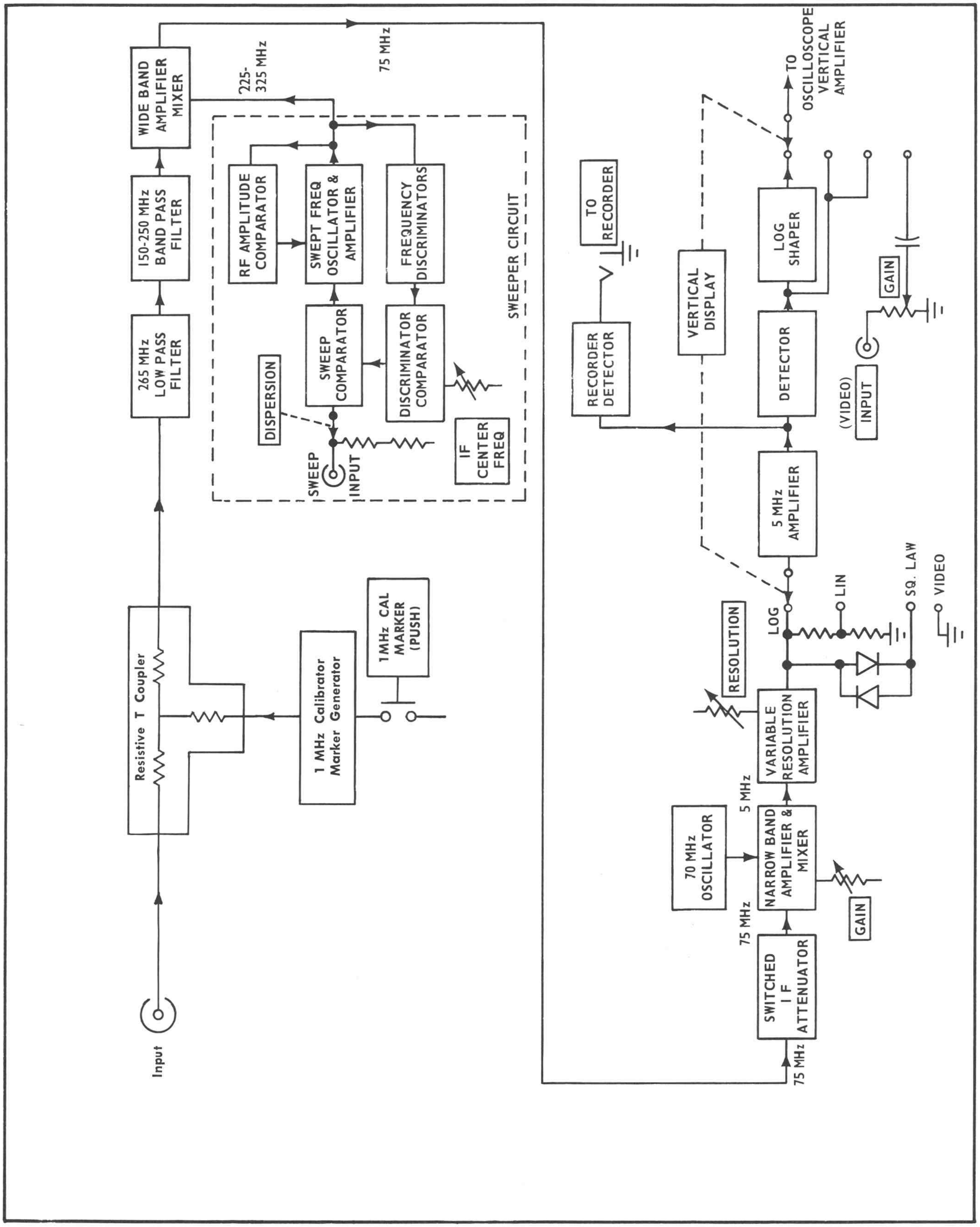



Fig. 3-1. Type 1L60 Block Diagram.

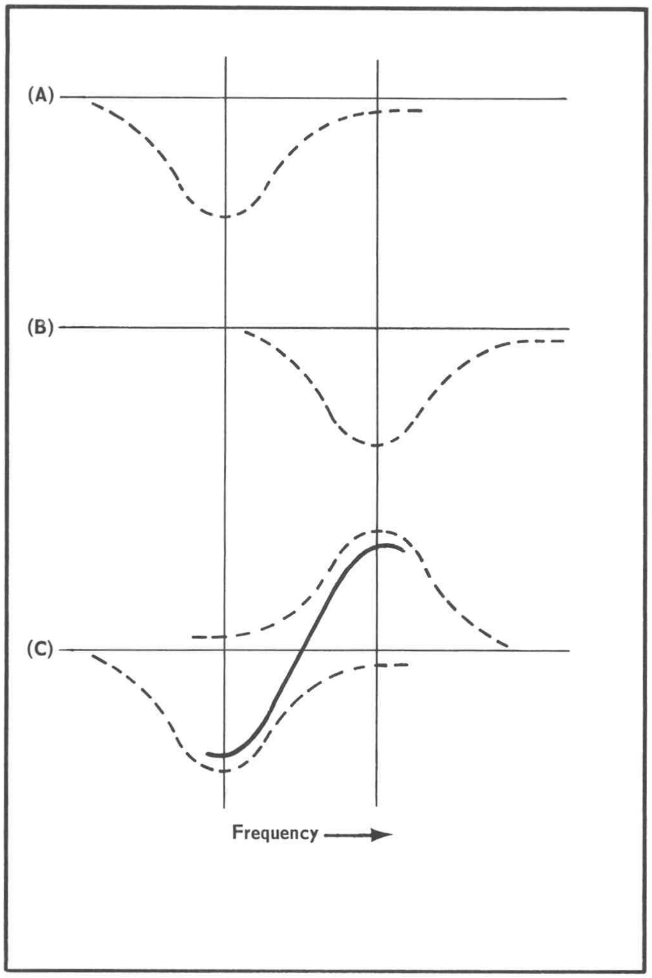



**Fig. 3-2. Frequency vs. voltage curves for kHz/cm Discriminator circuit.**
**(A) Output from D383.**
**(B) Ouptput from D386.**
**(C) Output from Discriminator Comparator Q260.**

In the Discriminator Comparator cidcuit of Q260, the detected outputs of the Frequency Discriminator are compared and the difference signal is sensed, amplified, and sent on to the Sweep Comparator as has already been described. IF CENTER FREQ controls R270 and R274 provide a means of controlling the center frequency of the display by adjusting the DC level of the feedback signal going to Q240.

The filter circuit of C358-L358 adjusts the linearity of the MHz/CM display by attenuating the harmonic components of the Swept-Frequency signal. R368 adjusts the impedance of D365 to set the slope of the kHz/CM Discriminator at twenty times the slope of the MHz/CM Discriminator.

The output amplitude of the Sweeper circuit must be kept constant for proper action of the discriminator circuits and for proper mixing action in the Wide-Band Mixer Amplifier Q140. This has been accomplished by the feedback loop through D361, Q280, and Q290. The amplitude of the swept-frequency signal is detected by D361. This voltage amplitude is compared to the fixed DC voltage at the IF Center Freq Range control R290. The resulting difference signal from the Amplitude Comparator circuit of Q290-Q280 is used to bias the base of Q320 to control the current supplied to the Swept-Frequency Oscillator Q310.

The swept-frequency signal is amplified by the push-pull amplifier circuit of Q340-Q350, converted to a single-ended signal by T347, filtered, and coupled to the 200 MHz Wide-Band Mixer through T363 and J363.

## IF Attenuator

The IF Attenuator is a six-section pi attenuator giving a total attenuation of 51 dB (355:1 voltage attenuation) in 1 dB steps. The attenuator maintains constant 50 Ω input and output impedance regardless of the IF ATTENUATOR switch settings. Low pass filters (C151-L151-C152 and C187-L188-C188) have been added to the input and output circuits of the attenuator to prevent harmonics from the following 70 MHz Oscillator from feeding back to mix with the Swept-Frequency (Sweeper) Oscillator signal to generate spurious signals.

## Narrow Band (IF) Amplifier

The Narrow-Band IF Amplifier circuit includes a two-stage 75 MHz Amplifier, a crystal controlled 70 MHz Local Oscillator, and a two-stage 5 MHz Amplifier.

The 75 MHz IF Amplifier (Q420 and Q430) is a conventional two-stage common-etmitter transformer-coupled amplifier. Both stages are peaked to 75 MHz-by C425 for the first stage, and by C435 for the second stage. GAIN control R411A varies the gain of both stages by changing the DC bias. Negative feedback through C422 neutralizes the first stage to keep it from oscillating.

The outputs of the 75 MHz IF Amplifier and the 70 MHz Oscillator are applied to the base of the mixer-amplifier Q450, which amplifies the difference frequency (5 MHz) of the two input signals. T454 of the mixer stage is tuned to 5 MHz, and couples the narrow-band signal to the base of Q460. This amplifier is peaked at 5 MHz by T464. The sig-

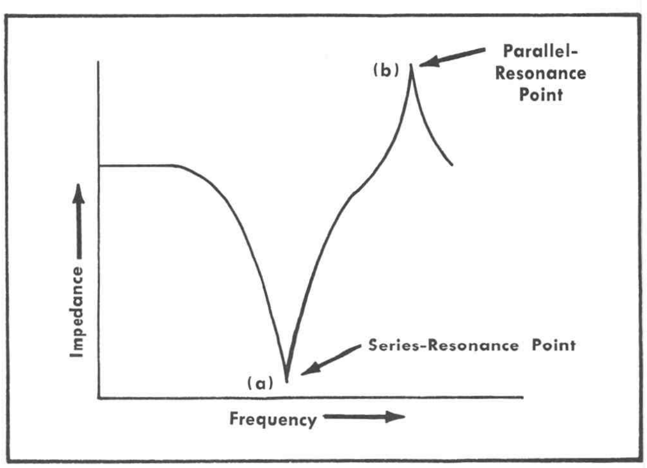



**Fig. 3-3. Typical impedance vs. frequency graph of a crystal. Note the series and parallel resonance points.**

nal is coupled through T464 to the Variable Resolution Amplifier.

## Variable Resolution Circuits

### Crystal Filter Circuit

The signal from the secondary of T464 is coupled to the 5 MHz crystal filter Y501. To understand how this circuit operates, consider the impedance characteristcs of the crystal. Fg. 3-3 shows a typical impedance versus frequency curve of a crystal.

In examining the curve from left to right, we first encounter a very low impedance point (a) at the series-resonant frequency. As the frequency increases, the impedance increases to a sharp peak (b) at the parallel-resonance frequency. Then the impedance drops fairly abruptly because of the parallel shunt capacitance of the crystal and its holder.

If this parallel capacitance is cancelled, the impedance of the crystal exhibits the impedance versus frequency curve shown in Fig. 3-4.

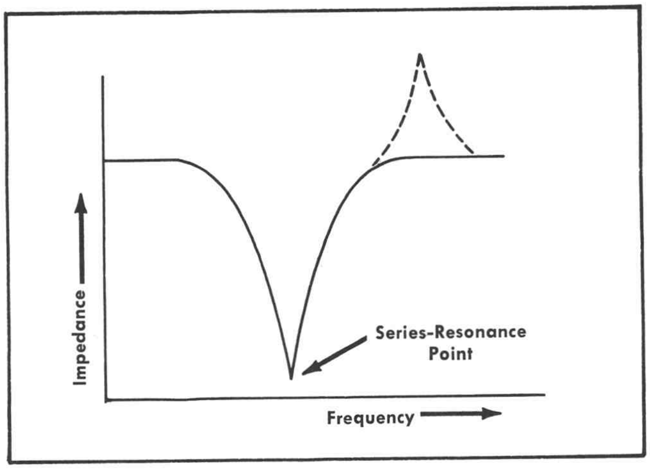



**Fig. 3-4. Impedance vs. frequency graph of a crystal when parallel capacitance is cancelled.**

This cancelling of the shunt capacitance of the crystal and its holder is accomplished by the series capacitance C504 (see Fig. 3-5). Since the voltage at the bottom end of the secondary of T464 (Fig. 3-5) is opposite in phase to the voltage on the top end, the capacitance reactance introduced by C504 will directly subtract from the shunt $X_C$ of the crystal. Hence, with C504 properly adjusted, Y501 exhibits no parallel resonance and assumes the impedance versus frequency curve of Fig. 3-4.

### Variable Resolution Filter

The resolution of the spectrum display is determined by the series resonant circuit of Y501, L508 and C508. When lightly loaded, the frequency response of the circuit will be much broader than the response of the crystal alone, giving a wide bandpass (low resolution) display. When the RESOLUTION control SW550 is turned counterclockwise (toward +100 volts), the increase in forward bias on D506 increases the loading on the series resonant circuit, thus lowering the

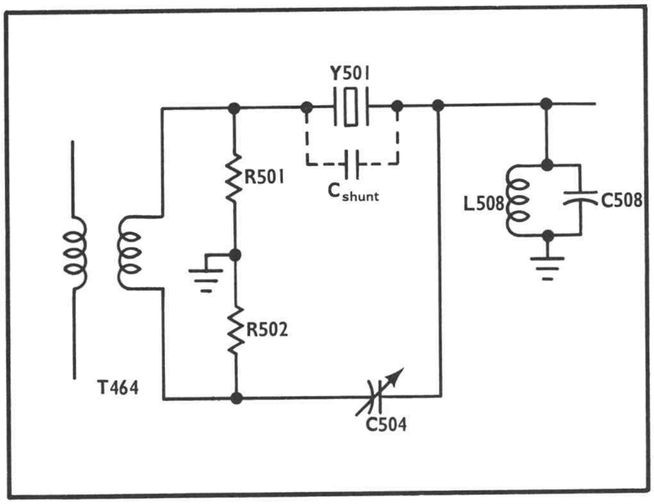



**Fig. 3-5. Shunt capacitance cancelling circuit for Y501.**

Q of the L508-C508 tank circuit. As a result, the crystal's sharp cutoff characteristic becomes the determining factor, resulting in a high-resolution display.

R543 is adjusted to set the resolution at 100 kHz with the RESOLUTION control at the clokwise end of its rotation. The other positions of the RESOLUTION control are not calibrated, although the resistance of each step of the voltage divider will be near optimum for most displays when the RESOLUTION control is coupled to the DISPERSION control.

Since the variable resolution circuit cannot be coupled directly to a low-impedance load, it is followed by emitter the filter from the relatively low input impedance of follower Q510 and Q520 to isolate the high impedance of the following amplifier Q530.

### Variable Resolution Amplifier

Q530 is a common-emitter amplifier which provides the increased signal amplitude required to operate the LOG and SQ LAW circuits of the Output Amplifier.

## Output Amplifier

### 5 MHz Amplifier and Detectors

The signal from the Variable Resolution Amplifier is connected to the input section of the Vertical Display switch SW660.

In the LOG position of SW660, there is no attenuation of the signal in the input section of the amplifier. This straight-through coupling of the signal provides full 40 dB dynamic range required for LOG display.

In the LIN position of the switch, the R606-R607 voltage divider attenuates the input signal by approximately 3 to 1 so that a signal giving a full-screen display in LIN position will continue to give full-screen when the switch is moved to one of the other positions.

In the SQ LAW position, the signal is coupled through two germanium diodes (D603 and D604) connected back to back and in series with R610 to form a voltage divider. To illustrate the action of the SQ LAW divider, Fig. 3-6A

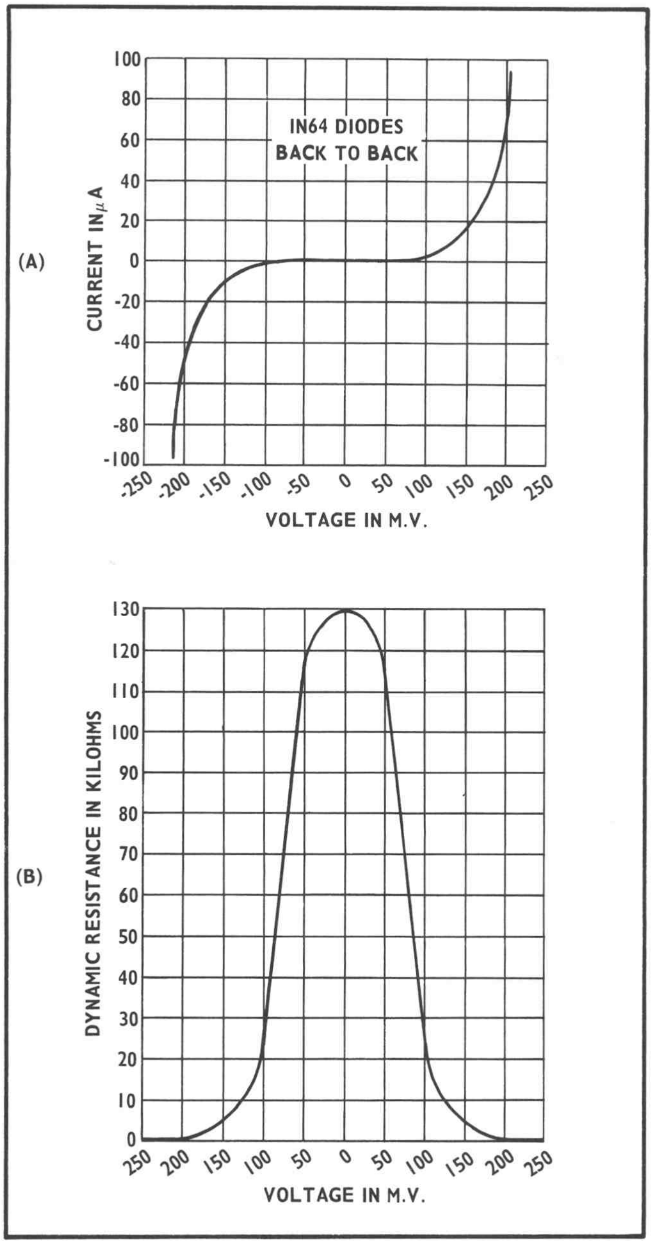



**Fig. 3-6. Characteristic curves for 1N64 diodes; (A) voltage vs. current; (B) voltage vs. dynamic resistance.**

shows current-versus-voltage characteristic curve for the back to back diodes. Fig. 3-6B shows the diode dynamic resistance

$$\Delta r = \frac{\Delta_e}{\Delta_i}$$

curve derived from Fig. 3-6A. Note that for very low millivolt signals, the diode resistance exceeds 100 kΩ. As a result, the divider ratio of 100:1 to 60 millivolts will pass about 1% of the signal; at 160 millivolts will be about 2:1 and 50% of the signal will pass. Since the circuit will normally operate with about 70 millivolts of signal for a full-screen display, the diodes will usually be operating along the steep portion of the resistance curve.

The non-linear dynamic resistance of the diodes results in a display that emphasizes small differences between similar signals. The vertical response of the SQ LAW display will be approximately proportional to the signal power.

In the VIDEO position of SW660, the spectrum display signal is grounded to prevent it from interfering with a signal connected to the VIDEO INPUT connector.

The signal from the VERTICAL DISPLAY switch is coupled through T610 to the 5 MHz crystal filter Y610, which is similar in action to Y501 with C610 cancelling out the shunt capacitance around Y610. However, unlike Y501, Y610 operates with a fixed bandpass. Filter C620-L620 helps shape the 100 kHz response and suppresses any spurious responses generated by Y610.

V620 and Q650 further amplify and isolate the 5 MHz signal before it is detected by D657 for the TO RECORDER output and by D660-D661 for the CRT display.

### Video Filter

The VIDEO FILTER switch SW661 places C661 across the output of D660 to limit the high frequency response of the detector circuit.

## VERTICAL DISPLAY Switching

In the LIN and SQ LAW positions of the VERTICAL DISPLAY switch, the signal is attenuated 2:1 by R662 and R663 before being connected through Pin 1 of the output connector P11 to the Vertical Amplifier circuits of the oscilloscope.

In the LOG position, the signal also passes through an attenuator before going to the output connector. The LOG attenuator is made up of R664 in series with silicon diodes D664 and D665. The silicon diodes in this circuit behave close to the ideal that voltage differences are proportional to the logarithm of the current applied. R664 converts the detector input voltage to current for this circuit. R665 helps suppress the small current-voltage offset of the silicon diodes to make the attenuation more nearly logarthmic. R666 (Log Cal) sets the maximum amplitude of the LOG display.

In the VIDEO position, the VERTICAL DISPLAY switch connects the VIDEO INPUT connector to the output connector P11 through C668 and GAIN control R441B.

## Vertical Positioning

The spectrum display and the VIDEO INPUT circuits are isolated from DC ground by the coupling capacitors C660 and C668. This allows the POSITION control network to set the DC reference level of the output circuits.

## 1 MHz Calibrator Marker Generator

When the 1 MHz CAL MARKER button is pushed it applies power to the 1 MHz Calibrator Marker generator. The output of the 1 MHz crystal controlled sine wave oscillator is converted into 1 MHz markers by a tunnel diode pulse network. The 1 MHz markers then are connected via the Resistive T Coupler to the Wide-Band Amplifier and mixer circuit.

# NOTES

# SECTION 4
# MAINTENANCE

## Introduction

This section of the manual contains information for use in maintenance and troubleshooting on the Type 1L60. The early part of the section deals with general preventive maintenance. This is followed by corrective maintenance information and ordering of replacement parts, then finally by detailed information on difficult repair and replacement procedures.

### PREVENTIVE MAINTENANCE

## General

Preventive maintenance consists of cleaning, visual inspection, lubrication, and if needed, recalibration. Preventive maintenance is generally more economical than corrective maintenance, since preventive maintenance can usually be done during idle periods at a time convenient to the user. The preventive maintenance schedule established for the instrument should be based on the amount of use and on the environment in which the instrument is used.

## Cleaning

The Type 1L60 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical leakage path.

CAUTION

**Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Some chemicals to avoid are benzene, toluene, xylene, acetone or similar solvents.**

## Exterior

Loose dust accumulated on the front panel of the instrument can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt and dust around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild solution of water and detergent. Abrasive cleaners should not be used.

## Interior

Due to its electrical conductivity under high-humidity conditions, dust in the interior of the instrument should be removed occasionally. The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air. (High-velocity air can damage some components.) Remove any dirt which remains with a soft paint brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning ceramic terminal strips.

## Lubrication

The life of the rotary switches will be lengthened if these devices are kept properly lubricated. Use a cleaning type lubricant (such as Cramoline) on shaft bushings, plug-in connector contacts and switch contacts. Lubricate the switch detents with a heavier grease (Beacon No. 325 or equivalent). The necessary materials and instructions for proper lubrication of Tektronix instruments are contained in a component lubrication kit which may be ordered from Tektronix. Order Tektronix Part No. 003-0342-00.

## Visual Inspection

The Type 1L60 should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated transistors or vacuum tubes, and heat damaged parts. Care must be taken if heat-damaged parts are located. Overheating is usually a symptom of other troubles. For this reason, it is essential to determine the actual cause of the trouble; otherwise the damage may be repeated.

## Tube and Transistor Checks

Periodic preventive maintenance checks, consisting only of removing the tubes and transistors from the instrument and testing them in a tester, are not recommended. The circuits within the instrument provide the only satisfactory means of checking tube and transistor performance. Defective tubes or transistors will usually be detected during recalibration of the instrument. Details of in-circuit tube and transistor checks are given in the trouble-shooting procedure later in this section.

## Performance Checks and Recalibration

To insure accurate measureements, the instrument performance should be checked after each 500 hours of operation or every six months if the instrument is used intermittently. The calibration procedure is helpful in isolating major troubles in the instrument. Moreover, minor troubles not apparent during regular operation are frequently revealed and corrected during recalibration. Performance Check instructions are given in Section 5; Calibration instructions are given in Section 6.

### CORRECTIVE MAINTENANCE

## General

Corrective Maintenance consists of component replacement and instrument repair.

## Obtaining Replacement Parts

**Local Purchase.** All electrical and mechanical part replacements for the Type 1L60 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, consult the Parts List for value, tolerance, and rating.

When selecting replacement parts, it is important to remember that the physical size and shape of the component may effect its performance at high frequencies. All replacement parts should be direct replacement unless it is known that a different component will not adversely affect instrument performance.

**Ordering Parts From Tektronix.** When ordering replacement parts from Tektronix, include the following information.

1. Instrument Type.
2. A description of the part (if electrical, include circuit number).
3. Tektronix Part Number.
4. Instrument Serial Number.

## Component Numbering

The circuit number of each electrical part is shown on the circuit diagrams. Note that a functional group of circuits is assigned a particular series of numbers. Table 4-1 lists the component numbers as they are assigned to the functional grouping of circuits.

**TABLE 4-1**

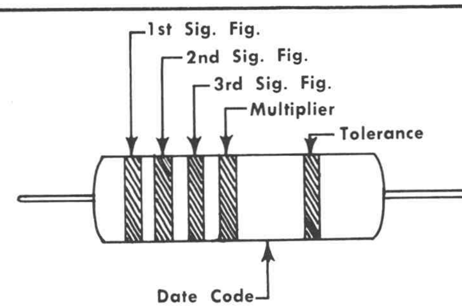
| Component No. Series | Component Numbering |
|---|---|
| 100-149 | Wide-Band Amplifier and Mixer |
| 150-199 | IF Attenuator |
| 200-399 | Sweeper Circuit |
| 400-499 | Narrow-Band Amplifier |
| 500-560 | Variable-Resolution Amplifier |
| 600-727 | Output Amplifier |
| 800-806 | 1 MHz Calibrator Marker Generator |

## Resistor Coding

The Type 1L60 uses a number of metal film resistors identified by their gray background color and color coding.

If the resistor has three significant figures with a multiplier, the resistor will be EIA color-coded. If it has four significant figures with a multiplier, the value will be printed on that resistor. For example, a 333 kΩ resistor will be color coded, but a 333.5 kΩ resistor will have its value printed on the resistor body.

The color-coding sequence is shown in Fig. 4-1.




| Color | 1st Sig. Fig. | 2nd Sig. Fig. | 3rd Sig. Fig. | Multiplier | Tolerance (±) % |
|---|---|---|---|---|---|
| Black | 0 | 0 | 0 | 1 | — |
| Brown | 1 | 1 | 1 | 10 | 1 |
| Red | 2 | 2 | 2 | 100 | 2 |
| Orange | 3 | 3 | 3 | 1,000 | — |
| Yellow | 4 | 4 | 4 | 10,000 | — |
| Green | 5 | 5 | 5 | 100,000 | 0.50 |
| Blue | 6 | 6 | 6 | 1,000,000 | 0.25 |
| Violet | 7 | 7 | 7 | 10,000,000 | 0.10 |
| Gray | 8 | 8 | 8 | 100,000,000 | 0.05 |
| White | 9 | 9 | 9 | 1,000,000,000 | — |
| Gold | | | | 0.1 | 5 |
| Silver | | | | 0.01 | — |
| No Color | | | | | 10 |

Fig. 4-1. Standard EIA color-coding of metal film resistors.

## Wiring Color Code

All insulated wire used in the Type 1L60 is color-coded according to the EIA standard color code to facilitate circuit tracing. The widest color strip identifies the first color of the code. Power supply voltages can be identified by three color stripes and the background color. White background color indicates a positive supply, and a tan background is used to indicate a negative supply. Table 4-2 shows the wiring color code for the power supply voltages used in the Type 1L60. The remainder of the wiring in the instrument is color coded with two or less stripes or has a solid background with no stripes. The color coding helps to trace a wire from one point in the instrument to another.

**TABLE 4-2**

| Supply | Background Color (Polarity) | 1st Stripe (1st No.) | 2nd Stripe (2nd No.) | 3rd Stripe (Multiplier) |
|---|---|---|---|---|
| −10 V | Tan | Brown | Black | Black |
| +10 V | White | Brown | Black | Black |
| −75 V | White | Violet | Green | Black |
| +100 V | White | Brown | Black | Brown |
| −150 V | Tan | Brown | Green | Brown |
| +225 V | White | Red | Red | Brown |
| +350 V | White | Orange | Green | Brown |

## Removing and Remounting the IF Chassis

1. Loosen the front set-screw on the DISPERSION RANGE switch shaft with a .05 inch Allen wrench and slide the shaft forward toward the front panel.



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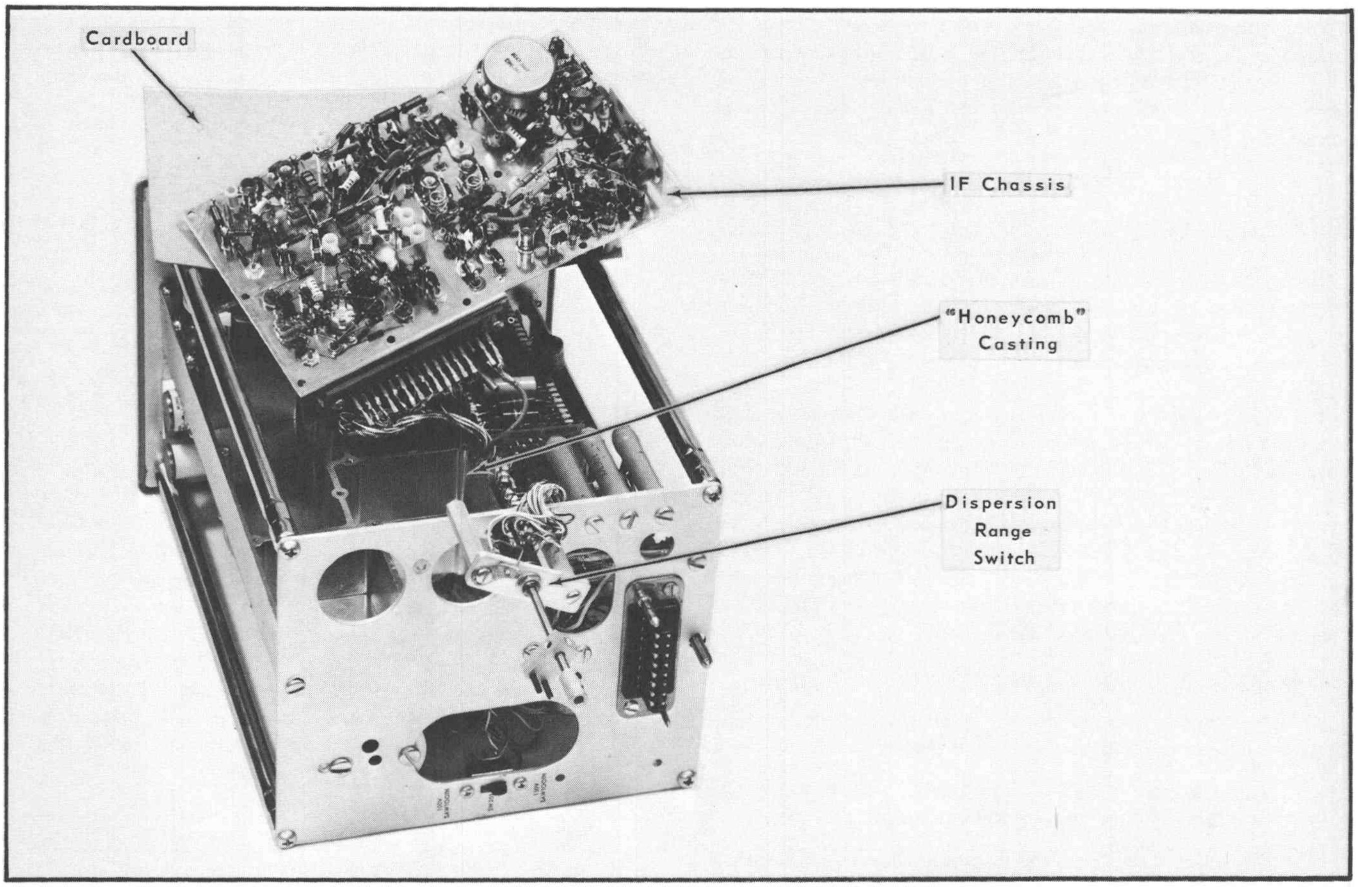



Fig. 4-2. Removing the IF Chassis.

