INSTRUCTION MANUAL

Serial Number B120820

TYPE 3L5

SPECTRUM ANALYZER PLUG-IN UNIT

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WARRANTY

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

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

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

Specifications and price change privileges reserved.

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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.

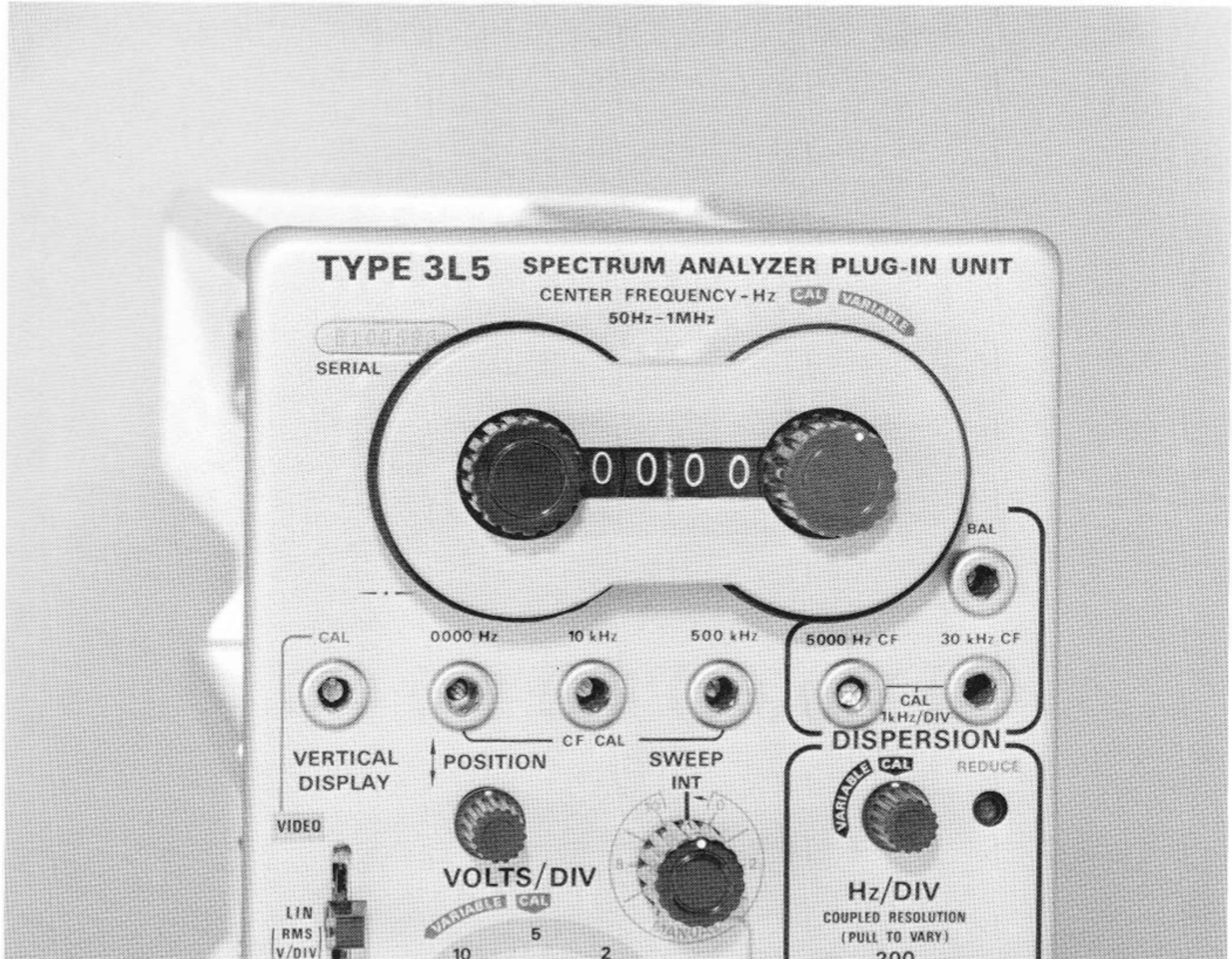

Fig. 1-1. Type 3L5 Spectrum Analyzer Plug-in Unit.

SECTION 1
SPECIFICATIONS

The Type 3L5 Spectrum Analyzer Plug-in Unit is designed for use with Tektronix oscilloscopes[1] that accept the 3-series plug-ins. The analyzer plugs directly into the oscilloscope which provides the required power.

The Time Base Units with the serial numbers listed and below, require a modification (040-0413-00) to provide a sweep signal to the analyzer. Type 2B67-15180, Type 3B1-4040, Type 3B3-4270, Type 3B4-740.

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 application.

The following electrical characteristics apply over the ambient temperature range indicated, or between 0° C to 50° C provided the ambient temperature has been stable for 4 hours; and provided that an initial warmup 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 to check the Operating Requirements listed in this section.

FREQUENCY DISPLAY (Horizontal Axis)

Characteristic	Operating Requirements	Supplemental Information
Center Frequency Range	50 Hz to 990 kHz	
Variable	≥10 kHz at the Center Frequency of 990 kHz	Extends the Center Frequency to 1 MHz or higher
Accuracy 50 Hz to 990 Hz	± (5% +50 Hz +50 Hz/°C max.) ≤ 1000 Hz change from 0° C to 50° C.	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.
1000 Hz to 9900 Hz	± (5% +100 Hz +100 Hz/°C max.) ≤ 2500 Hz change from 0° C to 50° C.	
10 kHz to 99 kHz	±(5% +3 kHz +200 Hz/°C)	
100 kHz to 990 kHz	±(5% +10 kHz +200 Hz/°C)	
Stability 50 Hz to 9900 Hz	≤100 Hz/hr at a stable (±1°C) ambient temperature.	
Dispersion Range Calibrated	10 Hz to 100 kHz	In 9 Calibrated steps
Variable	From near 0 Hz to the indicated position of the Hz/DIV selector	
Accuracy Center Frequency 50 Hz to 9900 Hz 10 kHz to 990 kHz	≤10% (20°C to 30°C) increasing to 20% (0°C to 50°C)	Measured over the center 8 divisions of the display. Upper limit of dispersion window must not exceed 10 kHz for the 50 Hz to 9900 Hz Center Frequency range, or 1MHz for the 10 kHz to 990 kHz Center Frequency range. Accuracy for a given Center Frequency can be improved with front panel calibration controls
Linearity	Within 3% (20° C to 30°C) Within 6% (0° C to 50° C)	
Resolution Bandwidth	≤10 Hz to ≥500 Hz (20° C to 30° C) ≤20 Hz to ≥500 Hz (0° C to 50° C)	Within ±1 dB amplitude change at 25°C ±5° C. Can be manually coupled with the DISPERSION switch or uncoupled and switched separately

[1]Type 565 must be modified to supply the Time Base sawtooth at pin 18 of the Interconnecting plug.

AMPLITUDE DISPLAY (Vertical Axis)

Characteristic	Operating Requirements	Supplemental Information
Input R and C		≈1 MΩ, ≈30 pF
Input Voltage, Maximum		300 V (DC + peak AC)
VARIABLE (VOLTS/DIV) Control	≥3:1 attenuation range from indicated VOLTS/DIV position	
VIDEO (Time vs Amplitude) Display Frequency Response		
.5 VOLTS/DIV to 100 VOLTS/DIV positions.	≤10 Hz to ≥1 MHz	
.1 VOLTS/DIV and .2 VOLTS/DIV positions.	≤10 Hz to ≥700 kHz	
Deflection Factor	0.1 to 100 volts peak to peak, V/DIV ÷ 100 knob pushed in.	
Accuracy	Within 6%, V/DIV ÷ 100 knob pushed in. Increased to 3%, V/DIV knob pulled out.	
LIN (Spectrum) Display Volts/DIV Range	0.001 to 2; RMS volts	In 11 calibrated steps
Accuracy	Within 6% (V/DIV ÷ 100 knob pulled out) 20° C to 30° C Within 3% (V/DIV ÷ 100 knob pushed in) 20° to 30° C	When calibrated with internal CALIBRATE signal. Add ±3% for temperature range 0° C to 50° C.
Display Flatness .001 VOLTS/DIV and .002 VOLTS/ DIV	+0.5 dB, −3.0 dB	Over the frequency range of 10 Hz to 1 MHz; 5000 Hz reference frequency
.005 VOLTS/DIV to 2 VOLTS/DIV	±0.5 dB	
LOG Spectrum Display	≥60 dB dynamic range over 8 div.	
Maximum Signal Level	50 dB above a 1.0 division reference.	
Noise Level		≤5 μV (RMS)
Spurious Signals Signal Applied	≥50 dB below the signal level	Log mode
Input Grounded	≤2 × noise	Log mode
Zero Frequency Feedthrough		Amplitude of 0 Hz signal, ≥1 to ≤4 divisions
Intermodulation Distortion	≥50 dB below the applied 8 div signal level	Log mode

OUTPUT SIGNALS

CALIBRATED MARKERS Frequency	5 kHz ±1%	Displayed on the CRT when the VOLTS/DIV selector is in the CALIBRATE 4 DIV 5000 Hz CENTER FREQ position
TO RECORDER Signal	5 mV to 15 mV for an 8 division display on CRT, across 600 Ω load.	
OSC OUT Signal (LO) Frequency	Must sweep ≥1 MHz	
Amplitude	≥1 volt, peak to peak, into load ≥ 1 kΩ.	

DEFLECTION FACTOR

POSITION Range	+ and − 8 divisions	

MECHANICAL CHARACTERISTICS

Characteristic	Information
Construction Chassis	Aluminum
Front-panel	Aluminum with anodized finish
Circuit Boards	Glass-epoxy laminate
Net Weight	≈6 pounds

ENVIROMENTAL 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 of representative.

Characteristic	Operating Requirements	Supplemental Information
Temperature Non-operating	—40°C to +65°C	
Operating	0°C to +50°C	To meet operating specifications the 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, ½ sine, 11 ms duration, 2 shocks per axis	Guillotine-type shocks
Transportation Package Vibration	1 hour at 1 g	
Package Drop	30 inches on 1 corner, all edges radiating from that corner and all flat surfaces	Total of 10 drops

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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 3L5 is designed to provide a spectral display of the frequency distribution of electromagnetic energy within the frequency range of 50 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, their frequencies, frequency drift, relative amplitude of the signals, the nature of any modulation, and many other characteristics.

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

Spectrum Analyzer Terms

The following glossary of spectrum analyzer terms is 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.

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 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 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 resetting 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.

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 potential 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).

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 Gausian 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 and 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

$$\text{resolution bandwidth} = 0.66\sqrt{\frac{\text{dispersion (in Hz)}}{\text{Sweep time (in seconds)}}}$$

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 as follows:

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 (spurii, spur)—An erroneous display of signal which does not conform to the indicated frequency or dial reading. Spurii and spur are the colloquialisms used to mean spurious (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, create 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

This control tunes the center frequency of the display from 50 Hz to 990 kHz.

CENTER FREQUENCY CAL Adjustments

These calibrate the Center Frequency at 0000 Hz, 10 kHz and 500 kHz.

VARIABLE CENTER FREQUENCY Control

This provides a continuously variable, overlapping adjustment of the Center Frequency. It extends the center frequency to 1 MHz when the CENTER FREQUENCY-Hz selector is in the 990 K position.

POSITION Control

Positions the display vertically.

VERTICAL DISPLAY Switch

The functions of this three-position switch are as follows:

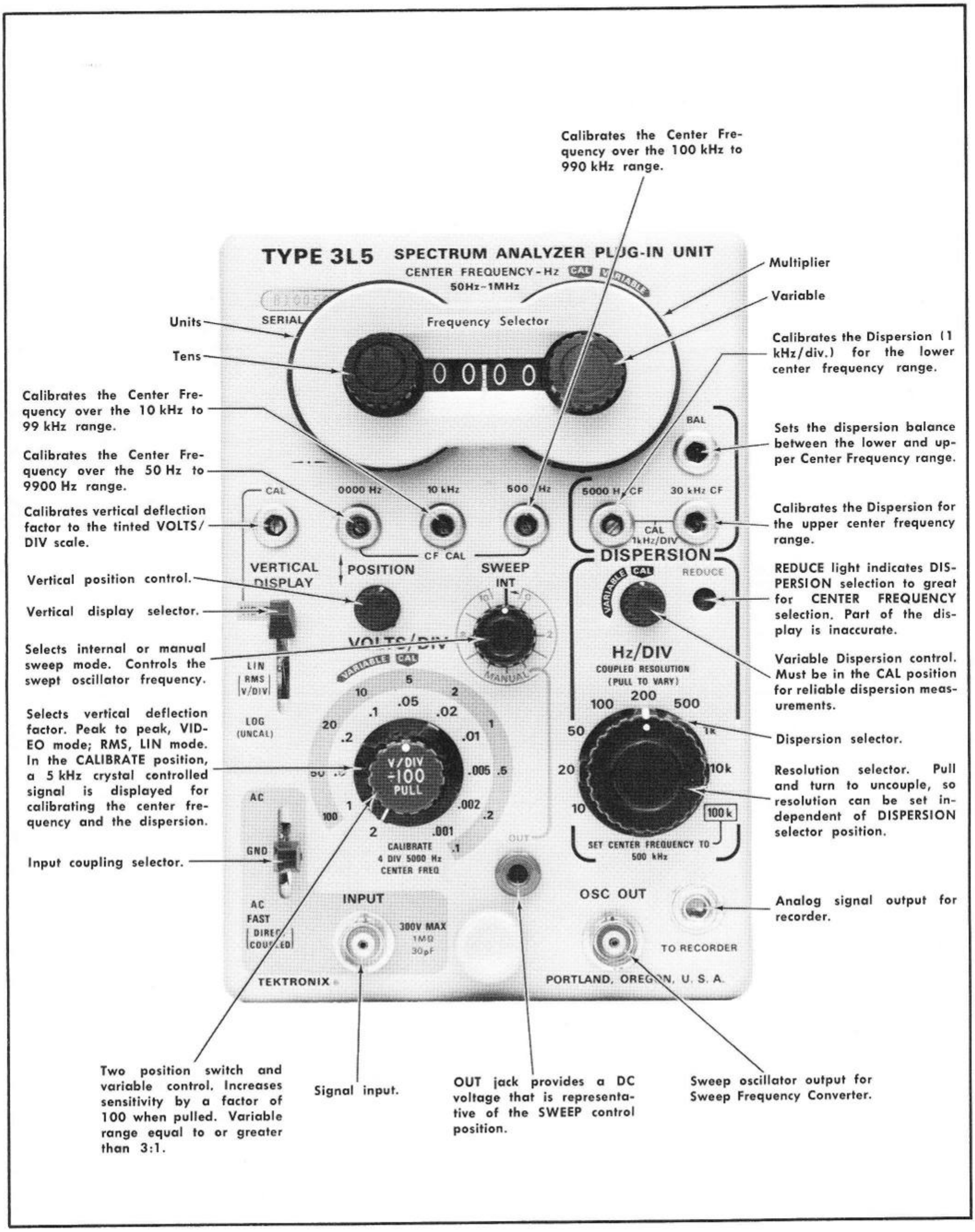


Fig. 2-1. Front panel controls on the Type 3L5 Spectrum Analyzer.

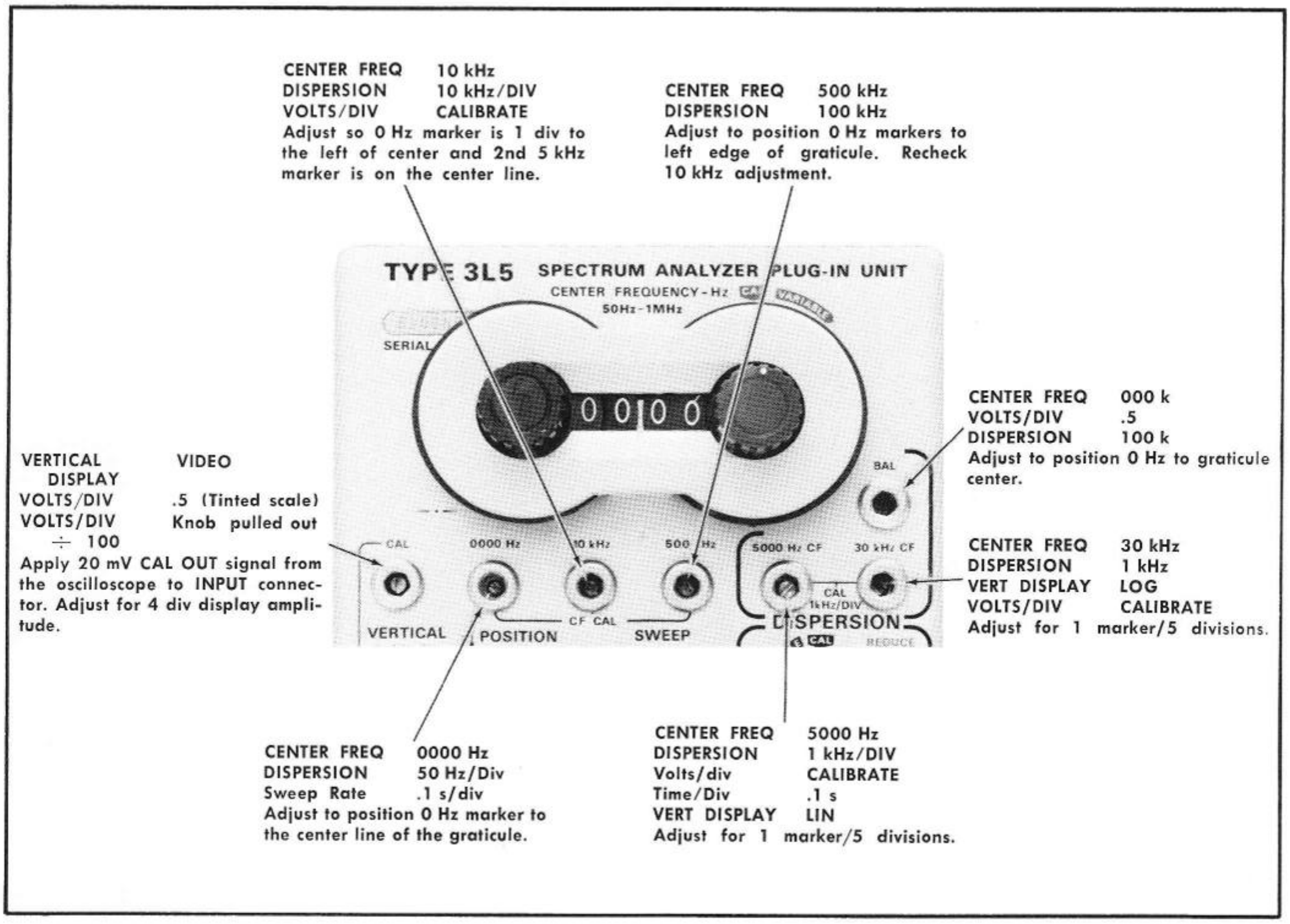


Fig. 2-2. Front panel calibration adjustments.

LIN (RMS V/DIV)—Selects linear display mode.

LOG—Selects a logarithmic display.

VIDEO—Selects an analog display (amplitude versus time). Use the tinted VOLTS/DIV scale when this switch is in the VIDEO position.

VIDEO CAL adjustment—Calibrates the vertical deflection factor, in peak-to-peak voltage, for VIDEO mode.

VOLTS/DIV Selector

This switch selects deflection factors from 0.1 V/div to 100 V/div (peak to peak) in VIDEO mode, and .001 V/div to 2 V/div (RMS) in the LIN mode. Selection is in a 1-2-5 sequence.

V/DIV ÷ 100 Switch

Extends the minimum vertical deflection factor to 10 μV/div by increasing the vertical sensitivity by a factor of 100.

Input Coupling Selector

The functions of this three-position switch are as follows:

AC—Capacitively couples the input signal to the input amplifier.

GND—Grounds the input.

AC FAST (DIRECT COUPLED)—Directly couples input signal to the input amplifier.

INPUT Connector

This connects signals to the unit. The maximum input level is 300 volts (DC + peak AC). The input time constant is approximately 30 μs (approximately 30 pF paralleled by 1 megohm).

DISPERSION Controls

The functions of the controls in this block are as follows:

Hz/DIV Selector—Selects dispersion (frequency excursion of the display) from 10 Hz/DIV to 100 kHz/DIV.

VARIABLE Dispersion—Provides a continuously variable adjustment of dispersion from near zero to that selected by the Hz/DIV switch.

REDUCE Dispersion Indicator—Lights when improper settings of the CENTER FREQUENCY and DISPERSION controls are selected. It indicates that the display may be misleading. For example: 5 kHz Center Frequency with 10 kHz/DIV dispersion.

5000 Hz CF CAL— Calibrates the dispersion for the CENTER FREQUENCY-Hz selector range, 10 Hz to 9900 Hz.

30 kHz CF CAL—Calibrates the dispersion for the CENTER FREQUENCY-Hz selector range, 10 Hz to 990 kHz.

BAL—Sets the dispersion balance between the upper and lower center frequency ranges. (Serial number B100590 and up.)

COUPLED RESOLUTION

This control is coupled with the DISPERSION selector. Pull and turn it to vary the resolution. The resolution bandwidth range is $\leq$10 Hz to $\geq$500 Hz.

SWEEP Control

This selects internal or manual sweep mode. In manual position it provides a means to manually sweep the display.

Sweep Manual OUT

This banana jack provides a DC output voltage that is a function of the position of the Manual Sweep control. When this voltage is applied as an external sweep control voltage to the horizontal plug-in unit, it provides a manual adjustment for the horizontal beam movement.

TO RECORDER Jack

The output of this jack is an analog voltage output from the spectral display for external recorders.

OSC OUT Connector

Provides an output from the swept local oscillator that is equal to or greater than 1 volt across a load equal to or greater than 1 kΩ.

FRONT PANEL ADJUSTMENTS

Introduction

Front panel calibration adjustment are provided on the Type 3L5 to enable the operator to calibrate 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 re-adjust 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 the means to check or calibrate the foregoing parameters. The internal calibrator is a 5 kHz signal. It is coupled into the spectrum analyzer display when the VOLTS/DIV selector is switched to the CALIBRATE 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 the 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 first IF amplifier. It appears on the spectrum as a 0 Hz or start spurious signal and is used to calibrate the low frequency end of the display.

Front Panel Calibration Adjustment Procedure (See Fig. 2-2)

The following calibration procedure compensates the front panel adjustments so the Type 3L5 meets 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 these front panel adjustments for specific settings. For example; the center frequency can be accurately set to any frequency where a marker can be observed (up 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. This procedure is elaborated to familiarize the operator with the adjustments so he may make adjustments at any desired setting of the Center Frequency and Dispersion controls. The center frequency and dispersion adjustments must be performed in the sequence given.

Preliminary

a. Plug the Type 3L5 into the vertical compartment and a time-base unit into the horizontal compartment of the plug-in oscilloscope. Connect the oscilloscope to a power source and turn the power switch on. Allow a 20 minute warm up period for the instrument to stabilize.

NOTE

The Time-Base Units with the serial numbers listed and below, require a modification (040-0413-00) to provide a sweep signal to the analyzer. Type 2B67—15180, Type 3B1—4040, Type 3B3—4270, Type 3B4—740.

b. Set the Type 3L5 and Time-Base unit controls as follows:

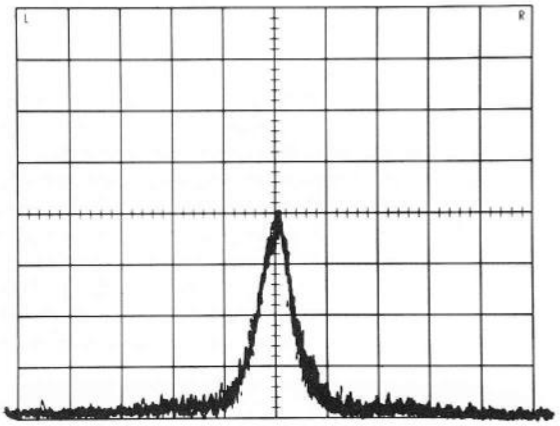
CENTER FREQUENCY-Hz	0000
VARIABLE	CAL
DISPERSION Hz/DIV	10 k
VARIABLE	CAL
RESOLUTION	10 k (COUPLED)
VERTICAL DISPLAY	LOG
Input Coupling	GND
VOLTS/DIV	.005 (Inner scale)
V/DIV ÷ 100	Knob pushed in
VARIABLE	CAL
SWEEP	INT

Plug-In Oscilloscope

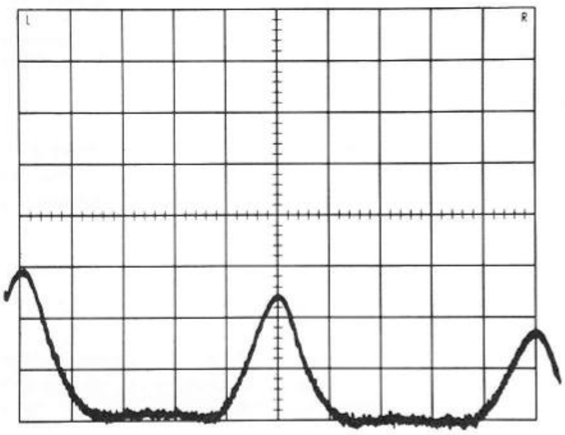
Time-Base Unit

Time/Div	.1 s
Triggering	Adjusted for a free running sweep

c. Position the trace to the bottom of the graticule and horizontally center the trace. Change the Time/Div to .2 s.



A. 0 Hz spurious response marker, with the CENTER FREQUENCY-Hz selector set to 0000.



B. 5 kHz markers with a dispersion of 1 kHz/DIV.

Fig. 2-3. Frequency markers to calibrate the Center Frequency and Dispersion.

d. Adjust the 0000 Hz CF CAL adjustment to center the 0 Hz spurious response marker as the Hz/DIV and RESOLUTION controls are reduced to 10. See Fig. 2-3. Set the Time/Div selector to 50 ms.

e. Switch the CENTER FREQUENCY-Hz selector to 00 k position. Adjust the 10 kHz CF CAL for minimum shift (within ±1 division) of the 0 Hz spurious response marker as the Hz/DIV-COUPLED RESOLUTION selectors are switched between the 100 k and 100 positions.

f. Switch the CENTER-FREQUENCY-Hz selector to 000 k position. Adjust the 500 kHz CF CAL for minimum shift (within ±1 division) of the 0 Hz spurious response marker as the Hz/DIV and the RESOLUTION selectors are switched between the 100 k and 200 positions.

NOTE

The 10 kHz and 500 kHz CF CAL adjustments interact. If either adjustment runs out of range, back the adjustment approximately 45° from the end then proceed to the other adjustment.

g. Set the DISPERSION to 100 k and center the 0 Hz marker with the Horizontal Position control. If the sweep does not extend beyond the right graticule edge, adjust the sweep length of the Time-Base unit to extend the sweep length.

h. Repeat steps (e) through (g) because of the interaction of the adjustments.

NOTE

With some Time-Base Units installed with the Type 3L5, it may be necessary to increase the sweep length so that the sweep extends past the graticule edges.

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 adjustment range seems insufficient, center both the 500 kHz CAL and the 10 kHz CAL and repeat the adjustments.

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	000 k
VERTICAL DISPLAY	LIN
VOLTS/DIV	.005
DISPERSION Hz/DIV	100 k

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

2. Adjust BAL

This adjustment sets the dispersion balance between the lower and upper center frequency decade switches. (Applicable to instruments with this modification.)

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	000 k
VERTICAL DISPLAY	LIN
VOLTS/DIV	.005
DISPERSION Hz/DIV	100 k

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

3. Adjust 10 kHz CAL

This adjustment calibrates the 10 kHz to 99 kHz range of the CENTER FREQUENCY-Hz selector.

a. Set the front panel controls as follows:

CENTER-FREQUENCY-Hz	10 k
VARIABLE	CAL
VERTICAL DISPLAY	LIN
DISPERSION	10 k
VOLTS/DIV	CALIBRATE
V/DIV ÷ 100	Pushed in

b. Adjust the 10 kHz C F CAL screwdriver adjustment so the 0 Hz marker signal is 1 division (± 0.2) to the left of center (10 kHz left of center; see Fig. 2-4A). Decrease the DISPERSION-Hz/DIV-COUPLED RESOLUTION selectors to 500 and readjust the 10 kHz C F CAL, if necessary, to center the 10 kHz marker.

c. The Center Frequency readout is now calibrated at 10 kHz. If desired, any center frequency readout within the range of 10 kHz to 99 kHz may be accurately calibrated in the same manner or the frequency error between the readout positions can be distributed over the range as follows:

1. Switch the CENTER FREQUENCY-Hz switch consecutively from 10 k toward 90 k in increments of 10 k.

2. The center marker will progressively move from the center of the graticule as the CENTER FREQUENCY-Hz switch setting is changed from 10 k to 90 k. Change the 10 kHz CAL screwdriver adjustment to balance the error between the 10 kHz CENTER FREQUENCY position and the 90 kHz CENTER FREQUENCY position.

4. Adjust 30 kHz C F—CAL 1 kHz/DIV

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
VARIABLE	CAL
VERTICAL DISPLAY	LOG
VOLTS/DIV	CALIBRATE
V/DIV ÷ 100	Pulled out
DISPERSION Hz/DIV	1 k
VARIABLE	CAL
Time/div	20 ms

b. Adjust the VARIABLE CENTER FREQUENCY control to position a marker to the center of the graticule.

c. Adjust the 30 kHz C F adjustment for 1 marker/5 divisions. See Fig. 2-3B.

d. Return the VARIABLE CENTER FREQUENCY control to the CAL position.

5. Adjust 5000 Hz C F—CAL 1 kHz/DIV

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

a. Set the controls as follows:

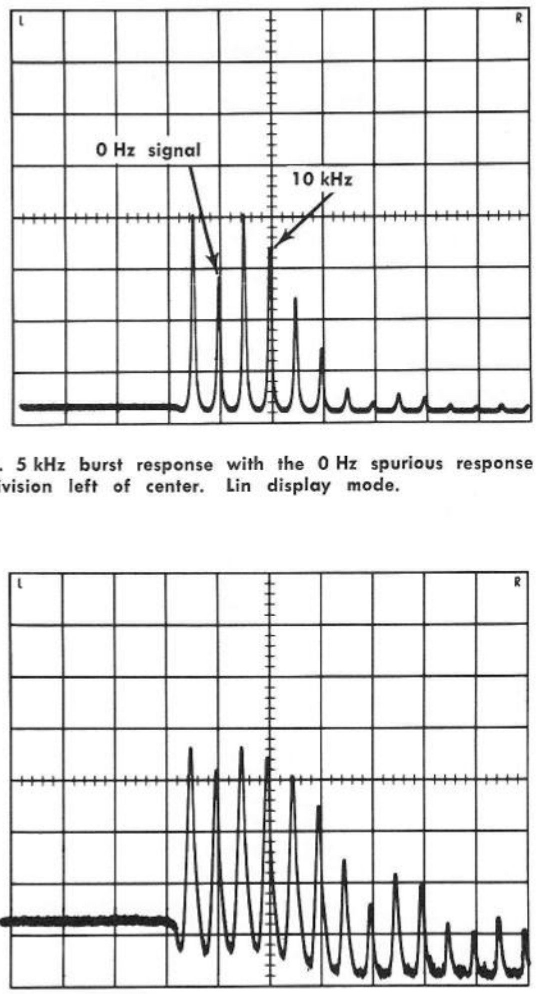
CENTER FREQUENCY	5000
VOLTS/DIV	CALIBRATE 4 DIV 5000 Hz CENTER FREQ
DISPERSION Hz/DIV	1 k

b. Adjust the 5000 Hz C F adjustment for 1 marker/5 divisions.

6. Adjust VIDEO CAL

This adjustment calibrates the amplitude for VIDEO displays.

a. Set the controls as follows:



A. 5 kHz burst response with the 0 Hz spurious response 1 division left of center. Lin display mode.

B. 5 kHz burst LOG display mode.

Fig. 2-4. Using the O Hz marker signal, and 5 kHz burst markers to calibrate dispersion and center frequency.

Spectrum Analyzer

VERTICAL DISPLAY	VIDEO
VOLTS/DIV	.5 (Outer ring)
V/DIV ÷ 100	Pulled out

Oscilloscope

Plug-In Time Base Unit

Time/Div	.5 ms
Triggering	Free running sweep
Amplitude Calibrator	20 mVOLTS

b. Apply the output from the oscilloscope Calibrator to the Type 3L5 INPUT connector.

c. Adjust the VIDEO CAL adjustment so that the display amplitude is 4 divisions.

d. Remove the Calibrator signal from the Type 3L5 INPUT.

FIRST TIME OPERATION

The following procedure demonstrates the basic functions of the controls and connectors for the Type 3L5. This should be performed after the front panel calibration.

