

INSTRUCTION MANUAL

Serial Number _____

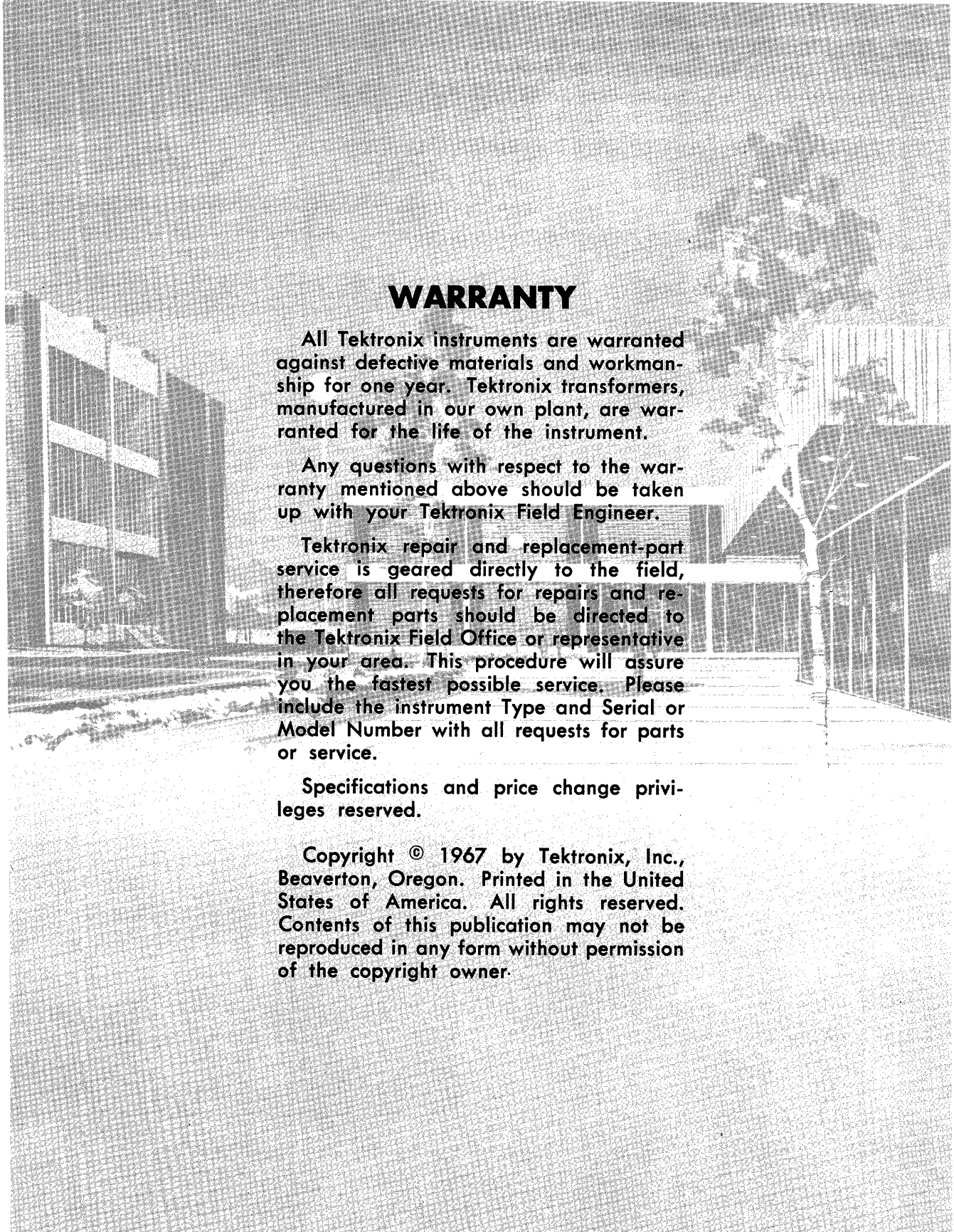
**TYPE 1L5
SPECTRUM
ANALYZER**

Tektronix, Inc.

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070-0600-01

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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.

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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.

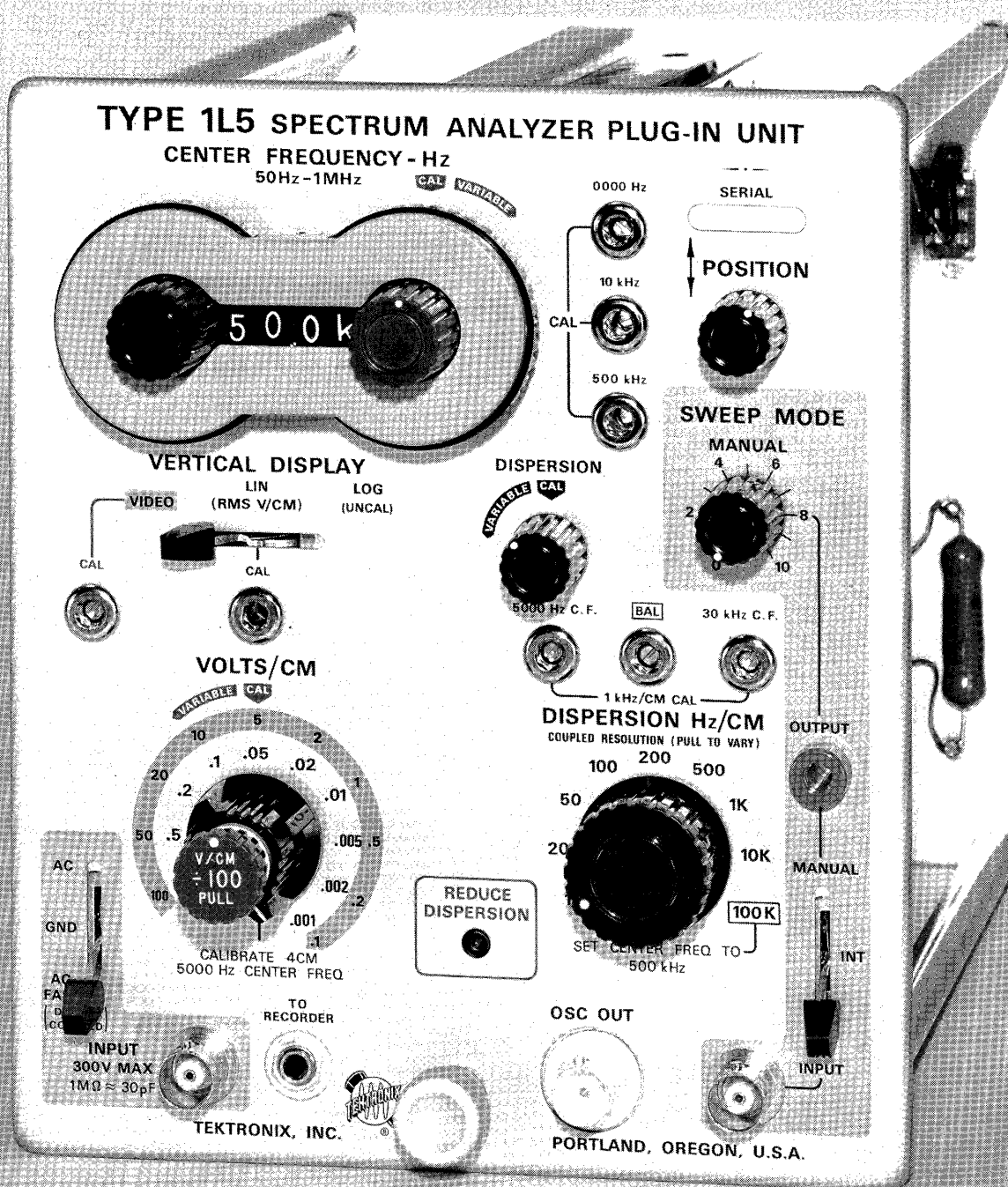


Fig. 1-1. Type 1L5 Spectrum Analyzer Plug-In Unit.

SECTION 1

CHARACTERISTICS

The Type 1L5 Spectrum Analyzer Plug-In Unit is designed for use with Tektronix oscilloscopes that accept the 1-series and letter-series plug-in units. The analyzer plugs directly into the oscilloscope which provides the required power.

The analyzer displays signal amplitude as a function of frequency for a selected portion of the spectrum. Frequency is displayed along the horizontal axis (dispersion) and signal amplitude on the vertical axis. Front panel controls provide a means to optimize the unit performance for a wide variety of applications.

The following electrical characteristics apply over an ambient temperature range of 0°C to 50°C, unless otherwise indicated, provided the environmental ambient temperature has been stable for 4 hours; and an initial warm-up period of 20 minutes, with power applied, is provided for the instrument to stabilize. The performance check procedure given in Section 5 of this manual provides a convenient method of checking the Operating requirements listed in this section.

FREQUENCY DISPLAY (Horizontal Axis)

Characteristic	Operating Requirements	Supplemental Information
Center Frequency Range	50 Hz to 990 kHz	In 10 Hz steps, 50 Hz to 990 Hz In 100 Hz steps, 1000 Hz to 9900 Hz In 1 kHz steps, 10 kHz to 99 kHz In 10 kHz steps, 100 kHz to 990 kHz
Variable	≥ 10 kHz at the Center Frequency of 990 kHz	Extends the Center Frequency to 1 MHz or higher
Center Frequency Accuracy		VARIABLE control must be in the CAL position. The temperature coefficient (50 Hz/°C, 100 Hz/°C and 200 Hz/°C) applies after a stable ambient temperature period of 4 hrs., minimum.
50 Hz to 990 Hz	$\pm (5\% + 50 \text{ Hz} + 50 \text{ Hz}/^\circ\text{C max.})$ $\leq 1000 \text{ Hz change from } 0^\circ\text{C to } 50^\circ\text{C}$	
1000 Hz to 9900 Hz	$\pm (5\% + 100 \text{ Hz} + 100 \text{ Hz}/^\circ\text{C max.})$ $\leq 2500 \text{ Hz change from } 0^\circ\text{C to } 50^\circ\text{C}$	
10 kHz to 99 kHz	$\pm (5\% + 3 \text{ kHz} + 200 \text{ Hz}/^\circ\text{C})$	
100 kHz to 990 kHz	$\pm (5\% + 10 \text{ kHz} + 200 \text{ Hz}/^\circ\text{C})$	
Stability		
50 Hz to 9900 Hz	$\leq 100 \text{ Hz/hr at a stable } (\pm 1^\circ\text{C}) \text{ ambient temperature.}$	
Dispersion Accuracy		Measured over the center 8 centimeters of the display. Upper limit of dispersion window must not exceed 10 kHz for the 50 Hz to 9900 Hz Center Frequency range, or 1 MHz for the 10 kHz to 990 kHz Center Frequency range. Accuracy for a given Center Frequency can be improved with front panel calibration controls.
Center Frequency		
50 Hz to 9900 Hz	$\pm 10\%$ at $25^\circ\text{C} \pm 5^\circ\text{C}$. Increases to $\pm 20\%$ at $25^\circ\text{C} \pm 25^\circ\text{C}$	
10 kHz to 990 kHz	$\pm 15\%$	
Linearity	Within $\pm 3\%$ (20°C to 50°C) Within $\pm 6\%$ (0°C to 50°C)	
Resolution Bandwidth	$\leq 10 \text{ Hz to } \geq 500 \text{ Hz}$ (20°C to 30°C) $\leq 20 \text{ Hz to } \geq 500 \text{ Hz}$ (0°C to 50°C)	With $\leq \pm 1 \text{ dB}$ amplitude change at $25^\circ\text{C} \pm 5^\circ\text{C}$.
Input R and C		$\approx 1 \text{ M}\Omega$, $\approx 30 \text{ pF}$
Input Voltage, Maximum		300 V (DC + peak AC)
VARIABLE VOLTS/CM Control	$\geq 3:1$ attenuation range from indicated VOLTS/CM position	
VIDEO (Time vs Amplitude) Display		
Frequency Response		
.5 VOLTS/CM to 100 VOLTS/CM	$\leq 10 \text{ Hz to } \geq 1 \text{ MHz}$	
.1 VOLTS/CM and .2 VOLTS/CM	$\leq 10 \text{ Hz to } \geq 700 \text{ kHz}$	

AMPLITUDE DISPLAY (Vertical Axis) cont

Characteristic	Performance Requirements	Supplemental Information
VOLTS/CM Range	0.1 to 100 volts peak to peak	Increased to 1 mV to 1.0 V with the V/CM $\div$ 100 knob pulled out
Accuracy	Within $\pm 6\%$	Increased to $\pm 3\%$ when the V/CM $\div$ 100 knob is pulled out
V/CM $\div$ 100 Accuracy	Within $\pm 3\%$	Increases vertical sensitivity by a factor of 100 with the knob pulled out
LIN (Spectrum) Display Volts/CM Range	0.001 to 2; RMS volts	In 11 calibrated steps
Accuracy	Within $\pm 6\%$ (V/CM $\div$ 100 knob pulled out) 20°C to 30°C Within $\pm 3\%$ (V/CM $\div$ 100 knob pushed in) 20°C to 30°C	When calibrated with internal CALIBRATE signal. Increases to $\pm 3\%$ with V/CM $\div$ 100 knob pushed in
Display Flatness .001 VOLTS/CM and .002 VOLTS/CM	+0.5 dB, -3.0 dB	Over the frequency range of 10 Hz to 1 MHz; 5000 Hz reference frequency
.005 VOLTS/CM to 2 VOLTS/CM	Within ± 0.5 dB	
LOG Spectrum Display Maximum Signal Level	≥ 60 dB dynamic range (50 dB above a 1 cm reference)	Log sensitivity is uncalibrated
Noise Level	$\leq 5 \mu\text{V}$ (RMS)	
Spurious Signals With a Reference Signal	≥ 50 dB below the applied signal level	Log mode
Input Grounded	$\leq 2\times$ noise level	Log mode
Zero Frequency Feedthrough		Amplitude of 0 Hz signal ≤ 1 to ≥ 4 centimeters
Intermodulation Distortion	≥ 50 dB below the applied signal levels	Log mode

OUTPUT SIGNALS

Calibrated Markers Frequency	5 kHz $\pm 1\%$	Displayed on the CRT when the VOLTS/CM selector is in the CALIBRATE 4 CM 5000 Hz CENTER FREQ position
TO RECORDER Signal	5 mV to 15 mV for a 6 centimeter display on the CRT	Into 600 Ω load
OSC OUT Signal (LO) Frequency	Must sweep ≥ 1 MHz	
Amplitude	≥ 1 volt, peak to peak	Source load ≈ 1 k Ω
POSITION Control Range	+ and - 8 CM	

ENVIRONMENTAL CHARACTERISTICS

The following environmental test limits apply when tested in accordance with the recommended test procedure. This instrument will meet the electrical performance requirements given in this section following environmental test. Complete details on environmental test procedures, including failure criteria, etc., may be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.

MECHANICAL CHARACTERISTICS

Characteristic	Information
Construction	
Chassis	Aluminum
Front-panel	Aluminum with anodized finish, red and black knobs
Circuit Boards	Glass-epoxy laminate

ENVIRONMENTAL CHARACTERISTICS

Characteristic	Performance Requirements	Supplemental Information
Temperature		
Non-operating	—40°C to +65°C	
Operating	0°C to +50°C	Instrument must stabilize at an ambient temperature within this range for 4 hours, before operation.
Altitude		
Non-operating	To 50,000 feet	
Operating	To 15,000 feet	
Vibration		
Operating	15 minutes each axis at 0.015 inches; frequency varied from 10-50-10 c/s at 1-minute cycles. Three minutes each axis at any resonant point or at 50 c/s	Tested with instrument secured to vibration platform
Shock		
Non-operating	30 g's, 1/2 sine, 11 ms duration, 1 shock per axis	Guillotine-type shocks
Transportation		
Package Vibration	1 hour at 1 g	
Package Drop	30 inches on one corner, all edges radiating from that corner and all flat surfaces.	Total of 10 drops

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

SECTION 2

OPERATING INSTRUCTIONS

Introduction

A Spectrum Analyzer is an instrument that graphically presents a plot of amplitude as a function of frequency for a selected portion of the spectrum. The Type 1L5 is designed to provide a spectral display of the frequency distribution of electromagnetic energy within the frequency range of 10 Hz to 1 MHz. Signals are displayed as a spectrum on an associated oscilloscope CRT screen with signal energy plotted on the vertical axis against frequency on the horizontal axis.

This type of display provides the following information. The presence or absence of signals within a frequency spectrum, their frequencies, frequency drift, relative amplitude of the signals and the nature of modulation if any, plus many other characteristics.

This section of the manual describes the function of the front panel controls and connectors, and includes a procedure for first time operation to introduce the operator to the operational function of controls. The remainder of the section describes operation techniques and gives some measurement applications with signal interpretations.

Installation

The unit is designed to operate in any Tektronix oscilloscope accepting letter- or I-series plug-in units. In addition, it may be used with a Tektronix Type 127, 132 or 133 Plug-In Power Supply, with the output displayed on the CRT of any oscilloscope that has a 100 or 150 volt sweep voltage available.

Oscilloscope Modification

If the Type 1L5 Spectrum Analyzer is to be used with previous Tektronix Type 541, 541A, 543, 543A, 545 or 545A oscilloscopes, a modification is required to the plug-in oscilloscope to correct undesirable display distortion and dispersion non-linearity. This distortion is caused by a part of the vertical output signal from the Vertical Signal Out C.F. V1223A (V1050B, Type 545), feeding into Spectrum Analyzer on the +225 V supply. The distortion appears as a change of dispersion linearity with a change of the analyzer GAIN control setting and is most noticeable in the narrow dispersion settings such as 100 kHz/cm. It also appears as a non-symmetrical response to a CW signal in which the slope of one side of the signal drops abruptly to the base line. See Fig. 2-1.

Change the +225 volt supply for the Vertical Signal Out C.F. (V1223A cathode resistor) from the junction of R1008 and R1007 (R1153 and R1152, Type 545) or the +225 V (DEC) and connect it to the other side of R1008 (R1153, Type 545) which is the +225 V supply. See Fig. 2-2.

Spectrum Analyzer Terms

The following glossary of spectrum analyzer terms is

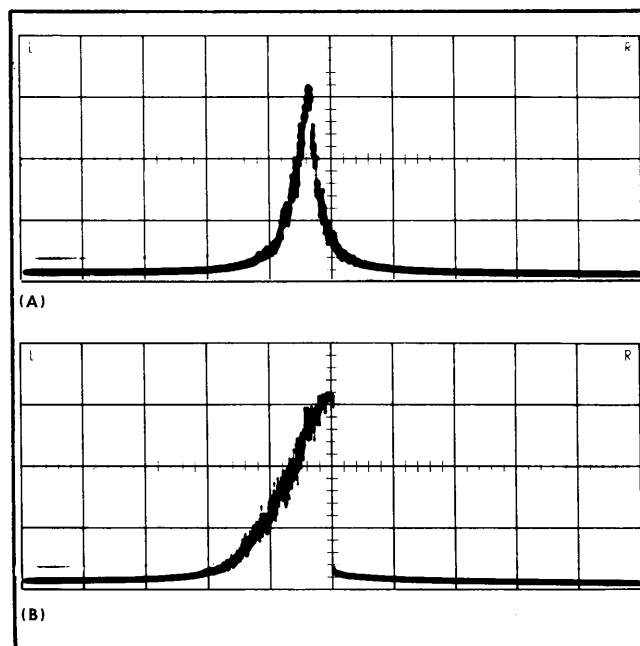


Fig. 2-1. (A) Normal response to a cw signal. (B) Effect of distortion on a cw signal.

presented as an aid to understanding the terms as they are used in this manual.

Spectrum Analyzer—A device that displays a graph of the relative power distribution as a function of frequency, typically on a cathode-ray tube or chart recorder.

Types: Real-time and non real-time.

A real-time spectrum analyzer performs a continuous analysis of the incoming signal, with the time sequence of events preserved between input and output.

A non-real-time spectrum analyzer performs an analysis of a repetitive event by a sampling process.

Methods: Swept front end and swept intermediate frequency.

A swept front end spectrum analyzer is a superheterodyne spectrum analyzer in which the first local oscillator is swept.

A swept IF spectrum analyzer is a superheterodyne spectrum analyzer in which a local oscillator other than the first is swept.

Center frequency (radio frequency or intermediate frequency)—That frequency which corresponds to the center of the reference coordinate.

Center frequency range (radio frequency)—That range of frequencies which can be displayed at the center of the

Operating Instructions—Type 1L5

reference coordinate. When referred to a control (e.g., Intermediate Frequency Center Frequency Range) the term indicates the amount of frequency change available with the control.

Dispersion (sweep width)—The frequency sweep excursion over the frequency axis of the display. Can be expressed as frequency/full frequency axis, or frequency (Hz)/division in a linear display.

Display flatness—Uniformity of amplitude response over the rated maximum dispersion (usually in units of dB).

Drift (frequency drift)—Long term frequency changes or instabilities caused by a frequency change in the spectrum analyzer local oscillators. Drift limits the time interval that a spectrum analyzer can be used without retuning or re-setting the front panel controls (units may be Hz/s, Hz/°C, etc).

Dynamic range (on screen)—The maximum ratio of signal amplitudes that can be simultaneously observed within the graticule (usually in units of dB).

Dynamic range (maximum useful)—The ratio between the maximum input power and the spectrum analyzer sensitivity (usually in units of dB).

Frequency band—A range of frequencies that can be covered without switching.

Frequency scale—The range of frequencies that can be read on one line of the frequency indicating dial.

Incidental frequency modulation (residual frequency modulation)—Short term frequency jitter or undesired frequency deviation caused by instabilities in the spectrum analyzer local oscillators. Incidental frequency modulation limits the usable resolution and dispersion (in units of Hz).

Incremental linearity—A term used to describe local aberrations seen as non-linearities for narrow dispersions.

Linear display—A display in which the vertical deflection is a linear function of the input signal voltage.

Linearity (dispersion linearity)—Measure of the comparison of frequency across the dispersion to a straight line frequency change. Measured by displaying a quantity of equally spaced (in frequency) frequency markers across the dispersion and observing the positional deviation of the markers from an idealized sweep as measured against a linear graticule. Linearity accuracy, expressed as a percentage, is within $\frac{\Delta W}{W} \times 100\%$ where ΔW is maximum

positional deviation and W is the full graticule width.

Maximum input power—The upper level of input power that the spectrum analyzer can accommodate without degradation in performance (spurious responses and signal compression). (Usually in units of dBm.)

Minimum usable dispersion—The narrowest dispersion obtainable for meaningful analyses. Defined as ten times the incidental frequency modulation when limited by "incidental frequency modulation" (in units of Hz).

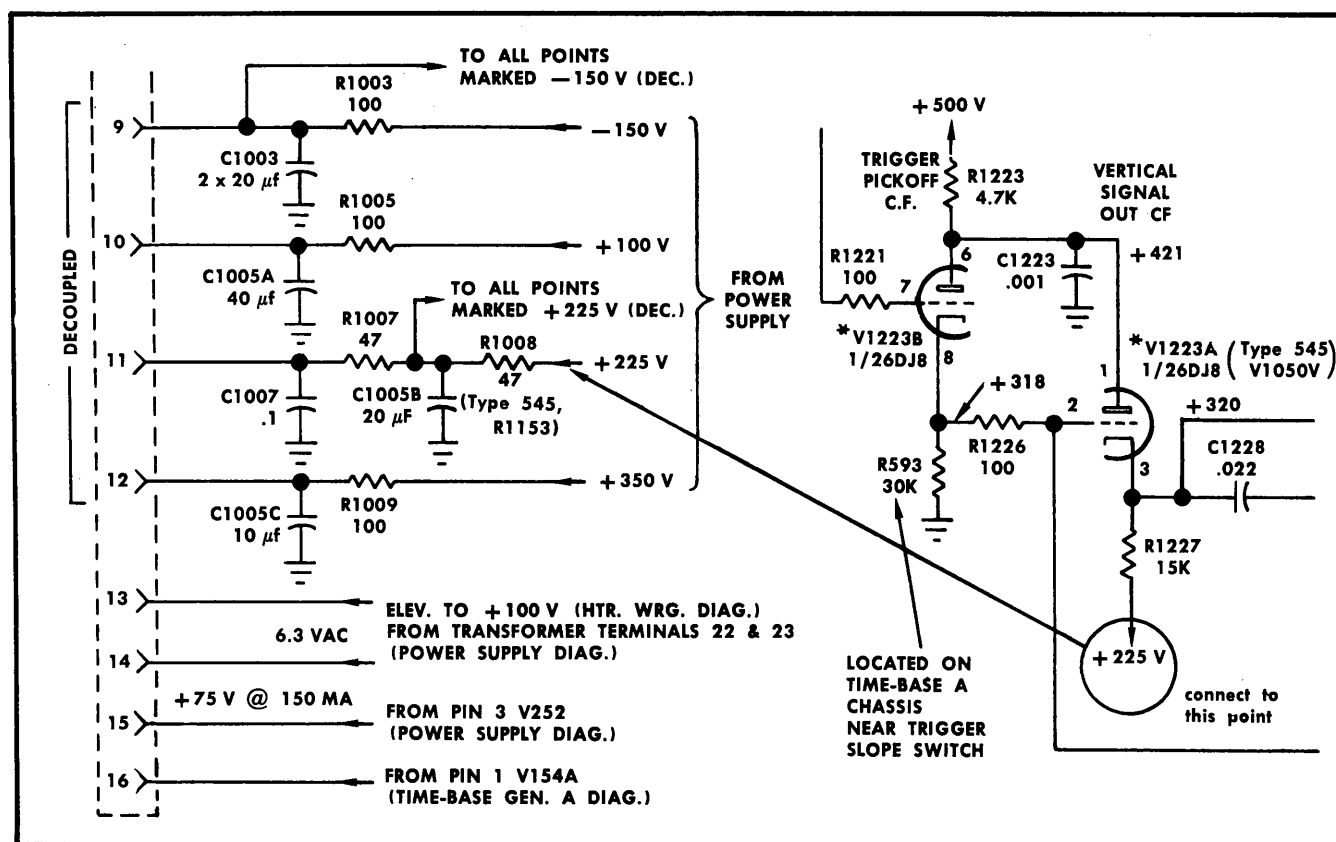


Fig. 2-2. Change as indicated on this partial schematic of the Vertical Amplifier.

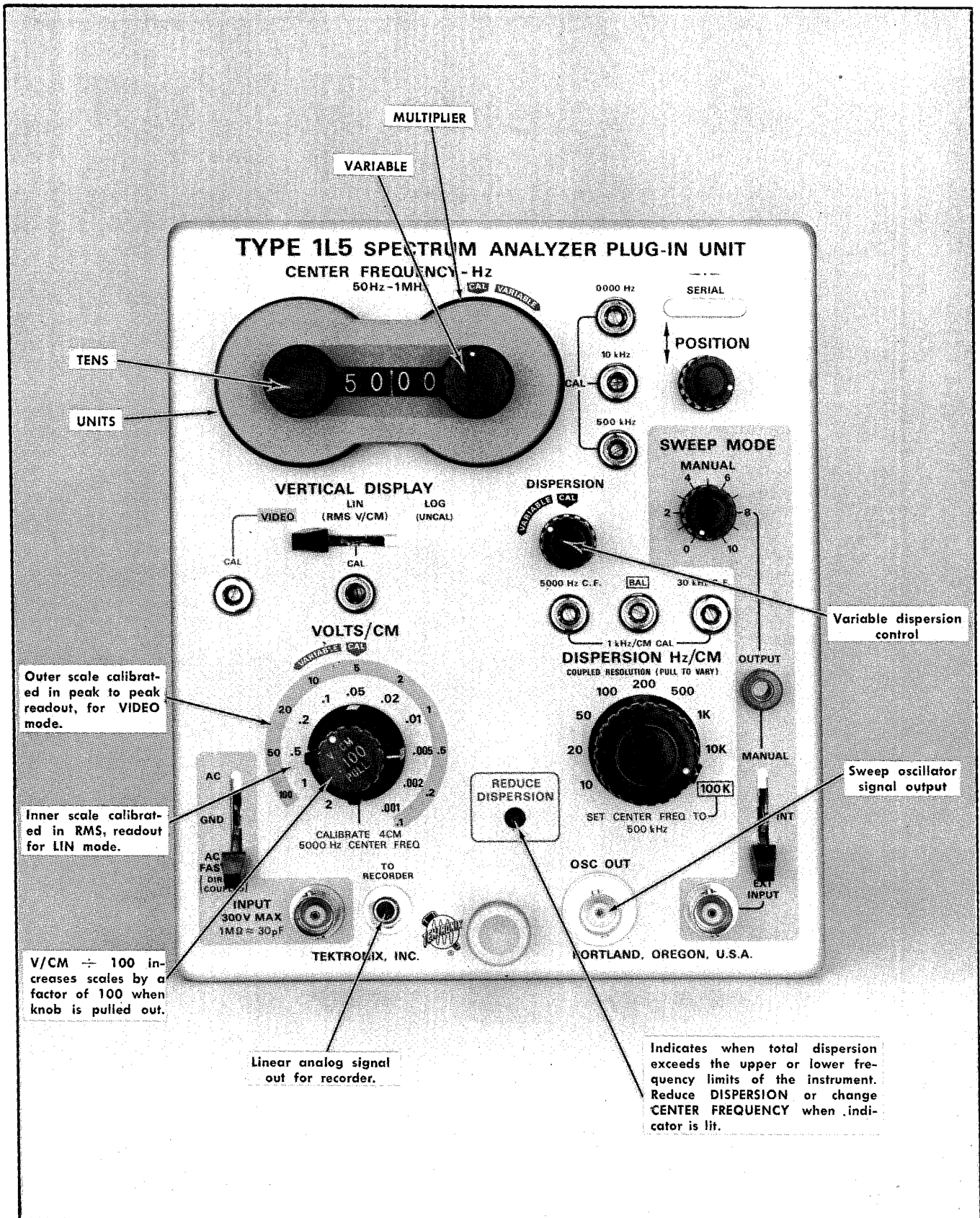


Fig. 2-3. Front-panel controls of the Type 1L5 Spectrum Analyzer Plug-In Unit.

Preliminary
1. Horizontally center the trace at the bottom of the graticule.

2. Set the three VARIABLE controls to CAL.

3. Apply EXT INPUT sweep.

6. CENTER FREQ 0000 Hz
DISPERSION 50 Hz/CM
Sweep Rate .1 s/cm
Adjust to position 0 Hz marker to the center line of the graticule.

7. CENTER FREQ 5000 Hz
DISPERSION 1 K
VERT DISPLAY LIN
VOLTS/CM CAL
Sweep Rate .1 s/cm
Adjust for a 4 cm Cal marker at center line of graticule.

8. VERTICAL DISPLAY VIDEO
VOLTS/CM .5 (Tinted)
V/CM 100 Pulled Out
Apply 20 mV Calibrator signal from the oscilloscope to the INPUT. Adjust for 4 cm display amplitude.

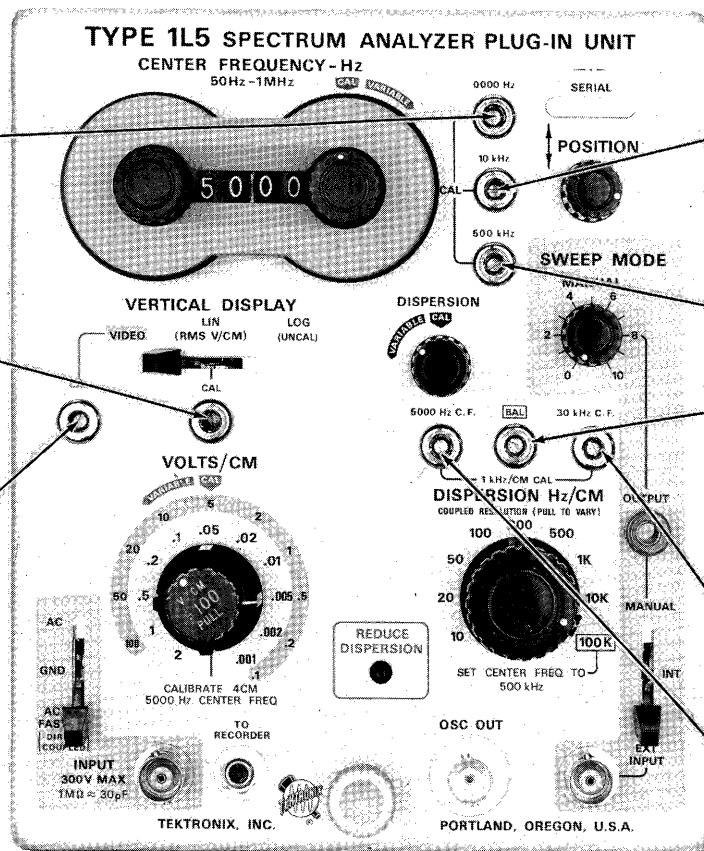
3. CENTER FREQ 10 kHz
DISPERSION 10 kHz
Adjust so 0 Hz marker is 1 cm left of graticule center.

*1. CENTER FREQ 000 k
DISPERSION Hz/CM 100 K
Adjust for minimum shift of 0 Hz marker, as DISPERSION Hz/CM is switched between 100 K and 500 positions.

2. CENTER FREQ 000 k
DISPERSION 100 KHz
Adjust to position 0 Hz marker to the graticule center line.

*4. CENTER FREQ 30 kHz
DISPERSION 1 K
Adjust for 1 cal marker/5 cm.

*5. CENTER FREQ 5,000 Hz
DISPERSION 1 K
VOLTS/CM CALIBRATE
Adjust 0000 Hz CAL to position a Cal marker to graticule center. Adjust for 1 marker/5 cm.



* If INT Sweep Mode is used, adjust the Horizontal Position control to center the 0 Hz in step 1, and adjust the VARIABLE DISPERSION control for 1 marker/5 cm in step 4 and 5.

Fig. 2-4. Front-panel calibration adjustments.

Phase Lock—The frequency synchronization of the local oscillator with a stable reference frequency.

Resolution—The ability of the spectrum analyzer to resolve and display adjacent signal frequencies. The measure of resolution is the frequency separation (in Hz) of two equal amplitude signals, the displays of which merge at the 3 dB-down point. The resolution of a given display depends on three factors; sweep speed, dispersion and the bandwidth of the most selective (usually last IF) amplifier.

Resolution bandwidth—the —6 dB bandwidth (with Gaussian response) of the analyzer, with the dispersion and sweep time adjusted for the minimum displayed bandwidth of a CW signal. Resolution and resolution bandwidth become synonymous at very long sweep times.

Optimum resolution—The best resolution obtainable for a given dispersion and a given sweep time. Theoretically or mathematically:

$$\text{Optimum resolution} = \sqrt{\frac{\text{dispersion (in Hz)}}{\text{sweep time (in seconds)}}}$$

Optimum resolution bandwidth—The bandwidth at which best resolution is obtained for a given dispersion and sweep time. Theoretically and mathematically: Optimum resolution bandwidth = $0.66 \sqrt{\frac{\text{Dispersion (in Hz)}}{\text{Sweep time (in seconds)}}}$.

Safe power level—The upper level of input power that the spectrum analyzer can accommodate without physical damage (usually in units of dBm).

Scanning velocity—Product of dispersion and sweep repetition rate (units of Hz/unit time).

Sensitivity—Rating factor of spectrum analyzers ability to display signals.

1. Signal equals noise: That input signal level (usually in dBm) required to produce a display in which the signal level above the residual noise is equal to the residual noise level above the baseline. Expressed as: Signal + noise = twice noise.

2. Minimum discernible signal: That input signal level (usually in dBm) required to produce a display in which the signal is just visible within the noise.

Skirt selectivity—A measure of the resolution capability of the spectrum analyzer when displaying signals of unequal amplitude. A unit of measure (usually in Hz) is the bandwidth at some level below the 6 dB down points. For example 10 dB, 20 dB or 40 dB down.

Spurious response (spuri, spur)—An erroneous display or signal which does not conform to the indicated frequency or dial reading. Spuri and spur are the colloquialisms used to mean spurious response (plural) or spurious response (singular) respectively. Spurious responses are of the following type:

1. IF feedthrough—Signal frequencies within the IF passband of the spectrum analyzer that are not converted in the first mixer but pass through the IF amplifier and produce displays on the CRT that are not tunable with the RF center frequency controls.

2. Image response—The superheterodyne process results in two major IF responses, separated from each other by

twice the IF. The spectrum analyzer is usually calibrated to only one of these two responses. The other is called the image.

3. Harmonic conversion—The spectrum analyzer will respond to signals that mix with harmonics of the local oscillator and produce the intermediate frequency. Most spectrum analyzers have dials calibrated for some of these higher order conversions. The uncalibrated conversions are spurious responses.

4. Intermodulation—In the case of more than one input signal, the myriad of combinations of the sums and differences of these signals between themselves and their multiples, creates extraneous responses known as intermodulation. The most harmful intermodulation is third order, caused by the second harmonic of one signal combining with the fundamental of another.

5. Video detection—The first mixer will act as a video detector if sufficient input signal is applied. A narrow pulse may have sufficient energy at the intermediate frequency to show up as intermediate frequency feedthrough.

6. Internal—A spurious response on the display caused by a signal generated within the spectrum analyzer that is in no way connected with an external signal.

7. Anomalous IF responses—The filter characteristic of the resolution-determining amplifier may exhibit extraneous passbands. This results in extraneous spectrum analyzer responses when a signal is being analyzed.

8. Zero frequency feedthrough—(zero pip)—The response produced when the first local oscillator frequency is within the IF passband. This corresponds to zero input frequency and is sometimes not suppressed so as to act as a zero frequency marker.

Sweep repetition rate—The number of sweep excursions per unit of time. Approximately the inverse of sweep time for a free-running sweep.

Sweep time—The time required for the spot in the reference coordinate (frequency in spectrum analyzer) to move across the graticule. (In a linear spectrum system, sweep time is Time/Division multiplied by total divisions.)

CONTROLS AND CONNECTORS

The following is a brief description of the operation or function of the controls and connectors on the front panel. See Fig. 2-1. A more detailed description is given later in this section under operating information.

CENTER FREQUENCY-Hz Selector	Tunes the center frequency of the display from 50 Hz to 990 kHz.
CENTER FREQUENCY CAL Adjustment	Calibrates the Center Frequency at 0000 Hz, 10 kHz and 500 kHz.
VARIABLE CENTER FREQUENCY Control	Provides variable, adjustment of the Center Frequency. Extends the center frequency to 1 MHz when the CENTER FREQUENCY selector is in the 990 K position.
POSITION Control	Vertically positions display.

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VERTICAL DISPLAY Switch	LIN (RMS V/CM)—Selects linear display mode LOG—Selects a logarithmic display VIDEO—Selects an analog display (amplitude versus time). Use tinted VOLTS/CM scale for video displays, to measure amplitudes. VIDEO CAL Adjustment—Calibrates vertical deflection factor, in peak to peak voltage, for VIDEO mode. LIN CAL Adjustment—Calibrates vertical deflection factor, in RMS voltage, for LIN mode.	For example: 5 kHz Center Frequency with 10 kHz/CM dispersion. 5000 Hz C.F. CAL Adjustment—Calibrates the dispersion for the CENTER FREQUENCY-Hz selector range, 10 Hz to 9900 Hz. 30 kHz C.F. CAL Adjustment—Calibrates the dispersion for the CENTER FREQUENCY-Hz selector range, 10 kHz to 990 kHz. BAL Adjustment—Sets dispersion balance to position the center frequency of the display to the center of the graticule.
VOLTS/CM Selector	Selects deflection factors from 0.1 V/cm to 100 V/cm (peak to peak) in VIDEO mode, and .001 V/cm to 2 V/cm (RMS) in the LIN mode. Selection is in a 1-2-5 sequence.	Control is coupled with the DISPERSION selector. Pull to vary resolution. Resolution range ≤ 10 Hz to ≥ 500 Hz.
V/CM $\div$ 100 Push-pull Switch	Extends minimum vertical deflection factor to 10 μ V/cm by increasing the vertical sensitivity by a factor of 100.	MANUAL—Connects the MANUAL control to the sweep circuit to manually scan the spectrum display.
VARIABLE VOLTS/CM Control	Rotation of the same knob provides overlapping variable adjustment of the VOLTS/CM selections.	INT—Scans the spectrum display using the internal sawtooth signal supplied to the plug-in compartment (not available on all oscilloscopes, see Table 2-1).
Input Coupling Selector	AC—Capacitively couples the input signal to the input amplifier. GND—Grounds input amplifier and provides a zero volt DC reference. AC FAST (DIRECT COUPLED)—Directly couples input signal to the input amplifier to eliminate the RC time constant drift, when a DC biased signal is applied to the INPUT connector.	EXT INPUT—Scans the spectrum display using a sweep sawtooth signal connected to the EXT INPUT connector by an external jumper cable from the oscilloscope front-panel sawtooth output connector.
INPUT Connector	Connects signal to the unit. Maximum input, 300 volts (DC + peak AC). Input time constant, approximately 30 μ s. (Approximately 30 pF paralleled by 1 megohm.)	OUTPUT Banana Jack—Provides a front panel signal from the MANUAL control. When connected to the oscilloscope External Horizontal Input circuit, this signal moves the beam across the CRT in step with the frequency changes caused by rotation of the MANUAL control.
DISPERSION	Hz/CM Selector—Selects dispersion (frequency excursion of the display), from 10 Hz/CM to 100 kHz/CM. VARIABLE Dispersion Control—Provides a continuously variable adjustment of dispersion from near zero dispersion to the selected dispersion set by the Hz/CM switch. REDUCE DISPERSION Indicator—Lights when improper settings of the CENTER FREQUENCY and DISPERSION controls are selected. Indicates that the display may be misleading.	TO RECORDER Jack Provides a linear analog voltage output from the spectral display for external recorders. OSC OUT Connector Provides an output signal from the swept local oscillator, equal to or greater than 1 volt into a 1 kΩ load.

FRONT PANEL ADJUSTMENTS

Introduction

Front panel calibration adjustments are provided on the Type 1L5 to enable the operator to calibrate the following parameters: Vertical deflection factor, center frequency and dispersion. The calibration of these parameters is affected by the sawtooth voltage amplitude and vertical sensitivity of the oscilloscope main frame, it is therefore necessary to readjust, or check the calibration of these

adjustments when the analyzer is shifted from one main frame oscilloscope to another.

An internal calibrator and a 0 Hz spurious frequency marker provide a means to check or calibrate these parameters. The internal calibrator is a 5 kHz signal. It is coupled into spectrum analyzer display when the VOLTS/CM selector is switched to the CALIBRATE 4 CM 5000 Hz CENTER FREQ position. The amplitude and frequency of this signal provides both an amplitude reference and a frequency reference. Harmonics of this 5 kHz marker are observable to a center frequency of 100 kHz and in most cases to 200 kHz. The 0 Hz frequency marker occurs when the swept local oscillator frequency passes through the passband of the 1st amplifier. It appears on the spectrum as a 0 Hz or start marker signal and is used to calibrate the low frequency end of the display.

Front Panel Calibration Adjustment Procedure. See Fig. 2-4.

The following calibration procedure describes the front panel calibration adjustments. When adjusted, the Type 1L5 will make the specified accuracies at all frequencies and dispersion settings, within the operating limits of the unit. More accurate calibration can be obtained for specific frequencies and dispersion settings by adjusting the front panel adjustments for these specific settings. For example: The center frequency tracking can be accurately set to any frequency where a marker can be observed (to approximately 200 kHz) by means of the 10 kHz or 0000 Hz CAL adjustments. Accurate adjustments can be made above 200 kHz if an external reference frequency is available.

The calibration adjustments are grouped into three categories: center frequency adjustments, dispersion adjustments and amplitude adjustments. The following procedure is elaborated step by step to familiarize the operator with these adjustments so he may calibrate the instrument at any desired setting of the CENTER FREQUENCY and DISPERSION controls.

Preliminary

a. Set the Sweep Voltage selector at the rear panel of the Type 1L5 to the correct position (100 V or 150 V) for the oscilloscope being used. Table 2-1 lists some Tektronix oscilloscope types with their sweep voltage output and those that provide an internal sweep voltage to the plug-in connector. If your oscilloscope is not listed, check the specifications given in the oscilloscope Instruction Manual for the front panel sawtooth out signal amplitude.

TABLE 2-1

100 Volt Sawtooth	150 Volt Sawtooth	Internal Sawtooth
Type 544	All 530 Series	Type 549
Type 546	Type 543	Type 556
Type 547	Type 545 (A and B)	
Type 556	Type 549	
	Type 555	
	Type 580 Series	
	Type T Time-Base Plug-in	

b. Insert the Type 1L5 into the plug-in compartment, fasten the securing latch and connect a patch cord between the Oscilloscope Sweep Output and the 1L5 EXT INPUT connector.

CAUTION

Insert the plastic plug protector (part of Accessories) into the back of the banana plug on the patch cord. This will reduce shock hazard when plugging the banana plug into the Sweep Output connector on the Oscilloscope.

c. Turn the oscilloscope power ON and allow about 20 minutes warmup for the instrument to stabilize.

d. Set the Type 1L5 and plug-in oscilloscope front panel controls as follows:

CENTER FREQUENCY-Hz	000 k
VARIABLE	CAL
DISPERSION Hz/CM	100 K
VARIABLE	CAL
RESOLUTION	100 K (Coupled to Hz/CM Selector)
VERTICAL DISPLAY	LIN
Input Coupling	GND
VOLTS/CM	.5 (Outer Scale)
V/CM ÷ 100	Knob pushed in
VARIABLE	CAL
SWEEP MODE	EXT

Plug-In Oscilloscope

Time/Cm	50 ms
Triggering	Adjusted for a free running sweep

e. Position the trace to the bottom of the graticule area and horizontally center the trace.

1. Adjust 500 kHz CAL

This adjustment calibrates the 100 kHz to 990 kHz Center Frequency band. It also interacts with the 10 kHz to 99 kHz band and will usually require readjustment after the 10 kHz CAL has been performed. If you should run out of range on the adjustments, center both the 500 kHz CAL and the 10 kHz CAL and repeat.

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	000 k
VERTICAL DISPLAY	LIN
VOLTS/CM	.5
DISPERSION Hz/CM	100 K

b. Adjust the 500 kHz CAL for minimum display shift (± 1 cm) as the Hz/CM selector is switched from 100 K to 500 Hz position.

2. Adjust BAL

This adjustment sets the dispersion balance between the lower and upper center frequency decade switches.

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	000 k
VERTICAL DISPLAY	LIN
VOLTS/CM	.5
DISPERSION Hz/CM	100 K

b. Adjust BAL to position the 0 Hz marker signal response to the graticule center line.

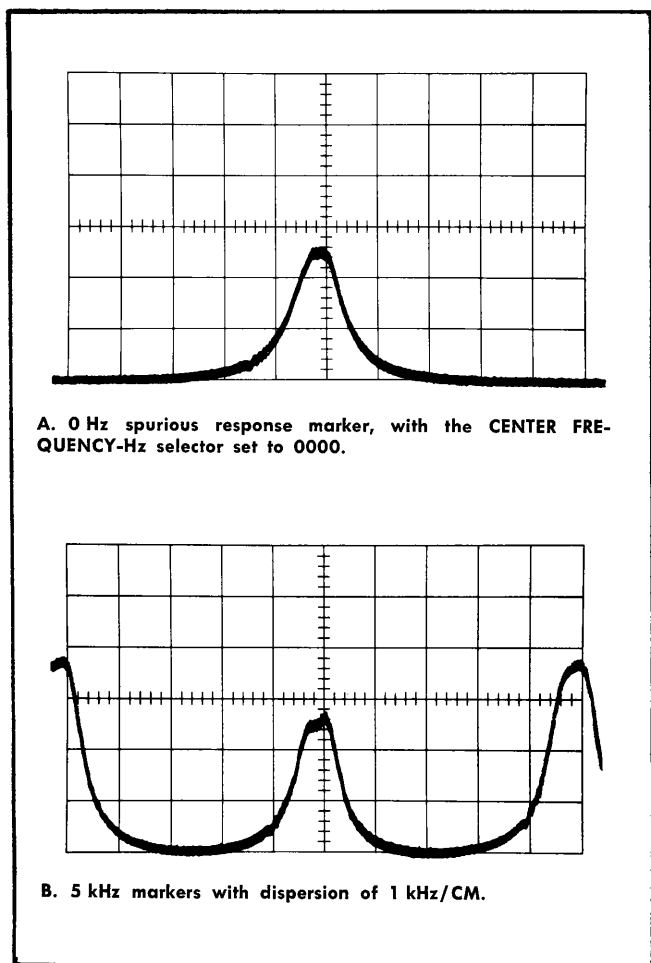


Fig. 2-5. Frequency markers to calibrate the Center Frequency and Dispersion.

NOTE

If the Type 115 is operated in INT Sweep Mode, adjust the Oscilloscope Horizontal Position control to center the 0 Hz marker.

3. Adjust 10 kHz CAL

This calibrates the 10 kHz to 99 kHz range of the center frequency switch.

- a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	10 k
VERTICAL DISPLAY	LIN
DISPERSION Hz/CM	10 K
VOLTS/CM	.5

- b. Adjust the 10 kHz CAL to align the 0 Hz marker 1 cm (± 2.5 mm) left of the graticule center.

- c. Switch the VOLTS/CM selector to CALIBRATE position, 5 kHz markers will be displayed. Adjust the 10 kHz CAL to position the second calibrator marker (to the right of the 0 Hz marker) on the graticule centerline. See Fig. 2-6A/B.

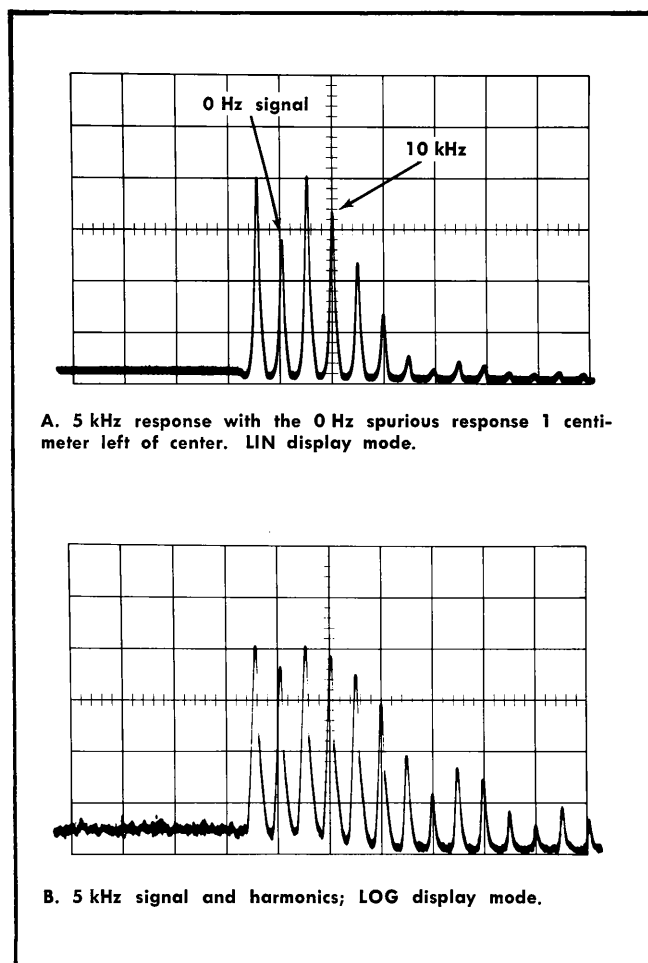


Fig. 2-6. Using the 0 Hz marker response and 5 kHz markers to calibrate dispersion and center frequency. DISPERSION Hz/CM - 10 K, CENTER FREQUENCY-Hz - 10 k.

- d. Switch the Hz/CM to 1 K position and continue adjusting the 10 kHz CAL to center the 10 kHz marker. The 10 kHz Center Frequency is now calibrated. The higher frequency positions of this CENTER FREQUENCY-Hz selector will not be as accurate; however, the errors may be evenly distributed over the range (10 kHz to 99 kHz) as follows:

Switch the CENTER FREQUENCY-Hz selector from 10 k to the 90 k position in 10 k increments. Change the 10 kHz CAL adjustment to split the error between the 10 kHz CENTER FREQUENCY display and the 90 kHz display. (The V/CM $\div$ 100 switch should be pulled out, to increase marker amplitude at the higher, CENTER FREQUENCY-Hz selector, frequency positions.)

4. Adjust 30 kHz C.F.—1 kHz/CM CAL

This control calibrates dispersion for the 10 kHz to 990 kHz CENTER FREQUENCY range.

- a. Set the controls as follows:

CENTER FREQUENCY-Hz	30 k
VERTICAL DISPLAY	LOG

VOLTS/CM	CALIBRATE
V/CM $\div$ 100	Pushed in
DISPERSION Hz/CM	1 K
RESOLUTION	100
Time/cm	50 ms

- Adjust the VARIABLE CENTER FREQUENCY control to position a marker to the center of the graticule.
- Adjust the 30 kHz C.F. adjustment for 1 marker/5 centimeters. See Fig. 2-5B.
- Recheck step 1 and step 3 because of the interaction.

NOTE

If the Type 1L5 is operated in INT Sweep Mode, adjust the VARIABLE DISPERSION control for 1 marker/5 cm as in 4 c.

5. Adjust 0000 Hz CAL -1 kHz/CM CAL

This adjustment calibrates the 50 Hz to 9900 Hz range of the CENTER FREQUENCY-Hz switch.

- Set the front panel controls as follows:

CENTER FREQUENCY-Hz	0000
VOLTS/CM	Any position other than CALIBRATE
DISPERSION Hz/CM	200
RESOLUTION	50 (Uncoupled)
Time/cm	50 ms

- Adjust the 0000 Hz CAL adjustment to position the 0 Hz marker to the center vertical line of the graticule. See Fig. 2-5A.

6. Adjust 5000 Hz C.F.—1 kHz/CM CAL

This adjustment calibrates dispersion for the 0000 Hz to 9900 Hz CENTER FREQUENCY.

- Set the controls as follows:

CENTER FREQUENCY-Hz	5000
VARIABLE	CAL
VOLTS/CM	CALIBRATE
V/CM $\div$ 100	Pushed in
DISPERSION Hz/CM	1 K
RESOLUTION	100

- Adjust the 5000 Hz C.F. screwdriver adjustment for 1 marker/5 centimeters. See Fig. 2-5B.

NOTE

If the Type 1L5 is operated in INT Sweep Mode, adjust the VARIABLE DISPERSION control for 1 marker/5 cm.

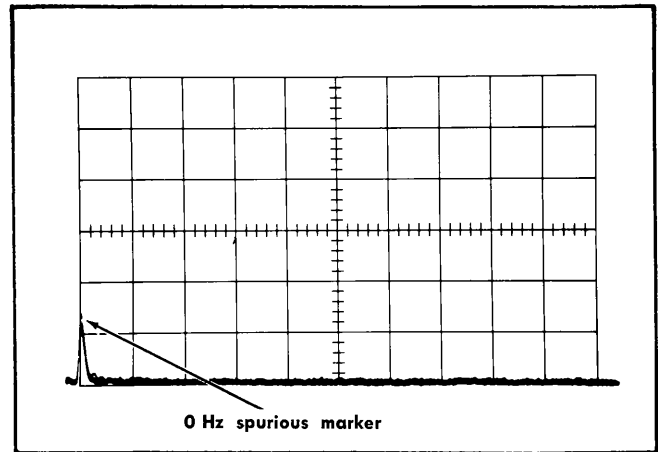


Fig. 2-7. 0 Hz marker signal adjusted to the zero graticule line.