2. Remove the two screws securing the DISPERSION RANGE switch to the rear plate and swing the switch assembly out of the way behind the rear plate.

3. Remove the fourteen Phillips head screws fastening the IF chassis to its base.

4. Swing the chassis up and out to rest on the instrument's spacer bars (See Fig. 4-2). (It may be necessary to disconnect the coaxial cable from J120, J147, and J401). Do not use force, because some of the parts are critically positioned and should not be moved out of adjustment.

5. Before turning on the power, check to make sure that none of the terminals and tie points are shorted or grounded. Also, reconnect any cables or wires that were disconnected. The ground-wire on the DISPERSION RANGE switch must be grounded for proper operation of the instrument.

6. Remount the IF chassis using the reverse of the procedures of steps 1 through 5. Do not force the chassis into place and check the wiring and connectors to prevent pinching and straining of the connections. When replacing the DISPERSION RANGE switch, be sure its shaft is properly coupled to SW365. Also, check the operation of the DISPERSION RANGE switch to be sure the knob is properly indexed.

## Replacing Ceramic Strips

Unsolder all connections, then use a $^3/_8$ inch diameter by 3 inch long plastic or hardwood dowel and a small (2 to 4 oz.) mallet to knock the stud pins (see Fig. 4-3) out of the chassis. Place one end of the dowel on the end of the stud pin protruding through the chassis. Rap the opposite end of the dowel smartly with the mallet. When both studs of the strip have been loosened in this fashion, the strip is removed as a unit. The spacers will probably come out with the studs. If not, they can be pulled out separately. An alternative method of removing the terminal strip is to use diagonal cutters to cut off the sides of the studs. The ceramic strip is removed and the studs pulled from the chassis with a pair of pliers.

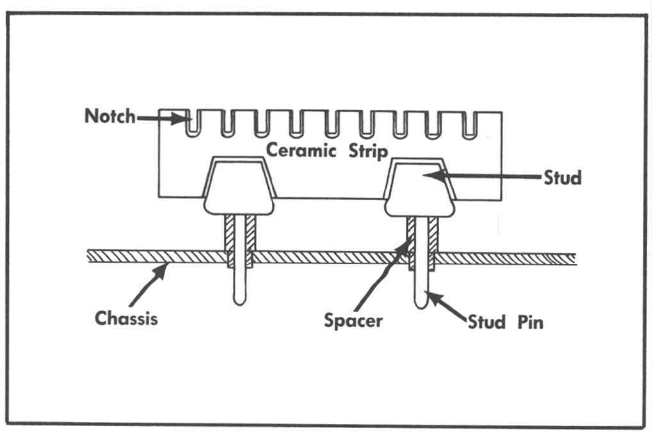



Fig. 4-3. Typical ceramic strip assembly.

After the damaged strip has been removed, place the undamaged spacers in the chassis holes. Then, carefully press the studs into the spacers until competely seated. If necessary, use a soft mallet and tap lightly, directly over the stud area of the strip.

## Soldering Techniques

**Ceramic Strips.** Because of the shape of the ceramic strip terminals, it is recommended that a soldering iron with a wedge-shaped tip be used. A wedge-shaped tip allows the heat to be concentrated on the solder in the terminals. It is important to use as little heat as possible while producing a full-flow joint. A special silver-bearing solder is used to establish a better bond to the plated notches in the ceramic strip. This bond may be broken by repeated use of ordinary tin-lead solder, or by excessive heat. Occasional use or ordinary 60/40 solder will not break the bond, but it is advisable to stock solder containing about 3% silver for the maintenance of Tektronix instruments. The solder may be purchased directly from Tektronix, Inc. in one-pound rolls; order by Part Number 251-0514-00.

The step-by-step technique is as follows:

1. Use long-nose pliers for a heat sink. Attach pliers between the component and the point where heat is applied.

2. Use a 50- to 75-watt soldering iron with a clean tip, properly tinned with solder containing about 3% silver.

3. Apply heat directly to the solder in the terminal notch without touching the ceramic. Do not twist the iron in the notch, as this may chip or break the ceramic strip.

4. Apply only enough heat to make the solder flow freely.

5. Do not attempt to fill the notch with solder; instead apply only enough solder to cover the wires adequately and form a small fillet. Overfilling the notches may result in cracked terminal strips. If the lead extends beyond the solder joint, clip off the excess close to the joint.

6. Remove all the wire clipping from the chassis.

**Circuit Board Assemblies.** Use ordinary electronic grade rosin core 60/40 solder and a 35- to 40-watt pencil soldering iron with a 1/8 inch wide chisel tip. The tip of the iron should be clean and properly tinned for best heat transfer in a short time to the soldered connection. A higher wattage soldering iron, if used and applied for too long a time, ruins the bond between the etched wiring and base material by charring the glass-epoxy laminate.

The step-by-step technique is as follows:

1. To remove a component, cut the leads near the body of the component. This frees the leads for individual unsoldering.

2. Grip the lead with needle-nose pliers. Apply the tinned tip of the soldering iron to the lead between the plier and the board, then pull gently.

3. When the solder first begins to melt, the lead will come out, leaving a clean hole. If the hole is not clean, use the soldering iron and a toothpick or a piece of enameled wire to open the terminal hole. Do not attempt to drill the solder out, or the "through-hole" plating might be distroyed.

4. Clean the leads on the new component and bend them to the correct shape. Carefully insert the leads into the holes from which the defective component was removed.

5. Apply the iron and a little solder to the connection to finish the solder joint.

## Transistor Replacement

Transistors should not be replaced unless they are actually defective. Transistors defects usually take the form of the transistor opening, shorting, or developing excessive leakage. These and other defects can usually be located by signal tracing, by making in-circuit voltage checks, or by using the substitution method.

NOTE

**If a transistor is removed from its socket, be sure to replace it in exactly the same position. Some transistors can be placed in the socket in four different positions. Fig. 4-4 shows the correct connections for the different transistors and socket combinations used in the Type 1L60 as seen from the top of the chassis. If a defective transistor is being replaced, the new transistor will probably have straight leads. Be sure to cut and bend the new leads so that they are identical to the leads of the old transistor.**

## Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connection, operation, and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedures given in this section.

**Check Associated Equipment.** Before proceeding with troubleshooting of the Analyzer, be sure that the equipment used with it is operating correctly, that the signal is properly connected, and that the interconnecting cables or probe are not defective.

Also, check the oscilloscope to make sure that it is operating properly, and that the sweep sawtooth signal from the oscilloscope is connected to the SWEEP INPUT connector of the Plug-In Unit. (Check the sawtooth signal at the connector. The sawtooth CF circuit may be dead without affecting the operation of the rest of the oscilloscope.) A faulty power supply in the oscilloscope can cause a variety of unusual trouble symptoms. The quickest way to check the operation of the oscilloscope is with another vertical plug-in unit if one is available. If faulty operation is still noted with a different plug-in unit, the trouble can be assumed to be in the oscilloscope.

**Check Control Settings.** Incorrect control settings can indicate a trouble that does not exist. For example, if the VERTICAL DISPLAY switch is in the VIDEO position there can be no spectrum display. As another example, if the DISPERSION switch is set to 0, there will be no frequency sweep

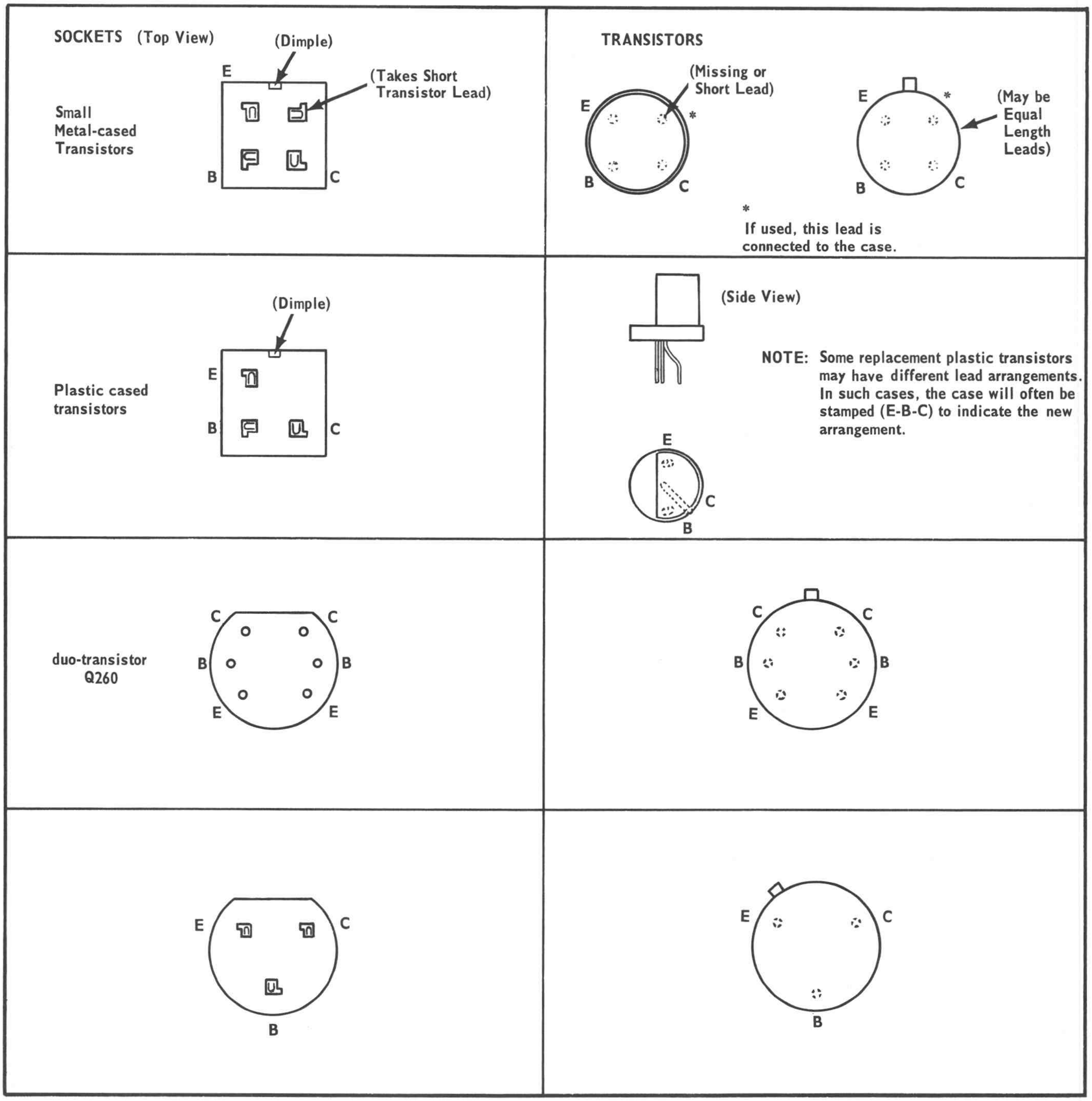



**Fig. 4-4. Transistor and transistor socket connections as viewed from top of the chassis.**

and probably no vertical deflection unless the IF Center Frequency controls are moved by hand. If there is any question about the correct function or operation of any control, see the Operating Instructions section of this manual.

**Check Instrument Calibration.** Check the calibration of the instrument, or the affected circuit if the trouble exists in one circuit. The indicated trouble may only be a result of misadjustment or may be corrected by recalibration. Complete instructions are given in the Calibration section of this manual. Individual calibration steps can be performed out of sequence in some cases. However, if the circuit affects the calibration of other circuits in the instrument or if several controls are interacting, a more complete calibration will be necessary. Before you change any adjustments during this check, note the settings so that you can return the controls to their orginal positions. This will often make recalibration much easier.

**Isolate Trouble to a Part of the Instrument.** Although some troubles may disrupt the operation of the entire instrument, most troubles will affect the operation of only one area or circuit.

**Visual Check.** Visually check the circuit in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged components, etc.

**Check Voltages and Waveforms.** Often the defective component can be located by checking for the correct voltages or waveforms in the circuit. Typical voltages and waveforms are given in the Schematic Diagrams.

NOTE

**Voltages and waveforms given on the diagrams are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the first page of the schematics.**

Most voltages measurements can be taken with a 20,000 ohms/volt DC voltmeter, but do not use a low-volts range on a high impedance circuit. Use a higher range, a more sensitive meter, or an oscilloscope. Accuracy of the voltmeter should be within 3% on all ranges. Be sure that the test probes are well insulated to prevent accidental shorting of the components.

For checking waveforms, use a test oscilloscope which has the following minimum specifications:

Bandwidth: DC to 10 MHz.

Deflection Factor: 0.05 Volts/division minimum.

Input Impedance: 10 MΩ paralleled by 10 pF when using a 10× probe.

Connections to the IF Chassis are made through square-pin connectors and clips. These connectors make convenient test points for troubleshooting, since much of the circuitry connected to them is inaccessible without disassembly of the instrument.

Tables 4-4 and 4-5 list the DC resistance between the various pins and ground, first with the cable-clips connected to the pins, and then with **all** the clips disconnected. The tables also list the resistance between the pins of P11 (the rear-plate connector) and ground.

The color code of the wires soldered to the clips is the same as the color code of the wires soldered to the pins except as noted; if the clips are disconnected, be sure that they are **all** reconnected properly before the power is applied.

The resistance measurements may vary considerably. Because of the semiconductors used in the circuitry, the ohmmeter readings will be affected by the biasing supplied by the internal voltages of the meter. Since ohmmeters differ in the internal voltage used on each range and in the currents required for deflection, the readings can vary as much as 50% between different types of meters, even when using the same range. For future reference, empty columns are provided in each table for logging your own measurements and the type of meter used.

**Check Individual Components.** The following procedures describe methods of checking individual components in the Spectrum Analyzer.

Transistors. The best check of transistor operation is actual performance under operating conditions. To check transistors using a voltmeter, measure the emitter-to-base and emitter-to-collector voltage and determine if the voltages are consistent with the normal circuit voltages given on the Schematic diagrams.

NOTE

**The analyzer uses several shielded chassis, which make it very difficult to reach much of the socket wiring for waveform and voltage checking. In many cases, it is easier to take these measurements from the top of the chassis by touching the probe to the transistor lead between the transistor body and the socket pin (see Fig. 4-4). This is especially true of the black epoxy-cased transistors.**

If there is some doubt about whether a transistor is good, substitute a new transistor; but first, be certain a defect in the circuit did not cause the first transisor to fail. Oherwise the new transistor may be damaged as soon as it is subject to the same conditions. If the orginal transistor is good, return it to the same socket. Unnecessary replacement of transistors is not only expensive but may also result in needless recalibration of the instrument.

**TABLE 4-4**

P11 Connector (Mounted on Rear Plate)

Meter ______________

| Pin | Resistance in Ohms[1] | |
|---|---|---|
| | | Reversed Polarity |
| 1 | 70 kΩ | 84 kΩ |
| 2 | 0 | 0 |
| 3 | 5.4 kΩ | 5.4 kΩ |
| 4-8 | NC | |
| 9 | 5.4 kΩ | 5.6 kΩ |
| 10 | 4.6 kΩ | 3.4 kΩ |
| 11 | 50 kΩ | 200 kΩ |
| 12-14 | NC | |
| 15 | 2.4 kΩ | 2.3 kΩ |
| 16 | NC | |

If substitute transistors are not available, a dynamic tester such as a Tektronix Type 575 may be used. Static-type testers are not as meaningful since they do not check operation under operating conditions.

Diodes. A diode can be checked for an open or shorted condition by measuring the resistance between terminals. With an ohmmeter scale having an internal source of about 1.5 volts, the resistance should be very high in one direction and very low when the leads are reversed.

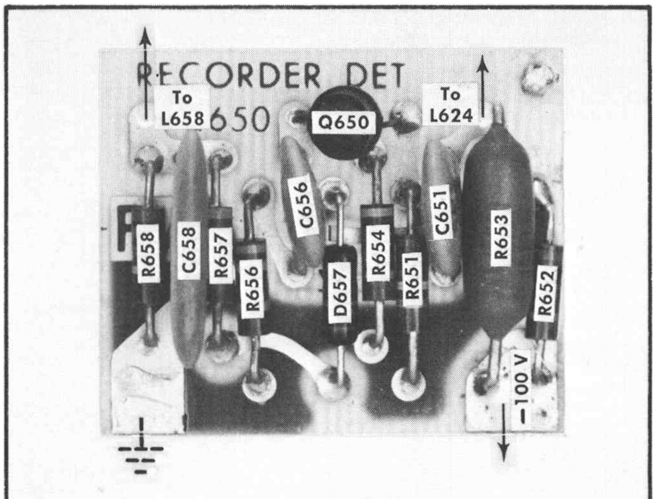
CAUTION

**Do not use an ohmmeter scale that has a high internal current, and do not use this technique to check tunnel diodes.**

Resistors. Resistors can be checked with an ohmmeter. Normally, resistors do not need to be replaced unless the measured value varies widely from the specified value.

Inductors. Check for open inductors by checking continuity with an ohmmeter. Shorted or partially-shorted inductors can usually be found by checking the response to high-frequency signals.

Capacitors. Leaky or shorted capacitors can best be detected by checking resistance with an ohmmeter on the highest resistance range. (Do not exceed the voltage rating of the capacitor.) The resistance reading should be high after initial charge of the capacitor. An open capacitor can best be detected by checking whether the capacitor passes AC signals.




RECORDER DETECTOR

**TABLE 4-5**

IF Chassis Square-Pin Connectors

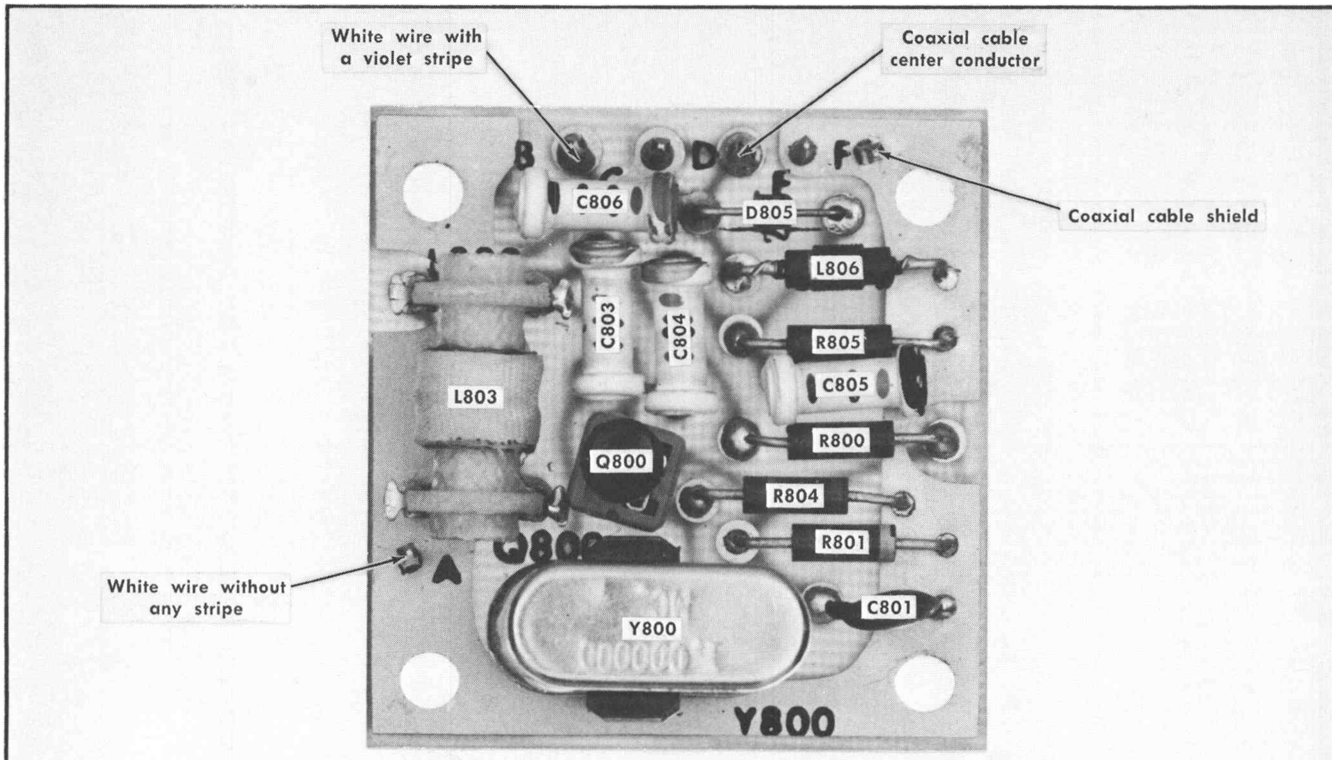
Meter________

| Pin | Resistance in Ohms[1] Cable Connected | | Cable Disconnected | |
|---|---|---|---|---|
| | | | | |
| A | 0 | | 0 | |
| B | 1 kΩ | | ∞ | |
| C | ∞ | | ∞ | |
| D | 5.6 kΩ | | 90 kΩ | |
| E | 3 kΩ | | 4 kΩ | |
| | | Reverse Polarity | | Reverse Polarity |
| F | 2 kΩ | 1.8 kΩ | 2.7 kΩ | 3.4 kΩ |
| G | 11 kΩ | 2.5 kΩ | ∞ | 2.7 kΩ |
| H | 3 kΩ | 2.4 kΩ | ∞ | 4.2 kΩ |
| I | 11 kΩ | 2.8 kΩ | ∞ | 2.9 kΩ |
| J | 850 Ω | 850 Ω | 280 kΩ | 2.7 kΩ |
| K | 27 kΩ | 6 kΩ | 220 kΩ | 2.7 kΩ |
| L | 90 kΩ | 3.7 kΩ | ∞ | 4 kΩ |
| M | 5 kΩ | 250 kΩ | 11 kΩ | ∞ |
| N | 100 kΩ | 2.7 kΩ | ∞ | 2.7 kΩ |
| O | 100 kΩ | 2.7 kΩ | ∞ | 2.8 kΩ |
| P | 100 kΩ | 6 kΩ | 150 kΩ | ∞ |

[1]Resistances printed in the table were measured with a Simpson Electric Co. Model 262 Multimeter.

0 Ω—40 kΩ readings were taken on the R × 1 k range.

50 kΩ—∞ readings were taken on the R × 100 k range.




1MHz CAL MARKER GENERATOR

**Fig. 4-5. Type 1L60 Circuit Boards.**

## NOTES

# SECTION 5
# PERFORMANCE CHECK

## Introduction

This Performance Check Procedure is offered to provide a systematic method of checking the performance of the Spectrum Analyzer without changing any of the internal calibration adjustments.[1]

The instrument should be checked following this procedure after each 500 hours of operation, or every six months if it is operated intermittently. Also follow the steps given in the appropriate section of this Performance Check after any corrective maintenance work.

Failure to meet the performance requirements given in this procedure indicates that the instrument requires internal checks and/or adjustments.

## RECOMMENDED EQUIPMENT

The following equipment is recommended for a complete performance check. Specifications given are the minimum necessary to check the Analyzer to the accuracy given in the Characteristics section of this manual. If the equipment is substituted, it must meet or exceed the specifications of the recommended equipment. Proper settings for any substitute equipment must be determined by the user.

1. Oscilloscope. Any Tektronix oscilloscope which accepts 1- or Letter-Series Vertical Plug-In Units.

2. Test Oscilloscope with 1× or 10× probes; minimum deflection factor, 0.01 volts/division; frequency response, DC to 10 MHz. Recommended equipment—Any Tektronix oscilloscope meeting the above requirements.

3. Marker Generator; output frequencies (timing pulses) 1 kHz to 20 MHz; 1 ms to .05 μs; timing accuracy, ±0.001%; 50 MHz and 100 MHz are very desirable but not absolutely necessary. Recommended equipment—Tektronix Type 184 Time-Mark Generator; or a Tektronix Type 180A Time-Mark Generator and Harmonic Modulator Unit, Tektronix Part No. 067-0518-00.

4. Calibrated Amplitude—Calibrated Frequency RF Generator, frequency range 10 MHz to 400 MHz variable; frequency accuracy, ±1%; output amplitude, —100 dB to 0 dB; amplitude accuracy, ±1 dB; and output impedance, 50 Ω. Suggested equipment—Hewlett-Packard Type 608E UHF Signal Generator.

5. Sine-Wave Generator(s) Needed to check frequency response of the VIDEO INPUT circuit. Output range, 10 Hz to 50 kHz and 50 kHz to >10 MHz; and frequency accuracy, ±5%. Suggested equipment: for 10 Hz to 50 kHz, use Heath Co. Model IG-72 Audio Generator. For 50 kHz to >10 MHz, use Tektronix Type 191 Signal Generator.

6. DC Voltmeter. Needed to check +10 V DC OUT. Sensitivity, ≥5000 Ω/Volt; accuracy, ±1% at 10 volts.

7. Small Screwdriver, 3/32 inch blade, Tektronix Part No. 003-0192-00.

8. Flexible Cable Plug-In Extension, Tektronix Part No. 012-0038-00.

9. 10:1 Attenuator, BNC connectors, Tektronix Part No. 011-0059-00.

10. Coaxial Cable, with BNC connectors, 3 needed. Tektronix Part No. 012-0057-00.

11. Connector Adapters, Type BNC female to Type GR, Tektronix Part No. 017-0063-00 (General Radio No. 874-QBJA); Type GR to Type N Male, Tektronix Part No. 017-0021-00 (General Radio No. 874-QNJ).

12. If the SWEEP INPUT patch cord and adapter supplied with the Analyzer is not available, a substitute can be made from a BNC patch cord (Tektronix Part No. 012-0087-00) and with 1/2 inch length of No. 16 wire inserted in one end. A banana plug patch cord (Tektronix Part No. 012-0031-00) and a BNC to binding post adapter (Tektronix Part No. 103-0033-00) may also be used.

## PROCEDURE

In the following procedure, control settings are called out at the start of each major step. If a control is not called out, it can be assumed that it does not need to be preset at that time.

### 1. Preliminary Set-Up of Equipment

a. Before inserting the Spectrum Analyzer into the oscilloscope, check Table 2-1 or the oscilloscope instruction manual to determine the amplitude of the front-panel sawtooth output voltage. Set SW201 (slide switch mounted on the rearplate of the Analyzer) to the appropriate position.

b. Insert the Spectrum Analyzer into the oscilloscope, fasten the securing latch, and turn on the power. Allow 10-20 minutes for warm-up.

c. Connect the oscilloscope SAWTOOTH OUT (or SAWTOOTH A) connector to the Analyzer SWEEP INPUT connector.

CAUTION

**Be careful when making this connection, since the sawtooth voltage can give a painful shock. Also be sure to plug the cable into the SWEEP INPUT, not one of the nearby RF INPUT connectors.**

d. Set the oscilloscope Mode (or Horizontal Display) switch to A or Normal.

**[1]When the Type 1L60 is used in some oscilloscopes, it may be necessary to adjust R204, this in turn may make it necessary to adjust C384 and C385. See step 2 of this procedure for details.**

e. Set the sweep controls for a free-running 5 ms/cm sweep.

## 2. Set Front Panel IF CENTER FREQ CAL ADJUSTMENT

a. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace on the bottom line of the graticule. |
| IF ATTEN | All OFF |
| IF CENTER FREQ | Midrange (000) |
| FINE IF CENTER FREQ | Midrange |
| DISPERSION RANGE | MHz/CM |
| DISPERSION-COUPLED RESOLUTION | 10 (outer ring) |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |

b. Apply a 200 MHz (5 ns sinewave) signal from the Type 184 Time-Mark Generator (or a 50 MHz signal if using the Type 180A and harmonic modulator unit) to the Analyzer RF INPUT connector through a 10:1 50 Ω attenuator.

c. Adjust the GAIN control so that the CRT display shows an IF feedthrough signal pip about 4 divisions in amplitude.

d. Set the IF CENTER FREQ CAL adjustment so that the signal pip does not shift as the DISPERSION-COUPLED RESOLUTION control is rotated between 10 and .2 (outer ring).

e. Set the oscilloscope Horizontal Position controls to align the pip with the center line of the graticule. If the pip can not be aligned with the Horizontal Position controls, adjust R204[2] to align the pip with the center line of the graticule.

f. Set the DISPERSION-COUPLED RESOLUTION control to 1 (outer ring) and set the DISPERSION RANGE to kHz/CM. The horizontal shift of the pip should not be more than 1 centimeter.

## 3. Set Front-Panel DISP CAL Adjustment

a. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF ATTEN | All OFF |
| IF CENTER FREQ | Midrange (000) |
| FINE IF CENTER FREQ | Midrange |
| DISPERSION RANGE | MHz/CM |
| DISPERSION-COUPLED RESOLUTION | 10 (outer ring) |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | SQ LAW |

[2]When R204 is adjusted, it then becomes necessary to adjust C384 and C385; see step 2 of the Calibration Procedure for details.

b. Apply 10 ns and .1 μs markers (100 MHz and 10 MHz) from the Time Mark Generator through a 10:1 attenuator to the RF INPUT connector.

c. Adjust the GAIN control for a marker display about 4 divisions high.

d. Adjust the FINE IF CENTER FREQ control to keep the markers aligned with the graticule lines while setting the DISP CAL adjustment for one marker per centimeter from the first to the ninth graticule lines. Ignore the right and left edges of the graticule—see Fig. 5-1.

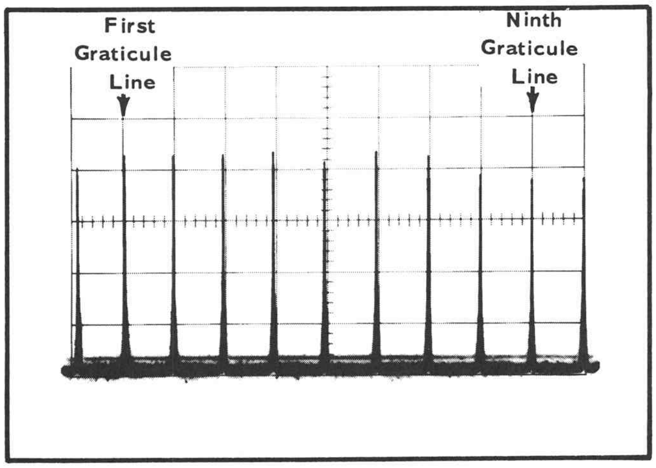



Fig. 5-1. DISP CAL adjustment display (Step 3).