Time Domain Operation (Video Amplification)

a. Set the front panel controls as follows:

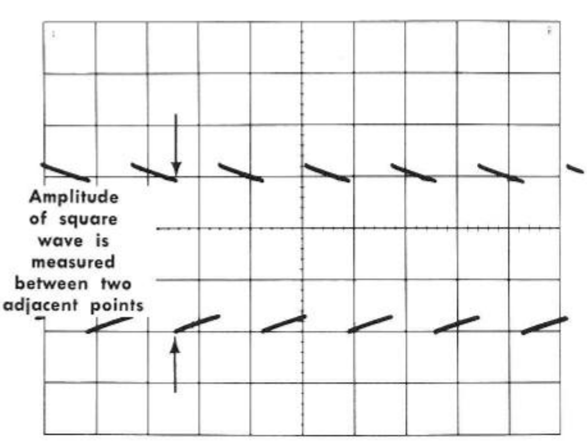
VERTICAL DISPLAY	VIDEO
VOLTS/DIV	.5 (Outer scale)
VARIABLE	CAL
V/DIV ÷ 100	Pushed in
Input Coupling	AC or AC FAST
POSITION	Midrange
Time Base Unit	
Time/Div	10 ms
Triggering	Auto, Internal source
Oscilloscope	
Calibrator	2 Volts

b. Connect a coaxial cable between the oscilloscope Cal Out connector and the Type 3L5 INPUT connector.

c. Adjust the Triggering controls for a stable triggered display (see Fig. 2-5). The AC coupled stages cause the slope between the top and bottom portions of the calibrator waveform.

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

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



A. Video display of oscilloscope Cal Out signal.

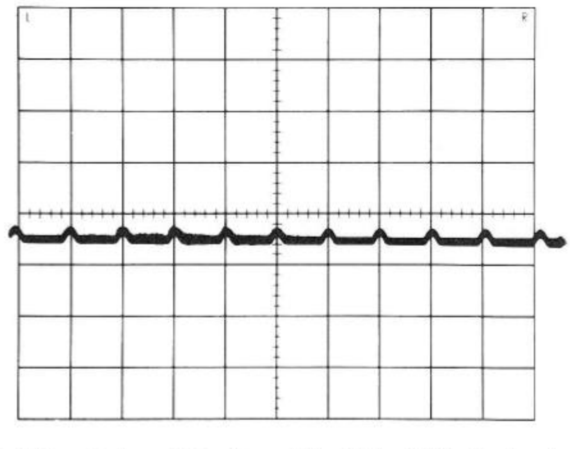

B. Video display of the Type 3L5 5 kHz Calibrate signal.

Fig. 2-5. 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/DIV	.5 (Outer scale)
VARIABLE	CAL
SWEEP	INT
DISPERSION-Hz/DIV COUPLED RESOLUTION	10 k
VARIABLE	CAL
Time Base Unit	
Time Div	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 3L5.

NOTE

If a signal source of 100 kHz is not available apply a signal within the frequency range of the Type 3L5 and change the CENTER FREQUENCY selector setting to the applied input frequency. Decrease the Hz/DIV selection until the REDUCED light is no longer lit.

c. Adjust the signal generator output or the VOLTS/DIV selector for a signal amplitude of approximately 6 divisions.

d. Tune the signal generator frequency above and below 100 kHz. Note the displayed signal moves proportionately across the screen. As the input signal frequency increases, the signal moves to the right of the graticule center; as the input frequency decreases, the signal moves toward 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 Hz/Div selector position multiplied by the 10 graticule divisions.

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. When selecting a center frequency below 100 kHz, switch the multiplier (right black knob; see Fig. 2-6) to the k readout position and the tens (small black knob) to 9. The tens selector will now shift the Type 3L5 center frequency below 100 kHz and the signal will move to the right side of the graticule.

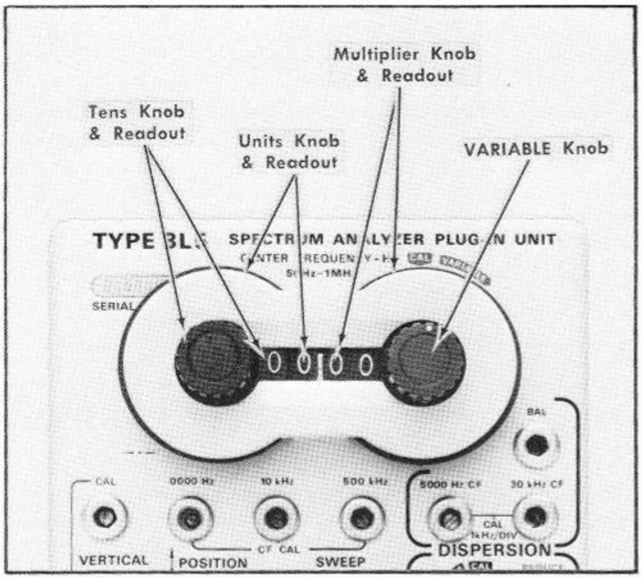


Fig. 2-6. CENTER FREQUENCY-Hz Selector.

f. Switch the CENTER FREQUENCY—Hz to 10 k. Note that the dispersion REDUCE indicator is on to signify that the display is misleading. Change the frequency of the signal generator to 10 kHz. Note the display. See Fig. 2-7.

g. Adjust the CENTER FREQUENCY VARIABLE control. This control provides continuous tuning of the center frequency through each step of the switched positions.

h. Reduce the DISPERSION-Hz/DIV selector to 1 k. The REDUCED indicator should no longer be lit and the display should now contain a single 10 kHz signal near screen center. Change the center frequency by turning the units knob (large knob behind the tens knob; see Fig. 2-6). Note that the 10 kHz signal now shifts in 1 kHz steps as the units knob is switched through its range.

i. Set the CENTER FREQUENCY selector 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. This is explained later in this section under Resolution and Sweep Rate.

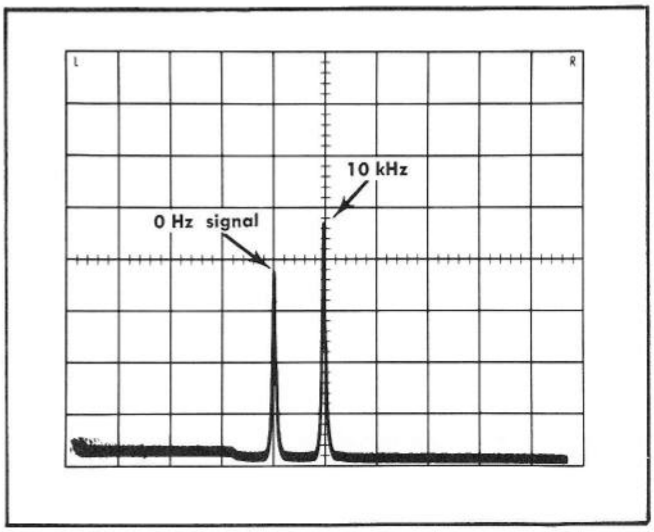


Fig. 2-7. When DISPERSION setting exceeds the upper or lower frequency limits of the Type 3L5, the display may be misleading. Illustration of a 10 kHz signal when DISPERSION equals 10 kHz/DIV and CENTER FREQUENCY-Hz is set to 10 K.

j. Decrease the sweep rate to .5 s/div. Note that the signal amplitude and symmetry are now comparable to the original amplitude and symmetry. The resolution bandwidth of the Type 3L5 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, set the Time/Div selector to 20 ms and the Triggering for a free running sweep.

GENERAL OPERATING INFORMATION

Signal Application

To ensure good results, certain precautions should be taken when signals are applied to the INPUT of the Spectrum Analyzer. Unshielded leads can be used to connect to a signal source when a high level, low frequency signal is monitored at a low impedance source. Most operating conditions, however, require the use of shielded leads to minimize stray electrostatic and electromagnetic pickup. Keep signal leads as short as possible and ground the shield at the signal source and the input of the anlyzer. This establishes a common ground between the signal source and the analyzer. The shield of the coaxial cable is normally used for this purpose.

Consider the effect of signal source loading due to the signal transporting leads and the input impedance of the analyzer. A mismatch between the signal source and the Type 3L5 will affect the display flatness. The input time constant of the analyzer is approximately 30 μs (1 MΩ paralleled by 30 pF). If optimum flatness is desired, and the signal strength is adequate, an attenuator pad or termination at the analyzer input will minimize reflections and optimize flatness.

Attenuator probes reduce the capacitive and resistive loading on the signal source. Probes must be properly compensated before they are used. Adjust the probe compensation as directed in the Instruction manual for the probe.

Vertical Display Modes

VIDEO—The Type 3L5 functions as a video (time domain peak-to-peak measuring device) amplifier with a frequency response of at least 10 Hz to 1 MHz for the .5 VOLTS/DIV to 100 VOLTS/DIV range and 10 Hz to 700 kHz for the .1 VOLTS/DIV and .2 VOLTS/DIV positions. The tinted scale for the VOLTS/DIV selector indicates the vertical deflection factor in peak-to-peak readings.

When signal amplitudes are measured, the width of the trace should be considered. Make the measurement from the same edge of the trace as illustratd in Fig. 2-8A. The calibrated deflection factors indicated by the VOLTS/DIV scale apply only when the VARIABLE control is in the CAL position. Serious errors will be introduced if the measurements are made with this control out of the CAL position.

V/DIV ÷ 100 knob decreases the deflection factor or increases sensitivity by a factor of 100 when it is pulled out. A white ring around the knob indicates when the knob is in the out position.

LIN—A spectrum of a frequency domain is displayed with the VERTICAL DISPLAY selector in the LIN position. Linear signal amplitude is calibrated in RMS voltage over the full graticule height. Accuracy of the amplitude measurements is within 3%, provided the resolution bandwidth is adjusted to optimize sensitivity. (See Resolution and Selecting Sweep Rate.)

Amplitude measurements are relative and should be measured to the center of the trace width. Use the inner scale of the VOLTS/DIV selector positions to determine graticule calibration.

LOG—This position produces a logarithmic response and increases the dynamic range of the display to at least 60 dB. This mode is most effective when there are large signal amplitude or level differences within the spectrum. See Fig. 2-8B.

Graticule calibration for the LOG mode is approximately 7 dB/div ±2 dB over the top 6 divisions and 9 dB between the 1st and 2nd division. The dynamic range between the baseline (or 0) and the 1st division is not linear. 60 dB is approximately 1 minor division above the baseline. Fig. 2-9 shows the graticule calibration for LOG mode.

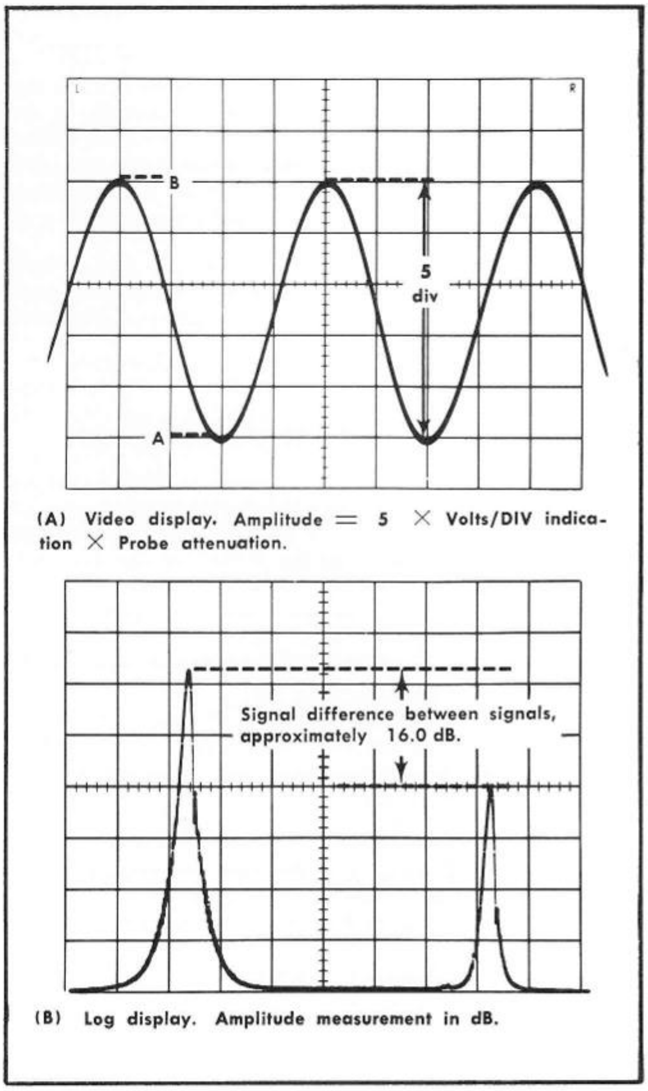


Fig. 2-8. Measuring signal amplitudes.

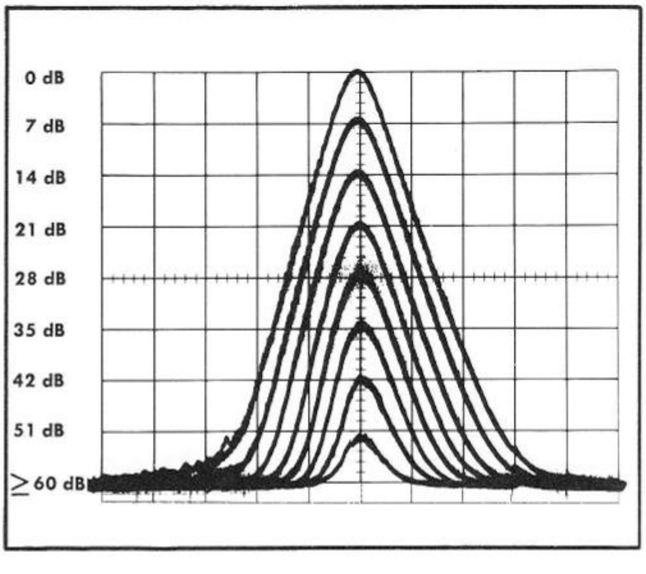


Fig. 2-9. Multiple of stored displays to illustrate Log mode calibration.

CENTER FREQUENCY-Hz Selector

The center frequency of the displayed spectrum is selected by three rotary switches and a variable potentiometer. These are grouped for front panel readout as shown in Fig. 2-6. The following precautions should be observed when setting these 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 900 k rather than 090 k.

REDUCE DISPERSION Caution Light

CENTER FREQUENCY-Hz and DISPERSION Hz/DIV selections are possible where the display window extends outside the indicated range of these controls, producing spurious signals on the display to the left of the 0 Hz marker. Dispersion and signal amplitude will be non-linear in this region.

A REDUCE dispersion indicator lights when the display extends beyond the range of the CENTER FREQUENCY-Hz and DISPERSION-Hz/DIV selections to indicate to the operator that a part of the display has no real meaning. The center of the display, within the limits of the analyzer, can still be used for valid information.

NOTE

An exception to the above occurs with a CENTER FREQUENCY-Hz selection of 2500 or 250 and a DISPERSION-Hz/DIV setting of 500 or 50. This combination lights the indicator; however, the display is usable.

OSC OUT Connector

This connector provides access to the swept oscillator (3 MHz to 2 MHz) frequency and may be used for accurate frequency measurements, either as an input to the Swept Frequency Converter (015-0107-00) or as an independent 3 MHz to 2 MHz sweeper.

Frequency measurement is described later under Precise Frequency Measurements. The Swept Frequency Converter converts the 3 MHz to 2 MHz sweep to a 0 to 1 MHz swept frequency.

The amplitude of the output signal is at least 1 V peak to peak into a load of 1 kΩ or more and typically measures 1.5 V to 2.0 V peak to peak. Output is very linear over the oscillator frequency range.

Sweep Mode Selector

The frequency spectrum of the analyzer for a given dispersion may be swept by the horizontal sweep voltage from the time-base unit or manually swept by the front panel SWEEP control. With the control in the INT position, the horizontal sweep voltage from the time-base unit is applied to the analyzer swept oscillator through pin 18 of the plug connector P-11. Sweep speed is a function of the Time/Div selector position.

When the SWEEP control is out of the INT detent, the swept frequency oscillator is connected to a DC voltage dependent on the SWEEP control position. This voltage is varied as the SWEEP control is rotated through its MANUAL range. Access to this voltage is provided at the OUTPUT connector jack. When this voltage is applied to the Ext Horiz Input connector of the time-base unit, it will synchronize the position of the CRT beam with the swept oscillator frequency, provided External Horizontal Input is selected for the time-base unit. The operator may now manually scan the spectrum or select any frequency within the spectrum by adjusting the SWEEP control. This provides a fairly precise control for frequency and amplitude measurements.

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

1. Select a time-base unit that has provisions for an external horizontal input with a variable attenuation control, (for example the Type 3B4) or install an amplifier plug-in unit (for example the 3A1) into the horizontal compartment of the oscilloscope.

2. Set the Horizontal Volts/Div selector or the Amplifier Volts/Div to 2.

3. Connect a patch cord (banana plug to BNC) between the Type 3L5 OUT jack and the time-base, Ext Horizontal Input connector, or the amplifier Input connector.

4. Turn the Type 3L5 SWEEP control to 0 (fully counterclockwise). Adjust the Horizontal Position control to position the beam to the left edge of the graticule or the 0 graticule line.

5. Turn the SWEEP control to 10 (fully clockwise). Adjust the Variable Volts/Div control to position the spot to the the right edge of the graticule.

6. Repeat (4) and (5) until the Type 3L5 SWEEP control will vary the sweep the full 10 graticule divisions.

7. Check and adjust, if necessary, the dispersion and center frequency calibration as directed under front panel adjustments.

Resolution and Selecting Sweep Rate

Resolution or resolution bandwidth is a function of the final IF bandwidth. This bandwidth governs the minimum frequency difference that can be resolved. Signals are considered resolved when the notch or dip between two equal amplitude signals is 3 dB down. The frequency difference between signals 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 resolution 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 bandwidth becomes wider; 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:

$$\frac{S}{S_o} = \left[1 + 0.195\left(\frac{D}{TB^2}\right)^2\right]^{\frac{1}{4}}$$ where S/S_o 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 sweep rate.

These same variables also determine the resolution of the analyzer. The loss in resolution can be expressed as follows:

$$\frac{R}{R_o} = \left[1 + 0.195\left(\frac{D}{TB^2}\right)^2\right]^{1/2}$$ where R/R_o is the ratio of the effective resolution of the analyzer to the measured resolution bandwidth at very slow speeds. R_o is somewhat arbitrary and is taken as the displayed width of the CW signal at the —6 dB point.

The resolution of the Type 3L5 Spectrum Analyzer is optimized for most settings of the DISPERSION selector when the RESOLUTION control is in the coupled position. Resolution can be varied from approximately 500 Hz to less than 10 Hz by uncoupling the RESOLUTION control from the DISPERSION selector and changing it as an independent function.

The sweep rate, as previously mentioned, should be set for optimum signal amplitude. As the DISPERSION settings are reduced the sweep speed should also be reduced to maintain sensitivity and resolution.

Frequency Measurements

Frequency measurements taken from the CENTER FREQUENCY-Hz dial are accurate to within the specifications listed in the Characteristics section. This accuracy can be increased for a narrow frequency range by the front panel calibration adjustments. The frequency of an applied signal is measured as follows:

1. Check the calibration of the DISPERSION and C F CAL adjustments as described previously in this section. Set the CENTER FREQUENCY VARIABLE control to the CAL position.

2. Tune the CENTER FREQUENCY-Hz selectors to center the signal in the graticule. Decrease the DISPERSION-Hz/DIV setting to improve the measurement accuracy.

3. Read the frequency indicated on the CENTER FREQUENCY dial.

An approximate frequency measurement can be made by noting the differecne in frequency between the graticule center and the signal position (Fig. 2-10), then add or subtract the noted difference to the CENTER FREQUENCY dial reading. (Signals to the right of screen center are above the CENTER FREQUENCY dial reading.)

Frequency Difference Measurements

Frequency separation measurements to 1 MHz can be made between signals as follows:

1. Adjust the DISPERSION selector so the signals to be measured are the maximum number of graticule divisions apart.

2. Set the TIME/DIV selector and the RESOLUTION control for optimum signal definition. (Sharp and clean signal display.)

3. Measure the distance, in graticule divisions, between the two signals (see Fig. 2-10).

4. Multiply the measured distance in step 3 by the DISPERSION-Hz/DIV setting. This is the frequency separation or frequency difference between the two signals.

NOTE

Accuracy of this measurement depends on the DISPERSION settings. See Characteristics Section.

Precise Frequency Measurement

Accurate frequency measurements of input signals may be performed by measuring the OSC OUT frequency with a

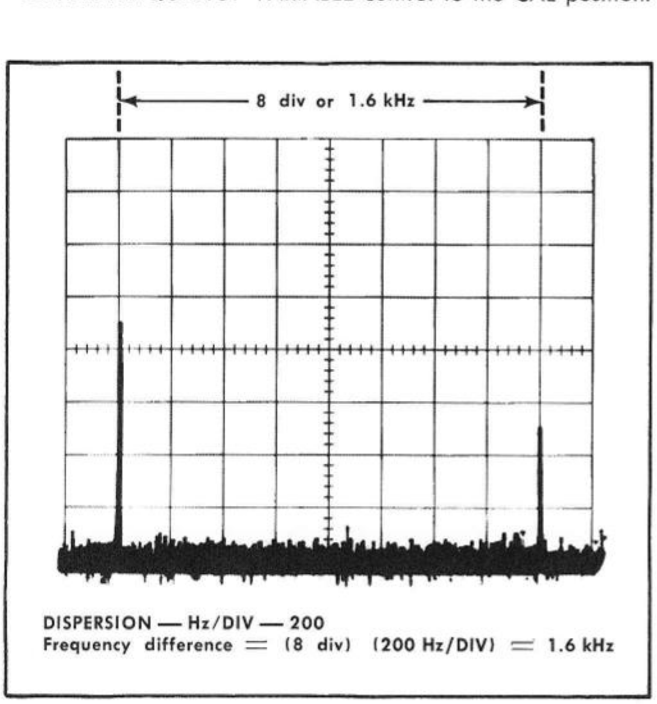


Fig. 2-10. Frequency difference measurement between two signals.

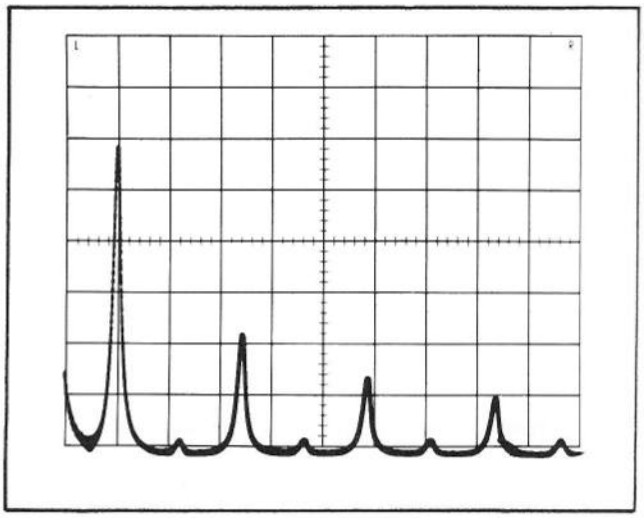
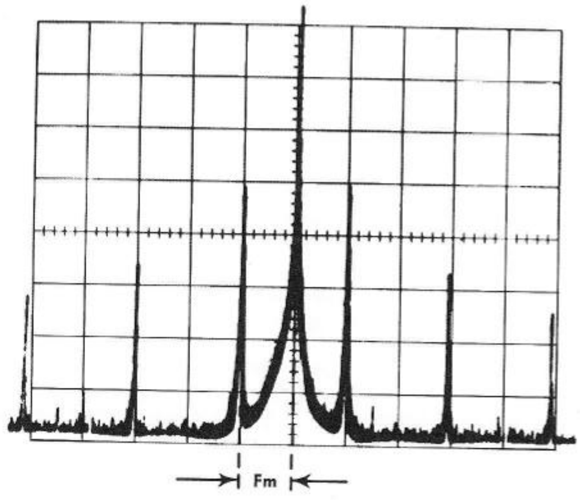
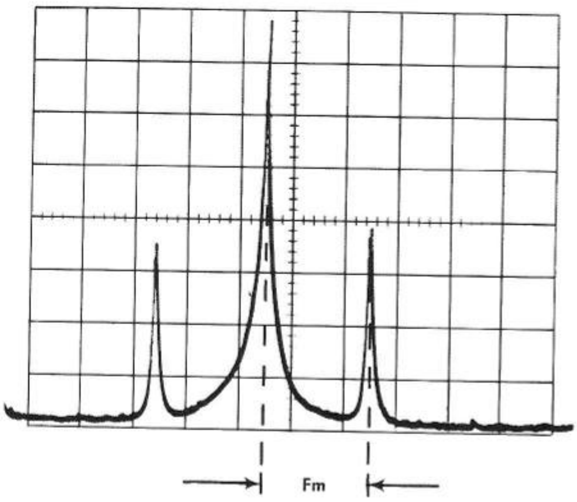


Fig. 2-11. Spectrum of a rectangular wave showing the odd order harmonics with the lower amplitude even order harmonic signal between each pip.

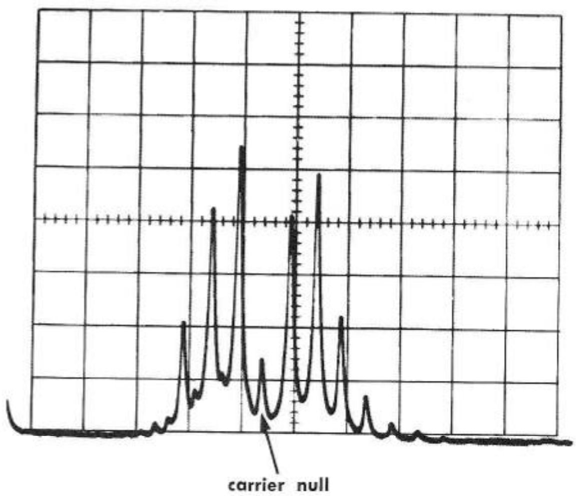


A. Over-modulated Am signal. Over modulation produces additional unwanted sidebands. Dispersion is 100 kHz/div and indicates a modulating frequency (Fm) of 100 kHz.



B. The same signal with the percentage of modulation reduced. 100% modulation produces sidebands which are ½ the carrier amplitude.

Fig. 2-12. Amplitude modulated displays.



Frequency modulated carrier almost at null. Individual sidebands are resolved. Dispersion 100 kHz/DIV.

Fig. 2-13. Frequency modulated displays.

frequency counter or other accurate measuring device. This is possible because the 2nd local oscillator in the Type 3L5 is a crystal controlled 3.1 MHz oscillator, and the 2nd IF amplifier contains 0.1 MHz crystal filters. When the swept local oscillator is manually tuned with the SWEEP control to the desired signal, the frequency at the OSC OUT connector is a precise difference frequency between 3 MHz and the frequency of the incoming signal. For example: If the measured OSC OUT frequency is 2.5 MHz, the incoming signal frequency is 3.0—2.5 MHz or 500 kHz. This measurement is as accurate as the 3.1 MHz crystal controlled oscillator, the 0.1 MHz crystal filter, and the measuring device.

A second method can be performed by applying a calibrated or crystal controlled frequency to the INPUT and calibrating the dial near the frequency of the input signal; then tuning the input signal to the same screen position and noting the dial reading plus or minus the measured dial accuracy.

APPLICATIONS

The Type 3L5 enables the operator to make waveform analysis of a wide range of complex electromagnetic signals. Through the use of suitable transducers, the Type 3L5 can also be used for analysis of many types of physical phenomena. Table 2-1 lists a few of these applications.

TABLE 2-1

Applications	Capabilities
Analysis of Complex Waveforms	Permits analysis of complex waveforms such as step functions, sawtooth voltages, square waves, etc. See Fig. 2-11 for the spectrum of a rectangular wave.
Distortion Measurements	Checks intermodulation distortion, phase or frequency distortion, harmonic distortion, etc. that is present in radio frequency and audio frequency circuits.
AM and FM Modulation Measurements	Measures modulation frequencies, amplitude moduation percentage (see Fig. 2-12), frequency modulation deviation and stability (see Fig. 2-13), etc.
Frequency Response Plots	Measures the bandpass of filter networks, IF stages, speakers, enclosures, etc.
Telemetry Signal Analysis	Can make a composite subcarrier analysis such as a check of subcarrier pre-emphasis, subcarrier oscillator check, interaction between channels, noise and hum.

Telephone Carrier System Checks	Can be used to monitor and trouble-shoot telephone communication channels from approximately 200 Hz to 1 MHz. Useful in spotting out-of-tolerance channel 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	Makes ultra-sonic noise and vibration (both sinusoidal and random) analysis. Useful for cavitation studies on large turbines and in milk pasteurization machinery. Vibration studies applicable to wind-tunnel analysis, large ventilating systems, fatigue studies in airframes or materials subject to constant vibration. Can make measurements of ultra-sonic and sonic wave propagation in geophysical applications such as ground propagation studies in reflection and absorption, or the use of ultra-sonics in the field oceanography.
Musical Tone Analysis:	Applicable when used with a storage oscilloscope in the study of musical instrument tones.
Speech Analysis	Useful in research of speech patterns in speech therapy, etc.
Medical Applications	Can be used as a research tool in the study of EMG, EKG, and EEG waveform analysis. Useful in microphysiology.

SECTION 3
CIRCUIT DESCRIPTION

Introduction

The Type 3L5 Spectrum Analyzer is a swept front end spectrum amplifier 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 the black diagram in Section 9, is used to describe the sequence of operation.

Incoming signals applied to the INPUT connector are fed through a calibrated attenuator and amplifier circuit, to establish the desired signal amplitude on the display. The signals are then coupled to the 1st mixer circuit, where they are mixed with the swept frequency output of the 1st local oscillator. The intermediate frequencies from the 1st mixer are amplified and fed through a filter circuit, with a 3 MHz center frequency, to the 2nd mixer. Spurious signals outside the 2.97 to 3.03 MHz bandpass of the filter are attenuated.

The 3 MHz IF signal is mixed with a 3.1 MHz 2nd local oscillator frequency and the 2nd intermediate frequency of 100 kHz is then applied through a variable resolution amplifier. The variable resolution amplifier provides a variable resolution bandwidth for the analyzer from $\leq$10 Hz to $\geq$500 Hz, by providing an adjustment of the bandwidth for the 100 kHz 2nd IF response.

The signal is then applied through a driver stage to both the recorder detector and the analyzer detector. The output video signal from the detector is attenuated through either a logarithmic or linear attenuator circuit for either a logarithmic or linear display. It is then amplified by a buffer and amplifier stage which drives the vertical deflection plates of the CRT in the associated oscilloscope.

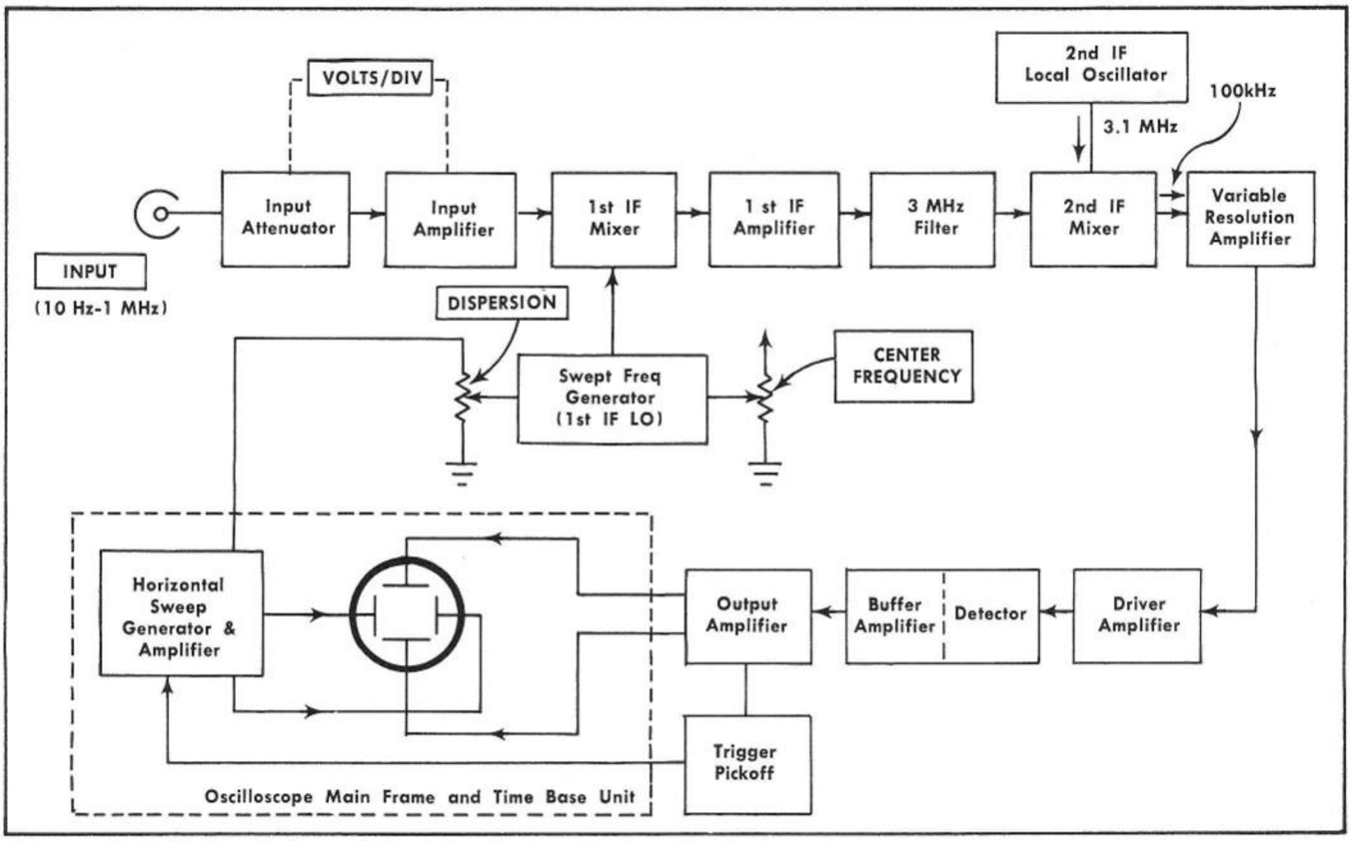


Fig. 3-1. Block diagram of basic circuits.