7. Adjust LIN CAL

This adjustment calibrates vertical amplitude for LIN spectrum display mode.

- Set the front panel controls as follows:

CENTER FREQUENCY-Hz	5000
VERTICAL DISPLAY	LIN
VOLTS/CM	CALIBRATE
VARIABLE	CAL
DISPERSION Hz/CM	1 K
RESOLUTION	COUPLED
Time/cm	50 ms

- Adjust the LIN CAL adjustment so that the marker at the center line of the graticule is 4 centimeters in amplitude.

8. Adjust VIDEO CAL

This adjustment calibrates the vertical amplitude for VIDEO displays (Time versus Amplitude).

- Set the controls as follows:

Spectrum Analyzer

VERTICAL DISPLAY	VIDEO
VOLTS/CM	.5
V/CM $\div$ 100	Knob pulled out
VARIABLE	CAL
Input Selector	AC FAST

Oscilloscope

Time/cm	.5 ms
Triggering	Free running sweep (Auto)
Amplitude Calibrator	20 mVolts

- Apply the output from the oscilloscope Calibrator to the Type 1L5 INPUT connector.

Operating Instructions—Type 1L5

- c. Adjust the VIDEO CAL screwdriver adjustment so that the display amplitude is 4 centimeters.
- d. Remove the Calibrator signal from the Type 1L5 INPUT.

9. Adjust VARIABLE DISPERSION (Applies to INT Sweep Mode only)

The BAL and 30 kHz C.F. screwdriver adjustments (Steps 2 and 4) are effective only when the Type 1L5 is operated in EXT Sweep Mode. If the Type 1L5 is to be operated in INT Sweep Mode, adjust the Oscilloscope Horizontal Position control to center the 0 Hz marker in Step 2b, and adjust the VARIABLE DISPERSION control for 1 cal marker/5 centimeters in Step 4c and 5b.

Operating the Type 1L5 in a Tektronix Plug-In Unit Power Supply (Types 127, 132, 133)

The Type 1L5 can be used in conjunction with one of the above power supplies and the output displayed on the CRT of any Tektronix oscilloscope having a 100 volt or 150 volt Sawtooth Out sweep voltage available at the front panel.

For such applications, connect the equipment and set the controls as follows:

1. Connect the + Output signal from the Power Supply Unit to the DC coupled Input of the Oscilloscope.
2. Set the Vertical POSITION control of the Type 1L5 to midrange and adjust the Vertical Position control of the Oscilloscope so that the trace is centered on the graticule.
3. Apply a 2 mV calibrator signal from the Oscilloscope to the INPUT connector of the Type 1L5.
4. Set the Type 1L5 VOLTS/CM switch to .5; pull the V/CM $\div 100$ knob out, and the VERTICAL DISPLAY switch to VIDEO.
5. Adjust the Volts/Division controls of the Oscilloscope for 4 divisions of vertical amplitude.
6. Make the front panel adjustments as directed earlier in this section.

First Time Operation

The following procedure demonstrates the basic functions of the controls and connectors for the Type 1L5. We recommend this procedure for unit familiarization. This should be performed after the front panel calibration.

Time Domain Operation (Video Amplification)

- a. Set the front panel controls as follows:

VERTICAL DISPLAY	VIDEO
VOLTS/CM	.5 (Outer scale)
VARIABLE	CAL
V/CM $\div 100$	Pushed in
Input Coupling	AC or AC FAST
POSITION	Midrange

Oscilloscope

Time/cm	10 ms
Triggering	Auto, Internal source
Calibrator	2 Volts

- b. Connect a coaxial cable between the oscilloscope Cal Out connector and the Type 1L5 INPUT connector.

- c. Adjust the Triggering controls for a stable triggered display. Display should resemble Fig. 2-8A. The AC coupled stages cause the top and bottom portion of the calibrator waveform to slope.

- d. Change the VOLTS/CM and VARIABLE control settings. Note their effect on the display. Remove the signal from the Calibrator by disconnecting and removing the cable.

- e. Switch the VOLTS/CM selector to the CALIBRATE (fully clockwise) position, change the Time/Cm to .2 ms and adjust the triggering controls for a triggered display. See Fig. 2-8B. This display is the video display of the 5 kHz internal oscillator. Pull the V/CM $\div 100$ knob out and note the increase in sensitivity, then push the control in.

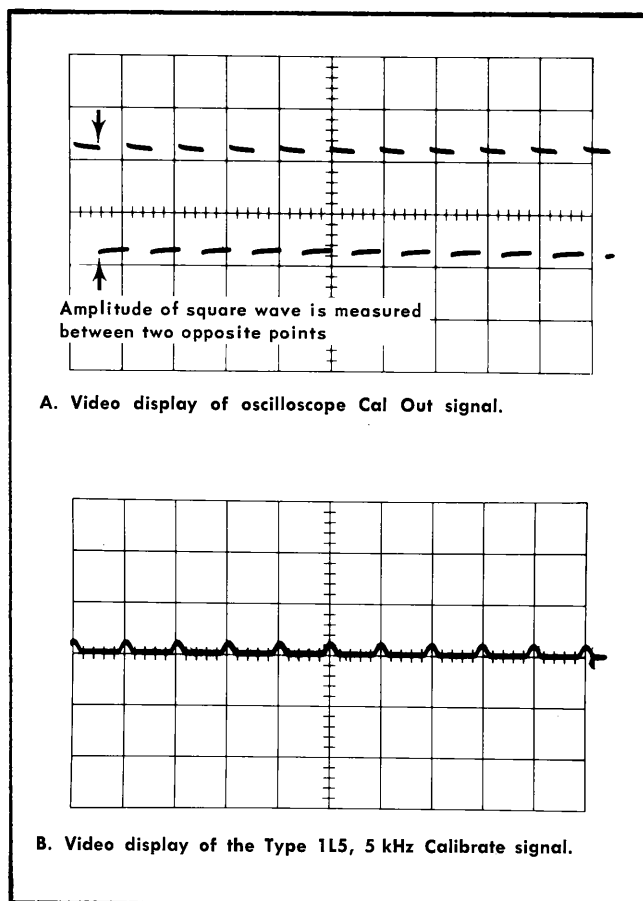


Fig. 2-8. Typical video displays.

Frequency Domain (Spectrum) Display

- a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	100 k
VERTICAL DISPLAY	LIN
Input Coupling	AC or AC FAST
VOLTS/CM	.5 (Outer scale)
VARIABLE	CAL
SWEEP	EXT INPUT
DISPERSION	
Hz/CM	10 K
VARIABLE	CAL
RESOLUTION	10 K (Coupled to the Hz/CM selector)
Time/cm	20 ms
Triggering	Adjusted for a free running sweep

b. Apply a 100 kHz signal from a Signal Generator or other signal source to the INPUT connector of the Type 1L5, and connect the oscilloscope Sweep Out to the Type 1L5 EXT INPUT connector.

NOTE

If a signal source of 100 kHz is not available, apply a signal within the frequency range of the Type 1L5 and change the CENTER FREQUENCY selector setting to the applied input frequency. Decrease the Hz/CM selection until the REDUCE DISPERSION light is no longer lit.

c. Adjust the Signal Generator output or the VOLTS/CM selector for a signal amplitude of approximately 4 centimeters.

d. Tune the Signal Generator frequency above and below 100 kHz. Note that the displayed signal moves proportionately across the screen, and as the input signal frequency increases above the CENTER FREQUENCY-Hz setting, the signal moves to the right of the graticule center. As the input frequency decreases below the center frequency, the signal moves to the left edge of the graticule. Check the frequency of the signal generator when the signal is at each extreme position of the graticule. The difference between the two readings is the total dispersion (or dispersion window) and should approximate the kHz/CM selector position, multiplied by the 10 centimeter window.

e. Return the signal to center screen. Adjust the CENTER FREQUENCY selector above and below 100 kHz and note the signal shift across the screen. To select a center frequency below 100 k, the Multiplier (right black knob; see Fig. 2-11) must be switched to the k readout position and the tens (small black knob) must be switched to 9. The tens selector will now shift the Type 1L5 center frequency below 100 kHz and the signal will move to the right side of the graticule.

f. Switch the CENTER FREQUENCY-Hz to 10 k. Note that the REDUCE DISPERSION indicator is lit, to signify that the display is misleading. Change the frequency of the signal generator to 10 kHz. Note the misleading display. See Fig. 2-9.

g. Adjust the CENTER FREQUENCY VARIABLE control. Note that this control provides continuous tuning of the Center Frequency through each step of the switched positions.

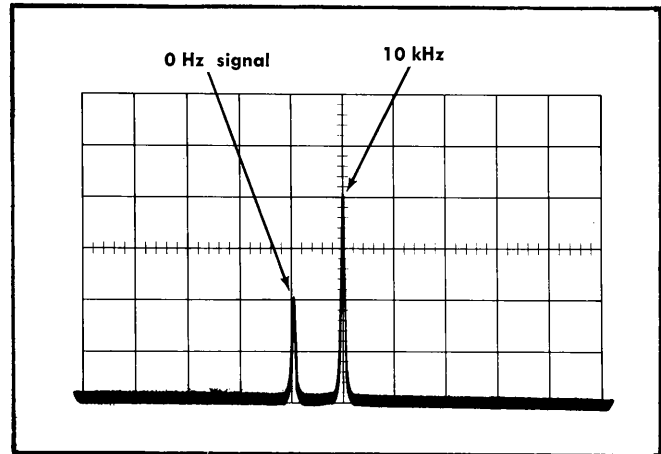


Fig. 2-9. When DISPERSION setting exceeds the upper or lower frequency limits of the Type 1L5, the display may be misleading. Illustration of 10 kHz signal when DISPERSION equals 10 kHz/CM and CENTER FREQUENCY-Hz is set to 10 k.

h. Reduce the DISPERSION Hz/CM switch setting to 1 K. The REDUCE DISPERSION indicator should no longer be lit and the display should contain a single 10 kHz signal near screen center. Switch the center frequency by turning the units knob (large knob behind the tens knob; see Fig. 2-11). Note that the 10 kHz signal now shifts in 1 kHz steps as the units knob is switched through its range. To switch the CENTER FREQUENCY below 10 kHz, set the tens indicator to 9, the units indicator to 0, and the Multiplier to 00. The CENTER FREQUENCY readout will now read 9000 Hz.

i. Set the CENTER FREQUENCY to 9000 and change the frequency of the signal generator to center the signal on screen. Note the signal amplitude and bandwidth at the -6 dB point. Uncouple the RESOLUTION control and decrease the resolution bandwidth by rotating the control counterclockwise to 50. Note the decrease in signal amplitude and the loss of signal symmetry.

j. Decrease the sweep rate to .5 s/cm. Note that the signal amplitude and symmetry are again comparable to its original amplitude and symmetry. (See Resolution and Selecting Sweep Rate.) The resolution bandwidth of the Type 1L5 can be varied from a bandwidth equal to or greater than 500 Hz to a bandwidth equal to or less than 10 Hz. Return the RESOLUTION control to the coupled position.

k. Set the VARIABLE DISPERSION control to the CAL position, the Time/Cm selector to 20 ms and the Triggering for a free running sweep.

GENERAL OPERATING INFORMATION

Signal Connection Precautions

There are precautions that should be taken when connecting signals to the Spectrum Analyzer INPUT to assure good results. Unshielded leads can sometimes be used to connect the Type 1L5 to a signal source, particularly when a high level, low frequency signal is monitored at a low impedance point. When any of these factors are missing

it becomes increasingly important to use shielded leads to minimize stray pickup. In all cases the signal transporting leads should be kept as short as practical. Avoid errors in reading by guarding against stray electric or magnetic coupling between the signal leads and external fields. The shield should be securely grounded, at the signal source and the analyzer, to establish a common ground between the source and the Type 1L5. The shield of a coaxial cable is normally used for this purpose.

Consider the effect of signal-source loading, and the resulting change in the source operating characteristics due to the loading by the signal transporting leads and the input circuit to the analyzer. The input time constant of the analyzer is approximately $30\ \mu\text{s}$ (1 megohm paralleled by 30 pF). A few feet of unterminated shielded cable may increase the parallel capacitance to 100 pF or more. Mismatches between the signal source and the Type 1L5 input will affect display flatness. If optimum flatness is desired and the signal strength is adequate, an attenuator pad or a termination at the analyzer input will minimize reflections and optimize display flatness.

Use of Attenuator Probes

Standard Tektronix probes can be used with the Type 1L5 analyzer. Attenuator probes reduce both the capacitance and resistance loading on the signal source. They also extend the measurement range of the VOLTS/CM selector to include substantially higher signal voltages or

amplitudes. Increase the measured amplitude by the attenuation factor of the probe.

Probes must be properly compensated before they are used. This is easily accomplished by using the oscilloscope Calibrator signal. Switch the VERTICAL DISPLAY selector to the VIDEO position and connect the probe to the Calibrator output connector. Adjust the probe compensation as shown in Fig. 2-10 for optimum square corner response on the displayed waveform.

CENTER FREQUENCY-Hz Selector

The center frequency of the spectrum display is selected by three switches and a variable potentiometer. These are grouped for front panel readout as shown in Fig. 2-11. The following precautions should be observed when setting the controls:

1. The Multiplier switch has only four positions. Do not try to force the switch past the stops. The other switches can be rotated in either direction through 360° .
2. When an accurate frequency reading is desired, make certain the VARIABLE control is in the CAL position.
3. The 0 setting of the "Tens" switch should be used only when the CENTER FREQUENCY-Hz setting is below 100. For example, use 4000 rather than 04 k, or 90 k rather than 090 k.

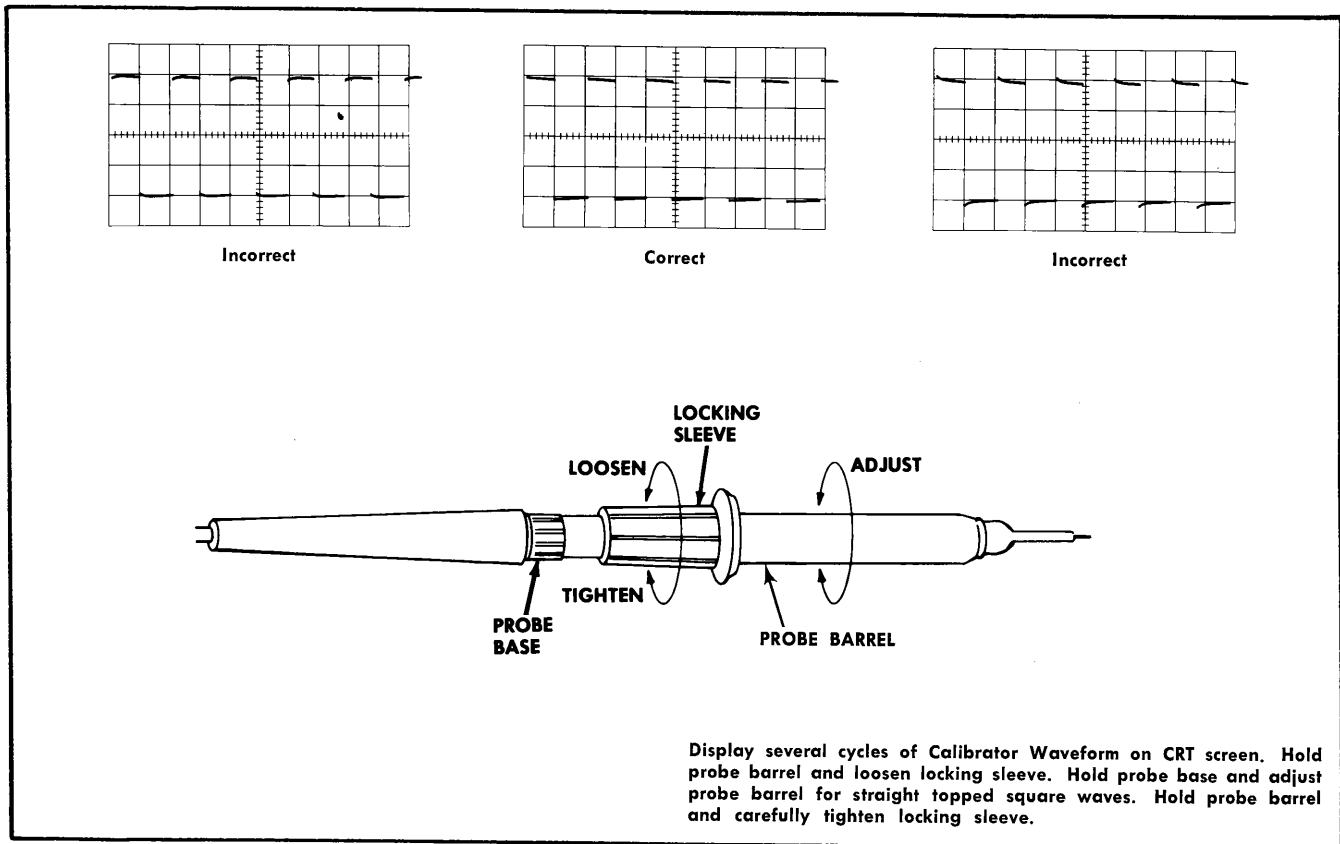


Fig. 2-10. Waveforms and adjustments for attenuator probe compensation.

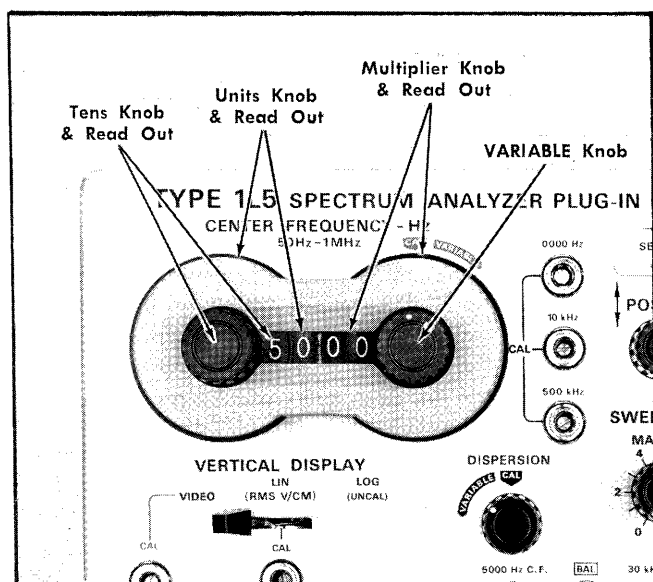


Fig. 2-11. CENTER FREQUENCY-Hz Selector.

Video Display (Time domain peak-to-peak measurements)

When the VIDEO DISPLAY selector is in the VIDEO position, the Type 1L5 functions as a vertical amplifier. The tinted scale for the VOLTS/CM selector indicates the vertical sensitivity in peak to peak readings. The frequency response of the video amplifier is ≤ 10 Hz to ≥ 1 MHz for the .5 VOLTS/CM to the 100 VOLTS/CM range and ≤ 10 Hz to ≥ 700 kHz when the selector is in either the .1 VOLTS/CM or .2 VOLTS/CM positions.

Spectrum Vertical Display Modes

The amplitude and appearance of the display is dependent on the display mode or the setting of the VERTICAL DISPLAY switch.

The LOG position increases the dynamic range of the display by attenuating large amplitude signals more than small amplitude signals. This produces a display which approximates a logarithmic response curve. The circuit is basically a compression circuit and is most effective when there are large signal amplitude differences.

The LIN (linear) position provides linear signal amplitude readout over the full 6 centimeter graticule height. The amplitude readout is calibrated in RMS voltages, provided the resolution bandwidth of the analyzer is adjusted to optimize sensitivity. See Resolution and Selecting Sweep Rate.

Sweep Mode Selector

The analyzer sweep oscillator may be swept by the oscilloscope horizontal sawtooth voltage, or it may be manually swept by means of the front panel MANUAL control. The following paragraphs describe the function of each position of this selector.

EXT INPUT mode. This mode is used for most applications. With the selector in this position a patch cord or cable is connected between the oscilloscope Sweep Output and the Type 1L5 EXT INPUT connector. The sweep frequency oscillator is synchronized with the horizontal beam movement across the CRT, so the horizontal axis of the display becomes a frequency domain.

The front panel BAL and 30 kHz C.F. (dispersion) adjustments provide calibration adjustments for differences between oscilloscope main frames. Their adjustment is described under Front Panel Calibration.

INT Mode. This position of the selector connects the oscilloscope sawtooth voltage to the analyzer through pin 6 of the plug-in interconnecting plug, provided the oscilloscope is wired this way. Check the oscilloscope plug-in connection diagram in the Instruction manual if there is doubt.

The BAL and 30 kHz C.F. adjustments are not connected when the selector is at the INT position, therefore the Horizontal Position control and the Type 1L5 VARIABLE DISPERSION control are adjusted to calibrate the dispersion. This is described in the Front Panel Calibration procedure.

MANUAL Mode. In this position the sweep oscillator can be manually swept by a variable DC voltage that is generated by rotating the MANUAL control. This variable voltage is available at the OUTPUT connector jack. By applying this voltage to the Ext Horiz Input Connector and setting the Horizontal Display selector to Ext position, the horizontal position of the CRT beam is synchronized to the local oscillator frequency.

With this arrangement the operator may manually scan the spectrum or select any frequency within the spectrum. This provides a more precise control for frequency and amplitude measurements.

The following procedure will prepare the analyzer for manual sweep operation.

1. Establish the desired display with an INT or EXT applied sweep.
2. Connect a patch cord between the MANUAL OUTPUT jack and the oscilloscope Ext Horiz In connector.

NOTE

If the oscilloscope mainframe has a 100-volt sawtooth (e.g. 547, 546, see Table 2-1), the voltage swing out of the MANUAL OUTPUT jack will be excessive for the oscilloscope external horizontal amplifier, unless the Sweep Voltage selector is switched to the 150 V position. Pull the Type 1L5 out, switch the Sweep Voltage selector to 150 V position, and reinsert the 1L5 into the plug-in compartment.

3. Switch the Horizontal Display selector to External, 10 $\times$ attenuator position.

4. Switch the Type 1L5 Sweep Mode selector to MANUAL position.

5. Rotate the MANUAL control fully counterclockwise to 0 and adjust the oscilloscope Horizontal Position control so the CRT beam is at the left edge of the graticule.

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6. Rotate the MANUAL control fully clockwise to 10 and adjust the oscilloscope Ext Horiz Variable 10:1 control to position the beam to the right edge of the graticule.

7. Repeat (5) and (6) until the MANUAL control will vary the beam across the width of the graticule.

REDUCE DISPERSION Caution Light

The Type 115 displays a spectrum of frequency over the range of approximately 10 Hz to 1 MHz. However, the CENTER FREQUENCY-Hz and DISPERSION Hz/CM switches can be set so the display "window" extends to frequencies outside this range. As a result, spurious signals may appear on the display to the left of the 0 Hz marker. If the display extends much above 1 MHz, the dispersion and signal amplitude will probably be non-linear.

A REDUCE DISPERSION indicator lights to caution or indicate to the operator that the display extends below or above the frequency range of the unit.

NOTE

An exception to the above is a combination with a CENTER FREQUENCY-Hz set to 2500 or 250 with the DISPERSION-Hz/CM set to 500 or 50 respectively. This also lights the indicator; however, this is a usable display.

The light is intended as a caution light, to indicate that a part of the display has no real meaning. The rest of the display can be used as long as the spurious portion of the display is ignored.

Amplitude Measurements

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor of the probe and the settings of the VERTICAL DISPLAY selector, VOLTS/CM and V/CM $\div$ 100 switches plus the VARIABLE VOLTS/CM control. In addition when measuring amplitudes of a spectrum display, the RESOLUTION control of the Spectrum Analyzer can cause errors in the readings, if the resolution is not optimized. See Resolution.

The VERTICAL DISPLAY switch selects one of three modes of operation: (1) VIDEO mode which provides peak-to-peak voltage measurements of time-based analog displays; (2) LIN mode which provides RMS voltage measurements of linear-amplitude spectrum displays; and (3) LOG mode, which provides an uncalibrated logarithmic spectrum display.

The calibrated deflection factors indicated by the settings of the VOLTS/CM switch, apply only when the VARIABLE VOLTS/CM control is set to the CAL position. Serious errors in amplitude measurements will result if the setting of this control is moved from the CAL position.

The V/CM $\div$ 100 knob decreases the deflection factor (increases sensitivity) by a factor of 100 when it is pulled out. A white ring on the shank of this knob becomes visible with the knob pulled out to indicate to the operator this increased sensitivity factor.

In measuring signal amplitudes, the width of the trace can be an appreciable part of the overall measurements. All measurements should therefore be made from the same edge (top or bottom) of the trace except in LOG mode. Note in Fig. 2-10 the points A and B correspond to the top edge of the trace. The measurement would be just as valid if points A and B corresponded to the bottom or center of the trace.

The VOLTS/CM switch is calibrated in RMS volts for the LIN Spectrum Display Mode. The calculations are made as described for the VIDEO display, except the inner scale of the VOLTS/CM switch is used and should be read out in RMS voltage.

The LOG Mode has been calibrated for a 60 dB dynamic range over a six centimeter display. Although it is not calibrated for precise amplitude measurements, each centimeter represents a change in amplitude of approximately 10 dB. Amplitude measurements should be made using the center of the trace. See Fig. 2-12B.

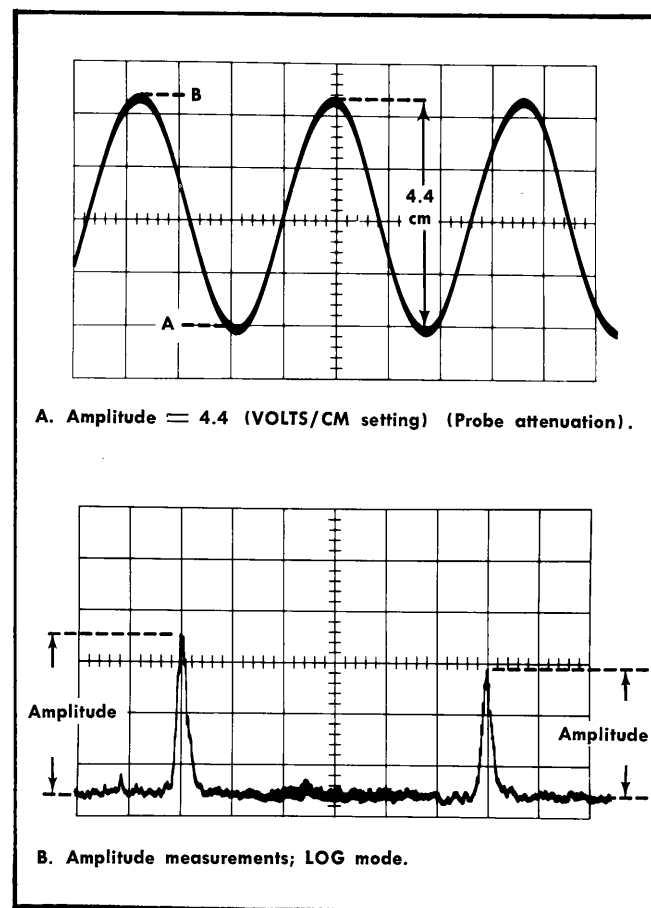


Fig. 2-12. Measuring signal amplitude.

Resolution and Selecting Sweep Rate

Resolution, or resolution bandwidth, is a function of the final IF bandwidth. This bandwidth governs the minimum frequency difference between signals that can be resolved.

Signals are considered resolved when the notch or dip between any two signals is 3 dB down. The frequency difference between signals at that time is the resolution of the analyzer. If the analyzer is tuned to a CW signal and the sweep rate is very slow, the display becomes a plot of the analyzer IF bandpass characteristics. The resolving ability of the analyzer or its effective resolution bandwidth is approximately the bandwidth at the -6 dB point of this CW response.

As the analyzer sweep rate is increased, the amplitude of the CW signal will decrease and the effective bandwidth increases; which signifies that both the sensitivity and resolution have been degraded by the analyzer sweep rate.

The loss of the analyzer sensitivity due to sweep rate and dispersion can be expressed mathematically as:

$\frac{S}{S_0} = \left[1 + 0.195 \left(\frac{D}{TB^2} \right)^2 \right]^{-1/4}$ where S/S_0 is the ratio of the effective sensitivity to the analyzer measured sensitivity, at very slow sweep rates or zero dispersion.

- D is the dispersion in hertz
- B is the -3 dB bandwidth of the analyzer in hertz
- T is the sweep time in seconds, or $\frac{D}{T}$ is the scanning velocity.

These same variable also determine the resolution of the analyzer. The loss in resolution can be expressed as follows:
 $\frac{R}{R_0} = \left[1 + 0.195 \left(\frac{D}{TB^2} \right)^2 \right]^{1/2}$ where R/R_0 is the ratio of the effective resolution of the analyzer to the analyzer measured resolution bandwidth at very slow speeds. R_0 is somewhat arbitrary and is taken as the displayed width of the CW signal at the -6 dB point.

The resolution of the Type 1L5 Spectrum Analyzer is optimized for most settings of the DISPERSION selector when the RESOLUTION control is in the coupled position. Resolution, however, can be varied from approximately 500 Hz to less than 10 Hz by uncoupling the RESOLUTION control and resetting it as an independent function of the DISPERSION selector.

The sweep rate, as previously mentioned, should be below the sweep rate at which there is no noticeable amplitude loss in the signal. Therefore, as the DISPERSION setting is reduced the sweep rate should also be reduced to maintain sensitivity and resolution bandwidth.

Frequency Measurements

The accuracy of frequency measurements taken directly from the CENTER FREQUENCY-Hz dial are within the specifications listed in the Characteristics section. This accuracy can be increased by optimizing the front-panel calibration adjustments for the desired range. Very precise frequency measurements can be performed by applying a calibrated frequency to the INPUT to establish a reference point on the displayed spectrum. Frequency measuring methods are described and grouped under the following headings.

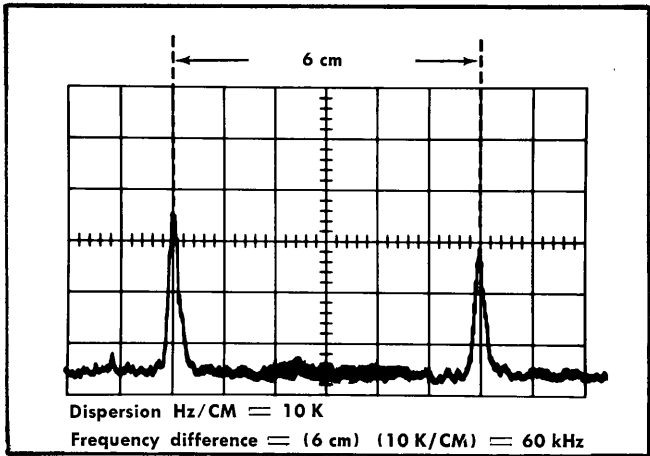


Fig. 2-13. Frequency difference measurements between two signals.

General Frequency Measurement: Check the Dispersion and Center Frequency calibration as described in Front Panel Calibration. Set the CENTER FREQUENCY VARIABLE control to CAL position. Adjust the CENTER FREQUENCY selectors to center the signal in the graticule. Decrease the DISPERSION to improve the measurement accuracy. Read the frequency as indicated on the CENTER FREQUENCY-Hz dial.

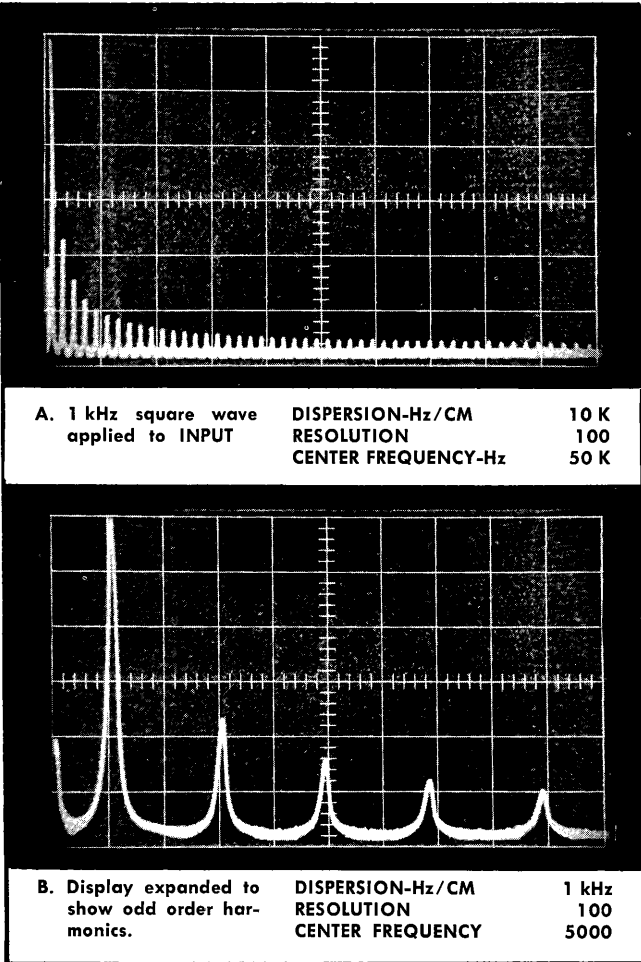


Fig. 2-14. Spectrum of a complex wave.

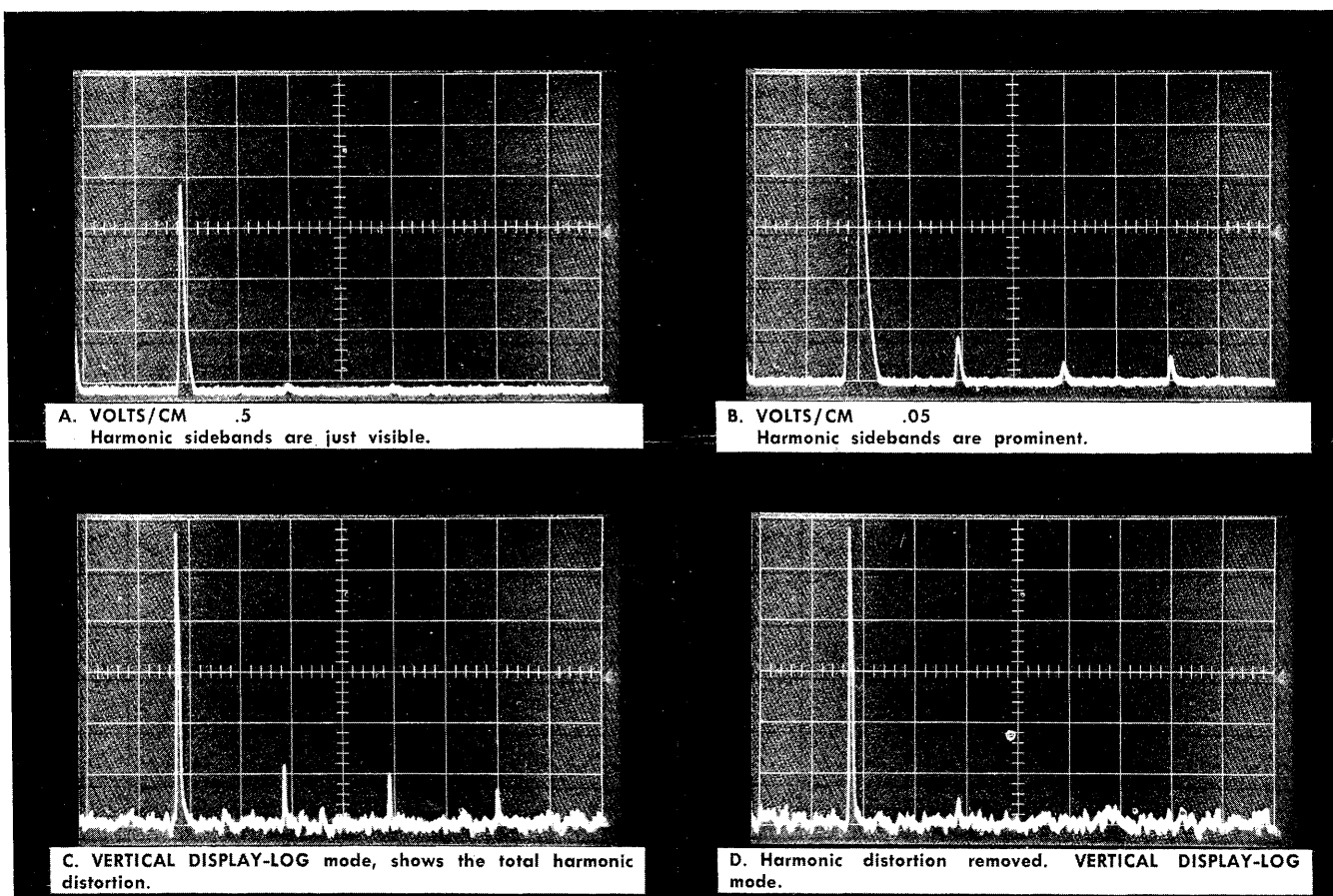


Fig. 2-15. Measuring harmonic distortion.

An approximate measurement can be made by noting the difference in frequency between the CENTER FREQUENCY (graticule center) and the signal position, then adding or subtracting this difference to the dial reading.

Frequency Difference Measurements: Frequency separation measurements to 1 MHz can be performed as follows:

1. Reduce the DISPERSION to separate the two signals by the maximum number of graticule divisions.
2. Optimize signal definition by increasing the RESOLUTION and decreasing the sweep rate.
3. Measure the signal separation in centimeters then multiply this reading by the Hz/CM selector setting. This is the frequency separation or frequency difference between the two signals (see Fig. 2-13). The accuracy of this measurement is dependent on the DISPERSION Hz/CM selector setting. See Characteristic section.

Precise Frequency Measurements: Accurate measurements of frequency may be performed as follows:

1. Manually tune the sweep oscillator with the MANUAL control to the desired signal on the display.
2. Measure the OSC OUT frequency with a frequency counter or other accurate measuring device.

3. The frequency of the signal equals the difference between the OSC OUT frequency and 3.0 MHz. For example; if the measured OSC OUT frequency is 2.5 MHz, the incoming signal frequency is $3.0 \text{ MHz} - 2.5 \text{ MHz}$ or 500 kHz.

The accuracy of this method is a function of the 3.1 MHz crystal-controlled oscillator for the 2nd mixer, the 0.1 MHz crystal filters for the 2nd IF amplifier and the accuracy of the measuring device.

Applications

The Type 1L5 spectrum analyzer is a versatile measuring device in the field of radiation measurements. It can be used as an aid for communications analysis (wire, radio, etc.), vibration analysis, sonic and ultra-sonic propagation, medical research, geophysical electronic measurements, plus many more special categories. The following are a few suggested applications for this instrument.

Analysis of Complex Waveforms: If a complex waveform, such as a step function, sawtooth voltage, square wave, etc., is applied to the spectrum analyzer, a plot of the waveform frequencies is displayed on the graticule. The spectrum of a square wave is illustrated in Fig. 2-12.

Distortion Measurements: Intermodulation distortion, phase and frequency distortion, harmonic distortion, etc., that are present in RF and audio amplifiers are measurable.

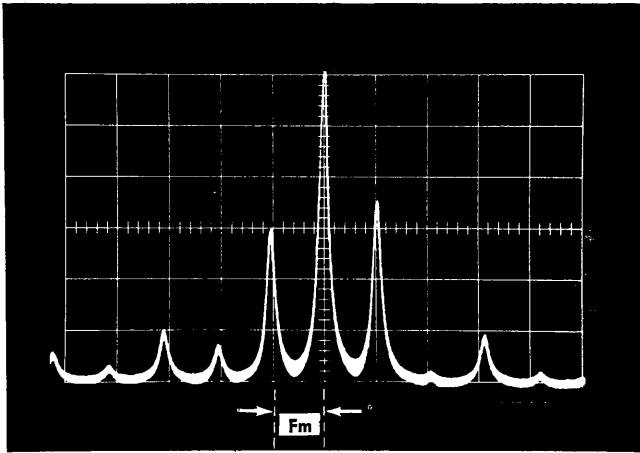


Fig. 2-16. Overmodulated AM signal. Overmodulation produces additional unwanted sidebands. Dispersion is 1 K and indicates a 1 kHz modulating (Fm) frequency.

Figures 2-15 through 2-17 illustrate the measurement and observation of harmonic distortion. Fig. 2-15A shows a 200 kHz signal at a VOLTS/CM selection of .5 volts. Fig. 2-13B shows the signal with a VOLTS/CM setting of .05 V, and the harmonic distortion present.

Fig. 2-15A shows the signal amplitude to be approximately 3.8 cm or 1.9 V RMS. Fig. 2-15B shows the amplitude of the 2nd harmonic to be approximately .045 V RMS, the 3rd harmonic .020 V and the 4th .025 V. The percentages of 2nd, 3rd and 4th order harmonic content are;

$$\frac{.045 \times 100}{1.9} = 2.37\%; \quad \frac{.020 \times 100}{1.9} = 1.05\%; \quad \text{and}$$

$$\frac{.025 \times 100}{1.9} = 1.32\%$$

By switching the VERTICAL DISPLAY selector to LOG position a 60 dB vertical window is provided, so that total harmonic distortion may be observed. Fig. 2-15C shows the signal of Fig. 2-15B with the Type 1L5 in LOG mode. Fig. 2-15D shows the display after the distortion has been removed.

AM and FM Modulation: Measurement of the modulation frequency or frequencies and the modulating percentage in amplitude modulated signals is illustrated in Fig. 2-16. Frequency deviation and stability in frequency modulated signals is illustrated in Fig. 2-17.

Frequency Stability in Oscillators: Fig. 2-18 illustrates line frequency (60 Hz) modulation in a 5000 Hz oscillator signal.

Frequency Response Plots: Frequency bandpass of filter networks, IF stages, speaker and speaker enclosures, etc., may be examined.

Telemetry Equipment: Composite subcarrier analysis such as a check of subcarrier pre-emphasis, subcarrier oscillator check, interaction between channels, noise and hum.

Telephone Carrier System: Monitoring and troubleshooting the telephone communication channels through the frequency spectrum from approximately 200 Hz to 1 MHz. The Type 1L5 can be used to spot out of tolerance channel

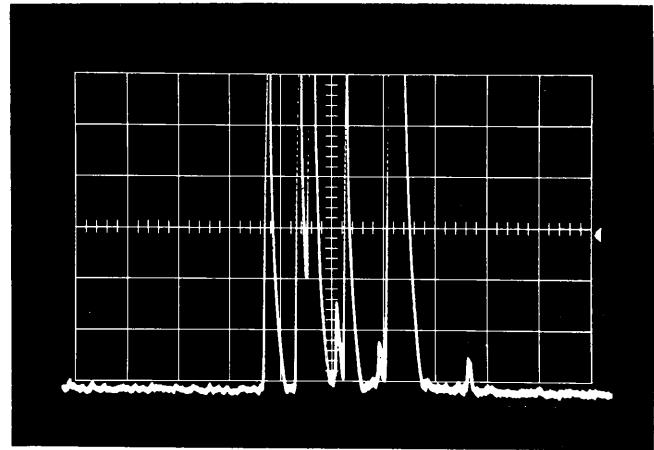


Fig. 2-17. Frequency modulated display.

levels, noise, distortion and other irregularities. Any portion of the observed spectrum can be opened for analysis by means of the Variable Dispersion control.

Sonic and Ultra-Sonic Analysis: Ultra-sonic noise or vibration analysis, both sinusoidal and random may be observed. Cavitation studies of large turbines, cavitation studies in milk pasteurization. Vibration studies applicable to wind tunnel analysis, large ventilating systems. Fatigue studies in airframes or other materials subjected to constant vibration.

Ultra sonic and sonic wave propagation in geophysical applications, such as ground propagation studies of reflection and absorption, or the use of ultra sonics in the field of oceanography.

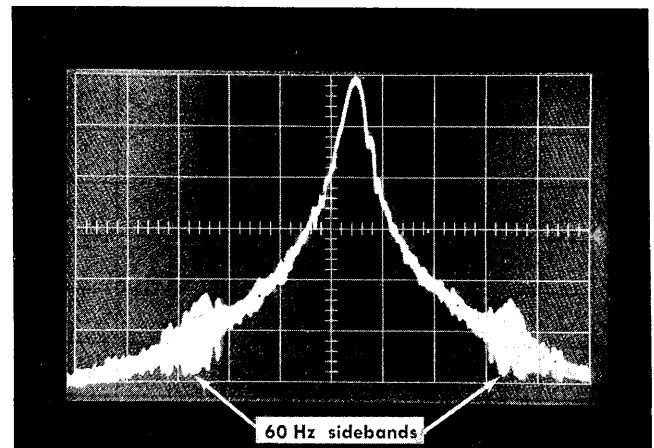


Fig. 2-18. Line frequency modulation in oscillators.

Musical Tone Analysis: Applicable when used with a storage type oscilloscope, in the study of tones from musical instruments such as organs, woodwind and brass instruments, bells, chimes, etc.

Speech Analysis: Research of speech patterns for areas in speech therapy, etc.

Medical Applications: Research in the study of EMG, EKG and EEG waveform analysis. Research in the field of microphysiology.

NOTES

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SECTION 3

CIRCUIT DESCRIPTION

Introduction

The Type 1L5 Spectrum Analyzer is a swept front end spectrum analyzer covering the frequency range from 10 Hz to 1 MHz. This section presents first a block diagram analysis, then a detailed circuit description of the individual circuits within each block.

Schematic diagrams showing all circuit components are located on the pull-out pages of Section 9, along with a detailed block diagram. Simplified diagrams are used in this section to help illustrate general circuit theory of operation. Refer to section 9 for detailed diagrams.

BASIC DESCRIPTION

A simplified block diagram is shown in Fig. 3-1. This along with a block diagram in Section 9 is used to describe the sequence of operation.

Signals within the frequency range of the Type 1L5, that are applied to the INPUT connector are fed through a calibrated attenuator and amplifier circuit, to establish the desired signal amplitude on the display. The output signals from the input amplifier are then applied through the LIN or LOG positions of the VERTICAL DISPLAY switch to the first mixer circuit, or through the VIDEO position of the switch to the driver amplifier stage.

The 1st mixer stage, mixes the incoming signal with the swept frequency output from the 1st local oscillator to produce an IF of 3 MHz which is amplified then applied through a filter circuit to the 2nd mixer. The bandpass of the filter is 2.97 MHz to 3.03 MHz. Spurious signals outside this bandpass are suppressed by the filter.

The 3 MHz IF signal is mixed with 3.1 MHz from a 2nd local oscillator and the 2nd IF of 100 kHz is then applied through a variable resolution amplifier. The bandwidth of the variable resolution amplifier may be adjusted from ≤ 10 Hz to ≥ 500 Hz to increase or decrease the resolution capabilities of the analyzer.

The signal is then applied through a driver stage to both the recorder detector and the analyzer detector. The output or video signal is applied through either a logarithmic or linear attenuator circuit depending on the position of the VERTICAL DISPLAY selector then coupled through a buffer or amplifier stage to the associated oscilloscope vertical amplifier through the plug-in connector P11.

A frequency domain (frequency versus amplitude) display is obtained by synchronizing a frequency swept 1st local oscillator with the horizontal beam movement of the CRT. The sweep oscillator is indirectly swept by the same sawtooth voltage that causes the horizontal beam movement. The amount by which the oscillator is swept is a function of the DISPERSION controls. The center of the sweep or the center frequency of the display is a function of the CENTER FREQUENCY controls.

Dispersion calibration and display linearity are provided through the feedback loop, which consists of a discriminator and comparator, to the oscillator circuit. The output frequency of the oscillator becomes a constant, times the instantaneous value of the incoming sawtooth waveform.

As the oscillator frequency decreases, the output from the discriminator becomes a positive-going voltage ramp. This sawtooth voltage is applied to either the comparator Q140 or Q120, depending on the CENTER FREQUENCY Hz (Multiplier) selector, and compared with the input sawtooth from the DISPERSION selector. The output voltage from the comparator tunes the swept oscillator circuit.

The oscillator center frequency is a function of the DC level of the comparator which is set by the CENTER FREQUENCY switching controls. The oscillator center frequency can be varied through the frequency range of 3 MHz to 2 MHz and the swept frequency width or dispersion can be varied from 100 kHz/cm (1 MHz total for a 10 centimeter sweep) to approximately zero. For example: If the controls are adjusted so the local oscillator is sweeping from 3 MHz to 2 MHz and signals of 500 kHz and 600 kHz are applied to the INPUT connector, an IF of 3 MHz is generated as the LO sweeps through 2.5 MHz and 2.4 MHz. Since 2.5 MHz is the center frequency of the LO, the 500 kHz signal will appear near the center of the display and the 600 kHz signal will appear 100 kHz to the right of center.

The crystal discriminator output is applied through two emitter follower amplifiers to comparator Q120. The transmission line discriminator output is applied to comparator Q140. With the CENTER FREQUENCY switching in either the 0 Hz or 00 Hz range, the crystal discriminator output is compared to the input sawtooth voltage. When the CENTER FREQUENCY switching is in either of the kHz ranges (K or 0 K) the line discriminator output is compared to the input sawtooth voltage at Q140, and Q120 becomes an emitter-coupled amplifier for the output signal from Q140.

The 5 kHz Calibrator supplies a 5 kHz fundamental frequency and its harmonics to the input amplifier, when the VOLTS/CM selector is in the CALIBRATE position. These markers provide frequency pips to check the dispersion and center frequency accuracy. A zero frequency marker or start spurious signal is supplied when the swept local oscillator (LO) frequency is 3 MHz.

DETAILED CIRCUIT DESCRIPTION

Attenuators and Input Amplifier

This circuit controls the signal amplitude of the display and heterodynes the incoming signal with the swept LO frequency to produce an IF of 3 MHz for the 2nd Mixer circuit.

Signals applied to the INPUT connector are either AC or DC (AC FAST position) coupled to the input attenuator through the selector switch SW1. A GND position between

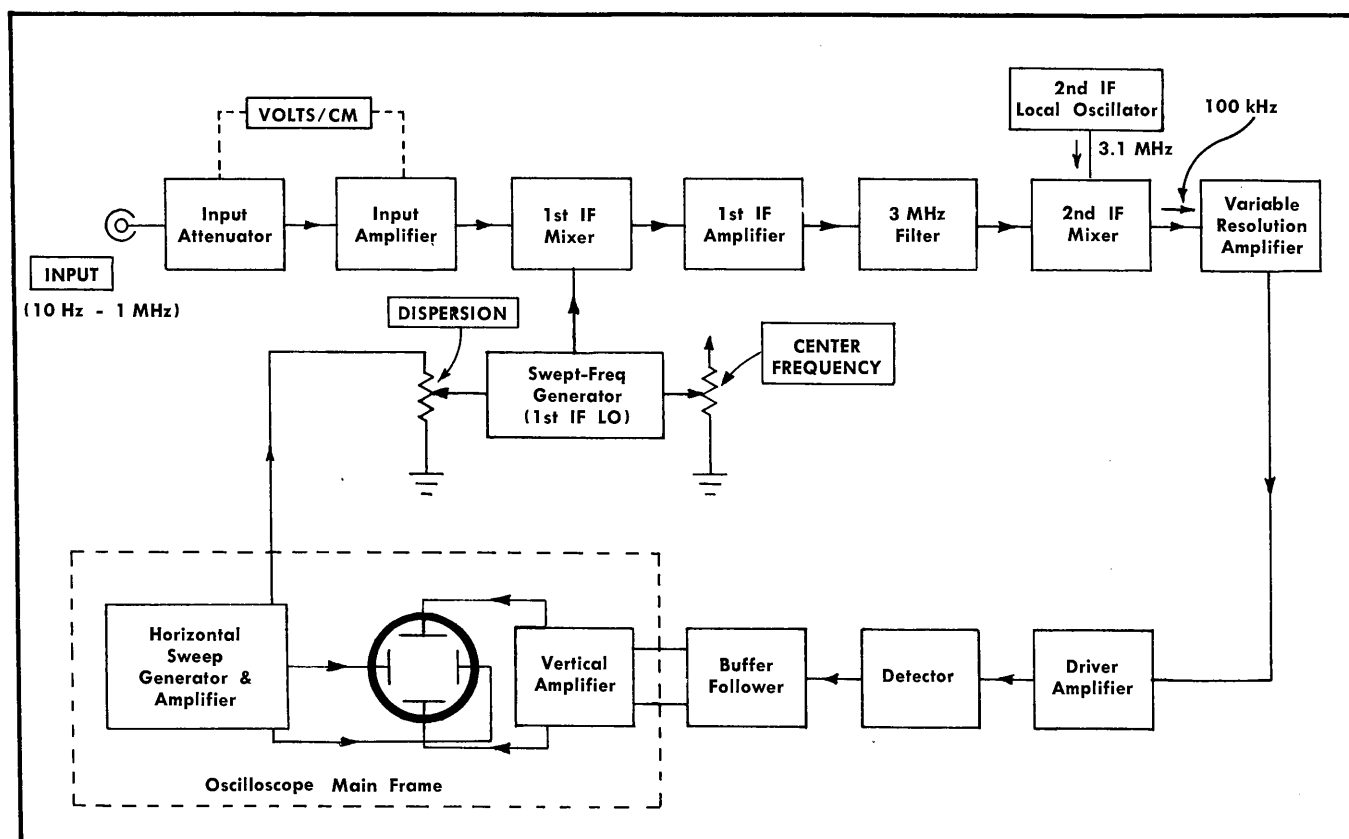


Fig. 3-1. Block diagram of basic circuits.

the AC FAST and AC positions of the selector grounds the input circuit when switching from AC coupling to AC FAST position. The GND position may be used to establish zero volt reference on the display without disconnecting the input signal.

The VOLTS/CM attenuator establishes the deflection factor for the analyzer. Except for the .001 and .002 positions of the VOLTS/CM selector, the basic deflection factor of the Type 1L5, for spectrum displays, is 5 mV (RMS) per centimeter; and 0.5 V peak to peak per centimeter for the time domain (VERTICAL DISPLAY switch in the VIDEO position) displays.

The VOLTS/CM attenuator provides a deflection factor range from .001 V/CM to 2 V/CM (RMS) in a 1, 2, 5 sequence when the V/CM $\div$ 100 knob is pushed in. With the knob pulled out the gain is increased by a factor of 100. The outer tinted scale around the VOLTS/CM selector indicates the deflection factor for Video displays with the V/DIV $\div$ 100 knob pushed in.

Frequency compensated attenuation networks for each position of the selector provide a constant impedance and input time constant (1 Meg paralleled by approximately 30 pF). C10 is adjusted to normalize this input time constant for all instruments.

Signal gain for the .001, .002 and .005 positions of the VOLTS/CM selector is controlled by the amount of negative feedback in the amplifier circuit. Feedback to the base of Q41 is a function of the ratio of R44 to R43 with R40-C40

and R41-C41 shunting R43 in the .002 and .001 positions to change the gain and provide optimum transient response.

Input Amplifier. The input stage to the amplifier contains a field effect transistor Q20, driving the emitter follower transistor Q30. This stage presents a high input impedance to the signal source plus the voltage to drive the gain control amplifier stage.