## 4. 1 MHz CAL MARKERS Signal Check

a. Apply 10 ns (100 MHz) and 1 μs (1 MHz) markers from the Time Mark Generator to the RF INPUT connector through a 10:1 Attenuator.

b. Change DISPERSION to 1 MHz/CM and align the first marker with the first graticule line as was done in Step 3d above.

c. Note the horizontal position of the ninth marker.

d. Disconnect the generator and push the 1 MHz CAL MARKER button.

e. Align the first marker with the first graticule line. The ninth marker should be in the position noted in step c above.

## 5. Sensitivity and Frequency Range Checks

a. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF ATTEN | All OFF |
| DISPERSION RANGE | kHz/CM |
| DISPERSION- | 200 (inner ring) |
| COUPLED RESOLUTION | Fully clockwise (10 MHz cm Resolution) (Uncoupled) |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |

b. Apply a —30 dBm 200 MHz signal from the Type 608E Signal Generator to the Analyzer RF INPUT connector.

c. Center the signal on the graticule with the Frequency control of the Signal Generator.

d. Adjust the Analyzer GAIN control until the average noise level is one division in amplitude.

e. Adjust the RF Attenuator control of the generator so that the displayed signal is twice as high as the noise level. (See Fig. 5-2.)

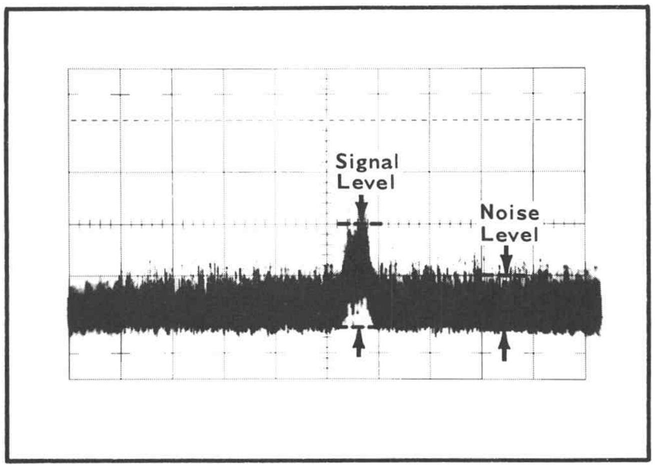



**Fig. 5-2. Typical display for Sensitivity Check (Step 5e).**

f. Check the setting of the RF Atten dial of the generator. It should read —110 dBm or less.

g. When the 100 kHz RESOLUTION display is within the sensitivity requirements given in part f above, the 1 kHz RESOLUTION display will also be within its sensitivity requirements.

## 6. Resolution Check

a. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF ATTEN | All OFF |
| DISPERSION RANGE | kHz/CM |
| DISPERSION-COUPLED | 50 (inner ring) |
| RESOLUTION | Fully clockwise |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |

b. Set the oscilloscope sweep rate to 50 ms/cm.

c. Apply a 200 MHz signal from the Time-Mark Generator HF Selector Output connector to the Analyzer RF INPUT connector.

d. Adjust the Analyzer GAIN control for a 6 centimeter signal.

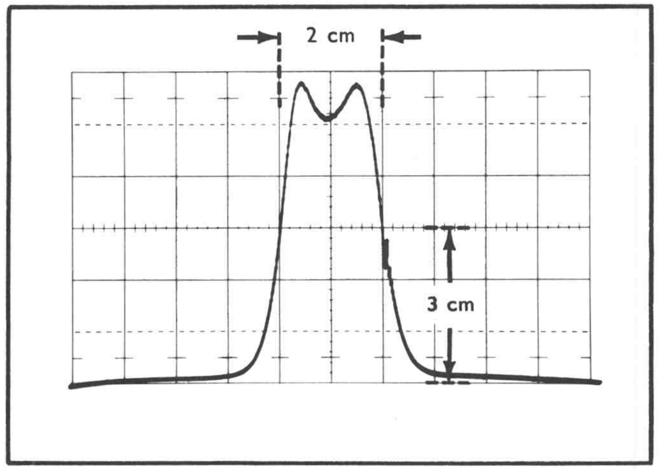



**Fig. 5-3. Typical display for Resolution Check (Step 7).**

e. Check the display for a signal width of 2 centimeters at 3 centimeters above the base line. (See Fig. 5-3.)

## 7. IF Attenuator Accuracy Check

a. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| DISPERSION RANGE | MHz/CM |
| DISPERSION-COUPLED RESOLUTION | (1 outer ring) |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |
| IF ATTEN | All OFF |

b. Apply a —70 dBm 200 MHz signal from the Type 608E RF Generator to the Analyzer RF INPUT connector.

c. Set the Spectrum Analyzer GAIN control so that the 200 MHz signal is exactly 6 centimeters high.

d. Switch the 1 dB IF ATTEN switch On (up) and adjust the Attenuator control of the generator so that the 200 MHz signal is exactly 6 centimeters high. The generator Attenuator control should read —69 dBm ±0.1 dBm.

e. Switch the 1 dB IF ATTEN switch to OFF.

f. Check the rest of the IF ATTEN steps as directed in Table 5-1.

**TABLE 5-1**

| Spectrum Analyzer If ATTEN switch On | RF Generator Attenuator Control Setting |
|---|---|
| 2 dB | —68 dBm ±.2 dBm |
| 4 dB | —66dBm ±.4 dBm |
| 8 dB | —62 dBm ±.8 dBm |
| 16 dB | —54 dBm ±1.6 dBm |
| 20 dB | —50 dBm ±2.0 dBm |

## 8. IF CENTER FREQ Control Range Check

a. Preset the controls on the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF CENTER FREQ | Midrange (000) |
| FINE IF CENTER FREQ | Midrange |
| DISPERSION RANGE | MHz/CM |
| DISPERSION-COUPLED RESOLUTION | 10 |
| VERTICAL DISPLAY | LOG |

b. Apply 100 MHz and 10 MHz markers from the Time-Mark Generator to the Analyzer RF INPUT connector.

c. Adjust the GAIN control so that the 10 MHz markers are visible.

d. The second harmonic of the 100 MHz signal should be centered on the graticule; if it is off-center, readjust the front-panel IF CENTER FREQ CAL adjustment.

e. Rotate the 10-turn IF CENTER FREQ control to both ends of its range. The markers must move at least 1 centimeter (10 MHz) from center in each direction.

f. Change the DISPERSION to 5 MHz/CM.

g. Rotate the 10-turn IF CENTER FREQ control through its range. The markers must move at least 25 MHz from center in each direction.

h. Center the 10-turn control and rotate the FINE IF CENTER FREQ control to the ends of its rotation. The markers must move at least 1 MHz in each direction.

i. Change the DISPERSION to 500 kHz/CM.

j. Rotate the 10-turn IF CENTER FREQ control to the ends of its rotation. The markers must move at least 2.5 MHz from center in each direction.

k. Center the 10-turn control and rotate the FINE IF CENTER FREQ control to both ends of its rotation. The markers must move at least 50 kHz in each direction.

## 9. Display Flatness Check

a. Preset the Spectrum Analyzer controls as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF CENTER FREQ | Midrange (000) |
| IF ATTEN | All OFF |
| DISPERSION RANGE | MHz/CM |
| DISPERSION-COUPLED RESOLUTION | 10 (outer ring) |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |
| FINE FREQ | Midrange (0) |

b. Apply a —50 dBm 200 MHz signal from the Type 608E Signal Generator to the Analyzer RF INPUT connector.

c. Set the Analyzer GAIN control for a 5 centimeter signal display.

d. Turn the Frequency control of the Type 608E generator from 150 MHz to 250 MHz and set it at the frequency giving the highest amplitude signal.

e. Set the Analyzer GAIN control for a 6 centimeter signal display.

f. Set the 1 and 2 IF ATTEN Switches to On, note the display, then return the switch to its OFF position.

g. Tune the Frequency control of the Type 608E generator from 150 MHz to 250 MHz and check that the signal display does not drop below the size noted in step f.

## 10. Dispersion Accuracy Check

a. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF CENTER FREQ | Midrange (000) |
| DISPERSION RANGE | MHz/CM |
| DISPERSION-COUPLED RESOLUTION | 10 |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LOG |

b. Connect the MARKER OUTPUT connector of the Type 184 Time-Mark Generator to the RF INPUT connector of the Analyzer through a 10:1 50 Ω Attenuator. (To use a Type 180A, see part d below.)

c. Depress the MARKER SELECTOR switches for 10 ns (100 MHz) and the modulation signal indicated in Table 5-2. (Be sure the 10 ns switch stays depressed each time the modulation signal is changed.)

d. If a Type 180A Time-Mark Generator is to be used in place of the Type 184, change the procedure of steps b and c as follows:

1. Connect the Marker Out connector of the Type 180A to the RF connector of the Harmonic Modulator Unit and depress the 50 MHz switch.

2. Connect a cable between the desired modulation signal banana jack and the Harmonic Modulator Modu 2 connector.

3. Connect the Harmonic Modulator Modu Harm Out connector to the Analyzer RF INPUT connector.

4. Set the Modulator controls as follows: Modu Freq 2 to On, 60 MHz Trap to Out, and the two Variable controls to the settings giving the most readable display.

e. Adjust the Analyzer GAIN control for a display about 5 centimeters high.

f. Use Table 5-2 to check the dispersion accuracy at each DISPERSION/CM setting. Position a modulation pip at the first graticule line and check the ninth pip displacement from the ninth graticule line for displays having 1 division/marker; if the display has 2 divisions/marker, check the fifth marker displacement from the ninth line (see Fig. 5-4).

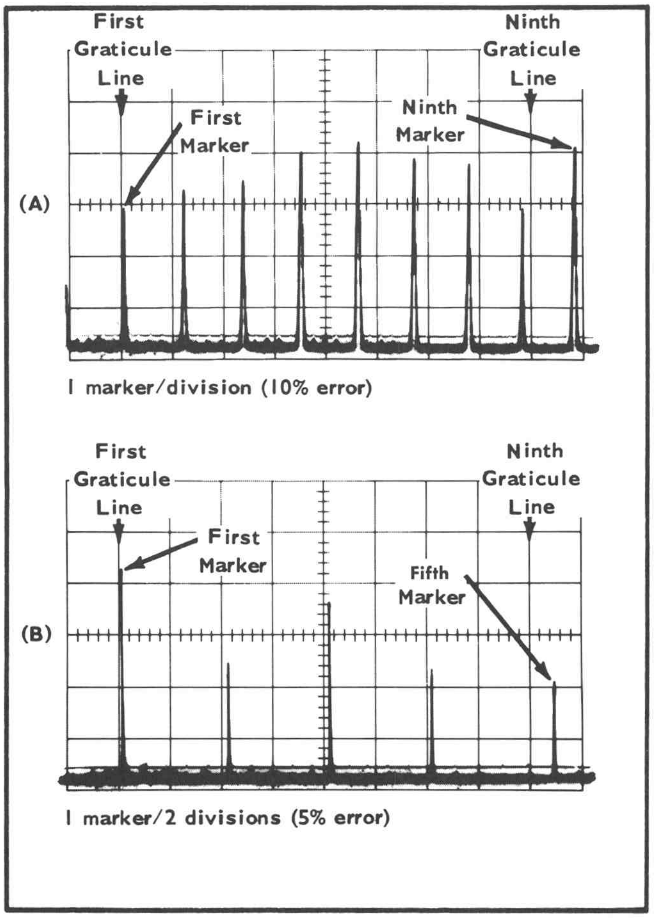



Fig. 5-4. Typical display for Dispersion Accuracy Check (Step 10).

## 11. Dispersion Linearity Check

a. Set up the equipment as directed in Step 10 (above).

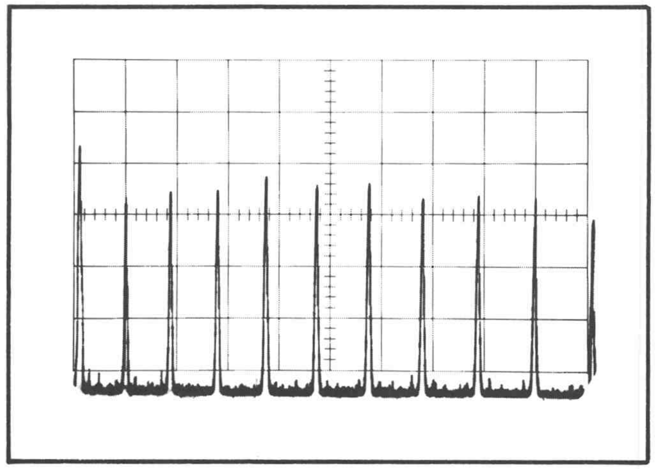


Fig. 5-5. Typical display for Dispersion Linearity Check (Step 11).

b. Set the IF CENTER FREQ controls to midrange.

c. At each DISPERSION/CM setting of Table 5-2, readjust the DISP CAL adjustment to align the correct markers with the first and ninth graticule lines (see Fig. 5-5). (The IF CENTER FREQ controls may be moved slightly away from center to position a marker at the first graticule line.)

d. All markers between the first and ninth graticule lines should be within 2.4 millimeters of the appropriate graticule lines.

## 12. Dynamic Range Check

a. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |

**TABLE 5-2**

| DISPERSION/ CM | Modulation Signal | CRT Display in Divisions/ Marker | Maximum Error | Notes |
|---|---|---|---|---|
| 10 MHz | .1 μs (10 MHz) | 1 | ±3% | Check with IF CENTER FREQ control centered. |
| 5 MHz | .1 μs (10 MHz) | 2 | ±3% | |
| 2 MHz | 15 μs (2 MHz) | 1 | ±5% | Over IF CENTER FREQ control range of + and —25 MHz. |
| 1 MHz | 1 μs (1 MHz) | 1 | ±7% | |
| .5 MHz | 1 μs (1 MHz) | 2 | ±10% | |
| .2 MHz | 5 μs (200 kHz) | 1 | ±15% | Over IF CENTER FREQ control range of + and —2.5 MHz. |
| 500 kHz | 1 μs (1 MHz) | 2 | ±3% | |
| 200 kHz | 5 μs (200 kHz) | 1 | | |
| 100 kHz | 10 μs (100 kHz) | 1 | | |
| 50 kHz | 10 μs (100 kHz) | 2 | | |
| 20 kHz | 50 μs (20 kHz) | 1 | | |
| 10 kHz | .1 ms (10 kHz) | 1 | | |
| 5 kHz | .1 ms (10 kHz) | 2 | | |
| 2 kHz | .5 ms (2 kHz) | 1 | | |
| 1 kHz | 1 ms (1 kHz) | 1 | | |

| | |
|---|---|
| IF ATTEN | All OFF |
| IF CENTER FREQ | Midrange |
| DISPERSION RANGE | MHz/CM |
| DISPERSION-COUPLED RESOLUTION | 1 (outer ring) |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LOG |

b. Apply a —40 dBm 200 MHz signal from the Type 608E Signal Generator to the Analyzer RF INPUT connector.

c. Adjust the GAIN control of the Analyzer for 6 centimeters of signal deflection.

d. Add 40 dB of IF ATTEN. (Set the 20 dB, 16 dB, and 4 dB switches to On.)

e. Check that the signal is just discernible.

f. Set the VERTICAL DISPLAY switch to LIN and switch all the IF ATTEN switches back to OFF.

g. Adjust the GAIN control of the Analyzer for 6 centimeters of signal deflection.

h. Add 26 dB of IF ATTEN. (Set the 20 dB, 4 dB, and 2 dB switches to On.)

i. Check that the signal is just discernible.

j. Set the VERTICAL DISPLAY switch to SQ LAW and return all the IF ATEN switches to OFF.

k. Adjust the Gain control of the Analyzer for 6 centimeters of display.

l. Add 13 dB of IF ATTEN. (Set the 8 dB, 4 dB, and 1 dB switches to On.)

m. Check that the signal is just discernible.

## 13. TO RECORDER Output Check

a. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| DISPERSION RANGE | MHz/CM |
| DISPERSION COUPLED RESOLUTION | 1 (outer ring) |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |

b. Push the 1 MHz CAL MARKER button.

c. Adjust the GAIN control for a 6 centimeter display. (Readjust the POS control if necessary to position the trace to the bottom line of the graticule.)

d. Measure the TO RECORDER signal with the test oscilloscope. Check for 24 millivolts to 4 millivolts.[3]

e. Disconnect the test oscilloscope.

[3]There will be only 1/2 the amplitude if the load is ≈600 ohms.

## 14. VIDEO FILTETR Check

a. Set up the Analyzer as directed in Step 14 a, b, and c above.

b. Switch on the VIDEO FILTER and check for an attenuated display resembling a reversed sawtooth (fast rise, slow decay).

c. Change the sweep rate to 1 s/cm. The display should be the same in either position of the VIDEO FILTER switch.

## 15. VIDEO INPUT Frequency Response Check

a. Insert the Analyzer directly into the oscilloscope plug-in compartment. (Do not use the extension.)

b. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the center line of the graticule. |
| GAIN | Fully clockwise |
| VERTICAL DISPLAY | VIDEO |
| VIDEO FILTER | Off |

c. Apply a 50 kHz signal from an audio generator to the VIDEO INPUT connector of the analyzer. Adjust the Output control of the generator to obtain 4 centimeters of deflection.

d. Monitor the signal amplitude with a DC coupled test oscilloscope for constant amplitude, and decrease the output frequency of the generator.

e. Check the frequency at which the Analyzer display falls to 2.8 centimeters. This frequency should be $\leq$ 16 Hz.

f. Apply a 50 kHz signal from the Constant Amplitude RF Generator to the VIDEO INPUT connector of the Analyzer. Adjust the signal amplitude for 4 centimeters of deflection.

g. Increase the signal frequency until the amplitude of the Analyzer display falls to 2.8 centimeters. At this point the output frequency should be $\geq$ 10 MHz.

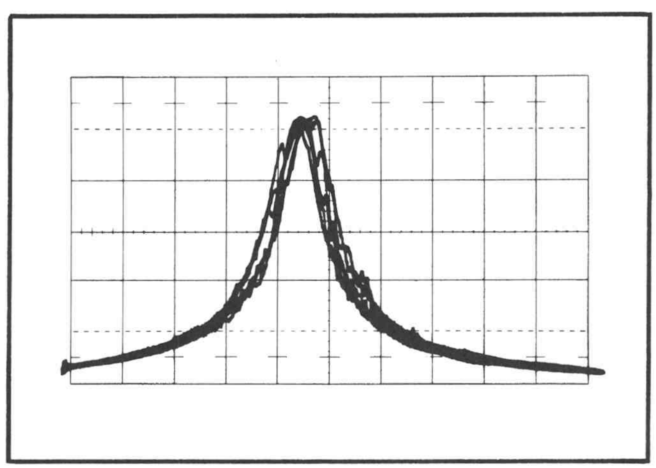


**Fig. 5-6. Typical display for Incidental Frequency-Modulation Check, showing several superimposed sweeps (Step 16).**

## 16. Incidental Frequency-Modulation Check

a. Insert the Analyzer directly into the oscilloscope plug-in compartment. (Do not use the extension.)

b. Preset the Spectrum Analyzer controls as follows:

| | |
|---|---|
| DISPERSION RANGE | kHz/CM |
| DISPERSION | 500 (inner ring) |
| IF ATTEN | All OFF |

c. Apply a 200 MHz signal from the Time-Mark Generator to the Analyzer RF INPUT connector and center the signal on the CRT.

d. Change the DISPERSION-COUPLED RESOLUTION switch to 1, adjusting the IF CENTER FREQ controls as needed to keep the signal centered on the screen.

e. Adjust the GAIN control for six centimeters of deflection.

f. Set the oscilloscope sweep rate to 20 ms/cm. The display must not show more than 0.2 centimeters of frequency modulation. (See Fig. 5-6.)

## 17. Check + 10 V DC OUT Voltage

a. Connect a 500 ohm load resistor between ground and the + 10 V DC OUT connector.

b. Measure the voltage across the load resistor with a voltmeter. Check for 10 volts ±0.5 volts.

## NOTES

# SECTION 6
# CALIBRATION

## Introduction

This Spectrum Analyzer is a stable laboratory instrument which should not require frequent recalibration. However, its performance should be rechecked as directed in Section 5 after every 500 hours of operation or every six months if used intermittently. This will assure that it is operating properly and indicate the sections of the instrument needing recalibration.

The following procedure is arranged in a sequence which will allow the unit to be checked and calibrated at the same time with the least interaction of adjustment and reconnection of equipment. If desired, a single step can usually be performed individually, provided interaction between adjustments is considered.

## Recommended Equipment

The following equipment is recommended for a complete calibration. Specifications given are the minimum necessary to check and calibrate the Analyzer to the accuracy given in the Characteristics Section of this manual. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment. Proper settings for any substitute equipment must be determined by the user.

1. Oscilloscope. Any Tektronix oscilloscope which accepts 1- or Letter-Series Vertical Plug-In Units.

2. Test Oscilloscope with 1× or 10× probes; minimum sensitivity 0.01/div; frequency response DC to 10 MHz. Recommended equipment-any Tektronix oscilloscope meeting the above requirements.

3. Marker Generator with output frequencies of 1 kHz to 50 MHz (10 MHz and 200 MHz are very desirable but not absolutely necessary); timing accuracy, ±0.001%. Recommended equipment-Tektronix Type 184 Time-Mark Generator; or a Tektronix Type 180A Time-Mark Generator and a Harmonic Modulator Unit, Tektronix Part No. 067-0518-00.

4. Calibrated Amplitude—Calibrated Frequency RF Generators with outputs of 50 to 400 MHz; frequency accuracy ±1%; signal amplitude —100 dBm to —30 dBm; amplitude accuracy ±1 dB, and output impedance 50 Ω. Suggested equipment—Hewlett-Packard Type 608E.

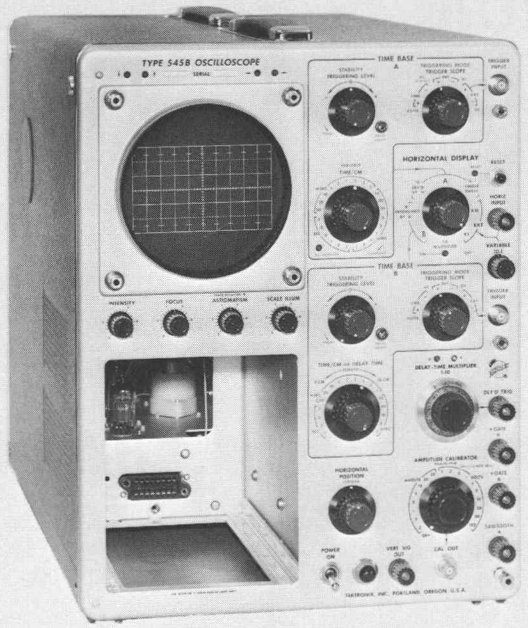
5. Sine-Wave Generator (needed to check frequency response of the VIDEO INPUT circuit) with output frequency ranges 10 Hz to 50 kHz and 50 kHz to >10 MHz: frequency accuracy ±5%. Suggeested equipment - for 10 Hz to 50 kHz, use Heath Co. Model IG-72 Audio Generator; for 50 kHz to 10 MHz, use Tektronix Type 191 Signal Generator.

6. Swept-Frequency Generator with frequency ranges 500 kHz to 300 MHz; and amplitude variation <±0.25 dB. Suggested equipment-Kay Type 122C Sweep Generator.

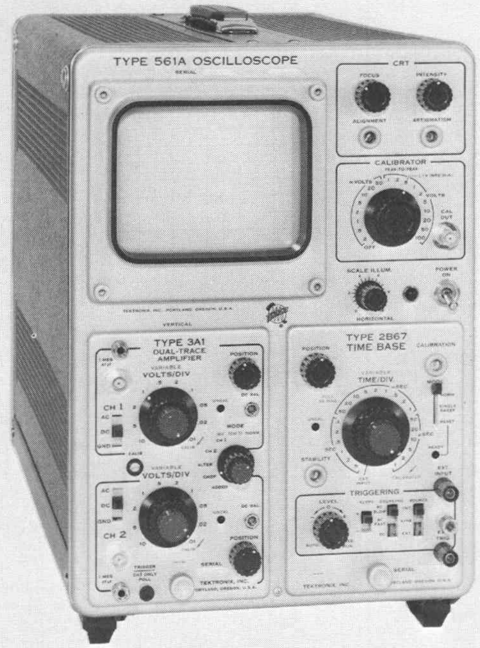
7. DC Voltmeter, with voltage range 0-10 V; sensitivity 20,000 Ω/V, and accuracy ±1%.

| | |
|---|---|
| 8. Coaxial Cables, BNC connectors 3 ea | Tektronix Part No. 012-0057-00. |
| 9. 10:1 Attenuator, BNC connectors | Tektronix Part No. 011-0059-00. |
| 10. T Adapter, BNC connectors | Tektronix Part No. 103-0030-00. |
| 11. Connector Adapters Type BNC Female to Type GR | Tektronix Part No. 017-0063-00. (General Radio No. 874-QBJA). |
| Type GR to Type N Male | Tektronix Part No. 017-0021-00 (General Radio No. 874-QNJ). |
| 12. Screwdriver with 3/32 inch diameter blade | Tektronix Part No. 003-0192-00. |
| 13. Tuning Tool—For 5/64 inch inside diameter hex slugs. Handle | Tektronix Part No. 003-0307-00. |
| Insert | Tektronix Part No. 003-0038-00. |
| 14. Minature phone plug. | |
| 15. Flexible Cable Plug-In Extension | Tektronix Part No. 012-0038-00. |

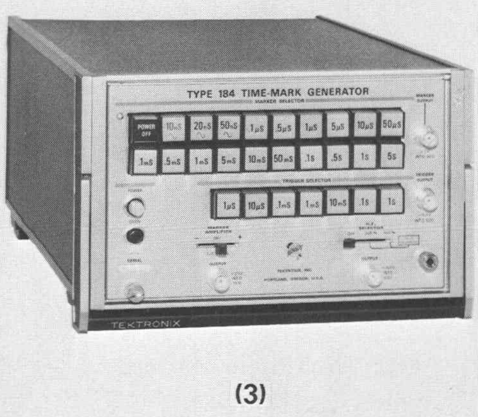
16. If the SWEEP INPUT patch cord and adpter supplied with the Analyzer is not available, a substitute can be made from a BNC patch cord (Tektronix Part No. 012-0087-00) with a 1/2 inch length of No. 16 wire inserted in one end. A banana plug patch cord (Tektronix Part No. 012-0031-00) and a BNC to binding post adapter (Tektronix Part No. 103-0033-00) may also be used.




(1)




(2)




(3)


(4)

Fig. 6-1. Recommended calibration equipment.

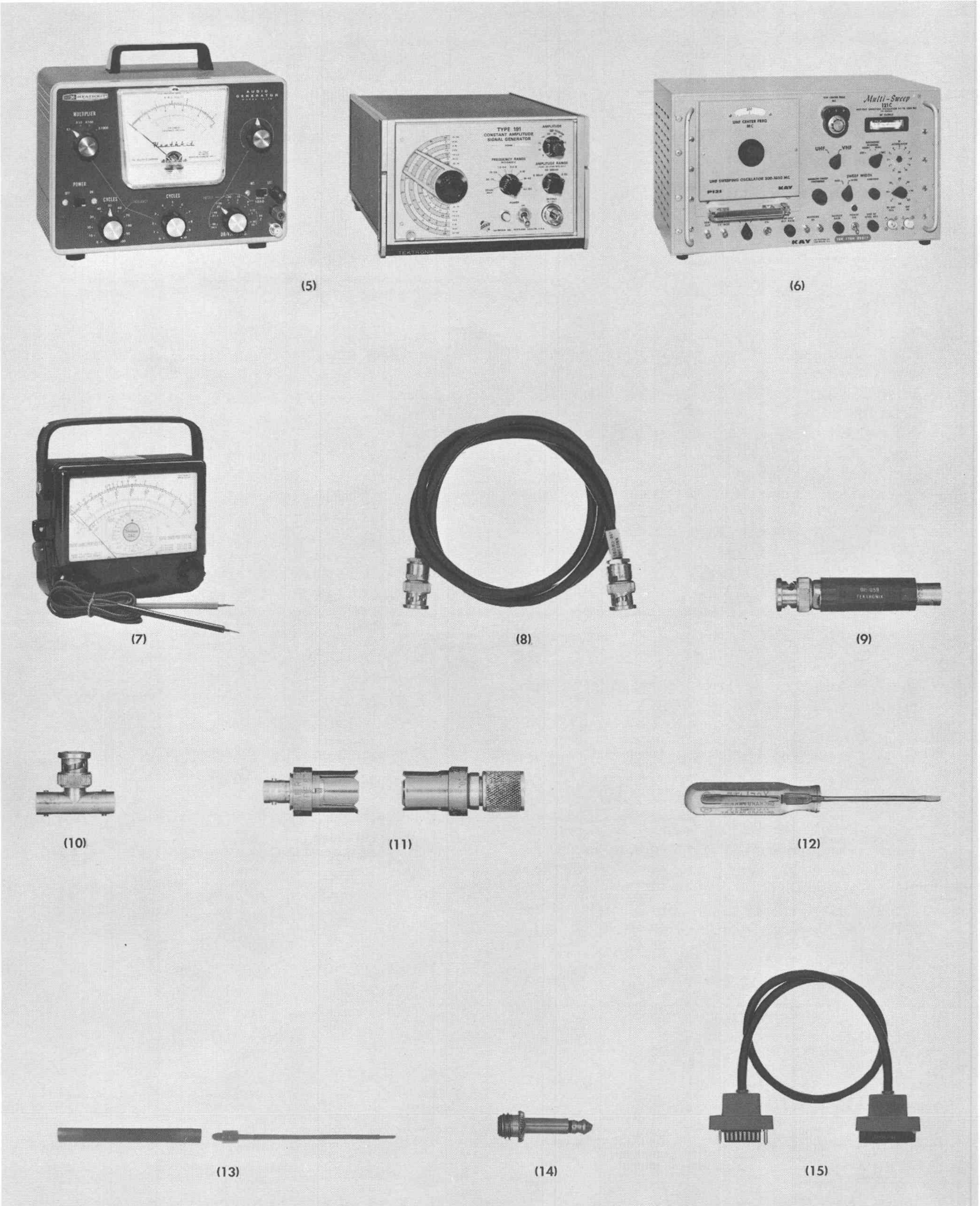



Fig. 6-2. Recommended Calibration equipment.

## CALIBRATION RECORD AND INDEX

This abriged Calibration Procedure has been provided as an index for locating a specific part of the complete procedure. A brief explanation below each step is included so an experienced calibrator can use the list as a condensed guide. Boxes are provided so each step can be checked off as it is completed. If desired, a check-off copy can be made prior to calibrating the unit. When completed, it can be used as a record of the calibration.