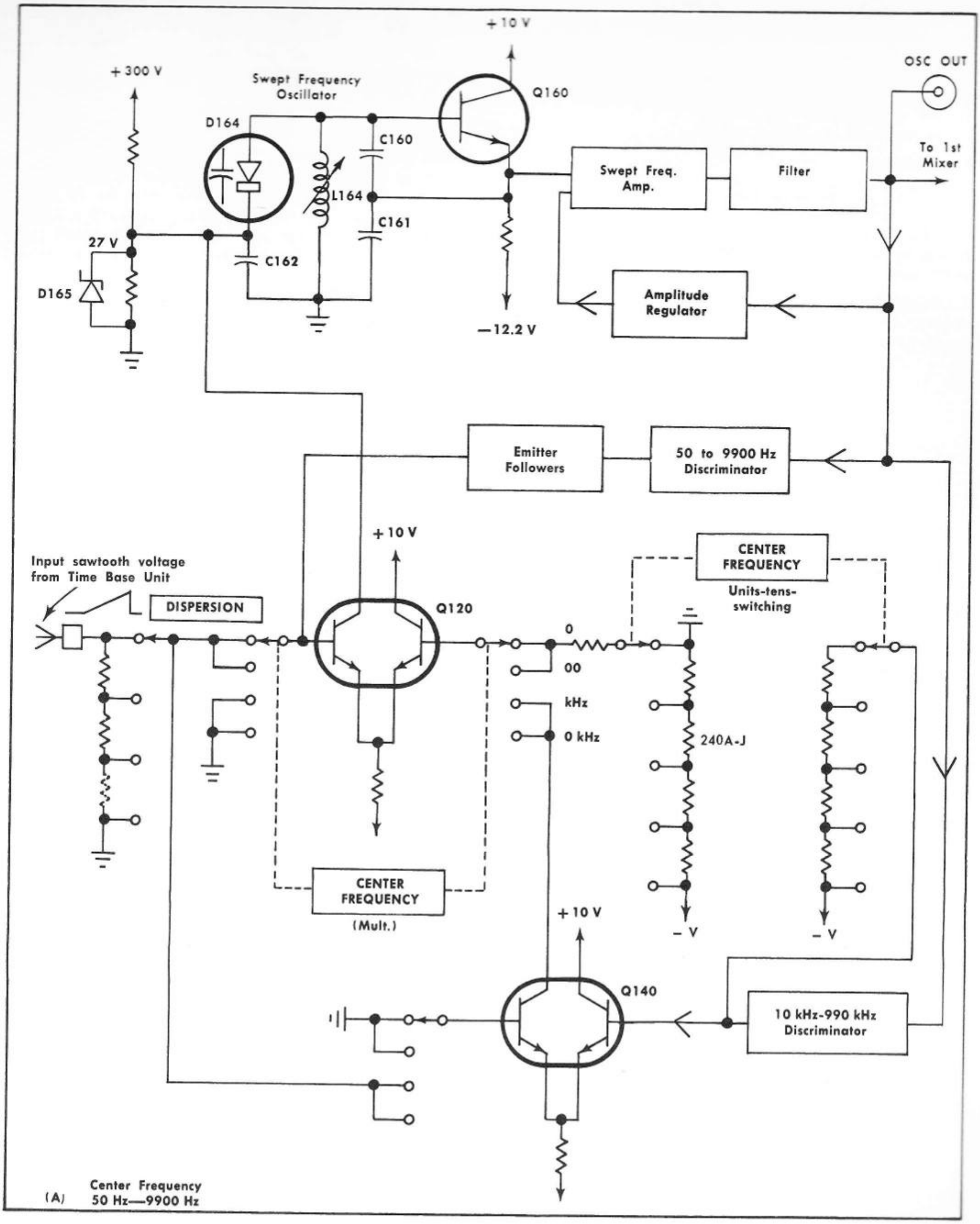


Fig. 3-2. Block diagram of swept oscillator circuit for 50 Hz to 9900 Hz center frequency range.

Part of the video signal is also picked off by the trigger pickoff circuit and applied through P11 of the Plug-In pin connector, to the associated time base trigger circuit for internal sweep triggering.

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 oscillator is indirectly swept by the same sawtooth voltage that causes the horizontal beam movement. The degree to which the oscillator is swept is a function of the DISPERSION controls. These controls are calibrated so the display can be read in Hz/division on the CRT graticule. 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, and compared with the input sawtooth from the SWEEP MODE selector. The output voltage from the comparator tunes the 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; the swept frequency width or dispersion can be varied from 100 kHz/div (1 MHz total for a 10 division 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 an amplifier 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. When the CENTER FREQUENCY switching is in either of the kHz ranges, the transmission line discriminator output is compared to the input sawtooth and Q120 becomes an amplifier for the output signal from Q140.

The 5 kHz Calibrator supplies a 5 kHz frequency markers to the input amplifier when the VOLTS/DIV selector is in the CALIBRATE position. These markers are used to check the dispersion and center frequency accuracy. A zero frequency marker burst or start spuria signal is supplied when the swept LO frequency is 3 MHz.

DETAILED CIRCUIT DESCRIPTION

Attenuators and Input Amplifier

This circuit controls the signal amplitude of the display and mixes the incoming signal with the 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 by the selector switch SW1. A GND position between the AC FAST and AC positions of the selector, grounds the input circuit when switching from AC coupling to AC FAST (DC). The GND position may be used to establish zero volt reference on the display without disconnecting the input signal.

The VOLTS/DIV attenuator establishes the deflection factor for the analyzer. Except for the .001 and .002 positions of the VOLTS/DIV selector, the basic deflection factor of the Type 3L5 for spectrum displays is 5 mV, RMS per division and 0.5 V peak to peak per division for the time domain (VERTICAL DISPLAY switch in the VIDEO position) displays.

The VOLTS/DIV attenuator provides a RMS deflection factor range from .001 V/div to 2 V/div in a 1, 2, 5 sequence, when the V/DIV ÷ 100 knob is pushed in. With the knob pulled out the gain is increased by a factor of 100. With the knob pushed in, the outer scale around the VOLTS/DIV selector indicates the deflection factor in peak voltage for the video displays.

Frequency compensated attenuation networks are used for each position of the selector to provide a constant input impedance and input time constant (1 Meg paralleled by approximately 30 pF). C-10 is adjusted to normalize this input time constant for all instruments.

Signal gain for the .001, .002 and .005 positions of the VOLTS/DIV selector is controled 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 and the drive for 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 signal is in phase with the input to the gate and reduces the gate to drain capacity of Q20.

D18, between the gate of Q20 and the —12.2 volt supply, limits the amplitude of the negative voltage swing to approximately —13 volts and protects both Q20 and Q30 from excess gate to source or base to emitter voltage.

The gain control stage consisting of Q40, Q42 and Q41 has an approximate gain of 2 when the VOLTS/DIV selector is at any of the positions between .005 and 2 volts and the VARIABLE control is in the CAL position.

The VARIABLE control R35 and resistor R36 form a voltage divider which provides a 3:1 range 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/DIV selector is in the .002 position, because R40-C40 shunts the feedback resistor R43 and reduces the signal feedback to Q41. The

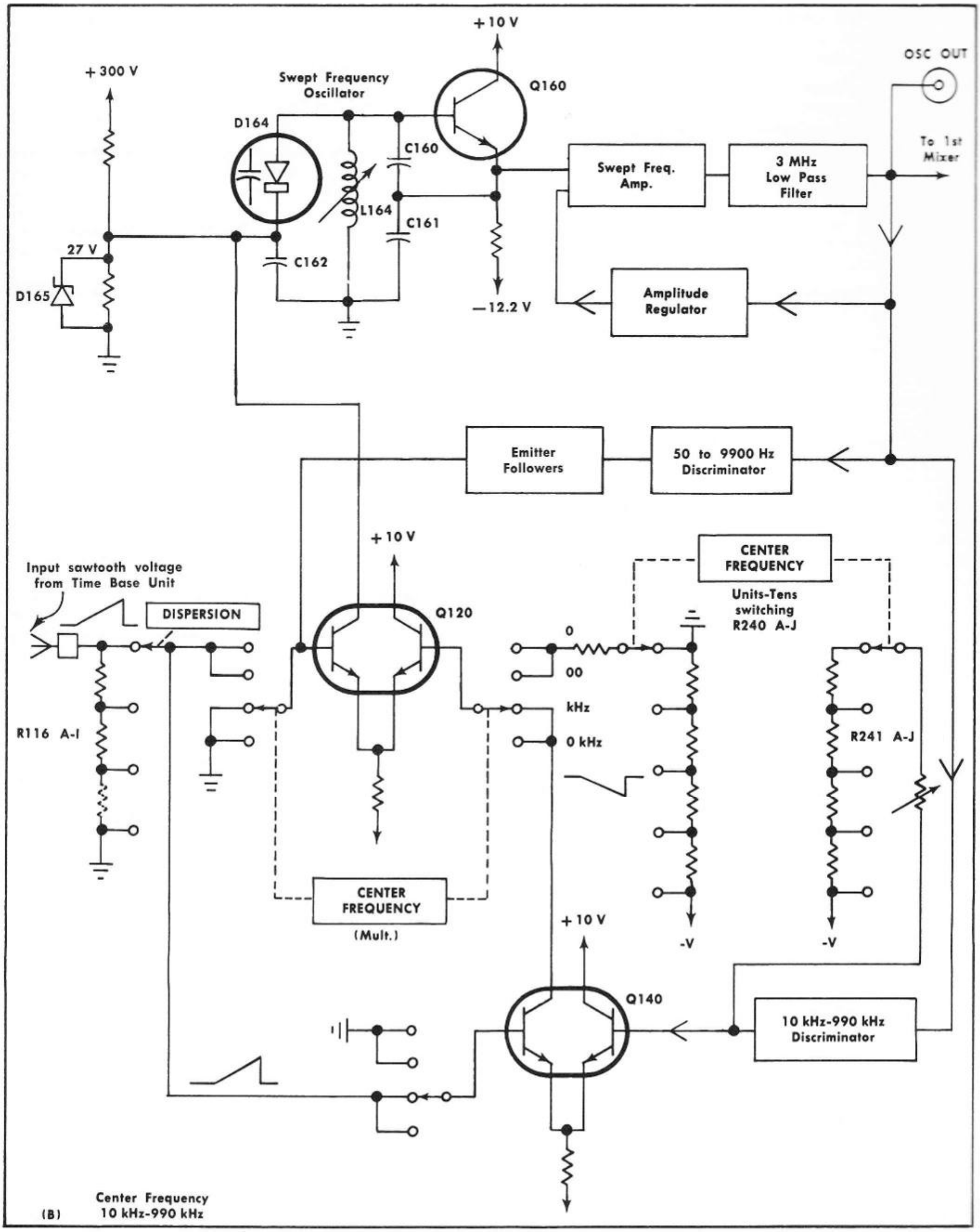


Fig. 3-3. Block diagram of swept oscillator circuit for 10 kHz to 990 kHz center frequency range.

gain of the stage is increased to about 10 when the VOLTS/DIV switch is changed to the .001 position.

The output amplifier stage is very stable and 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.

First Mixer

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

The 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, to provide a consant amplitude, linear calibration, of dispersion over the frequency range of the instrument. Frequency dispersion can be varied in calibrated steps from near zero to 1 MHz by the DISPERSION selector. The center frequency of the swept oscillator can be varied from 2 to 3 MHz by 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-C6161 is frequency swept by a negative-going sawtooth voltage that is applied to the voltage conrolled 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 range of Q120 and Q140, which shifts the DC level to the frequency determining circuit. The frequency dispersion is determined by the amplitude of the sawtooth voltage to D164. This voltage amplitude is a function of the input sawtooth voltage injected from the associated time-base unit and the setting of the front panel DISPERSION control. The DISPERSION control sets the amplitude of the sweeper voltage and the CENTER FREQUENCY multiplier switch selects the center frequency range (50-9900 Hz or 10 kHz-990 kHz).

To improve the frequency accuracy for the low frequency range (50 Hz to 9900 Hz), a crystal discriminator is switched into the loop and becomes the frequency to voltage converter. The crystal discriminator has a transfer gain which is approximately 100 times greater than the diode transmission line discriminator over the band of frequencies from 2.985 to 3.000 MHz. When the center frequency range is changed from Hz to kHz, the discriminator and sweep comparator are also changed. In the 50 Hz to 9900 Hz range, the crystal discriminator output signal is amplified and applied to comparator Q120. When the center frequency is changed to the 10 kHz to 990 kHz range, the transmission line discriminator output signal is applied with the sweep waveform to comparator Q140, and Q120 then becomes an emitter coupled amplifier.

The output signal of the oscillator is amplified and drives a push-pull power amplifier Q180-Q190. This amplified oscillator signal is applied through a 3 MHz low pass filter which attenuates harmonic multiples of the oscillator frequency, and reduces non-linearities that could result from these higher order harmonic frequencies.

The output oscillator signal to the 1st mixer is sampled by an amplitude regulator circuit which supplies a gain control bias to the power amplifier. This maintains a constant amplitude output signal to the feedback loop and to the 1st mixer, to provide uniform sensitivity and dispersion linearity over the frequency range of the Type 3L5.

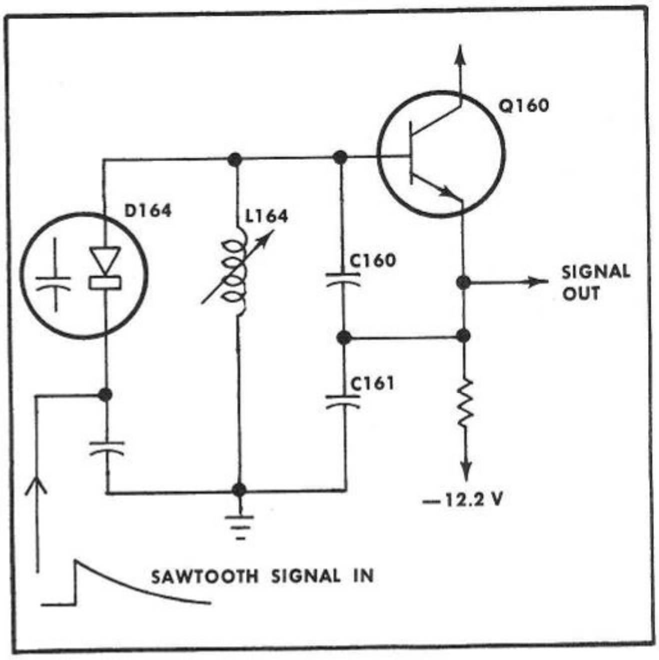


Fig. 3-4. Simplified diagram of the swept oscillator.

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 circuit to a center frequency of 3 MHz.

The DC level at the collector of Q120 or the cathode of D164 is clamped or prevented from dropping below about +9.2 volts by D163 when the CENTER FREQUENCY (MULTIPLIER) switch (SW120) is in the 50 Hz to 9900 Hz range; and clamped to about —0.6 V by D162 when the (MULTIPLIER) switch is in the 10 kHz to 990 kHz range.

Oscillator Amplifier

Emitter follower Q160 isolates the oscillator circuit from the loading of the voltage amplifier Q170. The amplified oscillator signal from the collector of Q170 is applied through the emitter follower Q171 and drives push-pull amplifier 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-C194, to the OSC OUT connector and 1st mixer.

A sample of the oscillator out 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 Q200. The voltage at the collector of Q200, coupled through zener diode D204, 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 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 $\frac{1}{8}$ 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 range. A sealed crystal unit provides approximately 100 times the transfer gain provided by the transmission line discriminator. Output signal from the discriminator is applied through the emitter followers Q130 and Q121 to the base of Q120. C138 tunes the discriminator to a center frequency of 3 MHz.

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 a Kelvin Varley attenuator. See Center Frequency switching.

Dispersion Switching

The DISPERSION selector SW115, provides calibrated dispersion in a 1, 2, 5 sequence over the range of 10 Hz/Div to 100 kHz/Div. The VARIABLE DISPERSION control R114 provides uncalibrated variable dispersion between each calibrated DISPERSION switch setting.

The horizontal sweep sawtooth from the time-base plug-in unit is connected to the INT position of the SWEEP MODE switch SW110. The amplitude of the sawtooth signal to the base of either Q120 or Q140 is a function of the DISPERSION Hz/DIV selector position. Front panel adjustments R110 and R114 calibrate the dispersion at a center frequency of 30 kHz and 5000 Hz. Switching the SWEEP MODE to MANUAL position provides manual dispersion control. R104 provides a 100 volt range which is comparable to the sawtooth voltage injected in the INT position of the SWEEP MODE switch.

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 FREQUENCY-Hz selector SW235A and SW235B. 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 diagram) is basically a Kelvin-Varley circuit. The (TENS) section is made up of 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 means of the 10 kHz CAL adjustment R232, which connects through R230 to the +125 volt supply, and the 500 kHz calibration adjustment R239, plus the VARIABLE CENTER FREQUENCY control R238, to the —100 volt supply.

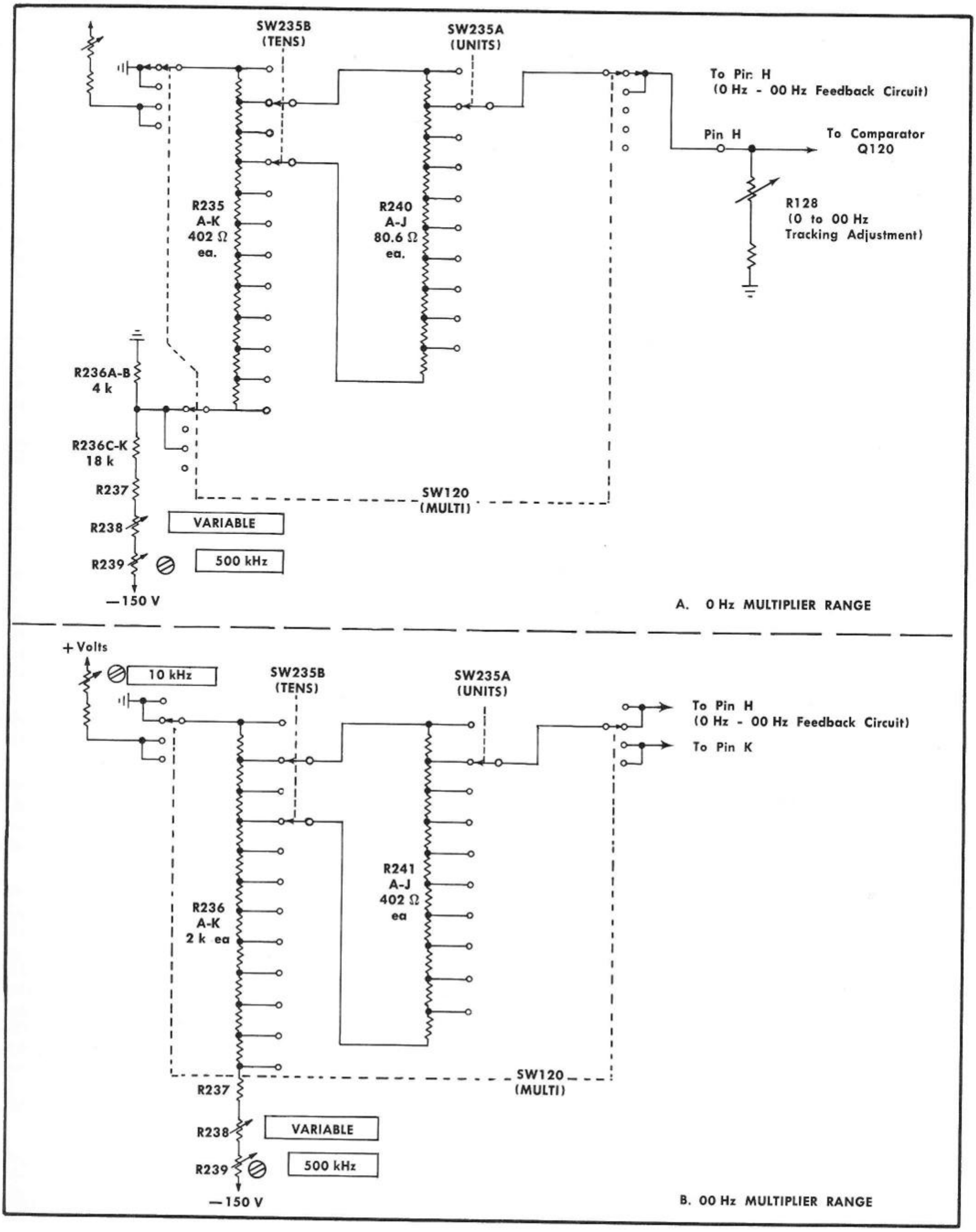


Fig. 3-5. Center frequency switching.

the 500 kHz calibration adjustment R239, plus the VARIABLE CENTER FREQUENCY control R238, to the —100 volt supply.

Dispersion Warning Light Switching

The REDUCE DISPERSION light provides a warning to the operator that the display will not meet dispersion accuracies, and he must reset either the CENTER FREQUENCY or the DISPERSION selectors. The indicator lights when the DISPERSION is set so the total indicated dispersion exceeds the instrument capabilities. For example: With the DISPERSION set to 100 kHz/DIV 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 to the +300 volt power supply.

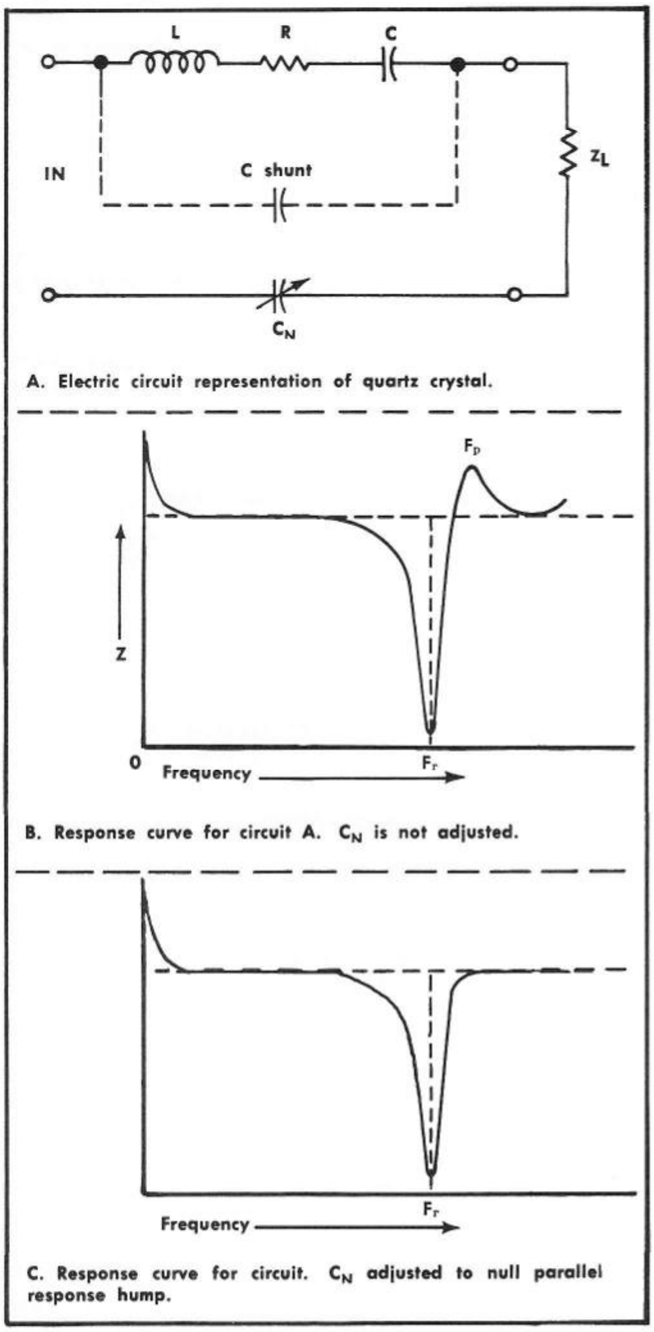


Fig. 3-6. Crystal filter equivalent circuit and impedance response curves.

Variable Resolution Amplifier

The resolving ability of the analyzer is a function of the variable resolution amplifier circuit. This circuit adjusts the resolution bandwidth 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 of 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.

The gain through the IF amplifier Q310 is controlled by 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. A portion of the collector signal of Q320 is coupled through C323 to neutralize the effect of the shunt capacitance of the quartz crystal 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 circuit stray capacitance. This parallel tuned circuit is shunted by the input impedance of amplifier Q330. Resolution bandwidth of the circuit is dependent on the characteristic 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 crystal[1]. 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 decerases and the series resonant response characteristic of the crystal becomes the dominant factor in determining the bandwidth of the circuit. The load-

[1] (Ref: F. Langford-Smith Radiotron Designars Handbook; 4th edition.)

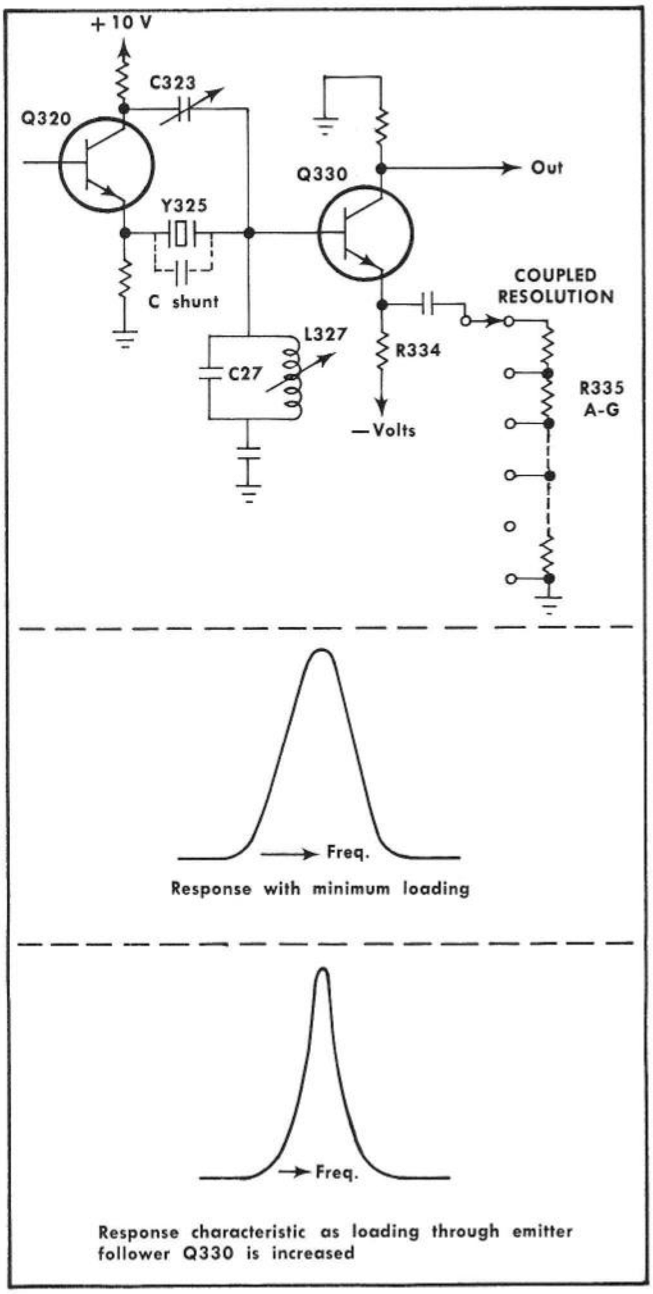


Fig. 3-7. Basic variable resolution circuit.

ing 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).

For an example, the beta of the transistor Q330 is approximately 200. When the COUPLED RESOLUTION switch SW335 is fully counterclockwise, there is an AC coupled load resistance of approximately 10 Ω between the emitter and ground. This sets the transistor input impedance to approximately 2,000 ohms (10 Ω 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 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

The 100 kHz 2nd IF signal from the variable resolution amplifier is applied through the VERTICAL DISPLAY switch to a operational amplifier Q400, which is driving another operational amplifier Q401 and Q410. Gain through Q400 is primarily set by the ratio of R402 and R400. 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 when it is in the VIDEO position. This prevents spectrum signals and noise from interfering with the video amplifier 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 spectrum display detectors are connected as a voltage doubler to provide the 60 dB dynamic range for the LOG display.

A pre-bias current of approximately 1 μA through R421 and the two diodes D420-D422 to the POSITION control increases the detector sensitivity to low amplitude signals. Additional compensation is also provided in the feedback circuit for 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 at a slightly higher level than D420 and D422, which AC couples a detected signal to the input of the operational amplifier and raises the gain of the amplifier, providing 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 emitter follower Q420 driving the emitter follower Q430.

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

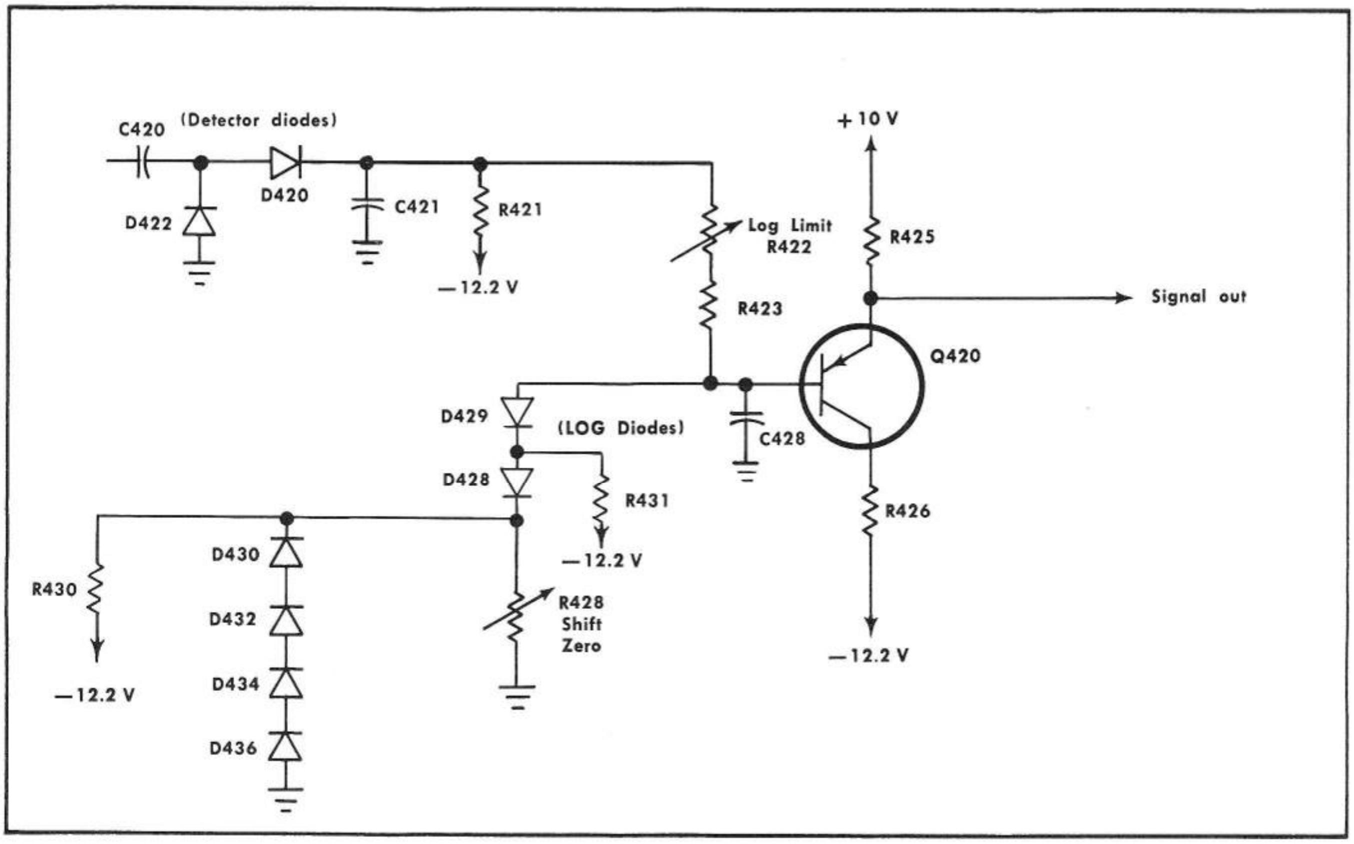


Fig. 3-8. Simplified drawing of the LOG attenuator circuit.