Frequency response and linearity is improved by bootstrapping the input amplifier. The output of emitter follower Q30 is coupled back, through C34-R34, to the drain of Q20. This feedback is in phase with the input signal to the gate and effectively reduces the gate to drain capacity of Q20.

D18 between the gate of Q20 and the -10 volt supply, limits the amplitude of the negative voltage swing to approximately -10.6 volts. This protects both Q20 and Q30 from excessive gate-to-source or base-to-emitter voltage.

The gain control stage, consisting of Q40, Q42 and Q41, has an approximate gain of two when the VOLTS/CM selector is positioned at or between .005 and 2 volts, with the VARIABLE control in the CAL position.

The VARIABLE control R35 in series with R36 and C36 to ground, is part of a voltage divider which provides a 3:1 attenuation ratio for the VARIABLE control. Signal current through Q40 is controlled by the feedback signal to the base of Q41. The gain of the stage is increased to approximately 5 when the VOLTS/CM selector is in the .002 position, because R40-C40 shunts the feedback resistor R43 and reduces

the signal feedback to Q41. The gain of the stage is increased to about 10 when the VOLTS/CM switch is changed to the .001 position.

The output amplifier stage consists of an operational amplifier Q50-Q60 driving an emitter follower Q70. The gain of Q50 is primarily set by the ratio of the feedback resistance R52 to the input resistance R51. The gain through Q60 is primarily determined by the ratio of R64 to R60 and its parallel resistance R52. Collector voltage for this amplifier is regulated by a 15 V zener diode D48.

The output signal from the emitter follower Q70 is applied through the LOG and LIN positions of the VERTICAL DISPLAY switch SW75 to the 1st mixer.

1st Mixer. The stage is a balanced mixer. R85 and C86 are adjusted for DC and signal balance. Incoming frequencies from the input amplifier and the local oscillator are applied across a balanced input so the output frequencies will be the heterodyne product of the two input frequencies. A small portion of the oscillator center frequency (3 MHz) is fed through the mixer to appear as a 0 Hz or start spurious signal on the spectrum display.

The output IF signal, centered at 3.0 MHz, is amplified by Q90 and fed through a 2.97 MHz to 3.03 MHz bandpass filter to the 2nd mixer and variable resolution amplifier circuit.

Sweeper or Dispersion and Discriminator circuits

The sweeper circuit contains the swept frequency local oscillator and a closed loop voltage-to-frequency converter. It supplies a constant amplitude, linear swept frequency signal to the 1st mixer, so accurate and linear calibration of dispersion over the frequency range of the instrument is obtained. Frequency dispersion can be varied from near zero to 1 MHz in calibrated steps by the DISPERSION selector. The center frequency of the swept oscillator is adjustable from 2 to 3 MHz by changing the CENTER FREQUENCY selector. Fig. 3-2 shows a simplified block diagram of this circuit.

A Colpitts oscillator, consisting of Q160, the tuned circuit L164-D164, and the capacitors C160-C161, is frequency swept by a negative-going sawtooth voltage from the comparator or amplifier Q120. This sawtooth voltage is applied to the voltage controlled variable capacitance diode D164. The center frequency of the oscillator is established by the DC level of the applied sawtooth. The CENTER FREQUENCY selector sets the dynamic operating level of Q120 and Q140. This sets the DC level to the frequency determining circuit. The frequency dispersion is determined by the amplitude of the sawtooth voltage applied to D164. This voltage amplitude is a function of the input sawtooth voltage and the setting of the front panel DISPERSION control. The DISPERSION control, a calibrated step attenuator, sets the amplitude of the sweeper voltage. The CENTER FREQUENCY multiplier switch sets the DC level of the sweeper voltage and sets the center frequency within the range (50-9900 Hz or 10 kHz-990 kHz) of the instrument.

The frequency accuracy for the low frequency decade (50 Hz to 9900 Hz), is improved by switching a crystal discriminator into the loop for the frequency to voltage converter.

The crystal discriminator has a transfer gain approximately 100 times greater than the diode transmission line discriminator for the band of frequencies from 2.985 to 3.000 MHz. When the center frequency multiplier switch is in the 0 Hz or 00 Hz positions, the discriminator output signal is coupled through emitter follower Q130 and Q121 to comparator Q120. When the center frequency is changed to the kHz or 0 kHz range, the transmission line discriminator output signal is applied with the sweep waveform to comparator Q140. Q120 then becomes an emitter coupled amplifier.

The output signal from the swept oscillator is applied through an amplifier and driver stage to drive a push-pull power amplifier Q180-Q190. This amplifier signal is then applied through a 3 MHz low pass filter to reduce nonlinearities that could result from higher order harmonic frequencies of the oscillator fundamental frequency.

The output signal amplitude to the 1st mixer is regulated by an amplitude regulator circuit. This constant amplitude output signal to the feedback loop and to the 1st mixer provides uniform sensitivity and dispersion linearity over the frequency range of the Type 1L5.

Swept Frequency Oscillator. Fig. 3-4 is a simplified diagram of the oscillator. Q160 is connected as a Colpitts oscillator. The frequency of oscillation is determined by the L and C constants in the tuned circuit L164 and D164.

D164 is a voltage controlled variable capacitance diode. The capacitance of the diode increases as the input sawtooth voltage decreases; therefore, the resonant frequency of the tuned circuit decreases. L164 tunes the center frequency of the oscillator.

The DC level at the collector of Q120, or the cathode of D164, is clamped or prevented from going more negative than 9.2 volts by D161, when the CENTER FREQUENCY (MULTIPLIER) switch (SW120) is in the 50 Hz to 9900 Hz range. When the (MULTIPLIER) switch is in the 10 kHz to 990 kHz range, it is prevented from going more negative than about ground by D162.

NOTE

Instruments prior to Serial No. 324 used a back diode oscillator D165 as shown in the schematic diagram section.

Oscillator Amplifier. The oscillator output signal from the emitter of Q160 is amplified by Q170 and applied through emitter follower Q171 to a push-pull amplifier stage containing Q180-Q190. Push-pull signal from the amplifier is changed to a single-ended output signal through T190 and applied through the low pass filter network, L191-C191, L192-C192 and L194, to the OSC OUT connector and through pin S to the 1st mixer.

A sample of the oscillator signal is detected by the voltage doubler circuit, containing diodes D218-D220. This sample of voltage is then summed at the base of Q210 with a reference DC voltage set by the Osc Amp adjustment R214. Q210 is a DC amplifier driving Q220. The voltage at the collector of Q200, which is set by the amplitude of the feedback signal, controls the forward bias of the push-pull amplifier Q180-Q190.

The gain of this feedback loop is sufficient to maintain a constant amplitude signal output to the 1st mixer and the

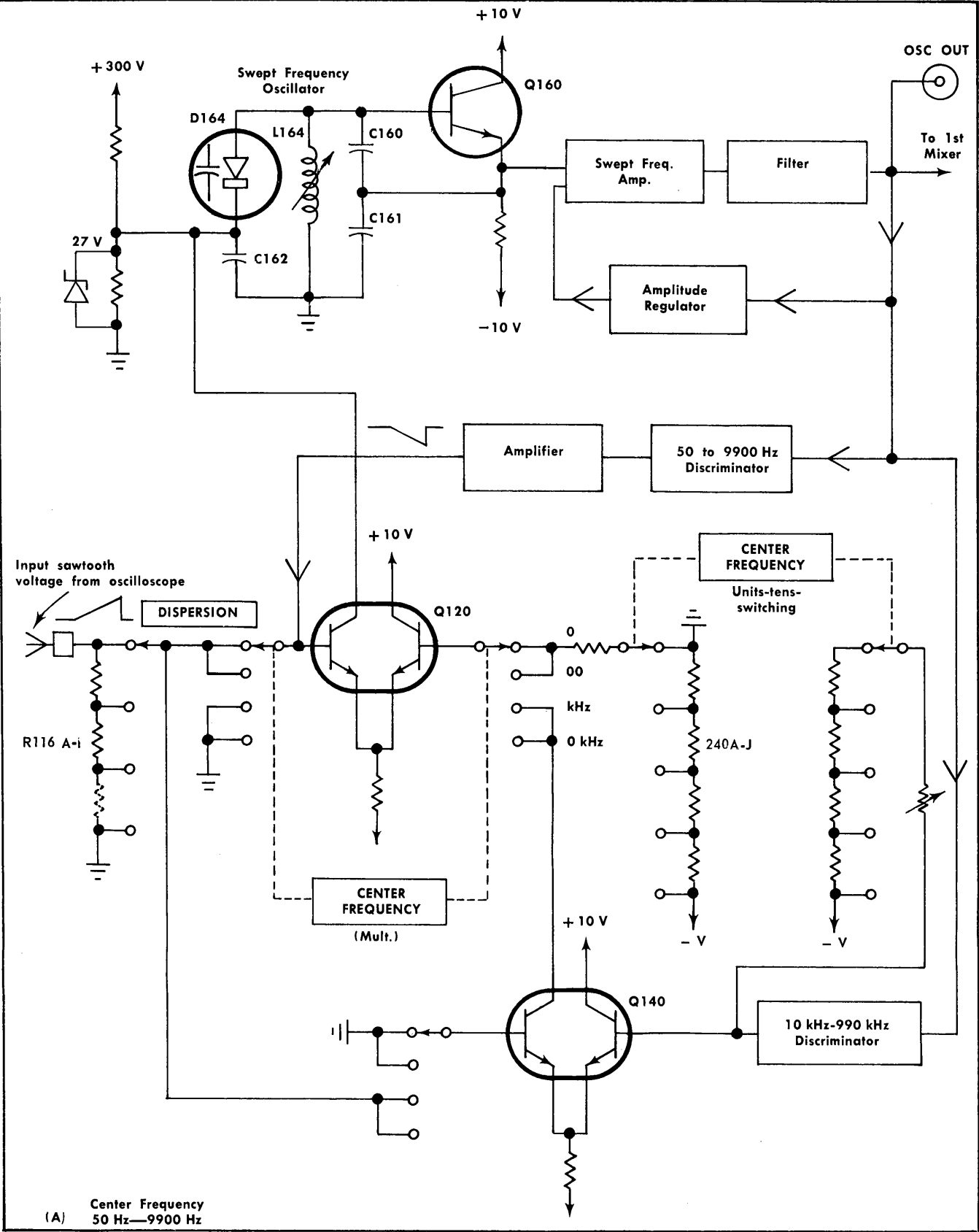


Fig. 3-2. Block diagram of swept oscillator circuit for 50 Hz to 9900 Hz center frequency range.

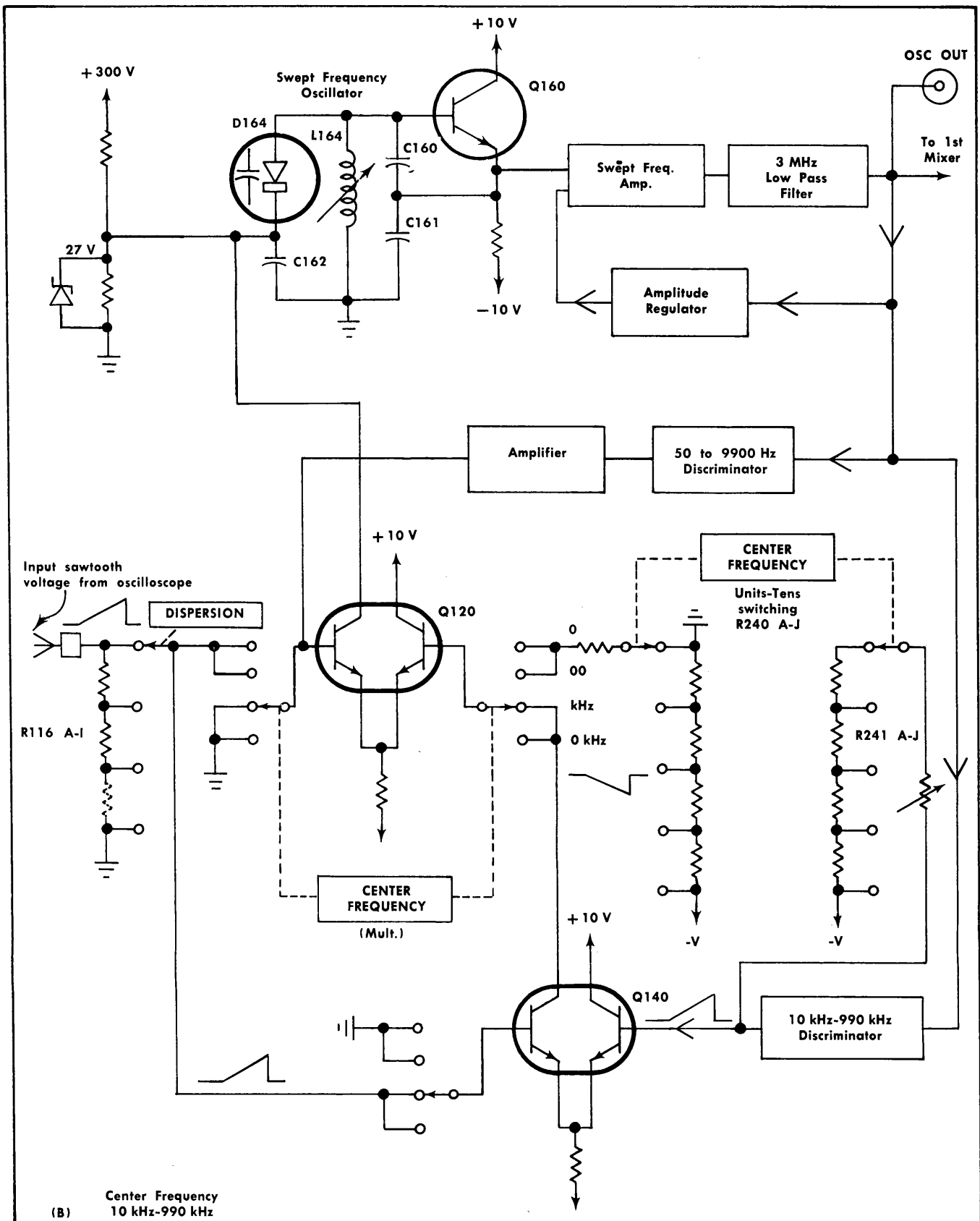


Fig. 3-3. Block diagram of swept oscillator circuit for 10 kHz to 990 kHz center frequency range.

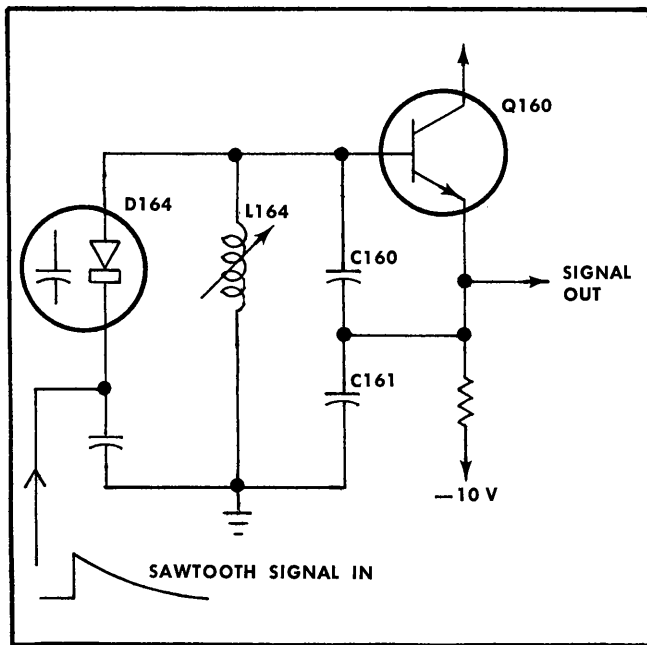


Fig. 3-4. Simplified diagram of the swept oscillator.

discriminator circuits. The push-pull output amplifier Q180-Q190 is disabled when the VERTICAL DISPLAY switch is set to the VIDEO position.

Transmission Line Discriminator. The discriminator generates a positive-going voltage output when the frequency input is decreasing through the center frequency range from 10 kHz to 990 kHz.

D154 and D157 are matched diodes at the input end of two transmission lines. D154 is on the input of a $\frac{1}{8}$ wavelength (at 3 MHz) open ended transmission line and D157 is at the input of a $\frac{1}{8}$ wavelength shorted transmission line. A $\frac{1}{8}$ wavelength transmission line is capacitive when the line is open, therefore as the input frequency to the line decreases, the input impedance increases. A shorted $\frac{1}{8}$ wavelength line is inductive, therefore its input impedance decreases as the input frequency decreases.

The voltage across capacitor C155 will become less negative and the voltage across C157 will become more positive as the input frequency to the discriminator decreases. This positive-going voltage ramp is summed at the base of the comparator Q140, with a DC voltage level that is set by the CENTER FREQUENCY switching selector. R156 sets the DC balance of the discriminator circuit.

Crystal Discriminator. The 50 Hz to 9900 Hz discriminator provides the more stringent accuracy requirements of the lower frequency and narrow dispersion range. A crystal unit provides approximately 100 times the transfer gain the transmission line discriminator provides. Output signal from the discriminator is applied through the emitter followers Q130 and Q121 to the base of Q120.

The DC output level of the comparator is set by the front panel 0000 Hz CAL adjustment R120. The Center Frequency (0 Hz and 00 Hz) adjustment R128 sets the 0000 to 9900 Hz

tracking of the center frequency switching circuit. See Center Frequency switching.

Dispersion Switching. The oscilloscope sweep sawtooth signal is applied to the Swept-Frequency generator by one of two paths; an internal connection through the oscilloscope plug-in connector, for those oscilloscopes providing the proper signal at pin 6 of the interconnecting plug; or externally through a patch cord connecting the analyzer's front panel EXT INPUT (Sweep) connector to the oscilloscope's Sweep A, or Sawtooth Out) connector.

Since the Tektronix oscilloscope used with this plug-in may have either a 100-volt sawtooth or a 150-volt sawtooth at its front panel connector, R105 can be switched into the circuit to compensate for this difference so that the analyzer can be used with either group of oscilloscopes.

The front-panel DISP BAL adjustment R108 sets the center DC level of the external sawtooth to zero so that the center frequency of the display does not change as the DISPERSION switch setting is changed. DISP CAL adjustment R110 sets the amplitude of the sawtooth voltage applied to the VARIABLE DISPERSION control when the SWEEP MODE switch is in the EXT position. When this switch is set to MANUAL, the DC voltage set by the MANUAL sweep control R102 establishes the input voltage. The instrument then acts as a fixed-tuned indicator.

The DISPERSION switch SW115 selects a position on a calibrated attenuator which attenuates the amplitude of the input sawtooth in a 1-2-5 sequence to give calibrated dispersions, ranging from 10 Hz/CM to 100 kHz/CM. The uncalibrated VARIABLE DISPERSION control R114 provides variable dispersion down to approximately zero between the calibrated DISPERSION switch settings.

The sweep output from the oscilloscope is connected to the EXT or INT position of the SWEEP MODE switch SW105. SW101 adds R105 in series with the input voltage divider network to reduce input sawtooth voltage amplitudes of 150 volts.

When the SWEEP MODE switch is in the EXT position the amplitude of the sawtooth to the dispersion attenuator (R116 A - I) is altered by the adjustments R110 (30 kHz C.F.), R114 (5000 Hz C.F.) and R108 (BAL) which calibrate the high dispersion settings for the upper and lower decade CENTER FREQUENCY (MULTIPLIER) switch positions. When the SWEEP MODE switch is in the INT position, the incoming sawtooth (at pin 6 of P11) is applied through the VARIABLE Dispersion control R113 to the dispersion determining circuit. Dispersion calibration for the INT position of the SWEEP MODE switch is accomplished with the VARIABLE control.

Manual control of the swept oscillator is provided when the SWEEP MODE switch is in MANUAL position. R102 provides an approximate 100 volt range of adjustment.

Center Frequency Switching

The center frequency of the spectrum display is set by the voltage level applied from the CENTER FREQUENCY switching circuit to the base of the comparator transistors. With the CENTER FREQUENCY (MULTIPLIER) switch SW120, in the 0 Hz position, the voltage level applied to the base of the comparator Q120, is set by the voltage divider network R240 (A to J) and R235 (A to K) sections of the CENTER FRE-

QUENCY-Hz selector SW235A and SW235B. See Fig. 3-5. With the CENTER FREQUENCY (MULTIPLIER) switch set to the 00 Hz position, the voltage level applied to Q120 is set by the voltage divider network R241 (A to J) and R236 (A to K).

When the CENTER FREQUENCY (MULTIPLIER) switch is in the kHz positions, the switching circuit is connected to the comparator Q140 and the sequence is repeated for the kHz and 0 kHz positions of the multiplier switch.

The voltage divider switching circuit (see Fig. 3-5 and the Center Frequency Switching diagram) is basically a Kelvin-Varley circuit. The (TENS) section contains 11 identical series resistors (R235 A-K or R236 A-K) connected across a voltage source. Two resistors of the TENS section are shunted by the resistance of the UNITS section (resistors R240 A-J or R241 A-J). This provides 10 equal voltage steps for the UNITS section between each selected pair of the TENS section.

The voltage range across the voltage divider network is calibrated by the 10 kHz CAL adjustment R232 which connects through R230 to the +225 volt supply and the 500 kHz calibration adjustment R239, plus the VARIABLE CENTER FREQUENCY control R238, to the -150 volt supply.

Dispersion Warning Light Switching

The REDUCE DISPERSION light, B115, provides a warning to the operator that the display is misleading and will not meet dispersion accuracies. The CENTER FREQUENCY or the DISPERSION selectors must be reset so the displayed dispersion does not sweep below 0 Hz or above 1 MHz. For example: With the DISPERSION set to 100 kHz/CM and the CENTER FREQUENCY set to any frequency except 500 kHz, the display dispersion is either above 1 MHz or below 0 Hz. Power is supplied to the REDUCE DISPERSION light through SW235A from the +350 volt power supply.

There is an exception. With a combination CENTER FREQUENCY-Hz set to 2500 or 250 and a DISPERSION Hz/CM setting of 500 or 50 respectively, the indicator will light; however, this is a usable display.

Variable Resolution Amplifier

The resolving ability of the analyzer is a function of the variable resolution amplifier circuit. This circuit adjusts the resolution of the analyzer from a bandwidth equal to or less than 10 Hz to a bandwidth equal to or greater than 500 Hz.

The input IF signal, centered at 3 MHz, is applied through a four section filter network to a mixer amplifier Q280. The 3 MHz IF is mixed with 3.1 MHz from a crystal controlled oscillator Q290, and the difference frequency (100 kHz, 2nd IF) at the collector of Q280 is applied through J280 to the variable resolution circuit board. The 100 kHz IF signal is applied through emitter follower Q300 to an IF amplifier Q310 and the variable resolution circuit.

The variable resolution circuit consists of two 100 kHz quartz crystal filter amplifier stages. Bandwidth of the circuit is a function of these filter networks.

The input filter to the 2nd mixer contains four parallel resonant circuits tuned to 3.0 MHz and the parallel circuit L270-C270 which is resonant to 3.2 MHz. The bandpass of the filter is approximately 60 kHz. Any 3.2 MHz frequency

components are attenuated by the filter to prevent their mixing with the 3.1 MHz oscillator frequency and generating internal spurious signals. L270 is adjusted to minimize this spurious response.

The gain through the IF amplifier Q310 is controlled by the Lin Cal adjustment R316. This adjustment calibrates the vertical display, in RMS volts, for the linear spectrum display.

The amplified 100 kHz IF signal at the collector of Q310 is coupled through C314 to a phase splitter amplifier Q320. The effect of the shunt capacitance of the quartz crystal Y325 is effectively neutralized by coupling a portion of the signal at the collector of Q320 through C323 to Y325.

Crystal Y325 is a 100 kHz crystal connected in series with the signal path to amplifier Q330. The output load for the crystal is the parallel resonant circuit consisting of L327, C327, C329 and stray circuit capacitance. This parallel tuned circuit is shunted by the input impedance of amplifier Q330. Resolution bandwidth of the circuit is dependent on the characteristics response of the crystal at its series resonant frequency and the Q of this parallel tuned circuit. Fig. 3-6 illustrates the impedance versus frequency curve of a quartz crystal². Since capacitor C323 neutralizes the shunt capacitance around the crystal, the crystal is equivalent to a series tuned circuit with a very narrow bandpass.

As the loading of the parallel tuned circuit is increased, the Q of the circuit decreases and the series resonant response characteristics of the crystal becomes the dominant factor in determining the bandwidth of the circuit. The loading is varied by changing the emitter load resistance of Q330. See Fig. 3-7. The input impedance of an emitter follower is about equal to the transistor beta times the emitter load resistance. Therefore, the bandwidth of the circuit is varied by changing the emitter load resistor R335 (A to G).

As an example, the beta of the transistor Q330 is normally around 200. When the COUPLED RESOLUTION switch SW335 is fully counterclockwise, there is an AC coupled load resistance of approximately $10\ \Omega$ between the emitter and ground. This sets the transistor input impedance to approximately 2000 ohms ($10\ \Omega$ times 200). This impedance shunts the parallel resonant circuit (L327-C327) and the crystal series response becomes the dominant factor in determining the resolution bandwidth. Therefore the analyzer resolution increases as the COUPLED RESOLUTION control is turned counterclockwise.

Reducing the transistor input impedance will also reduce the gain of the stage; however, the gain of this stage is held fairly constant by means of the coupling circuit between the collector and emitter. When C332 is correctly adjusted, the signal amplitude at the base of Q340 is relatively independent of the RESOLUTION switch setting.

Q340, Y345 and Q350 are part of a second variable resolution circuit that functions in the same manner as the circuit described above. The use of two circuits provides a very narrow skirt or steep slope to the 100 kHz response.

Output Driver Amplifier

The 100 kHz 2nd IF signal from the variable resolution amplifier is applied through the VERTICAL DISPLAY switch

² (Ref: F. Langford-Smith Radiotron Designers Handbook; 4th edition.)

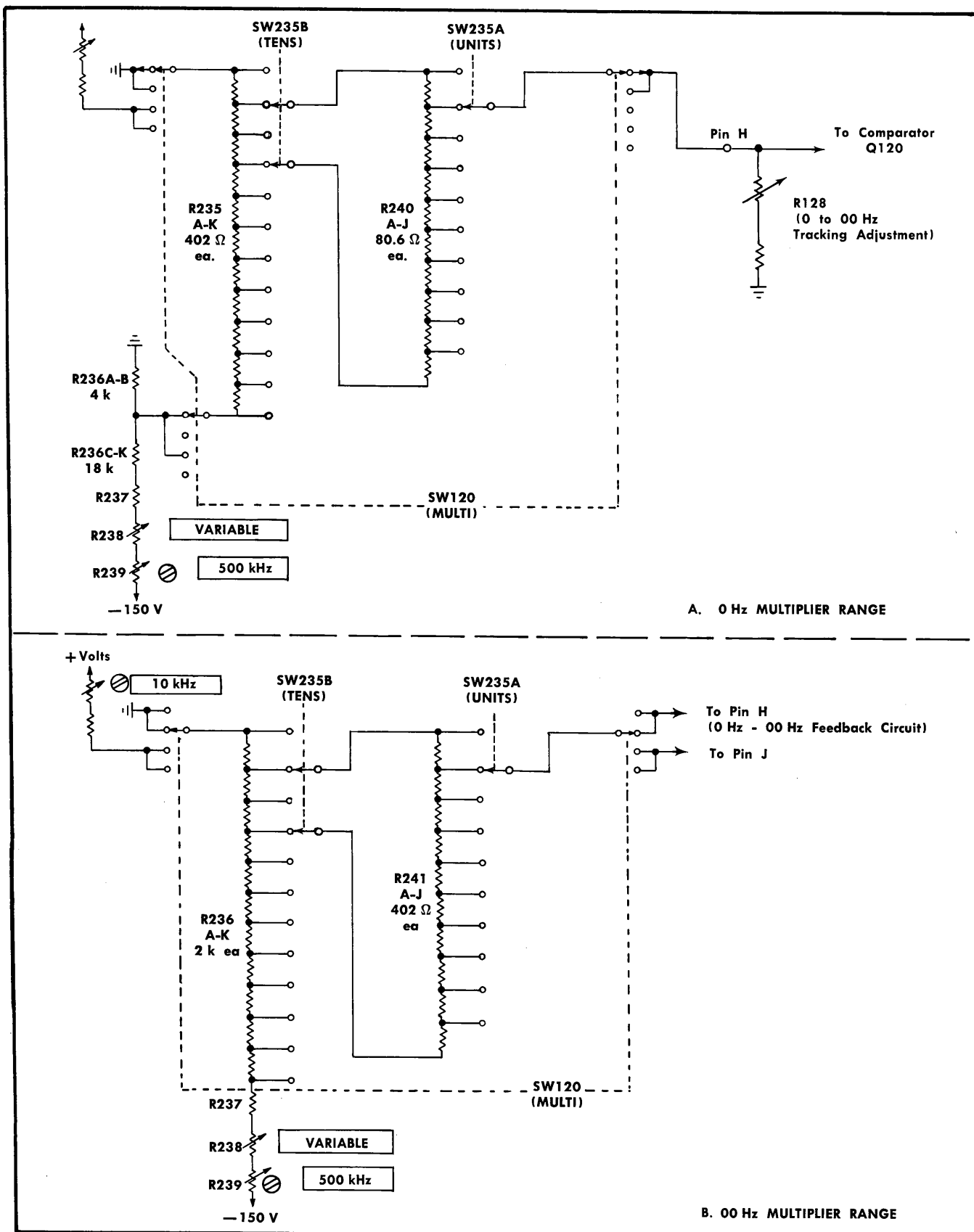


Fig. 3-5. Center frequency switching. (A) 0 Hz Multiplier Range. (B) 00 Hz Multiplier Range.

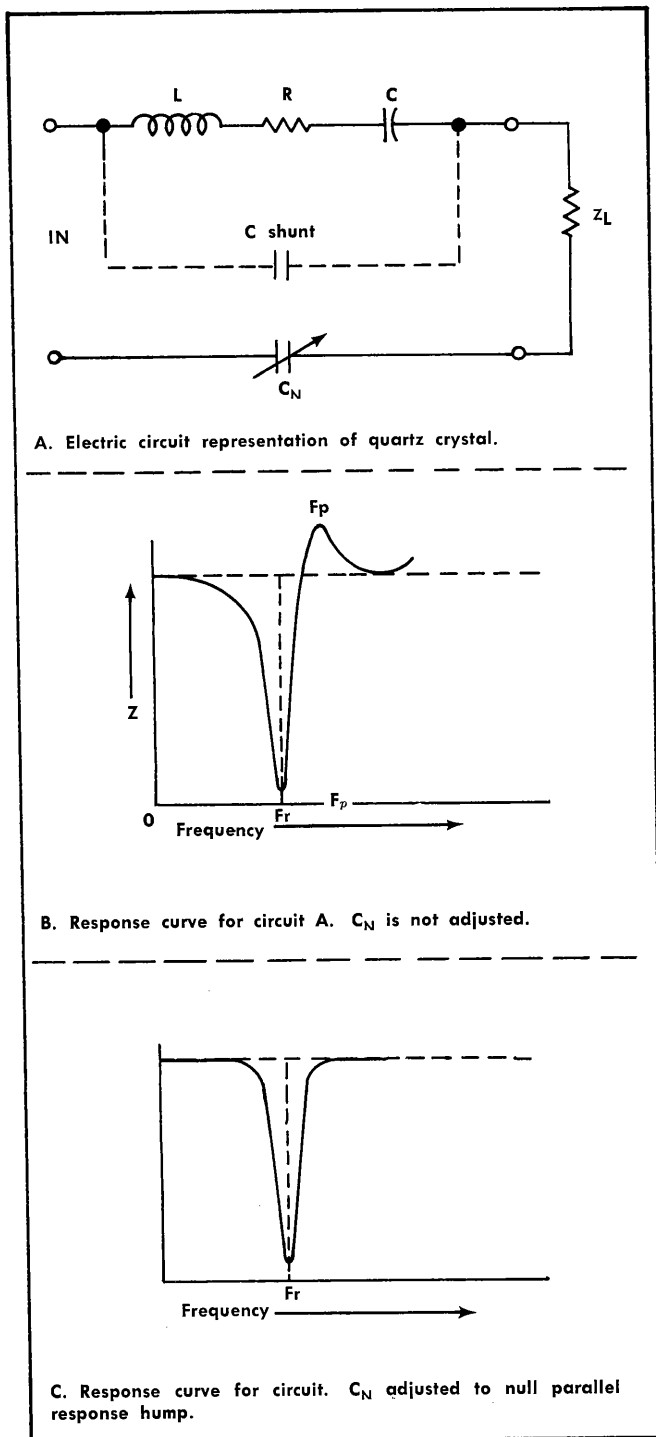


Fig. 3-6. Crystal filter equivalent circuit and impedance response curves.

to Q400, an operational amplifier which is driving another operational amplifier Q401 and Q410. Gain through Q400 is primarily set by the ratio of R402 (R_f) and R400 (R_{in}). Gain through Q401 and Q410 is primarily a function of the ratio of the feedback network (R411, R412, C412 and C413) and the input impedance (R405-C405) to Q401. The base of the input amplifier is grounded by the VERTICAL DISPLAY switch

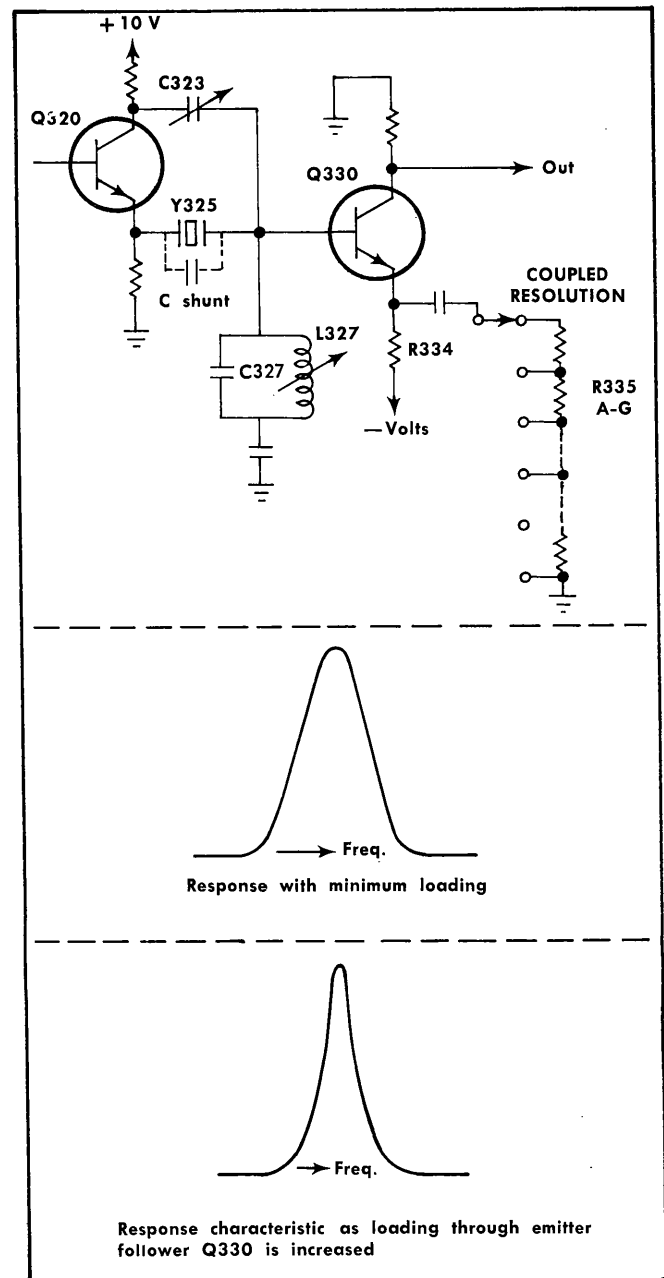


Fig. 3-7. Basic variable resolution circuit.

when it is in the VIDEO position. This prevents spectrum signals and noise from interfering with the video amplification function of the instrument when it is used as a conventional vertical amplifier for time domain displays.

The operational amplifier provides the signal current for the recorder output detector D415 and the spectrum display detectors D420-D422. The diode detector for the LIN and LOG displays are connected as a voltage doubler to provide the 60 dB dynamic range for the LOG display.

A pre-bias current of approximately 1 μ A through R421 and the two diodes D420-D422 to the POSITION control increases the detector sensitivity and compensates for low

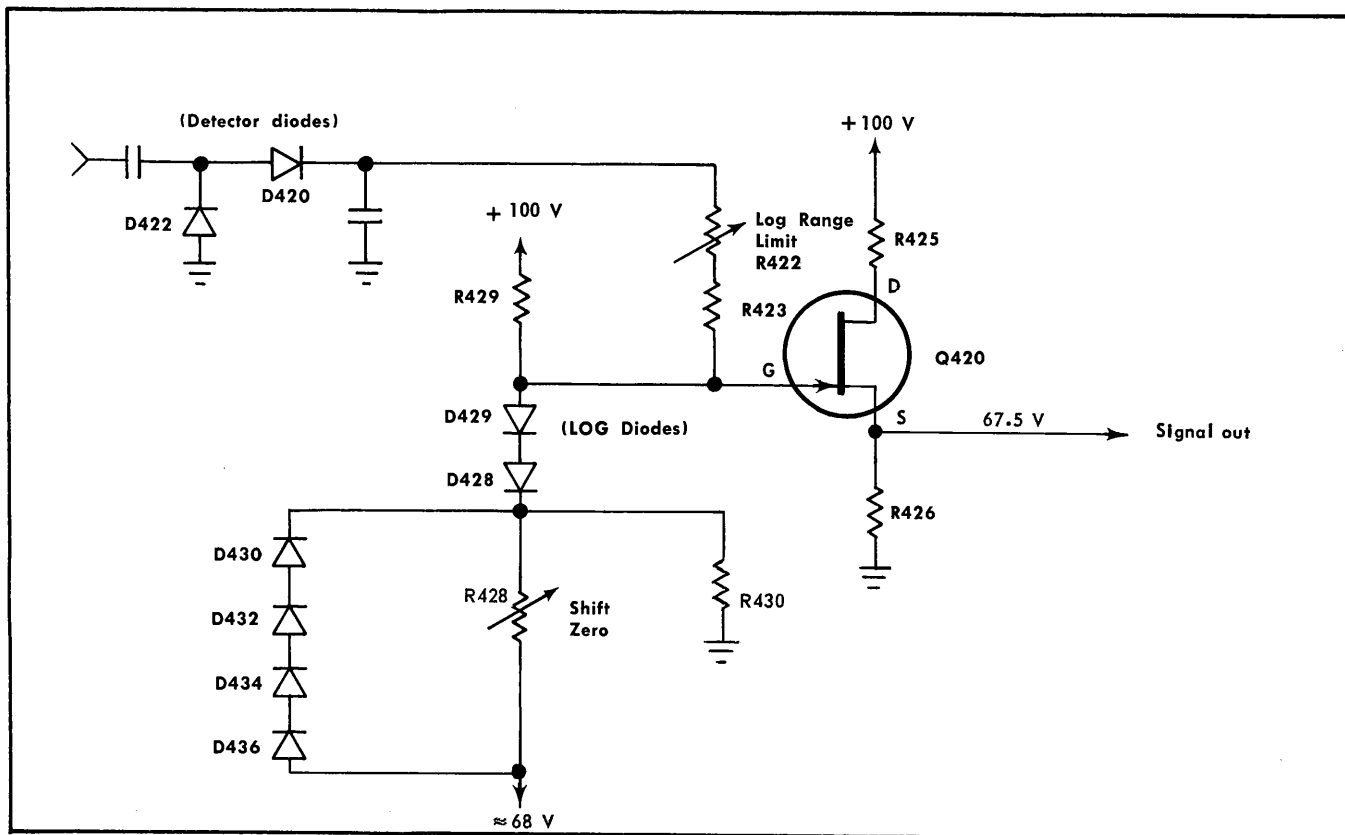


Fig. 3-8. Simplified drawing of the LOG attenuator circuit.

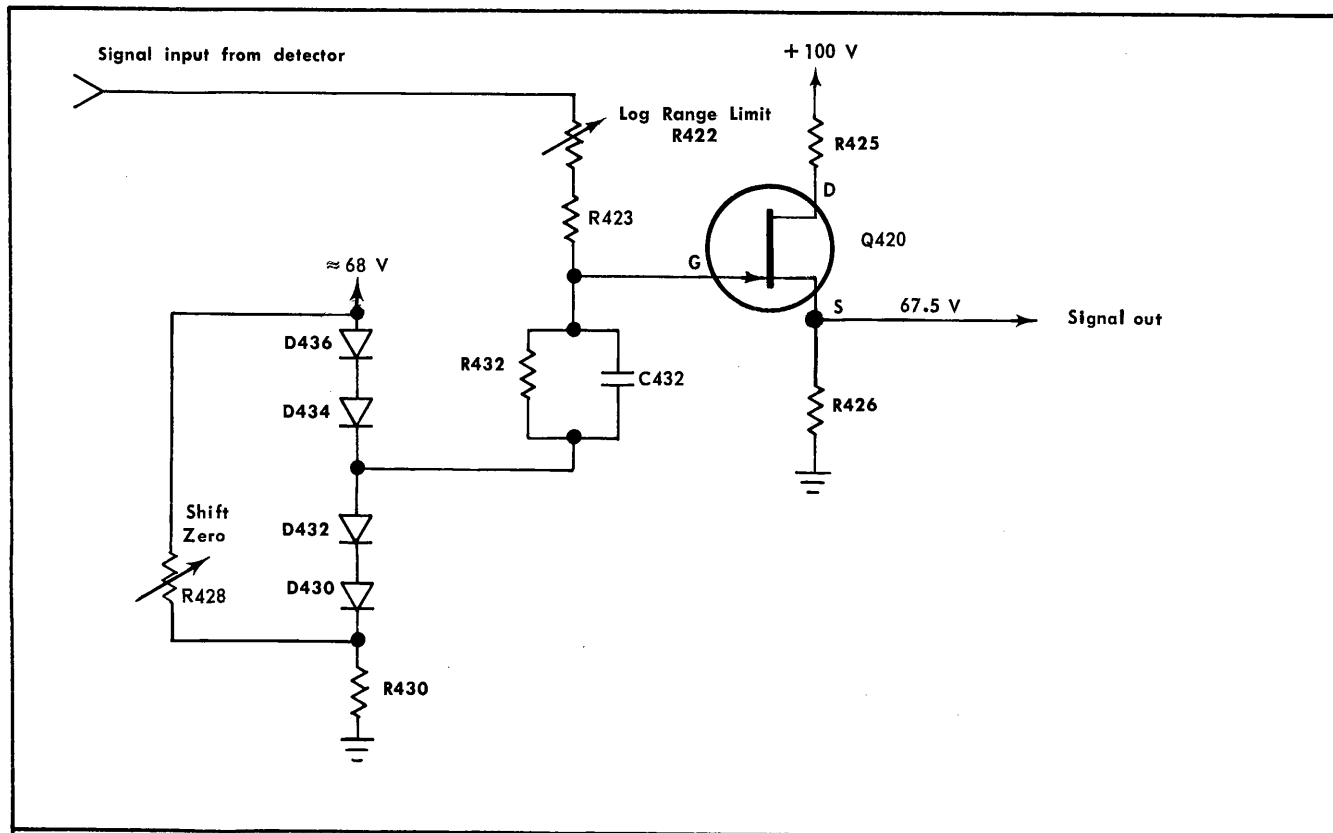


Fig. 3-9. Simplified LIN attenuator circuit.

amplitude signal loss across C420 when signal amplitude is not sufficient to turn on D420. Additional low signal level compensation is also provided in the feedback circuit of the operational amplifier Q401-Q410.

The AC (100 kHz) feedback for the operational amplifier is the signal across the recorder detector D415. The DC feedback is taken from the collector of Q410. D415 is pre-biased slightly higher than D420 and D422, which AC couples a detected signal to the input of the operational amplifier and raises the gain of the amplifier, thus providing the additional pre-bias for the detector diodes. R420 provides gain adjustment for the operational amplifier and sets the dynamic range of the LOG display.

The high impedance output of the detector is transferred to a low impedance drive signal by the source follower field effect transistor Q420.

For a logarithmic display the input impedance to the base of Q420 is a function of the logarithmic circuit. See Fig. 3-8. Low amplitude signals appear across D429 in series with D428, with little or no attenuation. As the signal amplitude increases, the current through the diodes becomes an exponential function of the signal voltage across the diodes. R423 and R422 become the signal current source for the diodes, so the voltage at the base of Q420 becomes a function of the diode current or a logarithmic function.

R428 establishes the zero voltage point by setting the pre-bias current through the log diodes. R420 and R422 set the dynamic range of the log circuit.

When the VERTICAL DISPLAY switch is in the LIN position the input impedance to the base of Q420 becomes a function of the parallel RC network R432-C432. See Fig. 3-9. The diodes D430, D432, D434 and D436 provide a fixed voltage source to the base of Q420 and temperature compensation to the LOG diodes D428-D429 and the detector diodes D420-D422. When the VERTICAL DISPLAY switch is set to LIN or

VIDEO positions, D429 and D428 are effectively out of the circuit, so only D430 and D432 are left in the circuit to compensate for temperature changes in the detector diodes.

For VIDEO operation (Fig. 3-10) the gate of Q420 is returned through R433 to the fixed voltage source. R436 (VIDEO CAL adjustment) calibrates the gain of the amplifier for video operation.

Calibrator

The Calibrator is a Wien bridge oscillator that supplies a 5 kHz signal to calibrate the dispersion of the display by means of the front panel adjustments, when the Type 1L5 unit is changed to another oscilloscope. When the VOLTS/CM selector is in the CALIBRATE 4 CM 5000 Hz CENTER FREQ position, +10 volts is supplied through SW5 to the oscillator and an output 5 kHz signal is applied through SW5 to the Input Amplifier circuit.

Q500 and Q510 are connected as a direct coupled complementary (PNP to NPN) amplifier. Oscillator frequency is dependent on the phase shifting network in the feedback loop to the base of Q500. R502 provides a fine adjustment of the oscillator frequency.

Constant output amplitude is maintained by the amplitude regulator circuit of Q520. The signal at the collector of Q510 is detected by D520 and compared to the reference voltage set by R520 and R524. The difference voltage is then amplified and summed by the operational amplifier Q520 at the collector and coupled back to the emitter of Q500 to regulate the output signal amplitude of the oscillator.

The output from the calibrator is a rectified signal taken from the center arm of potentiometer R522. This signal is rich in harmonics and provides 5 kHz calibration markers for the spectrum display.

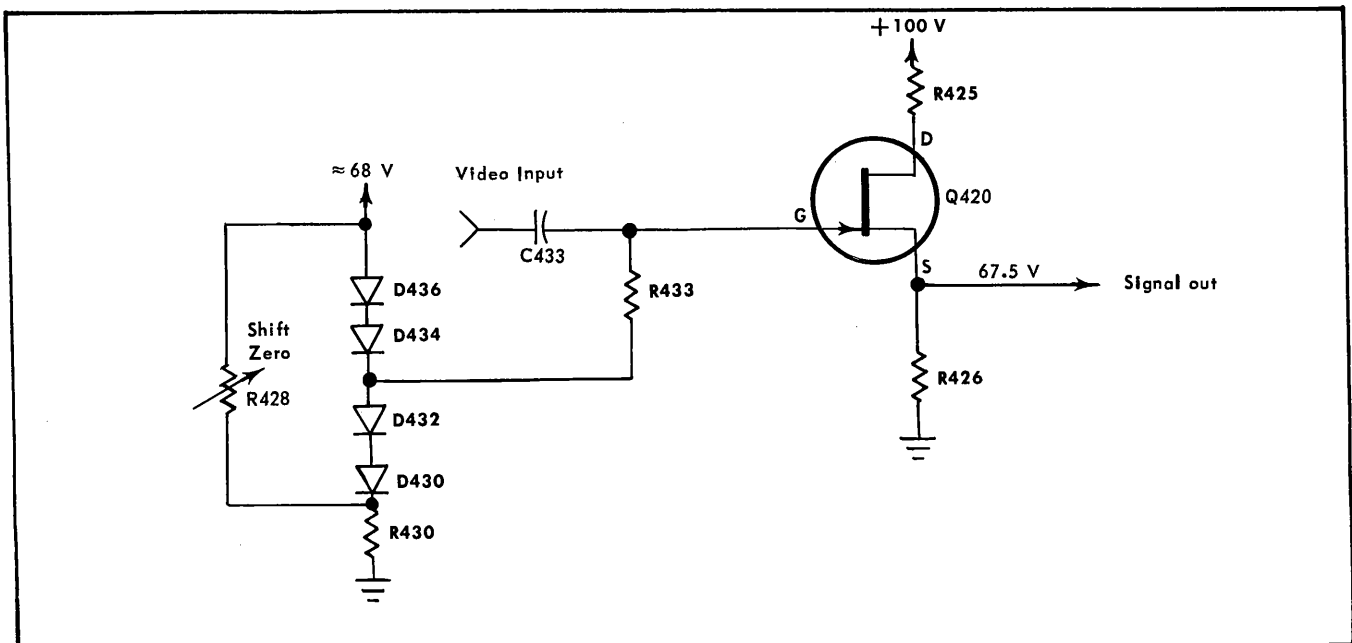


Fig. 3-10. Simplified VIDEO attenuator input circuit.

Power Distribution

The +10-volt and -10-volt potentials for the instrument are supplied by two shunt-regulated power supplies.

In the +10-volt supply, the reference voltage established at the junction of R450 and R452 sets the base voltage of Q450 to slightly under 10 volts. This reference voltage will remain constant, regardless of any changes in the + and - 10 volts supplies.

Under normal stable conditions when the +10 volts bus is at +10 volts, the difference voltage between the base and emitter of Q450 will bias it into conduction. The resulting collector current through R455 will bias the base of Q451 to just above zero volts. Since the emitter of Q451 is connected to ground, this forward bias will cause Q451 to conduct.

If the +10 volts supply voltage should increase, for some reason, the voltage on the emitter of Q450 will increase. This will increase its forward bias and cause Q450 to con-

duct harder, dropping more voltage across R455. This in turn would increase the forward bias on Q451, and increase the current through R459 to cause the +10 volts supply to return to +10 volts.

A drop in the +10 volts supply would have the opposite effect. The resulting decrease in the forward bias of Q450 would decrease the forward bias on Q451, resulting in less current through R459 which would return the +10 volts supply to 10 volts.

The action of the -10 volt regulator is very similar to the +10 volt regulator. R460 and R462 reference the base voltage of Q460 slightly negative with respect to ground to bias it into conduction. The resulting current through R465 forward biases Q461 and regulates the current from the -150 volt supply through R469.

If the voltage should decrease toward ground, the forward bias of Q460 would decrease, which would decrease the forward bias of Q461 and lower the current through R469 to regulate the -10 volt supply.

SECTION 4

MAINTENANCE

Introduction

This section of the manual pertains to the maintenance and troubleshooting of the Type 1L5. The first portion describes some general preventive measures to help minimize major problems. This is then followed by some maintenance techniques, information on replacing components and circuit boards, and concludes with some troubleshooting information.

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 it 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 the environment in which the instrument is used.

We recommend servicing and recalibration after each 500-hour period of operation, or more frequently if the instrument is operated under adverse conditions such as a high temperature or a dusty and corrosive atmosphere. If the instrument is used only occasionally, it should be serviced and recalibrated at least once every six months.

Exterior Cleaning

Loose dust accumulated on the outside of the instrument can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and 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.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastic and paint used in this instrument. Some chemicals to avoid are benzene, toluene, xylene, acetone or similar solvent.

Interior Cleaning

Dust in the interior of the instrument should occasionally be removed due to its electrical conductivity under high-humidity conditions. The recommended way to clean the interior is to blow off the accumulated dust with dry, low-velocity air. 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 or around narrow spaces such as cleaning ceramic terminal strips and circuit boards.

Lubrication

The reliability of potentiometers, rotary switches and other moving parts can be increased if they are properly lubricated. Use a cleaning-type lubricant (such as Tektronix Part No. 006-0218-00) on shaft bushings and switch contacts. Lubricate switch detents with a heavier grease (such as Tektronix Part No. 006-0219-00). Potentiometers should be lubricated with a lubricant which will not affect electrical characteristics (such as Tektronix Part No. 006-0220-00). Do not over-lubricate. A lubrication kit containing the necessary lubricant and instructions is available from Tektronix. Order Tektronix Part No. 003-0342-00.

Visual Inspection

After cleaning, the instrument should be carefully inspected for such defects as poor connections, damaged parts and improperly seated transistors. The remedy for most visible defects is obvious; however, if heat-damaged parts are discovered, determine the cause of over-heating before the damaged parts are replaced, otherwise the damage may be repeated.

Transistor Checks

Periodic preventive maintenance checks, consisting of removing transistors from the instrument and testing them in a tester, are not recommended. The circuits within the instrument provide the only satisfactory check on transistor performance. Defective transistors are usually detected during recalibration of the instrument. Methods of in-circuit transistor checks are given in the troubleshooting procedure later in this section.

Performance Checks and Recalibration

To insure accurate measurements, 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 will help to isolate major troubles in the instrument or to locate minor troubles which may not be apparent during regular operation. Performance check procedure is given in Section 5. Calibration instructions are described in Section 6.

CORRECTIVE MAINTENANCE

Corrective maintenance consists of component replacement and instrument repair. Special techniques or procedures required to replace components or assemblies are described in this section.

Obtaining Replacement Parts

Local Purchase. All electrical and mechanical replacement parts for the Type 1L5 can be obtained through your local Tektronix Field Office or representative. Many of the standard electronic components, however, can be obtained locally in less time than that required to order from Tektronix, Inc. Before purchasing or ordering replacement parts, consult the Parts List for the value, tolerance and rating of the component. The Parts section also contains instructions on how to order any replacement parts from Tektronix.

NOTE

When selecting a replacement part, it is important to remember that the physical size and shape of the component may affect its performance in the circuit. See Replacing Components in this section.

In addition to the standard electronic components, some special parts are used in this instrument. These parts are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. These special parts are indicated in the Parts Section by an asterisk preceding the part number. Order all special parts directly from your Tektronix Field Office or representative.

Soldering Techniques

WARNING

Disconnect the instrument from the power source before soldering.

To solder or unsolder any small or short-lead component:

1. Use needle-nosed pliers or a hemostat as a heat sink between the soldering point and the component.
2. Use a moderately hot iron for a short period of time.
3. Manipulate your tools with care to avoid damage to small components.
4. Use only enough solder to make a good bond.

Due to the presence of normal stray fields and capacitance within the instrument, the locations of some components are important to the operation of the system. Be sure to install replacement components in the exact positions occupied by the original parts.

After soldering any connection, clip off the excess length of the soldered leads. Be sure that these ends are not dropped into the instrument where they could cause electrical shorting.

Fig. 4-1 illustrates a handy tool for holding bare wires in place while soldering. It can be made from a short length of wooden dowel or thermoset plastic.

When soldering to a wafer-type switch, do not let the solder flow around and beyond the rivet on the switch terminal. The spring tension of the switch control may be destroyed by excess solder.