**Type 1L60, Serial No.** ______________________

**Calibratiion Date** ______________________

**Calibrator** ______________________

☐ 1. Preliminary Setup ..................... Page 6-5

☐ 2. Adjust Dispersion ..................... Page 6-5
Adjust C358 and R290 for 1 marker/centimeter (10 MHz/CM dispersion).
Adjust R368 for 1 marker/2 centimeters (500 kHz/CM dispersion).
Adjust C384, C385 for a centered 500 kHz/CM display.
Check kHz/CM dispersion for ±3% accuracy.
Check MHz/CM dispersion accuracy over full range of the IF CENTER FREQ control for:
±3% at 10 MHz/CM
±3% at 5 MHz/CM
±5% at 2 MHz/CM
±7% at 1 MHz/CM
±10% at .5 MHz/CM
±15% at .2 MHz/CM

☐ 3. Check Dispersion Linearity ............. Page 6-6
Check the display in all kHz/CM and MHz/CM positions for ±3% linearity.

☐ 4. Adjust Resolution ..................... Page 6-7
Adjust C504, C508, R543, C610, C620, L624 for 100 kHz resolution.
Check for 1 kHz resolution.

☐ 5. Adjust Center Frequency of Sweep ...... Page 6-9
Adjust R253 (Center Freq Range adjust) so that the DISPERSION control setting does not affect the MHz/CM center frequency).
(Adjust C384 and C385 so that the DISPERSION control setting does not affect the kHz/CM center frequency.)

☐ 6. Check IF CENTER FREQ Control Range .. Page 6-10

| DISPERSION | COARSE (10 turn) | FINE |
|---|---|---|
| 1 kHz/CM to 500 kHz/CM | ≥ + & —2.5 MHz | ≥ + & —50 kHz |
| .2 MHz/CM to 5 MHz/CM | ≥ + & —25 MHz | ≥ + & —1 MHz |
| 10 MHz/CM | ≥ + & —10 MHz | |

☐ 7. Adjust 1 MHz Calibrator Marker Generator ........ .................................... Page 6-10
Adjust L803 for maximum 1 MHz CAL MARKER OUT signal.

☐ 8. Adjust IF Amplifier Response .......... Page 6-11
Adjust L114, C425, C435, T454 for maximum 200 MHz signal amplitude; T464, L444 for stable display.

☐ 9. Adjust Wide-Band Amplifier Response ... Page 6-12
Adjust L134 and C137 for flat response to 150-250 MHz swept frequency signal.

☐ 10. Adjust Wide-Band Amplifier Filter ...... Page 6-13
Adjust L147 for minimum deflection of a 65 MHz signal.
Adjust L144 for maximum deflection of a 200 MHz signal.

☐ 11. Check Display Flatness ................ Page 6-14
Check display for ±1.4 dB flatness from 150 MHz to 250 MHz.

☐ 12. Check Sensitivity ...................... Page 6-14
Check Sensitivity with RESOLUTION control fully-clockwise for —110 dBm.
At the same time, check for a signal display at the extreme ends of each band.

☐ 13. Adjust and Check Dynamic Ranges ...... Page 6-15
Check LIN display ≥ 26 dB dynamic range.
Adjust R666 (Log Cal) so that the LOG display has a 40 dB dynamic range.
Check SQ LAW display for ≥ 13 dB dynamic range.

☐ 14. Check IF Attenuator Accuracy .......... Page 6-15
Check each IF ATTEN switch for ±0.1 dB/dB accuracy.

☐ 15. Check TO RECORDER Output Amplitude .......... ..................................... Page 6-16
Check for 12 to 40 mV/centimeter (DISPLAY switch set to LIN).

☐ 16. Check Operation of VIDEO FILTER switch ........ ..................................... Page 6-17

☐ 17. Check Frequency Response of VIDEO INPUT Circuit ..................................... Page 6-18
Check for ≤16 Hz to ≥10 MHz frequency response.

☐ 18. Check Incidental Frequency Modulation .. Page 6-19
Check for not more than 1 minor division of frequency modulation with an input 200 MHz signal.

☐ 19. Check +10 V DC OUT Voltage ........ Page 6-20
Check for 10 volts ±0.5 volts.

## PROCEDURE

In the following procedure, control settings are called out at the start of each major step. If a control is not called out, it can be assumed that it does not need to be preset at that time.

NOTE

**The setup pictures in this section may not show an instrument which is identical to the instrument being calibrated, however, the various connections will be made in the same manner.**

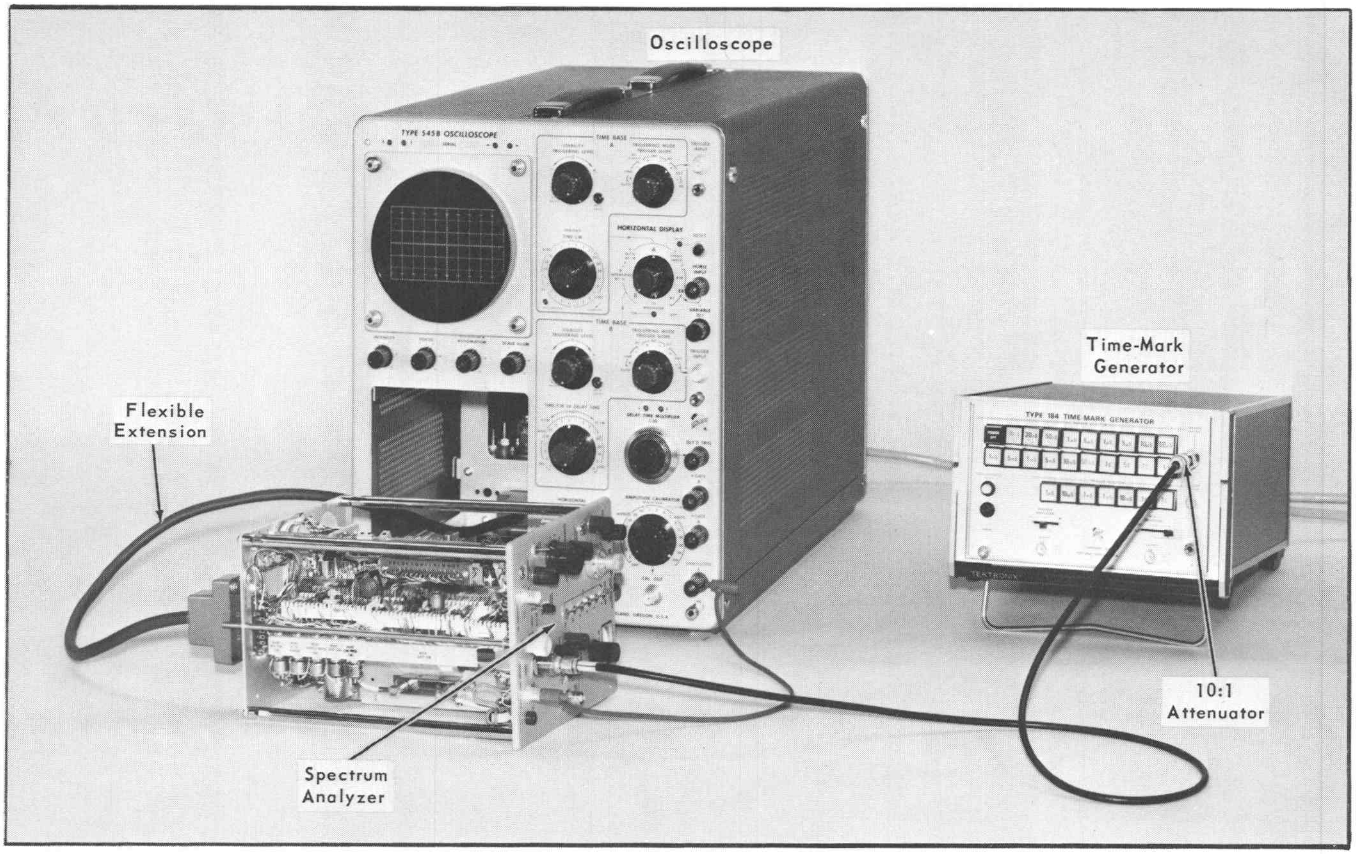



Fig. 6-3. Setup for adjusting and checking Dispersion (Steps 2 and 3).

## 1. Preliminary Set-up of Equipment

a. Before inserting the Spectrum Analyzer into the oscilloscope, check Table 2-1 or the oscilloscope instruction manual to determine the amplitude of the sawtooth output voltage and set SW201 (slide switch mounted on the rear plate of the Analyzer) to the appropriate position.

b. Insert the Spectrum Analyzer into the oscilloscope, fasten the securing latch, and turn on the power. Allow 10 to 20 minutes for warm up before making any adjustments.

c. Connect the oscilloscope Sawtooth Out (or Sawtooth A) signal to the Analyzer SWEEP INPUT connector.

CAUTION

**Be careful when making this connection, since the sawtooth voltage can give a painful shock. Also be sure to plug the cable into the SWEEP INPUT, not the nearby RF IPNUT connector.**

d. Set the oscilloscope Mode (or Horizontal Display) switch to A or Normal.

e. Set the sweep controls for a free-running 10 ms/cm sweep.

## 2. Adjust Dispersion

a. Connect the equipment as shown in Fig. 6-3.

If a Type 180A Time-Mark Generator must be used in place of the Type 184 shown, connect it to the Spectrum Analyzer as follows:

1. Connect the MARKER OUT connector of the Type 180A to the RF connector of the Harmonic Modulator Unit and depress the 50 MHz pushbotton on the Type 180A.

2. Connect a cable between the desired modulation signal and the Harmonic Modulator Modu 2 connector.

3. Connect the Harmonic Modulator Modu Harm Out connector to the Analyzer RF INPUT connector.

4. Set the Modulator's controls as follows: Modu Freq 2 to On, 60 MHz Trap to Out, and the two Variable controls to the settings giving the most readable display.

b. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| FINE IF CENTER FREQ | Midrange (000) |
| IF CENTER FREQ | Midrange |
| DISPERSION RANGE | MHz/CM |
| DISPERSION—COUPLED RESOLUTION | 10 (outer ring) |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LOG |

c. Depress the Marker Selector switches for 10 $\mu$s (100 MHz) and .1 $\mu$s (10 MHz).

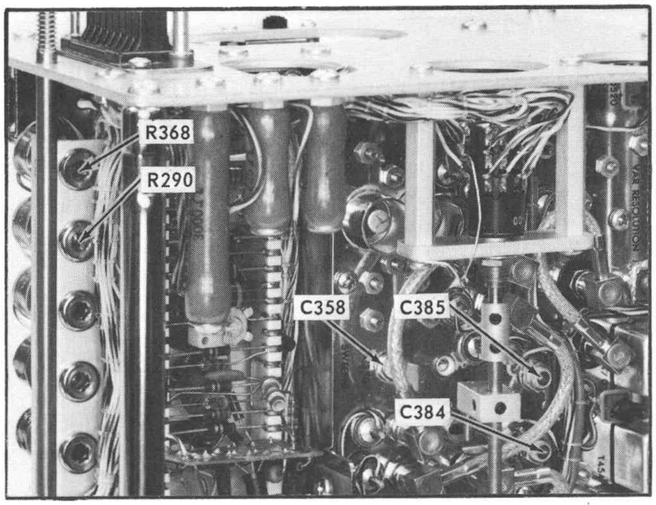



**Fig. 6-4. Location of Dispersion adjustments (Step 2).**

d. Adjust the Spectrum Analyzer GAIN control for a display about 5 centimeters in amplitude.

e. Adjust C358 (see Fig. 6-4) and the front panel DISP CAL adjustment for 1 marker/centimeter over the middle eight centimeters of the display. If the dispersion is nonlinear, readjust R290 (IF CF Range) while adjusting C358 to obtain the best dispersion and linearity. Monitor Pin P with the test oscilloscope to keep the voltage at this pin between —0.8 and —1.1 volts. Also check for an IF CENTER FREQ range of ≤20 MHz.

f. Change the DISPERSION to 500 kHz/CM, apply a 1 MHz signal from the Time-Mark Generator and remove the probe.

g.· Adjust R368 (kHz/CM Cal- see Fig. 6-4) for 1 marker/2 centimeters.

h. If the display is not centered, adjust C384 and C385 (see Fig. 6-4) so that it is centered. If necessary, readjust R368 for the correct dispersion again.

i. Check the kHz/CM DISPERSION linearity at the ends of the IF CENTER FREQ range. With a marker at the first graticule line, the fifth markers should be within 3 millimeters of the ninth graticule line.

j. If the 500 kHz/CM is not within these specifications, turn C384 and C385 very slightly in opposite directions so as to keep the display centered, readjust R368 for 1 marker/2 centimeters and recheck the dispersion at the ends of the IF CENTER FREQ control range. Repeat this procedure until the dispersion is within specifications at both ends of the IF CENTER FREQ range.

k. Center the IF CENTER FREQ control and check the dispersion accuracy at each DISPERSION/CM setting, using Table 6-1. Position a modulation mark at the first graticule line and check the displacement of the ninth marker from the ninth graticule line for displays having 1 division/marker. If the display should have 2 divisions/marker, then check the displacement of the fifth marker from the ninth line (See Fig. 6-5).

## 3. Check Dispersion Linearity

a. Set up the equipment as directed in steps 2a through 2d.

b. At each DISPERSION/CM setting of Table 6-1, readjust the front-panel DISP CAL adjustment to align markers with the first and ninth graticule lines. The IF CENTER FREQ controls may be rotated slightly away from center to position a marker at the first graticule line.

c. All markers between the first and ninth graticule lines should be within 2.4 millimeters of the appropriate graticule lines.

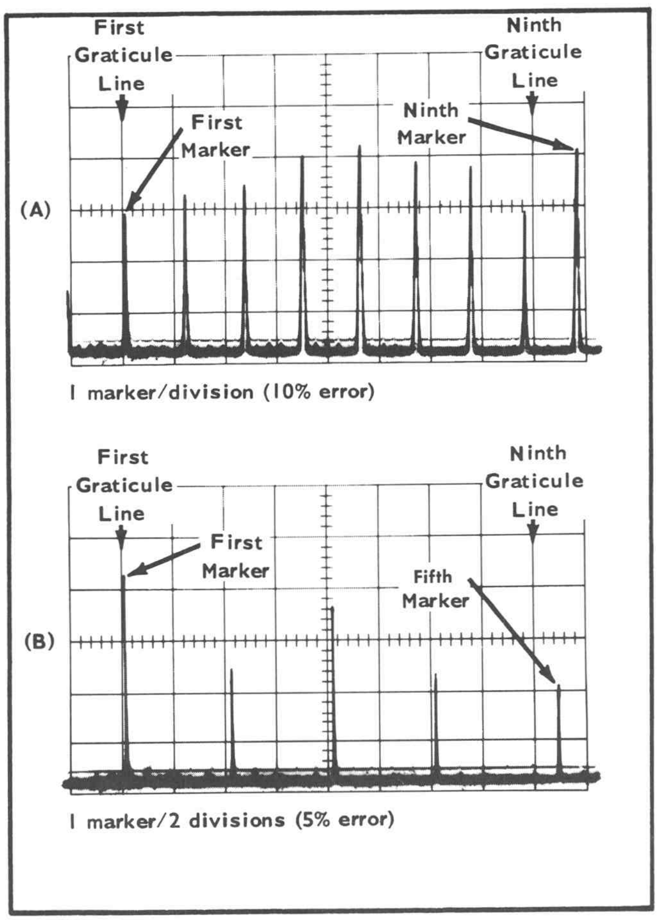



**Fig. 6-5. Typical displays for Dispersion adjustments (Step 2).**

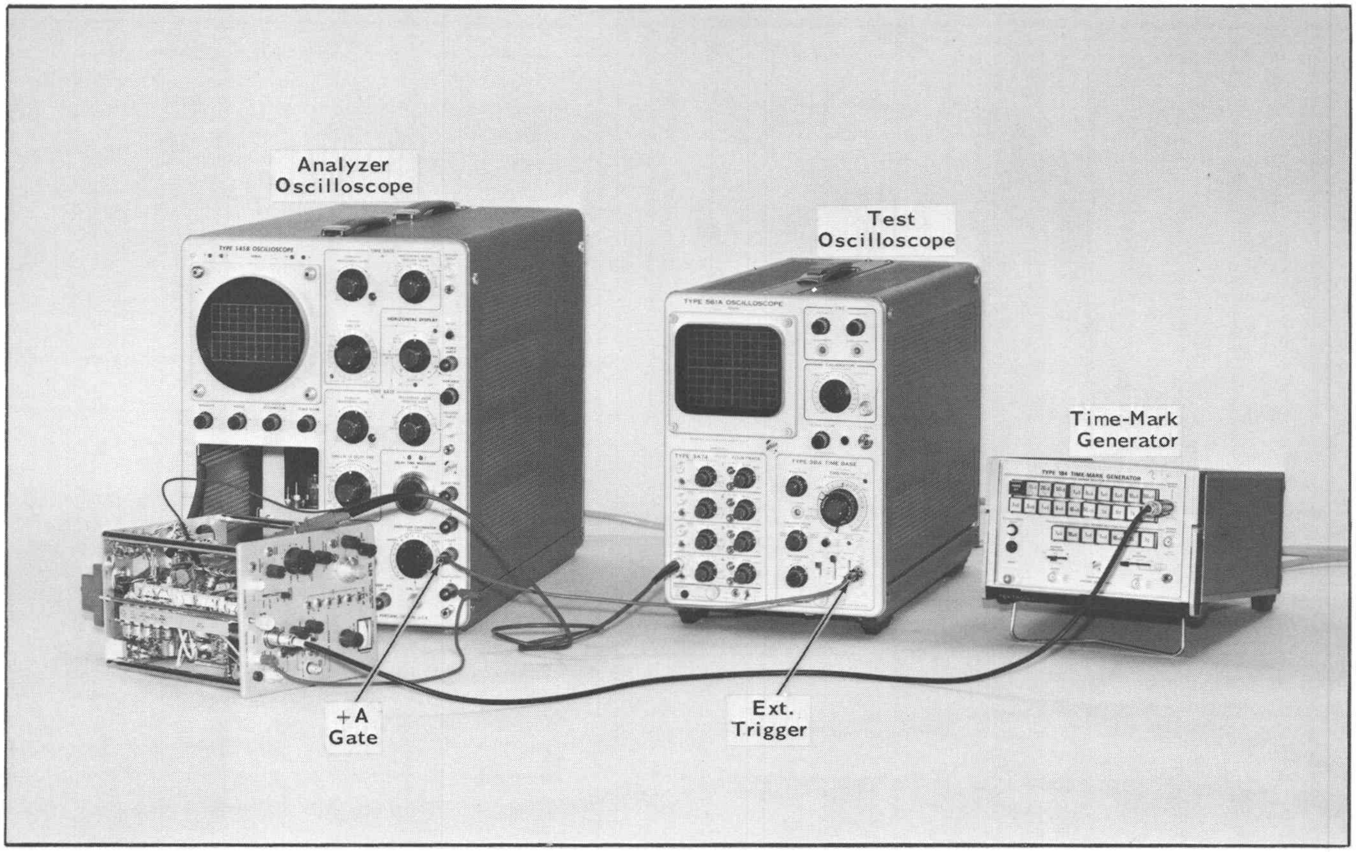



Fig. 6-6. Setup for adjusting Resolution (Step 4).

## 4. Adjust Resolution

a. Connect the equipment as shown in Fig. 6-6. (The test oscilloscope probe is on Pin B of the IF Chassis square-pin connector board.)

b. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF ATTEN | All OFF |
| DISPERSION RANGE | kHz/CM |
| DISPERSION | 50 |
| RESOLUTION | Fully Clockwise |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |

c. Set the Analyzer oscilloscope sweep to 20 ms/cm; set the test oscilloscope sweep rate to 50 ms/cm; and set the Time-Mark Generator for a 200 MHz signal.

d. See Fig. 6-7 for the location of the adjustments described below.

e. Adjust C504 and C508 for a display on the test oscilloscope similar to Fig. 6-8. Set C504 for minimum display width at 1 centimeter above the baseline and set C508 for the most symmetrical display. Touch up the settings of C504 and C508 for the best symmetry. When the capacitors are properly set, the display on the test oscilloscope will be symmetrical at each position of the RESOLUTION control.

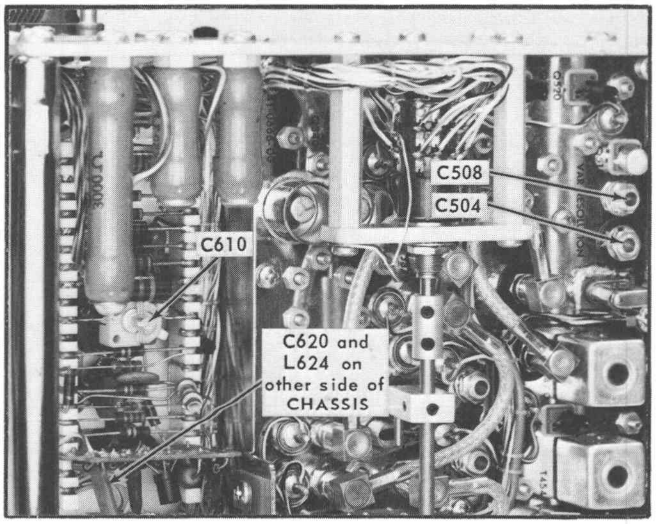



Fig. 6-7. Location of Resolution adjustments (Step 4).

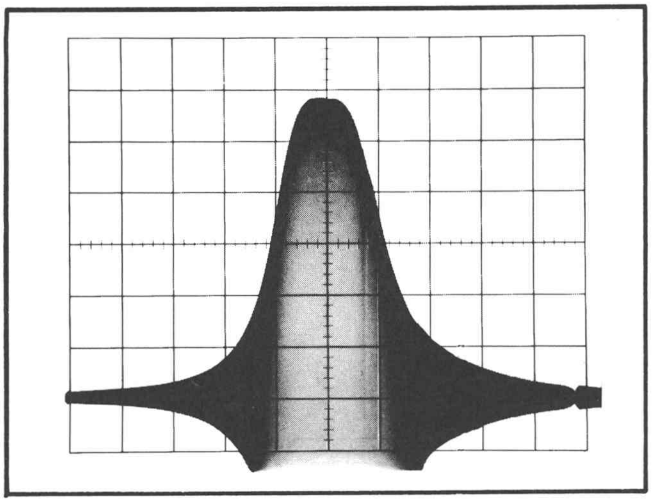


Fig. 6-8. Typical test oscilloscope display for adjusting C504 and C508 (Step 4e).

f. Remove the probe and adjust C610 for equal curves at the base of the spectrum display (see Fig. 6-9).

g. Adjust C620 and L624 for a symmetrical waveform. Recheck the adjustment of C610.

h. Turn the RESOLUTION knob to the next counterclockwise position.

i. Adjust R543 (100 kHz Res Cal) for a signal 1.2 centimeters wide at 3 centimeters above the baseline. See Fig. 6-10. (Adjust the GAIN control for a signal amplitude of 6 centimeters during this step.)

j. There is considerable interaction between the above steps, so return the RESOLUTION control to the clockwise position and repeat Steps e through i until the display for each step are satisfactory.

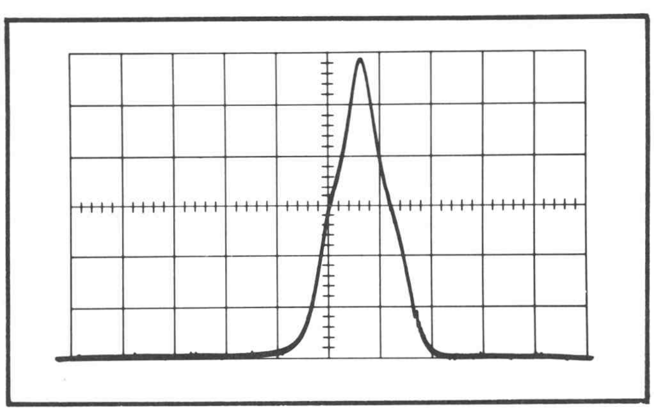


Fig. 6-9. Typical spectrum display for adjusting C610 (Step 4f).

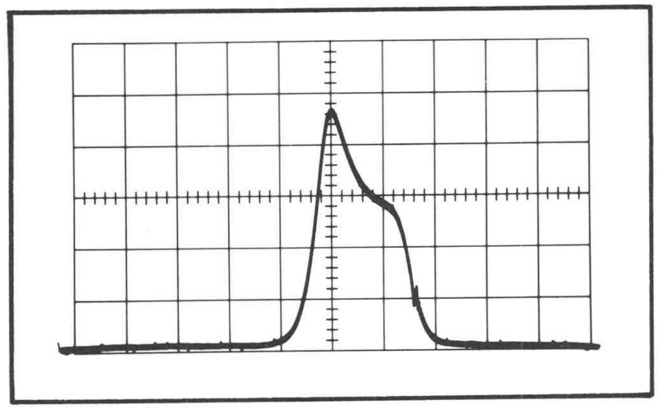


Fig. 6-10. Typical spectrum display for adjusting R543 (Step 4i).

k. When properly calibrated, the resolution waveform should be 100 kHz wide at 3 centimeters above the baseline when the RESOLUTION control is turned fully clockwise, and should become narrower at each step as the control is turned counterclockwise. At the fully counterclockwise position, the resolution should not be more than 1 kHz wide at 3 centimeters above the baseline. (See Fig. 6-11.)

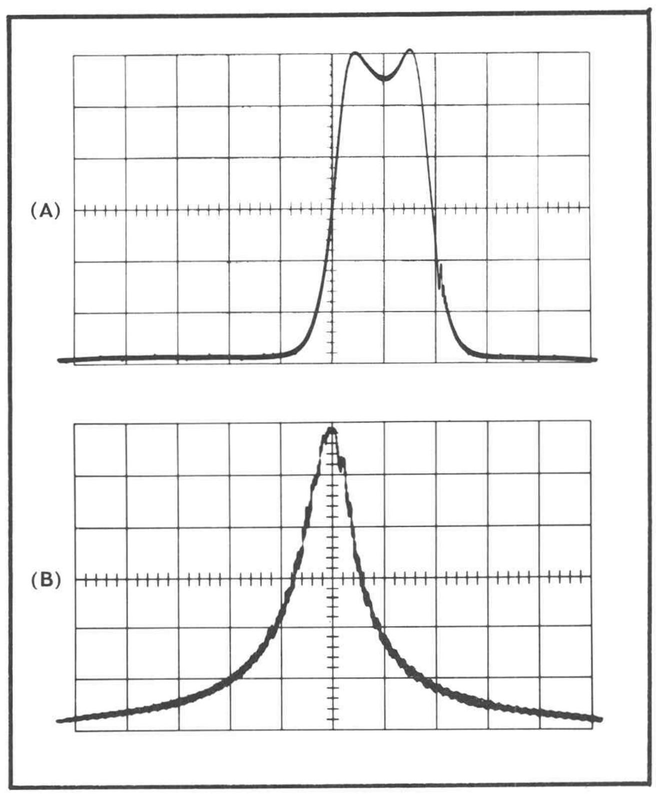



Fig. 6-11. Typical spectrum display for Step 4k. (A) 100 kHz/CM Resolution, (B) 1 kHz/CM Resolution.

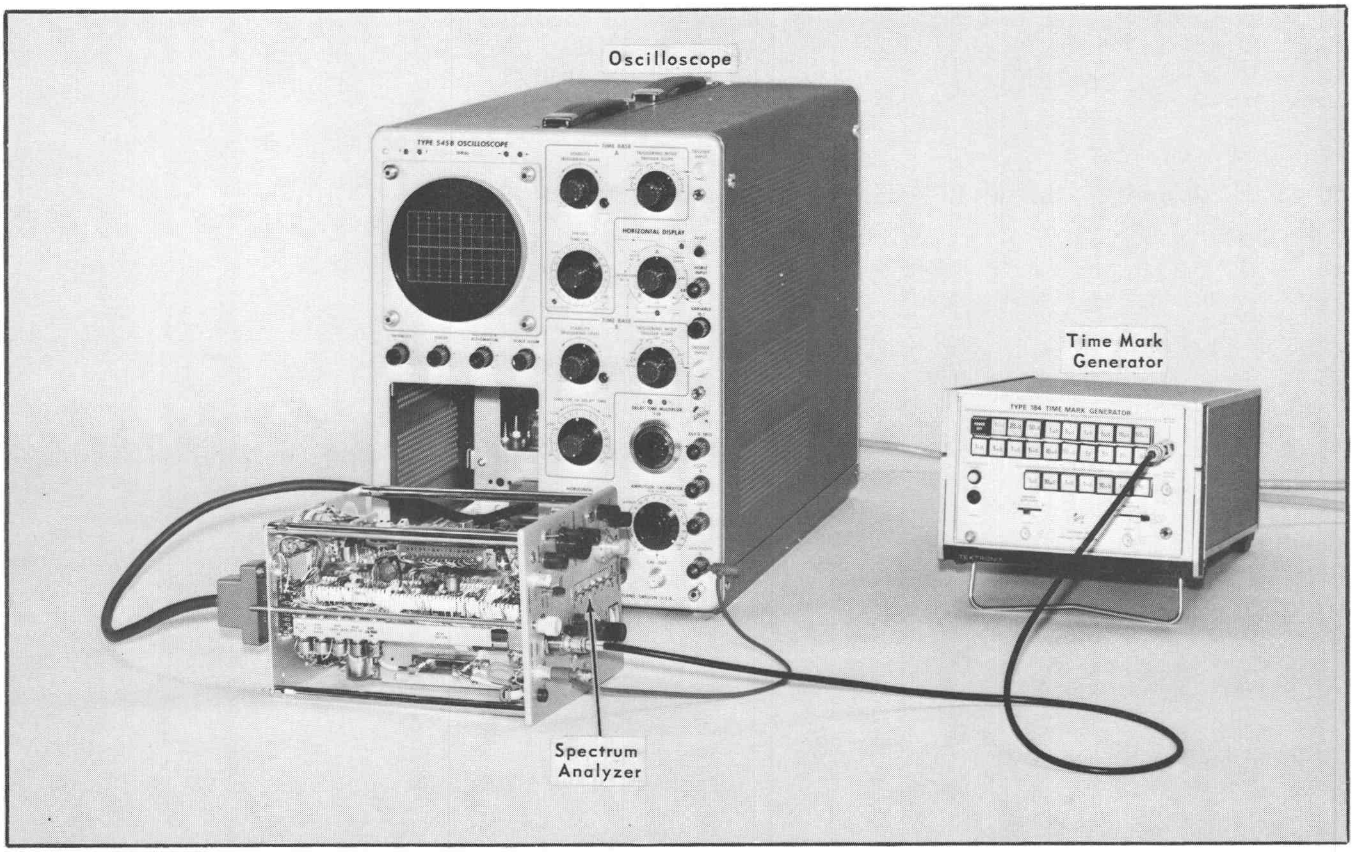



Fig. 6-12. Setup for Steps 5 and 6.