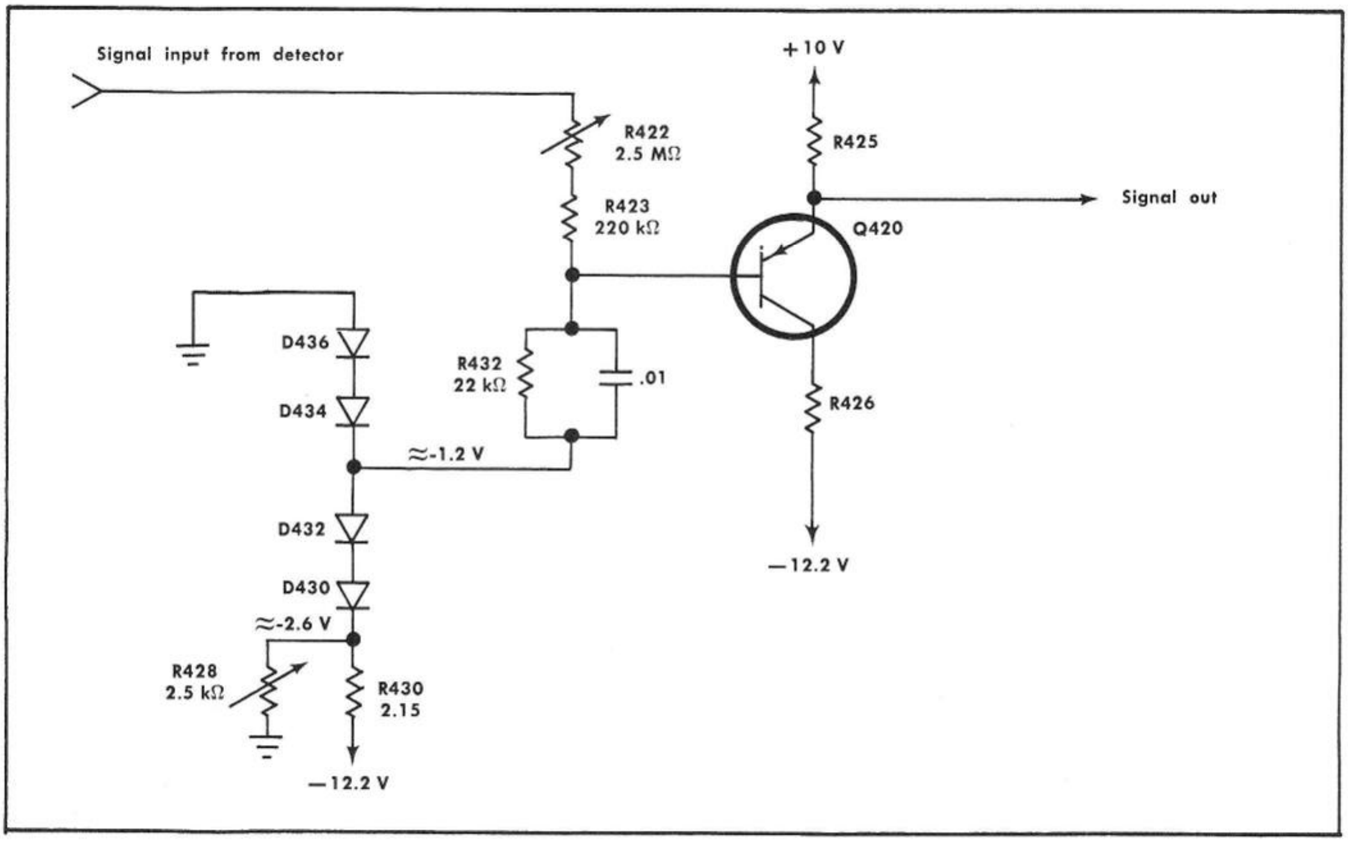


Fig. 3-9. Simplified LIN attenuator circuit.

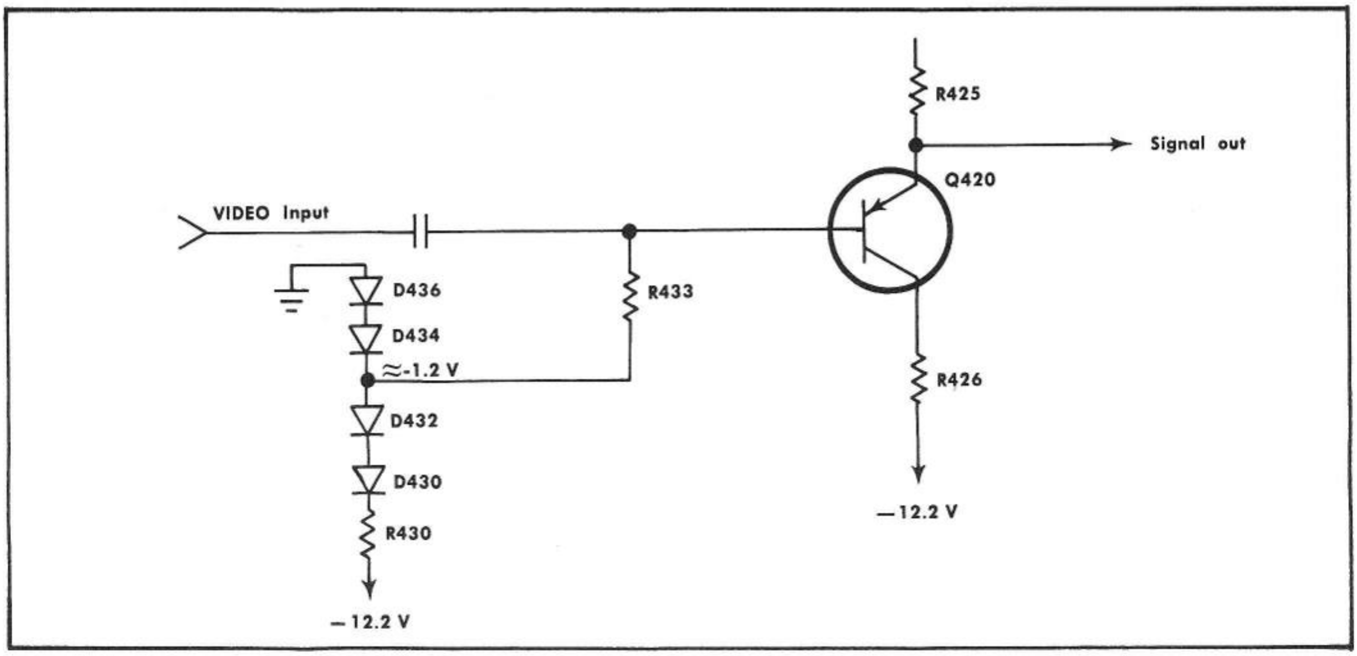


Fig. 3-10. Simplified VIDEO attenuator input circuit.

diodes. R423 and R422 become the signal current source for the diodes so the voltage at the base of Q420 becomes a logarithmic function.

R428 estabilshes the zero voltage point by setting the pre-bias current through the log diodes. R440 and R422 sets 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.

For VIDEO operation (Fig. 3-10) the base of transistor Q420 is returned through R433 to the fixed voltage source.

The output amplifier section contains a trigger pickoff circuit Q441, Q442, and an emitter coupled paraphase amplifier Q450-Q460 driving a push-pull output amplifier V480.

A signal voltage input to the paraphase amplifier generates the current drive for the output amplifier, which is connected as an operational amplifier. An input voltage of approximately 1.5 volts at the base of Q450 sets the collector current of Q450 to approximately 2 mA. Approximately 1 mA of this current is supplied through R455 with the remaining 1 mA flowing through R454. A current of approximately 1 mA through R454 sets the output signal voltage to the vertical deflection plates to approximately 182 volts.

The gain through the paraphase amplifier is set by the VIDEO CAL adjustment R462. Vertical positioning is provided by R468, which offsets the current balance through the paraphase amplifier and the drive to the output amplifier.

Diodes D464-D466 and D454-D456 decrease the recovery time and prevent overdriving the output amplifier. Feedback capacitors C490-C491 and C480-C481 improve the risetime response of the amplifier.

The trigger amplifier is an operational amplifier. Input impedance to the amplifier is high; therefore, this stage isolates the input to the paraphase amplifier from the triggering circuits. Gain of the amplifier is primarily set by the ratio of R446 and R445.

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 3L5 unit is changed to another oscilloscope. When the VOLTS/DIV selector is in the CALIBRATE 4 DIV 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 complimentary (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 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 contact arm of potentiometer R522. This signal is rich in harmonics and provides 5 kHz calibration markers for the spectrum display.

Power Distribution and the 10 Volt Supply

All voltages except the +10 volts are distributed from the oscilloscope power supply. The +10 volt supply is regulated and provided by Q600 and Q601. Q600 is the control amplifier which sets the current through the regulator Q601.

NOTES

SECTION 4
MAINTENANCE

Introduction

This section of the manual pertains to the maintenance and troubleshooting of the Type 3L5. The first portion describes some general preventive measures to help minimize major problems. This is then followed by some maintenance techniques and information on replacing components and circuit boards. The section 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 usually operated under adverse conditions (such as a high temperature or a dusty or corrosive atmosphere). Even 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 solvents.

Interior Cleaning

Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high-humidity conditions. The best 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 narrow spaces or for cleaning ceramic terminal strips and circuit boards.

Lubrication

The reliability of potentiometers, rotary switches and other moving parts can be increased if they are kept 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 a thorough 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 overheating before the damaged parts are replaced; otherwise, the damage may be repeated.

Transistor Checks

Periodic preventive maintenance checks, consisting only 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. Details of in-circuit transistors 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 is an aid in the isolation or major troubles in the instrument, and in location of minor troubles which may not be apparent during regular operation. Instructions on how to conduct a performance check are 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 in this instrument are described in this section.

Obtaining Replacement Parts

Local Purchase. All electrical and mechanical parts replacements for the Type 3L5 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 is 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 List contains instructions on how to order replacement parts from Tektronix.

NOTE

When selecting the replacement parts, 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 manufacured or seleced by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronics, Inc., in accrdance with our specifications. These special parts are indicated in the Parts List by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. 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 to act as a heat sink between the soldered or 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 thermostet plastic.

When soldering to a wafer-type switch, do not let the solder flow around and beyond the rivet on the switch ter-

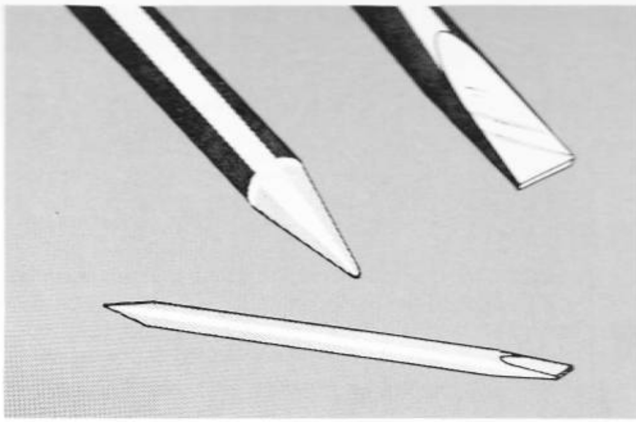


Fig. 4-1. Soldering aid for use with bare wires.

minal. The spring tension of the switch contact may be destroyed by excess solder and the switch need to be replaced.

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-nosed 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.

5. Clip the excess lead 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 the 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 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. If a wire extends beyond the solder joint, clip off the excess.

4. Clean the flux from the solder joint with a flux-remover solvent to maintain good environmental characteristics.

Component Replacement

Transistor Replacement. Transistors, field effect transistors 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 transistors are replaced, check the calibration of that portion of the circuit.

In many cases, component damage may occur as a result of inserting transistors incorrectly in the sockets. Lead configuration differs between manufacturers. Some transistors have the lead code configuration stamped on the case. Before the semiconductor is removed, note its physical orientation in the socket so that it can be re-inserted correctly. If there is doubt about the correct lead configuration, refer to the manufacturer's base diagram. Fig. 4-3 illustrates both the transistor lead configuration and the socket connection, for 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 normally are not replaced. If a switch is defective, replace the entire assembly. Replacement switches can be ordered either wired or unwired; refer to the Parts List for the applicable part numbers.

Circuit Board Assembly Replacement. If a circuit board is damaged and cannot be repaired, a circuit board without components, or, if desired, a unit completely wired with components mounted may be obtained by the normal ordering procedure.

The Dispersion and Variable Resolution circuit boards may be removed by disconnecting the push-on square pin connectors, removing the mounting screws and lifting the circuit boards out of their positions. The Input Amplifier circuit board is removed as follows:

1. Remove the VOLTS/DIV and V/DIV ÷ 100 knobs and mounting nuts.

2. Remove the VOLTS/DIV switch and circuit board mounting screws.

3. Disconnect the pin connectors and unsolder R15.

4. Lift the VOLTS/DIV assembly up and back until the V/DIV ÷ 100 switch linkage is clear, then slide the board out from under the switch assembly.

Figures 4-4 through 4-7 show the wiring color code for the circuit boards and should be used to indicate the location of each pin connector.

Component Numbering and Identification

The circuit number of each electrical part is shown on the circuit diagram. A functional group of circuits (such as the Input Amplifier) are assigned a particular series of numbers. Table 4-1 lists the assigned component numbers for the various circuits.

TABLE 4-1

Circuit Number Location

Circuit No.	Diagram	No.
1-99	Attenuators and Input Amplifier	1
100-249	Swept-Frequency Generator Center Frequency Switching Dispersion Warning Light Switching	2 3 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 identified. The circuit board sections of the diagrams are outlined in blue, to aid in locating 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 stripe 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 code, varying from a solid color and no stripes, to a solid color and one or more stripes, is an aid in point-to-point circuit tracing.

TABLE 4-2

Power Supply Wiring

Supply	Background Color	1st Stripe	2nd Stripe	3rd Stripe
−10 V[1]	Tan	Brown		
+10 V[1]	White	Brown		
−12.2 V	Tan	Brown	Red	Black
−100 V	Tan	Brown	Black	Brown
+125 V	White	Brown	Red	Brown
+300 V	White	Orange	Black	Brown

[1]Exception: Color code partially conforms to EIA standard.

Resistor Color Code. A number of precision metal-film resistors are used in this instrument. These resistors can usually be 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 33 kΩ resistor will be color coded, but a 333.5 kΩ resistor will have its value printed on the resistor body. The color code sequence is shown in Fig. 4-2.

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

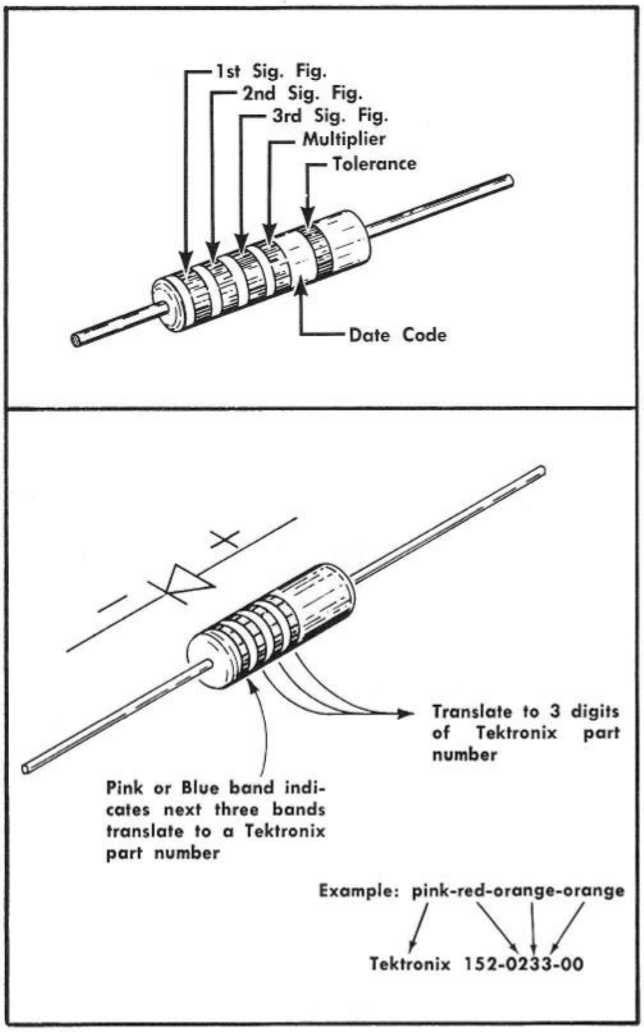


Fig. 4-2. Color coding of metal film resistors and signal diodes.

Switch Wafer Identification. Switch wafers shown 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. 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 partcular switching function.

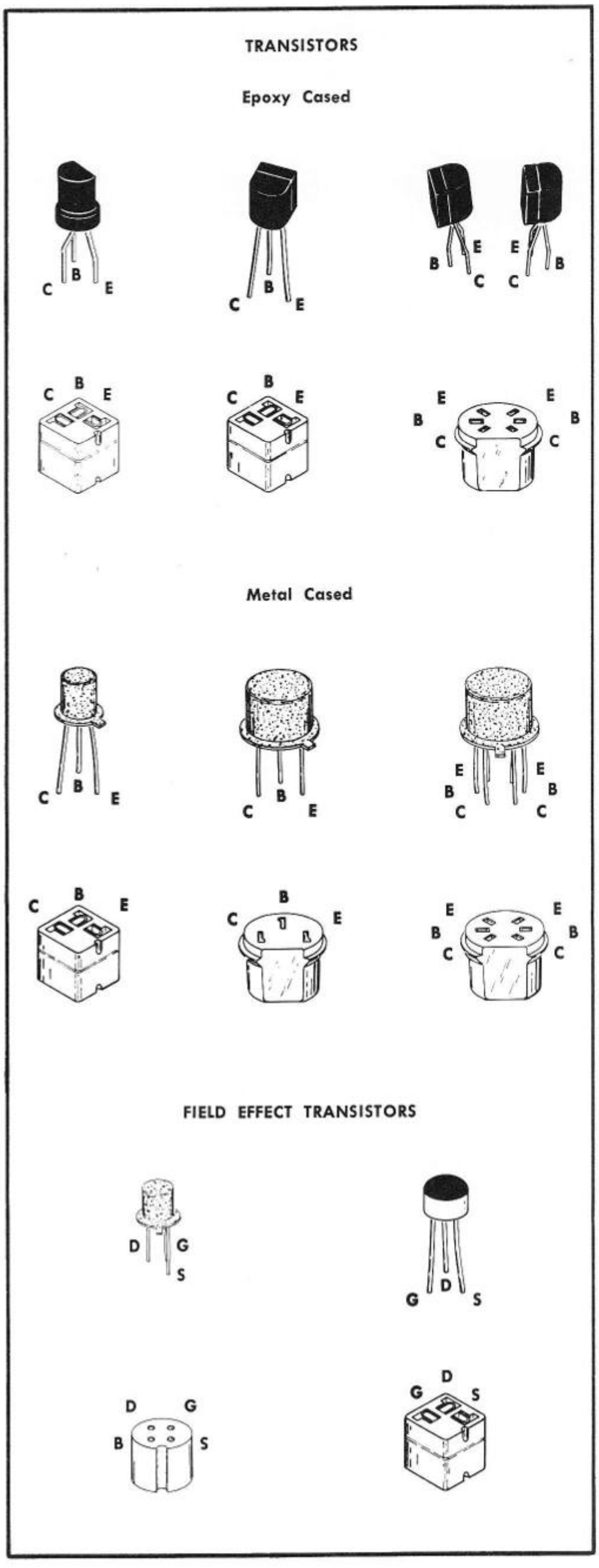


Fig. 4-3. Electrode configuration for socket-mounted transistors and FET's.

TROUBLESHOOTING

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 3L5, and not improper control settings or malfunctioning associated equipment. Note the effect the controls have on the trouble symptoms. Normal or abnormal operation of each control helps establish the location and nature of the trouble. Control functions are described in the Operations section.

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

Check circuit voltages and waveforms against those shown in section 9 of this manual. Fig. 4-4 through Fig. 4-8 provide board wiring drawings and component layout information. It is usually best if the trouble is not isolated to a circuit to 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 circuit 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 circuit boards provide a unique method to isolate circuit resistances and voltages. Check circuit conditions before disconnecting voltages to make certain that bias voltages are not removed which could cause excessive overloads.

Transistors and F.E.T. Substitution or Replacement

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. If a transistor is removed be certain to replace it in the same position in the socket. Fig. 4-3 shows the correct connections for the types of transistors and field effect transisors used in the Type 3L5.

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.

NOTES

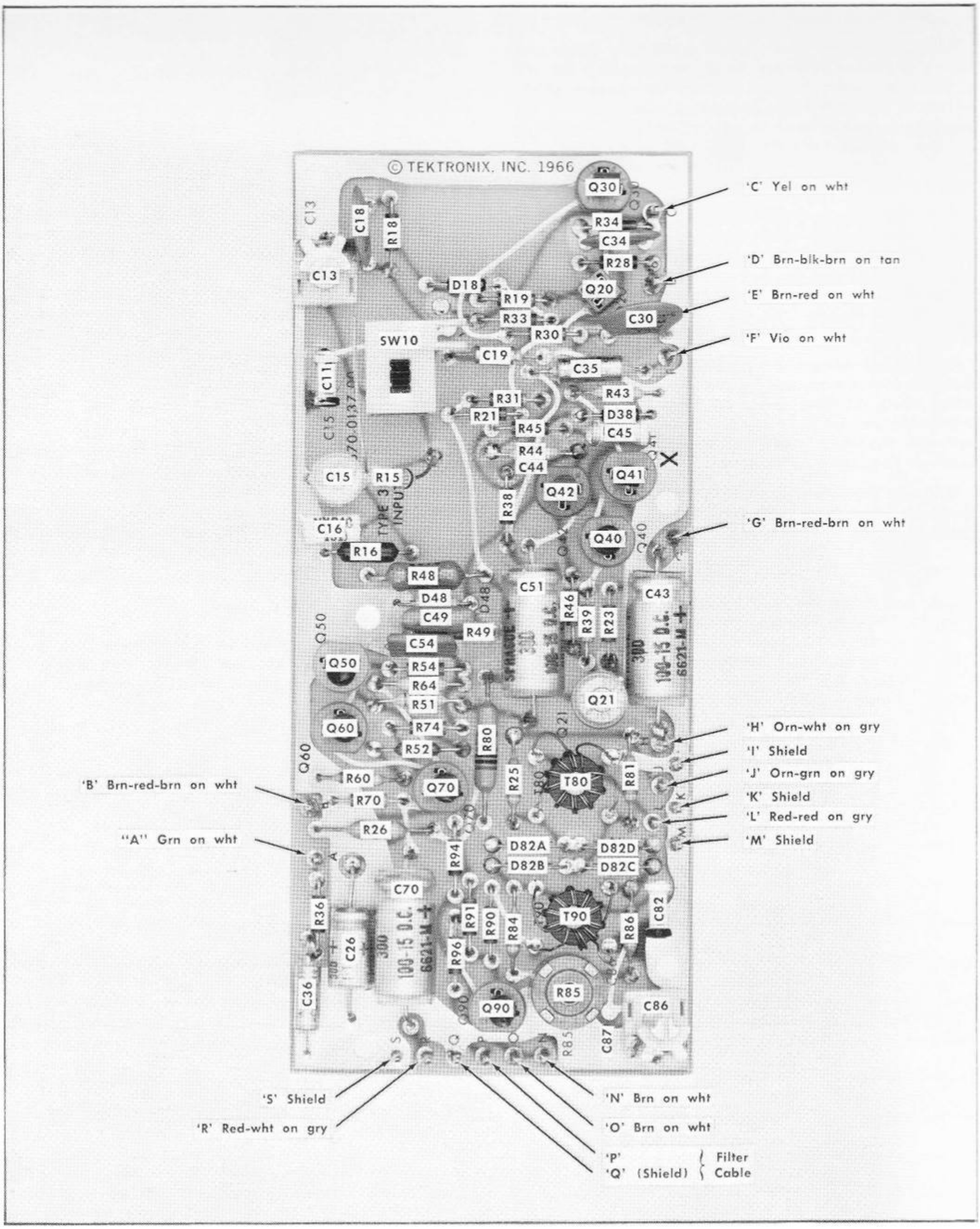


Fig. 4-4. Input Amplifier and 1st IF Mixer Circuit Board.

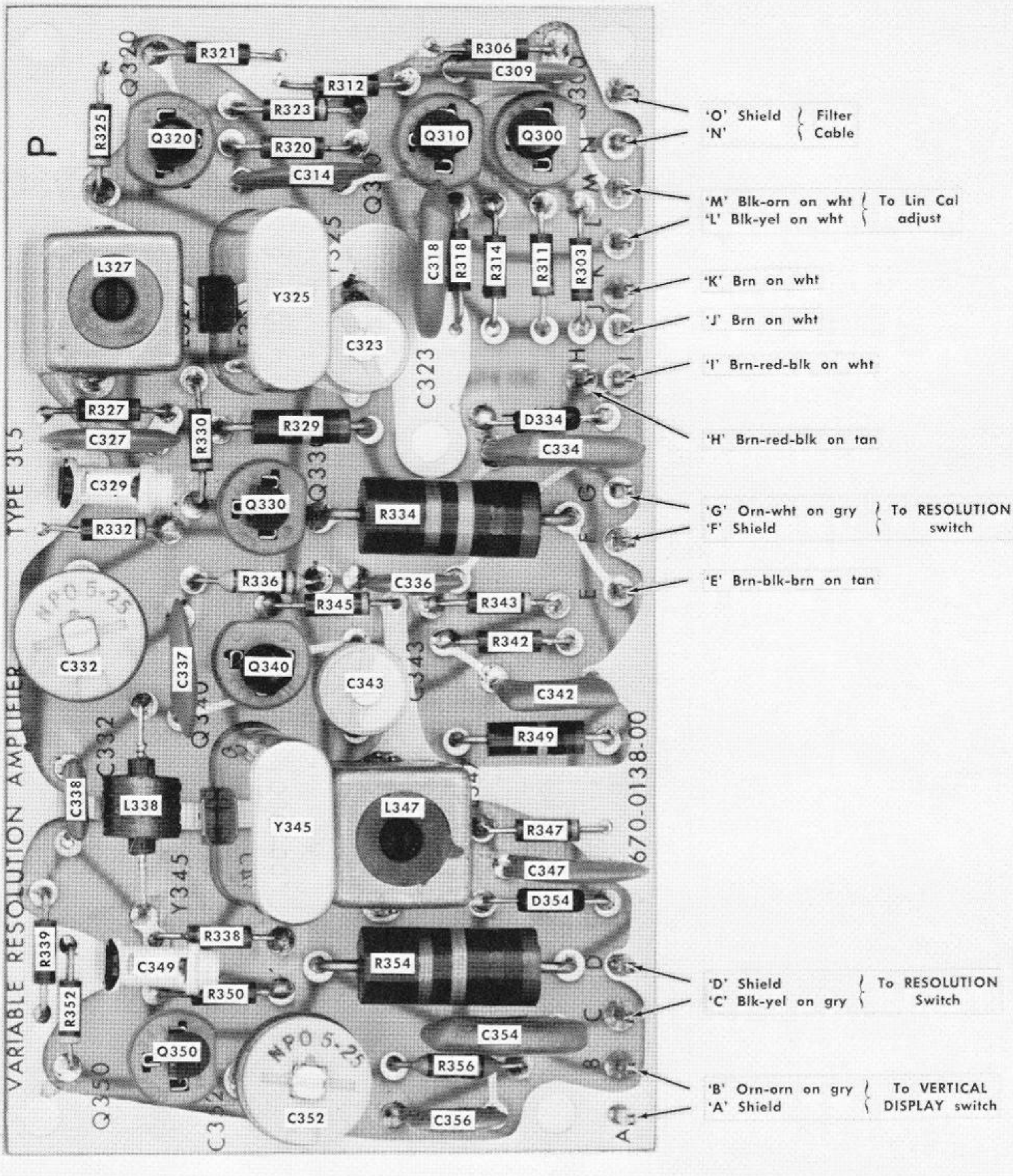


Fig. 4-5. Variable Resolution Circuit Board.

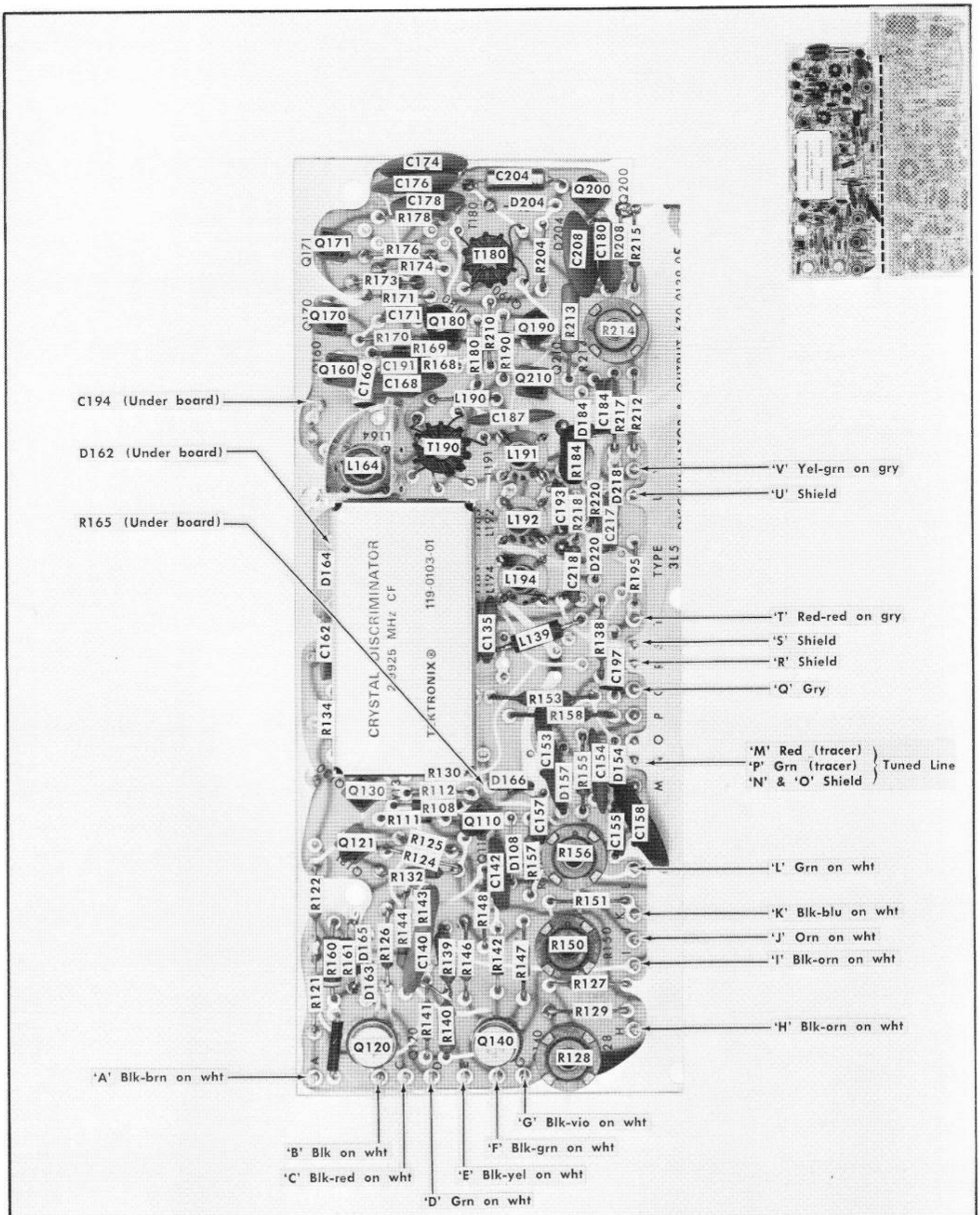
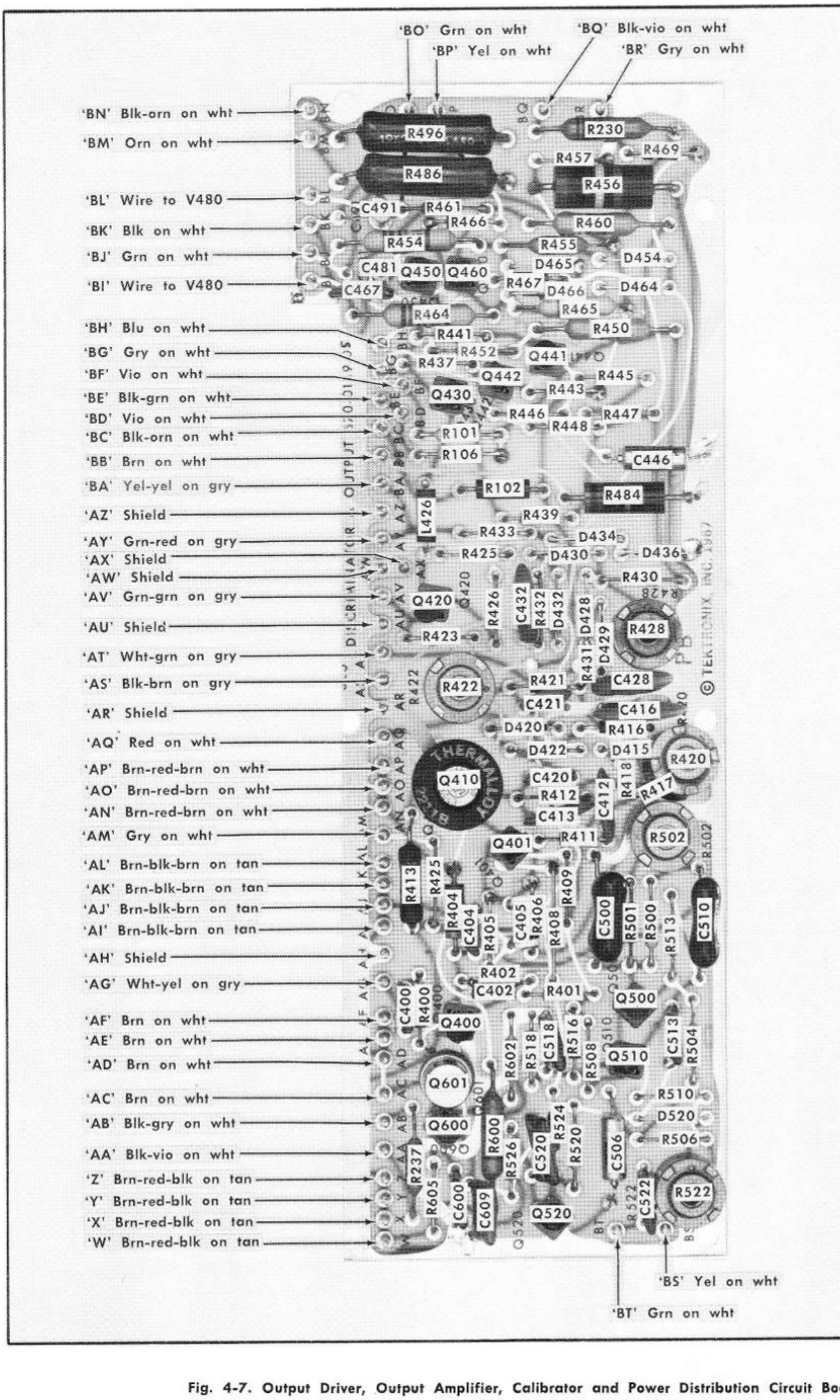


Fig. 4-6. Swept Frequency Generator Circuit Board.