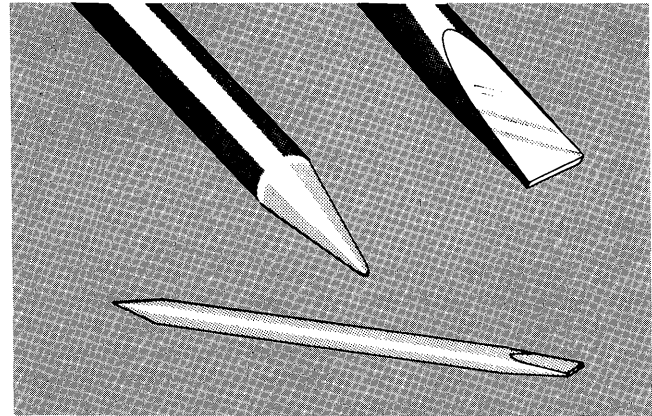


Fig. 4-1. Soldering aid for use with bare wires.

Circuit Boards. Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the circuit boards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the etched wiring from the base material.

The following technique should be used to replace a component on a circuit board.

1. Grip the component lead with long-nose pliers or a hemostat. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board, as it may damage the board.
2. When the solder begins to melt, gently pull the lead out. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object such as a toothpick or enameled wire into the hole.
3. Bend the leads of the new component to fit the holes in the board. If the component is replaced while the board is mounted in the instrument, cut the leads so they will just protrude through the board. Insert the leads into the plated holes through the board until the component is firmly seated. If it does not seat properly, heat the solder and gently press the component into place.
4. Apply the iron and a small amount of solder to the connection to make a firm solder joint. Too much solder may wick through the eyelet and short to another circuit. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink device.
5. Clip the excess lead wire that protrudes through the board.
6. Clean the area around the soldered connection with a flux-remover solvent to maintain good environmental characteristics. Be careful not to remove information printed on the board.

Metal Terminals. When soldering metal terminals (for example, switch terminals, potentiometers, etc.), ordinary 60/40 solder may be used. The soldering iron should have a 40- to 75-watt rating with a $\frac{1}{8}$ inch wide chisel-shaped tip.

Observe the following precautions when soldering metal terminals:

1. Apply only enough heat to make the solder flow freely.
2. Apply only enough solder to form a solid connection.
3. Clip off excess wire that extends beyond a solder connection.
4. Clean the flux from the solder joint with a flux-remover solvent.

Component Replacement

Transistor Replacement. Transistors, Field Effect transistors (F.E.T.'s) and diodes should not be replaced unless they are actually defective. If they are removed for any reason, return them to their original socket. Unnecessary replacement or changes may affect the instrument calibration. When they are replaced, check the calibration of that portion of the circuit.

It is possible to insert many transistors incorrectly in their sockets. Lead configuration differs between manufacturers. Before the semi-conductor is removed, note its physical orientation in the socket so it can be re-inserted correctly. If there is doubt about the lead configuration, refer to the manufacturer's base diagram. Fig. 4-3 illustrates the types of transistors used in this instrument. The pictorial circuit board component layout at the end of this section may also serve as a guide to show the correct position of each transistor.

Rotary Switch Replacement. Individual wafers or mechanical parts of rotary switches are usually not replaced. If a switch is defective the entire assembly is replaced. Replacement switches may be ordered either wired or unwired; refer to the Parts section for the applicable part numbers.

Circuit Board Assembly Replacement. Circuit boards without components, or, if desired, a unit completely wired with components mounted may be obtained through the normal ordering process.

Electrical connections to the circuit boards are made with push-on square pin connectors. To disconnect, lift off the connector. After the wires have been disconnected, removal of the Sweeper and Output Amplifier board and the Variable Resolution Amplifier board is a matter of removing the mounting screws and sliding the board from its position. To remove the Input Amplifier board proceed as follows:

1. Remove the VOLTS/CM and V/CM $\div$ 100 knobs and mounting nuts.
2. Remove the VOLTS/CM switch and the circuit board mounting screws.
3. Disconnect the pin connectors and unsolder R15.
4. Lift the VOLTS/CM switch assembly up and back to clear the V/CM $\div$ 100 linkage, then slide the board out from under the switch assembly. Figs. 4-4 through 4-7 should be used to identify the pin connectors with the wiring color code when replacing the pin connectors.

Component Numbering and Identification

The circuit number of each electrical part is shown on the circuit diagrams. A functional group of circuits (such as the

Input Amplifier) are assigned a series of numbers. Table 4-1 lists the assigned component numbers for the various circuits.

TABLE 4-1

Circuit No.	Diagram	No.
1-99	Attenuators and Input Amplifier	1
100-249	Swept-Frequency Generator	2
	Center Frequency Switching	3
	Dispersion Warning Light Switching	4
250-360 (and J90)	Variable Resolution Amplifier	5
400-439 (and SW75)	Output Driver and Detectors	6
440-500	Output Amplifier	7
500-530	Calibrator	8
600-630	Power Distribution	9

Circuit Boards. Figs. 4-4 through 4-7 show the individual boards, with the circuit numbers for each component. In addition, the circuit board sections on the diagrams are outlined in blue, to aid in locating individual components.

Wiring Color Code. All insulated wire used in this instrument is color-coded according to the EIA standard color code (as used for resistors) 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 following background color code: white, positive voltage; tan, negative voltage. Table 4-2 shows this wiring color code (with exceptions) for the power cabling. The remainder of the wiring is color coded, varying from a solid color and no stripes, to a solid color and one or more stripes, to aid in point-to-point circuit tracing.

Table 4-2
Power Supply Wiring

Supply	Back-ground Color	1st Stripe	2nd Stripe	3rd Stripe
-10 V ¹	Tan	Brown		
+10 V ¹	White	Brown		
-150 V	Tan	Brown	Green	Brown
+100 V	White	Brown	Black	Brown
+225 V	White	Red	Red	Brown
+350 V	White	Orange	Green	Brown

¹Exception: Color code partially conforms to EIA standard.

Resistor Color Code. A number of precision metal-film resistors are used in this instrument. These resistors are usually identified by their gray body color. If a metal-film resistor has a value indicated by three significant figures and a multiplier, it will be color coded according to the EIA standard resistor color code. If it has a value indicated by four significant figures and a multiplier, the value will be printed on the body of the resistor. For example, a 333 k Ω resistor will be color coded, but a 333.5 k Ω resistor has the value printed on the resistor body. The color code sequence is shown in Fig. 4-2.

Maintenance—Type 1L5

Composition resistors are color coded according to the EIA standard resistor color code.

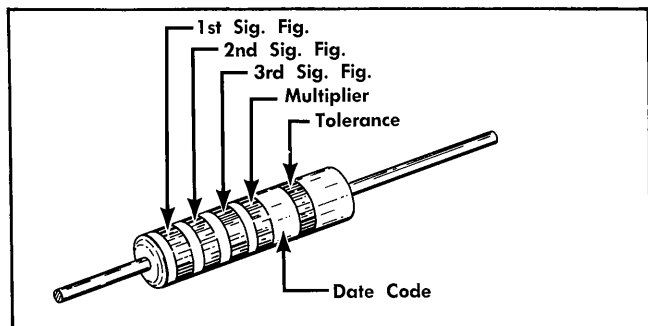


Fig. 4-2. Color coding of metal-film resistors.

Switch Wafer Identification. Switch wafers on the diagrams are coded to indicate the position of the wafer in the complete switch assembly. The numbered portion of the code refers to the wafer number counting from the front, or mounting end of the switch, toward the rear of the switch. The letters 'F' and 'R' indicate whether the front or the rear of the wafer performs the particular switching function. For example, a wafer designated 2R indicates that the rear of the second wafer is used for this particular switching function.

TROUBLESHOOTING

Troubleshooting is a technique gained through experience. Many circuit troubles interact and indicate more than one malfunction. For this reason a table of troubles and possible causes could be misleading. A suggested procedure to troubleshoot is as follows:

Attempt to isolate the trouble to a circuit by operational and visual checks. Verify that the apparent trouble is actually a malfunction within the Type 1L5 and not improper control settings or malfunctioning associated equipment. Note the effect the controls have on the trouble symptoms. Normal and abnormal operation of each control helps establish the location and nature of the trouble. Control functions are described in the Operating Instructions..

Check the instrument calibration or the calibration of the affected circuit. Many trouble symptoms are corrected by correct calibration. Complete calibration procedure is given in Section 6. Before changing any calibration adjustment settings during this check, note the adjustment position, so it can be returned to its original state. This will facilitate recalibration after the trouble has been found and corrected.

Check circuit voltages and waveforms against those shown on the diagrams of Section 9 of this manual. Fig. 4-4 through Fig. 4-7 provide board wiring and component layout information. If the trouble can not be isolated to a particular circuit, start with the power distribution circuit, then proceed consecutively from one circuit to the next.

When the trouble has been isolated to a circuit, refer to the circuit description in Section 3 for a description of the normal operation.

CAUTION

Use care when measuring voltages or waveforms on live circuits. The small size and high density of components in this instrument establishes a condition such that an inadvertent movement of the test probe or the use of oversized probes may short circuit between components.

The pin connectors to the circuits boards provide a way to isolate circuit resistance and voltages. Check circuit conditions before disconnecting voltages to make certain that bias voltages are not removed, which could cause excessive overloads.

Transistor and F.E.T. Substitution or Replacement

It was previously stated that transistors should not be replaced unless they are actually defective; however, temporary substitution is often a convenient way to detect defective transistors. Before a substitution is made, check circuit conditions to be certain that a replacement will not be damaged. Because transistors can be inserted into their sockets incorrectly, it is advisable to check the orientation of each transistor before substituting another one in its place. Fig. 4-3 shows the correct connections for the types of transistors and F.E.T.'s used in the Type 1L5.

In-Circuit Diode Checks

In-circuit diode checks may be performed with a voltmeter. A comparison check of the voltages on each side of the diode with the typical voltages listed on the diagram will help isolate faulty diodes. Forward-to-back resistance ratios can be checked by referring to the schematic and pulling appropriate transistors and square pin connectors to remove low resistance loops around the diode.

CAUTION

Do not use an ohmmeter scale that has a high internal current. Do not check the forward-to-back resistance ratios of tunnel diodes, zener diodes or the mixer diodes.

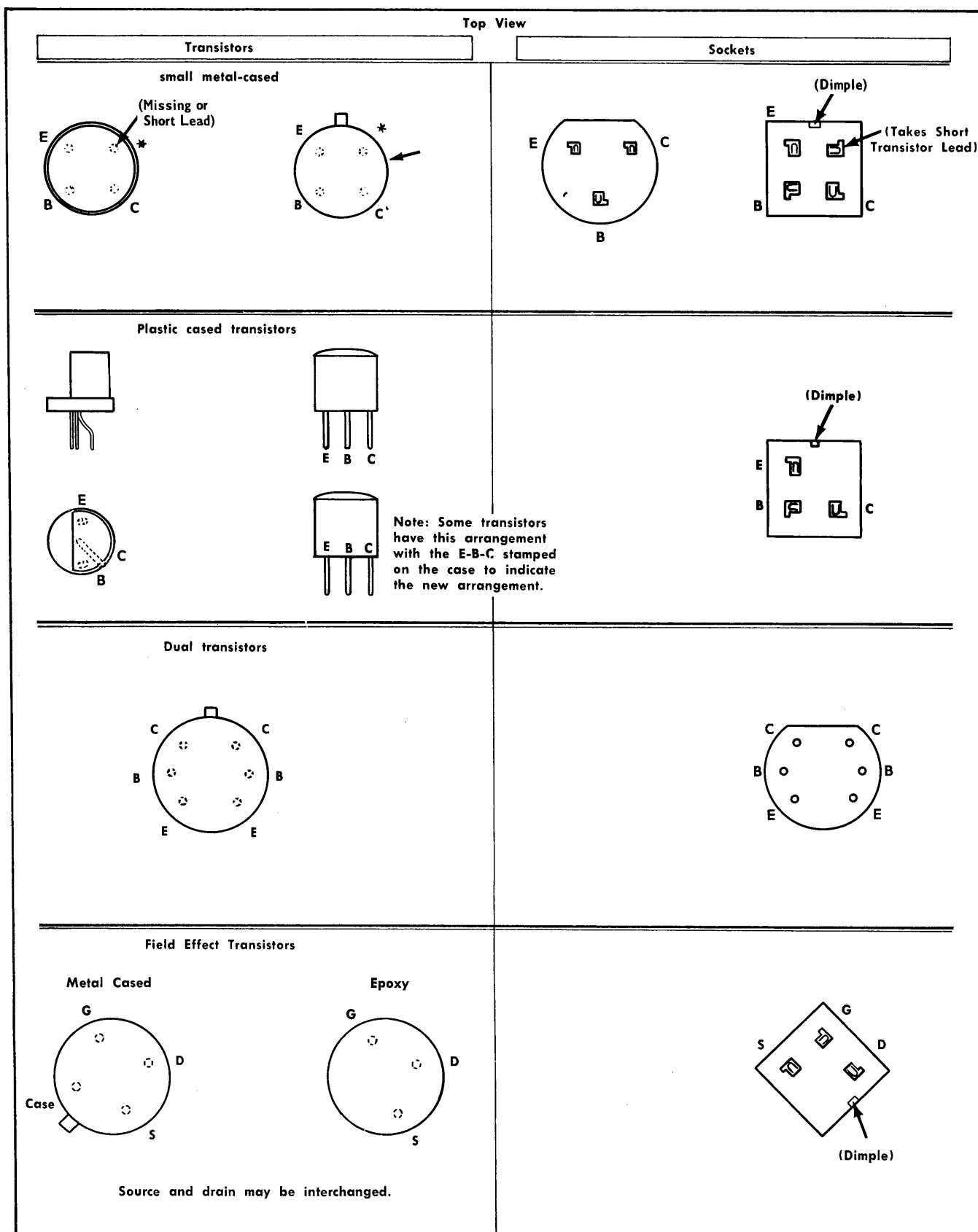


Fig. 4-3. Transistor and F.E.T. lead and socket configuration as viewed from the top.

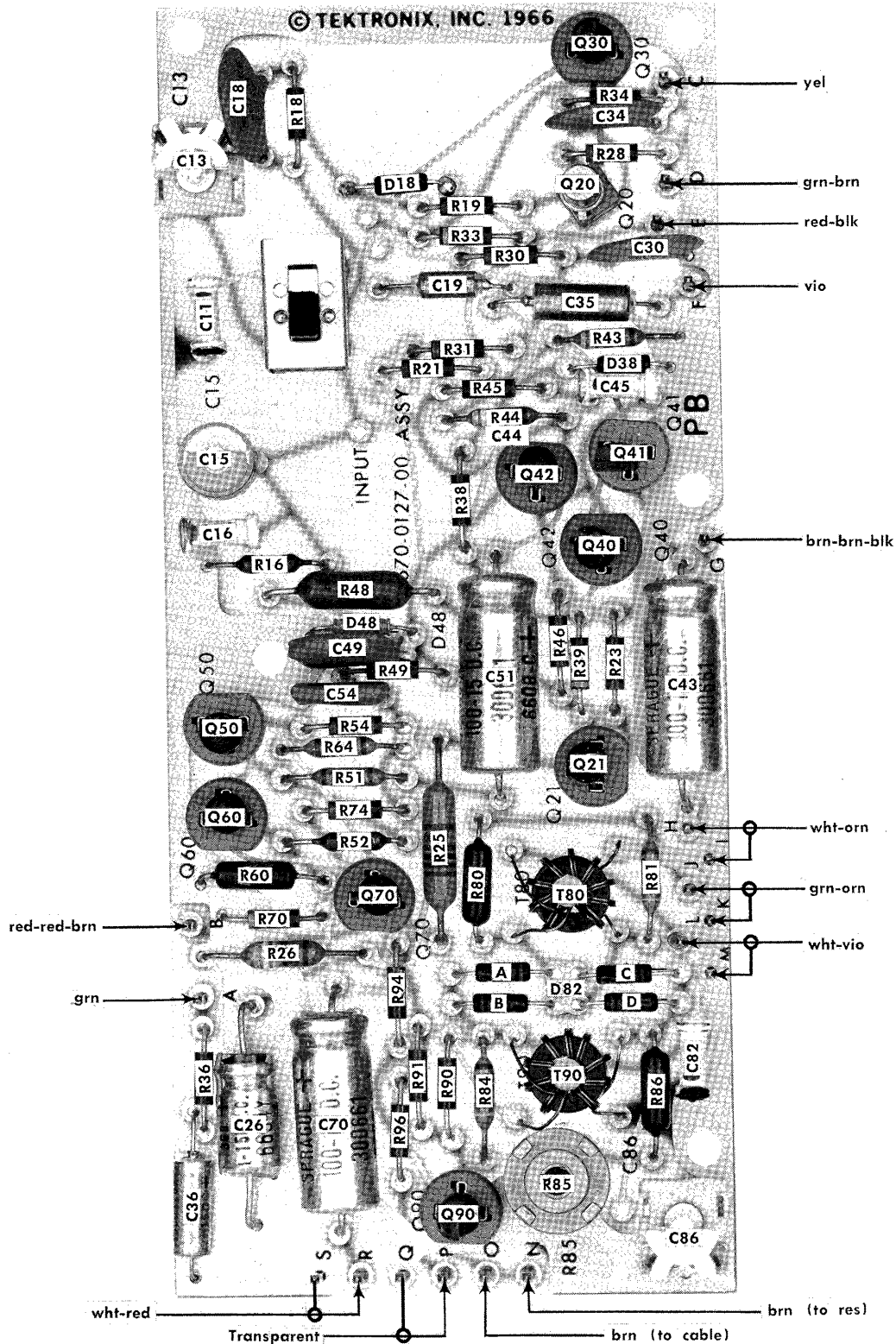


Fig. 4-4. Input Amplifier and 1st IF Mixer circuit board.

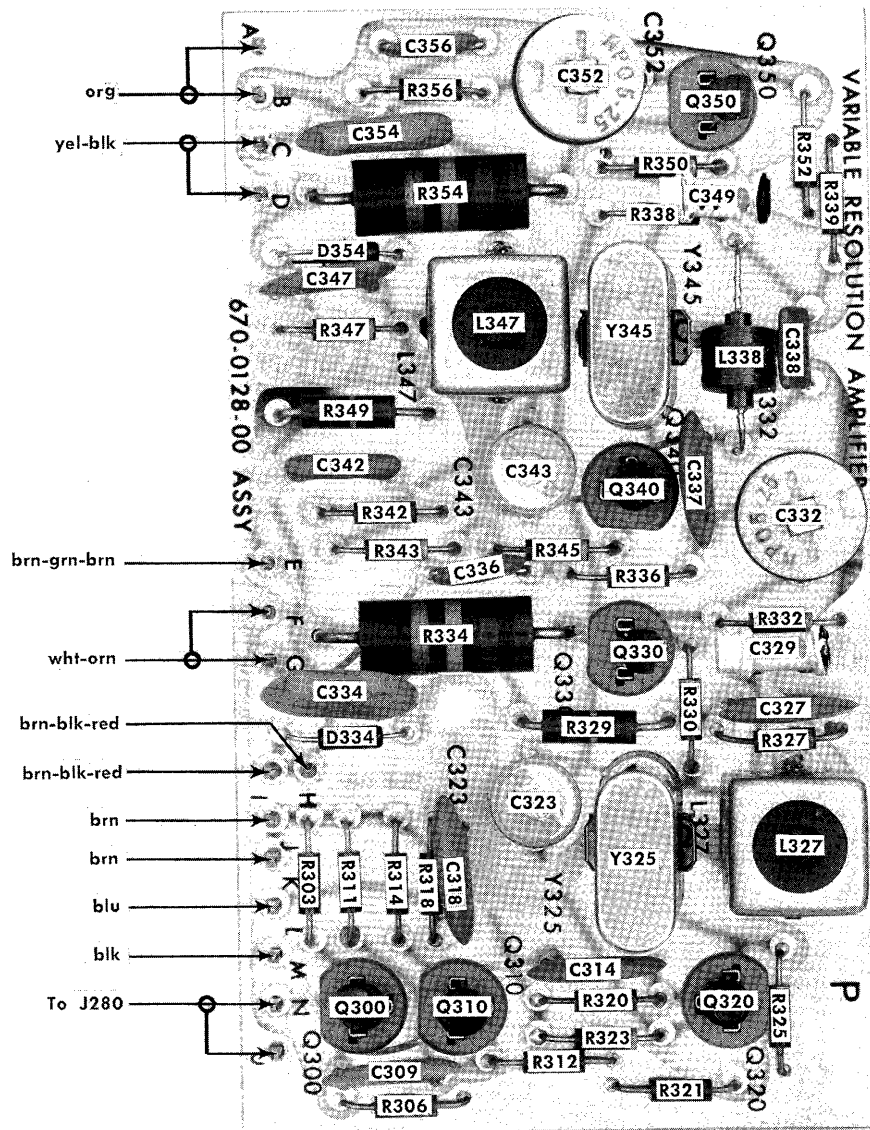


Fig. 4-5. Variable Resolution circuit board.

4-8

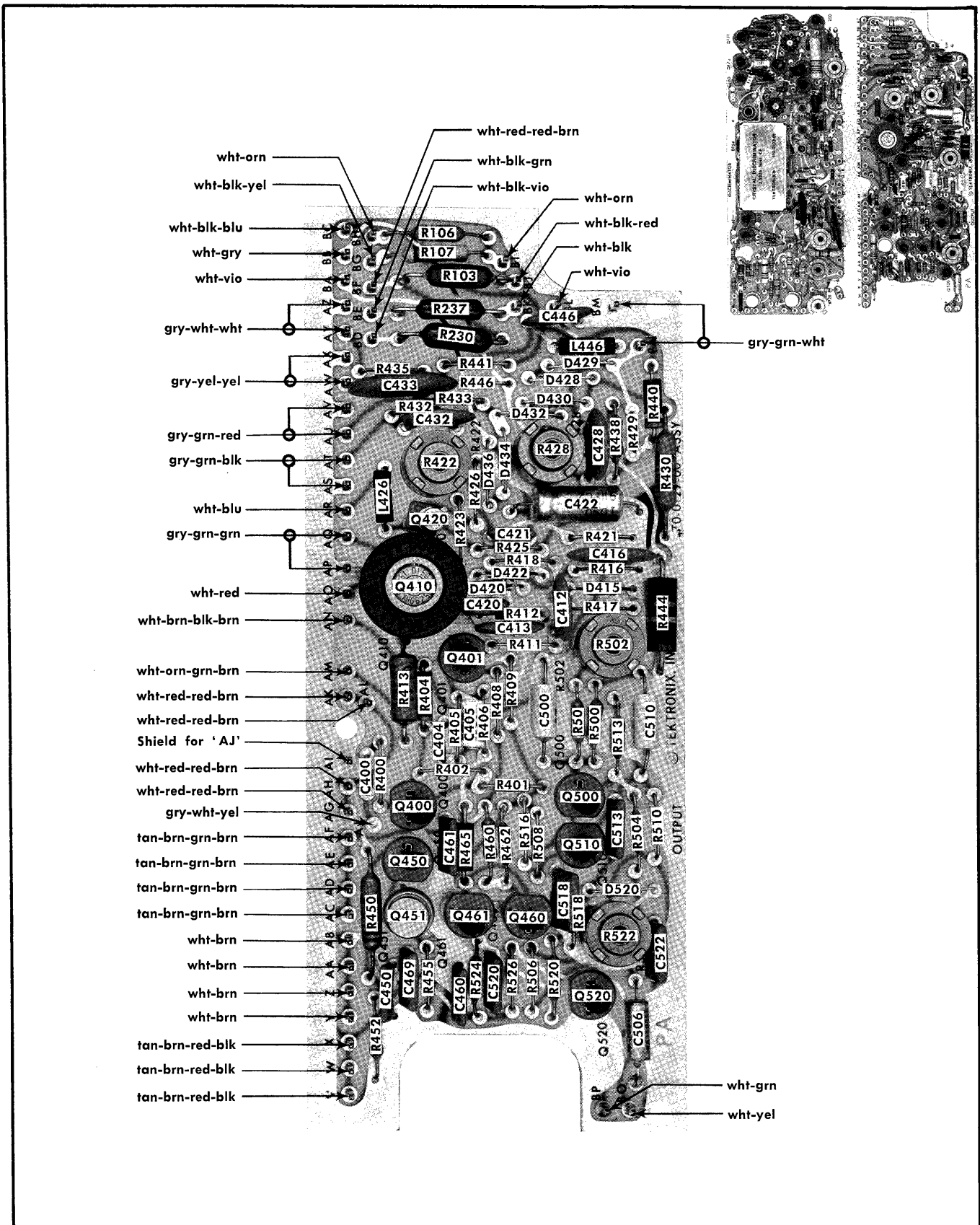


Fig. 4-7. Output Driver, Output Amplifier, Calibrator and Power Distribution circuit board.

NOTES

SECTION 5

PERFORMANCE CHECK

Introduction

This section of the manual provides a means of checking the performance of the Type 1L5. It is intended to check the calibration of the instrument without performing the complete Calibration Procedure. The Performance Check does not include the adjustment of any internal controls. Failure to meet the requirements given in this procedure indicates the need for internal checks or adjustments, details of which will be found in the Calibration Procedure.

Recommended Equipment

The following equipment is recommended for a complete performance check. Specifications given are the minimum necessary to perform this procedure. All equipment must be calibrated and operating within the original specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For accuracy and convenience, special calibration fixtures may be used in this procedure. These fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

Equipment List

1. Plug-In Oscilloscope. Oscilloscope with a 6 cm vertical height that will accept the Type 1L5 Spectrum Analyzer. This oscilloscope should be the one that the Type 1L5, being calibrated, will normally be used in. The front panel adjustments will require readjustment if the analyzer is changed to another oscilloscope. A Type 549 Storage Oscilloscope is used in this procedure.

2. Test Oscilloscope. Minimum requirements: Bandwidth, DC to 10 MHz; vertical sensitivity and accuracy, 0.005 V/CM to 10 V/CM, $\pm 3\%$; sweep rate and accuracy, 1 s/cm to .2 μ s/cm, $\pm 3\%$. Tektronix 540, 550 or 560 series with appropriate plug-in units. For example: 545B with the Type 1A1 Plug-In Unit.

3. Time-Mark Generator. Minimum requirements: Marker output, 50 ms (20 Hz) to 10 μ s (100 kHz); marker accuracy, within $\pm 0.01\%$. Tektronix Type 184 Time-Mark Generator.

4. Two, (2) Wide-Range Signal Generators. Minimum requirements: Frequency output and accuracy, 10 Hz to 1 MHz, $\pm 1\%$; output amplitude, ≥ 2 volts peak to peak. Hewlett-Packard Type 241A Oscillator or General Radio Type 1310-A.

5. Square-Wave Generator. Minimum requirements: Repetition rate, 1 kHz; risetime, ≤ 15 nanoseconds; output amplitude, variable between 0.5 and 100 volts. Tektronix Type 106 Square-Wave Generator.

6. Standard-Amplitude Calibrator (SAC). Minimum requirements: Output amplitude and accuracy, 0.005 volts to 100 volts, $\pm 0.3\%$. Tektronix Part Number 067-0502-00.

7. Probes:

a. P6006 10 $\times$ Passive Probe. Tektronix Part Number 010-0127-00.

b. P6011 1 $\times$ Passive Probe. Tektronix Part Number 010-0193-00.

8. Input RC Normalizer: RC = 1 M Ω $\times$ 30 pF, equipped with BNC connectors. Tektronix Part Number 067-0552-00.

9. Three (3) 50 Ω coaxial cables. 42 inches long, BNC connectors. Tektronix Part Number 012-0057-00.

10. Patch Cord with BNC to banana plug tips. Tektronix Part Number 012-0091-00.

11. Termination, 50 Ω BNC. Tektronix Part Number 011-0049-00.

12. Four (4), 50 Ω , 10:1 attenuators, BNC connectors. Tektronix Part Number 011-0059-00.

13. Three (3), 50 Ω , 5:1 attenuators, BNC connectors. Tektronix Part Number 011-0060-00.

14. BNC, T connector, male to female. Tektronix Part Number 103-0030-00.

15. Binding post to BNC plug. General Radio, Type 273-QBJ.

16. Miniature phone plug and 600 Ω load. Test fixture to check TO RECORDER signal amplitude. Consists of a 600 Ω , 5%, $\frac{1}{2}$ watt resistor soldered across a miniature phone plug. See item 17 of Fig. 6-1.

17. Step Attenuator, 1 dB to 51 dB (combinations of 1, 2, 4, 8, 16 and 20 dB), 600 Ω . Tektronix Part Number 011-0093-00.

18. Termination, 600 Ω . Tektronix Part Number 01-0092-00.

PERFORMANCE CHECK PROCEDURE

General

In the following procedure, test equipment connections or control settings should not be changed except as noted. If only a partial check is desired, refer to the preceding step(s) for setup information.

The following procedure uses the equipment listed under Recommended Equipment. If substitute equipment is used, control settings or setup must be altered to the requirements of the equipment used.

Some of the checks in this procedure require the use of a test oscilloscope and it is referred to in these terms. The oscilloscope associated with the Type 1L5 is referred to as a plug-in oscilloscope.

NOTE

The following performance check is applicable over a temperature range of 20°C to 30°C provided the environmental ambient temperature has been stable for a minimum of 4 hours.

Performance Check—Type 1L5

Set the Sawtooth Selector switch on the rear panel of the Type 1L5 to the appropriate setting. (150 V for the Type 549 Storage Oscilloscope; check the Oscilloscope Instruction Manual if a different Plug-In oscilloscope is used.)

Install the Type 1L5 into the vertical compartment of the plug-in oscilloscope. Connect the oscilloscope and associated test equipment to a suitable power source and turn the power switches ON. Allow at least 20 minutes warm-up time before checking the instrument to given accuracies.

Preliminary Procedure

1. Check the Type 1L5 for smooth operation and proper indexing of all front-panel controls except the screwdriver adjustments.
2. Connect a patch cable between the Sweep A connector and the Type 1L5 EXT INPUT connector.
3. Perform the front panel calibration adjustments as outlined in the operating instructions, Section 2.
4. Preset the front panel controls as follows:

CENTER FREQUENCY-Hz	0000
VARIABLE	CAL
DISPERSION-Hz/CM	100
VARIABLE	CAL
RESOLUTION	Coupled to dispersion
VOLTS/CM	.5 (Outer scale)
VARIABLE	CAL
V/CM ÷ 100	Pushed in
VERTICAL DISPLAY	LIN
Input Coupling	GND
SWEEP	EXT

Oscilloscope

Time/Cm	.2 s
Triggering	Adjusted for a free running sweep

1. Check Center Frequency Range

Requirement: Frequency range, 50 Hz to 990 kHz; Variable control range must extend the Center Frequency to 1 MHz or higher. (Range ≥ 10 kHz to 990 kHz center frequency.)

- Adjust the 0000 Hz C.F. CAL to position the 0 Hz spurious signal to the graticule center as the Hz/CM-COUPLED RESOLUTION position is reduced to 10.
- Return the Input Coupling selector to AC position, set the CENTER FREQUENCY-Hz selector to 50 and the DISPERSION-Hz/CM selector to 20.
- Apply a 50 Hz signal from the Wide-Range Signal Generator through a 50 Ω termination to the Type 1L5 INPUT connector.
- Check—The 50 Hz signal must be displayed within the graticule area. CENTER FREQUENCY accuracy, within $\pm (5\% + 50 \text{ Hz})$ of the dial reading for the 50 Hz to 990 Hz range.
- Change the CENTER FREQUENCY-Hz setting to 990 kHz, the DISPERSION Hz/CM and coupled RESOLUTION to 100 K and the Time/cm to 50 ms. Increase the frequency from the signal generator to 990 kHz.

f. Check—The 990 kHz signal must be displayed within 60 kHz.

g. Decrease the DISPERSION-Hz/CM to 10 K.

h. Vary the CENTER FREQUENCY-Hz, VARIABLE control through its range. Note the displayed signal shift in centimeters. Increase the frequency of the signal generator to 1 MHz.

i. Check—VARIABLE control range must equal or exceed 10 kHz (≥ 1 centimeter with a dispersion of 10 kHz/cm). This must extend the C.F. to 1 MHz or higher.

j. Return the VARIABLE control to the CAL position.

2. Check Center Frequency Accuracy

Requirement:

50 Hz to 990 Hz

$\pm (5\% + 50 \text{ Hz} + 50 \text{ Hz}/^\circ\text{C} \text{ max.})$

$\leq 1000 \text{ Hz change from } 0^\circ\text{C to } 50^\circ\text{C.}$

1000 Hz to 9900 Hz

$\pm (5\% + 100 \text{ Hz} + 100 \text{ Hz}/^\circ\text{C} \text{ max.})$

$\leq 2500 \text{ Hz change from } 0^\circ\text{C to } 50^\circ\text{C.}$

10 kHz to 99 kHz

$\pm (5\% + 3 \text{ kHz} + 200 \text{ Hz}/^\circ\text{C})$

100 kHz to 990 kHz

$\pm (5\% + 10 \text{ kHz} + 200 \text{ Hz}/^\circ\text{C})$

a. Insure that the CENTER FREQUENCY-Hz, VARIABLE control is in the CAL position. Apply the frequencies listed in Table 5-1 to the Type 1L5 INPUT connector and check the CENTER FREQUENCY-Hz selector tracking. The DISPERSION Hz/CM—COUPLED RESOLUTION controls should be set to the low dispersion (10 to 100 Hz) positions when checking the low frequency end of the CENTER FREQUENCY-Hz range and increased to the high dispersion (500 to 100 k) settings for the kHz range of the CENTER FREQUENCY-Hz selector. Adjust the sweep rate for optimum signal definitions as the DISPERSION—COUPLED RESOLUTION selections are changed.

Table 5-1

Input Signal Frequency	CENTER FREQUENCY-Hz Selection	Tolerance at a stable ambient temperature
100 Hz, 200 Hz 500 Hz, 900 Hz	100, 200, 500 900	$\pm(5\% + 50 \text{ Hz})$
1000 Hz, 5000 Hz 9900 Hz	1000, 5000, 9900	$\pm(5\% + 100 \text{ Hz})$
10 kHz, 50 kHz, 99 kHz	10 k, 50 k, 99 k	$\pm(5\% + 3 \text{ kHz})$
100 kHz, 300 kHz 650 kHz, 900 kHz	100 k, 300 k, 650 k, 900 k	$\pm(5\% + 10 \text{ kHz})$

3. Check Video Deflection Factor and VOLTS/CM Selector Accuracy

Requirement: The VIDEO deflection factor accuracy is within $\pm 6\%$ for all positions of the VOLTS/CM selector with the V/CM attenuator pushed in, and $\pm 3\%$ for all positions with the V/CM ÷ 100 attenuator knob pulled out.

a. Apply the output signal from the Standard Amplitude Calibrator (SAC) through a 50 Ω coaxial cable to the Type 1L5 INPUT connector.

b. Set the front panel controls as follows:

VERTICAL DISPLAY	VIDEO
VOLTS/CM	.5 (outer scale)
V/CM $\div$ 100	Knob pulled out
VARIABLE	CAL
Input Coupling Switch	AC

Oscilloscope

Time/cm	.1 ms
Triggering	Free Running

c. Apply a 20 mV square wave signal from the SAC. Adjust the front panel Video CAL for a display amplitude of 4 centimeters.

d. Check the accuracy of the VOLTS/CM selector as listed in Table 5-2.

TABLE 5-2

Analyzer VOLTS/CM Switch Setting (Outer Scale)	SAC Output in Volts	Display Amplitude in Centimeters	Maximum Error in Millimeters
.1	5 mV	5	± 1.5
.2	10 mV	5	± 1.5
.5	20 mV	4	0 (Set in Step C)
1	50 mV	5	± 1.5
2	.1 V	5	± 1.5
5	.2 V	4	± 1.2
10	.5 V	5	± 1.5
20	1 V	5	± 1.5
50	2 V	4	± 1.2
100	5 V	5	± 1.5
Push the V/DIV $\div$ 100 knob in			
.5	2 V	4	± 1.2

e. Set the VOLTS/CM selector to 1 (Outer scale), then adjust the Standard Amplitude Calibrator output for a signal amplitude of 5 volts. Center the 5 centimeter display on screen with the POSITION controls.

f. Turn the VARIABLE VOLTS/CM control fully counterclockwise.

g. Check—Display amplitude should decrease to ≤ 1.67 centimeters. (VARIABLE control range $\geq 3:1$.)

4. Check Range of POSITION Control

Requirement: POSITION control range must shift the trace + and — 8 centimeters or more.

a. Set the SAC generator output to 5 volts, set the VOLTS/CM selector to 1. Adjust the VARIABLE, VOLTS/CM control for a 4 centimeter display amplitude.

b. Increase the SAC output to 10 volts. Turn the POSITION control clockwise.

c. Check—Bottom of the display must position on or above the top graticule line.

d. Turn the POSITION control fully counterclockwise.

e. Check—Top of the display must position on or below the bottom graticule line.

f. Remove the signal from the Standard Amplitude Calibrator.

5. Check Baseline Shift

Operational Check (this is not a requirement): The display baseline should not shift off the graticule when the VERTICAL DISPLAY switch setting is changed from LIN to VIDEO and LOG.

a. Uncouple the RESOLUTION control and turn fully counterclockwise.

b. Position the VIDEO display baseline to the center line of the graticule.

c. Check—The baseline should remain within the graticule area when the VERTICAL DISPLAY switch is changed from LIN to VIDEO to LOG positions.

6. Check Spurious Signal Amplitude and Noise Level

Requirement: With a 50 dB signal applied, above a reference amplitude of 1.0 centimeter, LOG mode; the amplitude of spurious signals, (except the start spurious signal, fundamental and harmonics) must not exceed 1.0 centimeters. With the Type 1L5 input grounded, and maximum sensitivity, the amplitude of spurious signals must not exceed $2 \times$ the noise level.

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	500 k
DISPERSION Hz/CM	100 K
RESOLUTION	200
VERTICAL DISPLAY	LOG
VOLTS/CM	.005
Time/Cm	2 s

b. Apply a 500 kHz signal from the Wide Range Signal Generator through three $5 \times$ attenuators ($125 \times$ attenuation) and a 50Ω termination to the Type 1L5 INPUT connector.

c. Adjust the signal generator output control for a display amplitude of 1.0 centimeter.

d. Remove the three attenuators and set the VOLTS/CM selector to .002. (The signal source must remain terminated).

e. Check—Amplitude of spurious signals must not exceed 1.0 centimeter. (Ignore the 0 Hz start signal, fundamental and harmonics.)

f. Remove the signal from the Wide Range Signal Generator.

g. Change the front panel controls to the following positions:

CENTER FREQUENCY-Hz	500 k
DISPERSION Hz/CM	100 K

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VERTICAL DISPLAY	LIN
VOLTS/CM	.001
V/CM $\div$ 100	Pulled out
Input Coupling	GND
Time/CM	.5 s

h. Check—Measure the noise reference level on the display. Must not exceed 0.5 centimeter.

i. Set the Input Coupling selector to AC position.

j. Check—Amplitude of spurious signals, except the 0 Hz start spurious signal, must not exceed $2\times$ noise level. See Fig. 5-1.

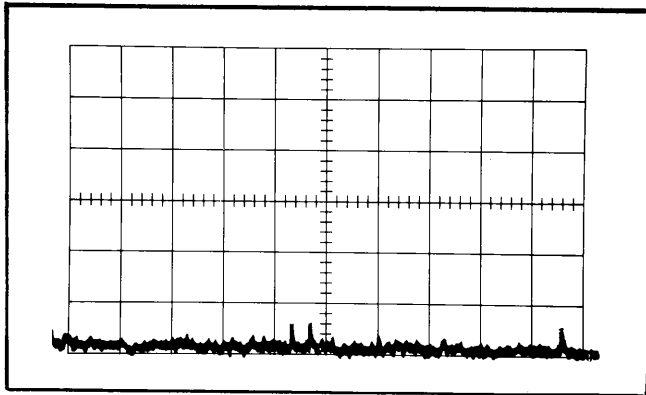


Fig. 5-1. Typical display to illustrate signal to noise ratio less than 2:1.

7. Check 0 Hz Spurious Signal Feedthrough

Zero frequency feedthrough signal amplitude is typically between 1 and 4 centimeters. This amplitude is not a requirement.

a. Set the front panel controls as follows:

VERTICAL DISPLAY	LIN
VOLTS/CM	.005
CENTER FREQUENCY-Hz	0000
DISPERSION Hz/CM	1 K
Input Coupling	GND
Time/CM	50 ms

b. Check—Amplitude of 0 Hz (zero frequency feed-through signal) should measure between 1 to 4 centimeters.

8. Check Resolution Bandwidth

Requirement: Resolution can be varied from a bandwidth equal to or less than 10 Hz to 500 Hz or more.

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	5000
VERTICAL DISPLAY	LIN

DISPERSION-Hz/CM	500
RESOLUTION	Uncoupled and fully clockwise
VOLTS/CM	.005
Input Coupling	AC
Time/CM	50 ms

b. Apply a 5 kHz signal from the Wide Range Signal Generator to the Type 1L5 INPUT connector. Adjust the frequency and amplitude of the signal for a centered 6 centimeter signal amplitude.

c. Check—Signal display should be symmetrical and the bandwidth at the -6 dB point (50% down), must equal or exceed 500 Hz. See Fig. 5-2A.

d. Change the sweep rate to 2 s/cm, decrease the dispersion Hz/CM and COUPLED RESOLUTION to 10. It may be necessary to slightly readjust the signal generator frequency to keep the signal centered. Adjust the signal generator output control to maintain a signal amplitude of 6 centimeters.

e. Check for a symmetrical display and a resolution bandwidth that is ≤ 10 Hz at the -6 dB level. See Fig. 5-2B.

f. Remove the signal from the Wide Range Signal Generator and return the Hz/CM-COUPLED RESOLUTION selectors to the 100 K position.

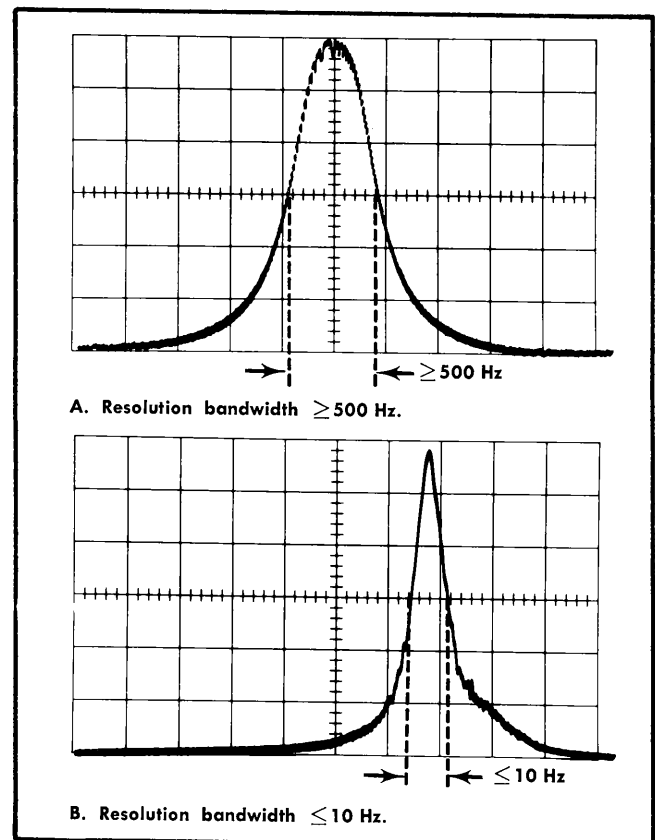


Fig. 5-2. Typical displays when checking resolution bandwidth.

9. Check Dispersion Accuracy

Requirement: Within the center frequency range, 50 Hz to 9900 Hz, accuracy $\pm 10\%$; within the center frequency range, 10 kHz to 990 kHz, accuracy $\pm 15\%$.

Dispersion accuracy is checked over the center 8 centimeters of the graticule. Align the first marker to the 1st graticule line and read the error as the displacement between the 9th graticule line and the appropriate marker. See Fig. 5-2. Dispersion window upper limit must not exceed 1 MHz for the 10 kHz to 990 kHz center frequency range, or 10 kHz for the 10 Hz to 9900 Hz frequency range.

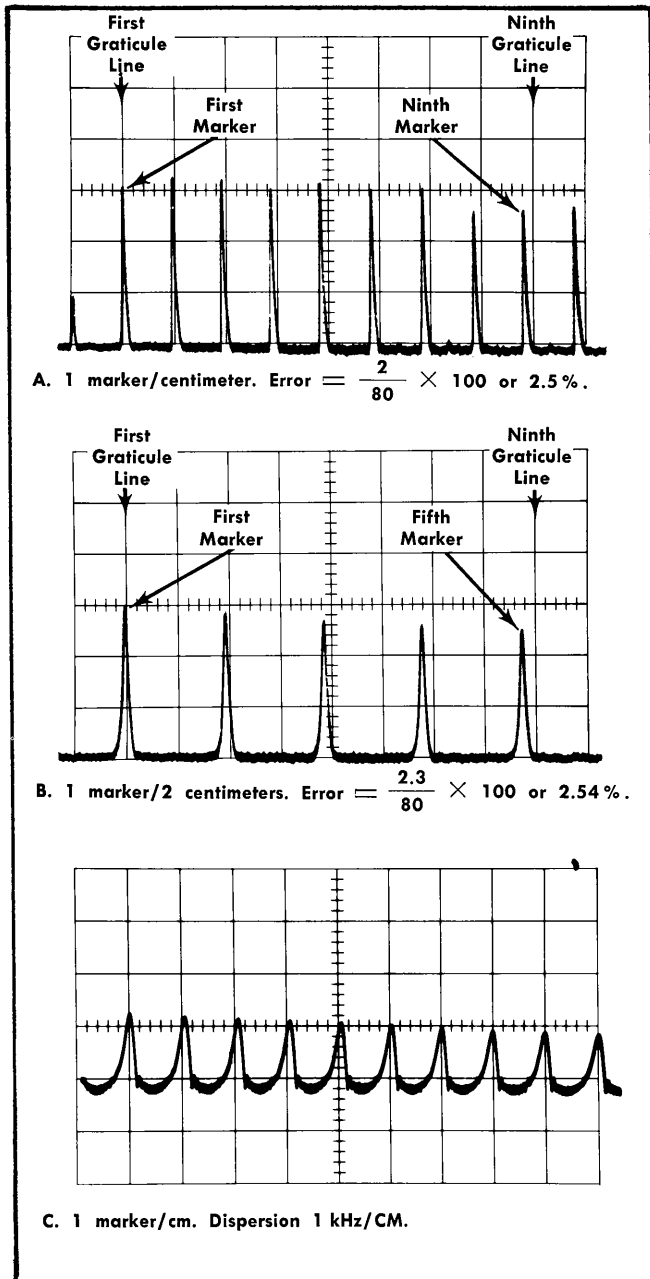


Fig. 5-3. Typical spectrum displays when checking dispersion accuracies.

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	500 k
VERTICAL DISPLAY	LOG
Input Coupling	AC
VOLTS/CM	.005
DISPERSION Hz/CM	100 K
VARIABLE	CAL
Time/Cm	50 ms

b. Apply 10 μ s time markers from the Time-Mark Generator through a 50 Ω termination to the Type 1L5 INPUT connector.

c. Align the 1st marker to the 1st graticule line, using the Horizontal Position control or the VARIABLE CENTER FREQUENCY control. Check dispersion accuracy for the 10 kHz to 990 kHz center frequency range as per Table 5-3. See Fig. 5-3. Increase the resolution by adjusting the RESOLUTION and decreasing the sweep rate as the dispersion is decreased.

TABLE 5-3

CENTER FREQUENCY-Hz Selection	DISPERSION-Hz/CM Selection	Time Markers	Allowable Error
500 k	100 K	10 μ s (1 marker/cm)	$\pm 15\%$
950 k, 500 k, 100 k, 50 k,	10 K	.1 ms (1 marker/cm)	
990 k, 500 k, 100 k, 50 k, 10 k	1 K (RESOLUTION 100)	1 ms (1 marker/cm)	

d. Change the CENTER FREQUENCY-Hz selection to 5000, the Hz/CM-COUPLED RESOLUTION to 1 K and the Time-Mark Generator output for 1 ms markers.

e. Check the dispersion accuracy, as per Table 5-4, over the 10 Hz to 9900 Hz center frequency range. Decrease the sweep rate and adjust the RESOLUTION to optimize marker display as the dispersion is decreased.

TABLE 5-4

CENTER FREQUENCY-Hz Selection	DISPERSION-Hz/CM Selector	Time Markers	Allowable Error
5000	1 K	1 ms	$\pm 10\%$
7500, 2500	500	1 ms (1 marker/2 cm)	
9000, 5000, 1000	200	5 ms	
	100	10 ms	
9500, 9000, 500	50	10 ms (1 marker/2 cm)	
5000, 100	20	50 ms	
5000, 50	10	50 ms (1 marker/2 cm)	

10. Check Dispersion Linearity

Requirement: Linearity within $\pm 3\%$.

Linearity error is indicated by the maximum distance any marker is displaced from its specified graticule line when compared with an 8 centimeter display. See Fig. 5-4.

a. Check the dispersion linearity as listed in Table 5-5. Each time the settings of the DISPERSION Hz/CM selector and the CENTER FREQUENCY-Hz selector are changed, use the Horizontal Position and VARIABLE DISPERSION controls to position markers under the first and ninth graticule lines as shown in Fig. 5-4. The maximum displacement of any marker from its specified point within the center 8 centimeters of a 10 centimeter display, must not exceed 2.4 millimeters.

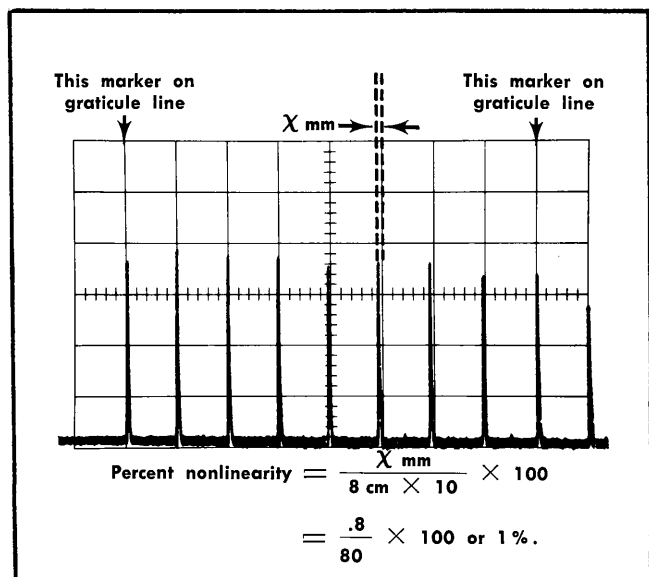


Fig. 5-4. Display illustrates dispersion linearity measurements.

TABLE 5-5

DISPERSION Hz/CM Switch Setting	Time Markers	Check at CENTER FREQUENCY-Hz Selector Settings:
100 K	10 μ s (100 kHz)	500 k
1 K	1 ms (1 kHz)	500 k, 100 k, 30 k
200	5 ms (200 Hz)	100 k, 30 k, 9000
20	50 ms (50 Hz)	9000, 500, 100

b. Return the VARIABLE DISPERSION control to CAL position. Remove the signal from the Time-Mark Generator.

11. Check Display Flatness

Requirement: The display flatness for the .001 VOLTS/CM and the .002 VOLTS/CM range is within ± 0.5 dB to -3 dB (10 Hz to 1 MHz). The display flatness for the .005 VOLTS/CM to 2 VOLTS/CM range is within ± 0.5 dB (10 Hz to 1 MHz).

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	5000
VERTICAL DISPLAY	LIN
VOLTS/CM	.001
V/CM $\div$ 100	Pushed in
VARIABLE	CAL
DISPERSION-Hz/CM	10 K
Time/CM	50 ms

b. Apply a 5 kHz signal from the Wide Range Signal Generator, through a T connector, to both the Vertical Input of a test oscilloscope monitor and through an attenuator or termination to the Type 1L5 INPUT connector.

c. Adjust the output of the signal generator for a signal amplitude of 5 centimeters on the plug-in oscilloscope CRT. Adjust the test oscilloscope gain for a reference display amplitude of 5 centimeters on the test (or monitor) oscilloscope.

d. Check the display flatness over the 10 kHz to 990 kHz frequency range as follows:

1. Set the CENTER FREQUENCY selector to 50 kHz, the DISPERSION Hz/CM to 10 K and the sweep time to 2 s/cm.

2. Apply a 50 kHz signal from the signal generator. Re-establish the reference amplitude of 5 centimeters on the test oscilloscope.

3. Tune the analyzer through the dispersion window in 10 kHz steps with the CENTER FREQUENCY-Hz selector, checking the display flatness. Display flatness must remain within ± 0.5 dB to -3 dB of the reference amplitude. (3.56 to 5.3 centimeters.)

4. Change the signal generator frequency and the CENTER FREQUENCY-Hz selector to 500 kHz. Set the DISPERSION Hz/CM to 100 K. Check the display flatness in 100 kHz increments through the remainder of the 10 kHz to 990 kHz frequency range, re-establish the reference amplitude after each change, then check the display flatness by tuning the CENTER FREQUENCY-Hz control below and above the applied signal generator frequency.

e. Check the display flatness over the 10 Hz to 9900 Hz range by checking the flatness with a signal frequency of 9000 Hz, then 10 Hz, applied to the Type 1L5 INPUT. Decrease the DISPERSION Hz/CM setting as the center frequency is decreased, or when the REDUCE DISPERSION indicator lights.

f. Repeat the flatness check for each position of the VOLTS/CM selector. Display flatness for the .001 and .002 VOLTS/CM positions must remain within ± 0.5 dB to -3 dB, and for the .005 VOLTS/CM to 2 VOLTS/CM range, ± 0.5 dB. Pull the V/CM $\div$ 100 knob out when checking the .5, 1 and 2 VOLTS/CM positions.

12. Check Video Frequency Response

Requirement: Video response is ≤ 10 Hz to ≥ 1 MHz for the .5 VOLTS/CM to 100 VOLTS/CM range, and ≤ 10 Hz to ≥ 700 Hz for the .1 VOLTS/CM and the .2 VOLTS/CM range.

- a. Set the front panel controls as follows:

VOLTS/CM	.5
VERTICAL DISPLAY	VIDEO
Input Selector	AC FAST

b. Apply the output from the Wide-Range Signal Generator through a T connector and 50 Ω termination to the Type 1L5 INPUT connector. Monitor the amplitude of the input signal to the Type 1L5 by connecting the vertical input for the test oscilloscope to the open connection on the T connector.

c. Set the frequency of the signal generator to 5 kHz and adjust the output for a display amplitude of 6 centimeters on the plug-in oscilloscope CRT. Adjust the gain of the test oscilloscope to establish a signal reference amplitude of 6 centimeters. Decrease the signal generator frequency until the display amplitude decreases to 4.25 centimeters on the plug-in oscilloscope. (Maintain a constant input amplitude signal.) Note the generator frequency. Increase the signal generator frequency until the display amplitude is again 4.25 centimeters and note the signal generator frequency.

d. Repeat the procedure in (c) for each position of the VOLTS/CM selector.

e. Check—Video bandwidth must equal or exceed the specified requirements.