## 5. Adjust Center Frequency of Swept-Frequency Oscillator

a. Connect the equipment as shown in Fig. 6-12.

b. Preset the front-panel controls as follows:

| | |
|---|---|
| Horizontal Position (Oscilloscope) | Center the trace horizontally on the graticule. |
| POS | Position the trace to the bottom line of the graticule. |
| IF CENTER FREQ | Midrange (000) |
| FINE IF CENTER FREQ | Midrange |
| DISPERSION RANGE | MHz/CM |
| VERTICAL DISPLAY | LIN |
| IF CENTER FREQ CAL (Screwdriver Adjust) | Centered |

c. Apply a 200 MHz signal from the generator.

d. Adjust the Center Freq Range control R253 (see Fig. 6-13) so that the signal does not shift in position as the DISPERSION—COUPLED RESOLUTION control is rotated.

e. Set the DISPERSION—COUPLED RESOLUTION control to 10 (outer ring) and adjust R204 to center the display.

f. Change the DISPERSION RANGE to kHz/CM.

g. Adjust R368 (kHz/CM Cal) so that the signal does not shift in position when the DISPERSION—COUPLED RESOLUTION control is rotated between 500 kHz/CM and 20 kHz/

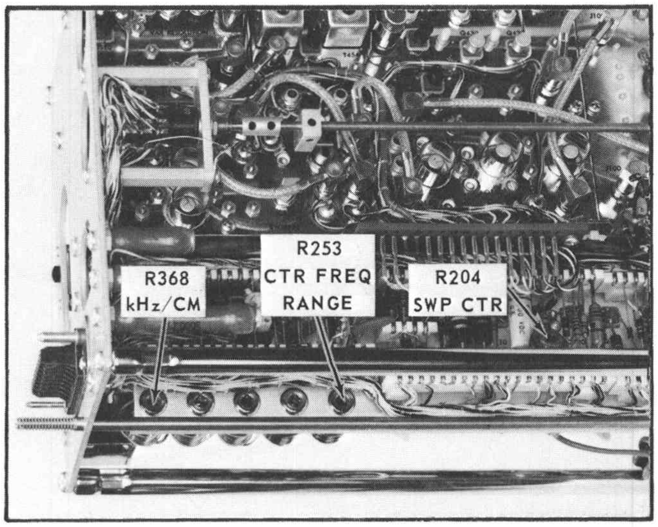



Fig. 6-13. Location of Center Frequency adjustments.

CM. (Significant changes in the setting of R368 will affect the accuracy of the kHz/CM Dispersion. If R368 is changed, be sure to recheck the adjustment of C384 and C385. (See Steps 2h through 2j.)

## 6. Check Range of the IF CENTER FREQ Controls

a. Preset the controls on the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF CENTER FREQ | Midrange (000) |
| FINE IF CENTER FREQ | Midrange |
| DISPERSION RANGE | MHz/CM |
| DISPERSION—COUPLED RESOLUTION | 10 |
| VERTICAL DISPLAY | LOG |

b. Connect the equipment as shown in Fig. 6-12. Set the generator for 100 MHz and 10 MHz markers.

c. Adjust the GAIN control so that the 10 MHz Markers are visible.

d. The 100 MHz signal should be centered on the graticule; if it is off-center, readjust R253 and R204 as directed in Step 5.

e. Rotate the 10-turn IF CENTER FREQ control to both ends of its range. If the markers do not move at least 1 centimeter (10 MHz) from center in each direction, then recheck settings of R290 (IF CF Range) and DISP CAL adjust—see Step 2e.

f. Change the DISPERSION to 5 MHz/CM.

g. Rotate the 10-turn IF CENTER FREQ control through its range. The markers must move at least 25 MHz from center in each direction.

h. Center the 10-turn control and rotate the FINE IF CENTER FREQ control to the ends of its rotation. The markers must move at least 1 MHz in each direction.

i. Change the DISPERSION to 500 kHz/CM.

j. Rotate the 10-turn IF CENTER FREQ control to the ends of its rotation. The markers move at least 2.5 MHz from center in each direction.

k. Center the 10-turn control and rotate the FINE IF CENTER FREQ control to both ends of its rotation. The markers must move at least 50 kHz in each direction.

## 7. Adjust 1 MHz Calibrator Marker Generator

a. Preset the controls of the Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF ATTEN | All OFF |
| IF CENTER FREQ | Midrange (000) |
| FINE IF CENTER FREQ | Midrange |
| DISPERSION RANGE | MHz/CM |
| DISPERSION—COUPLED RESOLUTION | 1 |
| VERTICAL DISPLAY | LIN |

b. Connect the equipment as shown in Fig. 6-12 except for the Time-Mark Generator which will not be used for this step.

c. Push the 1 MHz CAL MARKERS button.

d. Adjust L803 (located on 1 MHz Calibrator Marker Generator circuit board) for maximum signal amplitude. Turn L803 slowly; the correct setting is easily missed.

e. Release and then push the 1 MHz CAL MARKER button several times. The signal should reappear each time with no delay. Readjust L803 if necessary.

## NOTES

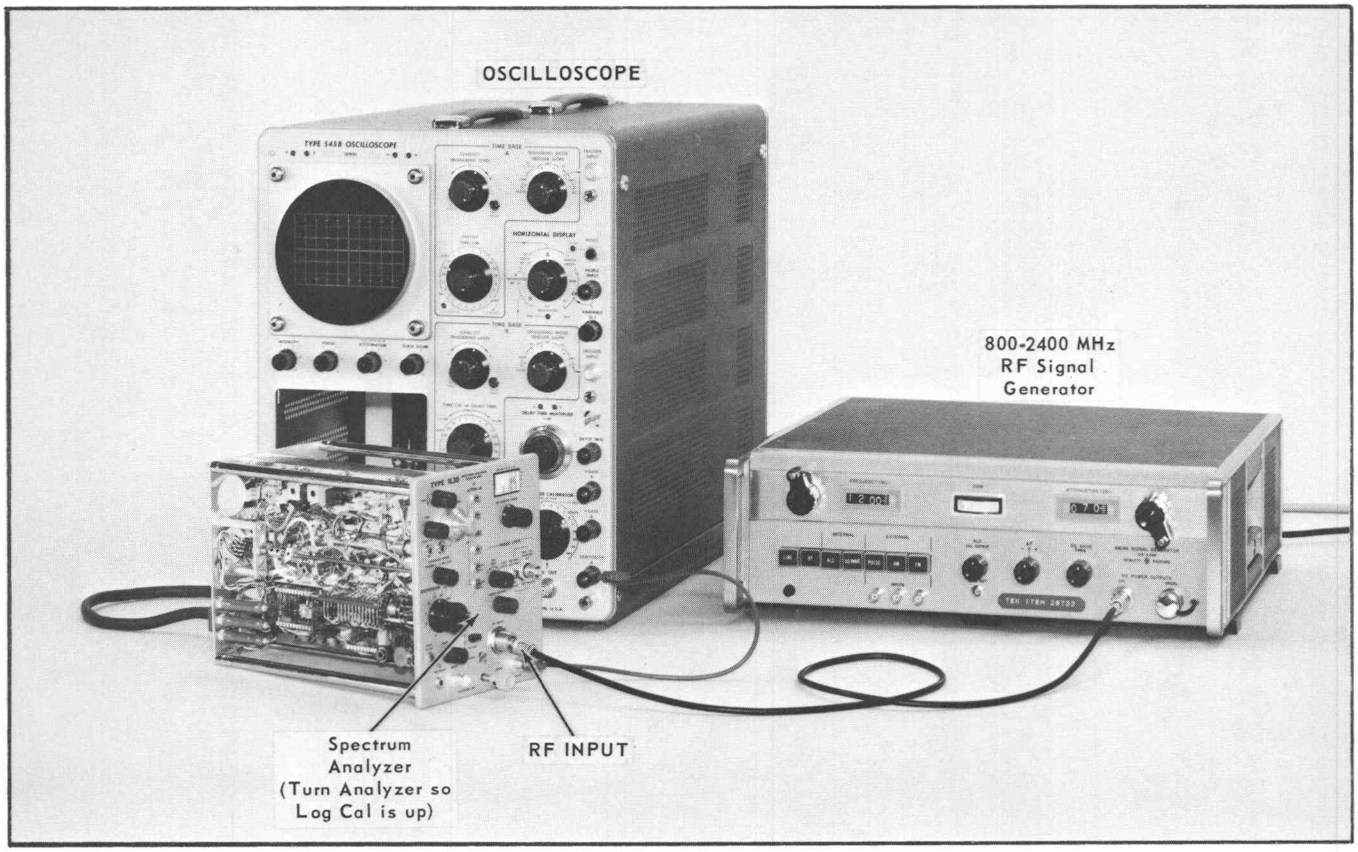



Fig. 6-14. Setup for adjusting Narrow-Band IF Amplifier (Step 8).

## 8. Adjust Narrow-Band IF Amplifier Peaking

a. Connect the equipment as shown in Fig. 6-14. Terminating the 50 ohm coaxial cable at the RF INPUT connector with a 50 ohm 10:1 (20 dB) termination.

b. Preset the front-panel controls of the Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF ATTEN | 20 dB On |
| DISPERSION RANGE | kHz/CM |
| DISPERSION—COUPLED RESOLUTION | 5 (outer ring) |
| GAIN | Fully clockwise |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |

c. Set the generator for a 200 MHz signal about 4 centimeters high.

d. Peak up C425, C435 and T454 and T464 (see Fig. 6-15) for maximum signal amplitude.

e. Turn the core of L444 (see Fig. 6-15) counterclockwise until the oscillator stops oscillating. Then, turn the core of L444 clockwise and set it about 1/4 of a turn past the point at which the oscillator starts.

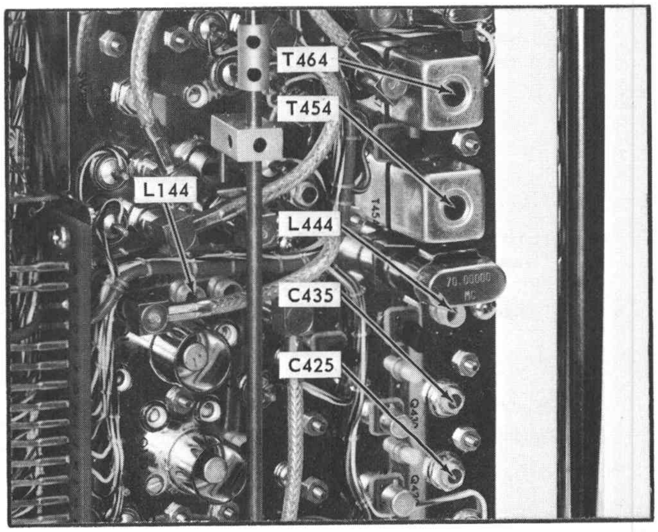



Fig. 6-15. Location of Narrow-Band IF Amplifier adjustments (Step 8).

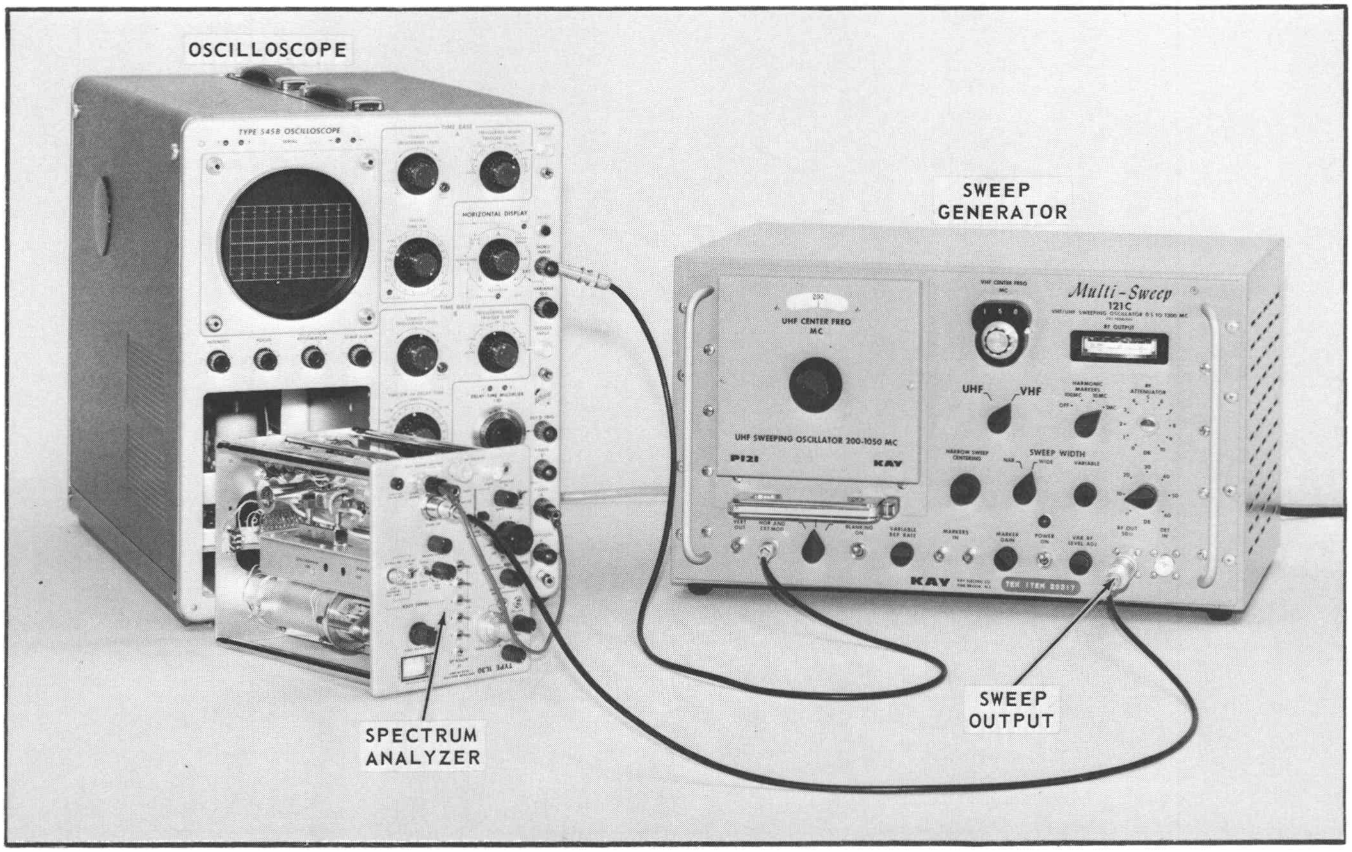



Fig. 6-16. Setup for adjusting Wide-Band Amplifier (Steps 9 and 10).

## 9. Adjust Wide-Band Amplifier Flatness

a. Connect the equipment as shown in Fig. 6-16.

b. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF ATTEN | 20 dB On |
| DISPERSION RANGE | MHz/CM |
| DISPERSION—COUPLED RESOLUTION | 10 (outer ring) |
| GAIN | Fully clockwise |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |

c. Set the Sweep Generator so that it sweeps from 130 MHz to 280 MHz.

d. Set the signal amplitude for about 4 centimeters of vertical deflection.

e. Adjust L134 and C137 (see Fig. 6-17) for the best flatness from 150 MHz to 250 MHz.

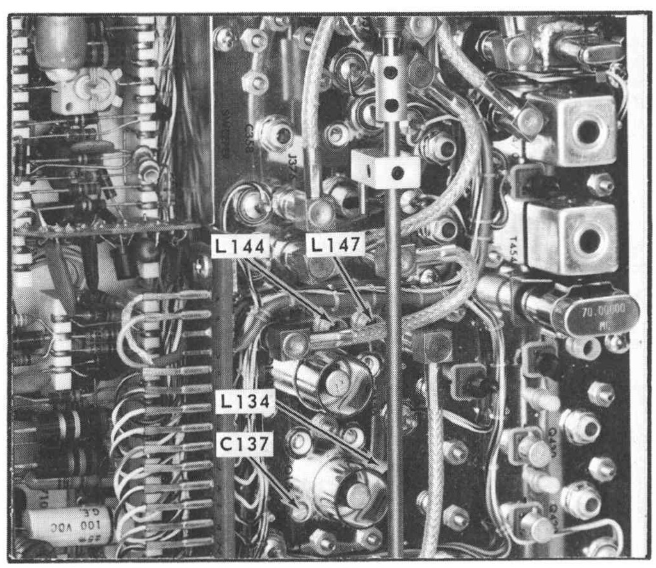



Fig. 6-17. Location of Wide-Band Amplifier adjustments (Step 9 and 10).

## 10. Adjust Wide-Band Amplifier Filters

a. After completing Step 9, disconnect the Sweep Generator and connect the RF Generator in its place.

b. Apply a —40 dBm 200 MHz signal, center the display with the IF CENTER FREQ control, and adjust L144 (see Fig. 6-17) for maximum signal amplitude.

c. Change the signal to 65 MHz and adjust L147 (see Fig. 6-17) for minimum response.

## NOTES

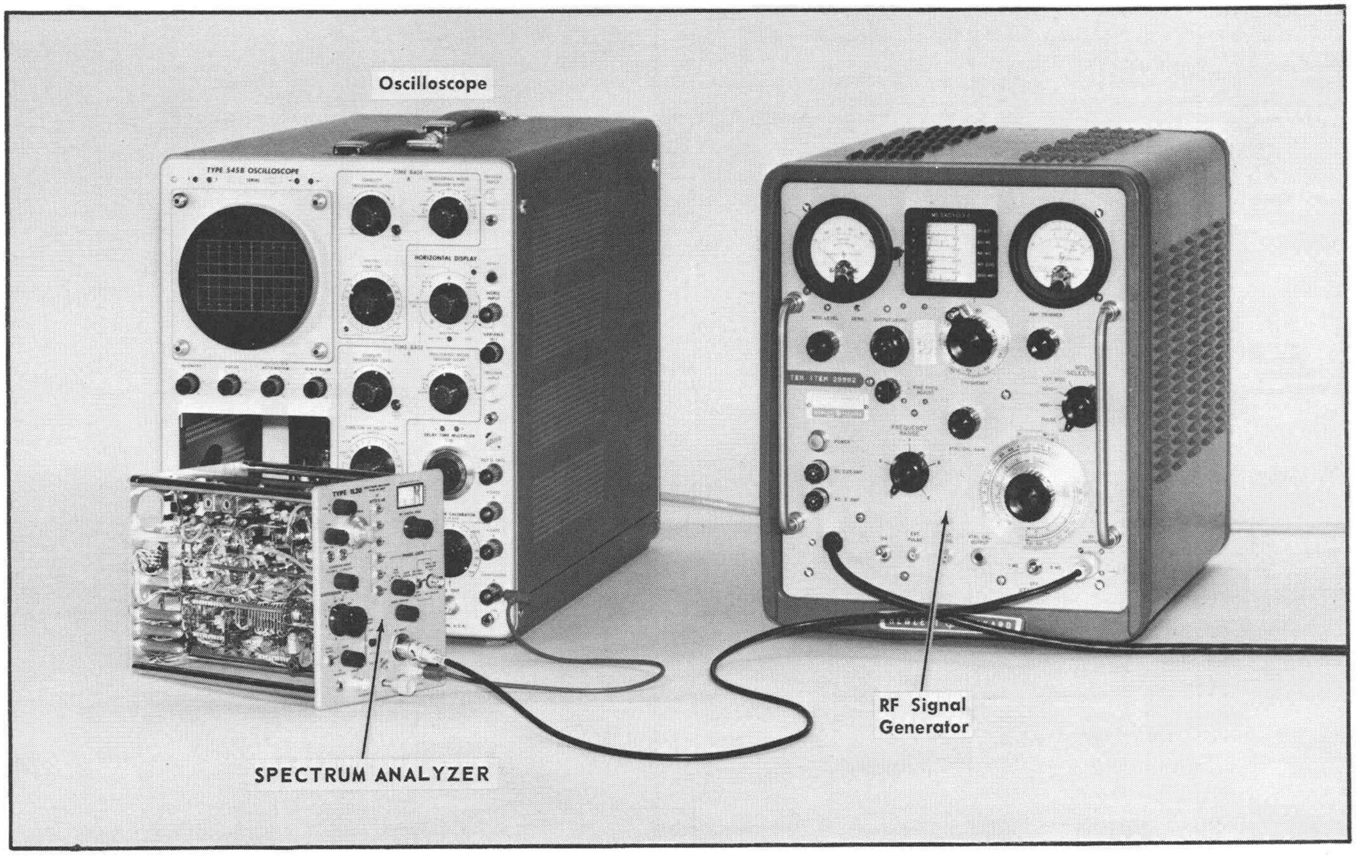



Fig. 6-18. Setup for checking Display Flatness Sensitivity, Dynamic Range, and IF Attenuator Accuracy (Steps 11 through 14).

## 11. Check Display Flatness

a. Set up the equipment as shown in Fig. 6-18. Terminating the 50 ohm coaxial cable at the RF INPUT connector with a 50 ohm 10:1 (20 dB) termination.

b. Preset the Spectrum Analyzer controls as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF CENTER FREQ | Midrange (000) |
| IF ATTEN | All OFF |
| DISPERSION RANGE | MHz/CM |
| DISPERSION—COUPLED RESOLUTION | 10 |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |

c. Set the generator for a —50 dBm 200 MHz signal.

d. Set the Analyzer GAIN control for a 5 centimeter signal display.

e. Turn the frequency control of the Type 608E Signal Generator from 150 MHz to 250 MHz and set it at the frequency giving the highest amplitude signal.

f. Set the Analyzer GAIN control for a 6 centimeter signal display.

g. Set the 1 dB and 2 dB IF ATTEN switches to On and note the display size. Return the switches to OFF.

h. Tune the frequency control of the signal generator from 120 MHz to 250 MHz and check that the signal display does not drop below the display size noted in step g.

NOTE

**Output amplitude of signal generator must remain constant as the frequency control is turned from 150 MHz to 250 MHz.**

## 12. Check Sensitivity

a. Connect the equipment as shown in Fig. 6-18.

b. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF ATTEN | All OFF |
| DISPERSION RANGE | kHz/CM |
| DISPERSION- | 00 |
| COUPLED RESOLUTION | Fully clockwise |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |

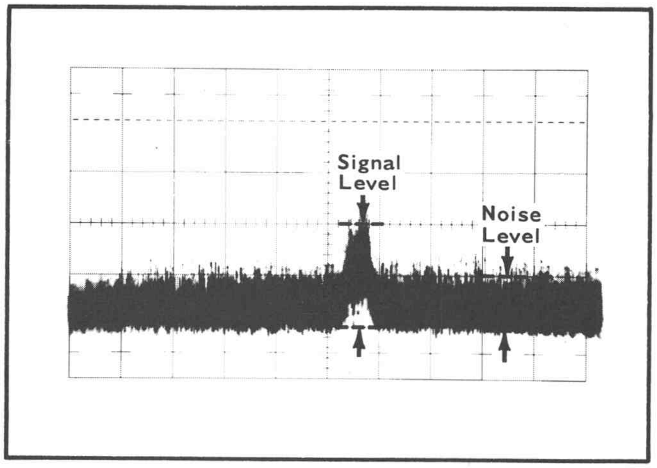



Fig. 6-19. Typical display for checking Sensitivity (Step 12).

c. Apply a —30 dBm 200 MHz signal from the Type 608E Signal Generator to the Analyzer RF INPUT connector.

d. Center the signal on the graticule with the Frequency control of the Signal Generator.

e. Adjust the Analyzer GAIN control until the average noise level is one centimeter in amplitude.

f. Adjust the RF Atten control of the generator so that the displayed signal is twice as high as the noise level (see Fig. 6-19).

g. Check the settings of the RF Atten dial of the generator. It should read —110 dBm or less.

h. When the 100 kHz RESOLUTION display meets the sensitivity requirements in part g above, the 1 kHz RESOLUTION display will also be within its sensitivity requirements.

## 13. Adjust and Check Dynamic Ranges

a. Connect the equipment as shown in Fig. 6-18.

b. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| IF ATTEN | All OFF |
| DISPERSION RANGE | MHz/CM |
| DISPERSION—COUPLED RESOLUTION | 1 (outer ring) |
| VIDEO FILTER | Off (down) |
| GAIN | Fully Counterclockwise |
| VERTICAL DISPLAY | LIN |

c. Set the generator for a 200 MHz signal.

d. Set the generator RF Attenuator control for 6 centimeters of signal amplitude.

e. Decrease the generator output by 50 dB and turn the Analyzer GAIN control fully clockwise. Check for at least 6 centimeters of signal amplitude. Reduce the generator output by 26 dB. The signal should still be visible.

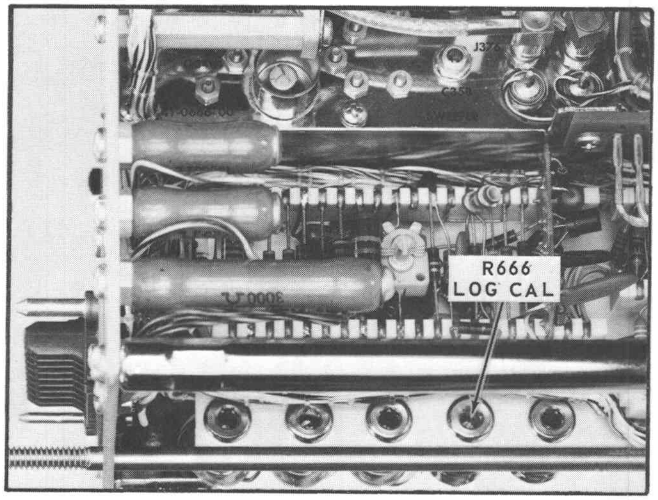



Fig. 6-20. Location of Log Cal adjustment R666 (Step 13h).

f. Change the VERTICAL DISPLAY to LOG.

g. Set the generator RF Attenuator control to —100 dBm and adjust the Analyzer GAIN control 'for 2 mm of signal.

h. Set the generator RF Attenuator control to —60 dBm and set Log Cal adjust R666 (see Fig 6-20 for a 6 centimeter signal.)

i. Return the generator RF Attenuator control to —100 dBm. The signal should still be visible.

j. Change the Vertical DISPLAY to SQ LAW.

k. Set the generator RF Attenuator control to —50 dBm.

l. Set the Analyzer GAIN control for 6 centimeters display.

m. Set the generator RF Attenuator control to —63 dBm. The signal should still be visible.

## 14. Check IF Attenuator Accuracy

a. Set up the equipment as shown in Fig. 6-18.

b. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| DISPERSION RANGE | MHz/CM |
| DISPERSION—COUPLED RESOLUTION | 1 (outer ring) |
| VIDEO FILTER | Off (down) |
| VERTICAL DISPLAY | LIN |
| IF ATTEN | All OFF |

c. Set the generator for a —70 dBm 200 MHz signal.

d. Set the Spectrum Analyzer GAIN control so that the 200 MHz signal is exactly 6 centimeters in amplitude.

e. Switch the 1 dB IF ATTEN switch On (up) and adjust the Attenuator control of the generator so that the 200 MHz display is exactly 6 centimeters high. The generator Attenuator control should read —69 dBm ±0.1 dBm.

f. Switch the 1 dB IF ATTEN switch to OFF.

g. Check the rest of the IF ATTEN steps as directed in Table 6-2.

**TABLE 6-2**

| Spectrum Analyzer IF ATTEN switch ON | RF Generator Attenuator Control Setting |
|---|---|
| 2 dB | —68 dBm ± .2 dBm |
| 4 dB | —66 dBm ± .4 dBm |
| 8 dB | —62 dBm ± .8 dBm |
| 16 dB | —54 dBm ±1.5 dBm |
| 20 dB | —50 dBm ±2.0 dBm |

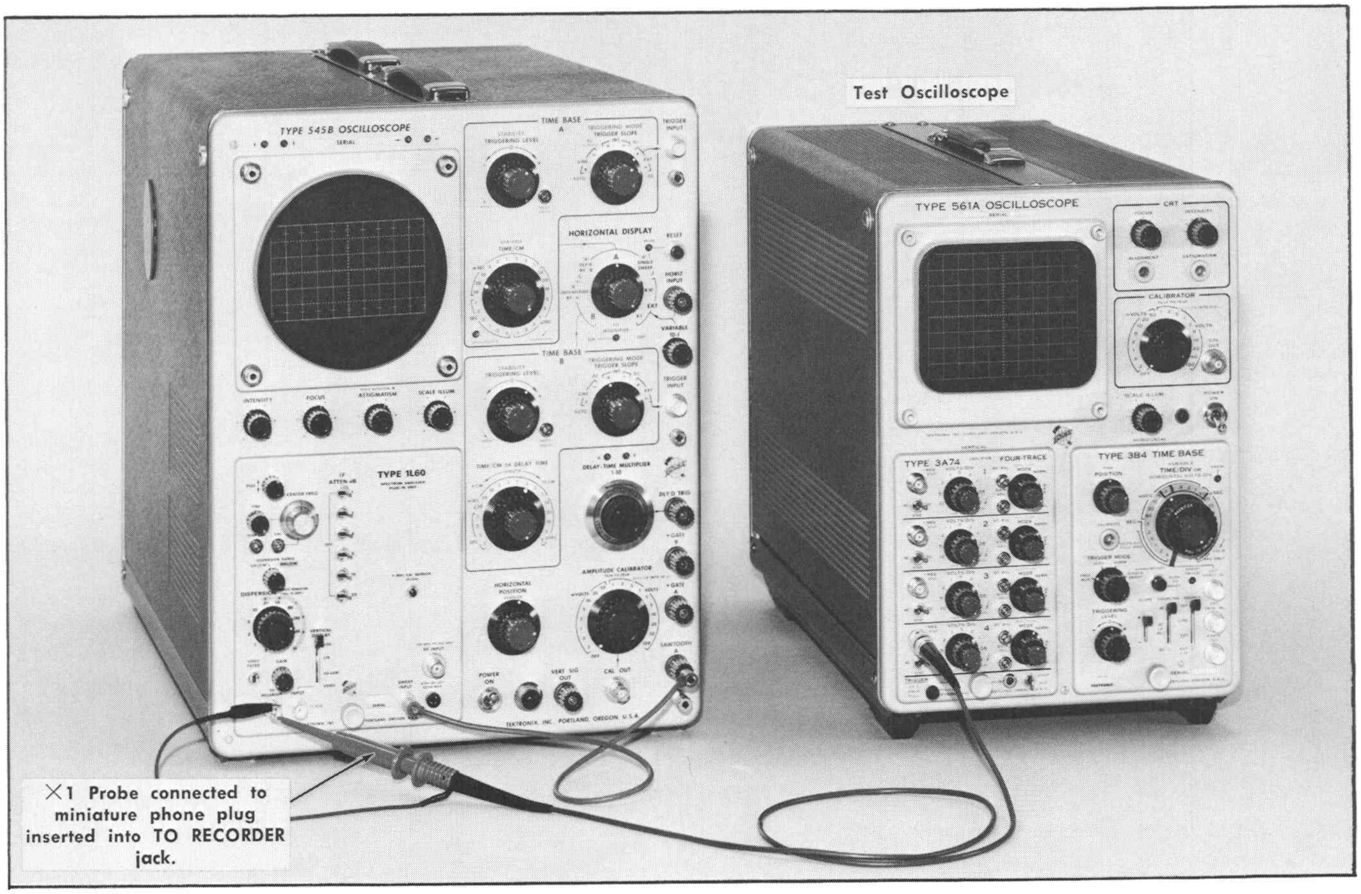



**Fig. 6-21. Setup for checking TO RECORDER Output Amplitude (Step 17).**

## 15. Check TO RECORDER Output Amplitude

a. Connect the equipment as shown in Fig. 6-21.

b. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the bottom line of the graticule. |
| DISPERSION RANGE | MHz/CM |
| DISPERSION—COUPLED RESOLUTION | 1 (outer ring) |
| VERTICAL DISPLAY | LIN |
| VIDEO FILTER | Off |
| 1 MHz CAL MARKER | Button pushed |

c. Adjust the GAIN control for a 6 centimeter display.

d. Measure the TO RECORDER signal with the test oscilloscope. Check for 24 millivolts to 40 millivolts.