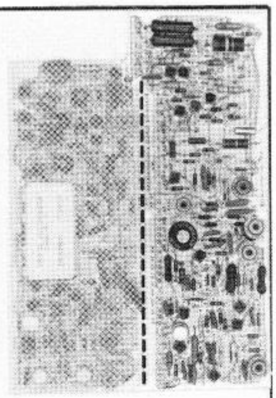


Fig. 4-7. Output Driver, Output Amplifier, Calibrator and Power Distribution Circuit Board.

SECTION 5
PERFORMANCE CHECK

This section of the manual provides a means of checking the performance of the Type 3L5. 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. Tektronix Type 564 or 561A with a 2B- or 3B-series time-base plug-in unit. The oscilloscope square-wave transient response must be correct for the Type 3L5 to make bandpass characteristics. Adjust, by using the 560-Series CRT Capacitance Standardizer; Tektronix Part Number 067-0500-00. This oscilloscope should be the oscilloscope in which the Type 3L5, being calibrated, will normally be used, because the front panel adjustments will have to be reset if the analyzer is changed to another oscilloscope. A Type 564 Storage Oscilloscope with a Type 3B4 Time-Base Plug-In Unit is used for this procedure.

2. Test Oscilloscope. Minimum requirements: Bandwidth, DC to 10 MHz; vertical sensitivity and accuracy, 0.005 V/Div to 10 V/Div, ±3%; sweep rate and accuracy, 1 s/div to .2 μs/div, ±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 μs (100 kHz); marker accuracy, within ±.001%. Tektronix Type 184 Time-Mark Generator.

4. Two, (2) Low-Frequency Signal Generators. Minimum requirements: Frequency output and accuracy, 10 Hz to 1 MHz, ±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 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, ±0.3%. Tektronix Part Number 067-0502-00.

7. Step Attenuator, 600 Ω. 0 to 51 dB with combinations of 1, 2, 4, 8, 16 and 20 dB. Tektronix Part No. 011-0093-00.

8. Probes:

a. P6006, 10× Passive Probe. Tektronix Part Number 010-0127-00.

b. P6011, 1× Passive Probe. Tektronix Part Number 010-0193-00.

9. Input RC Normalizer: RC = 1 MΩ × 30 pF, equipped with BNC connectors. Tektronix Part Number 067-0552-00.

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

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

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

13. Termination, BNC, 600 Ω. Tektronix Part Number 011-0092-00.

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

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

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

17. Binding posts to BNC plug. Tektronix Part Number 013-0094-00.

16. Miniature phone plug and 600 Ω load. Test fixture to check TO RECORDER signal amplitude. Consists of a 600 Ω, 5%, ½ watt resistor soldered across a miniature phone plug. See item 17 of Fig. 6-2.

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 3L5 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.

Install the Type 3L5 with the Time-Base Unit into the vertical and horizontal compartments 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 warmup time before checking the instrument to given accuracies.

Preliminary Procedure

1. Perform the front panel calibration adjustments as outlined in the Operating Instructions, Section 2.

2. Preset the front panel controls as follows:

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

Time-Base Unit

Time/Div	.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 at 990 kHz center frequency.)

a. Set the 0 Hz spurious signal to the graticule center with the 0000 Hz CF CAL adjustment as the Hz/DIV COUPLED RESOLUTION is reduced to 10.

b. Return the Input Coupling selector to AC position, set the CENTER FREQUENCY-Hz selector to 50 and the DISPERSION Hz/DIV selector to 20.

c. Apply a 50 Hz signal from the Low Frequency Signal Generator through a 50 Ω termination to the Type 3L5 INPUT connector.

d. Check—The 50 Hz signal must be displayed within the graticule area. [CENTER FREQUENCY accuracy, ±(5% +50 Hz) for the 50 Hz to 990 Hz range.]

e. Change the CENTER FREQUENCY-Hz setting to 990 kHz, the DISPERSION-Hz/DIV and coupled RESOLUTION to 100 k and the Time/Div to 50 ms. Increase the frequency from the signal generator to 990 kHz.

f. Check—The 990 kHz signal must be displayed within 0.6 major division from the graticule center.

g. Decrease the DISPERSION-Hz/DIV to 10 k.

h. Rotate the CENTER FREQUENCY-Hz VARIABLE control through its range. Note the total signal shift in divisions.

i. Check—VARIABLE control range must equal or exceed 10 kHz. (≥1 division with a dispersion of 10 kHz/div.) This will extend the Center Frequency 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	± (5% +50 Hz +50 Hz/°C)
1000 Hz to 9900 Hz	± (5% +100 Hz +100 Hz/°C)
10 kHz to 99 kHz	± (5% +3 kHz +200 Hz/°C)
100 kHz to 990 kHz	± (5% +10 kHz +200 Hz/°C)

a. Position the CENTER FREQUENCY-Hz VARIABLE control in the CAL detent. Apply the frequencies listed in Table 5-1 to the Type 3L5 INPUT connector and check the CENTER FREQUENCY-Hz selector tracking. The DISPERSION Hz/DIV—COUPLED RESOLUTION should be set to the narrow dispersion (10 to 100 Hz) positions when checking the low frequency end of the CENTER FREQUENCY-Hz range and increased to the wide dispersion (500 to 100 k) settings for the kHz range of the CENTER FREQUENCY-Hz selector. The sweep rate must also be adjusted for optimum signal defination 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	± (5% +50 Hz)
1000 Hz, 5000 Hz, 9900 Hz	1000, 5000, 9000	± (5% +100 Hz)
10 kHz, 50 kHz, 99 kHz	10 k, 50 k, 99 k	± (5% +3 kHz)
100 kHz, 300 kHz 650 kHz, 900 kHz	100 k, 300 k, 650 k, 900 k	± (5% +10 kHz)

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

Requirement: The VIDEO deflection factor accuracy is within 3% for all positions of the VOLTS/DIV selector with the V/DIV ÷ 100 knob pulled out and within 6% with the V/DIV ÷ 100 now pushed in.

a. Apply the output signal from the Standard Amplitude Calibrator (SAC) through a 50 Ω termination to the Type 3L5 INPUT connector.

b. Set the front panel controls as follows:

VERTICAL DISPLAY	VIDEO
VOLTS/DIV	.5
VARIABLE	CAL
V/DIV ÷ 100	Knob pulled out
Input Coupling Switch	AC
Time Base Unit	
Time/Div	.1 ms
Triggering	Free Running

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

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

Table 5-2

Analyzer VOLTS/DIV Switch Setting (Outer Scale)	SAC Output in Volts	Display Amplitude in Divisions	Maximum Error in Minor Divisions
.1	5 mV	5	±1.5
.2	10 mV	5	±1.5
.5	20 mV	4	0 (Set in 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
Fully counterclockwise (2 on inner scale)	10 V	5	±1.5
Push in V/DIV ÷ 100 knob			
.5	2 V	4	±1.2

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

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

g. Check—Display amplitude should decrease to 2 divisions or less. (VARIABLE control range ≥3:1.)

4. Check POSITION Control Range

Requirement: POSITION control must shift the trace + and —8 divisions with reference to the bottom graticule line.

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

b. Change the SAC output to 10 volts and turn the POSITION control fully clockwise.

c. CHECK—Bottom of the display must position on or above the center graticule lines.

d. Set the SAC output to 20 volts, then 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

Performance Requirement: The baseline should not shift off the graticule when the VERTICAL DISPLAY switch setting is changed from LIN to LOG.

a. Uncouple the RESOLUTION control and turn fully counterclockwise.

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

c. Check—The baseline must remain within the graticule area when the VERTICAL DISPLAY is switched between LIN and LOG positions.

6. Check Spurious Signal Amplitude and Noise Level

Requirement: With a 50 db signal applied above a reference of 1.0 divisions, LOG mode; the amplitude of spurious signals, (except the start spurious signal, fundamental and harmonics) must not exceed 1.0 divisions. With the input grounded, and maximum gain, the amplitude of spurious signals must not exceed 2× the noise level.

a. Set the front panel controls as follows:

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

b. Apply a 500 kHz signal from the Low Frequency Signal Generator through three (3) 5× attenuators and a 50 Ω termination to the Type 3L5 INPUT connector.

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

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

e. Check—Amplitude of spurious signals must not exceed 1.0 divisions. Except the 0 Hz start signal, fundamental and harmonics.

f. Remove the signal from the signal generator.

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

CENTER FREQUENCY-Hz	500 k
DISPERSION Hz/DIV	100 K
VERTICAL DISPLAY	LIN
VOLTS/DIV	.001
V/DIV ÷ 100	Pulled out
Input Coupling	GND
Time/Div	.5 s

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

i. Set the Input Coupling selector to AC position.

j. Check—Amplitude of spurious signals, within the dispersion window except the 0 Hz start signal, must not exceed 2× noise level. See Fig. 5-1.

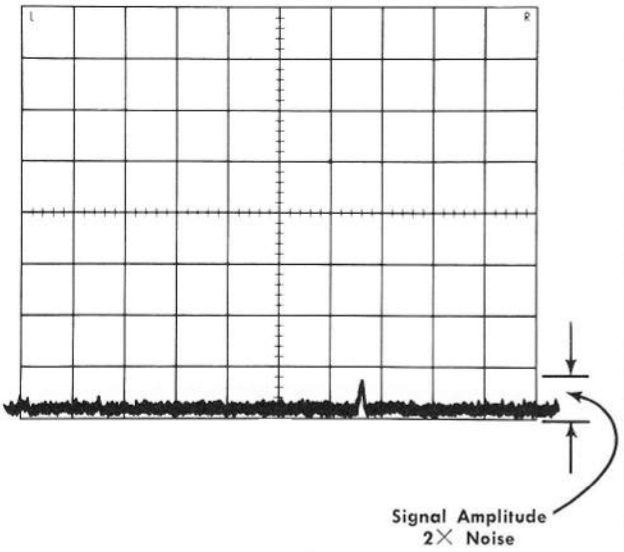


Fig. 5-1. Typical display illustrating signal to noise ratio less than 2:1.

7. Check 0 Hz Spurious Signal Feedthrough

The 0 Hz feed through signal amplitude is normally 1 to 4 divisions. This is not a requirement just a check.

a. Set the front panel controls as follows:

VERTICAL DISPLAY	LIN
VOLTS/DIV	.005
CENTER FREQUENCY-Hz	0000
DISPERSION Hz/DIV	100 K
Input Coupling	GND
Time/Div	50 ms

b. Check—Amplitude of 0 Hz (zero frequency feedthrough signal) should measure between 1 and 4 divisions.

8. Check Resolution Bandwidth

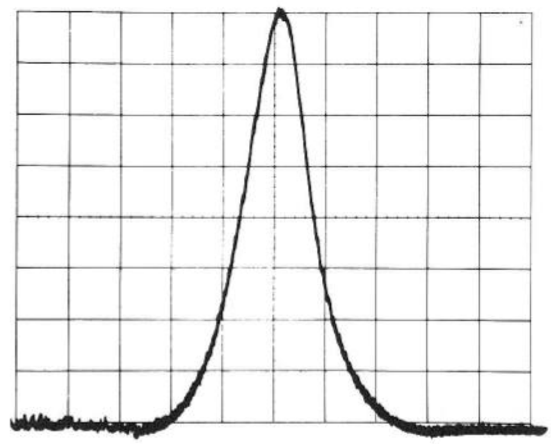
Requirement: Resolution can be varied from a bandwidth equal to or less than 10 Hz to 500 Hz or more.

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	5000
VERTICAL DISPLAY	LIN
DISPERSION-Hz/DIV	500
RESOLUTION	Uncoupled and fully clockwise
VOLTS/DIV	.005
Input Coupling	AC
Time/Div	50 ms

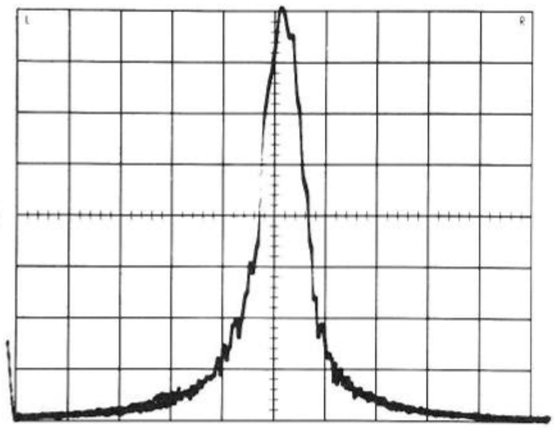
b. Apply a 5 kHz signal from the signal generator to the Type 3L5 INPUT connector. Adjust the frequency and amplitude of the signal for a centered 8 division signal amplitude.

(A)



Typical display with RESOLUTION control turned clockwise. DISPERSION 500 Hz/Div

(B)



Typical display with RESOLUTION control turned counterclockwise. DISPERSION 10 Hz/Div

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

Ⓑ

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

d. Change the sweep rate to .5 s/division, decrease the dispersion Hz/DIV 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 8 divisions.

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 signal generator and return the Hz/DIV-COULED RESOLUTION selectors to the 100 k position.

9. Check Dispersion Accuracy

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

Dispersion accuracy is checked over the center 8 divisions of the graticule. Align the first time marker to the 1st graticule line and read the error as the displacement between the 9th graticule line and the appropriate marker. (See Fig. 5-3.) 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.

a. Set the front panel controls as follows:

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

b. Apply 10 μs time markers from the Time-Mark Generator through a 50 Ω termination to the Type 3L5 INPUT connector.

c. Align the 1st time 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.) Adjust the RESOLUTION selector to optimize the display as the DISPERSION is decreased.

TABLE 5-3

CENTER FREQUENCY-Hz Selection	DISPERSION-Hz/DIV Selection	Time Markers	Allowable Error
500 k	100 K	10 μs (1 marker/div)	
990 k, 500 k, 100 k, 50 k, 10 k	10 K	.1 ms (1 marker div)	±10%
950 k, 500 k, 100 k, 50 k	1 K	1 ms (1marker/div)	

d. Change the CENTER FREQUENCY-Hz selector to 5000, the Hz/DIV-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. Increase the Time/Div and adjust the RESOLUTION to optimize marker display as the DISPERSION is decreased.

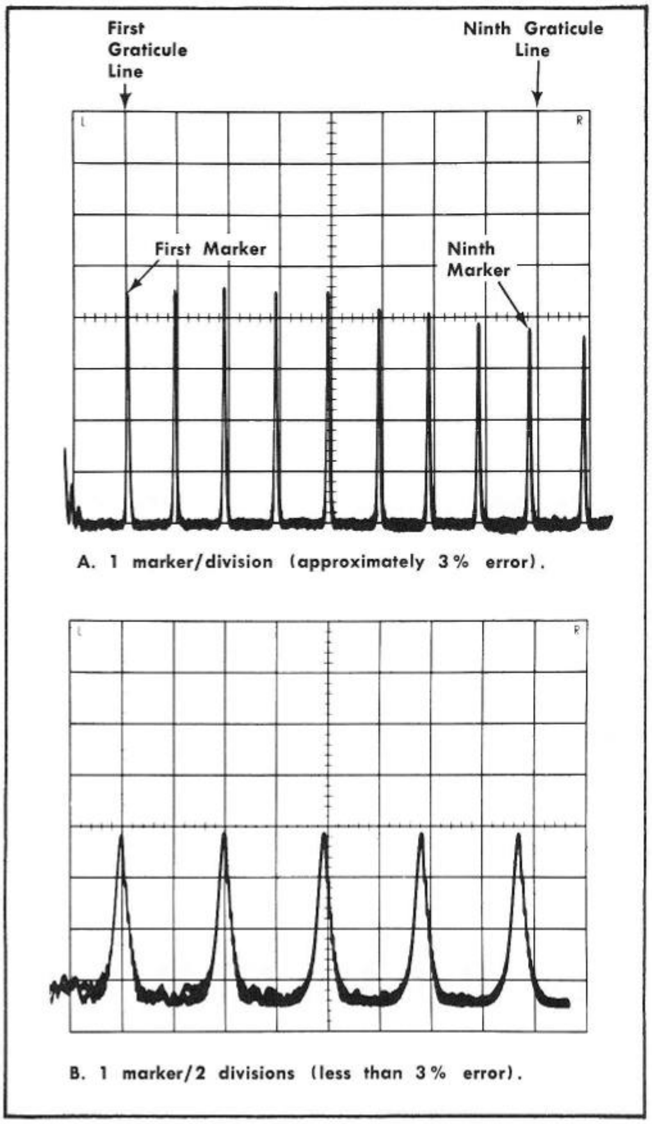


Fig. 5-3. Typical spectrum display for checking dispersion accuracies.

10. Check Dispersion Linearity

Requirement: Linearity within 3%.

Linearity is the measured distance, any marker is displayed from its respective graticule line when compared with an 8 major division display. See Fig. 5-4.

a. Check the dispersion linearity as listed in Table 5-5. Each time the settings of the DISPERSION-Hz/DIV 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 markers within the 8 divisions must not be more than 2.4 millimeters from their appropriate graticule lines.

TABLE 5-4

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

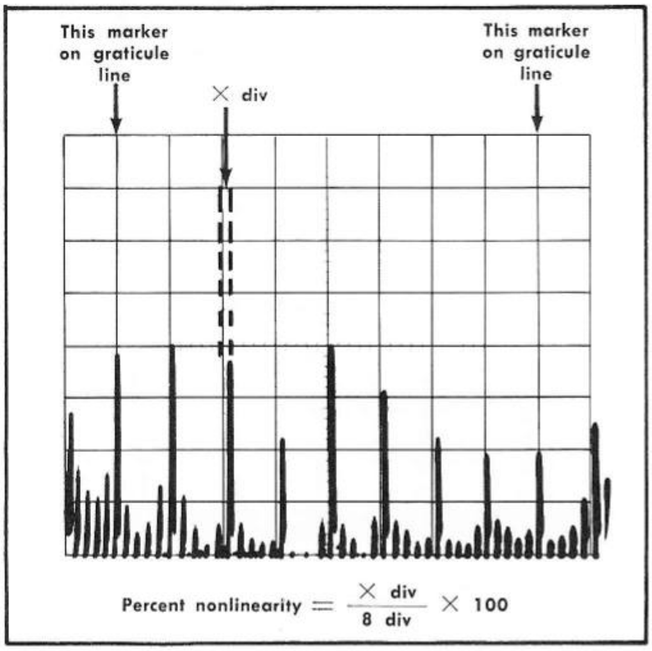


Fig. 5-4. Display illustrating linearity measurement.

TABLE 5-5

DISPERSION Hz/DIV Switch Setting	Time Markers	Check at CENTER FREQUENCY-Hz Switch Settings:
100 K	10 μs (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 (20 Hz)	9000, 500, 100

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

11. Check Display Flatness

Requirement: The display flatness for the .001 VOLTS/DIV and the .002 VOLTS/DIV range is within +0.5 dB to —3 dB. (10 Hz to 1 MHz). The display flatness for the .005 VOLTS/DIV to 2 VOLTS/DIV 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/DIV	.001
V/DIV ÷ 100	Pushed in
VARIABLE	CAL
DISPERSION-Hz/DIV	1 K

b. Apply a 5 kHz signal from the signal generator, through a T connector, to the Vertical Input of a test oscilloscope and through an attenuator or termination to the Type 3L5 INPUT connector.

c. Adjust the output of the signal generator for a signal amplitude of 6 divisions on the plug-in oscilloscope CRT. Adjust the test oscilloscope gain for a reference display amplitude of 6 divisions 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 10 kHz.

2. Apply a 50 kHz signal from the signal generator and re-establish the reference amplitude of 6 divisions 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. (6.36 to 4.25 divisions).

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

e. Check the display flatness for the 10 Hz to 9900 Hz range by checking the flatness with a 9000 Hz signal then a 50 Hz signal applied to the Type 3L5 INPUT. Decrease the Hz/DIV (DISPERSION) selection as the center frequency is decerased, or when the REDUCE dispersion indicator lights.

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

12. Check Video Frequency Response

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

a. Set the front panel controls as follows:

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

b. Apply the output from the signal generator through a T connector and 50 Ω termination to the Type 3L5 INPUT connector. Monitor the amplitude of the signal input to the Type 3L5 by connecting 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 divisions on the plug-in oscilloscope CRT. Adjust the gain of the test oscilloscope to establish a signal reference amplitude of 6 divisions. Decrease the signal generator frequency until the display amplitude decreases to 4.25 divisions 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 divisions and note the signal generator frequency.

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

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

13. Check LOG Display Range and LIN Mode Calibration

Requirement—Dynamic range of LOG display is 60 dB or more. LIN calibration within 3%.

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	50 k
VERTICAL DISPLAY	LIN
VOLTS/DIV	.005
V/DIV ÷ 100	Pushed in
DISPERSION-Hz/DIV	1 k
RESOLUTION	Fully clockwise
Time/Div	50 ms or slower

b. Apply 50 kHz signal from the Signal Generator through a BNC 'T' connector, a 600 Ω Step Attenuator, a coaxial cable, and a 600 Ω termination to the INPUT of the Type 3L5. Connect the test oscilloscope to the BNC 'T' connector to monitor the signal output amplitude. Set the Step Attenuator for 20 dB.

c. Adjust the Signal Generator for an output signal amplitude of 1 V peak to peak on the test oscilloscope. (1 V peak to peak, at the BNC 'T' connector, provides an input signal to the Type 3L5 of 100 mV peak to peak or 35 mV RMS.)

d. Center the signal on the analyzer display with the VARIABLE CENTER FREQUENCY-Hz control or the Signal Generator frequency control.

e. Check—Signal amplitude on the analyzer must equal 7 divisions ± 1.0 minor divisions.

f. Switch the VERTICAL DISPLAY selector to LOG and the Step Attenuator to 00 dB. Adjust Signal Generator output for a full screen (8 div.) signal amplitude.

g. Switch in 51 dB attenuation with the Step Attenuator.

h. Check—Signal amplitude should equal 1.0 division ± 0.5 major division. (50 dB range above a reference of 1.0 division.)

i. Switch the VOLTS/DIV selector to .05 and the Step Attenuator to 40 dB.

j. Check—Signal should still be discernible. (LOG mode dynamic range equal to or more than 60 dB.)

k. Switch the VERTICLE DISPLAY selector to LIN, the VOLTS/DIV to .005 and the Step Attenuator to 26 dB. Adjust the Signal Generator output for a display amplitude of 4 divisions.

l. Check—the accuracy of the LIN mode by selecting the attenuation settings listed in the following Table and noting the display amplitude. Accuracy of the display amplitude for LIN mode must be within 3%.

TABLE 5-6

Step Attenuator	Display Amplitude
26 dB	4 div. Set amplitude
20 dB	8 div. ± 1.2 minor div.
23 dB	5.6 div. ± 0.8 minor div.
29 dB	2.8 div. ± 0.4 minor div.
32 dB	2.0 div. ± 0.3 minor div.

14. Check TO RECORDER Signal Output

Requirement: 5 mV to 15 mV for a signal display amplitude of 8 divisions into a 600 Ω load.

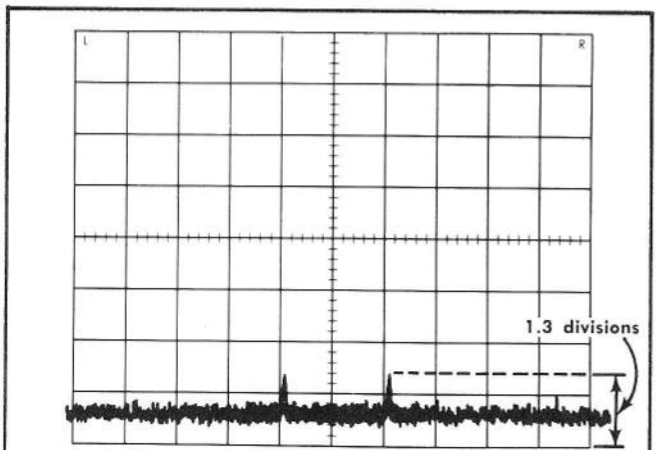
a. Set the front panel controls as follows:

CENTER-FREQUENCY-Hz	50 K
VERTICAL DISPLAY	LIN
VOLTS/DIV	.005
DISPERSION Hz/DIV	1 K

b. Apply a 50 kHz signal from the signal generator to the Type 3L5 INPUT connector. Adjust the signal generator output for a signal amplitude of 8 divisions.

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 between 5 mV and 15 mV. (If output signal level does not measure within this range, change the value of select resistor R416.)



A. 90 kHz and 110 kHz signals adjusted to an amplitude of 1.3 divisions.

B. Intermodulation sidebands less than 1.3 divisions.

Fig. 5-5. Typical display when checking intermodulation distortion.

15. Check Amplitude of Random Spurii

Requirement: Spurious signal amplitude equal to or less than 1.0 division with a 50 dB signal level above a 1.0 division reference amplitude.

a. Change the controls to the following settings:

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

b. Apply a 500 k signal from the signal generator through three (3) 5× attenuators and a 50 Ω termination to the Type 3L5 INPUT connector. Adjust the generator output for a display amplitude of 1.0 division on the CRT.

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

d. Check—Amplitude of spurious signals must not exceed 1.0 divisions. Ignore the start spuria, the fundamental and the 1st harmonic signal.

16. Check Intermodulation Distortion

Requirement: Intermodulation sideband amplitude ≤1.0 divisions with a 50 dB signal level about 1.0 divisions; LOG display.

a. Set the front-panel controls as follows:

CENTER FREQUENCY-Hz	100 k
VERTICAL DISPLAY	LOG
VOLTS/DIV	.005
DISPERSION-Hz/DIV	10 K
Time/Div	.5 s

b. Apply a 90 kHz and a 110 kHz signal from two signal generators, through isolation networks consisting of two (2) 10× attenuators to a BNC T connector. Connect three (3) 5× attenuators and a 50 Ω termination from the T connector to the Type 3L5 INPUT connector.

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 divisions 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/DIV selector to .002 position.

e. Check—Intermodulation distortion. The amplitude of the sidebands must not exceed 1.0 divisions. 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). Output amplitude must equal or exceed 1 volt peak to peak into load ≥1 kΩ.

a. Set the front-panel controls as follows:

CENTER FREQUENCY-Hz	500 k
VERTICAL DISPLAY	LIN
VOLTS/DIV	.005
DISPERSION Hz/DIV	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/Div to 1 μs and adjust the Triggering controls for a triggered display.

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

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

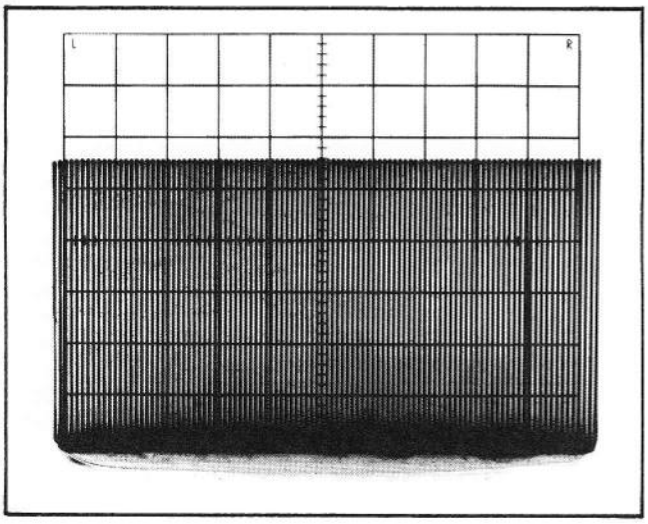


Fig. 5-6. 5 kHz calibrator markers with VIDEO display mode. Check drift of one cycle for 2 second period with a sweep trigger rate of 0.1 ms.

18. Check 5 kHz Calibrator Frequency

a. Requirement: Frequency 5 kHz ±1%.

b. Set the front-panel controls as follows:

VERTICAL DISPLAY	VIDEO
VOLTS/DIV	CALIBRATE
V/DIV ÷ 100	Knob pulled out
Time/Div	2 ms
Trigger Source	Ext

c. Apply 0.1 ms time markers from the Time-Mark Generator to the Ext Trig In connector of the Time Base Unit and adjust the Triggering controls for a trigger display.

d. Adjust the VOLTS/DIV VARIABLE control for a 5 kHz marker amplitude of approximately 6 divisions. See Fig 5-6.

e. Select one marker and measure its movement in divisions across the screen for a 2 second period. Must not exceed 10 divisions. (±1% of 5 kHz.)

This concludes the performance check for the Type 3L5. If the instrument has met all performance requirements, it will perform within the characteristics listed in Section 1.

NOTES

SECTION 6
CALIBRATION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The Type 3L5 specrum analyzer is a stable laboratory instrument which should not require frequent recalibration. However, performance should be checked after every 1000 hours of operation or every six months if used intermittently. This will ensure proper operation or indicate the section of the instrument that needs recalibration. If the instrument performs within the tolerances given in this procedure, it will meet all the specifications listed in Section 1 of this manual.

This procedure is arranged to calibrate and check the instrument performance with minimum interaction between adjustments and a minimum number of steps to connect or reconnect test equipment. A picture of the recommended or required test equipment precedes each step or group of related steps, with settings for the front panel controls. This allows any section of the calibration procedure to be performed with minimum confusion. Control settings that have changed from the previous setup picture are printed in bold type. External controls or adjustments that are referred to in the procedure are printed as labeled on the instrument with all letters capitalized (e.g. DISPERSION). Internal adjustments of the Type 3L5 and control settings for associated equipment have the initial letter capitalized (e.g. Time/cm or Sweep Center Adj.).

Complete each step in sequence for a complete calibration. To check a section or circuit within the instrument, turn to the desired section of the procedure. Start with the nearest setup if the check in the step or steps is not within tolerance. Adjustments that interact will be indicated and the indicated interaction must be checked.

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. If equipment is substituted for the recommended equipment, it must meet or exceed the specifications given.

Special calibration fixtures are recommended 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. Tektronix Type 564 or 561A with a 2B- or 3B-series time-base plug-in unit. The oscilloscope square wave transient response must be correct for the Type 3L5 to make bandpass specifications. Adjust by using the 560-series CRT Capacitance Standardizer, Tektronix Part No. 067-0500-00. This oscilloscope should be the one the Type 3L5 being calibrated will be used with. The front panel adjustments will require readjustment if the analyzer is changed to another oscilloscope. A Type 564 Storage Oscilloscope with a Type 3B4 Time-Base Plug-In Unit is used in this procedure.

2. Test Oscilloscope. Minimum requirements: Bandwidth, DC to 30 MHz; vertical sensitivity and accuracy, 0.005 V/Div to 10 V/Div, ±3%; sweep rate and accuracy, 1 s/div to .2 μs/div, ±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 μs (100 kHz); marker accuracy, within .001%. Tektronix Type 184 Time-Mark Generator.

4. Two (2) Low Frequency Signal Generator. Minimum requirements: Frequency output and accuracy, 10 Hz to 1 MHz, ±1%; output amplitude, 2 volts or more 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 nanosconds or less; output amplitude, variable between 0.5 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, ±0.3%. Tektronix Part No. 067-0502-00.

7. Step Attenuator, 600 Ω. 0 to 51 dB with combinations of 1, 2, 4, 8, 16 and 20 dB. Tektronix Part No. 011-0093-00.

8. Probes:

a. P6006 10× Passive Probe. Tektronix Part No. 010-0127-00.

b. P6011 1× Passive Probe. Tektronix Part No. 010-0193-00.

9. Flexible extension (allows the Spectrum Analyzer to be operated out of the oscilloscope plug-in compartment). Tektronix Part No. 012-0066-00.