13. Check Dynamic Range LOG Display and LINEARITY of LIN Display.

Requirement: Dynamic range of LOG display must equal or exceed 60 dB. Accuracy of LIN display within 3% (V/CM $\div$ 100 knob pushed in).

- a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	50 k
VERTICAL DISPLAY	LOG
VOLTS/CM	.005
V/CM $\div$ 100	Pushed in
DISPERSION	1 k
RESOLUTION	Fully clockwise
Time/cm	.2 s or slower

b. Apply a 50 kHz signal from the Wide Range Signal Generator through the 600 Ω Step Attenuator and 600 Ω termination to the Type 1L5 INPUT connector.

c. Set the Step Attenuator for 0 dB attenuation. Switch the Input Selector to GND position and position the trace to the bottom graticule line.

d. Switch the Input Selector to AC position. Adjust the signal generator output for a display amplitude of 6 cm (full screen). Center the signal on screen with the signal generator frequency control.

e. Switch the step attenuator from 0 dB to 50 dB in 10 dB steps. Note that the signal amplitude decreases approximately 1 cm/10 dB.

f. Set the step attenuator for 40 dB (20, 16, and 4 dB) attenuation and switch the VOLTS/CM selector to .05 (20 dB).

g. Check—Signal must be discernible above the display baseline. (Dynamic range, LOG mode must equal or exceed 60 dB.)

h. Set the VERTICAL DISPLAY selector to LIN position, the VOLTS/CM to .005, and the step attenuator to 26 dB. Adjust the signal generator output for a signal amplitude of 2 cm.

i. Check—The linearity accuracy of the LIN mode by switching the step attenuator to the positions indicated in the following table and noting the display amplitude. (This is an operational check of the detector diode linearity.)

Table 5-6

Step Attenuator	Display Amplitude
26 dB	2 cm (Set amplitude)
20 dB	4 cm $\pm$ 1 mm
32 dB	1 cm $\pm$ 1.0 mm

14. Check TO RECORDER Signal Output

Requirements: 5 mV to 15 mV into 600 Ω load for a signal display amplitude of 6 centimeters.

- a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	5000
VERTICAL DISPLAY	LIN
VOLTS/CM	.005
DISPERSION Hz/CM	1 K

b. Apply a 5 kHz signal from the signal generator to the Type 1L5 INPUT connector. Adjust the signal generator output for a signal amplitude of 6 centimeters.

c. Plug a miniature phone plug, terminated with a 600 Ω load resistor, (see equipment list), into the TO RECORDER jack. Connect the test oscilloscope probe across the 600 Ω load resistor.

d. Check the TO RECORDER output signal amplitude. Must measure within 5 mV to 15 mV.

e. Remove the test oscilloscope probe and the miniature phone plug.

f. Change the CENTER FREQUENCY-Hz setting and the signal generator frequency to 900 kHz. Decrease the DISPERSION-Hz/CM selector to 50. Keep the signal centered and maintain an amplitude of 6 centimeters.

g. Check incidental FM at 900 kHz, 500 kHz and 10 kHz. Must not exceed 10 Hz or 2 millimeters with a dispersion of 50 Hz/CM. Disregard signal drift.

15. Check Amplitude of Random Spuria

Requirement: Spurious signal amplitude equal to or less than 1.0 centimeter with a signal level 50 dB above a 1.0 centimeter reference amplitude; LOG mode.

- a. Change the controls to the following settings:

CENTER FREQUENCY-Hz	500 k
VERTICAL DISPLAY	LOG
VOLTS/CM	.005 (inner scale)
DISPERSION Hz/CM	100 K
RESOLUTION	200
Time/CM	.5 s

b. Apply a 500 kHz signal from the Wide-Range Signal Generator through three 5 $\times$ attenuators and a 50 Ω termination to the Type 1L5 INPUT connector. Adjust the generator output for a display amplitude of 1.0 centimeter on the CRT.

Performance Check—Type 1L5

c. Remove the three 5× attenuators and reconnect the terminated generator output to the INPUT connector. Change the VOLTS/CM selector to .002.

d. Check—Amplitude of spurious signals must not exceed 1.0 centimeter. (Ignore the start spurs, the fundamental and the 1st harmonic signal.)

16. Check Intermodulation Distortion

Requirement: Intermodulation sideband amplitude ≤ 1.0 centimeter with a 50 dB signal above a reference amplitude of 1 centimeter; LOG display.

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	100 k
VERTICAL DISPLAY	LOG
VOLTS/CM	.005
V/CM $\div$ 100	Pulled out
DISPERSION Hz/CM	10 K
Time/Cm	2 s

b. Apply a 90 kHz and 110 kHz signal from two signal generators, through isolation networks consisting of two 10× attenuators, to a BNC T connector. Connect three 5× attenuators and a 50 Ω termination from the T connector to the Type 1L5 INPUT.

c. Reduce the RESOLUTION to 20 and position the baseline of the display to the bottom graticule line. Return the RESOLUTION control to the 10 K position and adjust the output controls of the two signal generators for two signals that are 1 centimeter in amplitude, above the bottom graticule line. See Fig. 5-5A.

d. Remove the three 5× attenuators between the T connector and the 50 Ω termination. Reconnect the terminated T connector to the INPUT connector and change the VOLTS/CM selector to the .002 position.

e. Check—Intermodulation distortion. The amplitude of the sidebands must not exceed 1 centimeter. See Fig. 5-5B.

17. Check Oscillator Output

Requirement: With maximum dispersion, oscillator frequency must sweep ≥ 1 MHz (from approximately 3 MHz to 2 MHz).

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	500 k
VERTICAL DISPLAY	LIN
VOLTS/CM	.005
DISPERSION Hz/CM	100 K
VARIABLE	CAL
SWEEP	Manual (fully clockwise)

b. Connect the 10× probe from the test oscilloscope to the OSC OUT connector. Set the test oscilloscope Time/Cm to 1 μ s and adjust the Triggering controls for a triggered display.

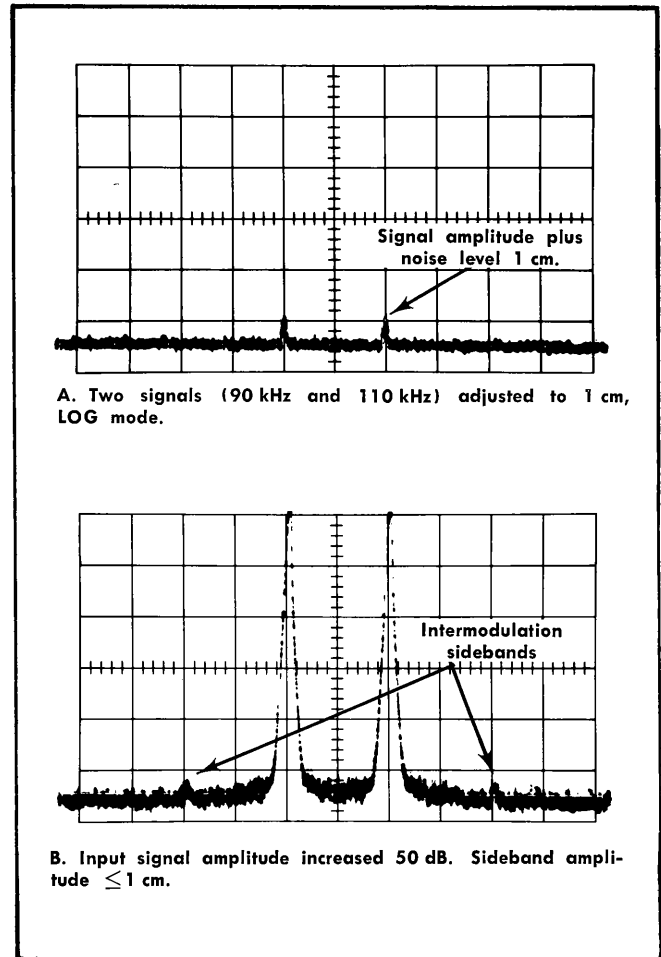


Fig. 5-5. Typical displays when measuring intermodulation distortion.

c. Check frequency shift of the oscillator as the SWEEP MODE MANUAL control is rotated through its range. Frequency shift must equal or exceed 1 MHz. (Approximately 2 cycles/centimeter to more than 3 cycles/centimeter.)

d. Measure the peak to peak amplitude of the oscillator signal. Must equal or exceed 1 volt.

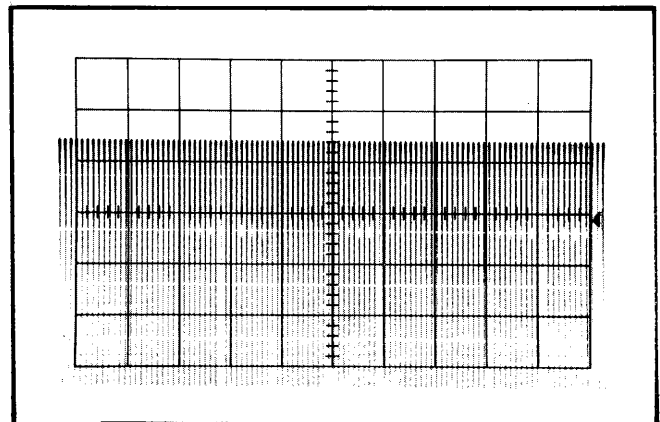


Fig. 5-6. 5 kHz calibrator markers with VIDEO display mode. Check drift of one cycle for a 2 second period with a sweep trigger rate of 0.1 ms.

18. Check the 5 kHz Calibrator Frequency

Requirement: Frequency 5 kHz $\pm 1\%$.

a. Set the front panel controls as follows:

VERTICAL DISPLAY	VIDEO
VOLTS/CM	CALIBRATE
V/CM $\div$ 100	Knob pulled out
VARIABLE	Fully counterclockwise
Time/Cm	2 ms
Trigger Source	Ext
Trigger Mode	Trig

b. Apply 0.1 ms time markers from the Time-Mark Generator to the EXT Trig In connector of the Plug-In Oscilloscope. Set the controls for external trigger and adjust the Triggering controls for a triggered display.

c. Adjust the Type 1L5 VOLTS/CM VARIABLE control for a 5 kHz marker amplitude of approximately 5 centimeters.

d. Select one marker, then measure its movement in centimeters across the screen for a 2 second period. Must not exceed 10 centimeters in 2 seconds. ($\pm 1\%$ of 5 kHz.)

This concludes the performance check for the Type 1L5. If the instrument has met all performance requirements, it will perform within the characteristics listed in Section 1.

NOTES

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

SECTION 6

CALIBRATION

Introduction

This spectrum analyzer is a stable laboratory instrument which should not require frequent recalibration. Its performance should be checked however, as directed in Section 5, approximately every 500 hours of operation or every six months if used intermittently. This will assure proper operation or indicate the section of the instrument that needs recalibration.

This calibration procedure is arranged in a sequence which will allow the instrument to be checked and calibrated with the least interaction of adjustments and reconnecting of test equipment. A single step can be performed, provided interaction between steps and adjustments is considered. However, because of the interaction between most circuits in this instrument, the most satisfactory results will be obtained if the complete calibration is performed.

Preliminary control settings and equipment setup are usually given at the start of each step of the procedure; however, in some cases it may be necessary to check the preceding major setup for complete control settings and test equipment setup. Front panel control settings for the Type 1L5 are printed in capital letters, and changes in control settings from the previous setup are printed in bold type. Internal adjustments, the associated oscilloscope and the test equipment front panel controls, are printed with initial capital letters.

RECOMMENDED EQUIPMENT

(See Fig. 6-1 and 6-2)

General

The following equipment or its equivalent is recommended for complete calibration of this plug-in unit. Specifications given are the minimum necessary for accurate calibration of the instrument and should not be construed as advertised performance characteristics. If the instrument performs within the guide tolerances given in this procedure, it will meet all characteristics listed in Section 1 of the manual. All test equipment is assumed to be correctly calibrated and operating within the original specifications. If other equipment is substituted for the recommended equipment, it must meet or exceed the specifications given in the following list.

Special calibration fixtures are recommended where necessary for the quickest and most accurate calibration. Order these fixtures by part number through your local Tektronix Field Office or representative.

NOTE

When performing a complete recalibration, best performance will be provided if each adjustment is made to the exact setting, even if the Check is within the allowable tolerance.

Equipment List

1. Plug-in Oscilloscope. Oscilloscope with a 6 cm vertical display height that will accept the Type 1L5 Spectrum Analyzer. This oscilloscope should be the oscilloscope the Type 1L5 being calibrated, will normally be used in. The front panel adjustments will require readjustment if the analyzer is changed to another oscilloscope. A Type 549 Storage Oscilloscope is used in this procedure.

2. Test Oscilloscope. Minimum requirements: Bandwidth, DC to 10 MHz; vertical sensitivity and accuracy, 0.005 V/CM to 10 V/CM, $\pm 3\%$; sweep rate and accuracy, 1 s/cm to .2 μ s/cm, $\pm 3\%$; triggering requirements, trigger to 3 MHz, internal trigger. Tektronix 540, 550 or 560-series with appropriate plug-in units. For example: 545B with the Type 1A1 Plug-In Unit.

3. Time-Mark Generator. Minimum requirements: Marker output, 50 ms (20 Hz) to 10 μ s (100 kHz); marker accuracy, within $\pm .001\%$. Tektronix Type 184 Time-Mark Generator.

4. Two (2) Wide-Range Signal Generators. Minimum requirements: Frequency output and accuracy, 10 Hz to 1 MHz, $\pm 1\%$; output amplitude, ≥ 2 volts peak to peak. Hewlett-Packard Type 241A Oscillator or General Radio Type 1310A.

5. Square-Wave Generator. Minimum requirements: Repetition rate, 1 kHz; risetime, ≤ 15 nanoseconds; output amplitude, variable between 0.5 volts and 10 volts. Tektronix Type 106 Square-Wave Generator.

6. Standard-Amplitude Calibrator (SAC). Minimum requirements: Output amplitude and accuracy, 0.005 volts to 100 volts, $\pm 0.3\%$. Tektronix Part Number 067-0502-00.

7. Probes:

a. P6006 10 $\times$ Passive Probe. Tektronix Part Number 010-0127-00.

b. P6011 1 $\times$ Passive Probe. Tektronix Part Number 010-0193-00.

8. Flexible extension (allows the Spectrum Analyzer to be operated out of the oscilloscope plug-in compartment). Tektronix Part Number 012-0038-00.

9. Input RC Normalizer: RC = 1 M Ω $\times$ 30 pF, equipped with BNC connectors. Tektronix Part Number 067-0552-00.

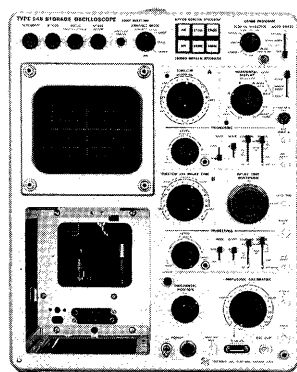
10. Three (3) 50 Ω coaxial cables. 42 inches long, BNC connectors. Tektronix Part Number 012-0057-00.

11. Patch cord with BNC to banana plug tips. Tektronix Part Number 012-0090-00 or 012-0091-00.

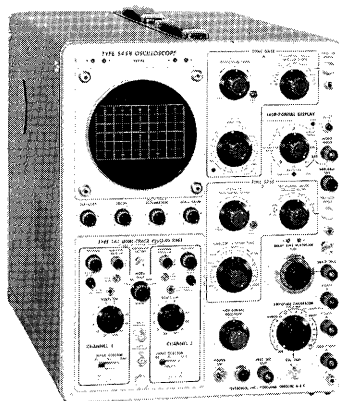
12. Termination, 50 Ω BNC. Tektronix Part Number 011-0049-00.

13. Four (4) 50 Ω , 10:1 attenuators, BNC connectors. Tektronix Part Number 011-0059-00.

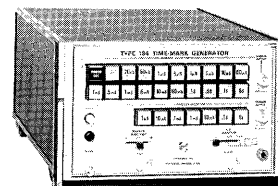
14. Three (3) 50 Ω , 5:1 attenuators, BNC connectors. Tektronix Part Number 011-0060-00.



(1)



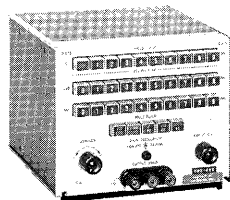
(2)



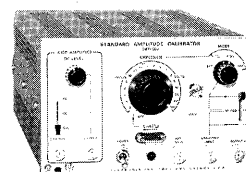
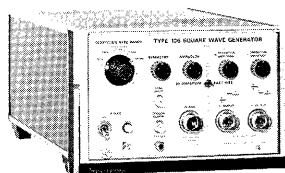
(3)



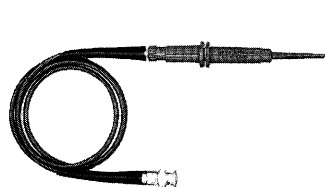
(4)



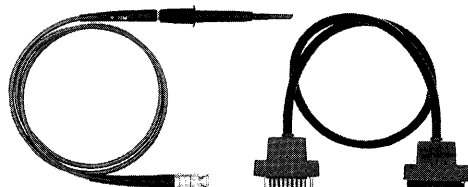
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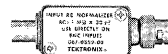
(6)



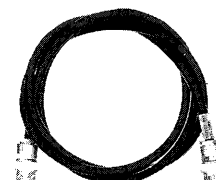
(7)



(8)



(9)



(10)



(11)



(12)



(13)



(14)



(15)



(16)



(17)

Fig. 6-1. Recommended equipment to calibrate the Type 1L5.



(20 A)



(20 B)



(20 C)



(20 D)

Fig. 6-2. Alignment tools required to calibrate the Type 1L5.

15. BNC T connector, male to female. Tektronix Part Number 103-0030-00.

16. Binding posts to BNC plug, General Radio Type 274-QBJ.

17. Miniature phone plug and 600 Ω load. (Test fixture to check TO RECORDER signal amplitude.) Consists of a 600 Ω , 5%, 1/2 watt resistor soldered across a miniature phone plug. See item 17 of Fig. 6-1.

18. Step Attenuator, 1 dB to 51 dB (combinations of 1, 2, 3, 4, 8, 16, and 20 dB) 600 Ω . Tektronix Part Number 011-0093-00 (not shown).

19. Termination, 600 Ω . Tektronix Part Number 011-0092-00 (not shown).

20. Alignment Tools:

a. Small screwdriver with a 3/32 inch blade.

b. Low-capacitance alignment tool and handle, for tuning 5/64 inch hex slugs. Tektronix Part Number 003-0307-00. Insert, Tektronix Part Number 003-0310-00.

c. Low-capacitance screwdriver. A 1/4 inch $\times$ 8 inch fiber rod with screwdriver-shaped ends. Tektronix Part Number 003-0209-00.

d. Low-capacitance alignment tool, to tune 1/8-inch powdered iron cores. Tektronix Part Number 003-0497-00.

CALIBRATION RECORD AND INDEX

This Abridged Calibration procedure is provided to aid in checking the operation of the Type 1L5. It may be used as a calibration guide by the experienced calibrator or as a calibration record. Since the step numbers and titles used here correspond to those in the complete Calibration procedure, the following procedure serves as an index for locating a step in the complete procedure. Characteristics are those listed in the Characteristics section of the instruction manual.

Type 1L5, Serial No. _____

Calibration Date _____

Calibrator _____

- ☐ 1. Preset Dispersion, 3 MHz Filter, 2nd Local Oscillator and Mixer. Page 6-7
- ☐ 2. Adjust Variable Resolution Amplifier Resolution ≥ 500 Hz to ≤ 10 Hz. Page 6-9
- ☐ 3. Calibrate Dispersion and Center Frequency Page 6-10
Dispersion Accuracy: 50 Hz to 9900 Hz, $\pm 10\%$
10 kHz to 990 kHz, $\pm 15\%$
Dispersion Linearity: $\pm 3\%$.
Center Frequency Accuracy:
50 Hz to 990 Hz
 $\pm (5\% + 50 \text{ Hz} + 50 \text{ Hz}/^\circ\text{C max.})$
 ≤ 1000 Hz change from 0°C to 50°C .
1000 Hz to 9900 Hz
 $\pm (5\% + 100 \text{ Hz} + 100 \text{ Hz}/^\circ\text{C max.})$
 ≤ 2500 Hz change from 0°C to 50°C .
10 kHz to 99 kHz, $\pm (5\% + 3 \text{ kHz} + 200 \text{ Hz}/^\circ\text{C})$
100 kHz to 990 kHz, $\pm (5\% + 10 \text{ kHz} + 200 \text{ Hz}/^\circ\text{C})$
- ☐ 4. Adjust LIN-LOG Calibration and Dynamic Range. Page 6-13
- ☐ 5. Check TO RECORDER Output Signal Amplitude. Page 6-14
- ☐ 6. Adjust Mixer Balance Page 6-14
- ☐ 7. Check Internal Noise Level Page 6-14
With the input grounded and controls set for maximum gain, the noise level must not exceed 0.5 centimeter.
- ☐ 8. Adjust 5 kHz Calibrator Frequency and Amplitude Frequency, 5 kHz $\pm 1\%$; amplitude, 4 centimeters for the CALIBRATE display. Page 6-15
- ☐ 9. Adjust VOLTS/CM Attenuator Compensation Page 6-16
Adjust as per Table 6-6 and 6-7.
- ☐ 10. Calibrate Video Deflection Factor, Check Input Attenuator Accuracy and Check Variable VOLTS/CM Control Range Page 6-20

- ☐ 11. Check Display Flatness Page 6-21
Display flatness for the .001 VOLTS/CM and .002 VOLTS/CM range is within +0.5 dB to -3 dB; for the .005 VOLTS/CM to the 2 VOLTS/CM position it is within ± 0.5 dB over the frequency range of 10 Hz to 1 MHz.

- ☐ 12. Check Video Display Frequency Response Page 6-22
Video response ≤ 10 Hz to ≥ 1 MHz, .5 to 100 VOLTS/CM range and ≤ 10 Hz to ≥ 700 kHz for the .1 and .2 VOLTS/CM positions.

- ☐ 13. Check Incidental Frequency Modulation Page 6-24
Incidental FM for the 50 Hz to 9900 Hz Center Frequency range is ≤ 5 Hz; for the 10 kHz to 990 kHz range ≤ 15 Hz.

- ☐ 14. Check Random Spurious Amplitude Page 6-25
Spurious signal amplitude ≤ 1.0 centimeter with a 50 dB signal applied above 1.0 centimeter reference signal.

- ☐ 15. Check Intermodulation Distortion Page 6-26
Intermodulation sideband amplitude ≤ 1.0 centimeter with a 50 dB signal above 1.0 centimeter, LOG display.

- ☐ 16. Check Operation of Manual Sweep Page 6-26
Manual operation of the SWEEP control must produce a variable output voltage at the OUT jack, which when connected to the Ext Horiz In connector of the oscilloscope, will manually position the beam across the CRT.

Preliminary Procedure

NOTE

The following calibration procedure is applicable over a temperature range of 0°C to 50°C, provided the environmental ambient temperature has been stable for a minimum of 4 hours.

1. Check the Type 1L5 for smooth operation and proper indexing of all front-panel controls except the screwdriver adjustments.
2. Set the Sawtooth Selector switch on the rear panel of the Type 1L5 to the appropriate setting. (150 V for the Type 549 Storage Oscilloscope; check the Oscilloscope Instruction Manual if a different Plug-In Oscilloscope is used.)

3. Connect the Type 1L5 by means of the flexible extension cable (Tektronix Part No. 012-0038-00) to the plug-in connector in the vertical compartment of the oscilloscope.

4. Apply power to all equipment and allow at least 20 minutes warm-up time, at room temperature, to allow the instrument to stabilize.

NOTE

There are steps in this procedure that direct the cal-

ibrator to change values of select components to attain calibration specifications. These selected components should only require changing after other components in the circuit, such as transistors have been changed.

5. Connect a patch cord or cable from the Type 1L5 EXT INPUT connector to the Sweep A or Sweep Output connector of the oscilloscope.

NOTES

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

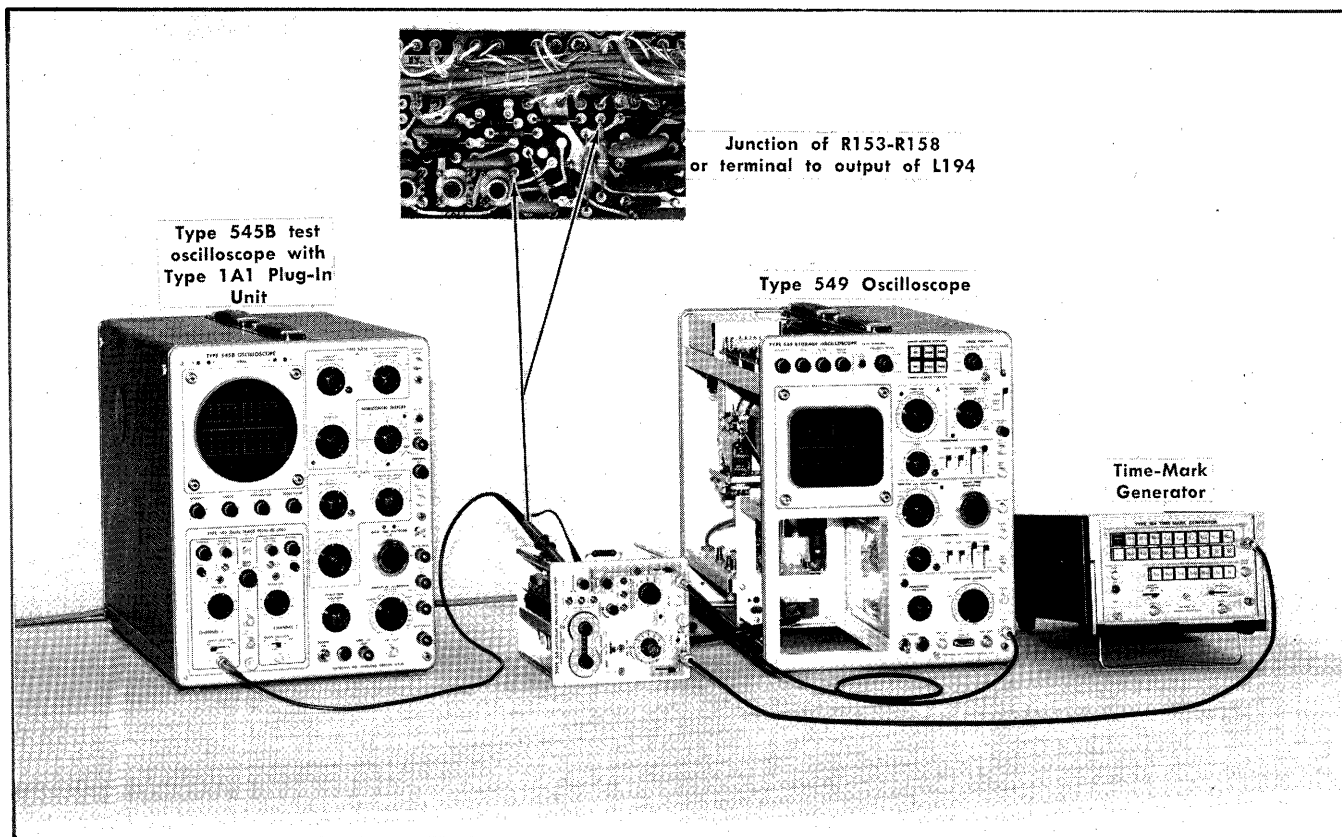


Fig. 6-3. Equipment setup for preliminary sweep oscillator and center frequency adjustments.

Type 1L5		Hz/CM—COUPLED RESOLUTION	100 K
CENTER FREQUENCY-Hz	500 k		
VARIABLE	CAL		
VERTICAL DISPLAY	LIN		
POSITION	Centered		
SWEEP MODE	EXT INPUT		
Input Selector	AC FAST		
VOLTS/CM	.5 (Outer scale)		
VARIABLE	CAL		
V/CM ÷ 100	Pushed in		
DISPERSION			
VARIABLE	CAL		
		Oscilloscope	
		Time/Cm	20 ms
		Triggering	Adjusted for a free running trace
		Test Oscilloscope	
		Time/Cm	.5 μ Sec (calibrated)
		Volts/Cm	.2 V (calibrated)

1. Pre-set Dispersion, Adjust 3MHz filter ① 2nd Local Oscillator and Mixer

a. Equipment setup is shown in Fig. 6-3.

b. Apply 10 μ s markers from the Time-Mark Generator through a 50 Ω termination to the INPUT connector of the Type 1L5.

c. Pre-adjust the front panel 30 kHz C.F. CAL adjustment so the total dispersion window is equal to or greater than 1 MHz. (1 marker/cm for a 10 cm sweep). If the dispersion will not adjust to 1 MHz, preset all the front panel CAL and the DISPERSION CAL adjustments to their midrange positions. If dispersion is equal to or greater than 1 MHz, proceed to step 2.

d. Connect the 10 $\times$ probe from the test oscilloscope to the junction of R153-R158 (Fig. 6-4). Adjust R214 (Fig. 6-4) for approximately 6.6 volt peak to peak oscillator signal amplitude on the test oscilloscope. It may be necessary to adjust L164 for oscillator operation. Recheck step (c).

NOTE

The 10 $\times$ probe must be a low capacitance (≤ 10 pF) probe and properly compensated.

e. Remove the 10 $\times$ probe from the output terminal of L194.

f. Adjust T290, L280 and the filter capacitors C252, C257, C262 and C267 (Fig. 6-4B) for maximum signal amplitude on the plug-in oscilloscope display.

g. Set the Input Selector to GND position and the CENTER FREQUENCY-Hz selector to 0000. Center the 0000 Hz CAL 10 turn adjustment. Adjust L164 (Fig. 6-4A) for a 0 Hz spurious signal on the CRT.

h. Change the CENTER FREQUENCY-Hz selector to 500 k. Adjust the front panel BAL adjustment to position the 0 Hz start spurious signal to the 0 (extreme left) graticule line.

i. Switch the Input Selector to AC FAST position. Adjust L191, L192 and L194 (Fig. 6-4A) for optimum dispersion linearity. Fig. 5-6 in section 5 illustrates linearity measurement.

j. Apply 1 ms time markers to the INPUT connector. Set the CENTER FREQUENCY-Hz to 5000, the DISPERSION to 1 K. Adjust the front panel 5000 Hz C.F. for approximately 1 marker/cm.

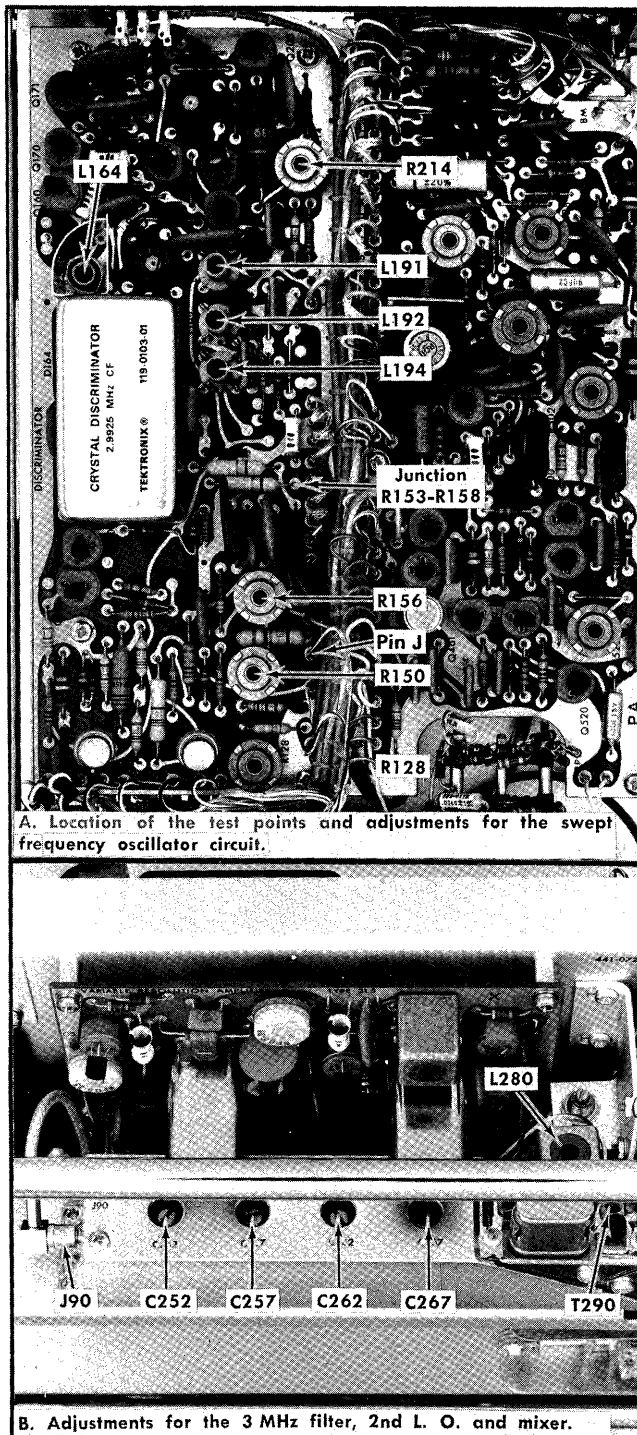


Fig. 6-4. Test points and adjustment locations for step 1.

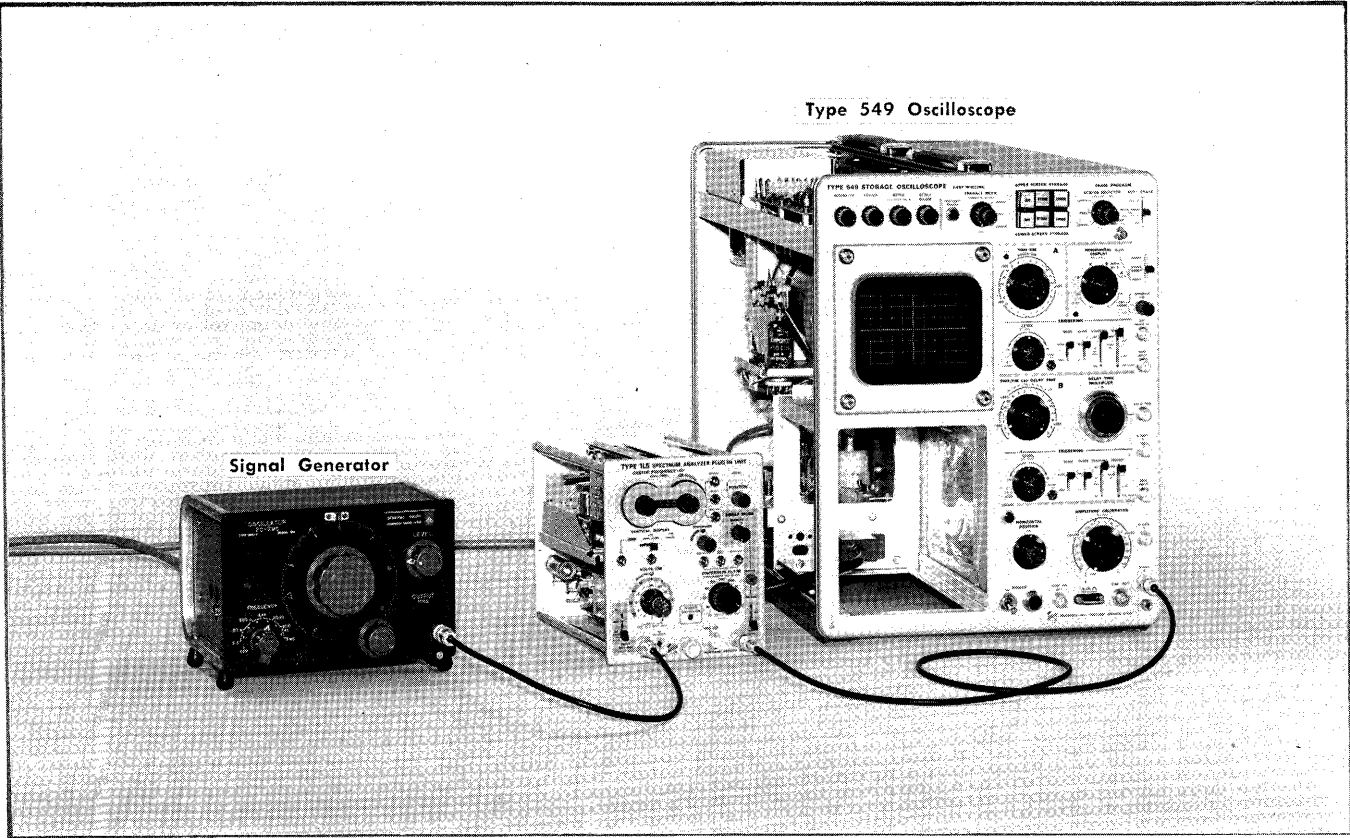
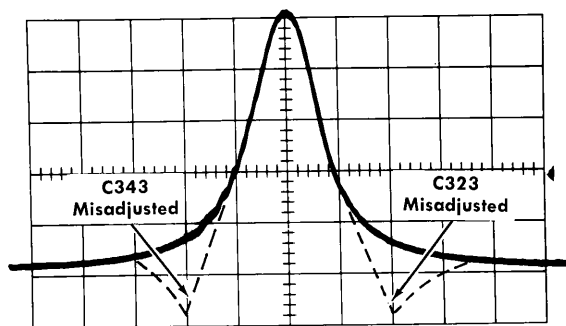
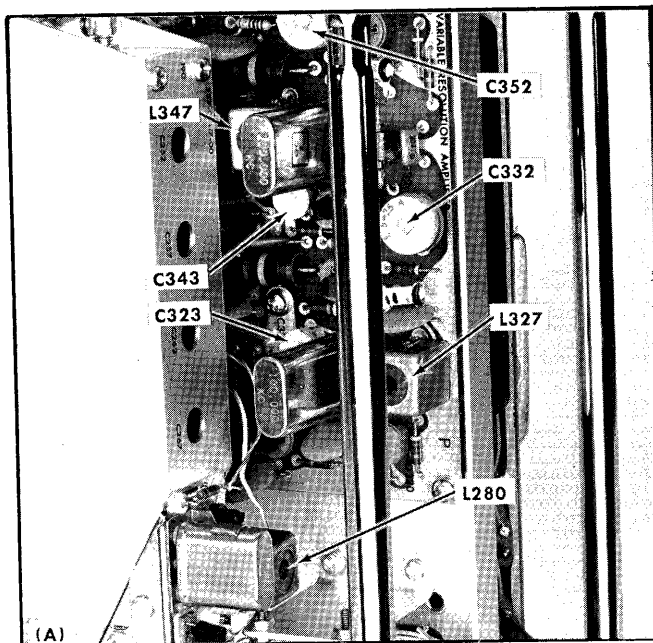


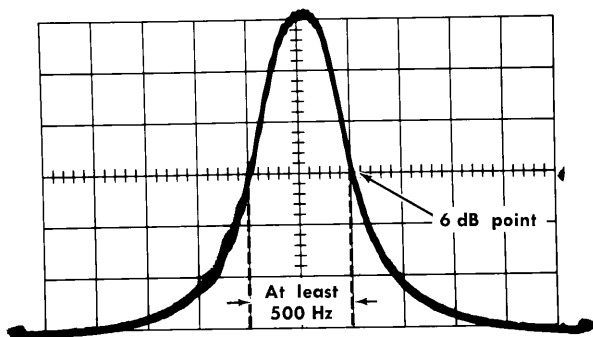
Fig. 6-5. Equipment setup to adjust resolution. Step 2.

Type 1L5		Type 549 Oscilloscope	
CENTER FREQUENCY-Hz	5000	DISPERSION VARIABLE	CAL
VARIABLE	CAL	Hz/CM	500
VERTICAL DISPLAY POSITION	LIN	RESOLUTION	Fully clockwise (Uncoupled)
	Centered sweep at the bottom graticule line		
SWEEP MODE	EXT INPUT	Test oscilloscope	
Input Selector	AC FAST	Time/Cm	50 ms
VOLTS/CM	.5 (Outer scale)	Triggering	Adjusted for a free running trace
VARIABLE	CAL		
V/CM ÷ 100	Pushed in		

NOTES



(B) (Solid trace is display after C323 and C343 are properly adjusted)



(C) Typical display at end of step 6.

Fig. 6-6. Variable resolution amplifier adjustments. (A) Location of the adjustments; (B) and (C) typical bandpass response characteristics.

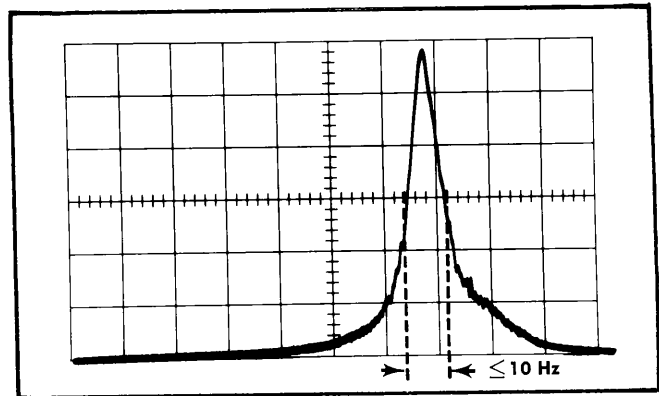


Fig. 6-7. Measuring the resolution bandwidth.

2. Adjust Variable-Resolution Amplifier

Performance Requirement: With RESOLUTION switch fully CW; the resolution bandwidth is ≥ 500 Hz. With RESOLUTION switch fully CCW, the resolution bandwidth is ≤ 10 Hz.

- Equipment setup is shown in Fig. 6-5.
- Apply a 5 kHz signal from the Wide Range Signal Generator to the INPUT connector of the Type 1L5. Adjust the generator output and frequency controls for a centered signal that is 6 centimeters in amplitude. See Fig. 6-6.
- Adjust C323 and C343 (Fig. 6-6A) for optimum display symmetry. See Fig. 6-6B. Keep the signal centered on the graticule during this adjustment by tuning the signal generator frequency.
- Adjust L327 and L347 (Fig. 6-6A) for maximum signal width at the -6 dB point (Fig. 6-6B). Maintain a 6 centimeter display for this measurement by adjusting the VOLTS/CM controls or the output of the signal generator.
- Repeat step (c) and (d). These adjustments may interact. The final display should be symmetrical with no large dips or other aberrations. When properly calibrated, L327 and L347 adjustments should rock the display back and forth through optimum symmetry and bandwidth.
- Adjust L280, (Fig. 6-6A) for optimum display amplitude.
- Change the sweep rate to 2 s/cm. Couple the RESOLUTION control to the DISPERSION Hz/CM control and set both controls to 500.
- Adjust the signal generator frequency and output to center a 6 centimeter signal.
- Adjust C332 and C352 for ≤ 1 centimeter of signal amplitude variation as the DISPERSION Hz/CM-COUPLED RESOLUTION is switched from the 500 to the 10 positions.
- Set the DISPERSION Hz/CM-COUPLED RESOLUTION controls to the 10 Hz position. Adjust the generator output to maintain a signal amplitude of 6 centimeters on the CRT.
- Check for a symmetrical display and a resolution bandwidth that is ≤ 10 Hz at the -6 dB point. See Fig. 6-7. (Sweep rate must be 2 s/cm or slower.)

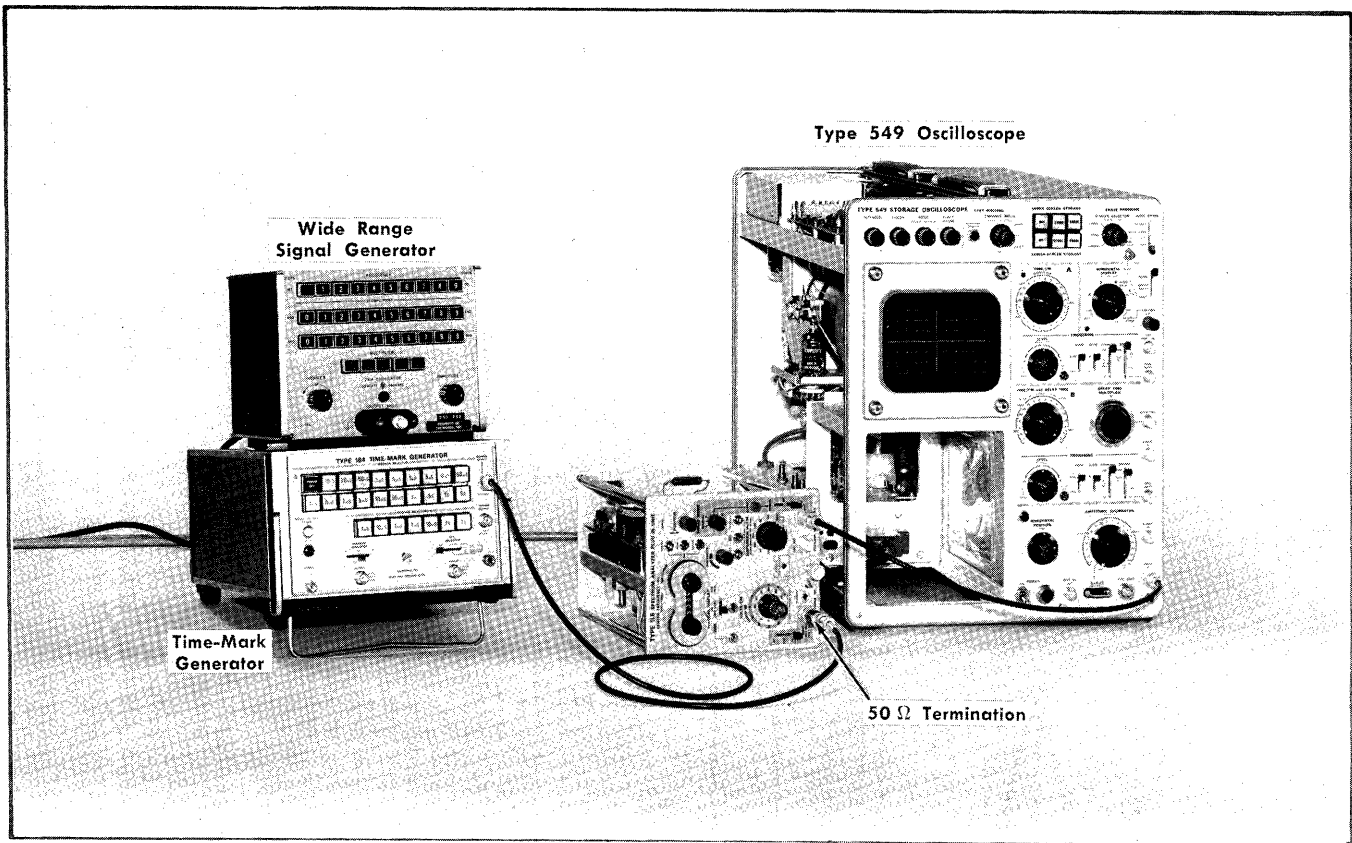


Fig. 6-8. Equipment setup to adjust or check dispersion and center frequency accuracy.

Type 1L5

CENTER FREQUENCY-Hz	500 k
VARIABLE	CAL
VERTICAL DISPLAY POSITION	LIN
	Trace centered horizontally and positioned to the bottom graticule line
SWEEP MODE	EXT INPUT
Input Selector	AC FAST
VOLTS/CM	As required for an adequate display amplitude
VARIABLE	CAL
V/CM ÷ 100	Pushed in
DISPERSION	
VARIABLE	CAL
Hz/CM-COUPLED RESOLUTION	100 K

Test Oscilloscope

Time/Cm	20 mSEC
Triggering	Adjusted for a free running trace

3. Adjust Dispersion and Center Frequency ①

a. Equipment setup is shown in Fig. 6-8.

b. Apply 10 μ s markers through a 50 Ω termination to the INPUT connector of the Type 1L5. Connect a ground strap between pin J (Fig. 6-9) and chassis ground.

c. Adjust L191, L192, L194 (Fig. 6-4) and the front panel 30 kHz C.F. — 1 kHz/CM adjustment for optimum dispersion accuracy, (1 marker/cm).

d. Switch the CENTER FREQUENCY-Hz to 0000 and the Input Selector to GND position. Adjust L164 if necessary for a 0 Hz spurious signal.

e. Return the CENTER FREQUENCY-Hz selector to 500 k position and the Input Selector to AC FAST position.

f. Adjust R156 (Fig. 6-4) for minimum signal shift between the 100 kHz and 200 Hz positions of the DISPERSION-Hz/CM selector.

NOTE

If these adjustments fail to calibrate the dispersion, try changing the selected value of C192. C192 value should range between approximately .0015 and .0027.

g. Set the DISPERSION to 100 K. Adjust the front panel BAL so the markers align with the graticule lines and 0 Hz spurious marker is at sweep start. Remove the ground strap to pin J.

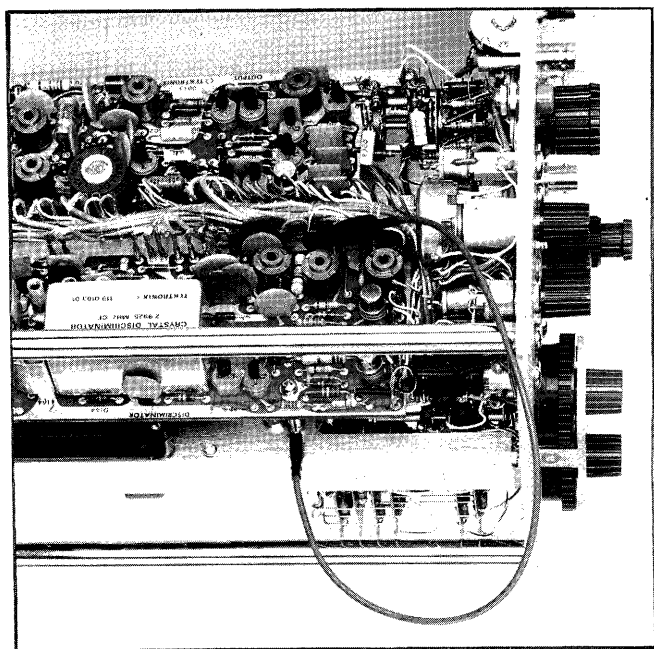


Fig. 6-9. Method of grounding pin J.

h. Adjust the front panel 500 kHz Center Frequency CAL adjustment for minimum display shift as the DISPERSION-Hz/CM selector is switched between the 100 K and 200 positions.

i. Set the DISPERSION-Hz/CM selector to 10 K. Adjust R150 (Fig. 6-4) for minimum display shift as the CENTER FREQUENCY-Hz selector is switched between 100 k and 900 k positions.

j. Set the CENTER FREQUENCY-Hz selector to 10 k, the Input Selector to GND. Adjust the 10 kHz CAL so the spurious 0 Hz start signal is 1 cm left of the graticule center.

k. Return the CENTER FREQUENCY-Hz to 500 k and repeat steps (h) and (j) because of the interaction.

l. Change the CENTER FREQUENCY-Hz to 500 k, the DISPERSION-Hz/CM to 100 K and set the Input Selector to AC FAST position. Recheck the dispersion for 1 marker/centimeter.

m. Set the DISPERSION-Hz selector to 1 K, uncouple the RESOLUTION and turn to 100, Time/Cm to 50 ms and the CENTER FREQUENCY-Hz to 30 k. Apply 1 ms markers from the Time-Mark Generator to the INPUT connector.

n. Check dispersion accuracy—Should check within 0.5 centimeters over the 8 centimeter window. Repeat (b) through (j) if dispersion accuracy is not within 0.5 cm.

o. Adjust 30 kHz C.F. for 1 marker/centimeter.

p. Check dispersion accuracy over the 10 kHz to 990 kHz frequency range as per Table 6-1. Dispersion accuracy is checked over the center 8 centimeters of the display. Dispersion window upper limit must not exceed 1 MHz for the 10 kHz to 990 kHz center frequency range.

TABLE 6-1

CENTER FREQUENCY-Hz Selection	DISPERSION-Hz/CM Selection	Time Markers	Allowable Error
500 k	100 K	10 μ s	$\pm 15\%$ (1.2 cm)
950 k, 500 k, 100 k, 50 k	10 K	.1 ms	
990 k, 550 k, 100 k, 50 k, 10 k	1 K	1 ms	

q. Remove the Time-Mark Generator signal and apply the output from the Wide Range Signal Generator to the INPUT connector. Set the CENTER FREQUENCY-VARIABLE control to CAL position.

r. Check the center frequency tracking over the 10 kHz to 990 kHz range as per Table 6-2. If dispersion or center frequency tracking is not within specifications, repeat calibration steps.

TABLE 6-2

CENTER FREQUENCY-Hz and Signal Generator	DISPERSION Hz/CM Selection	Accuracy
100 k, 500 k, 900 k	10 K	$\pm$ (5% of C.F. +10 kHz)
10 k, 30 k, 90 k	1 K	$\pm$ (5% of C.F. +3 kHz)

NOTE

This procedure applies to instruments Serial No. 324 and above. For earlier instruments that do not have the modification to the lower decade discriminator, replace steps s through x with the procedure given as steps s_1 through y_1 .

s. Remove the signal from the Wide Range Signal Generator. Change the CENTER FREQUENCY-Hz selector setting to 00 k, the DISPERSION to 10 K, the RESOLUTION to 100, the VOLTS/CM to CALIBRATE 4 CM position and the sweep rate to .2 s/cm.

t. Adjust L164, very slowly, until only one (1) 5 kHz marker appears to the left of the 0 Hz spurious signal. See Fig. 6-10. The 0 Hz spurious signal may be identified by rotating the VARIABLE/CM control counterclockwise. The 0 Hz signal will not change amplitude. Cement the core of L164 with a good grade rubber cement.

u. Change the DISPERSION to 50 Hz, the CENTER FREQUENCY-Hz selector to 0000 and the VOLTS/CM to .5. Connect the 10 $\times$ probe from the test oscilloscope to either side of C135 (located near L194). Adjust R137 for 4.0 ± 0.4 volts peak-to-peak signal. Remove the 10 $\times$ probe. Adjust the 0000 Hz CAL for minimum shift of the 0 Hz Signal as the DISPERSION is switched from 50 Hz to 1 kHz positions.

v. Change the CENTER FREQUENCY-Hz selector to 5000, DISPERSION to 1 K and the RESOLUTION to 100 Hz positions. Apply 1 ms time markers from the Time-Mark Generator, through a 50 Ω termination, to the INPUT connector of the Type 1L5.

w. Adjust the 5000 Hz C.F. CAL adjustment for approximately 1 marker/centimeter. (This adjustment is only approximate.)