## 16. Check Operation of VIDEO FILTER Switch

a. Push the 1 MHz CAL MARKER button.

b. Set the controls of the Analyzer as directed in Steps 15b and 15c above.

c. Switch the VIDEO FILTER to On (up) and check for an attenuated display resembling a sawtooth (see Fig. 6-22).

d. Change the sweep rate to 1 sec/cm. The display should not change appreciably when the VIDEO FILTER is switched in and out.

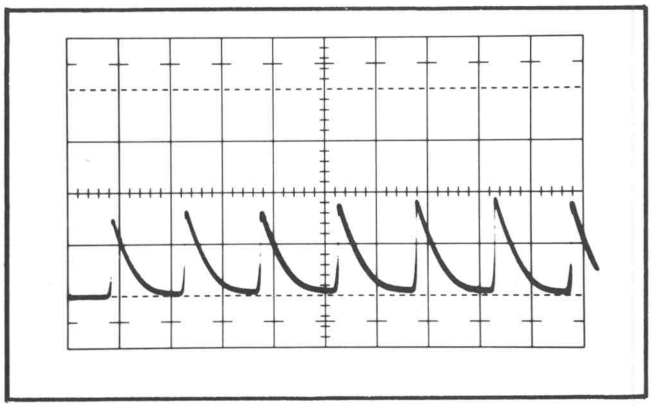


**Fig. 6-22. 1 MHz marker display with VIDEO FILTER switched to ON; 20 ms/cm sweep rate.**

## NOTES

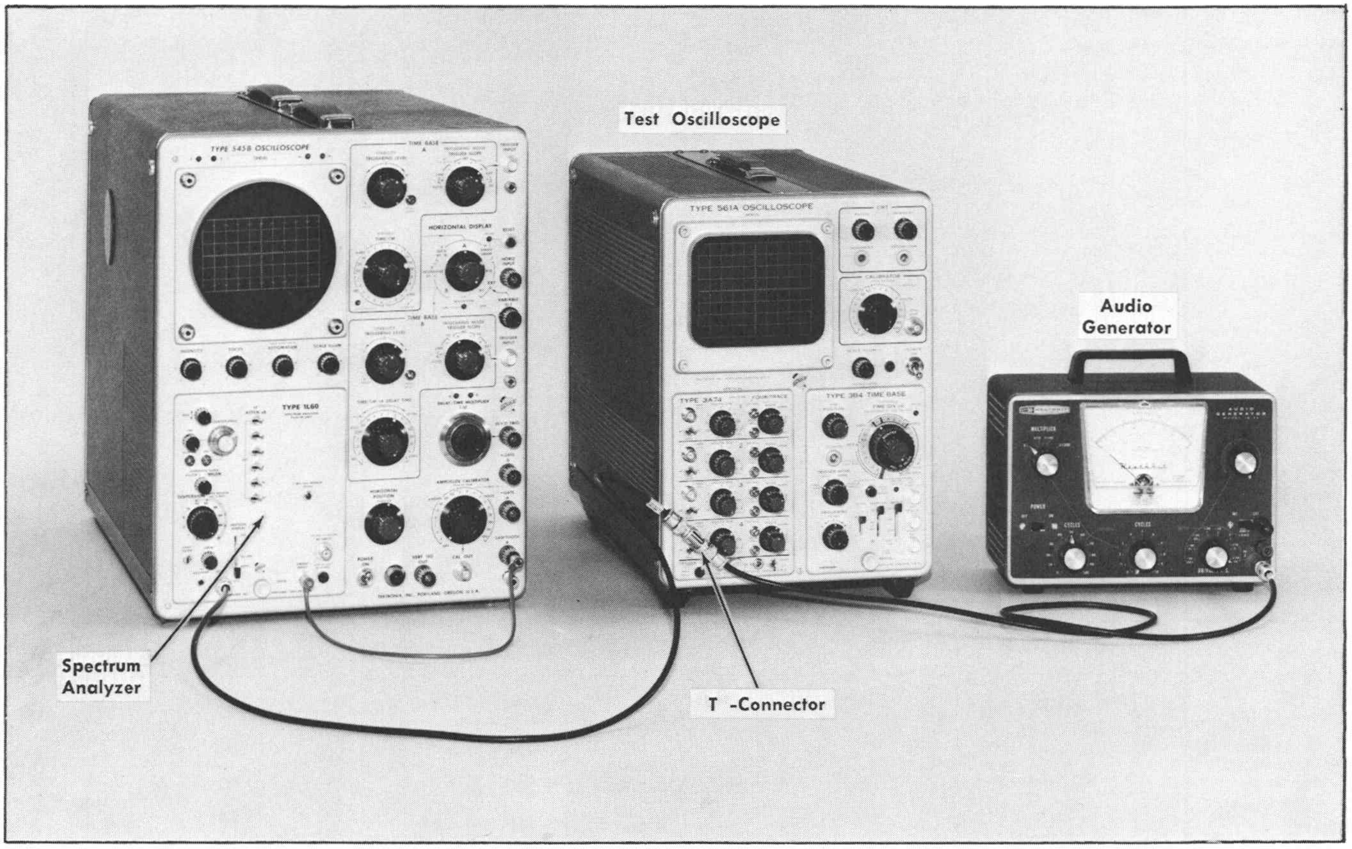



Fig. 6-23. Setup for checking VIDEO INPUT Frequency Response (Step 17).

## 17. Check Frequency Response of VIDEO INPUT Circuit

a. Connect the equipment as shown in Fig. 6-23.

b. Preset the controls of the Spectrum Analyzer as follows:

| | |
|---|---|
| POS | Position the trace to the center line of the graticule. |
| GAIN | Fully Clockwise |
| VERTICAL DISPLAY | VIDEO |

c. Apply a 50 kHz signal from the audio generator to the VIDEO INPUT connector of the Analyzer. Adjust the Output control of the generator to obtain 4 centimeters of deflection.

d. Monitor the signal amplitude with a DC coupled test oscilloscope for constant amplitude, and decrease the output frequency of the generator.

e. The frequency at which the Analyzer display amplitude falls to 2.8 centimeters should be $\leq$16 Hz.

f. Apply a 50 kHz signal from the Constant Amplitude RF Generator to the VIDEO INPUT connector of the Analyzer. Adjust the signal amplitude for 4 centimeters of deflection.

g. Increase the signal frequency until the amplitude of the Analyzer display falls to 2.8 centimeters. At this point the output frequency should be $\geq$10 MHz.

## NOTES

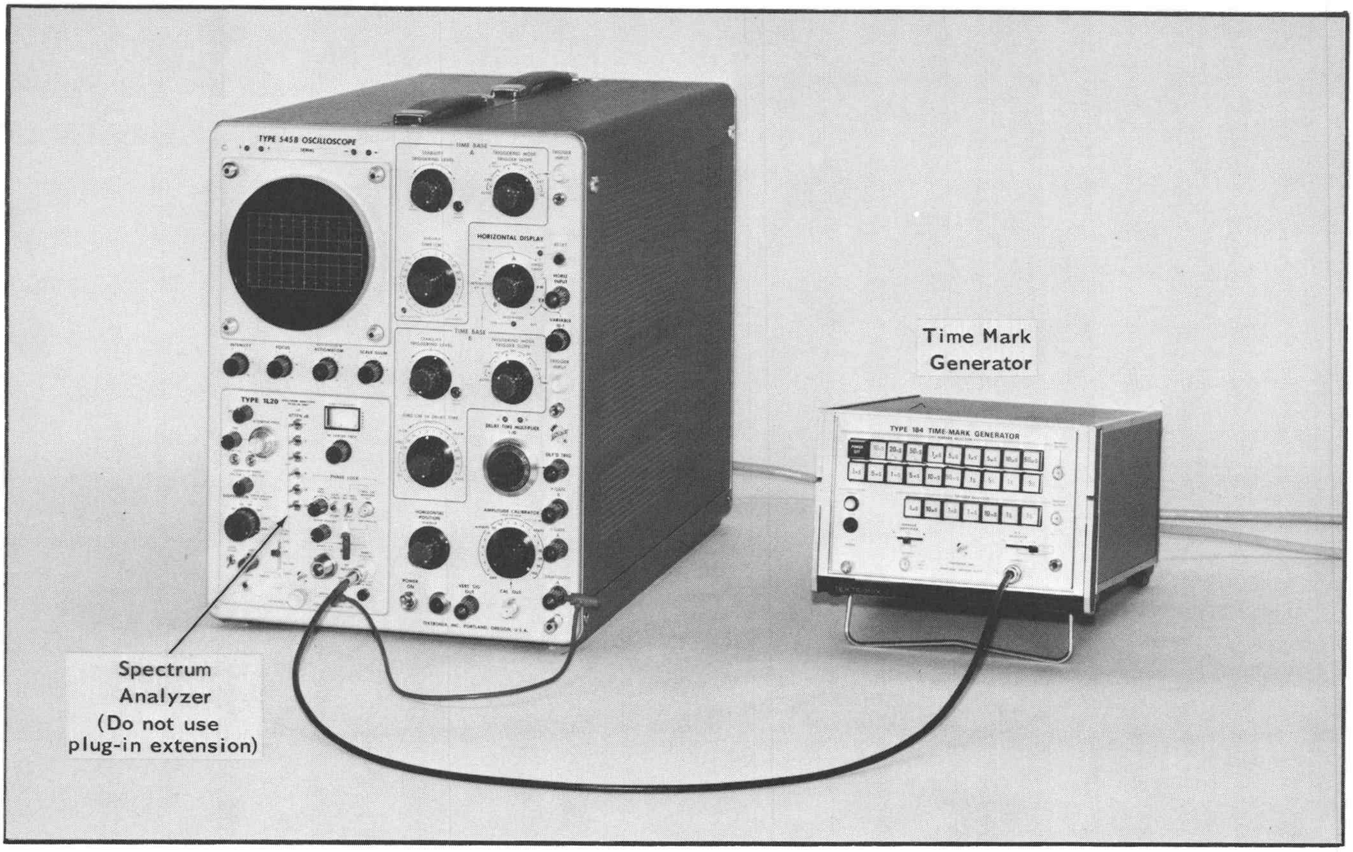



Fig. 6-24. Setup for checking Incidental Frequency-Modulation (Step 18).

## 18. Check Incidental Frequency Modulation

a. Set up the equipment as shown in Fig. 6-24.

b. Preset the controls as follows:

| | |
|---|---|
| DISPERSION RANGE | kHz/CM |
| DISPERSION | 500 (inner ring) |
| IF ATTEN | All OFF |
| VERTICAL DISPLAY | LIN |

c. Apply a 200 MHz signal from the Time-Mark Generator and center the signal on the CRT.

d. Change the DISPERSION—COUPLED RESOLUTION switch to 1, adjusting the IF CENTER FREQ controls as needed to keep the signal on the screen.

e. Adjust the GAIN control for six centimeters of deflection.

f. Adjust the IF CENTER FREQ and POS controls for a display similar to Fig. 6-25.

g. Set the oscilloscope sweep rate to 20 ms/cm. The display must not show more than 1 minor division of frequency modulation.

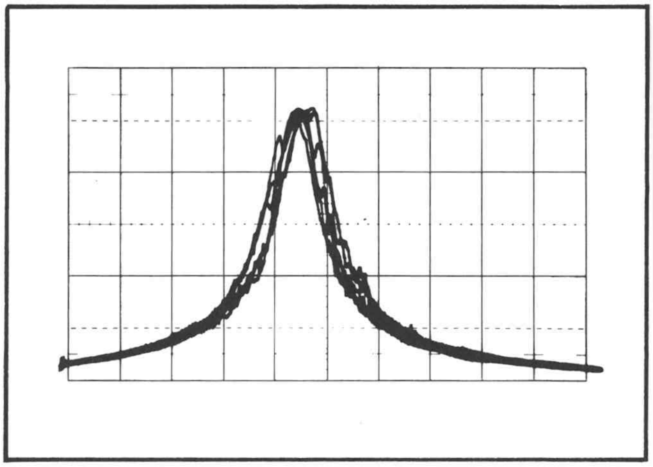


Fig. 6-25. Typical display for Incidental Frequency-Modulation Check (Step 18).

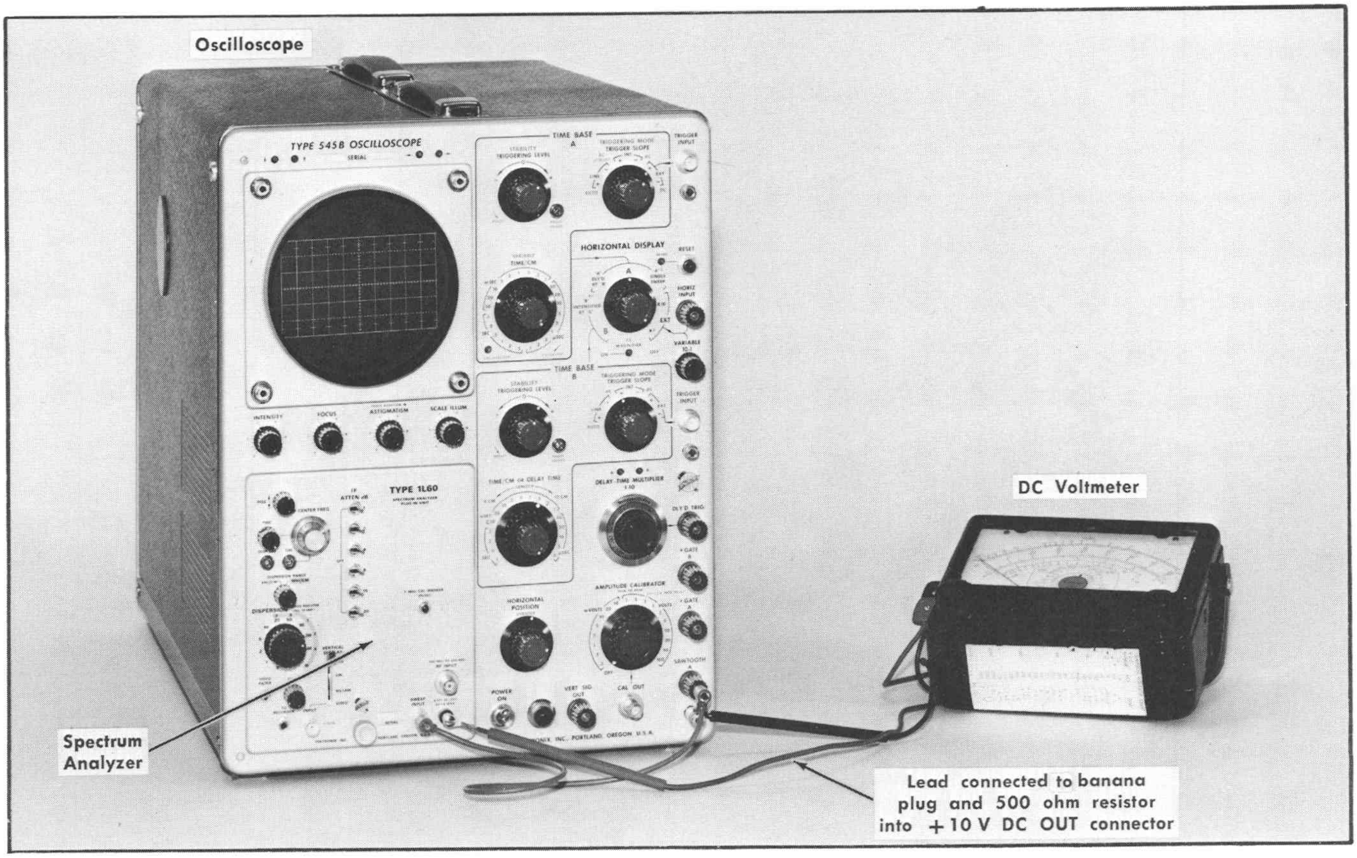



Fig. 6-26. Setup for checking +10 V DC OUT Voltage (Step 19).

## 19. Check +10 V DC OUT Voltage

a. Set up the equipment as shown in Fig. 6-26.

b. Connect a 500 ohm load resistor between ground and the +10 V DC OUT connector.

c. Measure the voltage across the load resistor. Check for 10 volts ±0.5 volts.

## NOTES



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# ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| A or amp | amperes |
| AC or ac | alternating current |
| AF | audio frequency |
| $\alpha$ | alpha—common-base current amplification factor |
| AM | amplitude modulation |
| $\approx$ | approximately equal to |
| $\beta$ | beta—common-emitter current amplification factor |
| BHB | binding head brass |
| BHS | binding head steel |
| BNC | baby series "N" connector |
| $\times$ | by or times |
| C | carbon |
| C | capacitance |
| cap. | capacitor |
| cer | ceramic |
| cm | centimeter |
| comp | composition |
| conn | connector |
| $\sim$ | cycle |
| c/s or cps | cycles per second |
| CRT | cathode-ray tube |
| csk | countersunk |
| $\Delta$ | increment |
| dB | decibel |
| dBm | decibel referred to one milliwatt |
| DC or dc | direct current |
| DE | double end |
| $^\circ$ | degrees |
| $^\circ$C | degrees Celsius (degrees centigrade) |
| $^\circ$F | degrees Fahrenheit |
| $^\circ$K | degrees Kelvin |
| dia | diameter |
| $\div$ | divide by |
| div | division |
| EHF | extremely high frequency |
| elect. | electrolytic |
| EMC | electrolytic, metal cased |
| EMI | electromagnetic interference (see RFI) |
| EMT | electrolytic, metal tubular |
| $\varepsilon$ | epsilon—2.71828 or % of error |
| $\geq$ | equal to or greater than |
| $\leq$ | equal to or less than |
| ext | external |
| F or f | farad |
| F & I | focus and intensity |
| FHB | flat head brass |
| FHS | flat head steel |
| Fil HB | fillister head brass |
| Fil HS | fillister head steel |
| FM | frequency modulation |
| ft | feet or foot |
| G | giga or $10^9$ |
| g | acceleration due to gravity |
| Ge | germanium |
| GHz | gigahertz |
| GMV | guaranteed minimum value |
| GR | General Radio |
| $>$ | greater than |
| H or h | henry |
| h | height or high |
| hex. | hexagonal |
| HF | high frequency |
| HHB | hex head brass |
| HHS | hex head steel |
| HSB | hex socket brass |
| HSS | hex socket steel |
| HV | high voltage |
| Hz | hertz (cycles per second) |
| ID | inside diameter |
| IF | intermediate frequency |
| in. | inch or inches |
| incd | incandescent |
| $\infty$ | infinity |
| int | internal |
| $\int$ | integral |
| k | kilohms or kilo ($10^3$) |
| k $\Omega$ | kilohm |
| kc | kilocycle |
| kHz | kilohertz |
| L | inductance |
| $\lambda$ | lambda—wavelength |
| $\gg$ | large compared with |
| $<$ | less than |
| LF | low frequency |
| lg | length or long |
| LV | low voltage |
| M | mega or $10^6$ |
| m | milli or $10^{-3}$ |
| M$\Omega$ or meg | megohm |
| $\mu$ | micro or $10^{-6}$ |
| mc | megacycle |
| met. | metal |
| MHz | megahertz |
| mm | millimeter |
| ms | millisecond |
| — | minus |
| mtg hdw | mounting hardware |
| n | nano or $10^{-9}$ |
| no. or # | number |
| ns | nanosecond |
| OD | outside diameter |
| OHB | oval head brass |
| OHS | oval head steel |
| $\Omega$ | omega—ohms |
| $\omega$ | omega—angular frequency |
| p | pico or $10^{-12}$ |
| / | per |
| % | percent |
| PHB | pan head brass |
| $\phi$ | phi—phase angle |
| $\pi$ | pi—3.1416 |
| PHS | pan head steel |
| $+$ | plus |
| $\pm$ | plus or minus |
| PIV | peak inverse voltage |
| plstc | plastic |
| PMC | paper, metal cased |
| poly | polystyrene |
| prec | precision |
| PT | paper, tubular |
| PTM | paper or plastic, tubular, molded |
| pwr | power |
| Q | figure of merit |
| RC | resistance capacitance |
| RF | radio frequency |
| RFI | radio frequency interference (see EMI) |
| RHB | round head brass |
| $\rho$ | rho—resistivity |
| RHS | round head steel |
| r/min or rpm | revolutions per minute |
| RMS | root mean square |
| s or sec. | second |
| SE | single end |
| Si | silicon |
| SN or S/N | serial number |
| $\ll$ | small compared with |
| T | tera or $10^{12}$ |
| TC | temperature compensated |
| TD | tunnel diode |
| THB | truss head brass |
| $\theta$ | theta—angular phase displacement |
| thk | thick |
| THS | truss head steel |
| tub. | tubular |
| UHF | ultra high frequency |
| V | volt |
| VAC | volts, alternating current |
| var | variable |
| VDC | volts, direct current |
| VHF | very high frequency |
| VSWR | voltage standing wave ratio |
| W | watt |
| w | wide or width |
| w/ | with |
| w/o | without |
| WW | wire-wound |
| xmfr | transformer |

## PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

## SPECIAL NOTES AND SYMBOLS

| | |
|---|---|
| ×000 | Part first added at this serial number |
| 00× | Part removed after this serial number |
| *000-0000-00 | Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components. |
| Use 000-0000-00 | Part number indicated is direct replacement. |
| ◐ | Screwdriver adjustment. |
| ▭ | Control, adjustment or connector. |

# SECTION 7
# ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

| Ckt. No. | Tektronix Part No. | Description | | | | | S/N Range |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

## Capacitors

Tolerance ±20% unless otherwise indicated.

| | | | | | | |
|---|---|---|---|---|---|---|
| C83 | 281-0616-00 | 6.8 pF | Cer | | 200 V | |
| C84 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | |
| C86 | 281-0616-00 | 6.8 pF | Cer | | 200 V | |
| C87 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | |
| C89 | 281-0616-00 | 6.8 pF | Cer | | 200 V | |
| C90 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | |
| C92 | 281-0616-00 | 6.8 pF | Cer | | 200 V | |
| C94 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | |
| C101 | 281-0101-00 | 1.5-9.1 pF | Air | Var | | |
| C102 | 281-0099-00 | 1.3-5.4 pF | Air | Var | | |
| C104 | 281-0101-00 | 1.5-9.1 pF | Air | Var | | |
| C105 | 281-0648-00 | 56 pF | Cer | | | 5% |
| C106 | 281-0101-00 | 1.5-9.1 pF | Air | Var | | |
| C107 | 281-0099-00 | 1.3-5.4 pF | Air | Var | | |
| C108 | 281-0101-00 | 1.5-9.1 pF | Air | Var | | |
| C123 | 281-0635-00 | 1000 pF | Cer | | 500 V | |
| C124 | 281-0523-00 | 100 pF | Cer | | 350 V | |
| C128 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% |
| C130 | 283-0103-00 | 180 pF | Cer | | 500 V | 5% |
| C132 | 283-0039-00 | 0.001 μF | Cer | | 500 V | |
| C133 | 281-0635-00 | 1000 pF | Cer | | 500 V | |
| C137 | 281-0063-00 | 9-35 pF | Cer | Var | | |
| C138 | 281-0635-00 | 1000 pF | Cer | | 500 V | |
| C139 | 283-0039-00 | 0.001 μF | Cer | | 500 V | |
| C140 | 283-0103-00 | 180 pF | Cer | | 500 V | 5% |
| C143 | 281-0635-00 | 1000 pF | Cer | | 500 V | |
| C145 | 281-0558-00 | 18 pF | Cer | | 500 V | |
| C146 | 281-0549-00 | 68 pF | Cer | | 500 V | 10% |
| C147 | 281-0523-00 | 100 pF | Cer | | 350 V | |
| C148 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% |
| C149 | 281-0635-00 | 1000 pF | Cer | | 500 V | |
| C151 | 281-0549-00 | 68 pF | Cer | | 500 V | 10% |
| C152 | 281-0549-00 | 68 pF | Cer | | 500 V | 10% |
| C187 | 281-0549-00 | 68 pF | Cer | | 500 V | 10% |
| C188 | 281-0549-00 | 68 pF | Cer | | 500 V | 10% |
| C231 | 285-0519-00 | 0.047 μF | Cer | | 400 V | |
| C245 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% |
| C246 | 283-0003-00 | 0.01 μF | Cer | | 150 V | |
| C248 | 285-0703-00 | 0.1 μF | PTM | | 100 V | 5% |
| C255 | 283-0001-00 | 0.005 μF | Cer | | 500 V | |

## Capacitors *(Cont)*

| Ckt. No. | Tektronix Part No. | Description | | | | | S/N Range |
|---|---|---|---|---|---|---|---|
| C274 | 281-0605-00 | 200 pF | Cer | | 500 V | | |
| C293 | 283-0010-00 | 0.05 μF | Cer | | 50 V | | |
| C300 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C310 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% | |
| C311 | 281-0613-00 | 10 pF | Cer | | 200 V | 10% | |
| C314 | 283-0563-00 | 1000 pF | Mica | | 500 V | 10% | |
| C315 | 281-0610-00 | 2.2 pF | Cer | | 200 V | | |
| C320 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C330 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C331 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C346 | 283-0050-00 | 0.008 μF | Cer | | 200 V | | |
| C347 | 283-0050-00 | 0.008 μF | Cer | | 200 V | | |
| C349 | 281-0503-00 | 8 pF | Cer | | 500 V | ±0.5 pF | |
| C357 | 283-0050-00 | 0.008 μF | Cer | | 200 V | | |
| C358 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | | |
| C361 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C362 | 281-0635-00 | 1000 pF | Cer | | 500 V | | |
| C363 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C365 | 283-0025-00 | 0.0005 μF | Cer | | 500 V | 5% | |
| C367 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C368 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C373 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C376 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C383 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C384 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | | |
| C385 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | | |
| C386 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C401 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% | |
| C412 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C413 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C416 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C422 | 281-0599-00 | 1 pF | Cer | | 200 V | ±0.25 pF | |
| C423 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% | |
| C424 | 281-0564-00 | 24 pF | Cer | | 500 V | 5% | |
| C425 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | | |
| C426 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% | |
| C427 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% | |
| C433 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% | |
| C434 | 281-0645-00 | 8.2 pF | Cer | | 500 V | ±0.25 pF | |
| C435 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | | |
| C436 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% | |
| C437 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C443 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C445 | 281-0564-00 | 24 pF | Cer | | 500 V | 5% | |
| C446 | 281-0579-00 | 21 pF | Cer | | 500 V | 5% | |

**Capacitors** *(Cont)*

| Ckt. No. | Tektronix Part No. | Description | | | | | S/N Range |
|---|---|---|---|---|---|---|---|
| C447 | 281-0550-00 | 120 pF | Cer | | 500 V | 10% | |
| C450 | 281-0511-00 | 22 pF | Cer | | 500 V | 10% | |
| C453 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C454 | 283-0566-00 | 100 pF | Mica | | 500 V | 5% | |
| C456 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C457 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C462 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C463 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C464 | 283-0566-00 | 100 pF | Mica | | 500 V | 5% | |
| C466 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C467 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C469 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C501 | 281-0523-00 | 100 pF | Cer | | 350 V | | |
| C502 | 281-0523-00 | 100 pF | Cer | | 350 V | | |
| C504 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | | |
| C508 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | | |
| C515 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% | |
| C524 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C525 | 283-0039-00 | 0.001 μF | Cer | | 500 V | | |
| C527 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C530 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C534 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C537 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C539 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C610 | 281-0099-00 | 1.3-5.4 pF | Air | Var | | | |
| C620 | 281-0105-00 | 0.8-8.5 pF | Cer | Var | | | |
| C623 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C626 | 283-0003-00 | 0.01 μF | Cer | | 150 V | | |
| C651 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C656 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C658 | 283-0083-00 | 0.0047 μF | Cer | | 500 V | 5% | |
| C660 | 281-0629-00 | 33 pF | Cer | | 600 V | 5% | |
| C661 | 283-0081-00 | 0.1 μF | Cer | | 25 V | +80%—20% | |
| C662 | 283-0001-00 | 0.005 μF | Cer | | 500 V | | |
| C668 | 285-0703-00 | 0.1 μF | PTM | | 100 V | 5% | |
| C801 | 283-0065-00 | 0.001 μF | Cer | | 100 V | 5% | |
| C803 | 281-0543-00 | 270 pF | Cer | | 500 V | 10% | |
| C804 | 281-0536-00 | 1000 pF | Cer | | 500 V | 10% | |
| C805 | 281-0503-00 | 8 pF | Cer | | 500 V | ±0.5 pF | |
| C806 | 281-0513-00 | 27 pF | Cer | | 500 V | | |

**Diodes**

| Ckt. No. | Tektronix Part No. | Description | | S/N Range |
|---|---|---|---|---|
| D240 | 152-0166-00 | Zener | 1N753A 0.4 W, 6.2 V, 10% | |
| D244 | *152-0061-00 | Silicon | Tek Spec | |
| D314 | 152-0231-00 | Silicon | MV 1872 | |
| D334 | *152-0107-00 | Silicon | Replaceable by 1N647 | |
| D361 | *152-0153-00 | Silicon | Replaceable by 1N4244 | |

## Diodes *(Cont)*

| Ckt. No. | Tektronix Part No. | Description | | S/N Range |
|---|---|---|---|---|
| D362 | *152-0185-00 | Silicon | Replaceable by 1N3605 | |
| D365 | *152-0153-00 | Silicon | Replaceable by 1N4244 | |
| D373 } D376 } | *153-0025-00 | Silicon | Selected 1N4244 (1 pair) | |
| D380 | 152-0238-00 | Silicon | 1N4442 | |
| D383 } D386 } | *153-0025-00 | Silicon | Selected 1N4244 (1 pair) | |
| D387 | 152-0238-00 | Silicon | 1N4442 | |
| D412 | *152-0107-00 | Silicon | Replaceable by 1N647 | |
| D454 | 152-0141-00 | Silicon | 1N3605 | |
| D506 | 152-0141-00 | Silicon | 1N3605 | |
| D550 | *152-0107-00 | Silicon | Replaceable by 1N647 | |
| D603 | 152-0188-00 | Germanium | 1N64 | |
| D604 | 152-0188-00 | Germanium | 1N64 | |
| D657 | 152-0186-00 | Germanium | 1N198 | |
| D660 | 152-0186-00 | Germanium | 1N198 | |
| D661 | 152-0186-00 | Germanium | 1N198 | |
| D664 | 152-0141-00 | Silicon | 1N3605 | |
| D665 | 152-0141-00 | Silicon | 1N3605 | |
| D805 | 152-0169-00 | Tunnel | 1N3712 1 mA | |

## Connectors

| Ckt. No. | Tektronix Part No. | Description | S/N Range |
|---|---|---|---|
| J1[1] | | | |
| J80 | 131-0372-00 | Coaxial | |
| J94 | 131-0372-00 | Coaxial | |
| J100 | 131-0372-00 | Coaxial | |
| J109 | 131-0372-00 | Coaxial | |
| J120 | 131-0372-00 | Coaxial | |
| J147 | 131-0372-00 | Coaxial | |
| J148 | 131-0372-00 | Coaxial | |
| J151 | 131-0372-00 | Coaxial | |
| J188 | 131-0372-00 | Coaxial | |
| J201 | 131-0106-00 | Chassis mtd., 1 contact, female | |
| J363 | 131-0372-00 | Coaxial | |
| J370 | 131-0372-00 | Coaxial | |
| J373 | 131-0372-00 | Coaxial | |
| J376 | 131-0372-00 | Coaxial | |
| J379 | 131-0372-00 | Coaxial | |
| J401 | 131-0372-00 | Coaxial | |
| J470 | 131-0372-00 | Coaxial | |
| J501 | 131-0372-00 | Coaxial | |
| J658 | 136-0094-00 | Socket w/hardware | |
| J669 | 131-0106-00 | Chassis mtd., 1 contact, female | |
| J720 | 136-0140-00 | Socket, Banana Jack Assembly | |

[1]Furnished as a unit with W1 (*030-0467-02).