10. Input RC Normalizer: RC = 1 MΩ X 30 pF, equipped with BNC connectors. Tektronix Part No. 067-0552-00.

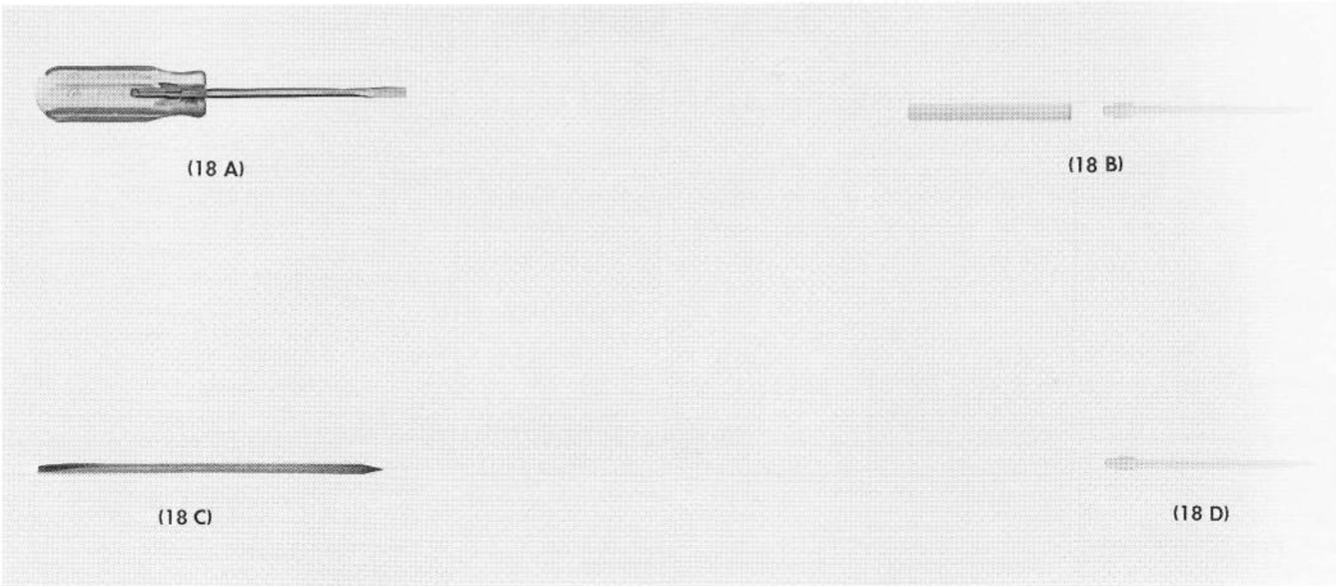


Fig. 6-1. Alignment tools for calibrating the Type 3L5.

11. Three (3), 50 Ω coaxial cables. 42 inches long, BNC connectors. Tektronix Part No. 012-0057-00.

12. Patch Cord with BNC to banana plug tips. Tektronix Part No. 012-0091-00.

13. Termination, 50 Ω BNC. Tektronix Part No. 011-0049-00.

14. Termination, 600 Ω, BNC. Tektronix Part No. 011-0092-00.

15. Four (4), 50 Ω 10:1 attenuators, BNC connectors. Tektronix Part No. 011-0059-00.

16. Three (3), 50 Ω, 5:1 attenuators, BNC connectors. Tektronix Part No. 011-0060-00.

17. BNC 'T' connector, male to male to female. Tektronix Part No. 103-0030-00.

18. Binding posts to BNC female connector. Tektronix Part No. 013-0094-00.

19. Miniature phone plug and 600 Ω load. (Test fixture to check TO RECORDER signal amplitude.) Consists of a 600 Ω, 5%, ½ watt resistor soldered across a miniature phone plug.

20. Alignment Tools: (Fig. 6-1)

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 No. 003-0307-00. Insert, Tektronix Part No. 003-0310-00.

c. Low-capacitance screwdriver. A ¼ inch X 8 inch fiber rod with scredriver-shaped ends. Tektronix Part No. 003-0209-00.

d. Low-capacitance alignment tool, to tune ⅛ inch O.D. powdered iron cores. Tektronix Part No. 003-0497-00.

CALIBRATION RECORD AND INDEX

This abridged procedure may be used as an aid to check the operation of the instrument, as a calibration guide for the experienced calibrator, or as a calibration record. It also serves as an index to the calibration steps.

Type 3L5, Serial Number ______________________

Calibration Date ______________________

Calibrator ______________________

- ☐ 11. Adjust Calibrator Frequency and Amplitude (Page 6-21)
- ☐ 12. Check Display Flatness (Page 6-23)
- ☐ 13. Check Incidental Frequency Modulation (Page 6-25)
- ☐ 14. Check Amplitude of Random Spurii (Page 6-25)
- ☐ 15. Check Intermodulation Distortion (Page 6-27)
- ☐ 16. Check Manual Sweep Operation (Page 6-27)
- ☐ 17. Check Internal Noise Level (Page 6-28)

NOTES

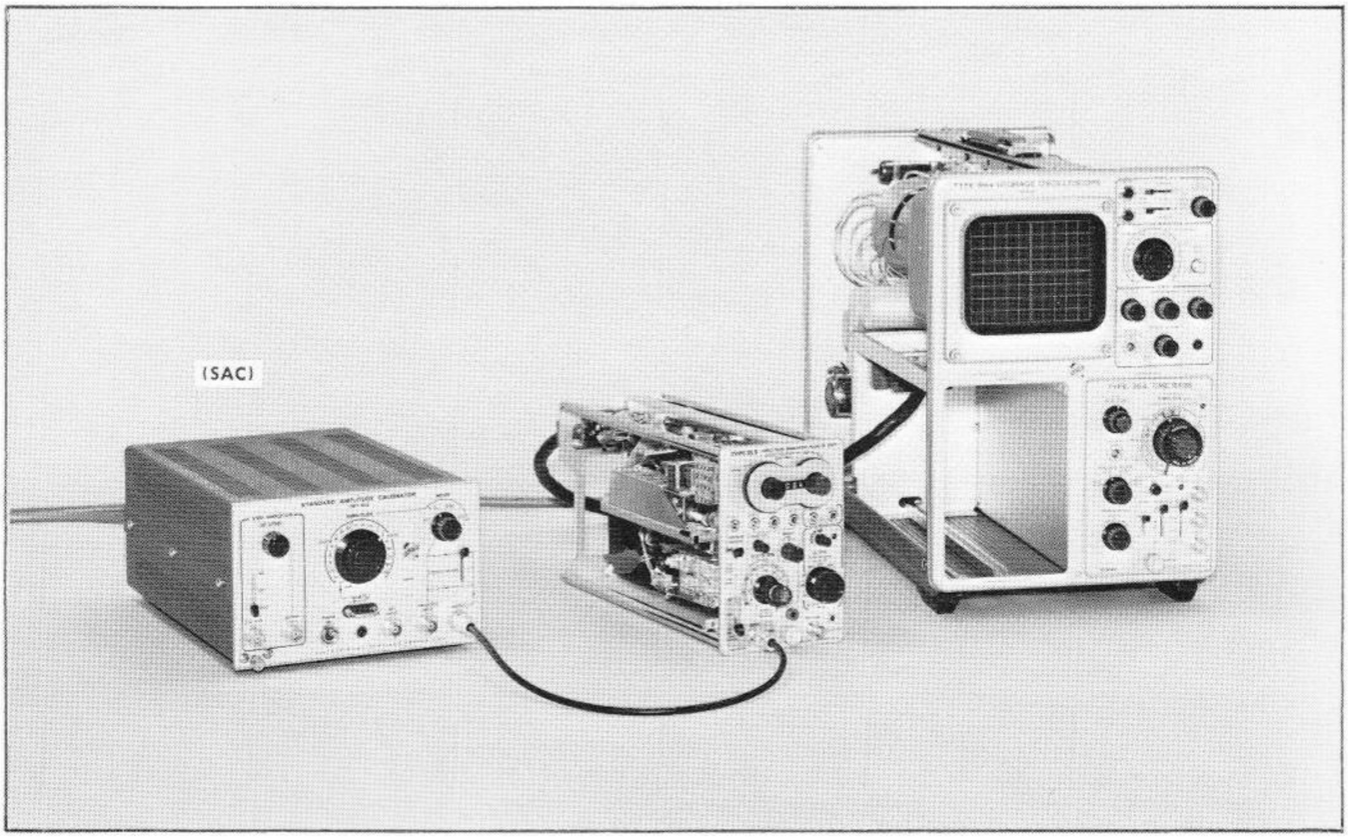


Fig. 6-2. Equipment setup for steps 1 and 2.

Type 3L5	
CENTER FREQUENCY-Hz	500 k
VARIABLE	CAL
VERTICAL DISPLAY	VIDEO
POSITION	Centered
SWEEP	INT
Input Selector	AC
VOLTS/DIV	.5 (Outer scale)
VARIABLE	CAL
V/DIV ÷ 100	Pulled out
DISPERSION	
VARIABLE	CAL
Hz/DIV—COUPLED RESOLUTION	100 k

Oscilloscope Time-Base Plug-In Unit

Time/Div	1 ms
Triggering	Adjusted for a free running trace

1. Adjust Video Deflection Factor, Check Input Attenuator Accuracy, and Check the Variable Volts/Div Range

a. Equipment setup is shown in Fig. 6-2.

b. Apply a 20 mV signal from the Standard Amplitude Calibrator to the INPUT connector of the Type 3L5.

c. Adjust the VIDEO CAL R436 (front panel adjustment), for a display amplitude of 4 divisions. (VOLTS/DIV selector in .5 position and V/DIV ÷ 100 knob pulled out.)

d. Check the VOLTS/DIV selector accuracy at each position as listed in Table 6-1.

e. Set the VOLTS/DIV selector to 1 (Outer scale), push in the V/DIV ÷ 100 control, then adjust the Standard Amplitude Calibrator output for a signal amplitude of 5 volts. Center the 5 division display on screen with the POSITION controls.

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

g. Check—Display amplitude should decrease to 2 divisions or less. (VARIABLE control range $\geq$ 3:1).

TABLE 6-1

Analyzer VOLTS/DIV Switch Setting (Outer Scale)	SAC Output in Volts	Display Amplitude in Divisions	Maximum Error in Minor Divisions
.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
Fully counter-clockwise (2 on inner scale)	10 V	5	±1.5
Push in V/DIV ÷ 100 knob			
.5	2 V	4	±1.2

2. Check POSITION Control Range

Requirement: POSITION control must shift the trace + and — 8 divisions, with the bottom graicule line as the reference.

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

b. Change the SAC output to 10 volts and turn the POSITION control fully clockwise.

c. CHECK—Bottom of the display must position on or above the center graticule lines.

d. Set the SAC output to 20 volts, then 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.

NOTES

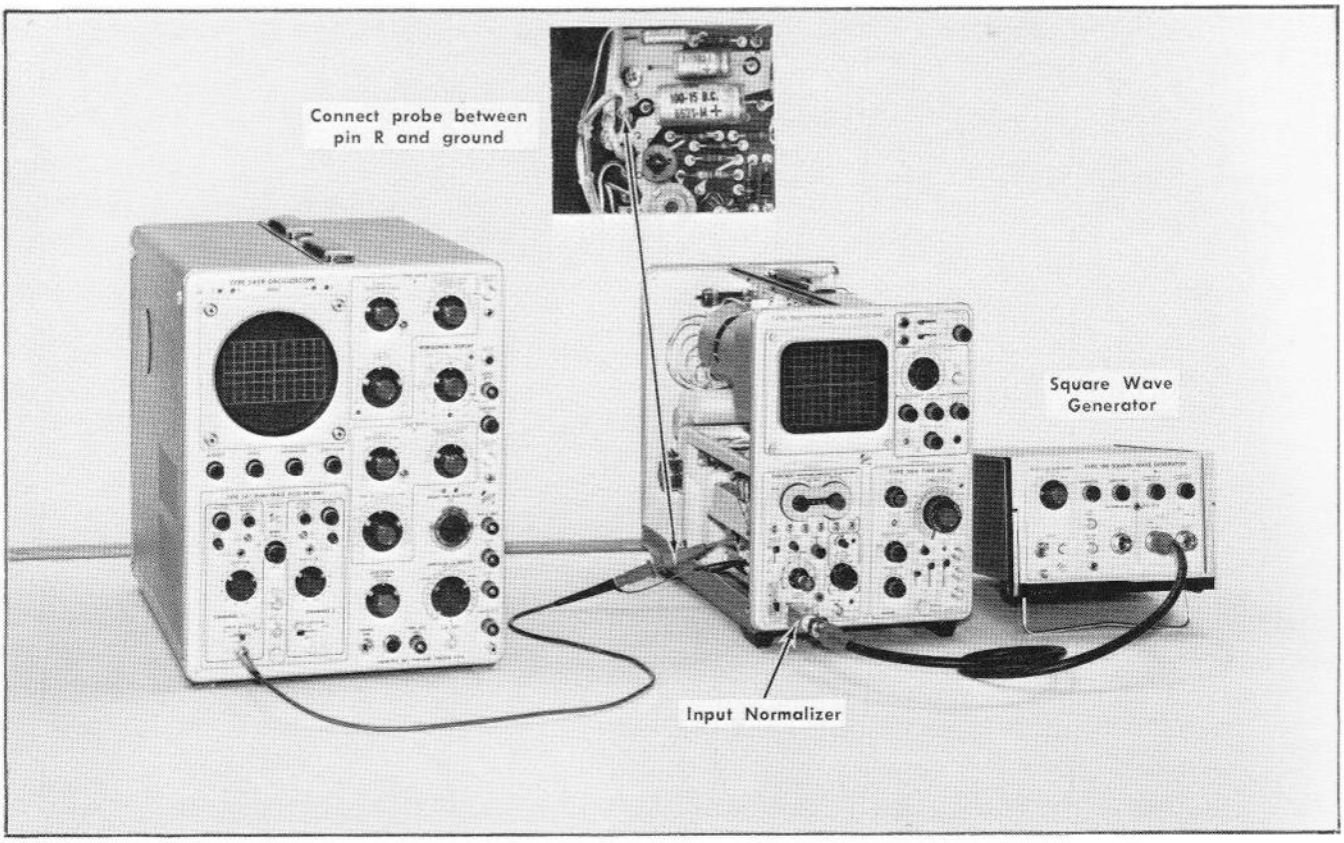


Fig. 6-3. Equipment setup for adjusting VOLTS/DIV compensation.

Type 3L5	
CENTER FREQUENCY-Hz	500 k
VARIABLE	CAL
VERTICAL DISPLAY	VIDEO
POSITION	Centered
SWEEP	INT
Input Selector	**AC FAST**
VOLTS/DIV	.5 (Outer scale)
VARIABLE	CAL
V/DIV ÷ 100	Pulled out
DISPERSION	
Hz/DIV—COUPLED RESOLUTION	100 k
VARIABLE	CAL
Oscilloscope Time Base Unit	
Time/Div	1 ms
Triggering	Adjusted for a free running trace

3. Adjust VOLTS/DIV Attenuator Compensation

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

b. Connect a properly compensated 10× probe from the test oscilloscope between pin R and ground of the Input Amplifier board. See Fig. 6-3.

c. Apply a 10 kHz signal from the square-wave generator through a 50 Ω termination and a 30 pF Normalizer to the INPUT connector on the Type 3L5. Adjust the signal generator output for a display amplitude of 4 divisions on the test oscilloscope.

d. Push in the V/DIV ÷ 100 knob. Adjust C15 and C13 (Fig. 6-4C) for optimum square wave response. C15 is adjusted for minimum aberrations and C13 for optimum flat top. See Fig. 6-4A. (The slope of the top and bottom of the square wave will not be flat because the amplifier stages are not DC coupled.)

f. Pull the V/DIV ÷ 100 knob out. Adjust the remaining compensation adjustments as listed in Table 6-2. Maintain a 4 division display amplitude on the test oscilloscope during these adjustments.

g. Check the response at all positions of the VOLTS/DIV selector. It may be necessary to readjust some of the compensation capacitors. Table 6-3 lists which capacitors affect each position.

h. Remove the 10× probe and the input 30 pF Normalizer.

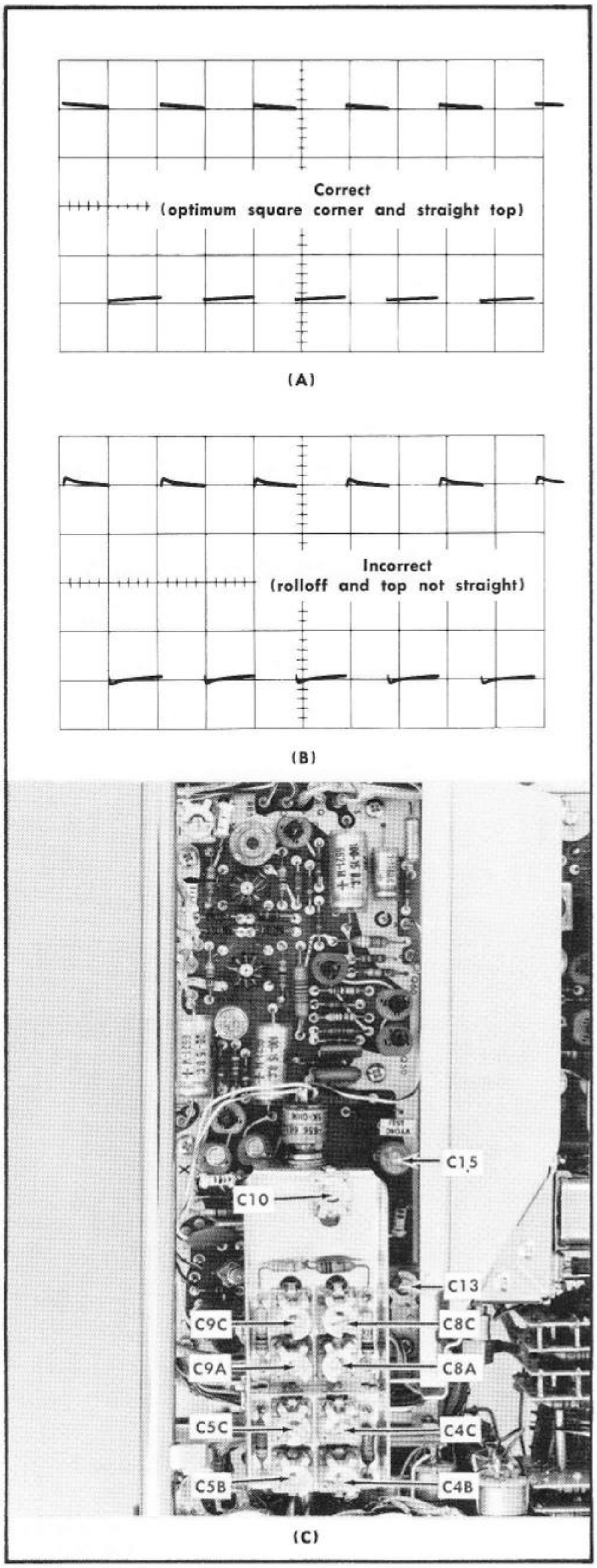


Fig. 6-4. Location of adjustments and typical response for the VOLTS/DIV attenuator compensation.

TABLE 6-2

VOLTS/DIV Selection (Outer Scale)	Adjust	For
1	C8C	Minimum spike
	C8A	Flat top
2	C9C	Minimum spike
	C9A	Flat top
5	C4C	Minimum spike
	C4A	Flat top
50	C5C	Minimum spike
	C5A	Flat top

TABLE 6-3

VOLTS/DIV (Outer Scale)	C8C	C9C	C4C	C5C
1	X			
2		X		
5			X	
10	X		X	
20		X	X	
50				X
100	X			X
Fully Counterclockwise		X		X

NOTES

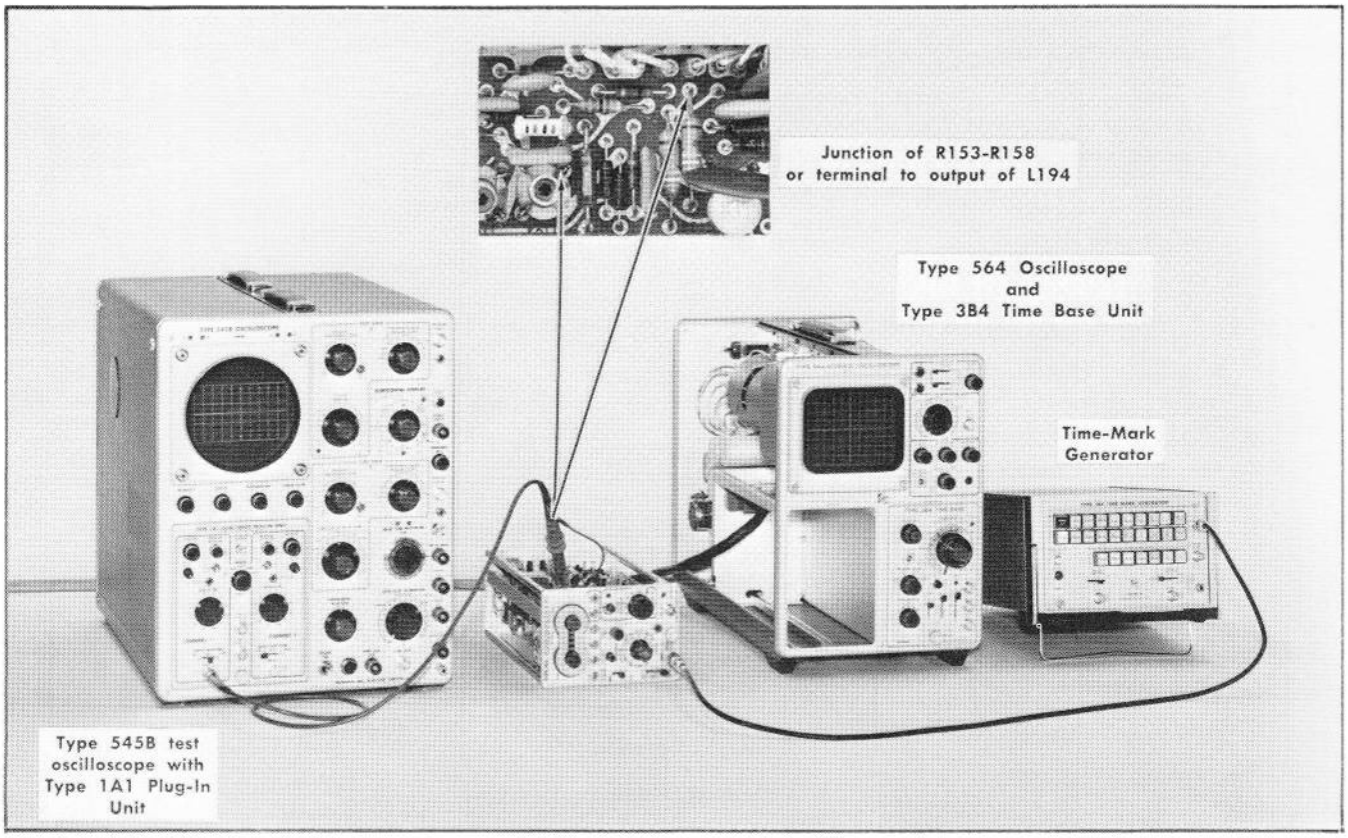


Fig. 6-5. Equipment setup for preliminary swept oscillator and center frequency adjustments. Step 4.

Type 3L5	
CENTER FREQUENCY-Hz	500 k
VARIABLE	CAL
VERTICAL DISPLAY	**LIN**
POSITION	Centered
SWEEP	INT
Input Selector	AC FAST
VOLTS/DIV	**.005 (Inner scale)**
VARIABLE	CAL
V/DIV ÷ 100	**Pushed in**
DISPERSION	
Hz/DIV—COUPLED RESOLUTION	100 k
VARIABLE	CAL
Oscilloscope Time-Base Unit	
Time/Div	**10 ms**
Triggering	Adjusted for a free running trace
Test Oscilloscope	
Time/Div	.5 μs (calibrated)
Volts/Div	.2 (calibrated)

4. Preliminary Adjustment of the Swept Oscillator and 3 MHz Filter

a. Equipment setup is shown in Fig. 6-5.

b. Preset the front panel Dispersion CAL, 30 kHz CF and BAL adjustments fully CCW. Connect a low-capacity (10 pF or less) 10× probe from the test oscilloscope to the output of the sweep oscillator (junction of R153-R158, Fig 6-6A). Apply 10 μs markers from the Time-mark Generator through a 50 Ω termination to the INPUT connector of the Type 3L5. Switch the SWEEP control to the MANUAL position.

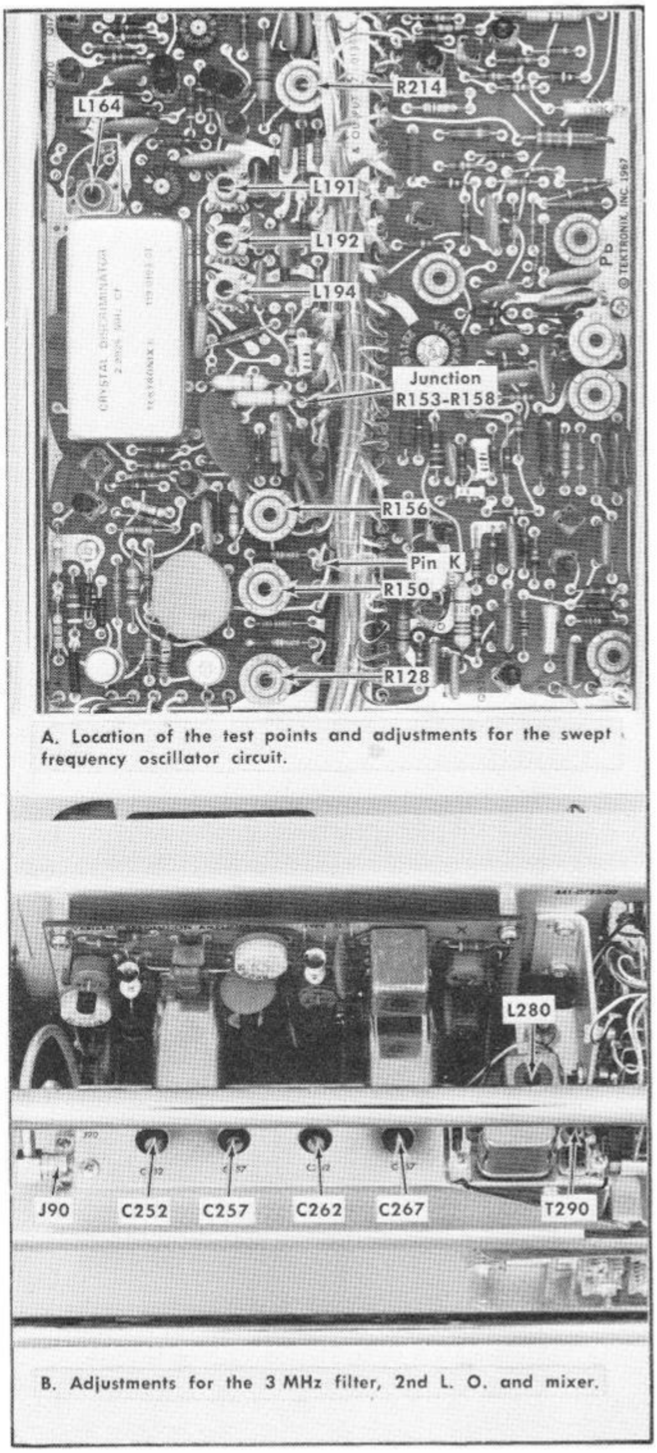
c. Adjust R214 (Fig. 6-6A) so the oscillator output is approximately 6.4 V peak to peak. Adjust L164 if the oscillator is not operating.

d. Turn the SWEEP control to the INT position and connect the test oscilloscope probe to the OSC OUT connector. Check oscillator output for swept frequency operation.

e. Adjust T290, L280 and capacitors C252, C257, C262, C267 (Fig. 6-6B) for maximum marker amplitude on the analyzer oscilloscope.

f. Switch the CENTER FREQUENCY-Hz selector to 000 k. Set the Input Selector to GND position.

g. Adjust L164 (Fig. 6-6A) for a 0 Hz marker signal on screen. The marker may not appear at the screen center.



A. Location of the test points and adjustments for the swept frequency oscillator circuit.

B. Adjustments for the 3 MHz filter, 2nd L. O. and mixer.

Fig. 6-6. Test points and adjustment locations for adjusting dispersion and center frequency.

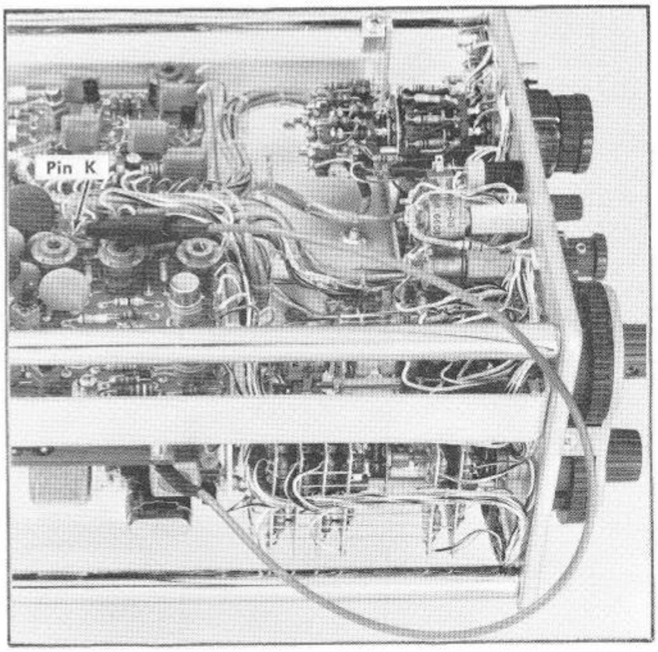


Fig. 6-7. Method of grounding pin K.

h. Switch the CENTER FREQUENCY-Hz selector to 500 k and the Input Selector to AC. Connect a ground strap (Fig. 6-7) between pin K and chassis ground.

i. Adjust the front panel 30 kHz CF, Dispersion CAL for approximately 1 marker/div or a 1 MHz window. Center the sweep on the graticule. Adjust the BAL control to position the 0 Hz marker at the 0 graticule line. Adjust R156 (Fig. 6-6A) for minimum display shift as the DISPERSION-Hz/DIV selector is switched between 100 k and 200 positions. Repeat these adjustments because of the interaction.

j. Switch the CENTER FREQUENCY-Hz selector to 5000, the DISPERSION-Hz/DIV to 1 k, the RESOLUTION to 100 and the Time/Div to 20 ms. Apply 1 ms markers from the Time-Mark Generator to the INPUT.

k. Adjust the front panel 5000 Hz CF for approximately 1 marker/div.

NOTE

These dispersion adjustments are only approximate for this step.

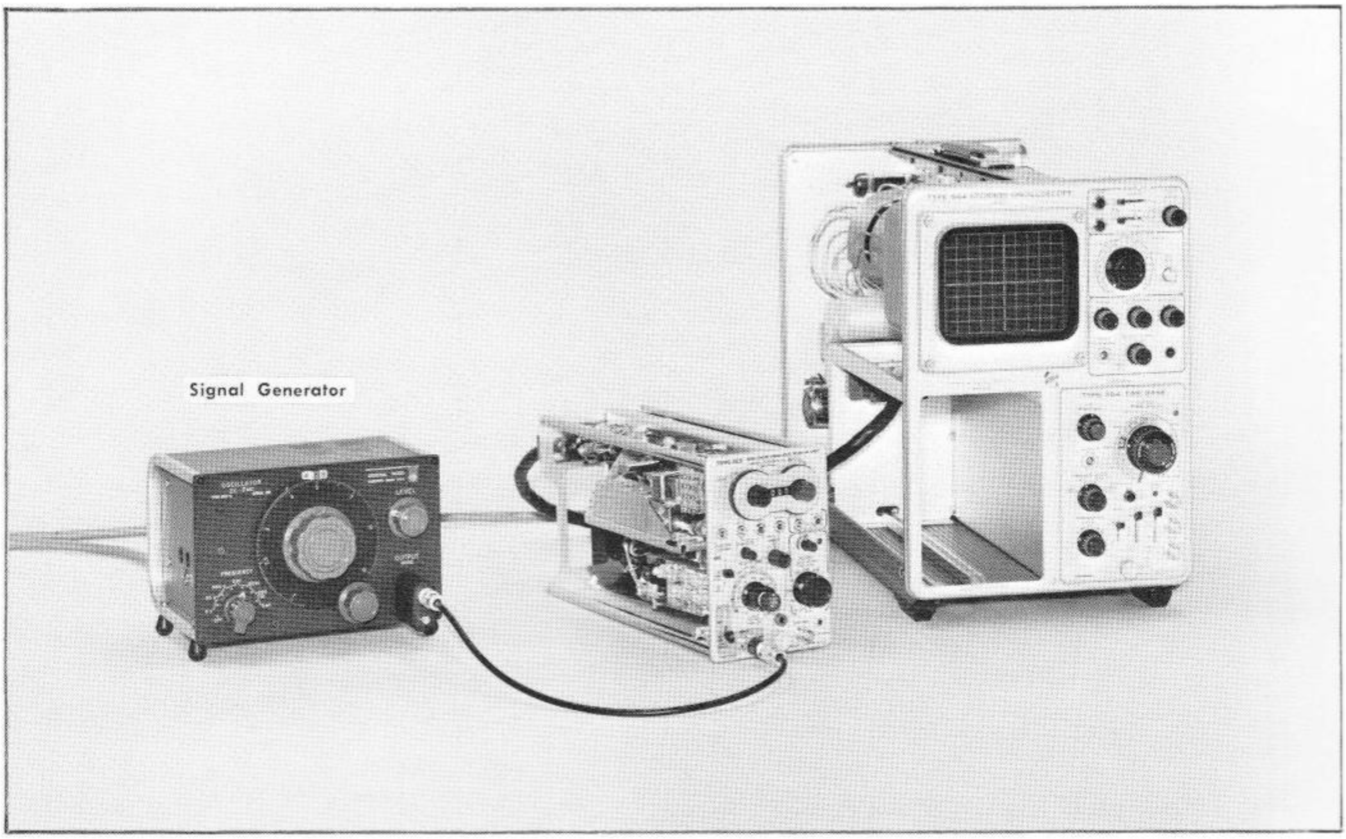


Fig. 6-8. Equipment setup for adjusting resolution. Step 5.