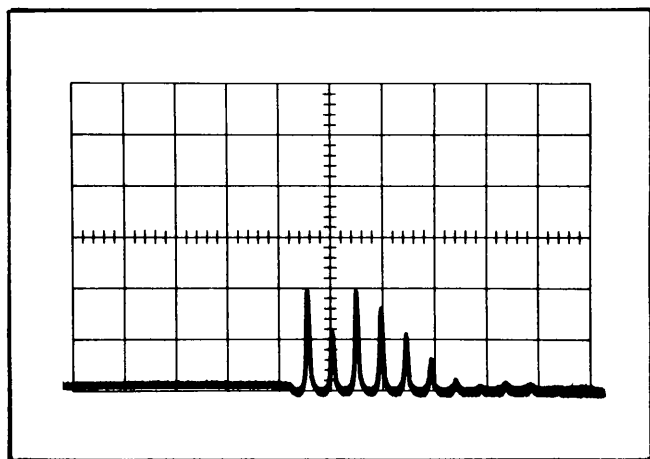


Fig. 6-10. Adjust L164 for one 5 kHz marker to the left of the 0 Hz spurious signal.

x. Switch the Input Selector to GND position, to short the input. Adjust R128, to align the 0 Hz spurious marker on the 0 (far left) graticule line.

y. Switch the Input Selector to the AC position and adjust the front panel 5000 Hz C.F. CAL for 1 marker/centimeter.

z. Repeat steps (w) through (y) until the dispersion is calibrated and balanced. Check dispersion accuracy over the 10 Hz to 9900 Hz frequency range as directed in Table 6-3. Dispersion window upper limit must not exceed 10 kHz for the 10 Hz to 9900 Hz center frequency range.

NOTE

The following steps s_1 through y_1 apply only to instruments that do not contain the modification to the discriminator. Below Serial No. 324.

s_1 . Remove the signal from the Wide Range Signal Generator and apply 1 ms time markers from the Time-Mark Generator to the INPUT connector. Change the CENTER FREQUENCY-Hz selector to 5000, the DISPERSION-Hz/CM to 1 K and the RESOLUTION to 100.

NOTE

If there is no display, adjust L164; then repeat the 10 kHz to 990 kHz accuracy check.

t_1 . Adjust the front panel 5000 Hz C.F. —1 kHz/CM CAL for 1 marker/cm. Remove the signal from the Time-Mark Generator.

u_1 . Set the Input Selector to GND, the CENTER FREQUENCY-Hz to 0000, and the DISPERSION Hz/CM to 1 K. Mechanically center the front panel 0000 Hz center frequency CAL adjustment.

v_1 . Return the Input Selector to AC FAST position and set the CENTER FREQUENCY-Hz to 5000. Apply 5000 Hz from the Wide Range Signal Generator to the INPUT connector. Adjust C138 (Fig. 6-4A) to center the signal on the screen.

NOTE

It may be necessary to change the value of selected capacitor C137.

w_1 . Set the CENTER FREQUENCY-Hz to 9000, DISPERSION-COUPLED RESOLUTION to 100 and apply a 9 kHz signal from the signal generator to the Type 1L5. Adjust R128 (Fig. 6-4) to center the signal on the screen.

x_1 . Repeat steps (v_1) and (w_1) because of the interaction, and reset the dispersion (step t_1).

y_1 . Remove the signal generator signal and apply time markers from the Time-Mark Generator to the INPUT. Check dispersion accuracy over the 10 Hz to 9900 Hz frequency range as per Table 6-3. Dispersion window upper limit must not exceed 10 kHz for the 10 Hz to 9900 center frequency range. Increase the resolution as the dispersion is decreased, by adjusting the RESOLUTION control and the sweep rate to optimize marker definition.

TABLE 6-3

CENTER FREQUENCY-Hz Selection	DISPERSION-Hz/CM Selector	Time Markers	Allowable Error
5000	1 K	1 ms (1 marker/cm)	$\pm 10\%$ (8 mm)
7500, 2500	500	1 ms (1 marker/2 cm)	
9000, 5000, 1000	200	5 ms (1 marker/cm)	
9500, 9000, 500	100	10 ms (1 marker/cm)	
	50	10 ms (1 marker 2/cm)	
5000, 100	20	50 ms (1 marker/cm)	
5000, 50	10	50 ms (1 marker 2/cm)	

aa . Remove the Time-Mark Generator signal, then apply the output from the Wide Range Signal Generator to the INPUT connector. Set the CENTER FREQUENCY-VARIABLE control to the CAL position. Check the center frequency tracking over the 10 Hz to 9900 Hz frequency range as per Table 6-4. If dispersion or center frequency accuracy is not within specifications, repeat calibration steps. (0000 Hz CAL must be readjusted to compensate for oscillator drift at the narrow dispersion settings.)

TABLE 6-4

CENTER FREQUENCY-Hz and Signal Generator	DISPERSION-Hz/CM Selection	Accuracy
9500, 5000, 1000	100	$\pm(5\% \text{ of C.F.} + 100 \text{ Hz})$
950, 550	100	$\pm(5\% \text{ of C.F.} + 50 \text{ Hz})$
100, 50	10	

ab . Connect the probe from the test oscilloscope to the front panel OSC OUT connector. Set the DISPERSION Hz/CM selector to 100 K and CENTER FREQUENCY-Hz to 500 k. Measure the amplitude of the oscillator output signal. Amplitude must equal or exceed 1 volt peak to peak.

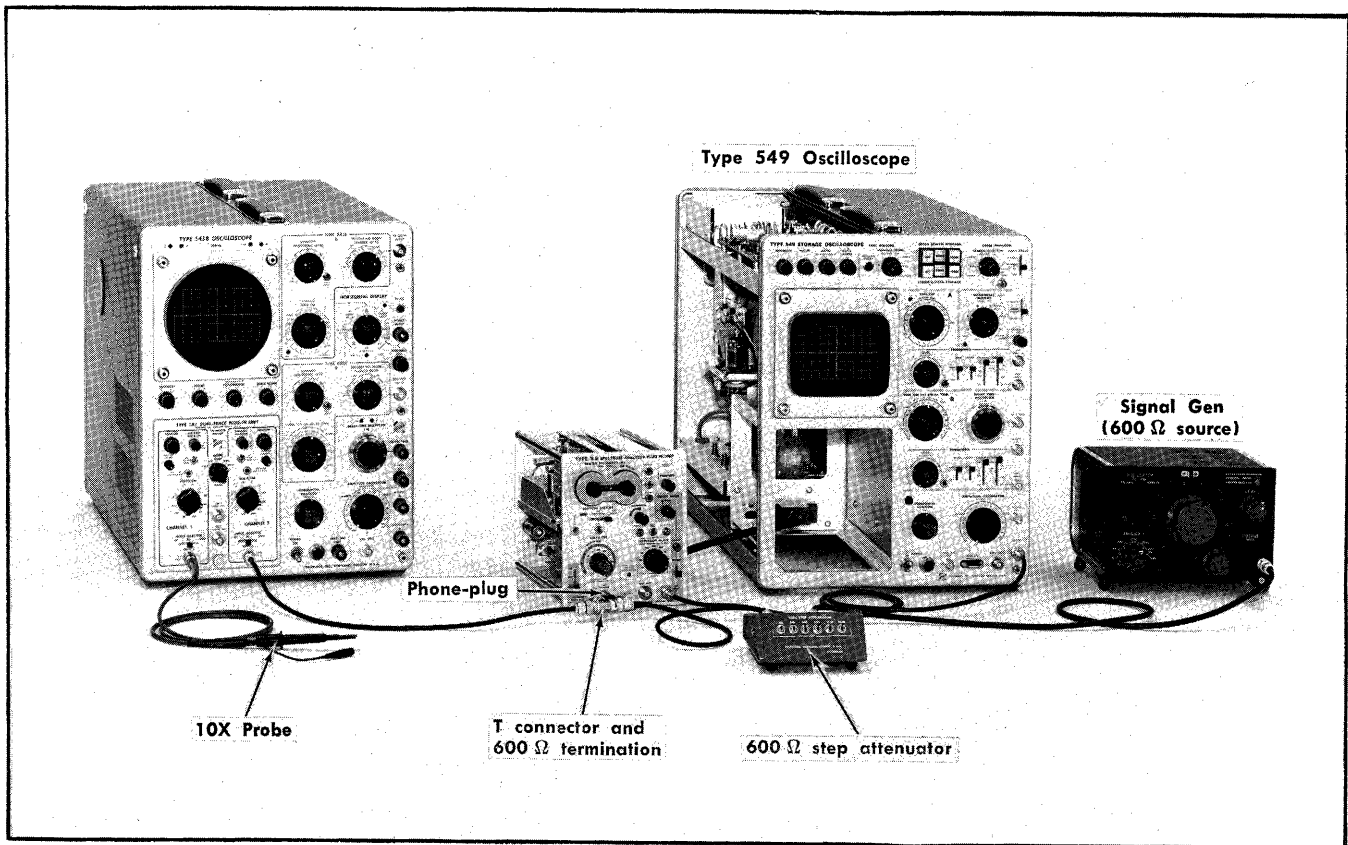


Fig. 6-11. Equipment setup to check dynamic range, adjust linear (RMS) calibration and check the recorder output signal.

Type 1L5

CENTER FREQUENCY-Hz	50 k
VARIABLE	CAL
VERTICAL DISPLAY	LIN
SWEEP MODE	EXT INPUT
Input Selector	AC
VOLTS/CM	.005
V/CM 100	Pushed in
VARIABLE	CAL
DISPERSION-Hz/CM	500
VARIABLE	CAL
RESOLUTION	1 k
Time/cm	.5 s or slower

Test Oscilloscope

Time/Cm	.5 sec
Triggering	Adjusted for a free running trace

4. Adjust LIN-LOG Calibration and Dynamic Range

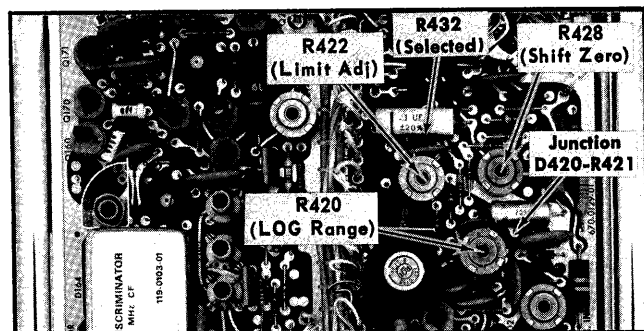
NOTE

This procedure is applicable for all instruments, except as noted in the text.

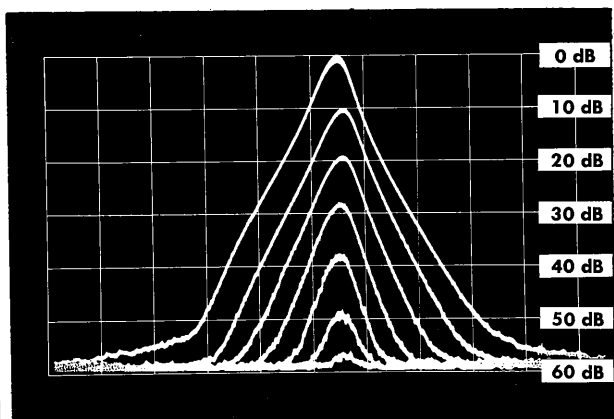
- Equipment setup shown in Fig. 6-11.
- Preset front panel LIN CAL (R316 adjustment) and internal adjustment R422 (Fig. 6-12) midrange. Preset R420 (added at SN 805 and up) approximately 20° counterclockwise from midrange position (or until noise decreases in LOG mode) and R428 approximately 40° from its full clockwise position.
- Apply 50 kHz signal from the signal generator through the step attenuator (600 Ω or 50 Ω depending on the signal source impedance), a BNC 'T' connector and a termination (600 Ω or 50 Ω) to the INPUT connector.

- Monitor the signal level to the INPUT of the Type 1L5 by connecting the test oscilloscope to the BNC 'T' connector through a coaxial cable.

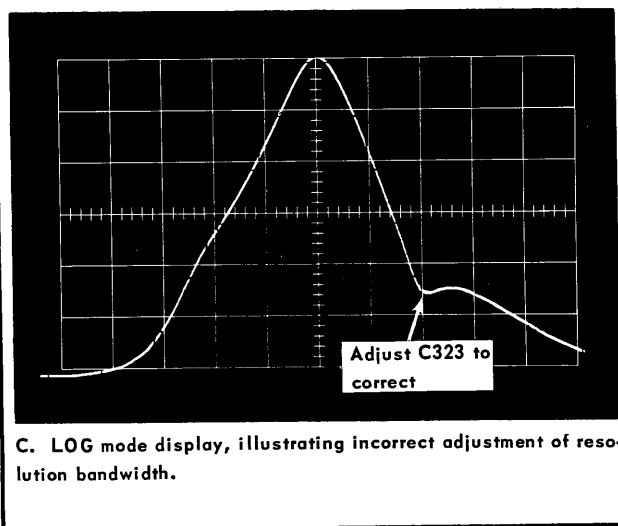
Calibration—Type 1L5



A. Location of the adjustments for step 4 and 5. (Dynamic range.)



B. Stored display, illustrating LOG mode display linearity.



C. LOG mode display, illustrating incorrect adjustment of resolution bandwidth.

Fig. 6-12. Adjustment and display illustrations to set dynamic range of LOG display.

e. Adjust the signal generator output for a signal level of 70 mV peak to peak on the test oscilloscope (equivalent to 25 mV RMS at the Type 1L5 INPUT). Center the display on screen with signal generator frequency control or the Type 1L5 VARIABLE CENTER FREQUENCY control.

f. Connect a 10 $\times$ probe from the test oscilloscope to the detector output (junction of R421, R422 and D420, see Fig. 6-12). Select a sweep rate, for the test oscilloscope, that is equal to or slower than the analyzer sweep rate.

g. With 70 mV peak to peak signal applied to the Type 1L5 INPUT, adjust LIN CAL (front panel) for a signal amplitude that is approximately 45 V peak at the detector output, then remove the test oscilloscope 10 $\times$ probe.

h. Adjust R422 for a 5 division display on the analyzer (LIN mode display).

i. Switch VERTICAL DISPLAY selector to LOG position and adjust the signal generator output for 300 mV signal level.

j. Adjust R428 for a 6 division display (readjust vertical POSITION control, because of trace shift, as R428 is adjusted).

k. Select 50 dB attenuation through the step attenuator.

l. Adjust R420 for a signal amplitude of 1 cm. (Applicable to instruments that have this adjustment.)

m. Recheck steps h through l, until the LOG mode display is calibrated at the 10 dB, 40 dB and 50 dB positions.

n. Switch the VOLTS/CM selector to .05 (20 dB increase in attenuation) and select 40 dB attenuation through the step attenuator. This provides a total attenuation of 60 dB.

NOTE

Distortion or non-symmetry at the base of the display may be caused by incorrect adjustment of the resolution bandwidth. See Fig. 6-12C. Re-check adjustments C323 and C343.

o. Check the dynamic range of LOG mode display. Must equal or exceed 60 dB. Signal should still be discernible on the display.

p. Return the VOLTS/CM selector to the .005 position. Switch the step attenuator from 0 dB to 50 dB in 10 dB steps. Note linearity between the 5 displays. If the analyzer oscilloscope has storage, switch the triggering to single sweep and store the display for each 10 dB step. See Fig. 6-12B.

q. Change the input signal level to 70 mV peak to peak and set the VERTICAL DISPLAY selector to LIN position and select 10 dB attenuation through the step attenuator.

r. Check signal amplitude. If display amplitude is within

1 cm of 5-cm amplitude, adjust R422 until the signal amplitude is 5 cm. If the signal amplitude is over 1 cm from 5 cm height, select a new value for resistor R432 (Minimum value for R432 is 18 k) so the signal amplitude is within the adjustment range of R422.

- s. Check accuracy of LIN mode display as follows:

NOTE

This is a operational check on the linearity of the detector diodes.

- 1) Set the VERTICAL DISPLAY selector to LIN position and select 26 dB of attenuation in the step attenuator.
- 2) Adjust the signal generator output for a signal amplitude of 2 cm on the display.
- 3) Check linearity of LIN mode, by selecting the attenuation listed in the following Table, through the step attenuator, and noting the signal amplitude.

Accuracy of LIN mode display should be within 5%. If error is excessive, adjust R428 (shift zero) for the best compromise between LIN and LOG mode.

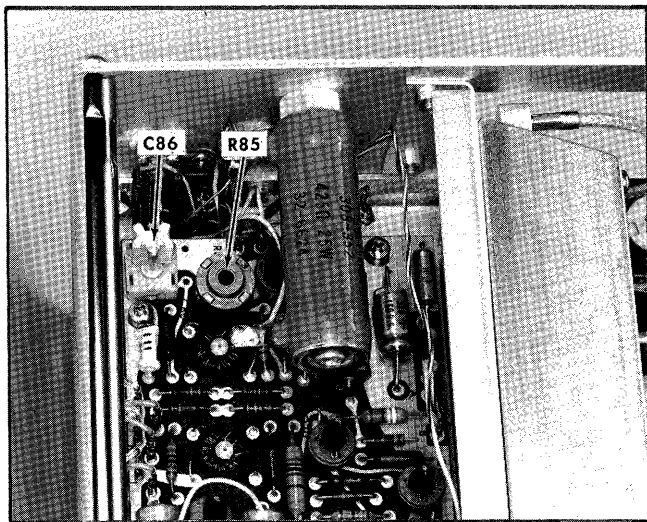


Fig. 6-13. Location of mixer balance adjustments.

Step	Attenuator	Display Amplitude
	26 dB	2 cm
	20 dB	4 cm ± 1.0 mm
	32 dB	1 cm ± 1.0 mm

5. Check Output Signal at the TO RECORDER Jack

- a. Equipment setup is given in step 4.
- b. Set the VERTICAL DISPLAY selector to LIN position and the Time/cm to 20 ms. Adjust the signal generator output for a full screen (6 cm) display.
- c. Plug the miniature phone plug, with the 600 Ω load resistor across the terminals, into the TO RECORDER jack. Connect a 1X probe from the test oscilloscope across the 600 load.
- d. Check—Signal output level across the 600 Ω load, must equal 5 mV to 15 mV.
- e. Remove the phone plug from the Type 1L5.

6. Adjust Mixer Balance (0 Hz spurious signal amplitude)

- a. Requirement—Amplitude should be ≥ 1 cm to ≤ 4 cm.
- b. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	0000
DISPERSION-Hz/CM	1 K

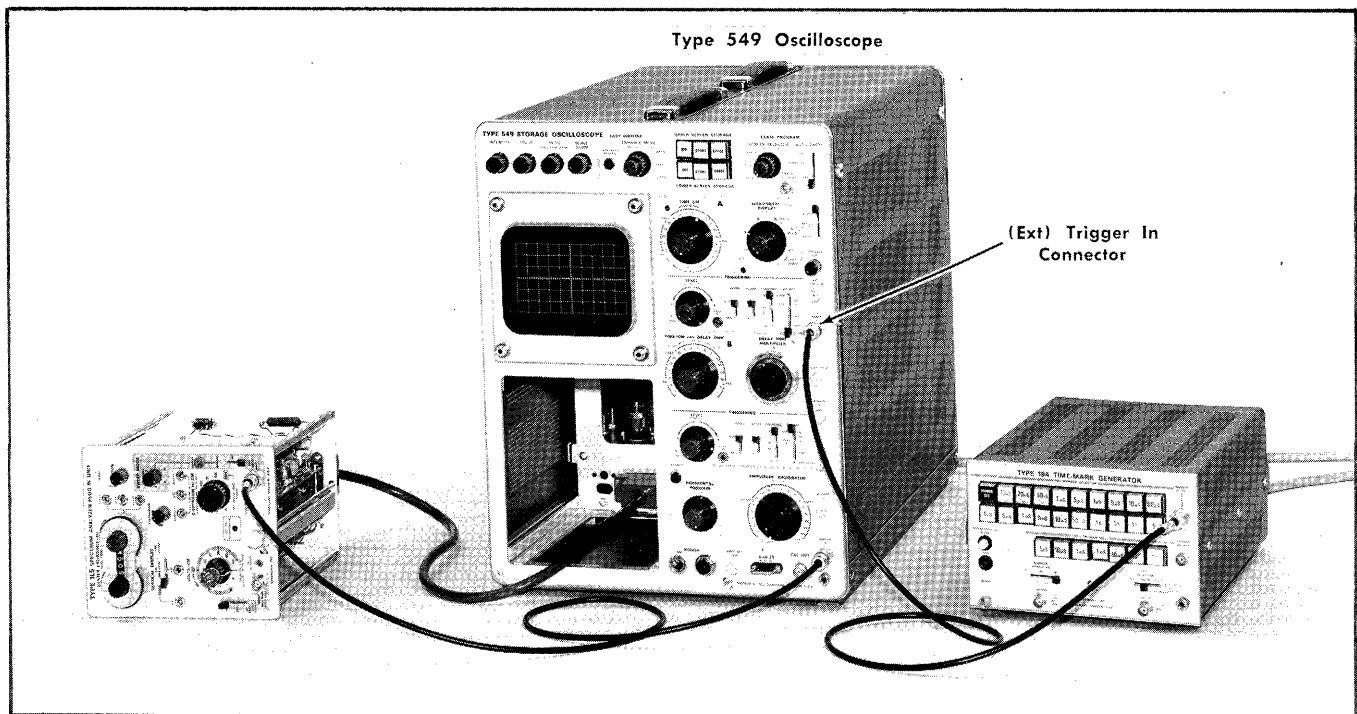


Fig. 6-14. Equipment setup for adjusting the 5 kHz Calibrator.

c. Adjust R85 and C86 (Fig. 6-13) for a 0 Hz signal amplitude between 1 and 4 cm. Change the value of select capacitor C87 if necessary.

7. Check Internal Noise Level

a. Install the Type 1L5 in the plug-in compartment of the oscilloscope and fasten the side panels of the oscilloscope in place before performing this check.

b. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	500 k
VERTICAL DISPLAY	LIN
DISPERSION Hz/CM	100 K
VOLTS/CM	.001
V/CM $\div$ 100	Pull knob out
Input Selector	GND

c. Check—Noise level must not exceed 0.5 centimeters.

Type 1L5

CENTER FREQUENCY-Hz	5000
VARIABLE	CAL
VERTICAL DISPLAY	VIDEO
VOLTS/CM	CALIBRATE 4 CM 5000 Hz CENTER FREQ
V/CM $\div$ 100	Pushed in
VARIABLE	CAL
DISPERSION-Hz/CM	1 K

Test Oscilloscope

Time/Cm	.2 ms
Triggering Source	Ext
Triggering Mode	Trig

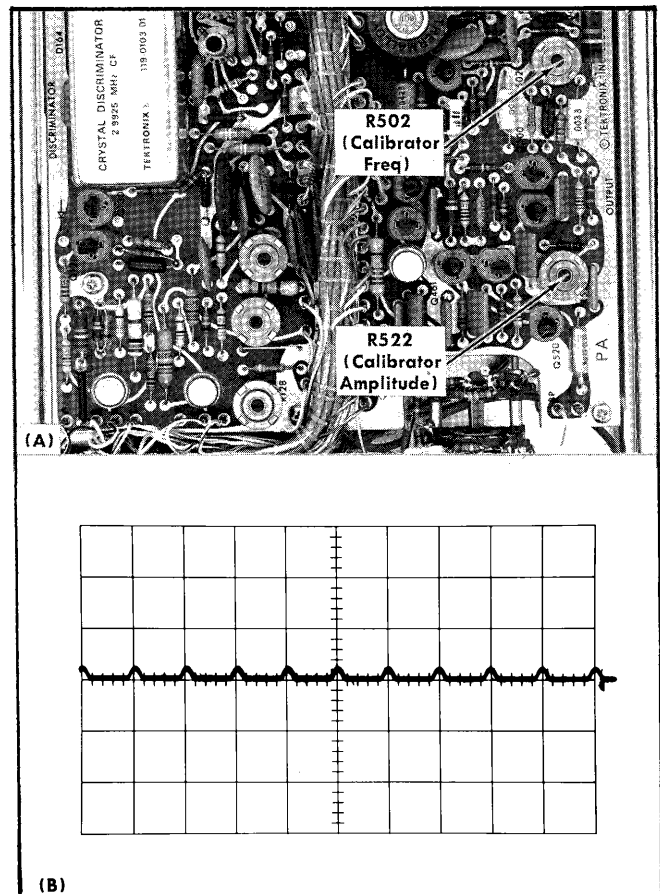


Fig. 6-15. Location of 5 kHz calibrator adjustments and typical display when checking frequency.

8. Adjust 5 kHz Calibrator Frequency and Amplitude ①

Requirement—Frequency, 5 kHz $\pm 1\%$; amplitude of 5 kHz fundamental signal, 4 centimeters.

a. Equipment setup is shown in Fig. 6-14.

b. Apply .1 ms markers from the Time-Mark Generator to the Ext Trig In connector of the plug-in oscilloscope. Switch the oscilloscope Trigger Source selector to Ext, the Mode selector to Trig and adjust the Triggering controls for a triggered display.

c. Adjust R502 (Fig. 6-15) for minimum display drift. (1 marker/cm at a sweep rate of .2 ms/cm.)

d. Change the controls as follows:

CENTER FREQUENCY-Hz	5000
DISPERSION Hz/CM	500
VERTICAL DISPLAY	LIN
V/CM	Pushed in
VARIABLE	CAL
Time/Cm	50 ms
Trigger Source	Int
Triggering	Auto or Free Running

Type 1L5

CENTER FREQUENCY-Hz	500 k
VARIABLE	CAL
VERTICAL DISPLAY	VIDEO
POSITION	Trace centered
SWEEP MODE	EXT INPUT
Input Selector	AC FAST
VOLTS/CM	.5 (Outer scale)
VARIABLE	CAL
V/CM $\div 100$	Knob pulled out
DISPERSION Hz/CM	100 K
VARIABLE	CAL
RESOLUTION	Coupled with DISPERSION

Test Oscilloscope

Time/Cm	10 μ s
Triggering Source	Int
Triggering Mode	Auto or free running
Volts/Cm	.01

e. Adjust R522 (Fig. 6-15) for a marker display amplitude of 4 cm.

f. Remove the Time-Mark Generator signal from the oscilloscope Ext Trig In connector.

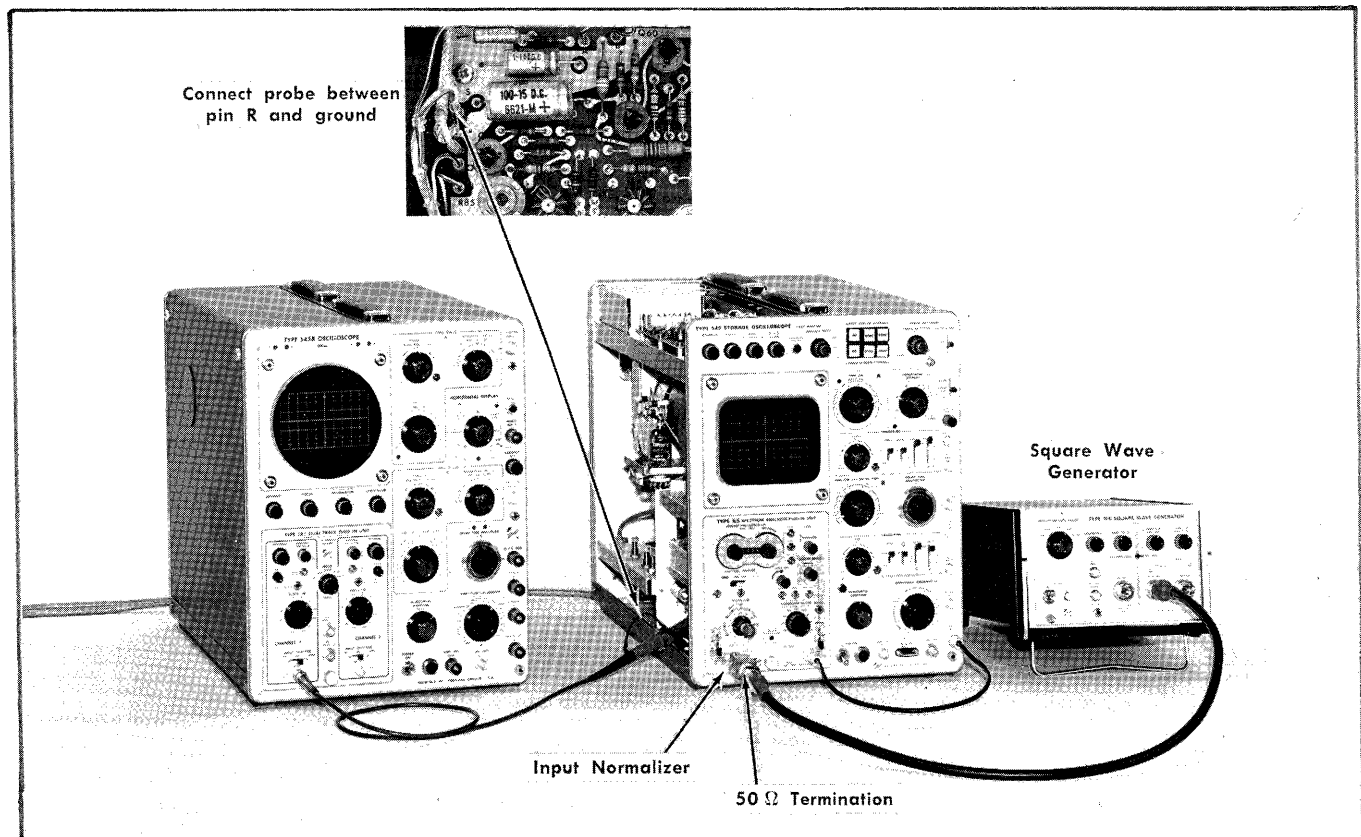


Fig. 6-16. Equipment setup for attenuator (VOLTS/CM) compensation adjustments.

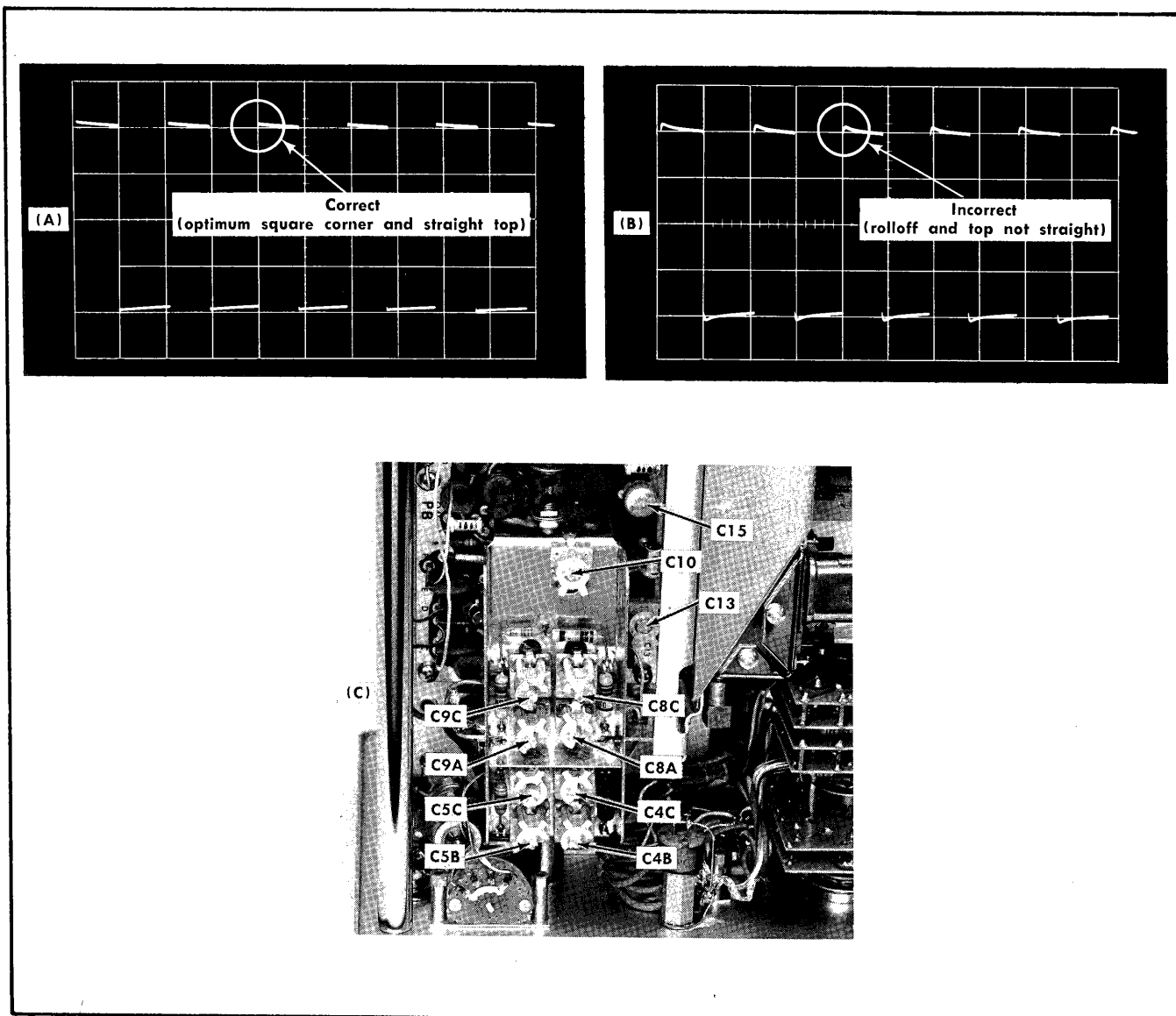


Fig. 6-17. Location of adjustments and typical response for the VOLTS/CM compensation.

9. Adjust VOLTS/CM Attenuator Compensation

①

- Equipment setup is shown in Fig. 6-16.
- Connect a properly compensated $10\times$ probe from the test oscilloscope, between pin R and ground of the Input Amplifier board. See Fig. 6-16.
- Apply a 1 kHz signal from the Square-Wave generator through a $50\ \Omega$ termination and a 30 pF Normalizer to the INPUT connector on the Type 1L5. Adjust the signal generator output for a display amplitude of 4 centimeters on the test oscilloscope.
- With the V/CM $\div 100$ knob pulled out and the VOLTS/CM selector at .005, adjust C10 (Fig. 6-17C) for optimum square wave response on the test oscilloscope.

e. Push in the V/CM $\div 100$ knob. Adjust C15 and C13 (Fig. 6-17) for optimum square wave response. C15 is adjusted for minimum aberrations and C13 for optimum flat top. See Fig. 6-17A. (The slope on the top and bottom of the square wave will not be flat, because the amplifier stages are not DC coupled).

f. Pull the V/CM $\div 100$ knob out. Adjust the remaining compensation adjustments as listed in Table 6-5. Maintain a 4 centimeter display amplitude on the test oscilloscope during these adjustments.

g. Check the response of the attenuator at all positions of the VOLTS/CM selector. It may be necessary to readjust some of the compensation capacitors. See Table 6-6 to determine which capacitors affect each position.

h. Remove the $10\times$ probe and the input 30 pF Normalizer.

TABLE 6-5

VOLTS/CM Selection (Outer Scale)	Adjust	For
1	C8C	Minimum spike
	C8A	Flat top
2	C9C	Minimum spike
	C9A	Flat top
5	C4C	Minimum spike
	C4B	Flat top
50	C5C	Minimum spike
	C5B	Flat top

TABLE 6-6

VOLTS/CM (Outer Scale)	C8C	C9C	C4C	C5C
1	X			
2		X		
5			X	
10	X		X	
20		X	X	
50				X
100	X			X
Fully Counter- clockwise		X		X

NOTES

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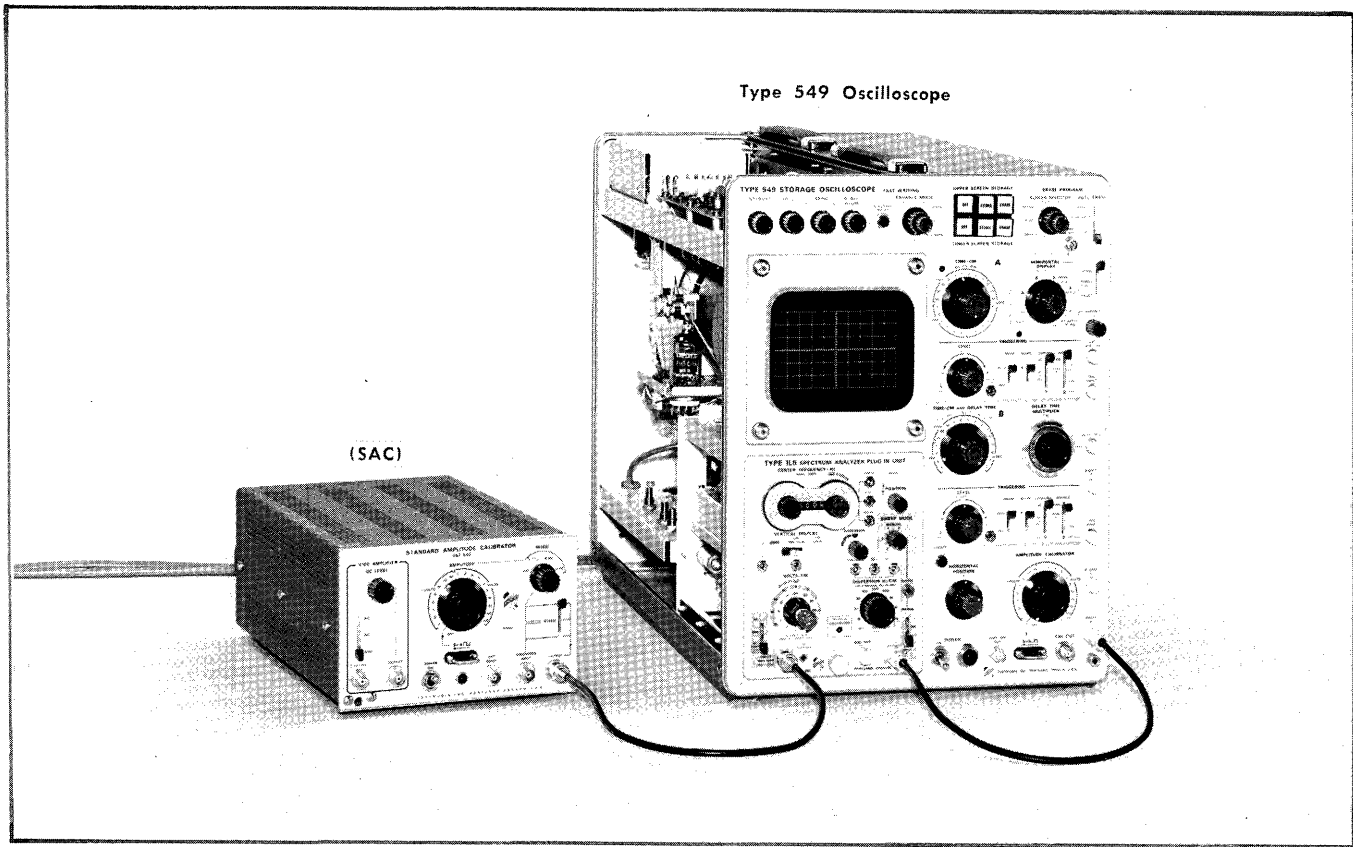


Fig. 6-18. Test equipment setup to adjust and check vertical deflection factor.

Type 1L5

CENTER FREQUENCY-Hz	500 k
VARIABLE	CAL
VERTICAL DISPLAY	VIDEO
POSITION	Centered
SWEEP MODE	EXT INPUT
Input Selector	AC FAST
VOLTS/CM	.5 (Outer scale)
VARIABLE	CAL
V/CM ÷ 100	Pulled out

DISPERSION	
VARIABLE	
Hz/CM—COUPLED	CAL
RESOLUTION	100 K

Test Oscilloscope	
Time/Cm	1 ms
Triggering	Adjusted for a free running trace

NOTES

10. Adjust Video Deflection Factor, Check Input Attenuator Accuracy and Check Variable Volts/CM Control Range

- a. Equipment setup is shown in Fig. 6-18.
- b. Apply a 20 mV signal from the Standard Amplitude Calibrator (SAC) to the INPUT connector of the Type 1L5.
- c. Adjust the VIDEO CAL R436, (front panel adjustment), for a display amplitude of 4 centimeters. (VOLTS/CM selector in .5 position and V/CM $\div$ 100 knob pulled out.)
- d. Check the VOLTS/CM selector accuracy at each position as listed in Table 6-7.
- e. Set the VOLTS/CM selector to 1 (outer scale), push in the V/CM $\div$ 100 control, then adjust the Standard Amplitude Calibrator output for a signal amplitude of 5 volts. Center the 5 centimeter display on screen with the POSITION controls.
- f. Turn the VARIABLE VOLTS/CM control fully counter-clockwise.
- g. CHECK—Display amplitude should decrease to 1.67 centimeters or less (VARIABLE control range $\geq$ 3:1).

TABLE 6-7

Analyzer VOLTS/CM Switch Setting (Outer Scale)	SAC Output in Volts	Display Amplitude in Centimeters	Maximum Error in Millimeters
.1	5 mV	5	± 1.5
.2	10 mV	5	± 1.5
.5	20 mV	4	0 (Set in step c)
1	50 mV	5	± 1.5
2	.1 V	5	± 1.5
5	.2 V	4	± 1.2
10	.5 V	5	± 1.5
20	1 V	5	± 1.5
50	2 V	4	± 1.2
100	5 V	5	± 1.5
Push in V/CM $\div$ 100 knob			
.5	2 V	4	± 1.2

NOTES

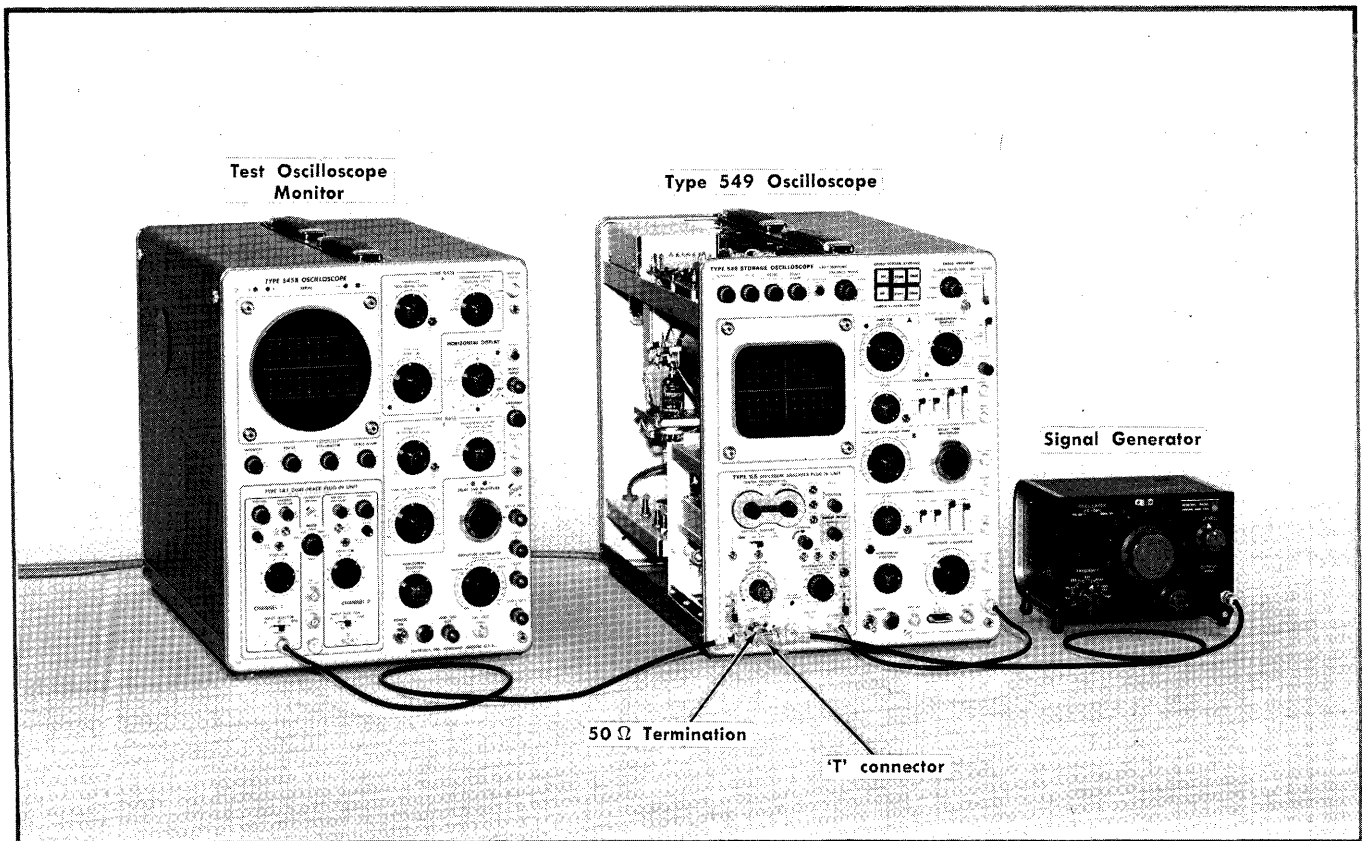


Fig. 6-19. Equipment setup to check spectrum display flatness.

Type 1L5

CENTER FREQUENCY-Hz 5000
 VARIABLE CAL
VERTICAL DISPLAY LIN
 POSITION Centered
 SWEEP MODE EXT INPUT
 Input Selector AC FAST
VOLTS/CM .001 (Inner Scale)
 VARIABLE CAL
V/CM ÷ 100 Pushed in
 DISPERSION
 VARIABLE CAL
Hz/CM—COUPLED 1 K
RESOLUTION

Test Oscilloscope

Time/Cm 50 ms
 Triggering Adjusted for a free running trace

11. Check Spectrum Display Flatness

Requirement: The display flatness for the .001 VOLTS/CM and .002 VOLTS/CM positions is within +0.5 dB, -3 dB over the frequency range 10 Hz to 1 MHz. The display flatness for the .005 VOLTS/CM to the 2 VOLTS/CM positions is within ±0.5 dB over the frequency range 10 Hz to 1 MHz.

a. Equipment setup is shown in Fig. 6-19. (1L5 must be installed in oscilloscope.)

b. Apply a 5 kHz signal from the Wide Range Signal Generator, through a T connector, to both the Vertical Input of a test oscilloscope monitor and through an attenuator or termination to the Type 1L5 INPUT connector.

c. Adjust the signal generator output to establish a reference signal amplitude of 5 centimeters on the plug-in oscilloscope. Adjust the Volts/Cm controls of the test oscilloscope to establish a reference signal amplitude of 5 centimeters on the test or monitor oscilloscope.

d. Check the display flatness as follows:

1. Change the signal generator frequency and the CENTER FREQUENCY-Hz selector to 50 kHz. Set the DISPERSION-Hz/CM to 10 K and the Time/Cm to 2 s.

2. Readjust if necessary the signal generator output to establish the reference signal amplitude of 5 cm on the monitor oscilloscope.

3. Tune the signal generator frequency through the dispersion window (10 kHz to 100 kHz) in 10 kHz steps, checking the display flatness. Display flatness for the .001 and .002 VOLTS/CM positions must remain within +0.5 dB, -3 dB of the reference amplitude (5.4 cm to 3.6 cm). Display flatness for the .005 to 2 VOLTS/CM positions must remain within ±0.5 dB (4.6 to 5.4 cm).

4. Change the signal generator frequency and the CENTER FREQUENCY-Hz selector to 500 kHz. Set the DISPERSION-Hz/CM to 100 K.

5. Re-adjust the signal generator output to maintain the reference amplitude on the monitor.

6. Check the display flatness over the 100 kHz to 900 kHz range. Tune the CENTER FREQUENCY-Hz selector and the signal generator frequency through the dispersion window in 100 kHz steps.

NOTE

If flatness is not within these specifications at the .005 position of the VOLTS/CM selector, change the value of selected capacitor C44.

7. Check the display flatness using the above procedure for the 10 Hz to 9900 Hz frequency range, with a 9000 Hz signal then a 50 Hz signal applied to the INPUT. Decrease the DISPERSION Hz/CM selector position as the CENTER FREQUENCY-Hz selection is decreased. Adjust the 0000 Hz CAL if necessary to compensate for drift at the low frequencies.

8. Repeat the above flatness check for each position of the VOLTS/CM selector. Pull out the $V/CM \div 100$ knob when checking the .5 to 2 VOLTS/CM positions.

12. Check Video Display Frequency Response

a. Equipment setup is given in step 11.

b. Apply a 5 kHz signal from the Wide Range Signal Generator through a BNC T connector to the INPUT of the 1L5 and the vertical input to the test oscilloscope.

c. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	5000
VERTICAL DISPLAY	VIDEO
VOLTS/CM	.5 (Outer scale)
V/CM ÷ 100	Pushed in
VARIABLE	CAL

d. Adjust the signal generator output for a signal amplitude of 6 centimeters on the plug-in oscilloscope screen, then adjust the test oscilloscope Volts/Cm or Variable controls for a reference signal amplitude of 6 centimeters.

e. Decrease the signal generator frequency until the display amplitude decreases to 4.25 centimeters on the plug-in oscilloscope. (Maintain a constant input amplitude signal.) Note the generator frequency. Increase the signal generator frequency until the display amplitude is about 4.25 centimeters. Note the signal generator frequency. Frequency response for the .5 to the 100 VOLTS/CM range of the selector is <10 Hz to >1 MHz.

f. Check the response for the .1 and .2 VOLTS/CM positions. Frequency response is <10 Hz to >700 kHz.

g. Remove the signal generator and the test oscilloscope connections to the Type 1L5 INPUT connector.

NOTES

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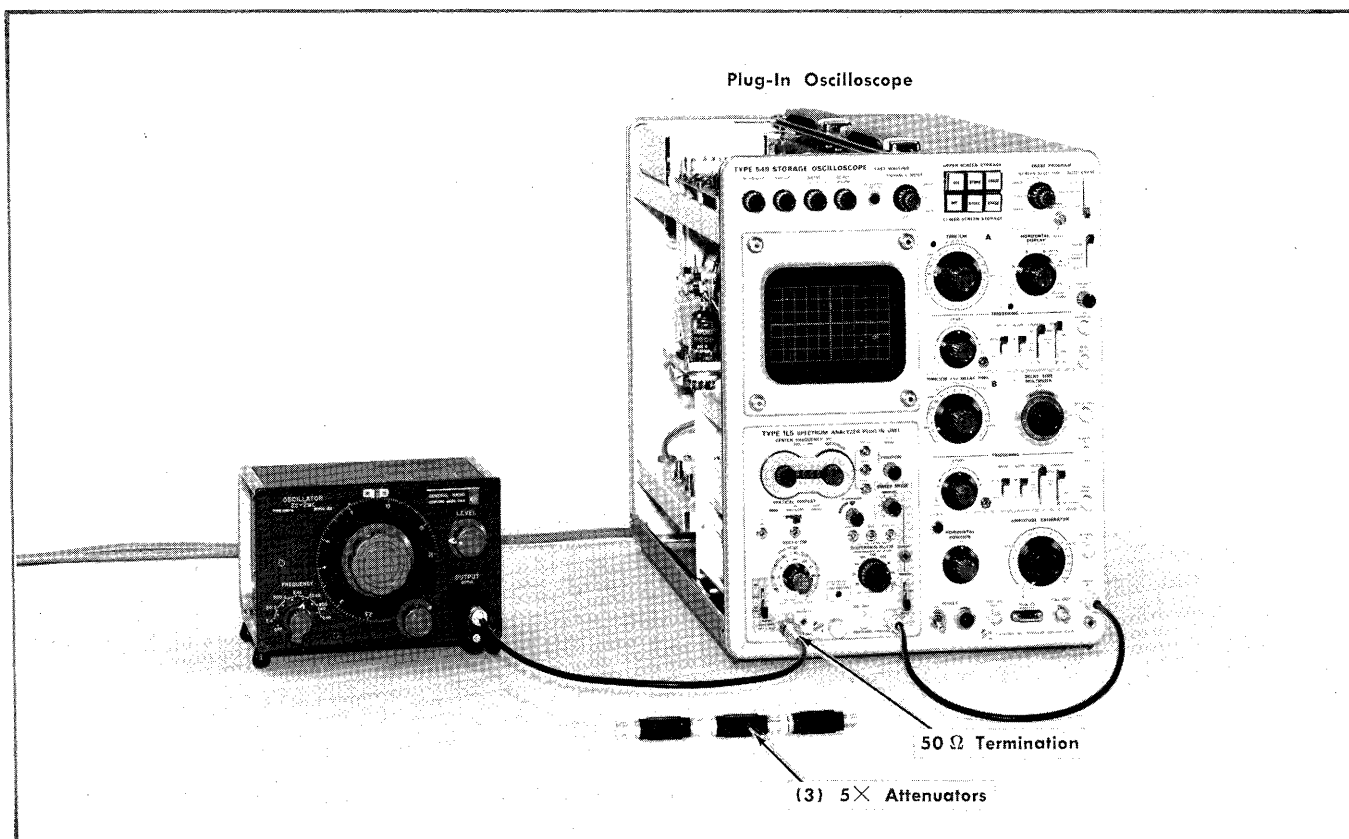


Fig. 6-20. Equipment setup to check incidental FM.

Type 1L5

CENTER FREQUENCY-Hz	9000 Hz
VARIABLE	CAL
VERTICAL DISPLAY	LIN
POSITION	Centered
SWEEP MODE	EXT INPUT
Input Selector	AC FAST
VOLTS/CM	.005 (Inner scale)
VARIABLE	CAL
V/CM $\div 100$	Pushed in
DISPERSION	
VARIABLE	CAL
Hz/CM—COUPLED	1 K
RESOLUTION	

Test Oscilloscope

Time/Cm	50 ms
Triggering	Adjusted for a free running trace

13. Check Incidental Frequency Modulation

This check is only operational. It provides an indication of circuit stability.

a. Equipment setup is shown in Fig. 6-20.

b. Apply a 9 kHz signal from the Wide Range Signal Generator to the INPUT connector of the 1L5. Adjust the output for a 6 centimeter display.

c. Reduce the DISPERSION Hz/CM to 10, adjusting the generator frequency to keep the signal centered on the graticule.

d. Change the sweep rate to .5 s/cm. Maintain 6-centimeter display amplitude that is centered within the graticule area.

e. Check the amount of incidental FM at the 50% or half amplitude point of the signal. Should not exceed 5 millimeters (Fig. 6-21).

f. Check the amount of incidental FM at 6000 Hz, 3000 Hz and 50 Hz by repeating the procedure of steps (b) through (e).

g. Change the CENTER FREQUENCY-Hz setting and the signal generator frequency to 900 kHz. Decrease the DISPERSION-Hz/CM selector to 50. Keep the signal centered and maintain an amplitude of 6 centimeters.

h. Check incidental FM at 900 kHz, 500 kHz and 10 kHz. Should not exceed 15 Hz or 3 millimeters with a dispersion of 50 Hz/CM.

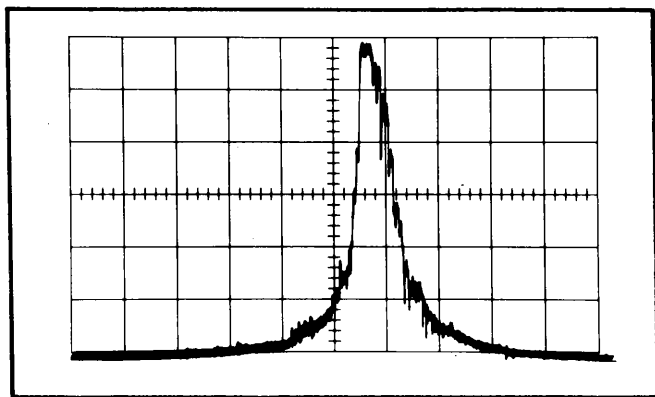


Fig. 6-21. Display to illustrate measurement of incidental FM. Measure the horizontal displacement of the signal at the highest vertical slope of the signal.