## Inductors

| Ckt. No. | Tektronix Part No. | Description | | | S/N Range |
|---|---|---|---|---|---|
| L81 | *108-0380-00 | 32 nH | | | |
| L83 | *108-0377-00 | 7 nH | | | |
| L84 | *108-0382-00 | 41 nH | | | |
| L86 | *108-0379-00 | 22 nH | | | |
| L87 | *108-0381-00 | 36 nH | | | |
| L89 | *108-0378-00 | 14 nH | | | |
| L90 | *108-0381-00 | 36 nH | | | |
| L101 | *108-0371-00 | 0.23 μH | | | |
| L102 | *108-0370-00 | 0.14 μH | | | |
| L104 | *108-0369-00 | 0.12 μH | | | |
| L105 | *108-0401-00 | 14 nH | | | |
| L106 | *108-0369-00 | 0.12 μH | | | |
| L107 | *108-0370-00 | 0.14 μH | | | |
| L108 | *108-0371-00 | 0.23 μH | | | |
| L124 | *108-0373-00 | 56 nH | | | |
| L134 | *114-0205-00 | 54-66 nH | Var | Core 276-0506-00 | |
| L144 | *114-0206-00 | 234-286 nH | Var | Core 276-0506-00 | |
| L147 | *114-0205-00 | 54-66 nH | Var | Core 276-0506-00 | |
| L151 | *108-0310-00 | 0.09 μH | | | |
| L188 | *108-0310-00 | 0.09 μH | | | |
| L313 | *108-0215-00 | 1.1 μH | | | |
| L314[2] | | | | | |
| L320 | *108-0215-00 | 1.1 μH | | | |
| L325 | 276-0507-00 | Core, Ferramic Suppressor | | | |
| L333 | *108-0215-00 | 1.1 μH | | | |
| L343 | *108-0215-00 | 1.1 μH | | | |
| L348 | *108-0304-00 | 45 nH | | | |
| L358 | *108-0372-00 | 27 nH | | | |
| L384 | *108-0374-00 | 55 nH | | | |
| L385 | *108-0374-00 | 55 nH | | | |
| L444 | *114-0207-00 | 180-220 nH | Var | Core 276-0506-00 | |
| L446 | 108-0215-00 | 1.1 μH | | | |
| L456 | 276-0507-00 | Core, Ferramic Suppressor | | | |
| L466 | 276-0507-00 | Core, Ferramic Suppressor | | | |
| L508 | 108-0363-00 | 67 μH | | | |
| L534 | 108-0226-00 | 100 μH | | | |
| L620 | 108-0366-00 | 67 μH | | | |
| L624 | 114-0209-00 | 28-60 μH | Var | Core not available separately | |
| L675 | 276-0507-00 | Core, Ferramic Suppressor | | | |
| L676 | 276-0507-00 | Core, Ferramic Suppressor | | | |
| L803 | *114-0208-00 | 95-150-μH | Var | Core 276-0506-00 | |
| L806 | *108-0311-00 | 0.18 μH | | | |
| LR413 | *108-0368-00 | 10 μH | (wound on a 1 kΩ, ½ W resistor) | | |
| LR423 | *108-0367-00 | 1 μH | (wound on a 1 kΩ, ¼ W resistor) | | |
| LR427 | *108-0367-00 | 1 μH | (wound on a 1 kΩ, ¼ W resistor) | | |

[2]Part of Sweeper Circuit Board.

## Inductors (Cont)

| Ckt. No. | Tektronix Part No. | Description | | S/N Range |
|---|---|---|---|---|
| LR433 | *108-0367-00 | 1 μH | (wound on a 1 kΩ, 1/4 W resistor) | |
| LR437 | *108-0368-00 | 10 μH | (wound on a 1 kΩ, 1/2 W resistor) | |
| LR443 | *108-0368-00 | 10 μH | (wound on a 1 kΩ, 1/2 W resistor) | |
| LR453 | *108-0368-00 | 10 μH | (wound on a 1 kΩ, 1/2 W resistor) | |
| LR457 | *108-0368-00 | 10 μH | (wound on a 1 kΩ, 1/2 W resistor) | |
| LR463 | *108-0368-00 | 10 μH | (wound on a 1 kΩ, 1/2 W resistor) | |
| LR467 | *108-0368-00 | 10 μH | (wound on a 1 kΩ, 1/2 W resistor) | |

## Plug

| | | |
|---|---|---|
| P11 | 131-0017-00 | Chassis mtd., 16 contact, male |

## Transistors

| | | | |
|---|---|---|---|
| Q120 | 151-0180-00 | Silicon | 40235 (RCA) |
| Q130 | 151-0180-00 | Silicon | 40235 (RCA) |
| Q140 | 151-0181-00 | Silicon | 40242 (RCA) |
| Q230 | *151-0155-00 | Silicon | Replaceable by 2N2925 |
| Q240 | *151-0096-00 | Silicon | Selected from 2N1893 |
| Q260 | *151-0104-00 | Silicon | Replaceable by 2N2919 |
| Q280 | *151-0155-00 | Silicon | Replaceable by 2N2925 |
| Q290 | *151-0155-00 | Silicon | Replaceable by 2N2925 |
| Q310 | 151-0173-00 | Silicon | 2N3478 |
| Q320 | *151-0153-00 | Silicon | Replaceable by 2N2923 |
| Q340 | 151-0173-00 | Silicon | 2N3478 |
| Q350 | 151-0173-00 | Silicon | 2N3478 |
| Q420 | 151-0181-00 | Silicon | 40242 (RCA) |
| Q430 | 151-0181-00 | Silicon | 40242 (RCA) |
| Q440 | 151-0175-00 | Silicon | 2N3662 |
| Q450 | 151-0175-00 | Silicon | 2N3662 |
| Q460 | 151-0175-00 | Silicon | 2N3662 |
| Q510 | 151-0181-00 | Silicon | 40242 (RCA) |
| Q520 | 151-0175-00 | Silicon | 2N3662 |
| Q530 | 151-0175-00 | Silicon | 2N3662 |
| Q650 | 151-0175-00 | Silicon | 2N3662 |
| Q710 | 151-0164-00 | Silicon | 2N3702 |
| Q717 | 151-0174-00 | Silicon | 2N3403 |
| Q720 | 151-0164-00 | Silicon | 2N3702 |
| Q727 | 151-0174-00 | Silicon | 2N3403 |
| Q800 | *151-0155-00 | Silicon | Replaceable by 2N2925 |

## Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

| | | | | | |
|---|---|---|---|---|---|
| R47 | 308-0258-00 | 6 kΩ | 3 W | WW | 5% |
| R48 | 308-0210-00 | 150 Ω | 5 W | WW | 5% |
| R49 | 308-0275-00 | 200 Ω | 5 W | WW | 5% |
| R60 | 119-0091-00 | Resistive "T" Network | | | |
| R123 | 315-0101-00 | 100 Ω | 1/4 W | | 5% |
| R128 | 315-0332-00 | 3.3 kΩ | 1/4 W | | 5% |

**Resistors** *(Cont)*

| Ckt. No. | Tektronix Part No. | Description | | | | | S/N Range |
|---|---|---|---|---|---|---|---|
| R130 | 315-0221-00 | 220 Ω | ¼ W | | | 5% | |
| R133 | 315-0101-00 | 100 Ω | ¼ W | | | 5% | |
| R134 | 315-0131-00 | 130 Ω | ¼ W | | | 5% | |
| R137 | 315-0101-00 | 100 Ω | ¼ W | | | 5% | |
| R138 | 315-0182-00 | 1.8 kΩ | ¼ W | | | 5% | |
| R140 | 315-0221-00 | 220 Ω | ¼ W | | | 5% | |
| R143 | 315-0101-00 | 100 Ω | ¼ W | | | 5% | |
| R148 | 315-0101-00 | 100 Ω | ¼ W | | | 5% | |
| R149 | 315-0472-00 | 4.7 kΩ | ¼ W | | | 5% | |
| R158 | 315-0620-00 | 62 Ω | ¼ W | | | 5% | |
| R159 | 315-0241-00 | 240 Ω | ¼ W | | | 5% | |
| R160 | 315-0620-00 | 62 Ω | ¼ W | | | 5% | |
| R163 | 315-0680-00 | 68 Ω | ¼ W | | | 5% | |
| R164 | 315-0151-00 | 150 Ω | ¼ W | | | 5% | |
| R165 | 315-0680-00 | 68 Ω | ¼ W | | | 5% | |
| R168 | 315-0121-00 | 120 Ω | ¼ W | | | 5% | |
| R169 | 315-0510-00 | 51 Ω | ¼ W | | | 5% | |
| R170 | 315-0121-00 | 120 Ω | ¼ W | | | 5% | |
| R173 | 315-0221-00 | 220 Ω | ¼ W | | | 5% | |
| R174 | 315-0240-00 | 24 Ω | ¼ W | | | 5% | |
| R175 | 315-0221-00 | 220 Ω | ¼ W | | | 5% | |
| R178 | 315-0431-00 | 430 Ω | ¼ W | | | 5% | |
| R179 | 315-0120-00 | 12 Ω | ¼ W | | | 5% | |
| R180 | 315-0431-00 | 430 Ω | ¼ W | | | 5% | |
| R183 | 315-0911-00 | 910 Ω | ¼ W | | | 5% | |
| R184 | 307-0107-00 | 5.6 Ω | ¼ W | | | 5% | |
| R185 | 315-0911-00 | 910 Ω | ¼ W | | | 5% | |
| R201 | 321-0332-00 | 28 kΩ | ⅛ W | | Prec | 1% | |
| R202 | 321-0358-00 | 52.3 kΩ | ⅛ W | | Prec | 1% | |
| R204 | 311-0465-00 | 100 kΩ | | Var | | | |
| R205 | 323-0395-00 | 127 kΩ | ½ W | | Prec | 1% | |
| R206 | 315-0362-00 | 3.6 kΩ | ¼ W | | | 5% | |
| R208 | 311-0310-00 | 5 kΩ | | Var | | | |
| R209 | 315-0512-00 | 5.1 kΩ | ¼ W | | | 5% | |
| R213 | 321-0231-00 | 2.49 kΩ | ⅛ W | | Prec | 1% | |
| R214 | 321-0164-00 | 499 Ω | ⅛ W | | Prec | 1% | |
| R215 | 321-0193-00 | 1 kΩ | ⅛ W | | Prec | 1% | |
| R217 | 321-0164-00 | 499 Ω | ⅛ W | | Prec | 1% | |
| R219 | 321-0135-00 | 249 Ω | ⅛ W | | Prec | 1% | |
| R220 | 321-0068-00 | 49.9 Ω | ⅛ W | | Prec | 1% | |
| R221 | 321-0097-00 | 100 Ω | ⅛ W | | Prec | 1% | |
| R223 | 321-0068-00 | 49.9 Ω | ⅛ W | | Prec | 1% | |
| R224 | 321-0047-00 | 30.1 Ω | ⅛ W | | Prec | 1% | |
| R225 | 321-0001-00 | 10 Ω | ⅛ W | | Prec | 1% | |
| R226 | 321-0001-00 | 10 Ω | ⅛ W | | Prec | 1% | |

**Transistors** *(Cont)*

| Ckt. No. | Tektronix Part No. | Description | | | | | S/N Range |
|---|---|---|---|---|---|---|---|
| R230 | 315-0512-00 | 5.1 kΩ | ¼ W | | | 5% | |
| R231 | 315-0204-00 | 200 kΩ | ¼ W | | | 5% | |
| R236 | 303-0513-00 | 51 kΩ | 1 W | | | 5% | |
| R240 | 321-0260-00 | 4.99 kΩ | ⅛ W | | Prec | 1% | |
| R241 | 323-0414-00 | 200 kΩ | ½ W | | Prec | 1% | |
| R243 | 304-0124-00 | 120 kΩ | 1 W | | | | |
| R244 | 315-0432-00 | 4.3 kΩ | ¼ W | | | 5% | |
| R245 | 315-0272-00 | 2.7 kΩ | ¼ W | | | 5% | |
| R246 | 316-0102-00 | 1 kΩ | ¼ W | | | | |
| R248 | 316-0101-00 | 100 Ω | ¼ W | | | | |
| R252 | 311-0310-00 | 5 kΩ | | Var | | | |
| R253 | 311-0329-00 | 50 kΩ | | Var | | | |
| R254 | 323-0440-00 | 374 kΩ | ½ W | | Prec | 1% | |
| R255 | 316-0101-00 | 100 Ω | ¼ W | | | | |
| R256 | 323-0440-00 | 374 kΩ | ½ W | | Prec | 1% | |
| R260 | 321-0423-00 | 249 kΩ | ⅛ W | | Prec | 1% | |
| R261 | 321-0423-00 | 249 kΩ | ⅛ W | | Prec | 1% | |
| R264 | 321-0147-00 | 332 Ω | ⅛ W | | Prec | 1% | |
| R265 | 321-0147-00 | 332 Ω | ⅛ W | | Prec | 1% | |
| R266 | 321-0147-00 | 332 Ω | ⅛ W | | Prec | 1% | |
| R267 | 323-0402-00 | 150 kΩ | ½ W | | Prec | 1% | |
| R268 | 321-0431-00 | 301 kΩ | ⅛ W | | Prec | 1% | |
| R269 | 321-0452-00 | 499 kΩ | ⅛ W | | Prec | 1% | |
| R270 | 311-0580-00 | 50 kΩ | | Var | | | |
| R271 | 301-0755-00 | 7.5 MΩ | ½ W | | | 5% | |
| R274 | 311-0590-00 | 2 kΩ | | Var | | | |
| R276 | 322-0469-00 | 750 kΩ | ¼ W | | Prec | 1% | |
| R280 | 321-0423-00 | 249 kΩ | ⅛ W | | Prec | 1% | |
| R286 | 315-0512-00 | 5.1 kΩ | ¼ W | | | 5% | |
| R290 | 311-0443-00 | 2.5 kΩ | | Var | | | |
| R291 | 323-0402-00 | 150 kΩ | ½ W | | Prec | 1% | |
| R293 | 315-0510-00 | 51 Ω | ¼ W | | | 5% | |
| R294 | 316-0562-00 | 5.6 kΩ | ¼ W | | | | |
| R295 | 315-0202-00 | 2 kΩ | ¼ W | | | 5% | |
| R296 | 316-0102-00 | 1 kΩ | ¼ W | | | | |
| R300 | 315-0102-00 | 1 kΩ | ¼ W | | | 5% | |
| R310 | 315-0562-00 | 5.6 kΩ | ¼ W | | | 5% | |
| R311 | 315-0392-00 | 3.9 kΩ | ¼ W | | | 5% | |
| R316 | 315-0221-00 | 220 Ω | ¼ W | | | 5% | |
| R333 | 321-0233-00 | 2.61 kΩ | ⅛ W | | Prec | 1% | |
| R334 | 315-0431-00 | 430 Ω | ¼ W | | | 5% | |
| R346 | 315-0680-00 | 68 Ω | ¼ W | | | 5% | |
| R356 | 315-0680-00 | 68 Ω | ¼ W | | | 5% | |
| R361 | 321-0395-00 | 127 kΩ | ⅛ W | | Prec | 1% | |
| R363 | 315-0221-00 | 220 Ω | ¼ W | | | 5% | |



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**Resistors** *(Cont)*

| Ckt. No. | Tektronix Part No. | Description | | | | | S/N Range |
|---|---|---|---|---|---|---|---|
| R365 | 315-0102-00 | 1 kΩ | ¼ W | | | 5% | |
| R367 | 308-0385-00 | 200 Ω | 3 W | | WW | 5% | |
| R368 | 311-0387-00 | 5 kΩ | | Var | | | |
| R373 | 315-0510-00 | 51 kΩ | ¼ W | | | 5% | |
| R376 | 315-0510-00 | 51 kΩ | ¼ W | | | 5% | |
| R380 | 316-0272-00 | 2.7 kΩ | ¼ W | | | | |
| R381 | 316-0274-00 | 270 kΩ | ¼ W | | | | |
| R383 | 315-0681-00 | 680 Ω | ¼ W | | | 5% | |
| R384 | 321-0097-00 | 100 Ω | ⅛ W | | Prec | 1% | |
| R385 | 321-0097-00 | 100 Ω | ⅛ W | | Prec | 1% | |
| R401 | 315-0680-00 | 68 Ω | ¼ W | | | 5% | |
| R410 | 315-0393-00 | 39 kΩ | ¼ W | | | 5% | |
| R411A } R411B } | 311-0588-00 | 5 kΩ<br>1 kΩ | | Var | | | |
| R414 | 315-0512-00 | 5.1 kΩ | ¼ W | | | 5% | |
| R416 | 315-0102-00 | 1 kΩ | ¼ W | | | 5% | |
| R426 | 315-0102-00 | 1 kΩ | ¼ W | | | 5% | |
| R436 | 315-0102-00 | 1 kΩ | ¼ W | | | 5% | |
| R448 | 315-0472-00 | 4.7 kΩ | ¼ W | | | 5% | |
| R454 | 315-0103-00 | 10 kΩ | ¼ W | | | 5% | |
| R456 | 315-0472-00 | 4.7 kΩ | ¼ W | | | 5% | |
| R464 | 315-0103-00 | 10 kΩ | ¼ W | | | 5% | |
| R466 | 315-0472-00 | 4.7 kΩ | ¼ W | | | 5% | |
| R501 | 317-0151-00 | 150 Ω | 1/10 W | | | 5% | |
| R502 | 317-0151-00 | 150 Ω | 1/10 W | | | 5% | |
| R514 | 315-0470-00 | 47 Ω | ¼ W | | | 5% | |
| R516 | 315-0242-00 | 2.4 kΩ | ¼ W | | | 5% | |
| R517 | 315-0242-00 | 2.4 kΩ | ¼ W | | | 5% | |
| R524 | 315-0470-00 | 47 Ω | ¼ W | | | 5% | |
| R525 | 315-0202-00 | 2 kΩ | ¼ W | | | 5% | |
| R530 | 315-0301-00 | 300 Ω | ¼ W | | | 5% | |
| R531 | 315-0203-00 | 20 kΩ | ¼ W | | | 5% | |
| R532 | 315-0562-00 | 5.6 kΩ | ¼ W | | | 5% | |
| R534 | 315-0102-00 | 1 kΩ | ¼ W | | | 5% | |
| R537 | 315-0101-00 | 100 Ω | ¼ W | | | 5% | |
| R539 | 315-0102-00 | 1 kΩ | ¼ W | | | 5% | |
| R540 | 301-0433-00 | 43 kΩ | ½ W | | | 5% | |
| R541 | 315-0224-00 | 200 kΩ | ¼ W | | | 5% | |
| R543 | 311-0326-00 | 10 kΩ | | Var | | | |
| R550 | 315-0151-00 | 150 Ω | ¼ W | | | 5% | |
| R551 | 315-0161-00 | 160 Ω | ¼ W | | | 5% | |
| R552 | 315-0111-00 | 110 Ω | ¼ W | | | 5% | |
| R553 | 315-0151-00 | 150 Ω | ¼ W | | | 5% | |
| R554 | 315-0331-00 | 330 Ω | ¼ W | | | 5% | |
| R555 | 315-0511-00 | 510 Ω | ¼ W | | | 5% | |

**Resistors** *(Cont)*

| Ckt. No. | Tektronix Part No. | Description | | | | | S/N Range |
|---|---|---|---|---|---|---|---|
| R556 | 315-0561-00 | 560 Ω | ¼ W | | | 5% | |
| R557 | 315-0104-00 | 100 kΩ | ¼ W | | | 5% | |
| R558 | 315-0394-00 | 390 kΩ | ¼ W | | | 5% | |
| R559 | 315-0394-00 | 390 kΩ | ¼ W | | | 5% | |
| R606 | 316-0102-00 | 1 kΩ | ¼ W | | | | |
| R607 | 316-0471-00 | 470 Ω | ¼ W | | | | |
| R610 | 316-0102-00 | 1 kΩ | ¼ W | | | | |
| R623 | 316-0101-00 | 100 Ω | ¼ W | | | | |
| R624 | 316-0103-00 | 10 kΩ | ¼ W | | | | |
| R626 | 316-0680-00 | 68 Ω | ¼ W | | | | |
| R628 | 316-0101-00 | 100 Ω | ¼ W | | | | |
| R651 | 316-0104-00 | 100 kΩ | ¼ W | | | | |
| R652 | 316-0105-00 | 1 MΩ | ¼ W | | | | |
| R653 | 308-0313-00 | 20 kΩ | 3 W | | WW | 1% | |
| R654 | 316-0471-00 | 470 Ω | ¼ W | | | | |
| R656 | 316-0332-00 | 3.3 kΩ | ¼ W | | | | |
| R657 | 316-0332-00 | 3.3 kΩ | ¼ W | | | | |
| R658 | 316-0681-00 | 680 Ω | ¼ W | | | | |
| R662 | 316-0124-00 | 120 kΩ | ¼ W | | | | |
| R663 | 316-0124-00 | 120 kΩ | ¼ W | | | | |
| R664 | 316-0683-00 | 68 kΩ | ¼ W | | | | |
| R665 | 316-0102-00 | 1 kΩ | ¼ W | | | | |
| R666 | 311-0382-00 | 1 MΩ | | Var | | | |
| R668 | 316-0104-00 | 100 kΩ | ¼ W | | | | |
| R669 | 323-0071-00 | 53.6 Ω | ½ W | | Prec | 1% | |
| R671 | 301-0512-00 | 5.1 kΩ | ½ W | | | 5% | |
| R672 | 311-0091-00 | 1 kΩ | | Var | | | |
| R673 | 303-0123-00 | 12 kΩ | 1 W | | | 5% | |
| R675 | 316-0471-00 | 470 Ω | ¼ W | | | | |
| R676 | 316-0471-00 | 470 Ω | ¼ W | | | | |
| R710 | 323-0438-00 | 357 kΩ | ½ W | | Prec | 1% | |
| R711 | 321-0288-00 | 9.76 kΩ | ⅛ W | | Prec | 1% | |
| R714 | 316-0103-00 | 10 kΩ | ¼ W | | | | |
| R720 | 321-0289-00 | 10 kΩ | ⅛ W | | Prec | 1% | |
| R721 | 321-0284-00 | 8.87 kΩ | ⅛ W | | Prec | 1% | |
| R724 | 301-0154-00 | 150 kΩ | ½ W | | | 5% | |
| R727 | 308-0020-00 | 3 kΩ | 10 W | | WW | 5% | |
| R800 | 315-0562-00 | 5.6 kΩ | ¼ W | | | 5% | |
| R801 | 315-0472-00 | 4.7 kΩ | ¼ W | | | 5% | |
| R804 | 316-0102-00 | 1 kΩ | ¼ W | | | | |
| R805 | 315-0510-00 | 51 Ω | ¼ W | | | 5% | |

## Switches

| Ckt. No. | Tektronix Part No. Unwired | Wired | Description | | S/N Range |
|---|---|---|---|---|---|
| SW159 | 260-0642-00 | | Toggle | IF ATTEN 20 dB | |
| SW164 | 260-0642-00 | | Toggle | IF ATTEN 16 dB | |
| SW169 | 260-0642-00 | | Toggle | IF ATTEN 8 dB | |
| SW174 | 260-0642-00 | | Toggle | IF ATTEN 4 dB | |
| SW179 | 260-0642-00 | | Toggle | IF ATTEN 2 dB | |
| SW184 | 260-0642-00 | | Toggle | IF ATTEN 1 dB | |
| SW201 | 260-0583-00 | | Slide | | |
| SW220[3] | 260-0759-00 | *262-0763-00 | Rotary | DISPERSION | |
| SW230 | 260-0757-00 | | Rotary | DISPERSION RANGE | |
| SW365 | 260-0643-00 | | Toggle | | |
| SW550[3] | | | Rotary | COUPLED RESOLUTION | |
| SW660 | 260-0758-00 | *262-0762-00 | Lever | VERTICAL DISPLAY | |
| SW661 | 260-0643-00 | | Toggle | VIDEO FILTER | |
| SW800 | 260-0247-00 | | Push | 1 MHz MARKER | |

## Transformers

| Ckt. No. | Tektronix Part No. | Description |
|---|---|---|
| T120 | *120-0428-00 | Toroid, 4 turns bifilar |
| T124 | *120-0325-00 | Toroid, 5 turns bifilar |
| T134 | *120-0325-00 | Toroid, 5 turns bifilar |
| T148 | *120-0325-00 | Toroid, 5 turns bifilar |
| T330 | *120-0340-00 | Toroid, 5 turns bifilar |
| T331 | *120-0340-00 | Toroid, 5 turns bifilar |
| T343 | *120-0340-00 | Toroid, 5 turns bifilar |
| T347 | *120-0340-00 | Toroid, 5 turns bifilar |
| T354 | *152-0340-00 | Toroid, 5 turns bifilar |
| T363 | *120-0340-00 | Toroid, 5 turns bifilar |
| T424 | *120-0425-00 | Toroid, 4 turns—1 turn |
| T434 | *120-0426-00 | Toroid, 7 turns—2 turns |
| T454 | 120-0356-00 | 3.45 MHz |
| T464 | 120-0356-00 | 3.45 MHz |
| T610 | *120-0427-00 | Toroid, 12 turns trifilar |

## Electron Tube

| Ckt. No. | Tektronix Part No. | Description |
|---|---|---|
| V620 | 154-0040-00 | 12AU6 |

## Cable Assemblies

| Ckt. No. | Tektronix Part No. | Description |
|---|---|---|
| W1 | *030-0467-02 | 11 inch |
| W75 | *175-0309-00 | 5 inch |
| W94 | *175-0364-00 | 11 inch |
| W110 | *175-0308-00 | 2 inch |
| W150 | *175-0313-00 | 3 inch |

[3] SW220 and SW550 furnished as a unit.

## Cable Assemblies *(Cont)*

| Ckt. No. | Tektronix Part No. | Description | S/N Range |
|---|---|---|---|
| W200 | *175-0358-00 | 1 9/16 inch | |
| W300 | *175-0358-00 | 1 9/16 inch | |
| W370[4] | | | |
| W375[4] | | | |
| W500 | *175-0358-00 | 1 9/16 inch | |
| W800 | *030-0501-01 | Cable Assembly | |

## Crystals

| | | | |
|---|---|---|---|
| Y440 | 158-0024-00 | 70 MHz | |
| Y501 | 158-0019-00 | 5 MHz | |
| Y610 | 158-0027-00 | 5 MHz | |
| Y800 | 158-0025-00 | 1 MHz | |

[4]Selected.

## IMPORTANT

### VOLTAGE AND WAVEFORM CONDITIONS

Circuit voltages measured with 20,000 Ω/volt VOM. All readings in volts. Voltages are measured with respect to chassis ground unless otherwise noted.

Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System.

Voltages and waveforms on the schematics (shown in blue) are not aboluste and may vary between instruments. Any apparent differences between voltage levels measured with the voltmeter and those shown on the waveforms may be due to circuit loading of the voltmeter.

The test oscilloscope used had the following characteristics: Minimum deflection factor, 0.1 volts/division using a 10 × probe; frequency response, DC to 10 MHz.

To indicate the true time relationship of the waveforms, the test oscilloscope was externally triggered by the + Gate signal of the Analyzer oscilloscope for all other waveforms.

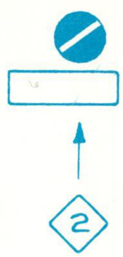
The waveforms were obtained with the Analyzer controls set as follows unless otherwise noted on the individual diagram:

| | |
|---|---|
| Signal Applied | Internal Markers (button pushed) |
| Sweep TIME/CM | 10 mS |
| Vertical POS | Align trace with bottom of graticule |
| IF CENTER FREQ | Midrange (000) |
| IF ATTEN | All OFF |
| GAIN | Midrange |
| VERTICAL DISPLAY | LIN |
| DISPERSION | 1 MHz/CM |
| RESOLUTION | Coupled |

Voltage readings were obtained under the same conditions except that the sweep was turned off and no signal was applied.