	Type 3L5
CENTER FREQUENCY-Hz	**50 k**
VARIABLE	CAL
VERTICAL DISPLAY	LIN
POSITION	**Centered sweep at the bottom graticule line**
Sweep	INT
Input Selector	AC FAST
VOLTS/DIV	.005 (Inner Scale)
VARIABLE	CAL
V/DIV ÷ 100	Pushed in
DISPERSION-Hz/DIV	**500**
RESOLUTION	**Fully clockwise (Uncoupled)**
VARIABLE	CAL

Oscilloscope Time-Base Plug-In Unit

Time/Dlv	**50 ms**
Triggering	Adjusted for a free running trace

5. Adjust Variable-Resolution Amplifier ⓿

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

b. Apply a 50 kHz signal from the low frequency signal generator to the INPUT connector of the Type 3L5. Adjust the generator output and frequency controls for a centered signal that is 6 divisions in amplitude. See Fig. 6-9.

c. Adjust C323 and C343 (Fig. 6-9A) for optimum skirt symmetry. See Fig. 6-9B. Keep the signal centered on screen during this adjustment by tuning the signal generator frequency or the VARIABLE CENTER FREQUENCY control.

d. Adjust L327 and L347 (Fig. 6-10A) for maximum signal width at the —6 dB amplitude point (Fig. 6-9C). Maintain a 6 division display for this measurement by adjusting the VOLTS/DIV controls or the output of the signal generator.

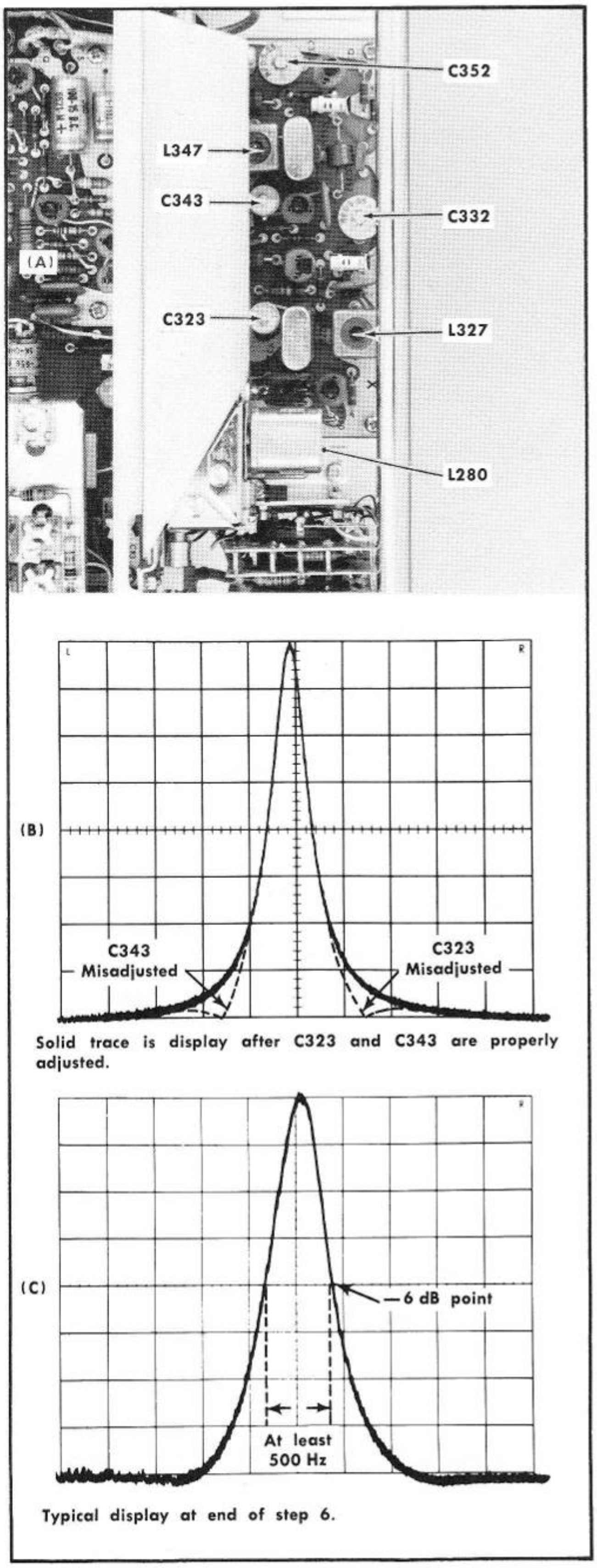
e. Repeat steps (c) and (d) because these adjustment interact. The final display should be symmetrical with no large dips or other aberrations. When properly calibrated, L327 and L347 adjustments should rock the display through a minimum amplitude and optimum bandwidth point.

f. Adjust L280 for maximum display amplitude.

g. Change the sweep rate to .5 s/div. Couple the RESOLUTION control to the DISPERSION Hz/DIV control and set both controls to 500.

h. Tune the signal to screen center and adjust the output for a signal amplitude of 8 divisions.

i. Adjust C332 and C352 for 1 division or less signal amplitude variation as the Hz/DIV-COUPLED RESOLUTION is switched between the 500 and the 10 positions.



Solid trace is display after C323 and C343 are properly adjusted.

Typical display at end of step 6.

Fig. 6-9. (A) Location of adjustments; (B) and (C) typical spectrum displays for Variable-Resolution Amplifier response.

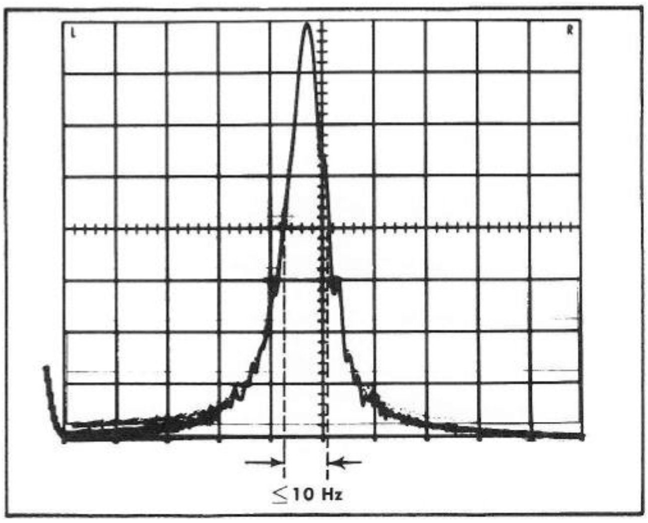


Fig. 6-10. Measuring resolution bandwidth.

j. Set the Hz/DIV-COUPLED RESOLUTION controls to the 10 Hz position. Adjust the generator output for a signal amplitude of 8 divisions.

k. Check for a symmetrical display and a resolution bandwidth that is 10 Hz or less at the —6 dB points. See Fig. 6-10. (Sweep rate must be .5 s/div or slower.)

NOTE

A more accurate adjustment of the skirt symmetry may be made in the LOG mode.

NOTES

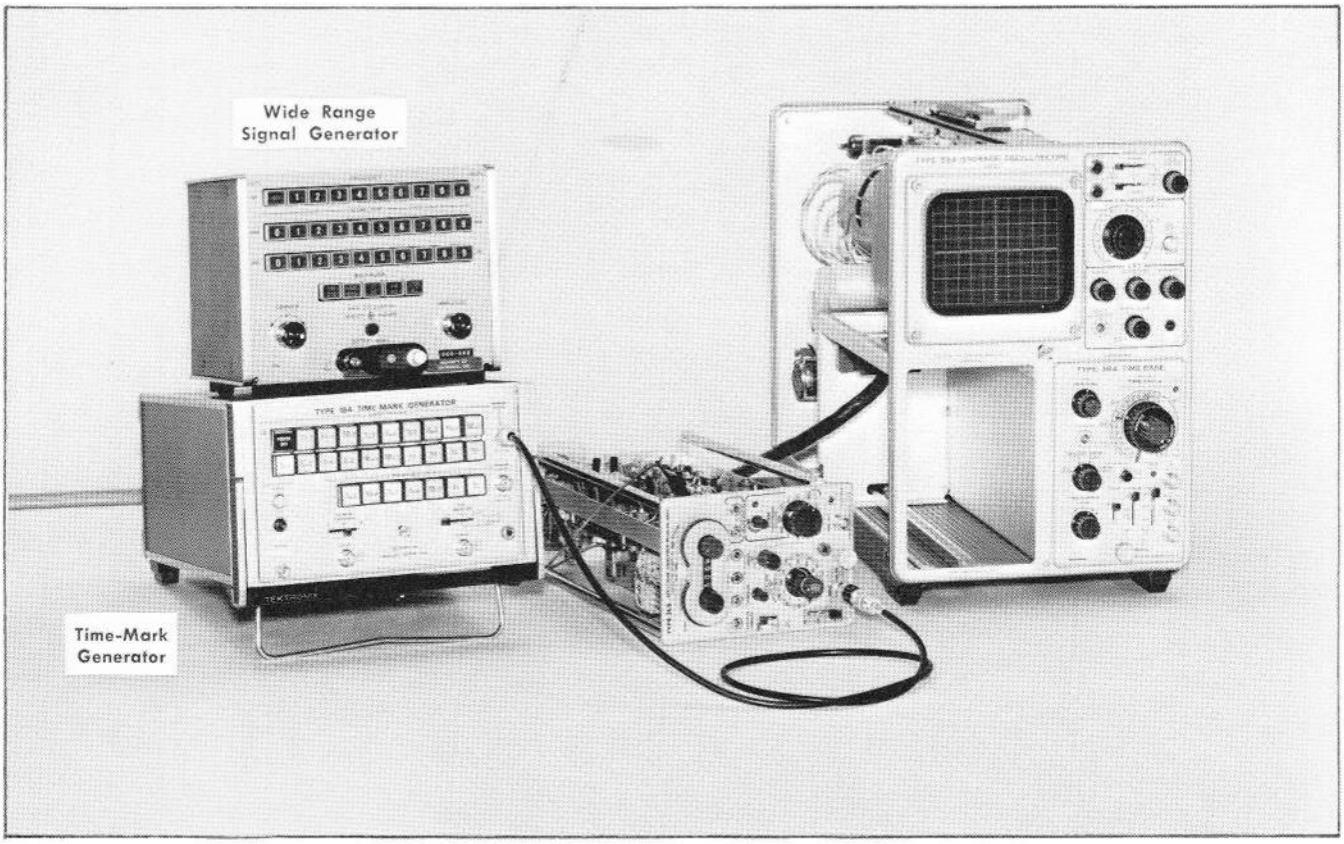


Fig. 6-11. Equipment setup for adjusting or checking dispersion, and center frequency.

	Type 3L5
CENTER FREQUENCY-Hz	**500 k**
VARIABLE	CAL
VERTICAL DISPLAY	LIN
POSITION	Centered horizontally and positioned to the bottom graticule line
SWEEP	INT
Input Selector	AC FAST
VOLTS/DIV	**As required for an adequate display**
VARIABLE	CAL
V/DIV ÷ 100	Pushed in
DISPERSION	
Hz/DIV-COUPLED	100 k
RESOLUTION	
VARIABLE	CAL

	Oscilloscope Time-Base Unit
Time/Div	**10 ms**
Triggering	Adjust for a free running trace

6. Adjust Dispersion and Center Frequency Calibration ⓘ

a. Equipment setup is shown in Fig. 6-11.

b. Apply 10 μs markers through a 50 Ω termination to the INPUT of the Type 3L5. Connect a ground strap between pin K (Fig. 6-7) and chassis ground. Adjust the VOLTS/DIV selector for suitable marker amplitude on the analyzer display.

c. Adjust L191, L192 and L194 for optimum dispersion linearity. Adjust the front panel 30 kHz CF Dispersion CAL for optimum dispersion accuracy (1 marker/div). L191 primarily affects the left portion of the display, L192 the center portion and L194 the right side. Interaction will be apparent. Adjustment technique will be acquired with experience.

d. Change the CENTER FREQUENCY-Hz selector to 000 k the DISPERSION-Hz/DIV to 10 k. Switch the Input Selector to GND and remove the ground strap to pin K.

e. Adjust L164 so the swept oscillator low frequency limit produces a 0 Hz marker signal. The center frequency of the swept oscillator frequency excursion is shifted as L164 is adjusted. If L164 is slowly adjusted through the range in which the 0 Hz marker is displayed, a portion of this range will produce a baseline shift to the left of the marker (Fig. 6-12A). This baseline shift is the lower frequency limit of the swept oscillator. Adjust L164 so the oscillator stops sweeping just to the left of the 0 Hz marker (Fig. 6-12B). This is indicated when the baseline to the left of the marker drops back to the base reference level.

f. Switch the CENTER FREQUENCY-Hz selector to 500 k. Reconnect the grounding strap to pin K and switch the Input Selector to AC.

g. Center the display in the graticule area with the Horizontal Position control. Position the 0 Hz marker to the 0 graticule line with the front panel BAL adjustment. (Applicable to instruments with the adjustable BAL modification.)

h. Adjust R156 for minimum display shift as the DISPERSION-Hz/DIV selector is switched between the 100 k and 200 positions.

i. Remove the ground strap to pin K. Adjust the front panel 500 kHz CF (center frequency) adjustment for minimum display shift as the DISPERSION-Hz/DIV selector is switched between the 100 k and 200 positions.

j. Set the DISPERSION-Hz/DIV to 10 k position. Adjust R150 (Fig. 6-6A) for minimum display shift as the CENTER FREQUENCY is switched between the 100 k and 900 k positions.

k. Switch the CENTER FREQUENCY selector to 10 k and the Input Selector to GND.

l. Adjust the 10 kHz CF CAL so the 0 Hz marker is 1 division left of the graticule center line.

m. Repeat steps f through l to minimize interaction between adjustments.

n. Change the CENTER FREQUENCY-Hz to 500 k, the DISPERSION-Hz/DIV to 100 k and set the Input Selector to AC FAST position. Recheck the dispersion for 1 marker/division.

o. Set the DISPERSION-Hz selector to 1 k, RESOLUTION to 100, sweep rate to 20 ms/div and the CENTER FREQUENCY-Hz to 30 k. Apply 1 ms markers from the Time-Mark Generator to the INPUT connector.

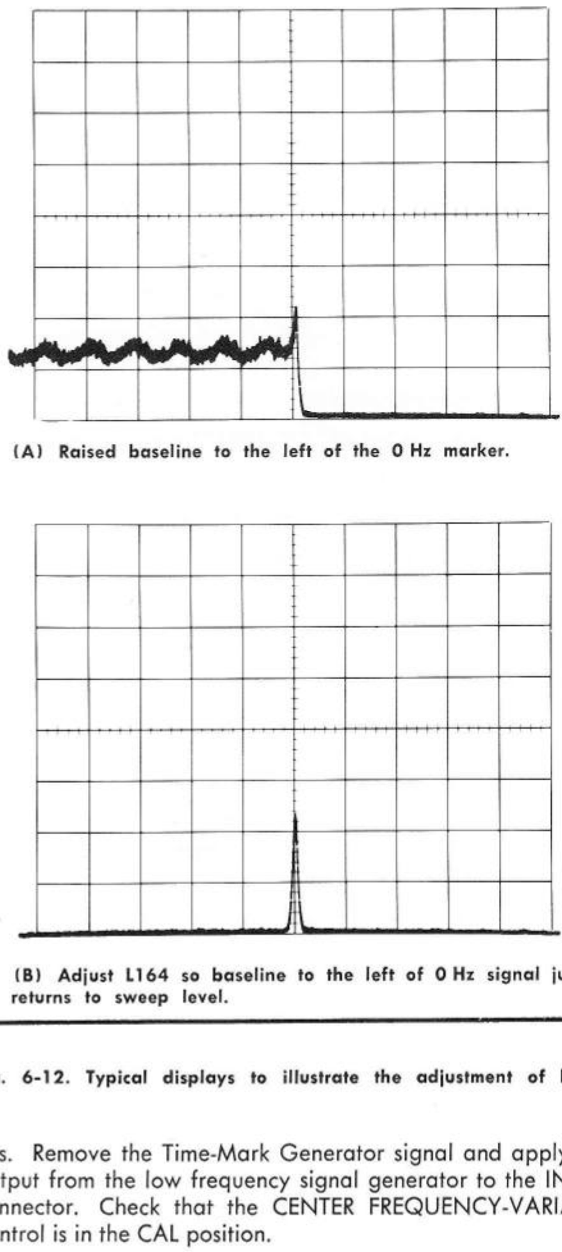
p. Check dispersion accuracy—It should be within 0.5 division over the center 8 division window. Repeat steps b through m if dispersion accuracy is not within this specification.

q. Adjust 30 kHz CF for 1 marker/division.

r. Check dispersion accuracy over the 10 kHz to 990 kHz frequency range as per Table 6-4. Dispersion window upper limit must not exceed 1 MHz for the 10 kHz to 990 kHz center frequency range. Linearity within 3%.

TABLE 6-4

CENTER FREQUENCY-Hz Selection	DISPERSION Hz/DIV Selection	Time Markers	Allowable Error
500 k	100 k	10 μs (1 marker/div)	
950 k, 500 k, 100 k, 50 k	10 k	.1 ms (1 marker/div)	±10%
990 k, 500 k, 100 k, 50 k, 10 k	1 k	1 ms (1 marker/div)	



(A) Raised baseline to the left of the 0 Hz marker.

(B) Adjust L164 so baseline to the left of 0 Hz signal just returns to sweep level.

Fig. 6-12. Typical displays to illustrate the adjustment of L164.

s. Remove the Time-Mark Generator signal and apply the output from the low frequency signal generator to the INPUT connector. Check that the CENTER FREQUENCY-VARIABLE control is in the CAL position.

t. Check the center frequency tracking over the 10 kHz to 990 kHz range as per Table 6-5. If dispersion or center frequency tracking is not within specifications, repeat calibration steps.

TABLE 6-5

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

u. Remove the signal from the low frequency signal generator. Change the CENTER FREQUENCY-Hz selector to 00 k, the DISPERSION COUPLED RESOLUTION to 10 k and the VOLTS/DIV to the CALIBRATE position. Set the sweep rate to .1 s/div.

v. Adjust L164, very slowly, until only one (1) 5 kHz marker remains to the left of the 0 Hz spurious marker. (To identify the 0 Hz marker, rotate the VARIABLE V/CM control counterclockwise out of the CAL position. The 0 Hz marker amplitude will remain constant.) Cement the core of the inductor in this position with a good grade rubber cement.

w. Change the DISPERSION selector to 1 kHz, the CENTER FREQUENCY-Hz to 0000 and the VOLTS/DIV to .5. Adjust the 0000 Hz CF CAL for minimum shift of the 0 Hz spurious marker, as the DISPERSION is switched from the 1 kHz position to the 50 Hz position.

x. Change the CENTER FREQUENCY-Hz selector to 5000, set the DISPERSION to 1 k and the RESOLUTION to 100. Apply 1 ms time-markers from the Time-Mark Generator through a 50 Ω termination, to the INPUT connector.

y. Adjust the 5000 Hz CF adjustment for approximately 1 marker/division. (This adjustment is only approximate.) Switch the Input Selector to GND position. Adjust R128, to align the 0 Hz spurious marker on the 0 Hz (far left) graticule line.

z. Return the Input Selector to the AC position and adjust the front panel 5000 Hz CF for 1 marker/division. Repeat steps y and z until the dispersion is calibrated and balanced.

aa. Check dispersion accuracy and linearity over the 10 Hz to 9900 Hz frequency range as per Table 6-6. Dispersion window upper limit must not exceed 10 kHz for the 10 Hz to 9900 Hz center frequency range. Linearity must be within 3%. Adjust the RESOLUTION control and the sweep rate at each check point to optimize marker definition.

TABLE 6-6

CENTER FREQUENCY-Hz Selection	DISPERSION-Hz/DIV Selector	Time Markers	Allowable Error
5000	1 k	1 ms	±10%
7500, 2500	500	1 ms (1 marker/2 div)	
9000, 5000, 1000	200	5 ms	
9500, 9000, 500	100	10 ms	
	50	10 ms (1 marker/2 div)	
5000, 100	20	50 ms	
5000, 50	10	50 ms (1 marker/2 div)	

ab. Remove the Time-Mark Generator signal. Apply the output from the low frequency signal generator to the INPUT connector. Set the CENTER FREQUENCY-VARIABLE control to CAL position. Check the center frequency tracking over the 10 Hz to 9900 Hz frequency range as per Table 6-7.

ac. Connect the 10× probe from the test oscilloscope to the front panel OSC OUT connector. Set the Hz/DIV selector to 100 k and the CENTER FREQUENCY to 500 k. Measure the amplitude of the oscillator output signal. Amplitude should equal or exceed 1 volt peak to peak.

TABLE 6-7

CENTER FREQUENCY-Hz and Signal Generator	DISPERSION-Hz/DIV Selection	Accuracy
9500, 5000, 1000, 950, 550	100	±(5% of C.F. +100 Hz)
100, 50	10	±(5% of C.F. +50 Hz)

NOTES

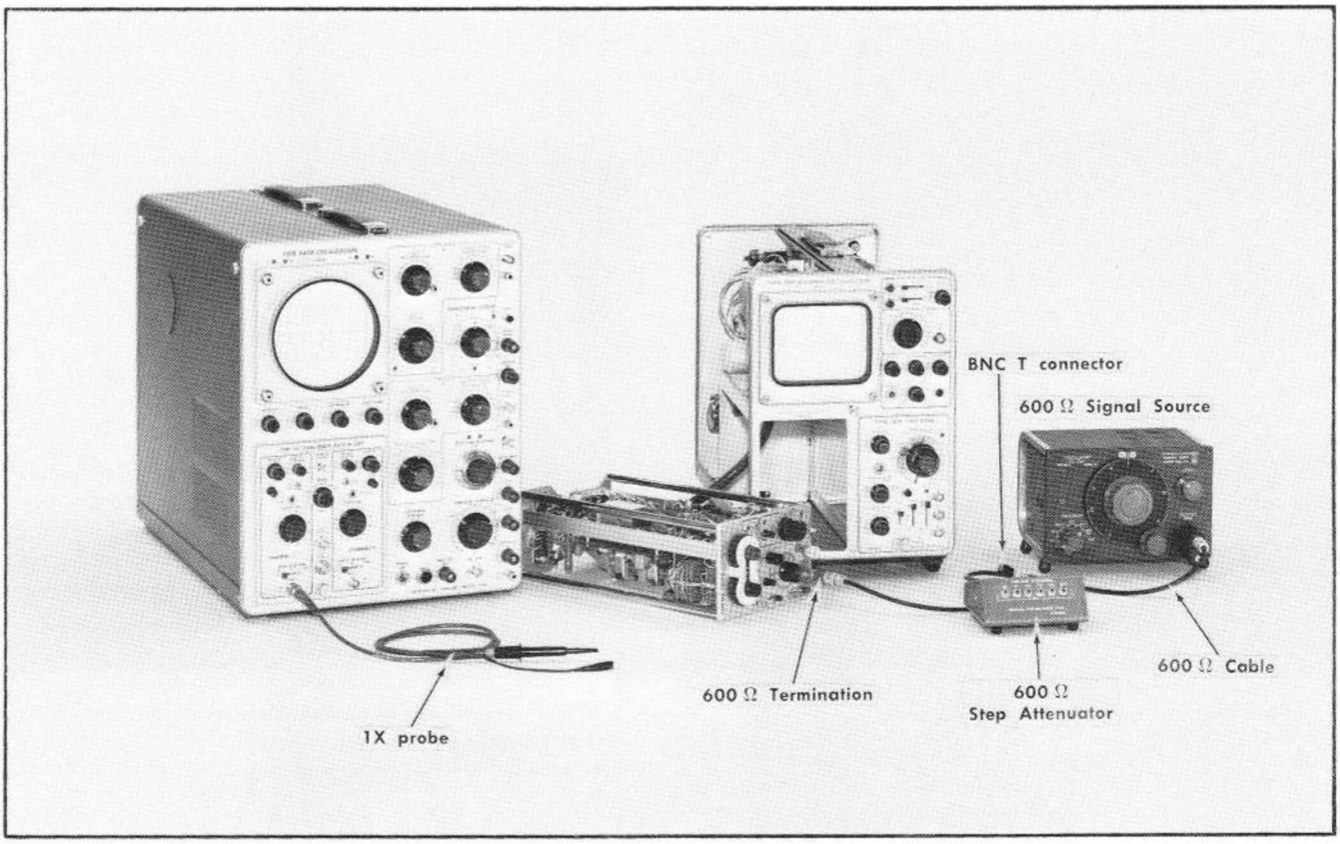


Fig. 6-13. Equipment setup to adjust Lin calibration, dynamic range of Log mode, and check output signal level at TO RECORDER jack.

	Type 3L5
CENTER FREQUENCY-Hz	**50 k**
VARIABLE	CAL
VERTICAL DISPLAY	LIN
POSITION	**Centered**
SWEEP	INT
Input Selector	AC FAST
VOLTS/DIV	**.005 (Inner scale)**
VARIABLE	CAL
V/DIV ÷ 100	Pushed in
DISPERSION-Hz/DIV	**1 k**
RESOLUTION	**Fully clockwise**
VARIABLE	CAL

Oscilloscope Time-Base Plug-In Unit

Time/Div	**50 ms**
Triggering	Adjust for a free running trace

7. Adjust LIN-LOG Calibration, Dynamic Range of Log Display and Check Display Linearity

NOTE

Check Video deflection factor (Step 1) before performing this step.

a. Equipment setup is shown in Fig. 6-13.

b. Pre-adjust Shift Zero R428, for minimum baseline shift as the VERTICAL DISPLAY selector is switched between the LIN and LOG positions. Preset Log Range adjustment R420 fully clockwise. Set the VERTICAL DISPLAY selector to the LIN position.

c. Apply 50 kHz signal from the signal generator through a BNC "T" connector, a 600 Ω Step Attenuator (set for 20 dB), a coaxial cable and 600 Ω termination to the INPUT of the Type 3L5. Connect the test oscilloscope to the BNC "T" connector to monitor the signal output amplitude.

d. Adjust the signal generator output for a signal amplitude of 1 V peak to peak on the test oscilloscope. (One volt peak to peak, at the T connector provides an input signal to the Type 3L5 with an amplitude of 100 mV peak to peak or 35 mV RMS.)

e. Disconnect the test oscilloscope from the "T" connector and connect the test oscilloscope through a 10× probe to the detector output (junction of D420-R421-R422, Fig. 6-14). Set the test oscilloscope Time/cm to the same sweep rate as the analyzer time-base unit.

f. Adjust Lin Cal R316, (Fig. 6-14) for a signal amplitude of about 40 volts at the detector output. (This is not critical, 40 V ±5 V is satisfactory.) Remove the test oscilloscope probe.

g. Adjust R422 (Fig. 6-14) for a signal amplitude of 7 divisions on the analyzer LIN mode display. Center the display with the VARIABLE CENTER FREQUENCY control or the signal generator frequency control.

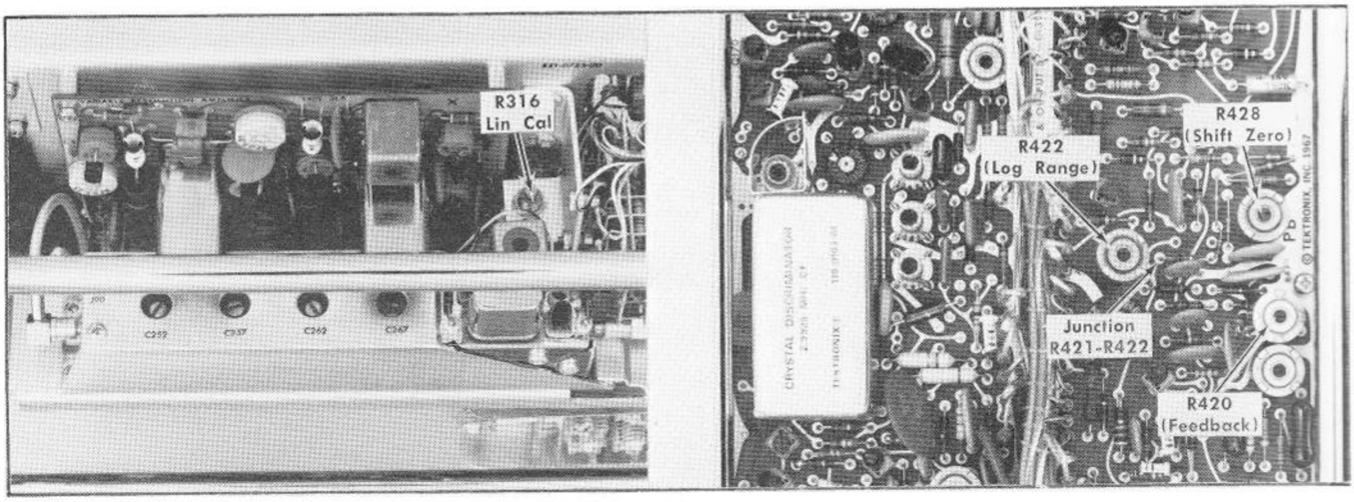


Fig. 6-14. Location of LIN-LOG calibration adjustments.

h. Adjust R428 for minimum display baseline shift between the LIN and LOG mode positions of the VERTICAL DISPLAY selector.

i. Switch the VERTICAL DISPLAY selector to LOG position and the step attenuator for 0 dB attenuation.

j. Adjust R428 and R422 (Fig. 6-14) for a signal with an amplitude of 8 divisions and optimum skirt symmetry as illustrated in Fig. 6-15A. R422 affects the slope and symmetry and R428 the signal amplitude. The display baseline reference will shift as these adjustments are performed, therefore, the baseline must be repositioned to measure signal amplitude. Distortion or non-symmetry at the base of the display may be caused by incorrect adjustment of the resolution bandwidth. Recheck the adjustment of C323 and C343.

k. Switch the step attenuator from 0 dB to 42 dB in 7 dB steps then to 51 dB. Note the linearity between these steps. If the analyzer oscilloscope has storage, switch the triggering to single sweep and store the display for each step. Graticule calibration is approximately 7 dB/div over the top 6 divisions and 9 dB between the 1st and 2nd division, LOG mode. See Fig. 6-16.

l. If the spacing between each display is linear, but the amplitude is high or low, check the Video CAL adjustment in step 1.

m. Adjust R428, R422, R420 and Lin Cal R316 for optimum linearity over the 51 dB dynamic range. (Top 7 graticule divisions). Adjustment interaction will be apparent; however the primary affect of each adjustment on the display is as follows:

Adjust R428 for the 0 dB to 7 dB range, adjust R422 for the 21 dB to 35 dB range, adjust Lin Cal R316 and R420 for the 42 dB to 51 dB range. Log Limit R420 adjustment, also affects LIN mode linearity. It should be set for the best compromise between the LIN and LOG mode display or close to the fully clockwise position.

When these adjustments are close to correct settings their effect is critical, therefore adjust each one only a few degrees then check linearity over the full dynamic range of the LOG mode.

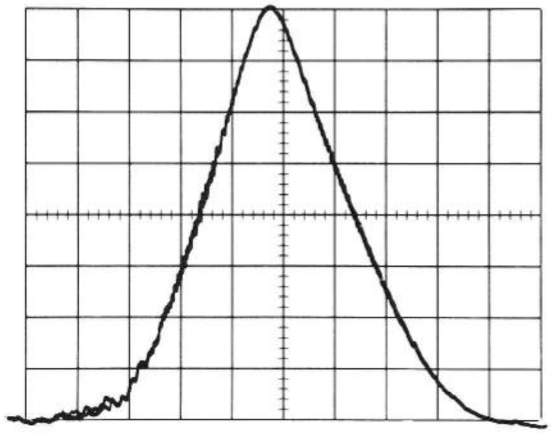
n. Set the VERTICAL DISPLAY selector to LIN position and the step attenuator for 20 dB. Re-check the input signal level to verify that it is still 35 mV RMS (step d).

o. Check—Signal amplitude, with the VOLTS/DIV selector in the .005 position, must equal 7 divisions. If the signal amplitude is within 0.5 division of the correct amplitude, adjust Lin Cal R316, to correct the error. If the signal amplitude error is greater than 0.5 division, correct by changing the value of select resistor R432. Increase the value if amplitude is short, and decrease the value if the amplitude is high.

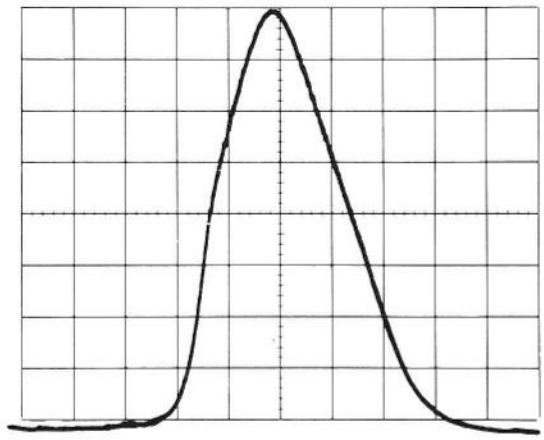
p. Check—The accuracy of the LIN mode display by setting the step attenuator to the selections called out in Table 6-6 and noting amplitude error. Accuracy of LIN mode display must equal or exceed 3%.