14. Check Amplitude of Random Spuria

Requirement: Spurious signal amplitude ≤ 1.0 centimeter with a 50 dB signal above a reference signal level of 1.0 centimeter.

- Equipment setup is given in step 12.
- Change the controls to the following settings:

CENTER FREQUENCY-Hz 500 k
VERTICAL DISPLAY LOG
VOLTS/CM .005 (Inner scale)

V/CM $\div$ 100	Pulled out
DISPERSION-Hz/CM	100 K
RESOLUTION	200 (uncoupled)
Sweep Rate	.2 s/cm

c. Apply a 500 kHz signal from the Wide Range Signal Generator through three 5X attenuators and a 50 Ω termination to the Type 1L5 INPUT connector. Adjust the generator output for a display amplitude of 1.0 centimeters on the CRT.

d. Remove the three 5X attenuators; reconnect the terminated generator output to the INPUT connector. Change the VOLTS/CM selector to .002.

e. Check that there are no spurious signals more than 1.0 centimeters in amplitude. Ignore the spurious start signal, the 500 kHz fundamental and the 1st harmonic signal.

If an excessive spurious signal is present at approximately 300 kHz, it may be due to misadjustment of L270 (effective after serial number 200). Proceed as follows:

1. Remove the two mounting screws for the filter assembly. Slide the assembly out so the adjustment to L270, on the bottom of the assembly, is accessible.
2. Using special adjustment tool, Tektronix Part Number 003-0497-00, adjust L270 for minimum spurious signal response.
3. Replace the assembly and the mounting screws.

NOTES

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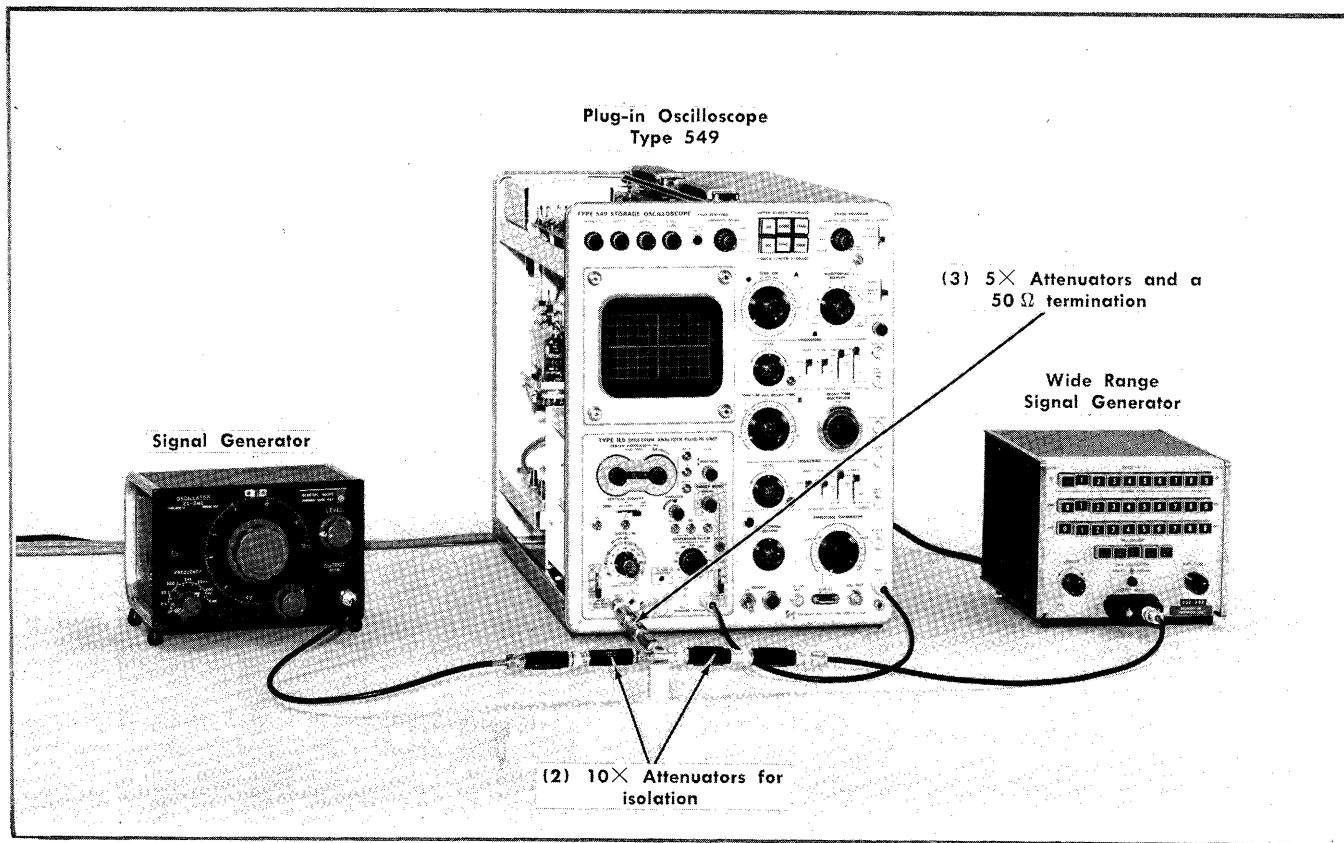


Fig. 6-22. Equipment setup to check intermodulation distortion.

Type 1L5

CENTER FREQUENCY-Hz	100 k
VARIABLE	CAL
VERTICAL DISPLAY POSITION	LOG
	Centered trace at the bottom graticule line
SWEEP MODE	EXT INPUT
INPUT SELECTOR	AC FAST
VOLTS/CM	.005 (Inner scale)
V/CM ÷ 100	Pulled out
DISPERSION Hz/CM	10 K
RESOLUTION	50

Test Oscilloscope

Time/Cm	.2 s
Triggering	Free running

15. Check Intermodulation Distortion

Requirement: Intermodulation sideband amplitude ≤ 1.0 centimeter with a 50 dB signal level above a reference of 1.0 centimeter; LOG display.

- Equipment setup is shown in Fig. 6-22.
- Apply 90 kHz and 110 kHz signal from two signal generators through isolation networks consisting of two

10 $\times$ attenuators, a BNC T connector, three 5 $\times$ attenuators and a 50 Ω termination to the INPUT connector of the Type 1L5.

c. Reduce the RESOLUTION to 20 and position the baseline of the display to the bottom graticule line. Return the RESOLUTION control to the 10 K position and adjust the output controls of the two signal generators for two signals that are 1.0 centimeter above the bottom graticule line. See Fig. 6-23A.

d. Remove the three 5 $\times$ attenuators between the T connector and the 50 Ω termination. Reconnect the terminated T connector to the INPUT connector and change the VOLTS/CM selector to the .002 position.

e. Check—Intermodulation distortion. The amplitude of the sidebands must not exceed 1.0 centimeter. See Fig. 6-23B.

16. Check Operation of Manual Sweep

a. Connect a patch cord (banana plug to BNC) between the OUTPUT jack and the Ext Horiz Input connector on the oscilloscope.

b. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	10 k
VERTICAL DISPLAY	LIN
VOLTS/CM	CALIBRATE 4 CM 5000 Hz CENTER FREQ

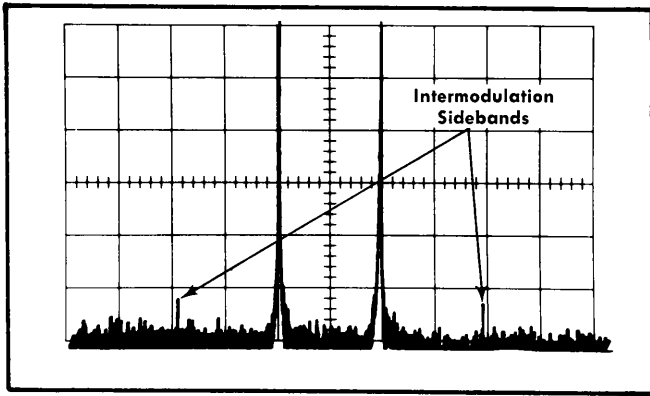


Fig. 6-23. Typical displays when measuring intermodulation distortion.

DISPERSION Hz/CM	10 K
Input Coupling	GND
SWEEP MODE	MANUAL (fully clockwise to 10)
Horizontal Display	10X

c. Position the beam to the left edge of the graticule with the Position control.

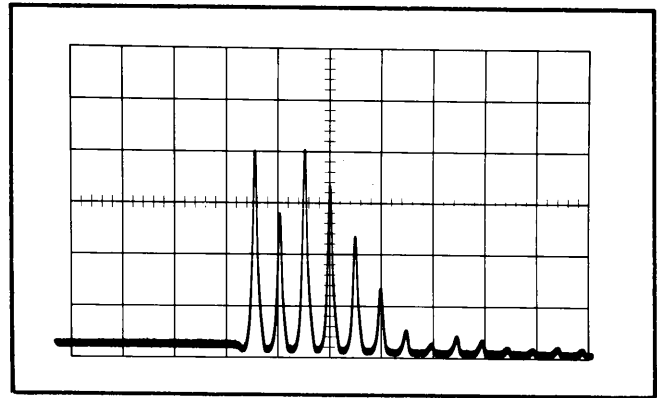


Fig. 6-24. Calibrator display when checking the MANUAL Sweep Mode operation.

d. Turn the Sweep Mode **MANUAL** control fully counter-clockwise to 0. Adjust the Variable 1:10 control to position the beam to the right edge of the graticule.

- e. Set the oscilloscope Upper and Lower Screen Storage selectors to Store.

- f. Rotate the SWEEP control through its range. The display should resemble Fig. 6-24.

NOTES

[illegible]

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PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	P/O	part of
DE	double end	PHB	pan head brass
dia	diameter	PHS	pan head steel
div	division	plstc	plastic
elect.	electrolytic	PMC	paper, metal cased
EMC	electrolytic, metal cased	poly	polystyrene
EMT	electrolytic, metal tubular	prec	precision
ext	external	PT	paper, tubular
F & I	focus and intensity	PTM	paper or plastic, tubular, molded
FHB	flat head brass	RHB	round head brass
FHS	flat head steel	RHS	round head steel
Fil HB	fillister head brass	SE	single end
Fil HS	fillister head steel	SN or S/N	serial number
h	height or high	S or SW	switch
hex.	hexagonal	TC	temperature compensated
HHB	hex head brass	THB	truss head brass
HHS	hex head steel	thk	thick
HSB	hex socket brass	THS	truss head steel
HSS	hex socket steel	tub.	tubular
ID	inside diameter	var	variable
inc	incandescent	w	wide or width
		WW	wire-wound

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.

SECTION 7

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description					S/N Range
Bulb							
B115	150-0035-00	Neon AID T2					
Capacitors							
Tolerance $\pm 20\%$ unless otherwise indicated.							
C1	*285-0697-01	0.1 μF	MT		600 V		
C4A	281-0503-00	8 pF	Cer		500 V	± 0.5 pF	
C4B	281-0102-00	1.7-11 pF	Air	Var			
C4C	281-0099-00	1.3-5.4 pF	Air	Var			
C4D	281-0509-00	15 pF	Cer		500 V	10%	
C5A	281-0504-00	10 pF	Cer		500 V	10%	
C5B	281-0102-00	1.7-11 pF	Air	Var			
C5C	281-0099-00	1.3-5.4 pF	Air	Var			
C5D	283-0606-00	250 pF	Mica		500 V	10%	
C8A	281-0099-00	1.3-5.4 pF	Air	Var			
C8C	281-0102-00	1.7-11 pF	Air	Var			
C8D	281-0505-00	12 pF	Cer		500 V	10%	
C9A	281-0102-00	1.7-11 pF	Air	Var			
C9C	281-0102-00	1.7-11 pF	Air	Var			
C10	281-0100-00	1.4-7.3 pF	Air	Var			
C11	281-0500-00	2.2 pF	Cer		500 V	± 0.5 pF	100-804X
C13	281-0077-00	1.3-5.4 pF	Air	Var			
C15	281-0092-00	9-35 pF	Cer	Var			100-804
C15	281-0075-00	5-25 pF	Cer	Var			805-up
C16	283-0552-00	200 pF	Mica		500 V	1%	
C18	283-0079-00	0.01 μF	Cer		250 V		
C19	290-0267-00	1 μF	Elect.		35 V		
C26	290-0164-00	1 μF	Elect.		150 V		
C30	283-0079-00	0.01 μF	Cer		250 V		
C34	283-0079-00	0.01 μF	Cer		250 V		
C35	290-0167-00	10 μF	Elect.		15 V		
C36	290-0167-00	10 μF	Elect.		15 V		
C40	281-0540-00	51 pF	Cer		500 V	5%	
C40A	Selected						
C41	281-0543-00	270 pF	Cer		500 V	10%	
C41A	Selected						
C43	290-0201-00	100 μF	Elect.		15 V		
C44	281-0628-00	15 pF	Selected	(nominal value)			
C45	281-0605-00	200 pF	Cer		500 V		

Capacitors (Cont)

Ckt. No.	Tektronix Part No.	Description		S/N Range		
C49	283-0024-00	0.1 μ F	Cer	30 V		100-1449
C49	283-0059-00	1 μ F	Cer	25 V	+20%—20%	1450-up
C50	283-0606-00	250 pF	Mica	500 V	10%	
C51	290-0201-00	100 μ F	Elect.	15 V		
C54	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C70	290-0201-00	100 μ F	Elect.	15 V		
C82	281-0504-00	10 pF	Cer	500 V	10%	
C86	281-0081-00	1.8-13 pF	Air	Var		
C87	Selected					
C135	283-0059-00	1 μ F	Cer	25 V	+80%—20%	100-323
C135	283-0010-00	0.05 μ F	Cer	50 V		324-up
C137	Selected					100-323X
C138	281-0093-00	5.5-18 pF	Cer	Var		
C139	283-0128-00	100 pF	Cer	500 V	5%	100-323X
C142	283-0079-00	0.01 μ F	Cer	250 V		100-323X
C153	283-0143-00	330 pF	Cer	250 V	5%	
C154	283-0081-00	0.1 μ F	Cer	25 V	+80%—20%	
C155	283-0078-00	0.001 μ F	Cer	500 V		
C157	283-0078-00	0.001 μ F	Cer	500 V		
C158	283-0143-00	330 pF	Cer	200 V	5%	
C160	281-0578-00	18 pF	Cer	500 V	5%	X324-up
C161	283-0116-00	820 pF	Cer	500 V	5%	X324-up
C162	283-0010-00	0.05 μ F	Cer	50 V		
C168	283-0079-00	0.01 μ F	Cer	250 V		
C171	281-0536-00	0.001 μ F	Cer	500 V	10%	
C174	283-0081-00	0.1 μ F	Cer	25 V	+80%—20%	
C176	283-0081-00	0.1 μ F	Cer	25 V	+80%—20%	
C178	283-0079-00	0.01 μ F	Cer	250 V		
C180	283-0079-00	0.01 μ F	Cer	250 V		
C184	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C187	283-0081-00	0.1 μ F	Cer	25 V	+80%—20%	
C191	281-0536-00	0.001 μ F	Cer	500 V	10%	100-323
C191	283-0594-00	0.001 μ F	Mica	100 V	1%	324-up
C192	283-0142-00	0.0027 μ F	Selected (nominal value)			
C194	283-0594-00	0.001 μ F	Mica	100 V	1%	100-323
C194	290-0136-00	2.2 μ F	Elect.	20 V		324-up
C197	281-0549-00	68 pF	Cer	500 V	10%	X324-up
C208	283-0081-00	0.1 μ F	Cer	25 V	+80%—20%	
C217	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C218	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C250	281-0523-00	100 pF	Cer	350 V		
C252	281-0044-00	80-480 pF	Mica	Var		
C253	285-0651-01	0.0017 μ F	PTM	100 V	5%	100-289
C253	283-0626-00	0.0018 μ F	Mica	500 V	5%	290-up
C255	283-0115-00	47 pF	Cer	200 V	5%	
C257	281-0044-00	80-480 pF	Mica	Var		

Capacitors (Cont)

Ckt. No.	Tektronix Part No.	Description		S/N Range		
C258	285-0651-01	0.0017 μ F	PTM	100 V	5%	100-289
C258	283-0626-00	0.0018 μ F	Mica	500 V	5%	290-up
C260	283-0115-00	47 pF	Cer	200 V	5%	
C262	281-0044-00	80-480 pF	Mica	Var		
C263	285-0651-01	0.0017 μ F	PTM		100 V	100-289
C263	283-0626-00	0.0018 μ F	Mica	Var	500 V	290-up
C265	283-0115-00	47 pF	Cer		200 V	5%
C267	281-0044-00	80-480 pF	Mica			
C268	285-0651-01	0.0017 μ F	PTM		100 V	100-289
C268	283-0626-00	0.0018 μ F	Mica		500 V	290-up
C270	283-0625-00	220 pF	Mica		500 V	1%
C273	283-0059-00	1 μ F	Cer		25 V	+80%—20%
C275	283-0059-00	1 μ F	Cer		25 V	+80%—20%
C280	283-0081-00	0.1 μ F	Cer		25 V	+80%—20%
C281	283-0114-00	0.0015 μ F	Cer		200 V	
C290	283-0081-00	0.1 μ F	Cer		25 V	+80%—20%
C292	283-0068-00	0.01 μ F	Cer		500 V	
C294	283-0068-00	0.01 μ F	Cer		500 V	
C297	283-0114-00	0.0015 μ F	Cer		200 V	
C298	281-0580-00	470 pF	Cer		500 V	10%
C309	283-0079-00	0.01 μ F	Cer		250 V	
C314	283-0079-00	0.01 μ F	Cer		250 V	
C318	283-0081-00	0.1 μ F	Cer		25 V	+80%—20%
C323	281-0092-00	9-35 pF	Cer	Var		100-289
C323	281-0093-00	5.5-18 pF	Cer	Var		290-up
C327	283-0079-00	0.01 μ F	Cer		250 V	
C329	281-0603-00	39 pF	Cer		500 V	5%
C332	281-0075-00	5-25 pF	Cer	Var		
C334	283-0111-00	0.1 μ F	Cer		50 V	
C335	285-0685-00	0.0068 pF	PTM		100 V	10% X324-up
C336	283-0003-00	0.01 μ F	Cer		150 V	
C337	283-0079-00	0.01 μ F	Cer		250 V	
C338	283-0108-00	220 pF	Cer		200 V	10%
C342	283-0059-00	1 μ F	Cer		25 V	+80%—20%
C343	281-0092-00	9-35 pF	Cer	Var		100-289
C343	281-0093-00	5.5-18 pF	Cer	Var		290-up
C347	283-0079-00	0.01 μ F	Cer		250 V	
C349	281-0603-00	39 pF	Cer		500 V	5%
C352	281-0075-00	5-25 pF	Cer	Var		
C354	283-0111-00	0.1 μ F	Cer		50 V	
C355	285-0685-00	0.0068 pF	PTM		100 V	10% X324-up
C356	283-0003-00	0.01 μ F	Cer		150 V	
C400	283-0067-00	0.001 μ F	Cer		200 V	10%
C402	281-0617-00	15 pF	Cer		200 V	X1160-up
C404	283-0067-00	0.001 μ F	Cer		200 V	10%
C405	281-0605-00	200 pF	Cer		500 V	

Capacitors (Cont)

Ckt. No.	Tektronix Part No.	Description				S/N Range
C412	283-0089-00	82 pF	Cer	1000 V	5%	
C413	283-0089-00	82 pF	Cer	1000 V	5%	
C415	283-0081-00	0.1 μ F	Cer	25 V	+80%—20%	
C416	283-0081-00	0.1 μ F	Cer	25 V	+80%—20%	
C420	283-0078-00	0.001 μ F	Cer	500 V		
C421	283-0078-00	0.001 μ F	Cer	500 V		
C422	290-0271-00	9 μ F	Elect.	125 V	+20%—15%	
C428	283-0079-00	0.01 μ F	Cer	250 V		
C430	283-0164-00	2.2 μ F	Cer	25 V		X1300-up
C432	283-0079-00	0.01 μ F	Cer	250 V		
C433	283-0008-00	0.1 μ F	Cer	500 V		100-323
C433	285-0622-00	0.1 μ F	PTM	100 V		324-up
C446	283-0079-00	0.01 μ F	Cer	250 V		
C450	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C460	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C461	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C469	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C500	285-0627-00	0.0033 μ F	PTM	100 V	5%	100-804
C500	283-0627-00	0.0033 μ F	Mica	500 V	5%	805-up
C506	290-0167-00	10 μ F	Elect.	15 V		
C510	285-0627-00	0.0033 μ F	PTM	100 V	5%	100-804
C510	283-0627-00	0.0033 μ F	Mica	500 V	5%	805-up
C513	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C518	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C520	283-0059-00	1 μ F	Cer	25 V	+80%—20%	
C522	283-0059-00	1 μ F	Cer	25 V	+80%—20%	

Diodes

D18	*152-0185-00	Silicon	Replaceable by 1N4152			
D38	*152-0185-00	Silicon	Replaceable by 1N4152			
D48	152-0031-00	Zener	1N718A 0.25 W 15 V	5%		100-679
D48	152-0243-00	Zener	1N965B 0.4 W 15 V	5%		680-up
D82A,B,C,D (4)	*153-0028-00	Silicon	Selected from 1N4244 (matched set)			
D132	*152-0185-00	Silicon	Replaceable by 1N4152			100-323X
D133	*152-0185-00	Silicon	Replaceable by 1N4152			100-323X
D154 } D157 }	*153-0029-00	Silicon	Selected from 1N4152 (matched pair)			
D161	*152-0185-00	Silicon	Replaceable by 1N4152			
D162	*152-0185-00	Silicon	Replaceable by 1N4152			
D163	*152-0185-00	Silicon	Replaceable by 1N4152			X324-up
D164	*152-0269-00	Voltage Variable Capacitance	Tek Spec			
D165	152-0070-00	Tunnel	BD4 0.1 mA			100-323
D165	152-0147-00	Zener	1N971B 0.4 W 27 V 5%			324-up
D200	*152-0185-00	Silicon	Replaceable by 1N4152			
D218	*152-0185-00	Silicon	Replaceable by 1N4152			
D220	*152-0185-00	Silicon	Replaceable by 1N4152			
D334	*152-0185-00	Silicon	Replaceable by 1N4152			
D354	*152-0185-00	Silicon	Replaceable by 1N4152			
D415	*152-0107-00	Silicon	Replaceable by 1N647			

Diodes (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
D420	*152-0107-00	Silicon	Replaceable by 1N647
D422	*152-0107-00	Silicon	Replaceable by 1N647
D428	152-0141-00	Silicon	1N4152
D428	152-0141-02	Silicon	1N4152
D428	*152-0322-00	Silicon	Tek Spec
D429	152-0141-00	Silicon	1N4152
D429	152-0141-02	Silicon	1N4152
D430	152-0008-00	Germanium	
D432	152-0008-00	Germanium	
D434	152-0008-00	Germanium	
D436	152-0008-00	Germanium	
D436	152-0141-02	Silicon	1N4152
D520	*152-0185-00	Silicon	Replaceable by 1N4152

Connectors

J1	131-0106-00	BNC, chassis mtd., 1 contact, female
J90	131-0372-00	Coaxial
J101	136-0139-00	Socket, Banana Jack Assembly
J105	131-0106-00	BNC, chassis mtd., 1 contact, female
J195	131-0276-00	BNC, chassis mtd., female
J280	131-0372-00	Coaxial
J415	136-0094-00	Socket, Tini-Jax

Inductors

L120	276-0557-00	Core, Toroid Ferrite			X500-up
L139	*108-0443-00	25 μ H			100-323X
L155	*175-0386-00	Delay Line			100-323
L155	*175-0386-01	Delay Line			324-up
L160	276-0557-00	Core, Toroid Ferrite			X500-up
L164	*114-0219-00	45-130 μ H	Var	Core 276-0568-00	
L190	108-0249-00	12 μ H			
L191	*114-0220-00	1-3 μ H	Var	Core 276-0568-00	
L192	*114-0222-00	2-6 μ H	Var	Core 276-0568-00	
L194	*114-0222-00	2-6 μ H	Var	Core 276-0568-00	
L253	*108-0416-00	1.5 μ H			
L258	*108-0416-00	1.5 μ H			
L263	*108-0416-00	1.5 μ H			
L268	*108-0416-00	1.5 μ H			
L270	108-0249-00	12 μ H			100-199
L270	*114-0233-00	8.5-15.5 μ H	Var	Core 276-0582-00	200-up
L280	114-0178-00	1300-3000 μ H	Var	Core not available separately	
L327	114-0176-00	10-40 mH	Var	Core not available separately	
L338	108-0324-00	10 mH			
L347	114-0176-00	10-40 mH	Var	Core not available separately	
L426	276-0528-00	Core, Ferramic Suppressor			
L446	276-0528-00	Core, Ferramic Suppressor			

Plug

P11	131-0017-00	Chassis mtd., 16 contact, male
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Electrical Parts List—Type 1L5

Transistors

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q20	*151-1004-00	Field Effect	Tek Spec
Q21	151-0150-00	Silicon	2N3440
Q30	151-0207-00	Silicon	2N3415
Q40	*151-0155-00	Silicon	Replaceable by 2N2925
Q41	151-0188-00	Silicon	2N3906
Q42	151-0188-00	Silicon	2N3906
Q50	*151-0155-00	Silicon	Replaceable by 2N2925
Q60	*151-0155-00	Silicon	Replaceable by 2N2925
Q70	*151-0155-00	Silicon	Replaceable by 2N2925
Q90	*151-0153-00	Silicon	Replaceable by 2N2923
Q120	*151-0104-00	Silicon, Dual	Replaceable by 2N2913
Q121	*151-0155-00	Silicon	Replaceable by 2N2925
Q121	151-0188-00	Silicon	2N3906
Q130	*151-0155-00	Silicon	Replaceable by 2N2925
Q130	151-0190-00	Silicon	2N3904
Q140	*151-0104-00	Silicon, Dual	Replaceable by 2N2913
Q160	*151-0155-00	Silicon	Replaceable by 2N2925
Q160	*151-0198-00	Silicon	Replaceable by MPS-918
Q170	*151-0155-00	Silicon	Replaceable by 2N2925
Q171	*151-0155-00	Silicon	Replaceable by 2N2925
Q180	151-0207-00	Silicon	2N3415
Q180	*151-0108-00	Silicon	Replaceable by 2N2501
Q190	151-0207-00	Silicon	2N3415
Q190	*151-0108-00	Silicon	Replaceable by 2N2501
Q200	*151-0155-00	Silicon	Replaceable by 2N2925
Q210	*151-0155-00	Silicon	Replaceable by 2N2925
Q280	*151-0153-00	Silicon	Replaceable by 2N2923
Q290	*151-0153-00	Silicon	Replaceable by 2N2923
Q300	*151-0153-00	Silicon	Replaceable by 2N2923
Q310	*151-0153-00	Silicon	Replaceable by 2N2923
Q320	*151-0155-00	Silicon	Replaceable by 2N2925
Q330	151-0190-00	Silicon	2N3904
Q330	151-0190-02	Silicon	2N3904
Q340	*151-0155-00	Silicon	Replaceable by 2N2925
Q350	151-0190-00	Silicon	2N3904
Q350	151-0190-02	Silicon	2N3904
Q400	*151-0155-00	Silicon	Replaceable by 2N2925
Q400	151-0190-00	Silicon	2N3904
Q401	*151-0155-00	Silicon	Replaceable by 2N2925
Q410	151-0150-00	Silicon	2N3440
Q420	*151-1004-00	Field Effect	Tek Spec
Q450	151-0188-00	Silicon	2N3906
Q451	*151-0136-00	Silicon	Replaceable by 2N3053
Q460	151-0188-00	Silicon	2N3906
Q461	151-0207-00	Silicon	2N3415
Q500	151-0188-00	Silicon	2N3906
Q510	*151-0155-00	Silicon	Replaceable by 2N2925
Q520	*151-0155-00	Silicon	Replaceable by 2N2925

Resistors

Ckt. No.	Tektronix Part No.	Description			S/N	Range
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R1	321-0161-00	464 Ω	$\frac{1}{8}$ W	Prec	1%	
R4C	322-0621-00	900 k Ω	$\frac{1}{4}$ W	Prec	1%	
R4D	321-0617-00	111 k Ω	$\frac{1}{8}$ W	Prec	1%	
R5C	322-0624-00	990 k Ω	$\frac{1}{4}$ W	Prec	1%	
R5D	321-0614-00	10.1 k Ω	$\frac{1}{8}$ W	Prec	1%	
R7	315-0470-00	47 Ω	$\frac{1}{4}$ W		5%	
R8C	322-0610-00	500 k Ω	$\frac{1}{4}$ W	Prec	1%	
R8D	322-0481-00	1 M Ω	$\frac{1}{4}$ W	Prec	1%	
R9C	322-0469-00	750 k Ω	$\frac{1}{4}$ W	Prec	1%	
R9D	321-0628-00	333 k Ω	$\frac{1}{8}$ W	Prec	1%	
R15	322-0624-00	990 k Ω	$\frac{1}{4}$ W	Prec	1%	
R16	321-0289-00	10 k Ω	$\frac{1}{8}$ W	Prec	1%	
R18	315-0105-00	1 M Ω	$\frac{1}{4}$ W		5%	
R19	315-0101-00	100 Ω	$\frac{1}{4}$ W		5%	
R21	315-0823-00	82 k Ω	$\frac{1}{4}$ W		5%	
R23	315-0101-00	100 Ω	$\frac{1}{4}$ W		5%	
R25	323-0373-00	75 k Ω	$\frac{1}{2}$ W	Prec	1%	
R26	322-0356-00	49.9 k Ω	$\frac{1}{4}$ W	Prec	1%	
R28	315-0334-00	330 k Ω	$\frac{1}{4}$ W		5%	
R30	315-0101-00	100 Ω	$\frac{1}{4}$ W		5%	
R31	315-0393-00	39 k Ω	$\frac{1}{4}$ W		5%	
R33	315-0472-00	4.7 k Ω	$\frac{1}{4}$ W		5%	
R34	315-0153-00	15 k Ω	$\frac{1}{4}$ W		5%	
R35	311-0656-00	5 k Ω		Var		
R36	315-0222-00	2.2 k Ω	$\frac{1}{4}$ W		5%	
R38	315-0223-00	22 k Ω	$\frac{1}{4}$ W		5%	
R39	315-0474-00	470 k Ω	$\frac{1}{4}$ W		5%	
R40	321-0215-00	1.69 k Ω	$\frac{1}{8}$ W	Prec	1%	
R41	321-0172-00	604 Ω	$\frac{1}{8}$ W	Prec	1%	100-429
R41	321-0173-00	619 Ω	$\frac{1}{8}$ W	Prec	1%	430-up
R43	321-0260-00	4.99 k Ω	$\frac{1}{8}$ W	Prec	1%	
R44	321-0260-00	4.99 k Ω	$\frac{1}{8}$ W	Prec	1%	
R45	315-0201-00	200 Ω	$\frac{1}{4}$ W		5%	
R46	315-0104-00	100 k Ω	$\frac{1}{4}$ W		5%	
R48	308-0351-00	4.87 k Ω	3 W	WW	1%	
R49	315-0101-00	100 Ω	$\frac{1}{4}$ W		5%	
R51	321-0167-00	536 Ω	$\frac{1}{8}$ W	Prec	1%	
R52	321-0193-00	1 k Ω	$\frac{1}{8}$ W	Prec	1%	
R54	315-0103-00	10 k Ω	$\frac{1}{4}$ W		5%	
R60	321-0161-00	464 Ω	$\frac{1}{8}$ W	Prec	1%	

100-429
430-up

Electrical Parts List—Type 1L5

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R64	321-0225-00	2.15 kΩ	1/8 W
R70	315-0332-00	3.3 kΩ	1/4 W
R74	315-0101-00	100 Ω	1/4 W
R80	321-0161-00	464 Ω	1/8 W
R81	321-0158-00	432 Ω	1/8 W
R84	321-0158-00	432 Ω	1/8 W
R85	311-0433-00	100 Ω	1/4 W
R86	321-0161-00	464 Ω	1/8 W
R90	315-0561-00	560 Ω	1/4 W
R91	315-0222-00	2.2 kΩ	1/4 W
R94	315-0222-00	2.2 kΩ	1/4 W
R96	315-0102-00	1 kΩ	1/4 W
R101	315-0105-00	1 MΩ	1/4 W
R102	311-0636-00	25 kΩ	1/4 W
R103	308-0412-00	8.2 kΩ	3 W
R105	321-0327-00	24.9 kΩ	1/8 W
R106	322-0356-00	49.9 kΩ	1/4 W
R107	322-0385-00	100 kΩ	1/4 W
R108	311-0467-00	100 kΩ	1/4 W
R109	321-0180-00	732 Ω	1/8 W
R110	311-0169-00	100 Ω	1/4 W
R111	321-0149-00	348 Ω	1/8 W
R113	311-0656-00	5 kΩ	1/4 W
R114	311-0310-00	5 kΩ	1/4 W
R115	321-0101-00	110 Ω	1/8 W
R116A	321-0285-00	9.09 kΩ	1/8 W
R116B	321-0189-00	909 Ω	1/8 W
R116C	321-0166-00	523 Ω	1/8 W
R116D	321-0146-00	324 Ω	1/8 W
R116E	321-0097-00	100 Ω	1/8 W
R116F	321-0068-00	49.9 Ω	1/8 W
R116G	321-0047-00	30.1 Ω	1/8 W
R116H	321-0001-00	10 Ω	1/8 W
R116I	321-0001-00	10 Ω	1/8 W
R118	321-0289-00	10 kΩ	1/8 W
R119	322-0481-00	1 MΩ	1/4 W
R120	311-0467-00	100 kΩ	1/4 W
R120	311-0686-00	100 kΩ	1/4 W
R121	321-0452-00	499 kΩ	1/8 W
R121	321-0618-00	250 kΩ	1/8 W
R122	321-0323-00	22.6 kΩ	1/8 W
R122	321-0354-00	47.5 kΩ	1/8 W
R124	315-0101-00	100 Ω	1/4 W
R125	315-0223-00	22 kΩ	1/4 W
R125	321-0338-00	32.4 kΩ	1/8 W

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description				S/N Range
R126	321-0435-00	332 k Ω	$\frac{1}{8}$ W	Prec	1%	
R127	321-0193-00	1 k Ω	$\frac{1}{8}$ W	Prec	1%	100-187
R127	Selected					188-809
R127	321-0172-00	604 Ω		Selected (nominal value)		810-up
R128	311-0463-00	5 k Ω		Var		100-809
R128	311-0480-00	500 Ω		Var		810-up
R129	321-0452-00	499 k Ω	$\frac{1}{8}$ W	Prec	1%	
R130	315-0101-00	100 Ω	$\frac{1}{4}$ W		5%	
R132	321-0339-00	33.2 k Ω	$\frac{1}{8}$ W	Prec	1%	
R134	315-0103-00	10 k Ω	$\frac{1}{4}$ W		5%	
R135	321-0435-00	332 k Ω	$\frac{1}{8}$ W	Prec	1%	100-323X
R137	311-0462-00	1 k Ω		Var		X880-up
R138	321-0158-00	432 Ω	$\frac{1}{8}$ W	Prec	1%	100-323
R138	321-0197-00	1.1 k Ω	$\frac{1}{8}$ W	Prec	1%	324-678
R138	321-0197-00	1.1 k Ω		Selected (nominal value)		679-879
R138	321-0162-00	475 Ω	$\frac{1}{8}$ W	Prec	1%	880-up
R140	323-0485-00	1.1 M Ω	$\frac{1}{2}$ W	Prec	1%	
R141	321-0385-00	100 k Ω	$\frac{1}{8}$ W	Prec	1%	
R142	315-0103-00	10 k Ω	$\frac{1}{4}$ W		5%	
R143	321-0385-00	100 k Ω	$\frac{1}{8}$ W	Prec	1%	
R144	323-0498-00	1.5 M Ω	$\frac{1}{2}$ W	Prec	1%	
R146	321-0147-00	332 Ω	$\frac{1}{8}$ W	Prec	1%	
R147	321-0147-00	332 Ω	$\frac{1}{8}$ W	Prec	1%	
R148	322-0469-00	750 k Ω	$\frac{1}{4}$ W	Prec	1%	
R150	311-0465-00	100 k Ω		Var		
R151	323-0459-00	590 k Ω	$\frac{1}{2}$ W	Prec	1%	
R153	322-0068-00	49.9 Ω	$\frac{1}{4}$ W	Prec	1%	
R155	321-0260-00	4.99 k Ω	$\frac{1}{8}$ W	Prec	1%	
R156	311-0480-00	500 Ω		Var		
R157	321-0260-00	4.99 k Ω	$\frac{1}{8}$ W	Prec	1%	
R158	322-0068-00	49.9 Ω	$\frac{1}{4}$ W	Prec	1%	
R160	301-0224-00	220 k Ω	$\frac{1}{2}$ W		5%	100-323
R160	301-0684-00	680 k Ω	$\frac{1}{2}$ W		5%	324-up
R161	315-0273-00	27 k Ω	$\frac{1}{4}$ W		5%	100-323
R161	315-0154-00	150 k Ω	$\frac{1}{4}$ W		5%	324-up
R162	315-0473-00	47 k Ω	$\frac{1}{4}$ W		5%	100-323X
R165	315-0103-00	10 k Ω	$\frac{1}{4}$ W		5%	
R166	315-0151-00	150 Ω	$\frac{1}{4}$ W		5%	100-323X
R168	315-0101-00	100 Ω	$\frac{1}{4}$ W		5%	
R169	315-0472-00	4.7 k Ω	$\frac{1}{4}$ W		5%	100-323
R169	315-0103-00	10 k Ω	$\frac{1}{4}$ W		5%	324-up
R170	315-0272-00	2.7 k Ω	$\frac{1}{4}$ W		5%	
R171	315-0471-00	470 Ω	$\frac{1}{4}$ W		5%	100-323
R171	315-0102-00	1 k Ω	$\frac{1}{4}$ W		5%	324-up
R173	315-0102-00	1 k Ω	$\frac{1}{4}$ W		5%	
R174	315-0471-00	470 Ω	$\frac{1}{4}$ W		5%	
R176	315-0101-00	100 Ω	$\frac{1}{4}$ W		5%	
R178	315-0182-00	1.8 k Ω	$\frac{1}{4}$ W		5%	
R184	315-0100-00	10 Ω	$\frac{1}{4}$ W		5%	

Electrical Parts List—Type 1L5

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R194	Selected		100-323X
R195	315-0681-00	680 Ω	5%
R197	315-0102-00	1 k Ω	5%
R200	315-0221-00	220 Ω	5%
R204	315-0222-00	2.2 k Ω	5%
R208	315-0151-00	150 Ω	5%
R210	315-0104-00	100 k Ω	5%
R212	321-0281-00	8.25 k Ω	Prec 1%
R213	324-0369-00	68.1 k Ω	Prec 1%
R214	311-0480-00	500 Ω	Var
R215	321-0218-00	1.82 k Ω	Prec 1%
R215	321-0210-00	1.5 k Ω	Prec 1%
R217	321-0289-00	10 k Ω	Prec 1%
R218	317-0111-00	110 Ω	5%
R220	317-0111-00	110 Ω	5%
R230	308-0313-00	20 k Ω	3 W WW 1%
R232	311-0443-00	2.5 k Ω	Var WW 1%
R235A	321-0155-00	402 Ω	Prec 1%
thru K (11)			
R236A	322-0222-00	2 k Ω	Prec 1%
thru K (11)			
R237	308-0412-00	8.2 k Ω	3 W WW 1%
R238	311-0655-00	1 k Ω	Var WW 1%
R239	311-0443-00	2.5 k Ω	Var WW 1%
R240A	321-0088-00	80.6 Ω	Prec 1%
thru J (10)			
R241A	321-0155-00	402 Ω	Prec 1%
thru J (10)			
R245	301-0474-00	470 k Ω	5%
R270	315-0102-00	1 k Ω	5%
R273	315-0100-00	10 Ω	5%
R273	316-0102-00	1 k Ω	5%
R275	315-0100-00	10 Ω	5%
R275	316-0102-00	1 k Ω	5%
R280	315-0103-00	10 k Ω	5%
R284	315-0101-00	100 Ω	5%
R286	315-0223-00	22 k Ω	5%
R292	315-0101-00	100 Ω	5%
R294	315-0103-00	10 k Ω	5%
R295	315-0472-00	4.7 k Ω	5%
R297	315-0681-00	680 Ω	5%
R303	315-0101-00	100 Ω	5%
R306	315-0103-00	10 k Ω	5%
R311	315-0682-00	6.8 k Ω	5%
R312	315-0222-00	2.2 k Ω	5%
R314	315-0222-00	2.2 k Ω	5%
R314	315-0302-00	3 k Ω	5%
R316	311-0485-00	250 Ω	Var
R316	311-0486-00	500 Ω	Var

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R318	315-0222-00	2.2 k Ω 1/4 W	5% 100-199
R318	315-0102-00	1 k Ω 1/4 W	5% 200-up
R320	315-0103-00	10 k Ω 1/4 W	5% 100-199
R320	315-0682-00	6.8 k Ω 1/4 W	5% 200-up
R321	315-0222-00	2.2 k Ω 1/4 W	5%
R323	315-0471-00	470 Ω 1/4 W	5%
R325	315-0471-00	470 Ω 1/4 W	5%
R327	315-0472-00	4.7 k Ω 1/4 W	5%
R329	301-0104-00	100 k Ω 1/2 W	5%
R330	315-0470-00	47 Ω 1/4 W	5%
R332	315-0471-00	470 Ω 1/4 W	5%
R334	305-0223-00	22 k Ω 2 W	5%
R335A	315-0472-00	4.7 k Ω 1/4 W	5%
R335B	315-0222-00	2.2 k Ω 1/4 W	5%
R335C	315-0102-00	1 k Ω 1/4 W	5%
R335D	315-0331-00	330 Ω 1/4 W	5%
R335E	315-0101-00	100 Ω 1/4 W	5%
R335F	315-0470-00	47 Ω 1/4 W	5%
R335G	315-0100-00	10 Ω 1/4 W	5%
R336	315-0103-00	10 k Ω 1/4 W	5% 100-153
R336	321-0289-00	10 k Ω 1/8 W	Prec 1% 154-up
R338	315-0103-00	10 k Ω 1/4 W	5%
R339	315-0222-00	2.2 k Ω 1/4 W	5%
R342	315-0102-00	1 k Ω 1/4 W	5%
R343	315-0471-00	470 Ω 1/4 W	5%
R345	315-0471-00	470 Ω 1/4 W	5%
R347	315-0472-00	4.7 k Ω 1/4 W	5%
R349	301-0104-00	100 k Ω 1/2 W	5%
R350	315-0271-00	270 Ω 1/4 W	5%
R352	315-0471-00	470 Ω 1/4 W	5%
R354	305-0223-00	22 k Ω 2 W	5%
R355A	315-0472-00	4.7 k Ω 1/4 W	5%
R355B	315-0222-00	2.2 k Ω 1/4 W	5%
R355C	315-0102-00	1 k Ω 1/4 W	5%
R355D	315-0331-00	330 Ω 1/4 W	5%
R355E	315-0101-00	100 Ω 1/4 W	5%
R355F	315-0470-00	47 Ω 1/4 W	5%
R355G	315-0100-00	10 Ω 1/4 W	5%
R356	315-0103-00	10 k Ω 1/4 W	5% 100-153
R356	321-0289-00	10 k Ω 1/8 W	Prec 1% 154-up
R360	317-0473-00	47 k Ω 1/8 W	5% X1160-1299X
R400	315-0103-00	10 k Ω 1/4 W	5% 100-1299
R400	315-0242-00	2.4 k Ω 1/4 W	5% 1300-up
R401	315-0224-00	220 k Ω 1/4 W	5% 100-1299
R401	315-0334-00	330 k Ω 1/4 W	5% 1300-up
R402	315-0224-00	220 k Ω 1/4 W	5% 100-1299
R402	315-0334-00	330 k Ω 1/4 W	5% 1300-up
R404	301-0333-00	33 k Ω 1/2 W	5%
R405	315-0472-00	4.7 k Ω 1/4 W	5% 100-1159
R405	315-0392-00	3.9 k Ω 1/4 W	5% 1160-up

Electrical Parts List—Type 1L5

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R406	315-0105-00	1 MΩ	5%
R408	315-0101-00	100 Ω	5%
R409	315-0103-00	10 kΩ	5%
R411	315-0334-00	330 kΩ	5%
R412	315-0754-00	750 kΩ	5%
R413	308-0428-00	20 kΩ	1% WW
R416	315-0621-00	620 Ω	5% 100-199
R416	315-0621-00	620 Ω	Selected (nominal value) 200-up
R417	315-0105-00	1 MΩ	5%
R418	316-0106-00	10 MΩ	5% 100-199
R418	316-0685-00	6.8 MΩ	Selected (nominal value) 200-804
R418	315-0335-00	3.3 MΩ	5% 805-up
R420	311-0552-00	1 MΩ	Var X805-up
R421	316-0106-00	10 MΩ	5%
R422	311-0637-00	2.5 MΩ	Var 5%
R423	315-0224-00	220 kΩ	5%
R425	315-0102-00	1 kΩ	5%
R426	315-0154-00	150 kΩ	5%
R428	311-0496-00	2.5 kΩ	Var
R429	317-0107-00	100 MΩ	5%
R430	323-0330-00	26.7 kΩ	1% Prec
R432	315-0223-00	22 kΩ	Selected (nominal value) 100-809
R432	315-0163-00	16 kΩ	Selected (nominal value) 810-1299
R432	315-0203-00	20 kΩ	Selected (nominal value) 1300-up
R433	315-0105-00	1 MΩ	5%
R435	315-0102-00	1 kΩ	5%
R436	311-0546-00	10 kΩ	Var
R438	321-0289-00	10 kΩ	1% Prec
R440	301-0392-00	3.9 kΩ	5%
R441	315-0102-00	1 kΩ	5%
R442	311-0091-00	1 kΩ	Var
R444	303-0103-00	10 kΩ	5%
R446	315-0102-00	1 kΩ	5%
R450	323-0419-00	226 kΩ	1% Prec
R452	321-0289-00	10 kΩ	1% Prec
R455	315-0103-00	10 kΩ	5%
R459	308-0352-00	425 Ω	1% WW
R460	321-0289-00	10 kΩ	1% Prec
R462	321-0283-00	8.66 kΩ	1% Prec
R465	301-0154-00	150 kΩ	5%
R469	308-0234-00	5 kΩ	5% WW
R470	315-0154-00	150 kΩ	5%
R472	315-0101-00	100 Ω	5%
R474	315-0101-00	100 Ω	5%
R500	321-0288-00	9.76 kΩ	1% Prec
R501	321-0282-00	8.45 kΩ	1% Prec
R502	311-0496-00	2.5 kΩ	Var
R504	321-0193-00	1 kΩ	1% Prec
R506	315-0333-00	33 kΩ	5%

Resistors (Cont)

Crt. No.	Tektronix Part No.	Description			S/N Range	
R508	315-0103-00	10 k Ω	$\frac{1}{4}$ W			5%
R510	315-0562-00	5.6 k Ω	$\frac{1}{4}$ W			5%
R513	321-0228-00	2.32 k Ω	$\frac{1}{8}$ W		Prec	1%
R516	315-0102-00	1 k Ω	$\frac{1}{4}$ W			5%
R518	315-0222-00	2.2 k Ω	$\frac{1}{4}$ W			5%
R520	321-0289-00	10 k Ω	$\frac{1}{8}$ W		Prec	1%
R522	311-0480-00	500 Ω		Var		
R524	321-0385-00	100 k Ω	$\frac{1}{8}$ W		Prec	1%
R526	315-0103-00	10 k Ω	$\frac{1}{4}$ W			5%

Switches

	Unwired	Wired			
SW1	260-0621-00		Lever	AC-GND-AC FAST	100-2399
SW1	260-1168-00		Lever	AC-GND-AC FAST	2400-up
SW5	260-0809-00	*262-0784-00	Slide	VOLTS/CM	
SW10	260-0723-00		Slide	VOLTS/CM $\div$ 100	
SW75	260-0807-00		Lever	VERTICAL DISPLAY	
SW101	260-0583-00		Slide	100 V 150 V SAWTOOTH	
SW105	260-0808-00		Lever	SWEEP MODE	
SW115	260-0814-00	*262-0783-00	Rotary	DISPERSION Hz/CM	
SW120	260-0810-00	*262-0786-00	Rotary	CENTER FREQUENCY Hz (Multiplier)	
SW235A } SW235B }		*262-0785-00	Rotary	(Units) CENTER FREQUENCY Hz (Tens)	

Transformers

T80	*120-0459-00	Toroid	10 turns, bifilar	
T90	*120-0459-00	Toroid	10 turns, bifilar	
T180	*120-0459-00	Toroid	10 turns, bifilar	
T190	*120-0458-00	Toroid	3 windings	
T290	*114-0223-00		6-12 μ H Var	Core 276-0506-00

Crystals

Y135	119-0103-00	Discriminator	2.9925 MHz	100-323
Y135	*119-0103-01	Discriminator	2.9925 MHz	324-up
Y297	158-0026-00		3.1 MHz	
Y325	158-0022-00		100 kHz	
Y345	158-0022-00		100 kHz	

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
 Detail Part of Assembly and/or Component
 mounting hardware for Detail Part
 Parts of Detail Part
 mounting hardware for Parts of Detail Part
 mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

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.