### Schematic Symbols

The following symbols are used on the schematics:

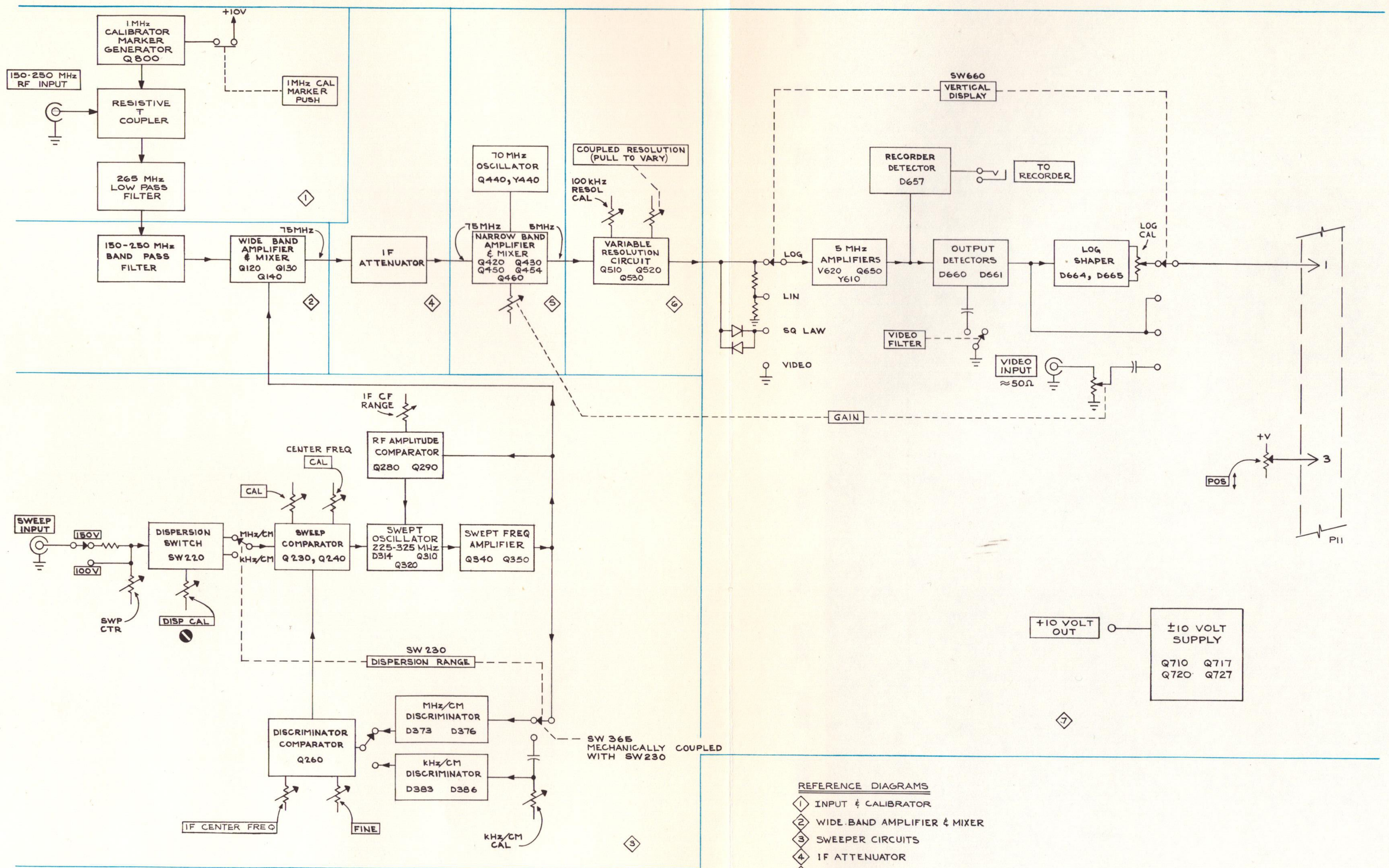



Screwdriver adjustment

Front-panel control or connector

Clockwise control rotation in direction of arrow

Input from, or output to indicated schematic




REFERENCE DIAGRAMS

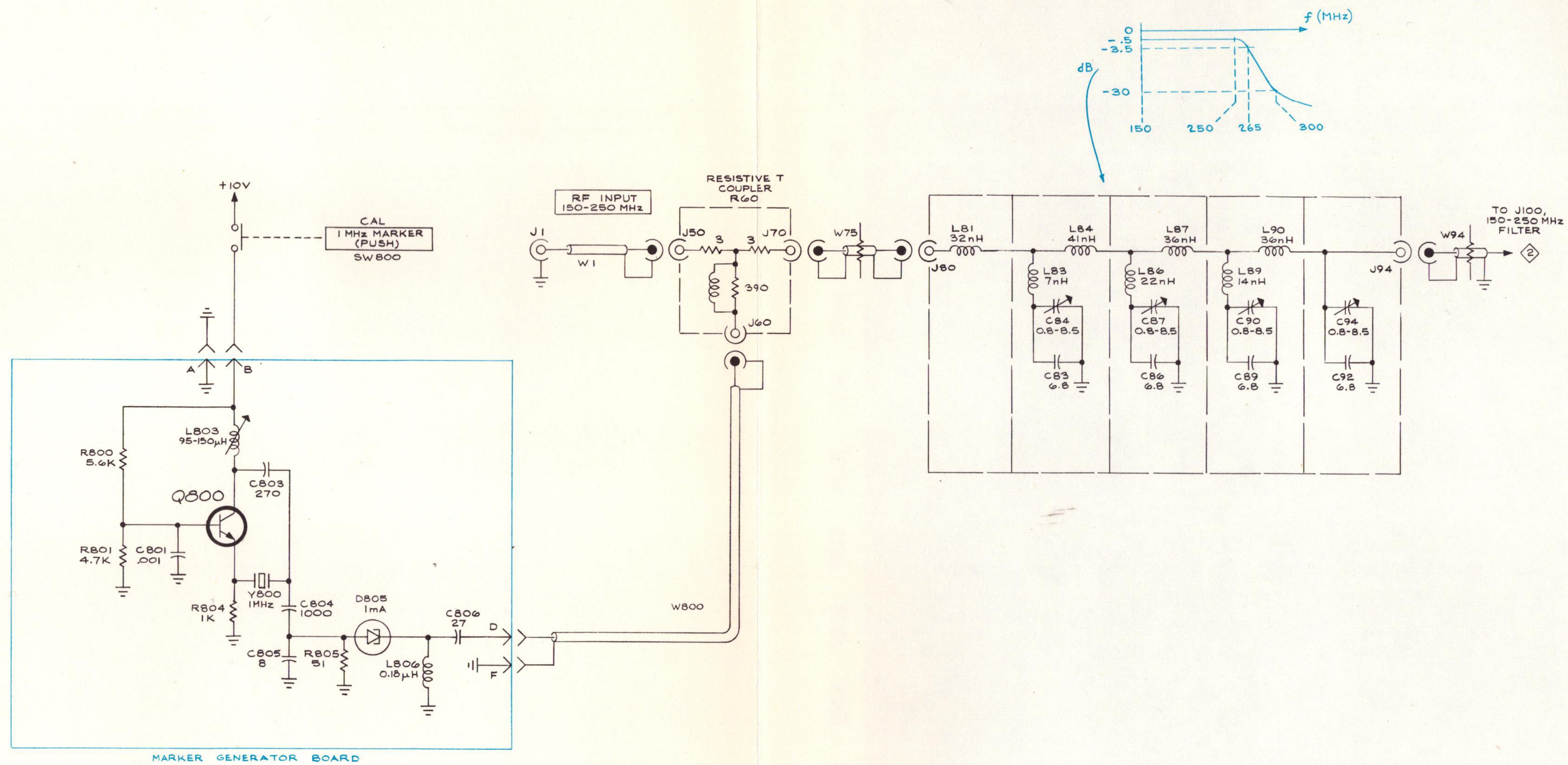
1. INPUT & CALIBRATOR
2. WIDE BAND AMPLIFIER & MIXER
3. SWEEPER CIRCUITS
4. IF ATTENUATOR
5. NARROW BAND IF AMPLIFIER 70MHz OSCILLATOR & MIXER
6. VARIABLE RESOLUTION CIRCUITS
7. OUTPUT AMPLIFIER

TYPE 1L60 SPECTRUM ANALYZER

A

1066

BLOCK DIAGRAM




REFERENCE DIAGRAMS

2 WIDE BAND AMPLIFIER & MIXER

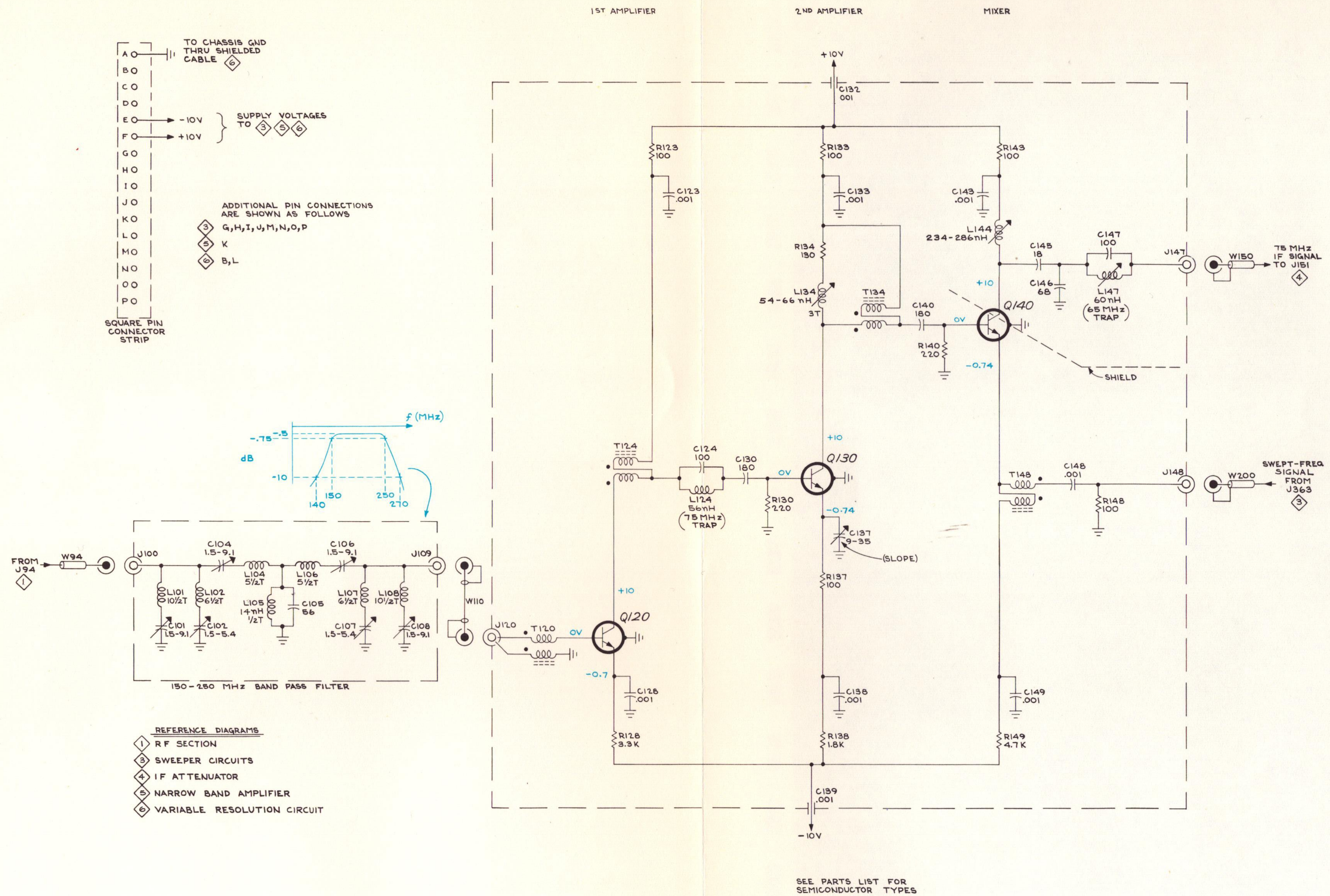
SEE PARTS LIST FOR
SEMICONDUCTOR TYPES

1066

1 MHz CALIBRATOR
MARKER GENERATOR
& RF SECTION 1

TYPE 1L60 SPECTRUM ANALYZER

A

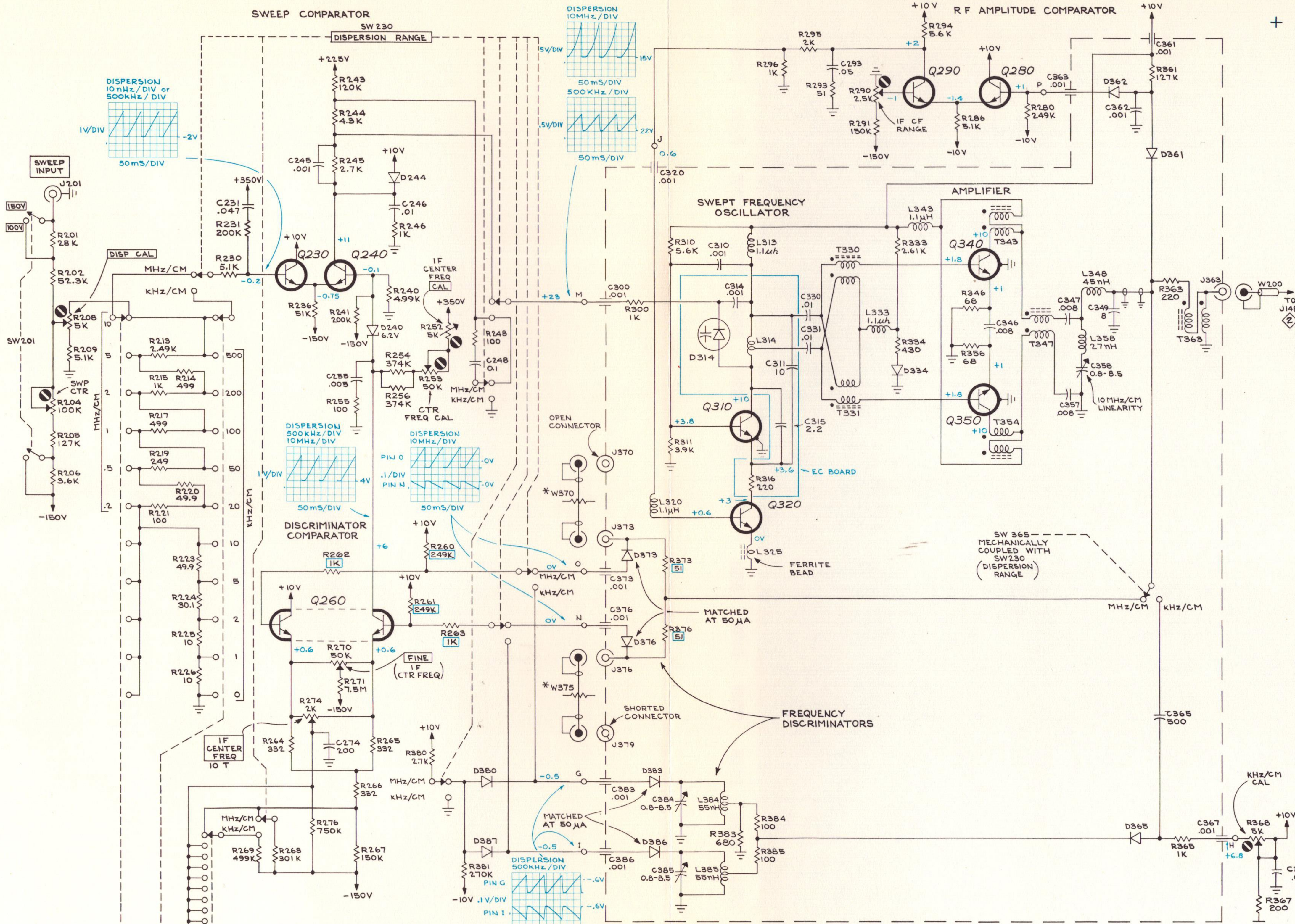



TYPE 1L60 SPECTRUM ANALYZER

A

1066

WIDE BAND AMPLIFIER AND MIXER ⟨2⟩




REFERENCE DIAGRAMS
② WIDE BAND AMPLIFIER

NOTES
SEE ② FOR SQUARE PIN CONNECTOR DETAILS
* LOSSY COAX SELECTED FOR BEST LINEARITY OF DISCRIMINATOR

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

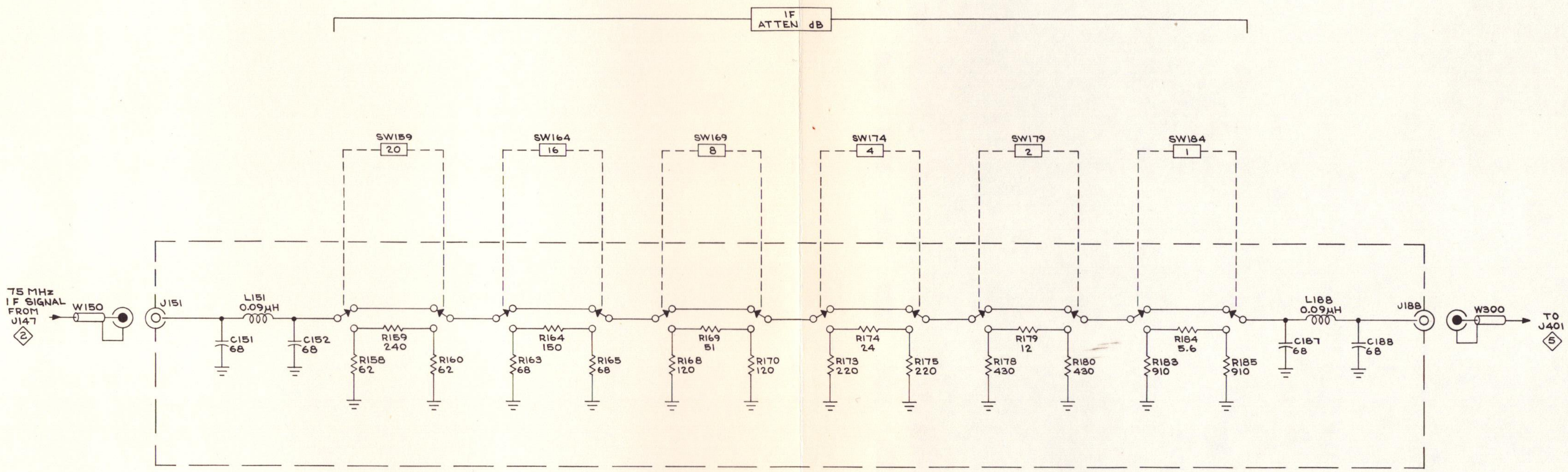
1066

TYPE 1L60 SPECTRUM ANALYZER

A

SWEEPER CIRCUITS ③

SWEEPER CIRCUITS ③

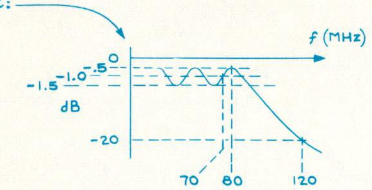


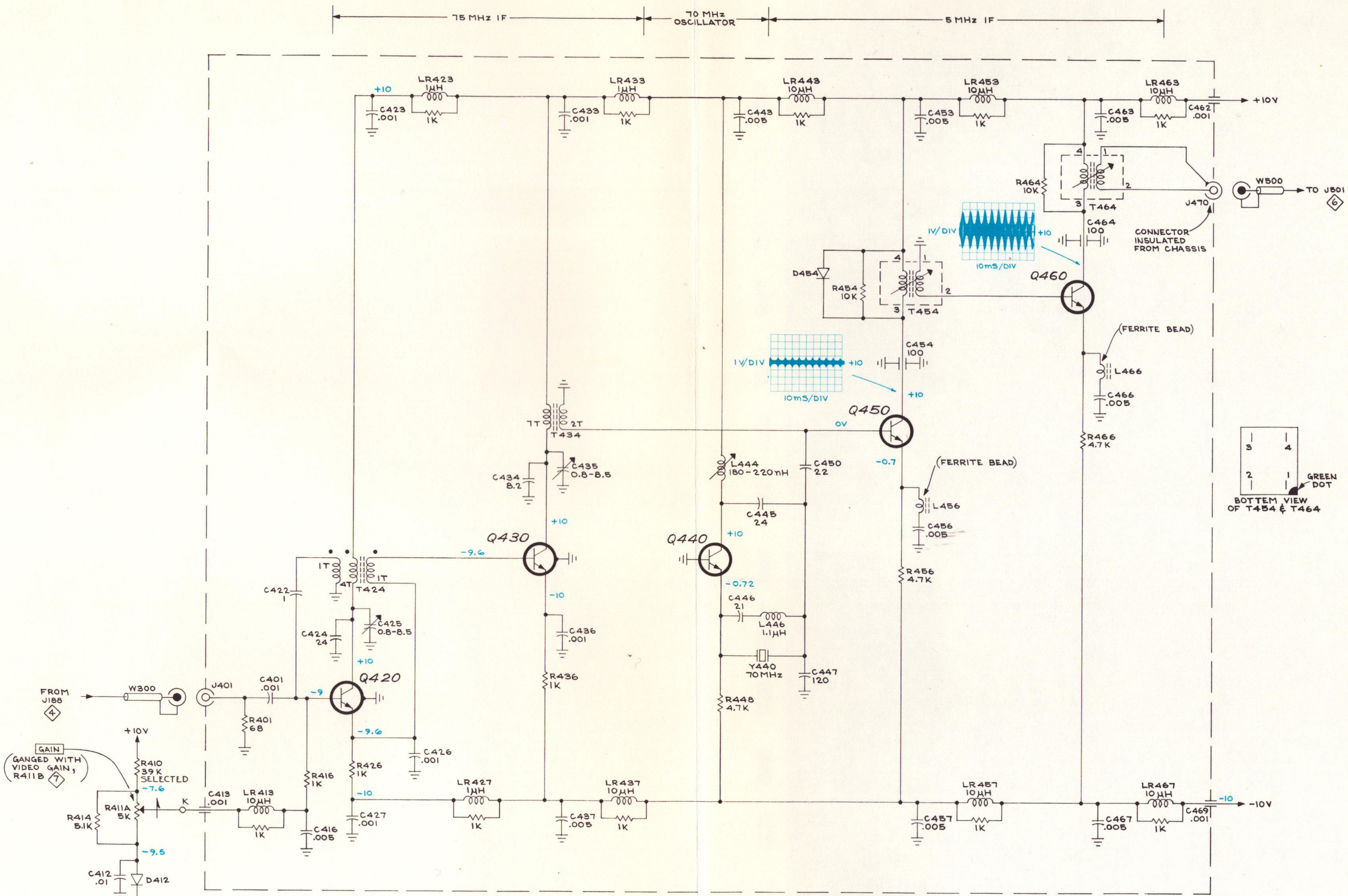

REFERENCE DIAGRAMS

2 WIDE BAND AMPLIFIER & MIXER

5 NARROW BAND IF AMPLIFIER 70MHz OSCILLATOR & MIXER

C151, L151, C152, C187, L188, C188 FORM A LOW PASS FILTER CHARACTERISTIC:






REFERENCE DIAGRAMS

- ⟨2⟩ WIDE BAND AMPLIFIER & MIXER
- ⟨4⟩ IF ATTENUATOR
- ⟨6⟩ VARIABLE RESOLUTION CIRCUITS
- ⟨7⟩ OUTPUT AMPLIFIER

NOTES:

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

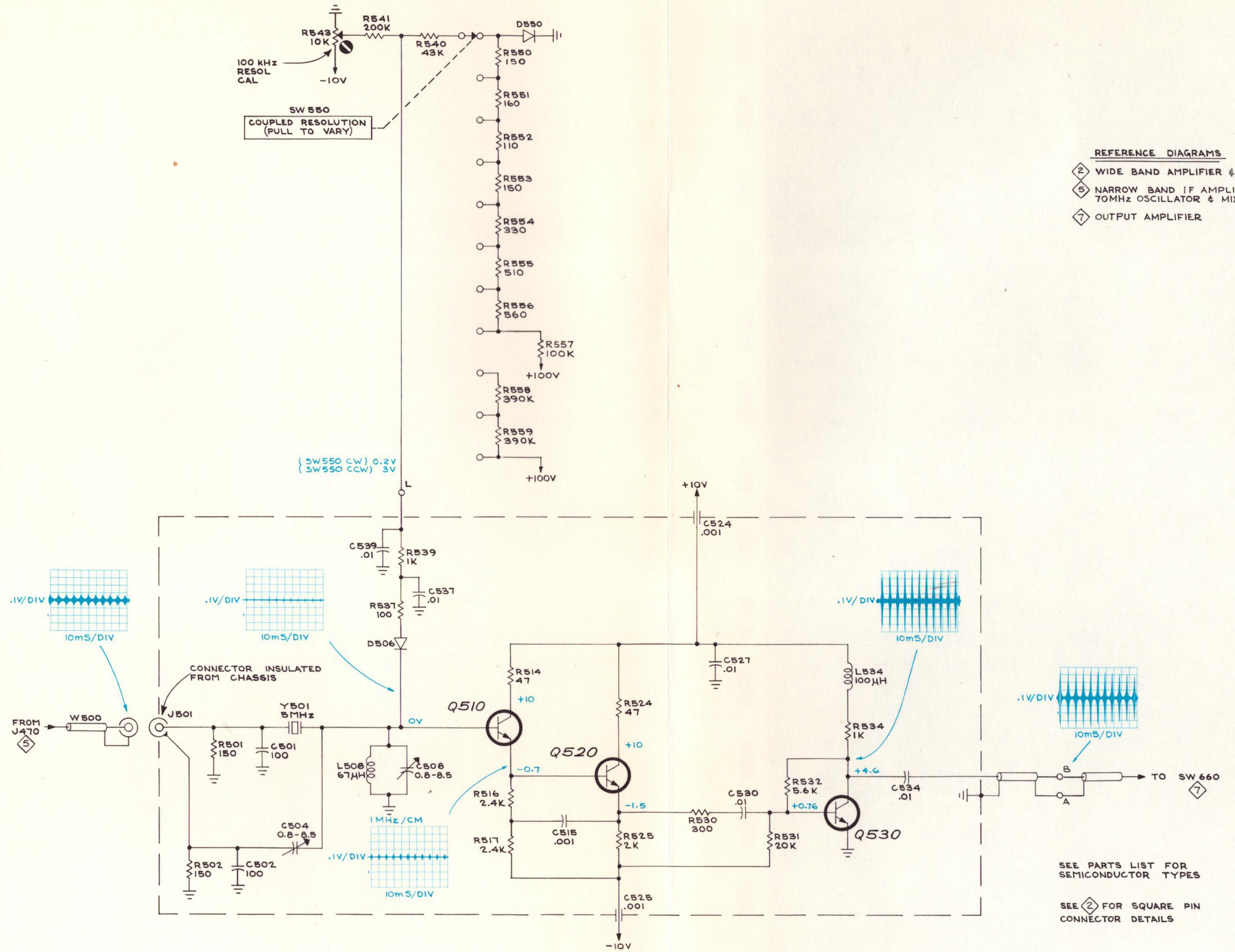
SEE ⟨2⟩ FOR SQUARE PIN CONNECTOR DETAILS

TYPE 1L60 SPECTRUM ANALYZER

A

1066

NARROW BAND IF AMPLIFIER
70 MHz OSCILLATOR & MIXER ⟨5⟩




REFERENCE DIAGRAMS

2 WIDE BAND AMPLIFIER & MIXER
5 NARROW BAND IF AMPLIFIER 70MHz OSCILLATOR & MIXER
7 OUTPUT AMPLIFIER

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

SEE 2 FOR SQUARE PIN CONNECTOR DETAILS

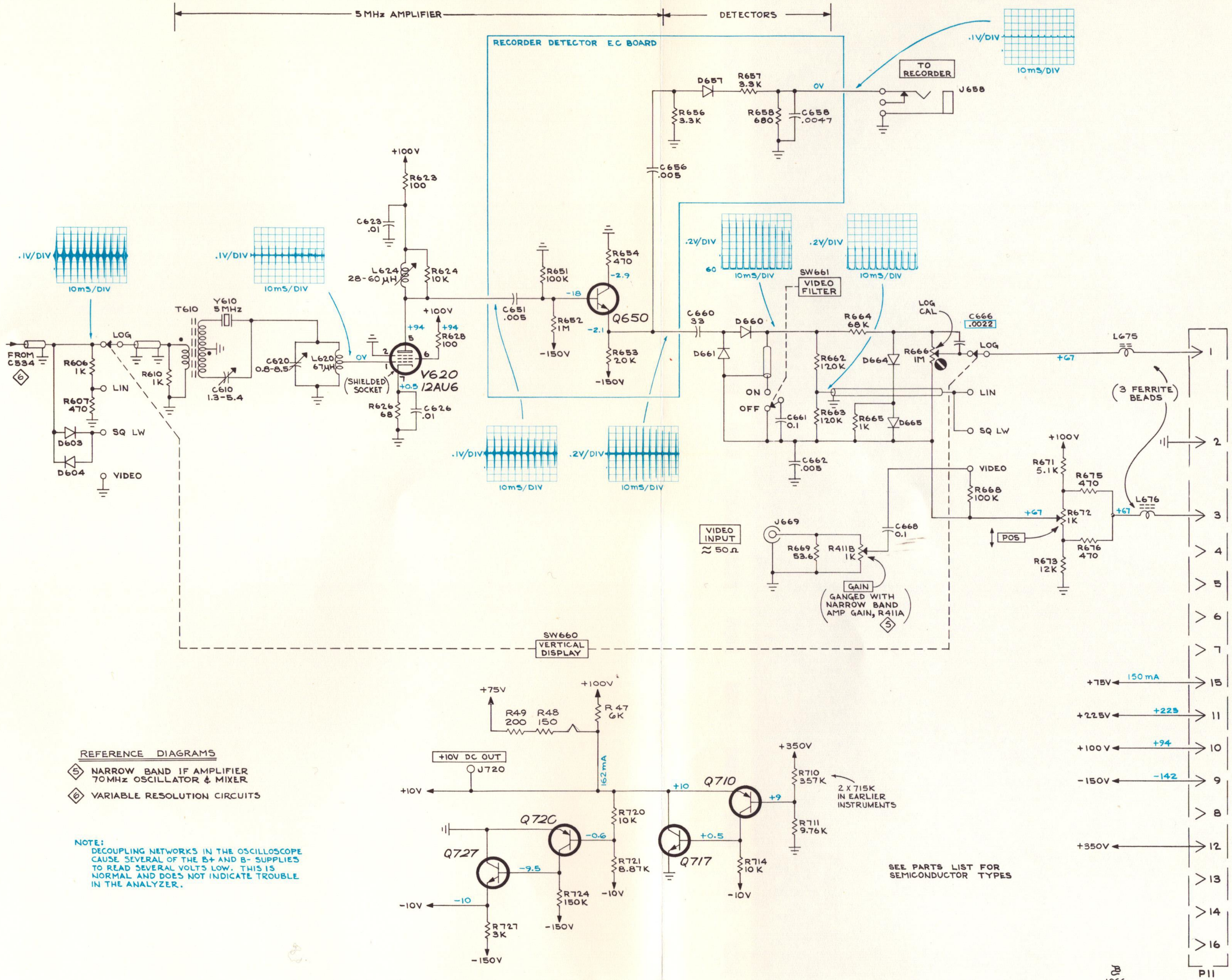
TYPE 1L60 SPECTRUM ANALYZER

A

1066

VARIABLE RESOLUTION CIRCUITS 6

VARIABLE RESOLUTION 6




TYPE 1L60 SPECTRUM ANALYZER A OUTPUT AMPLIFIER ⑦

OUTPUT AMPLIFIER ⑦

## MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

TYPE 1L60 Mod 139 G or H Addendum

## CORRECTION

Page 1-3; Fig. 1-2 A

CHANGE TO:

Coaxial Cable Tektronix Part No. 175-0395-00; to read; Coaxial Cable Tektronix Part No. 012-0098-00.

## INSERT CORRECTION

Page 1-1, TABLE 1-1

Sensitivity column;

Change " Clockwise Sensitivity " to read; " Continuous Wave Sensitivity "

Type 1L60 (Mod. 139E)

Oscillator Fundamental or Harmonic column;

Change " Fundamental (3.2 - 4.0 GHz) " to read: " Fundamental (4.0 - 5.0 GHz) "

(Mod. 139G)

Change " 3rd Harmonic " to read; " 3rd Harmonic of (4.0 - 5.0 GHz) "

(Mod. 139H)

Change " 3rd Harmonic " to read; " 3rd Harmonic of (5.0 - 6.0 GHz) "

# TEXT CORRECTION

Section 1 CHARACTERISTICS

Page 1-1, Electrical Characteristics,

Under Input Frequency, delete "Dial Accuracy ±(2MHz + 1% of dial reading)"

Section 3 CIRCUIT DESCRIPTION

Page 3-1, Block-Diagram Description,

Change second paragraph to read as follows:

A signal applied to the RF INPUT connector is fed through filter networks. These filters attenuate spurious signals outside the 150 to 250 MHz bandpass. The signal is amplified by the Wide Band Amplifier then mixed with the output signal from the Swept Frequency Oscillator circuit which is centered at 275 MHz. This swept frequency is synchronized with the time base of the associated oscilloscope.