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS

(Located behind diagrams)

FIG. 1 FRONT

FIG. 2 CHASSIS and REAR

FIG. 3 ACCESSORIES

SECTION 8

MECHANICAL PARTS LIST

FIG. 1 FRONT

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q t y	1	2	3	4	5	Description
1-1	366-0166-00			1						KNOB, charcoal—CENTER FREQUENCY-Hz (UNITS)
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-2	366-0169-00			1						KNOB, charcoal—CENTER FREQUENCY-Hz (TENS)
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-3	262-0785-00			1						SWITCH, wired—CENTER FREQUENCY-Hz (TENS)
	- - - - -			-						switch includes:
	- - - - -			1						SWITCH, unwired
-4	- - - - -			6						BOARD, circuit
	- - - - -			-						mounting hardware: (not included w/switch)
-5	210-0419-00			1						NUT, hex., shouldered, 3/8-32 x 0.500 inch
-6	407-0286-00			1						BRACKET, switch mounting
	- - - - -			-						mounting hardware: (not included w/bracket)
-7	210-0994-00			1						WASHER, flat, 0.125 ID x 0.250 inch OD
-8	211-0008-00			2						SCREW, 4-40 x 1/4 inch, PHS
-9	210-0001-00			2						LOCKWASHER, internal, #2
-10	210-0405-00			2						NUT, hex., 2-56 x 3/16 inch
-11	366-0369-00			1						KNOB, red—CAL—VARIABLE
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-12	366-0370-01			1						KNOB, charcoal—MULTIPLIER
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-13	262-0786-00			1						SWITCH, wired—MULTIPLIER
	- - - - -			-						switch includes:
	260-0810-00			1						SWITCH, unwired
-14	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-15	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-16	210-0046-00			1						LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
-17	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-18	376-0050-00			1						ASSEMBLY, coupling
	- - - - -			-						assembly includes:
	213-0022-00			4						SCREW, set, 4-40 x 3/16 inch, HSS
-19	354-0251-00			2						RING, coupling
-20	376-0046-00			1						COUPLING, plastic, 0.375 x 0.424 inch
-21	384-0418-00			1						SHAFT, extension
	- - - - -			-						mounting hardware: (not included w/switch)
-22	210-0419-00			1						NUT, hex., shouldered, 3/8-32 x 0.500 inch
-23	406-0757-01	100	359	1						BRACKET, spacer
	406-0757-00	360		1						BRACKET, spacer
-24	200-0374-00	100	929	1						COVER, dial
	200-0368-01	930		1						COVER, dial
	- - - - -			-						mounting hardware: (not included w/cover)
-25	211-0541-00			2						SCREW, 6-32 x 1/4 inch, 100° csk, FHS

FIG. 1 FRONT (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q t y	1	2	3	4	5	Description
1-26	366-0215-01			1						KNOB, charcoal—VERTICAL DISPLAY
-27	260-0807-00			1						SWITCH, lever—VERTICAL DISPLAY
	- - - - -			-						mounting hardware: (not included w/switch)
-28	220-0413-00			2						NUT, hex., $\frac{3}{16}$ x 0.562 inch long
-29	366-0215-01			1						KNOB, charcoal—AC GND AC FAST
-30	260-0621-00	100	2399	1						SWITCH, lever—AC GND AC FAST
	260-1168-00	2400		1						SWITCH, lever—AC GND AC FAST
	- - - - -			-						mounting hardware: (not included w/switch)
-31	220-0413-00			2						NUT, hex., $\frac{3}{16}$ x 0.562 inch long
-32	366-0365-02			1						KNOB, red—VARIABLE-CAL
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x $\frac{3}{16}$ inch, HSS
-33	366-0322-00			1						KNOB, charcoal—VOLTS/CM
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x $\frac{3}{16}$ inch, HSS
-34	262-0784-00			1						SWITCH, wired—VOLTS/CM
	- - - - -			-						switch includes:
	260-0809-00			1						SWITCH, unwired
-35	386-1107-00			1						PLATE
-36	131-0344-00			8						CONNECTOR, feed thru
	- - - - -			-						mounting hardware for each: (not included w/connector)
-37	358-0241-00			1						BUSHING, plastic
-38	- - - - -			9						CAPACITOR
	- - - - -			-						mounting hardware for each: (not included w/capacitor)
-39	214-0456-00			1						FASTENER, plastic
-40	348-0031-00			1						GROMMET, plastic, $\frac{3}{32}$ inch diameter
-41	441-0686-00			1						CHASSIS
	- - - - -			-						mounting hardware: (not included w/chassis)
-42	210-0001-00			2						LOCKWASHER, internal, #2
-43	210-0405-00			2						NUT, hex., 2-56 x $\frac{3}{16}$ inch
-44	131-0371-00			6						CONNECTOR, single contact
-45	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-46	210-0583-00			2						NUT, hex., $\frac{1}{4}$ -32 x $\frac{5}{16}$ inch
-47	210-0046-00			1						LOCKWASHER, internal, $\frac{1}{4}$ ID x 0.400 inch OD
-48	214-0813-00			1						ACTUATOR, disk

FIG. 1 FRONT (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q						Description
				t	Y	1	2	3	4	
1-49	376-0065-00			1						ASSEMBLY, coupling
	- - - - -			-						assembly includes:
-50	354-0251-00			2						RING, coupling
-51	213-0048-00			4						SCREW, set, 4-40 x 1/8 inch, HSS
-52	376-0064-00			2						COUPLING, shaft
-53	384-0654-00			1						SHAFT, extension
	- - - - -			-						mounting hardware: (not included w/switch)
-54	211-0008-00			2						SCREW, 4-40 x 1/4 inch, PHS
-55	210-0801-00			2						WASHER, flat, 0.140 ID x 0.281 inch OD
	210-0586-00			2						NUT, keps, 4-40 x 1/4 inch (not shown)
-56	210-0012-00			1						LOCKWASHER, internal, 3/8 x 1/2 inch OD
-57	210-0840-00			1						WASHER, flat, 0.390 ID x 9/16 inch OD
-58	210-0413-00			1						NUT, hex., 3/8-32 x 1/2 inch
-59	131-0371-00			3						CONNECTOR, single contact
	175-0426-00			1						ASSEMBLY, cable (OSC Out)
	- - - - -			-						assembly includes:
-60	131-0276-00			1						CONNECTOR, coaxial, 1 contact, BNC, w/hardware
-61	131-0371-00			2						CONNECTOR, single contact
-62	366-0153-00			1						KNOB, charcoal—POSITION
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-63	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-64	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD
-65	210-0583-00			1						NUT, hex., 1/2-32 x 5/16 inch
	210-0046-00	X770		1						LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
-66	366-0153-00			1						KNOB, charcoal—DISPERSION
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-67	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-68	210-0223-00			1						LUG, solder, 1/4 ID x 7/16 inch OD, SE
-69	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD
-70	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
	210-0046-00	X770		1						LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
-71	366-0236-00			1						KNOB, charcoal—SWEEP MODE
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-72	366-0215-01			1						KNOB, charcoal—MANUAL INT EXT INPUT
-73	260-0808-00			1						SWITCH, lever—MANUAL INT EXT INPUT
	- - - - -			-						mounting hardware: (not included w/switch)
-74	220-0413-00			2						NUT, hex., 3/16 x 0.562 inch long
-75	352-0084-00			1						HOLDER, neon light, 0.450 diameter x 0.650 inch long
-76	378-0541-00			1						FILTER, lens neon
-77	200-0609-00			1						CAP, lamp holder
-78	333-0939-01			1						PANEL, front
-79	386-1108-00			1						PLATE, subpanel front
	- - - - -			-						plate includes:
-80	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS

FIG. 1 FRONT (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q t y	1	2	3	4	5	Description
1-81	366-0295-00	100	389	1						KNOB, charcoal—COUPLED RESOLUTION
	366-0422-00	390	809	1						KNOB, charcoal—COUPLED RESOLUTION
	366-0422-01	810		1						KNOB, charcoal—COUPLED RESOLUTION
	- - - - -			-						knob includes:
	213-0048-00	100	389	1						SCREW, set, 4-40 x 1/8 inch, HSS
	213-0153-00	390		2						SCREW, set, 5-40 x 0.125 inch, HSS
-82	366-0296-00	100	389	1						KNOB, charcoal—DISPERSION Hz/CM
	366-0423-00	390		1						KNOB, charcoal—DISPERSION Hz/cm
	- - - - -			-						knob includes:
	213-0048-00	100	389	1						SCREW, set, 4-40 x 1/8 inch, HSS
	213-0153-00	390		2						SCREW, set, 5-40 x 0.125 inch, HSS
-83	262-0783-00			1						SWITCH, wired—DISPERSION Hz/CM
	- - - - -			-						switch includes:
	260-0814-00			1						SWITCH, unwired
	- - - - -			-						mounting hardware: (not included w/switch)
-84	210-0840-00			1						WASHER, flat, 0.390 ID x 7/16 inch OD
-85	210-0413-00			1						NUT, hex., 3/8-32 x 1/2 inch
-86	179-1102-00			1						CABLE HARNESS, switch
	- - - - -			-						cable harness includes:
	131-0371-00			9						CONNECTOR, single contact (not shown)
-87	366-0125-00			1						KNOB, gray, plug-in securing
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-88	210-0894-00			1						WASHER, plastic, 0.190 ID x 7/16 inch OD
-89	384-0510-00			1						ROD, securing
	- - - - -			-						rod includes:
-90	354-0025-00			1						RING, retaining
-91	136-0094-00			1						SOCKET
	- - - - -			-						mounting hardware: (not included w/socket)
	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD (not shown)
-92	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-93	136-0139-00			1						SOCKET, banana jack
	- - - - -			-						mounting hardware: (not included w/socket)
-94	210-0894-00			1						WASHER, plastic, 0.190 ID x 7/16 inch OD
-95	210-0465-00			2						NUT, hex., 1/4-32 x 3/8 x 3/16 inch
-96	210-0223-00			1						LUG, solder, 1/4 ID x 7/16 inch OD, SE
-97	131-0106-00			2						CONNECTOR, coaxial, 1 contact, BNC, w/hardware
	- - - - -			-						mounting hardware for each: (not included w/connector)
-98	210-0255-00			1						LUG, solder, 3/8 inch
-99	210-0202-00			1						LUG, solder, SE #6
	- - - - -			-						mounting hardware: (not included w/lug)
-100	210-0407-00			1						NUT, hex., 6-32 x 1/4 inch
-101	- - - - -			4						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
-102	210-0471-00			1						NUT, hex., 1/4-32 x 5/16 diameter x 1 1/32 inch long
-103	210-0223-00			1						LUG, solder, 1/4 ID x 7/16 inch OD, SE
-104	358-0054-00	100	719	1						BUSHING, banana jack
	358-0054-02	720		1						BUSHING, banana jack

FIG. 1 FRONT (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	1 2 3 4 5					Description
		Eff	Disc							
-105	- - - - -			3						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
-106	210-0471-00			1						NUT, hex., 1/4-32 x 5/16 diameter x 19/32 inch long
-107	358-0054-00	100	719	1						BUSHING, banana jack
	358-0054-02	720	2169	1						BUSHING, banana jack
	358-0054-00	2170		1						BUSHING, banana jack
-108	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-109	210-0471-00	100	323	1						NUT, hex., 1/4-32 x 5/16 diameter x 19/32 inch long
	220-0484-00	324		1						NUT, hex., 0.250-32 x 0.312 x 0.375 inch long
-110	210-0223-00			2						LUG, solder, 1/4 ID x 7/16 inch OD, SE
-111	358-0054-00	100	719	1						BUSHING, banana jack
	358-0054-00	720	2169	1						BUSHING, banana jack
	358-0054-00	2170		1						BUSHING, banana jack

FIG. 2 CHASSIS and REAR

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q t y	1	2	3	4	5	Description
2-1	670-0127-00			1						ASSEMBLY, circuit board—INPUT BOARD
	- - - - -			-						assembly includes:
	388-0765-00			1						BOARD, circuit
	- - - - -			-						board includes:
-2	214-0506-00			19						PIN, connector, straight
-3	136-0183-00			9						SOCKET, transistor, 3 pin
-4	136-0220-00			1						SOCKET, transistor, 3 pin
-5	260-0723-00			1						SWITCH, slide
	343-0159-00	X500		1						RETAINER, slide switch
	- - - - -			-						mounting hardware: (not included w/assembly)
-6	211-0116-00			6						SCREW, sems, 4-40 x 5/16 inch, PHB
-7	670-0128-00	100	1299	1						ASSEMBLY, circuit—VARIABLE RESOLUTION AMPLIFIER
	670-0128-01	1300		1						ASSEMBLY, circuit—VARIABLE RESOLUTION AMPLIFIER
	- - - - -			-						assembly includes:
	388-0764-00			1						BOARD, circuit
	- - - - -			-						board includes:
-8	214-0506-00			15						PIN, connector, straight
-9	136-0183-00			6						SOCKET, transistor, 3 pin
-10	352-0096-00			2						HOLDER, crystal
-11	136-0234-00			4						RECEPTACLE
	- - - - -			-						mounting hardware: (not included w/assembly)
-12	211-0116-00			5						SCREW, sems, 4-40 x 5/16 inch, PHB
-13	670-0129-00	100	322	1						ASSEMBLY, circuit board—DISCRIMINATOR & OUTPUT
	670-0129-01	323	1159	1						ASSEMBLY, circuit board—DISCRIMINATOR & OUTPUT
	670-0129-05	1160	1299	1						ASSEMBLY, circuit board—DISCRIMINATOR & OUTPUT
	670-0129-07	1300		1						ASSEMBLY, circuit board—DISCRIMINATOR & OUTPUT
	- - - - -			-						assembly includes:
	337-1000-00	X500		1						SHIELD
	388-0766-00			1						BOARD, circuit
	- - - - -			-						board includes:
-14	214-0506-00			68						PIN, connector, straight
-15	136-0183-00			19						SOCKET, transistor, 3 pin
-16	136-0235-00			2						SOCKET, transistor, 6 pin
-17	136-0220-00			1						SOCKET, transistor, 3 pin
-18	214-0565-00			2						FASTENER, pin
-19	214-0761-00			1						HEATSINK, transistor
	214-0693-00	X324		2						HEATSINK, transistor
-20	386-1106-00	100	322	1						PLATE, shield
	337-0944-00	323		1						SHIELD
-21	- - - - -			1						CRYSTAL, discriminator
	- - - - -			-						mounting hardware: (not included w/crystal)
-22	210-0849-00			2						WASHER, fiber, shouldered, #4
-23	210-0994-00			2						WASHER, flat, 0.125 ID x 0.250 inch OD
-24	210-0586-00			2						NUT, keps, 4-40 x 1/4 inch
	- - - - -			-						mounting hardware: (not included w/assembly)
-25	211-0116-00			8						SCREW, sems, 4-40 x 5/16 inch, PHB
	610-0480-00			1						ASSEMBLY, FILTER & MIXER
	- - - - -			-						assembly includes:
-26	136-0153-00			1						HOLDER, crystal
	- - - - -			-						mounting hardware: (not included w/holder)
-27	213-0055-00			1						SCREW, thread forming, 2-32 x 3/16 inch, PHS

FIG. 2 CHASSIS and REAR (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q t Y						Description
					1	2	3	4	5	
2-28	136-0218-00			2						SOCKET, transistor, 3 pin
	- - - - -			-						mounting hardware for each: (not included w/socket)
-29	354-0285-00			1						RING, socket mounting
-30	131-0157-00			2						CONNECTOR, terminal, standoff
-31	131-0161-00			2						CONNECTOR, terminal, feed thru
-32	131-0372-00			2						CONNECTOR, coaxial, 1 contact w/hardware
-33	352-0101-00			4						HOLDER, plastic
	- - - - -			-						mounting hardware for each: (not included w/holder)
-34	361-0008-00			1						SPACER, plastic, 0.281 inch long
-35	441-0692-00			1						CHASSIS, plug-in converter
	- - - - -			-						mounting hardware: (not included w/chassis)
-36	211-0005-00			4						SCREW, 4-40 x 1/8 inch, PHS
-37	441-0685-00			1						CHASSIS
-38	407-0269-00			1						BRACKET
-39	337-0867-00			1						SHIELD
	- - - - -			-						mounting hardware: (not included w/shield)
-40	211-0065-00			2						SCREW, 4-40 x 3/16 inch, PHS
-41	211-0008-00			2						SCREW, 4-40 x 1/4 inch, PHS
-42	386-1109-00			1						PLATE, rear
-43	131-0017-00			1						CONNECTOR, 16 contact
	- - - - -			-						mounting hardware: (not included w/connector)
-44	211-0008-00			2						SCREW, 4-40 x 1/4 inch, PHS
-45	210-0586-00			2						NUT, keps, 4-40 x 1/4 inch
-46	131-0227-00			5						CONNECTOR, terminal, stand off
	- - - - -			-						mounting hardware for each: (not included w/connector)
-47	358-0176-00			1						BUSHING, plastic
-48	260-0583-00			1						SWITCH, slide—SAWTOOTH 100V-150V
	- - - - -			-						mounting hardware: (not included w/switch)
-49	211-0022-00			2						SCREW, 2-56 x 3/16 inch, RHS
-50	210-0405-00			2						NUT, hex., 2-56 x 3/16 inch
-51	175-0423-00			1						ASSEMBLY, cable, 4 1/2 inch
	- - - - -			-						assembly includes:
-52	131-0371-00			2						CONNECTOR, single contact
-53	343-0081-00			1						CLAMP, black plastic, 3/16 inch
	- - - - -			-						mounting hardware: (not included w/clamp)
-54	210-0457-00			1						NUT, keps, 6-32 x 5/16 inch

FIG. 2 CHASSIS and REAR (Cont)

Fig. & Index 'ON	Tektronix Part No.	Serial/Model Eff	No. Disc	Q t y	1 2 3 4 5					Description
2-55	210-0202-00			1						LUG, solder, SE #6
	- - - - -			-						mounting hardware: (not included w/lug)
-56	211-0504-00			1						SCREW, 6-32 x 1/4 inch, PHS
-57	210-0407-00			1						NUT, hex., 6-32 x 1/4 inch
-58	441-0684-00			1						CHASSIS, main
	- - - - -			-						mounting hardware: (not included w/chassis)
-59	211-0504-00			3						SCREW, 6-32 x 1/4 inch, PHS
-60	211-0507-00			1						SCREW, 6-32 x 5/16 inch, PHS
-61	210-0457-00			5						NUT, keps, 6-32 x 5/16 inch
-62	- - - - -			1						RESISTOR
	- - - - -			-						mounting hardware: (not included w/resistor)
-63	212-0037-00			1						SCREW, 8-32 x 1 3/4 inches, FIL HS
-64	210-0008-00			1						LOCKWASHER, internal, #8
-65	210-0809-00	100	1279	1						WASHER, centering
	210-0808-00	1280		1						WASHER, centering
-66	210-0462-00			1						NUT, hex., 8-32 x 1/2 x 23/64 inch
-67	212-0004-00			1						SCREW, 8-32 x 5/16 inch, PHS
-68	348-0055-00			1						GROMMET, plastic, 1/4 inch diameter
-69	337-0866-00			1						SHIELD
	- - - - -			-						mounting hardware: (not included w/shield)
-70	211-0008-00			2						SCREW, 4-40 x 1/4 inch, PHS
-71	384-0631-00			4						ROD, spacer
	- - - - -			-						mounting hardware for each: (not included w/rod)
-72	212-0044-00			1						SCREW, 8-32 x 1/2 inch, RHS
-73	376-0063-00			1						COUPLER, slide switch to disk
	175-0386-00	100	323	1						ASSEMBLY, cable
	175-0386-01	324		1						ASSEMBLY, cable
	- - - - -			-						assembly includes:
-74	380-0049-00			1						HOUSING
-75	200-0482-00			1						COVER
-76	211-0513-00			2						SCREW, 6-32 x 5/8 inch, PHS
-77	210-0407-00			2						NUT, hex., 6-32 x 1/4 inch
-78	131-0371-00			4						CONNECTOR, single contact
	- - - - -			-						mounting hardware: (not included w/assembly)
-79	211-0017-00			3						SCREW, 4-40 x 3/4 inch, RHS

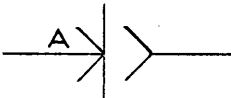
FIG. 2 CHASSIS and REAR (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
-80	179-1101-00			1						CABLE HARNESS, chassis
	- - - - -			-						cable harness includes:
	131-0371-00			74						CONNECTOR, single contact
-81	175-0424-00			1						ASSEMBLY, cable, 6 inch
	- - - - -			-						assembly includes:
	131-0371-00			2						CONNECTOR, single contact (not shown)

SECTION 9

DIAGRAMS

The following symbols are used on the diagrams:

	Screwdriver adjustment
	Front, side, or rear-panel control on connector
	Clockwise control rotation in direction of arrow
	Refer to indicated diagram
	Connection to circuit board made with pin connector at indicated pin
	Connection soldered to circuit board
	Blue line encloses components located on circuit board

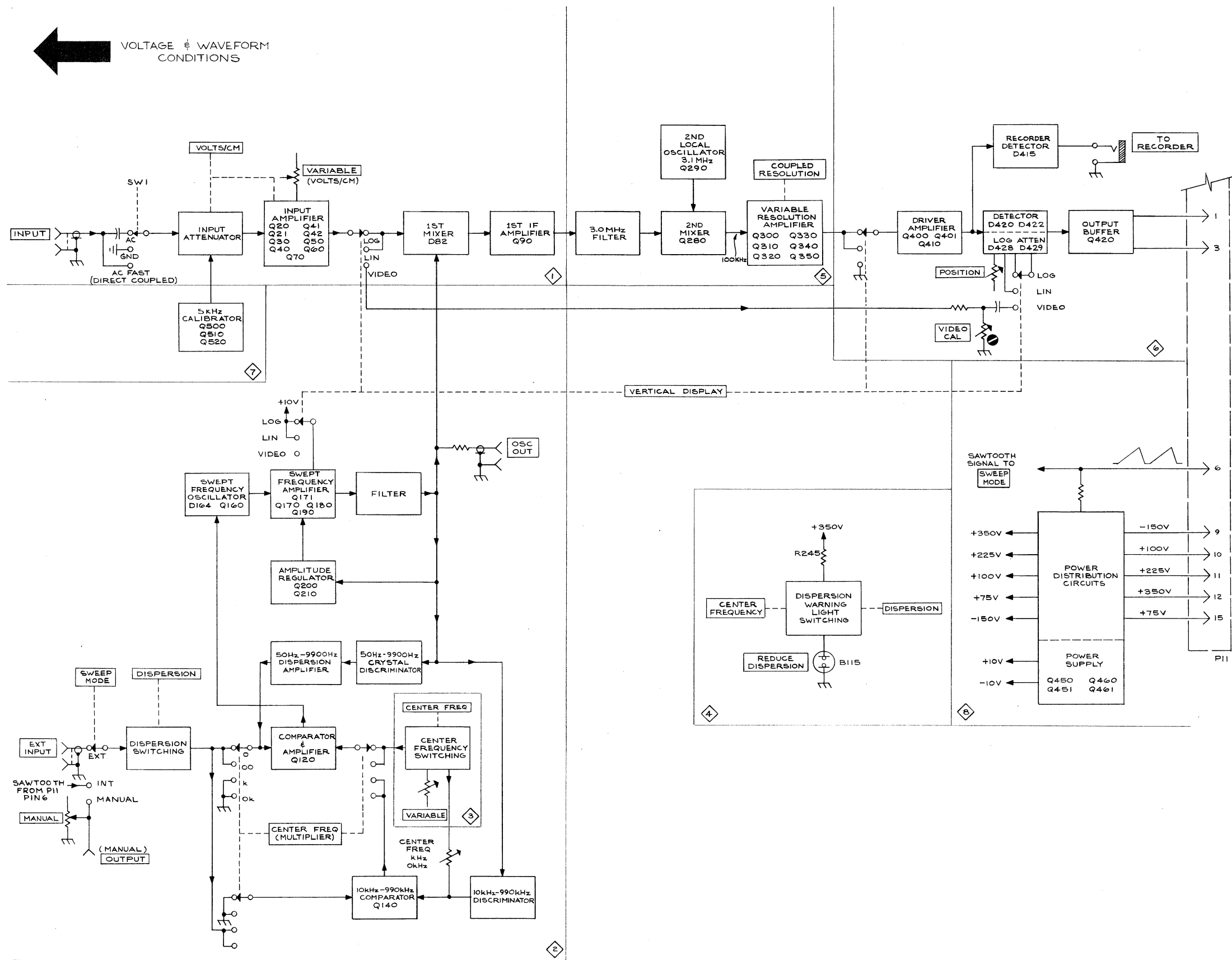
IMPORTANT

Circuit voltages were measured with a DC coupled oscilloscope. All readings are in volts with chassis ground as the reference unless otherwise noted on the diagram.

Waveforms shown are actual waveform photographs, taken with a Tektronix Oscilloscope Camera System mounted on a Type 545B Oscilloscope with a Type 1A1 vertical plug-in unit.

Voltages and waveforms on the schematics (shown in blue) are not absolute and may vary between instruments. Any apparent difference between voltage levels measured and those shown in the waveforms may be due to circuit loading of the measuring device.

The waveforms were obtained with the controls of the analyzer, plug-in oscilloscope and test oscilloscope as noted on each individual diagram.



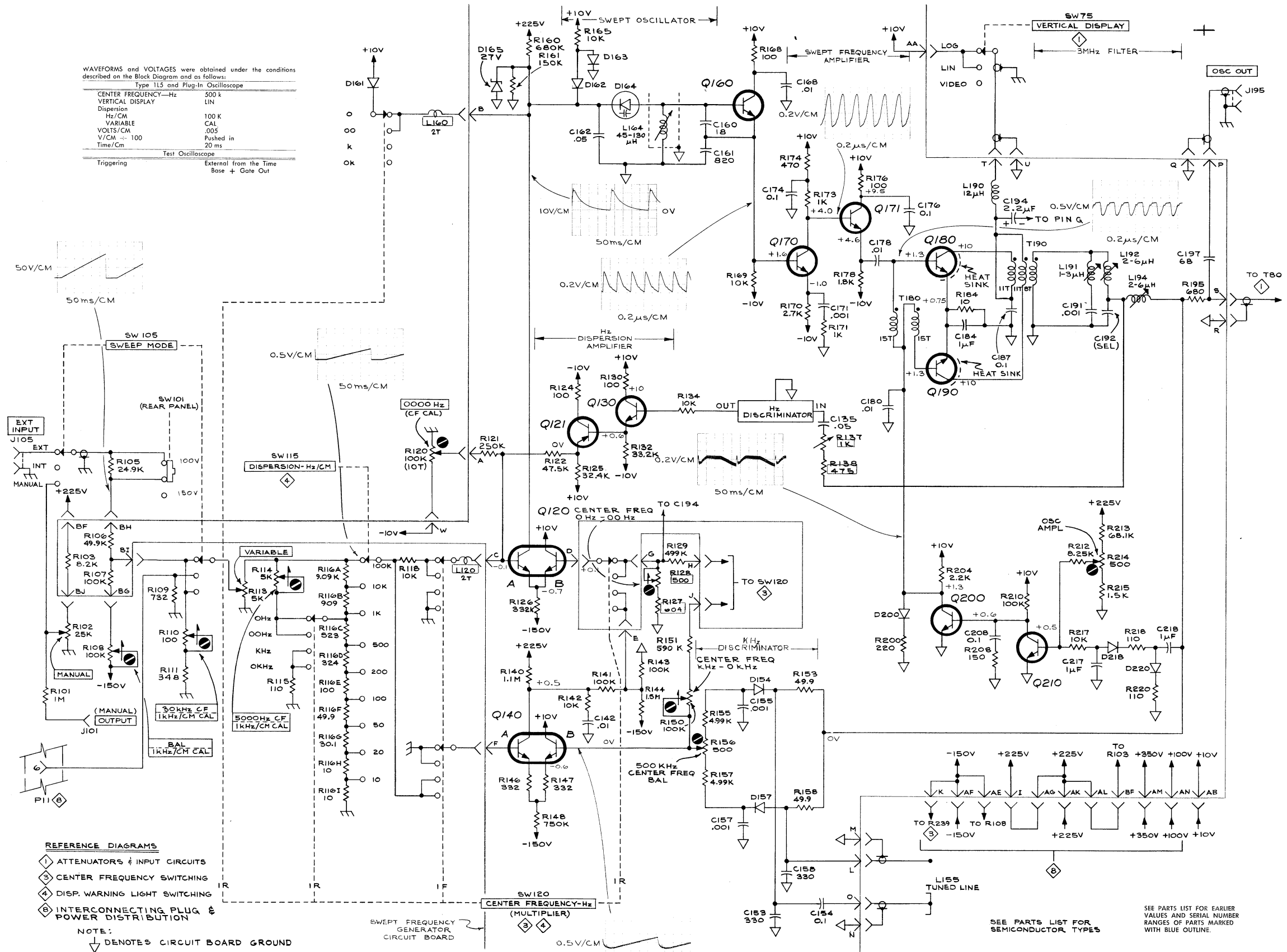
TYPE 1L5 SPECTRUM ANALYZER

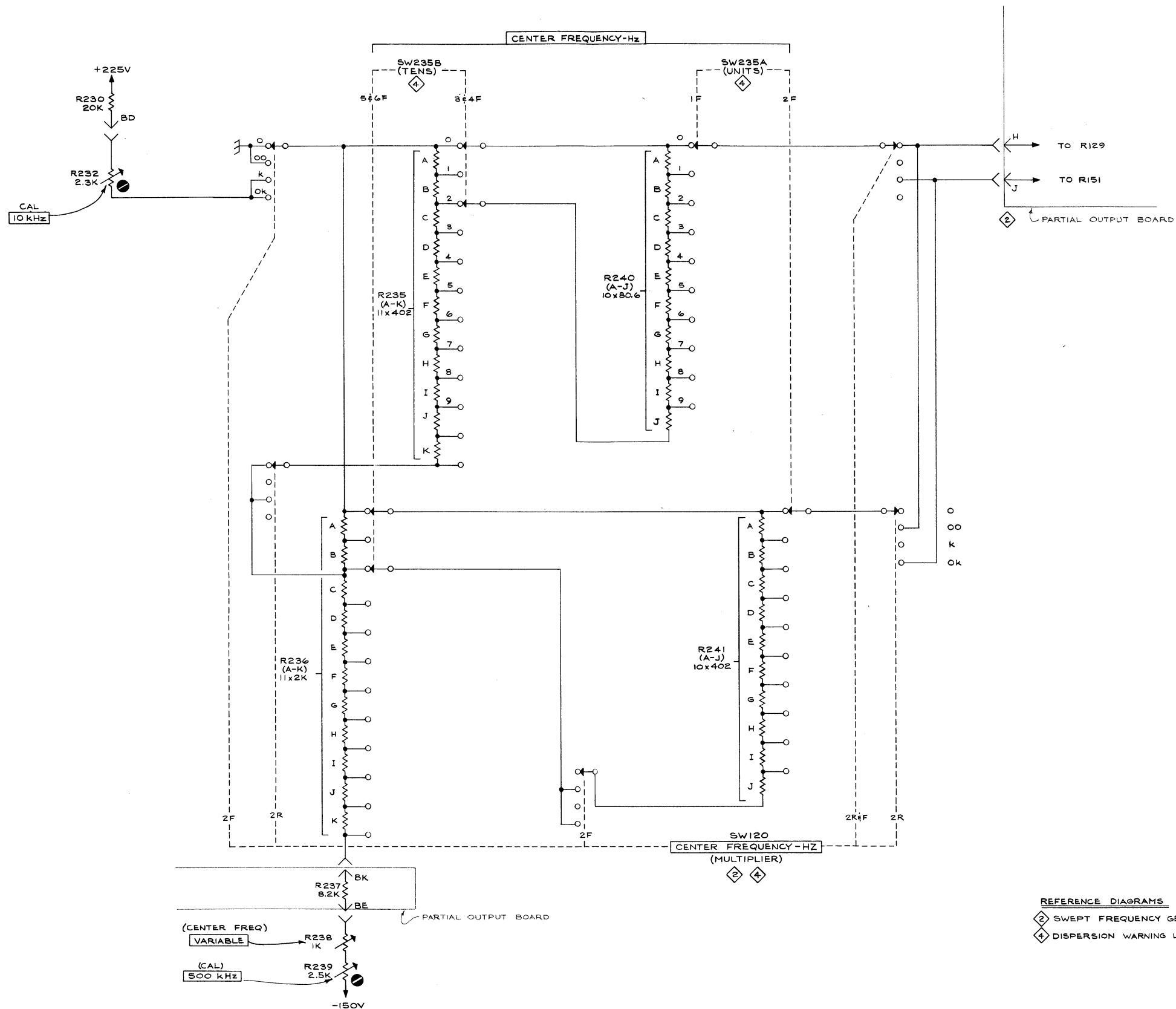
B₂

BLOCK DIAGRAM

WAVEFORMS and VOLTAGES were obtained under the conditions described on the Block Diagram and as follows:

Type 1L5 and Plug-In Oscilloscope	
CENTER FREQUENCY—Hz	500 k
VERTICAL DISPLAY	LIN
Dispersion	100 K
Hz/CM	CAL
VARIABLE	.005
VOLTS/CM	Pushed in
V/CM → 100	20 ms
Time/CM	20 ms
Test Oscilloscope	
Triggering	External from the Time Base + Gate Out





REFERENCE DIAGRAM
 ② SWEPT FREQUENCY GENERATOR
 ④ DISPERSION WARNING LIGHT SYSTEM

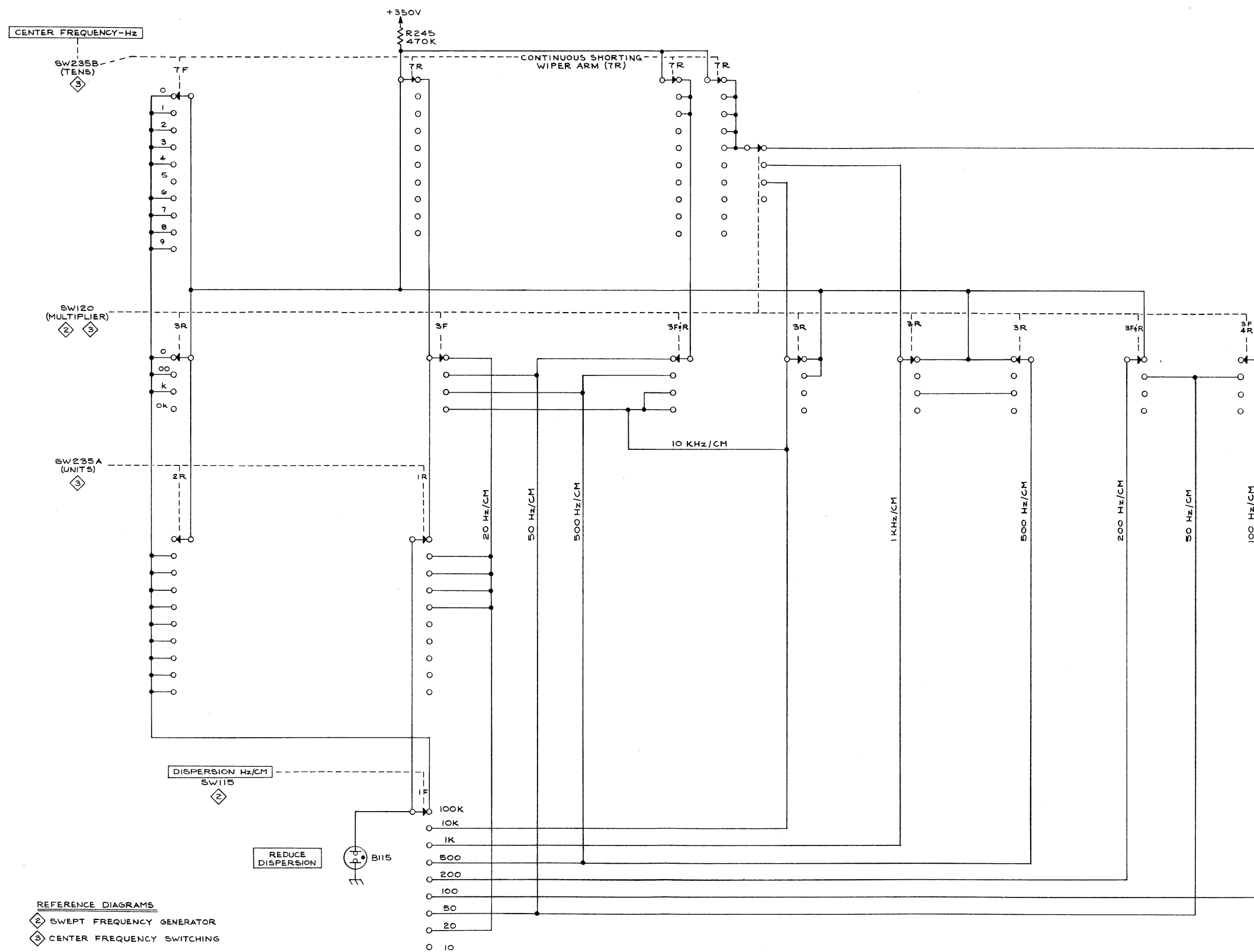
TYPE 1L5 SPECTRUM ANALYZER

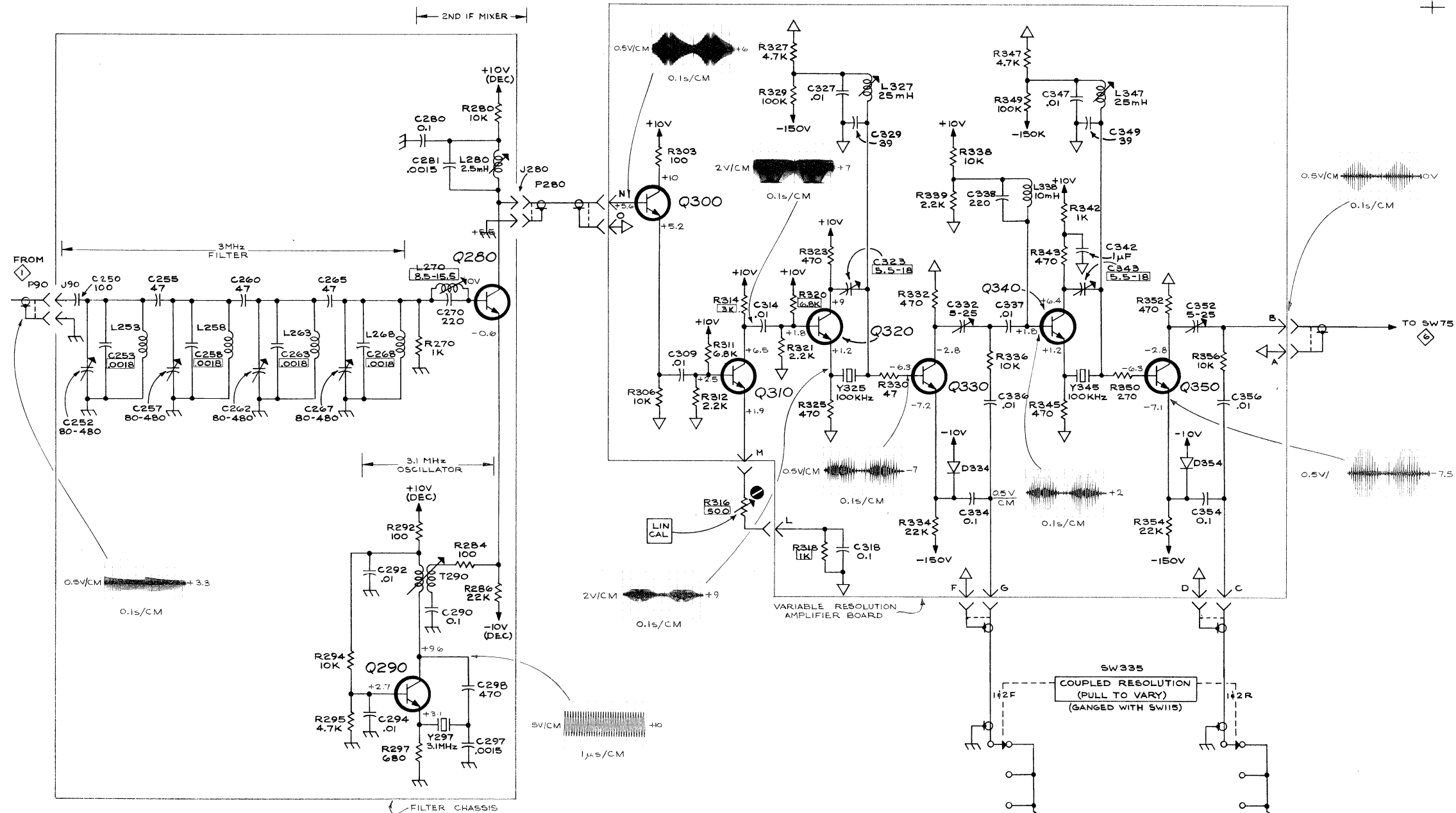
A₁

CENTER FREQUENCY SWITCHING ③

1266

3 CENTER FREQ SWITCHING





SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS

- ① ATTENUATORS & INPUT CIRCUITS
- ② OUTPUT AMPLIFIER

NOTE: DENOTES CIRCUIT BOARD GROUND

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE

WAVEFORMS and VOLTAGES were obtained under the conditions described on the Block Diagram and as follows:

Type 1L5 and Plug-In Oscilloscope	
CENTER FREQUENCY—Hz	500 k
VERTICAL DISPLAY	LIN
VOLTS/CM	CALIBRATE
V/CM	Pulled out
Hz/CM	100 K
Time/CM	50 ms
Triggering	External from the Time Base + Gate Out

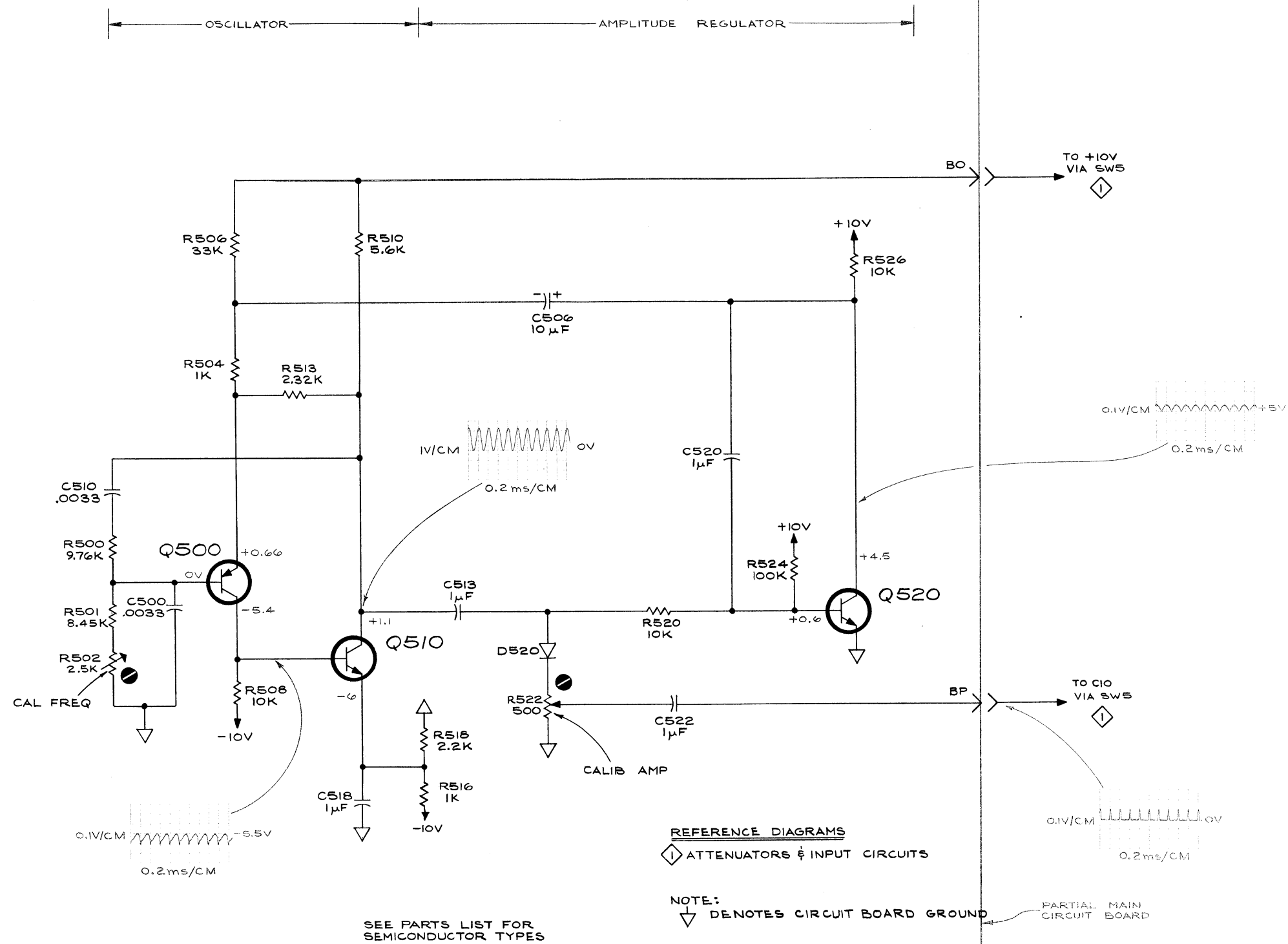
VARIABLE RESOLUTION AMPLIFIER ⑤

⑤ VAR RESOLUTION AMP



WAVEFORMS and VOLTAGES were obtained under the conditions described on the Block Diagram and as follows:

Type 1L5 and Plug-in Oscilloscope	
CENTER FREQUENCY—Hz	10 K
VERTICAL DISPLAY	LIN
VOLTS/CM	CALIBRATE
V/CM — 100	Pushed in
Hz/CM	10 K
Time/CM	50 ms
POSITION	Adjusted to center the trace.
Test Oscilloscope	
Triggering	External from the Time Base + Gate Out



TYPE 1L5 SPECTRUM ANALYZER

A₂

CALIBRATOR

1266

7 CALIBRATOR

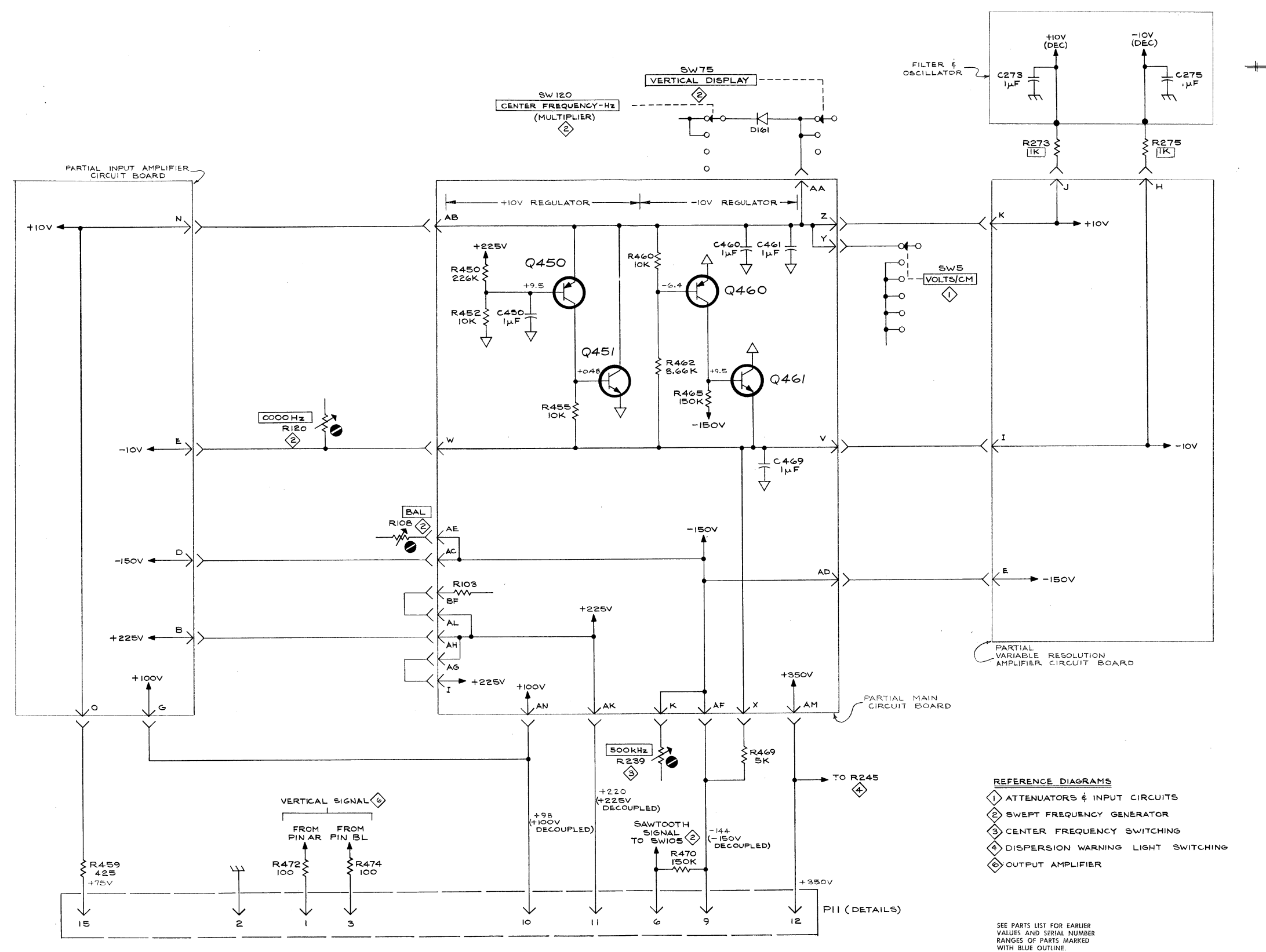


FIG. 1 FRONT

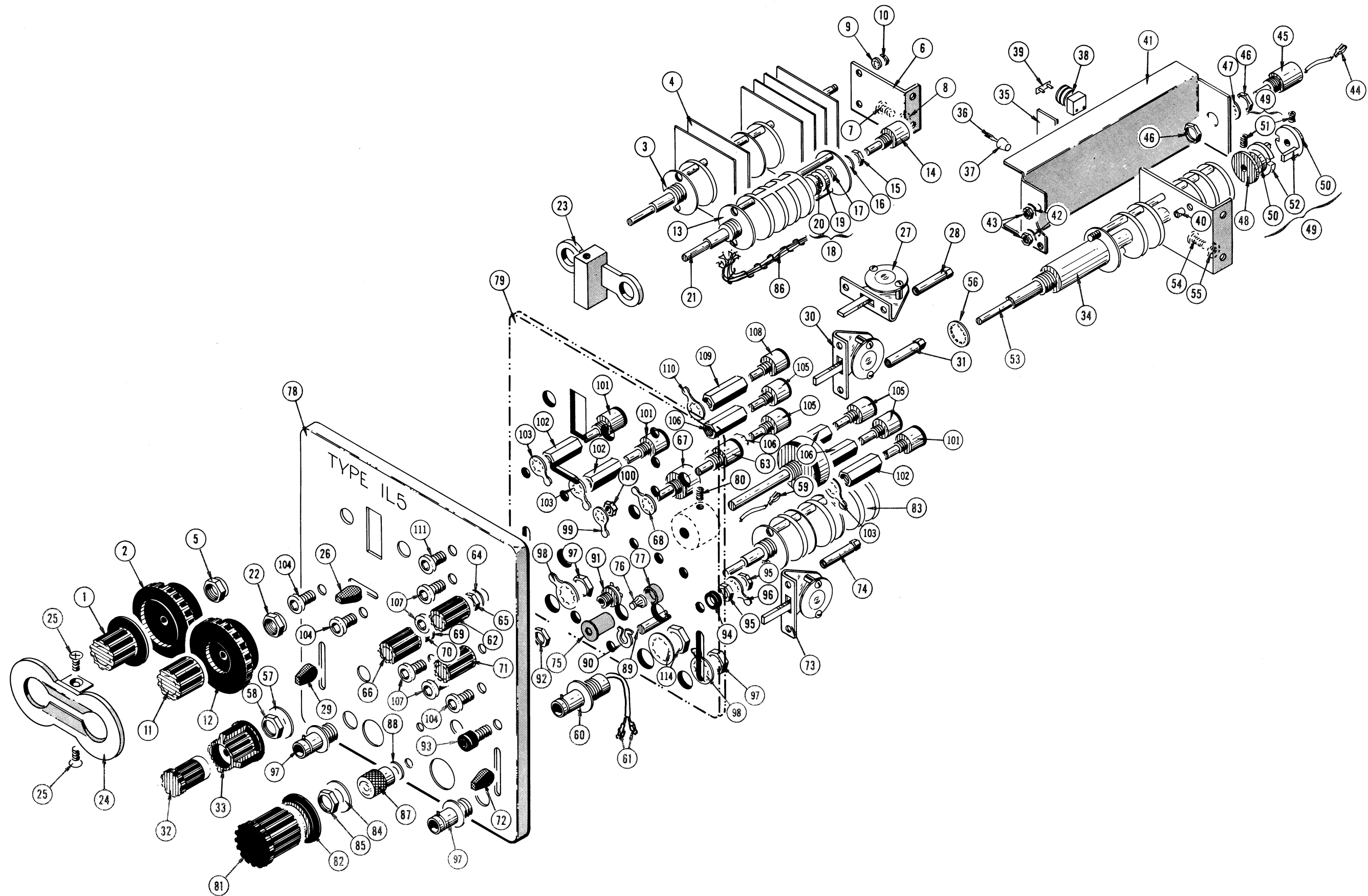


FIG. 1

TYPE 1L5 SPECTRUM ANALYZER PLUG-IN UNIT

FIG. 2 CHASSIS and REAR

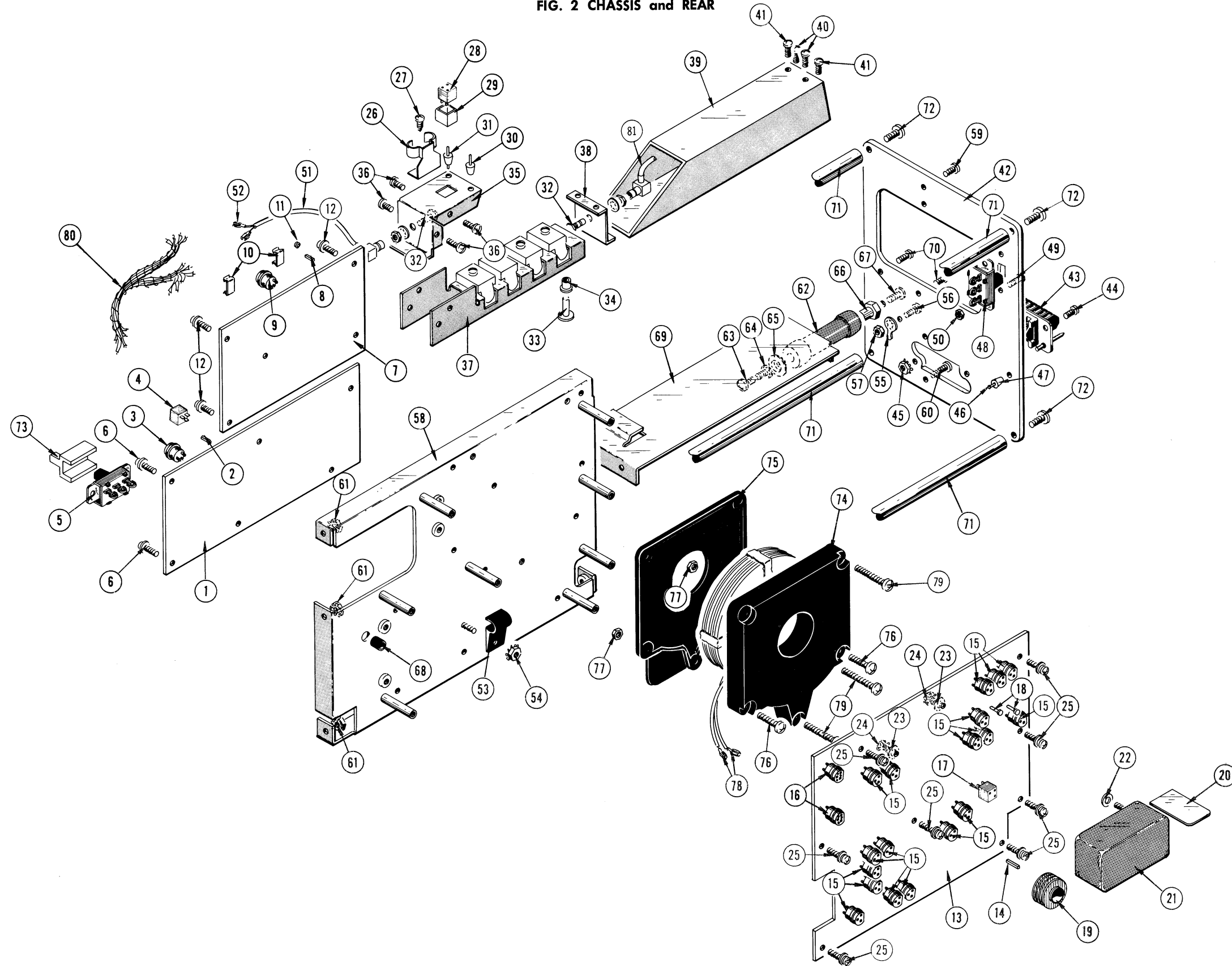


FIG. 2

TYPE 115 SPECTRUM ANALYZER PLUG-IN UNIT

FIG. 3 STANDARD ACCESSORIES

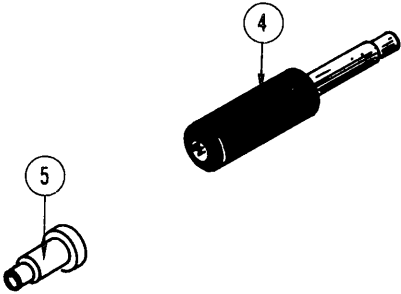
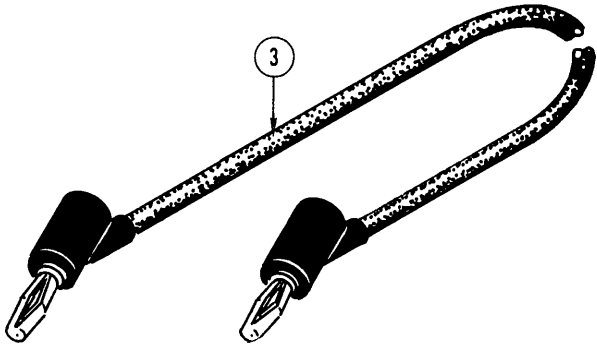
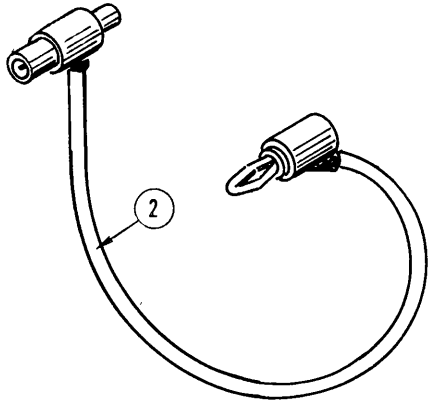
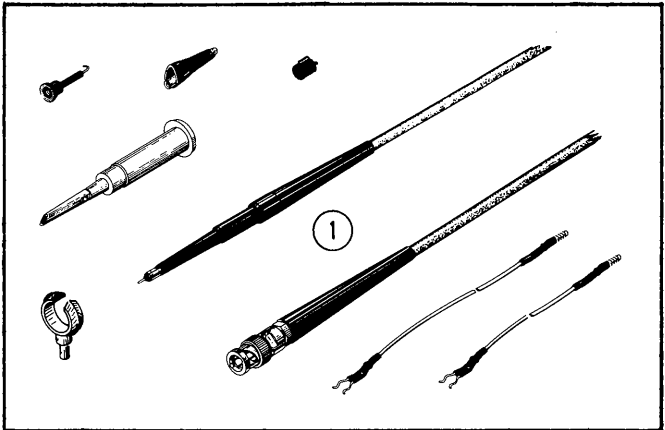


Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description
				t y	1	2	3	4	
3-1	010-0193-00			1	PROBE, package, P6011, BNC, X1, 42 inches				
-2	012-0091-00			1	CORD, patch, BNC to banana, 18 inches, red				
-3	012-0031-00			1	CORD, patch, banana, 18 inches, red				
-4	134-0052-00			1	PLUG, red				
-5	134-0076-00			1	PLUG, protector				
	070-0600-01			2	MANUAL, instruction (not shown)				

K4XL's BAMA

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