Degradation of linearity over the dynamic range of the LIN mode, may occur if the signal drive to the LIN detector is low. Adjust Lin Cal to increase signal drive to the detector then repeat adjustment procedure for the best compromise between LIN and LOG mode. Drive range of Lin Cal adjustment for a 35 mV RMS signal, with the VOLTS/DIV selector at the .005 position, is approximately 10 V to better than 150 volts at the detector output.

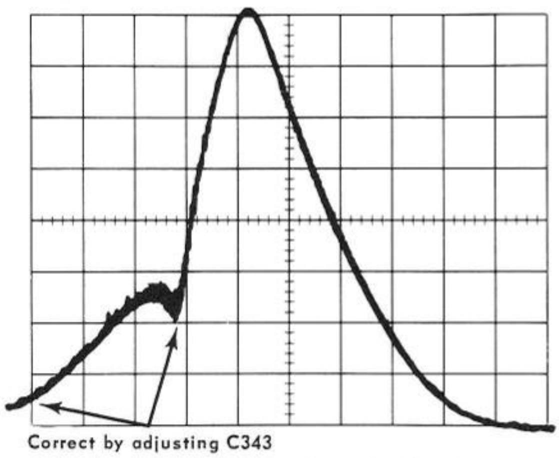
q. Repeat procedure if adjustments have affected LIN calibration.



(A) Ideal 8 div display. R422 and R428 correctly adjusted.



(B) Slope linearity incorrect. Correct by adjusting R422.



(C) Distortion produced when resolution bandwidth is incorrectly adjusted.

Fig. 6-15. Typical Log displays produced as the dynamic range of the Log mode is adjusted. Dispersion 1 k, Resolution fully clockwise.

TABLE 6-8

Step Attenuators	Display Amplitude
26 dB	4 div. (Set amplitude with signal generator output)
20 dB	8 div. ±1.2 minor div.
23 dB	5.6 div. ±0.8 minor div.
29 dB	2.8 div. ±0.4 minor div.
32 dB	2.0 div. ±0.2 minor div.

8. Check TO RECORDER Output Signal Amplitude

a. Equipment setup is given in step 7.

b. Set the following front panel controls as listed:

VERTICAL DISPLAY	LIN
VOLTS/DIV	.005 (Inner scale)
V/DIV ÷ 100	Pushed in
DISPERSION-Hz/DIV	1 k
RESOLUTION	Fully clockwise

c. Plug the minature phone plug with 600 Ω load resistor across the terminals (see equipment list) into the TO RECORDER jack. Connect a 1× probe from the test oscilloscope across the load resistor.

d. Adjust the signal generator output for a signal amplitude of 8 divisions on the analyzer display.

e. Check—Voltage output across the 600 Ω load resistor. It should measure 5 mV to 15 mV with a full 8 divisions display. (If the output does not measure within this range, change the value of select resistor R416.)

f. Remove the phone plug from the TO RECORDER jack.

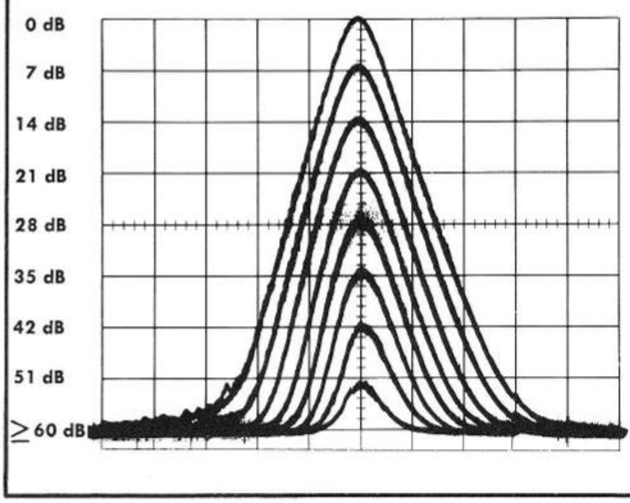


Fig. 6-16. Stored display, illustrating graticule calibration for LOG display. (7 dB/div for top 6 divisions and 9 dB between the 1st and 2nd graticule division.)

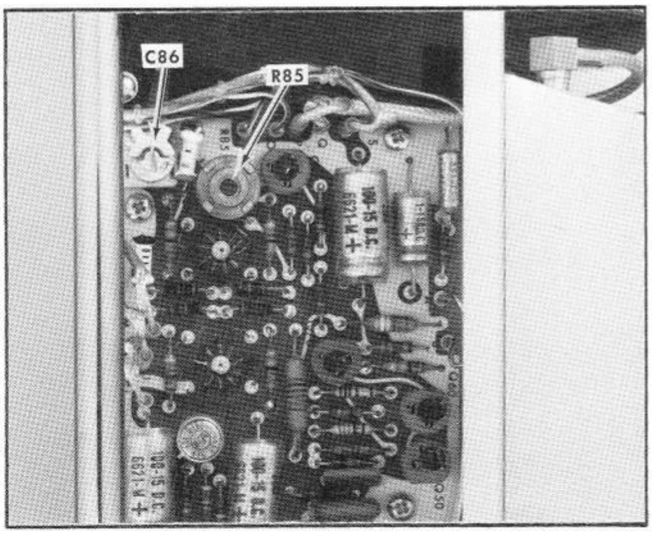


Fig. 6-17. Location of mixer balance adjustments.

9. Adjust Mixer Balance (0 Hz marker signal amplitude).

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	**0000**
DISPERSION-Hz/DIV	1 k
Input Selector	**GND**

b. Adjust R85 and C86 (Fig. 6-17) for a 0 Hz marker signal amplitude that is approximately 1 to 4 divisions. Change the value of select capacitor C87 if necessary to obtain this amplitude.

NOTES

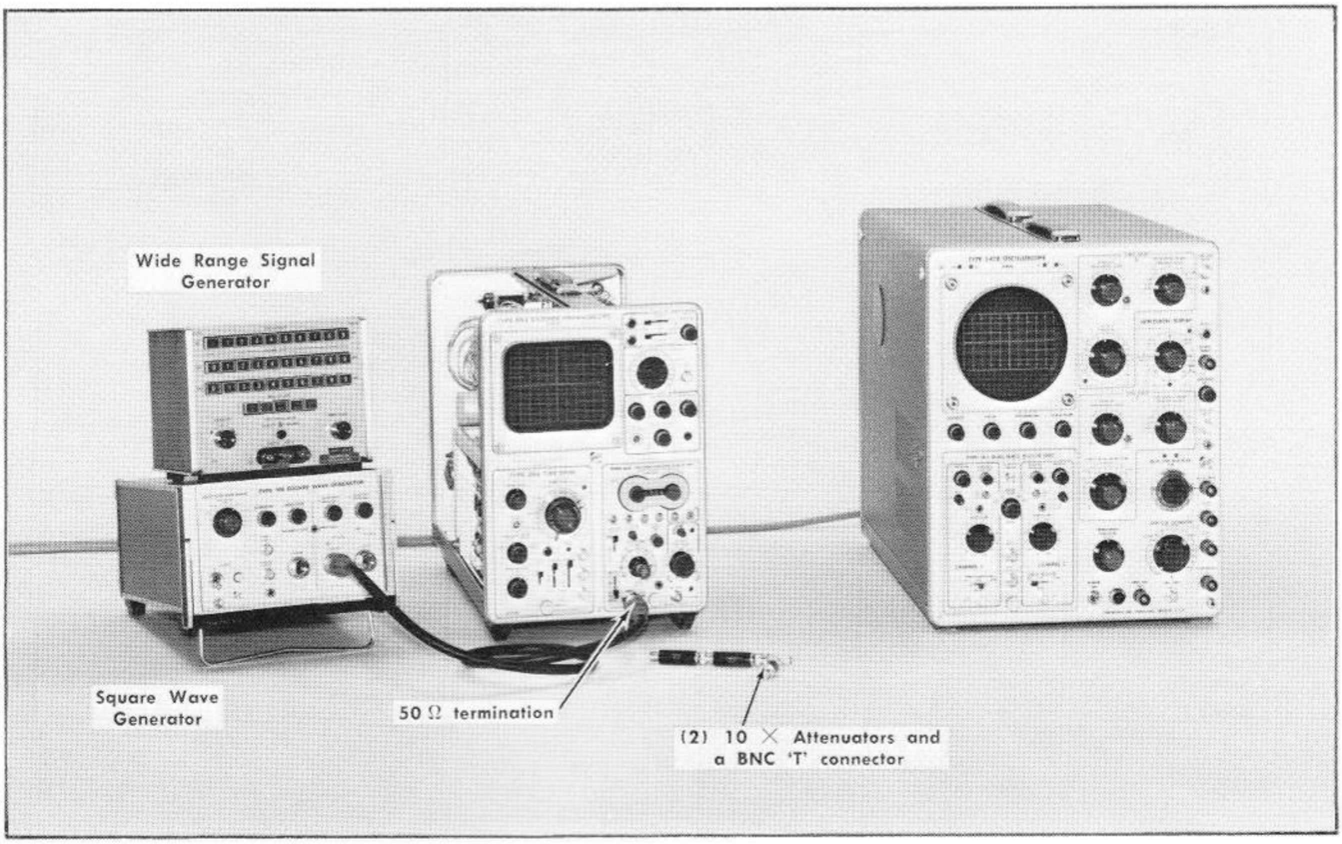


Fig. 6-18. Equipment setup for adjusting the output amplifier compensation and checking the video frequency response.

Type 3L5

CENTER FREQUENCY-Hz	**500 k**
VARIABLE	CAL
VERTICAL DISPLAY	**VIDEO**
POSITION	Centered
SWEEP	INT
Input Selector	AC FAST
VOLTS/DIV	**.5 (Outer Scale)**
VARIABLE	CAL
V/DIV ÷ 100	Pulled out
DISPERSION	
VARIABLE	CAL
Hz DIV—COUPLED RESOLUTION	**100 k**

Oscilloscope Time Base Unit

Time/Div	**10 μs**
Triggering	Adjust for a free running trace

10. Adjust Output Amplifier Compensation and Check Video Frequency Response

a. Equipment setup is shown in Fig. 6-18.

NOTE

The Type 3L5 must be in the right-hand or horizontal compartment and the Time Base Unit must be in the left-hand or vertical compartment for this step.

b. Apply a 10 kHz signal from the square-wave generator to the INPUT connector of the 3L5. Adjust the generator output for a display amplitude of 6 divisions.

c. Set the Time/Div selector to 10 μs and adjust the Triggering Level control for a triggered display.

d. Adjust capacitors C481 and C491 (Fig. 6-19A) in equal increments for optimum front corner response. (Fig. 6-19B.)

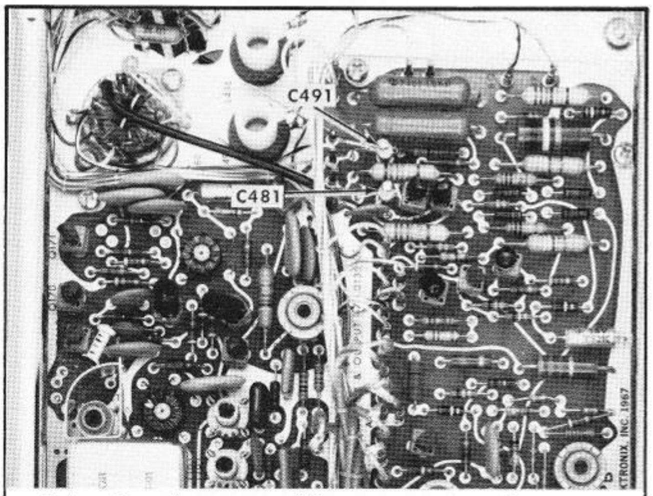
e. Disconnect the signal from the square-wave generator.

f. Apply a 10 kHz signal from the signal generator through a T connector, two 10× attenuators, and a 50 Ω termination to the INPUT connector of the Type 3L5.

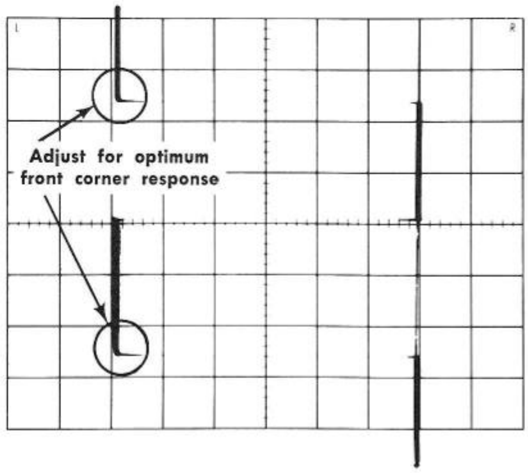
g. Monitor the input signal amplitude by connecting the vertical Input of the test oscilloscope to the T connector.

h. Adjust the signal generator output control for a signal amplitude of 6 divisions on the plug-in oscilloscope CRT. Adjust the test oscilloscope Volts/Cm and Variable control for a signal reference amplitude of 6 divisions.

i. Increase the frequency of the signal generator to 1 MHz. Readjust the signal generator output control to return the sig-



A. Location of output amplifier compensation adjustments.



B. Adjust C481-C491 for optimum front corner response.

Fig. 6-19. Location of C481-C491 and typical waveform response.

nal amplitude to the reference amplitude of 6 divisions on the test oscilloscope. Fig. 6-20.

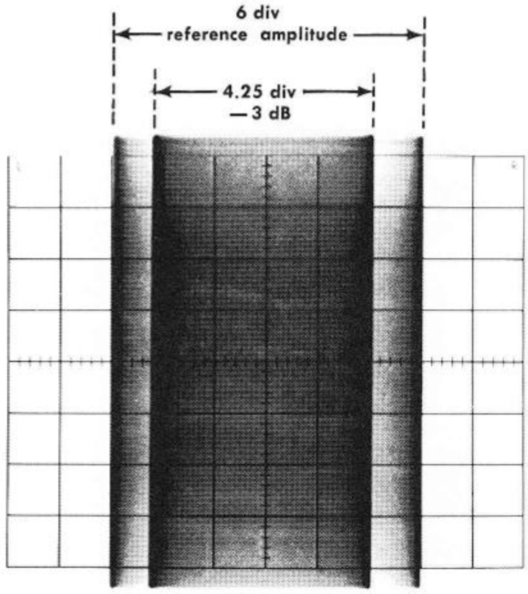


Fig. 6-20. Double exposure illustrating two levels when measuring video frequency response.

j. Check the amplitude of the display on the Type 3L5 plug-in oscilloscope CRT. It must equal or exceed 4.25 divisions (—3 dB point).

k. Change the VOLTS/DIV selector to .1 VOLTS/DIV. Change the signal generator frequency to 700 kHz. Adjust the signal generator output for a signal amplitude of 6 divisions on the test oscilloscope.

l. Check the amplitude of the display on the Type 3L5 plug-in oscilloscope. Must equal or exceed 4.25 divisions ($\leq$3 dB at 700 kHz). If video response does not meet specifications, perform step 1 then repeat this step.

m. Return the Type 3L5 to the vertical compartment and the Time Base Unit to the horizontal compartment.

NOTES

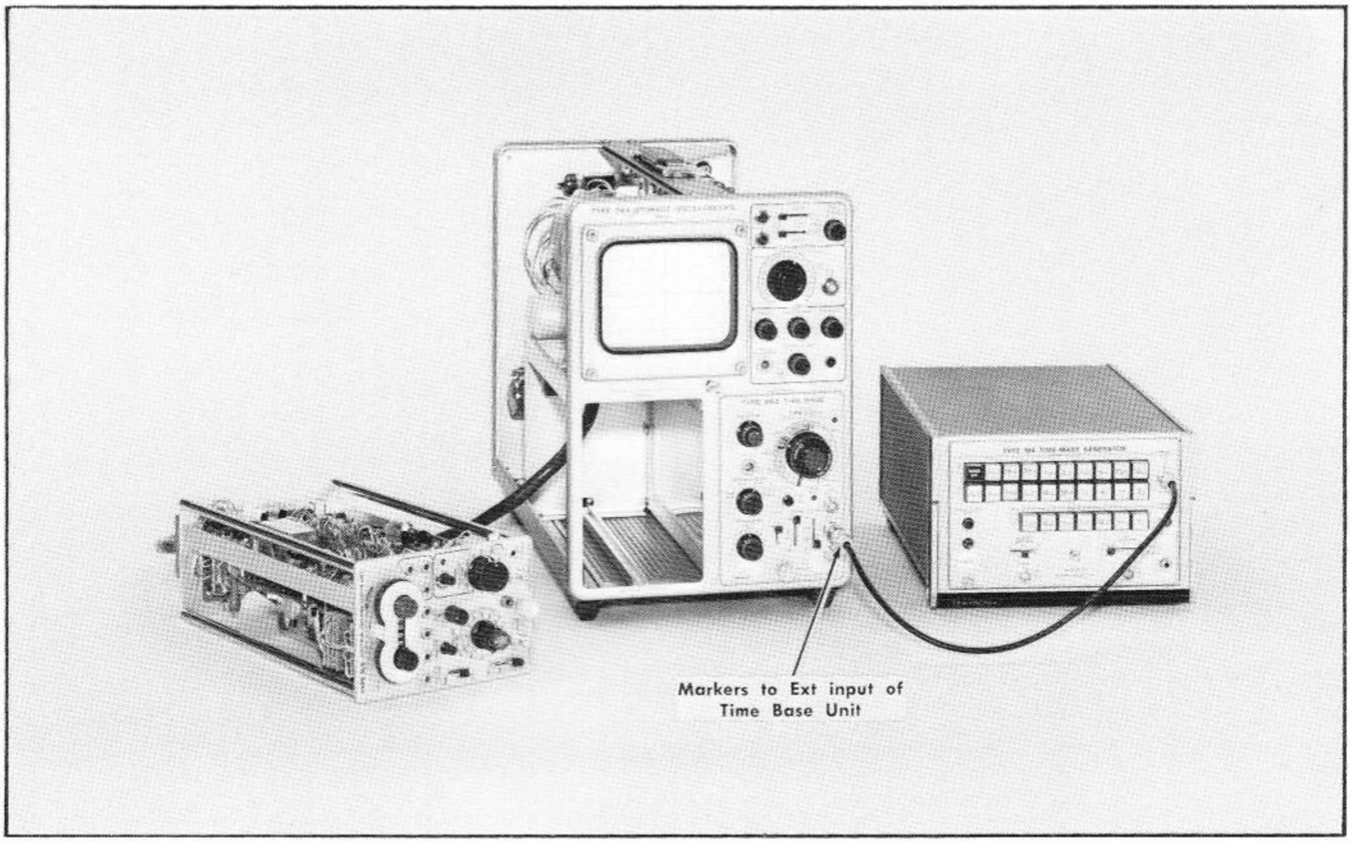


Fig. 6-21. Equipment setup for adjusting the 5 kHz calibrator.

	Type 3L5
CENTER FREQUENCY-Hz	**10 k**
VARIABLE	CAL
VERTICAL DISPLAY	LIN
POSITION	Centered
SWEEP	INT
Input Selector	AC FAST
VOLTS/DIV	**CALIBRATE**
VARIABLE	CAL
V/DIV ÷ 100	Pushed in
DISPERSION-Hz/DIV	**10 k**
COUPLED RESOLUTION	
VARIABLE	CAL

	Oscilloscope Time-Base Unit
Time/Div	**10 ms**
Trggering	**Ext**

11. Adjust Calibrator Frequency and Amplitude

Performance Requirement: Frequency, 5 kHz ±1%. Amplitude, 4 divisions, CALIBRATE display.

a. Equipment setup is shown in Fig. 6-21.

b. Apply 1 ms markers from the Time-Mark Generator to the External Trigger Input of the Time-Mark Unit. Set the

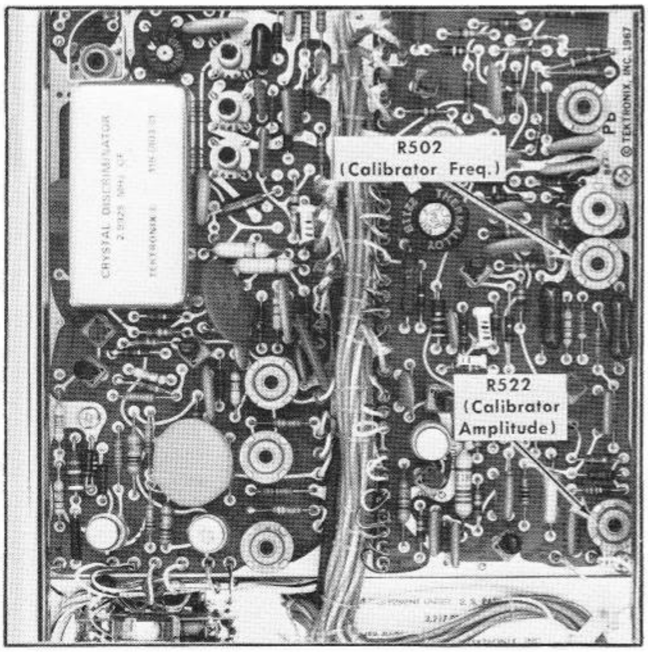
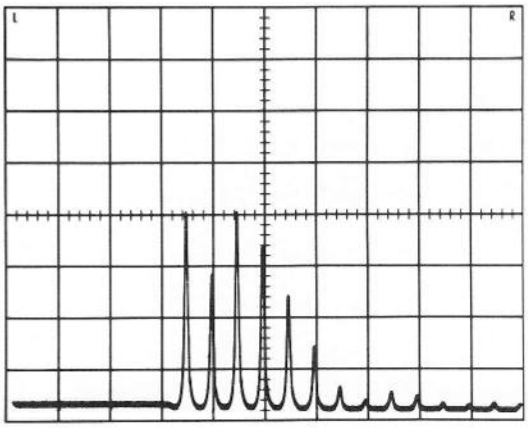
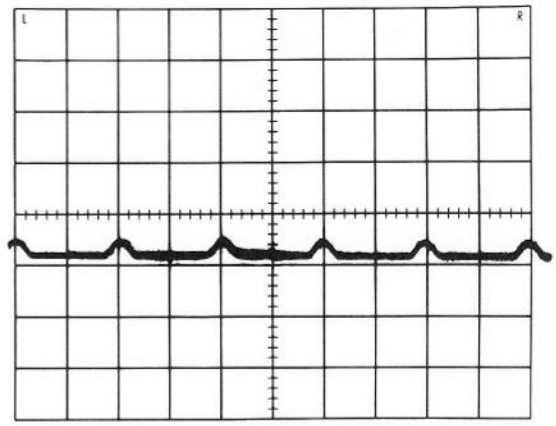


Fig. 6-22. 5 kHz Calibrator Adjustments.



A. 5 kHz Calibrator display with a dispersion of 10 kHz/DIV.



B. With a Time/Div rate of .1 ms, adjust R502 for 1 marker/2 divisions.

Fig. 6-23. 5 kHz Calibrator displays.

Trigger Source to Ext and adjust the Level control for a triggered sweep.

c. Adjust R522 (Fig. 6-22) for a 4 division display amplitude of the 5 kHz fundamental frequency marker. See Fig. 6-23A.

d. Switch the VERTICAL DISPLAY selector to the VIDEO position. Change the Time/Division to .1 ms.

e. Adjust R502 (Fig. 6-22) for 1 marker/2 divisions and minimum display drift. See Fig. 6-23B.

NOTES

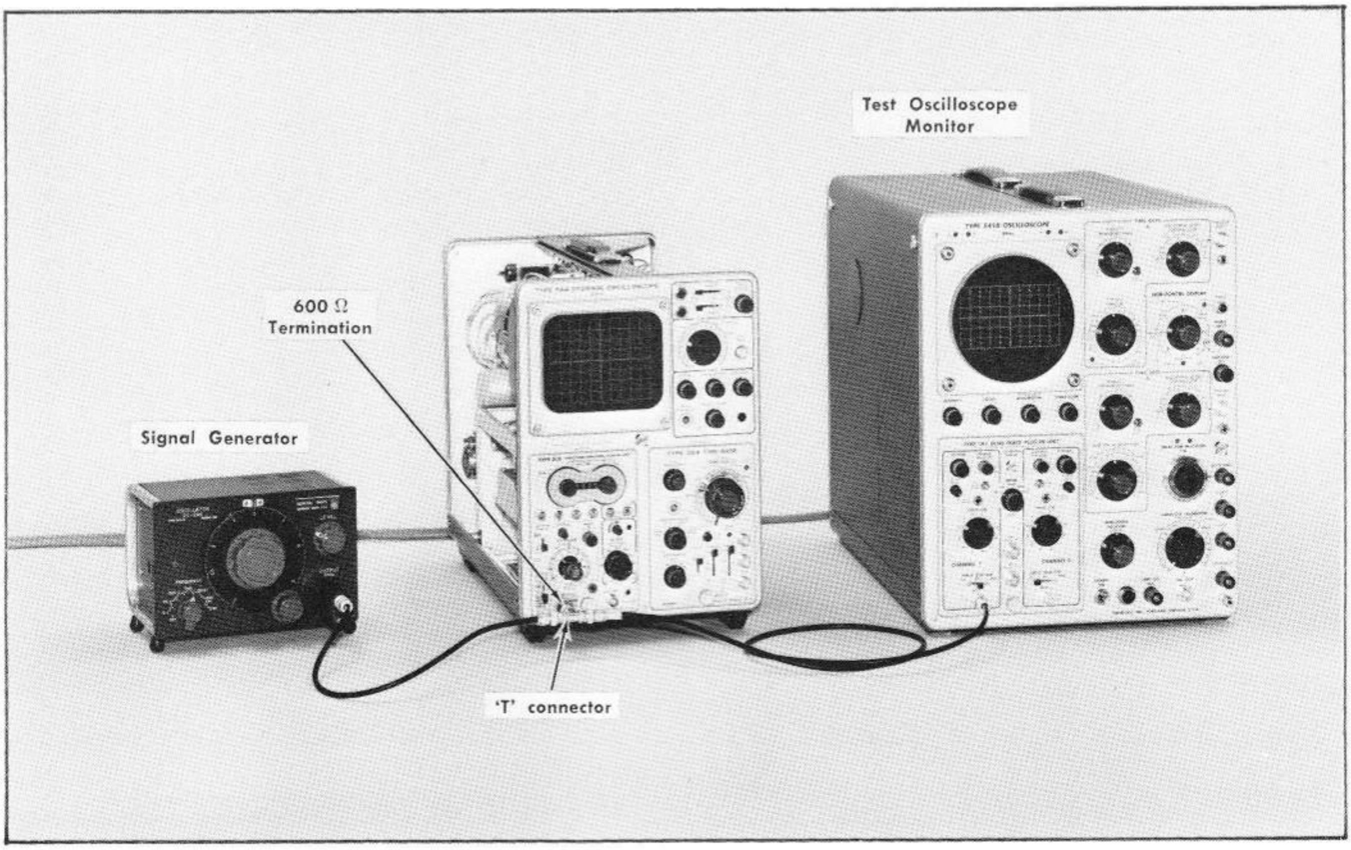


Fig. 6-24. Equipment setup to check display flatness.

	Type 3L5
CENTER FREQUENCY-Hz	**5000**
VARIABLE	CAL
VERTICAL DISPLAY	LIN
POSITION	Centered
SWEEP	INT
Input Selector	AC FAST
VOLTS/DIV	**.001 (Inner scale)**
VARIABLE	CAL
V/DIV ÷ 100	Pushed in
DISPERSION Hz/DIV	10 k
COUPLED RESOLUTION VARIABLE	CAL
	Oscilloscope Time Base Unit
Time/Div	**20 ms**
Triggering	**Adjusted for a free running trace**

12. Check Display Flatness

The display flatness for the .001 VOLTS/DIV and .002 VOLTS/DIV position is +0.5 dB to —3 dB (10 Hz to 1 MHz). The display flatness for the .005 VOLTS/DIV to 2 VOLTS/DIV range is within ±0.5 dB. (10 Hz to 1 MHz).

a. Equipment setup is shown in Fig. 6-24.

b. Apply a 5 kHz signal from the low frequency signal generator through a BNC "T" connector and a 600 Ω termination to the INPUT of the Type 3L5. Connect the test oscilloscope to the "T" connector to monitor the input signal level.

c. Adjust the output of the signal generator for a signal amplitude of 6 divisions on the plug-in oscilloscope CRT. Adjust the test oscilloscope gain for a reference display amplitude of 6 divisions on the test oscilloscope.

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

1. Set the CENTER FREQUENCY selector to 10 kHz.

2. Change the signal generator frequency to 50 kHz and adjust the generator output to re-establish the 6 division reference level 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 (6.36 to 4.25 divisions).

4. Change the signal generator frequency in 100 kHz increments through the remainder of the 10 kHz to 990 kHz frequency range. Re-establishing the reference amplitude after each change, and check the display flatness by tuning the CENTER-FREQUENCY-Hz selector below and above the applied frequency.

e. Check display flatness for the 10 Hz to 9900 Hz range with a 9000 Hz signal and a 50 Hz signal applied to the Type 3L5 INPUT. Decrease the Hz/DIV (DISPERSION) selection as the center frequency is decreased, or when the REDUCED dispersion indicator lights.

f. Repeat the flatness check for each position of the VOLTS/DIV selector. Display flatness for the .001 and .002 VOLTS/DIV positions must remain within +0.5 dB to —3 dB. Display flatness for the .005 to the 2 VOLTS/DIV range is ±0.5 dB. (Pull the V/DIV ÷ 100 knob out when checking the .5, 1 and 2, VOLTS/DIV positions.)

NOTE

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

NOTES

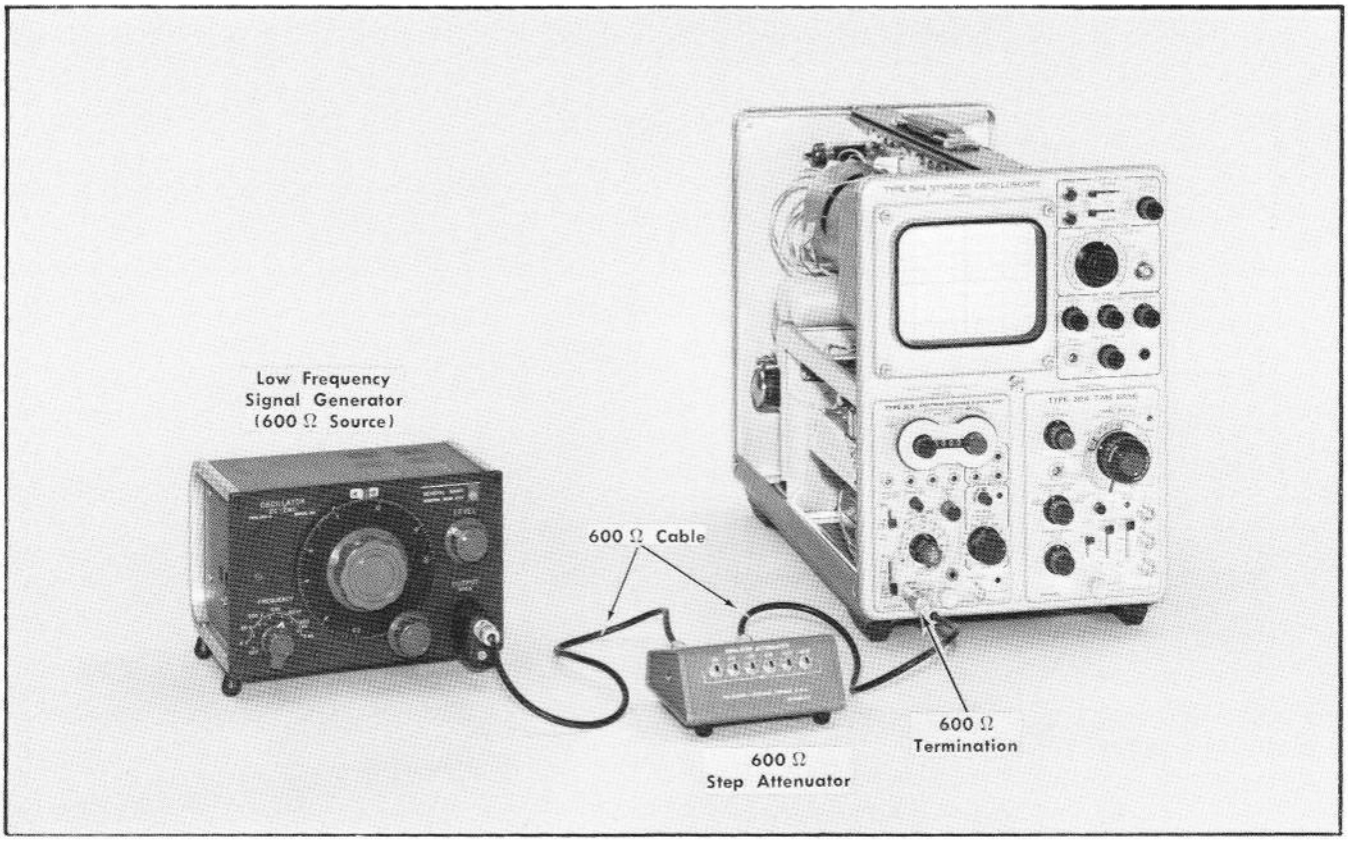


Fig. 6-25. Equipment setup to check incidental frequency modulation and random spurii.

Type 3L5	
CENTER FREQUENCY-Hz	**9000**
VARIABLE	CAL
VERTICAL DISPLAY	LIN
POSITION	Centered
SWEEP	INT
Input Selector	AC FAST
VOLTS/DIV	**.005 (Inner scale)**
VARIABLE	CAL
V/DIV ÷ 100	Pushed in
DISPERSION-Hz/DIV	**1 k**
COUPLED RESOLUTION	
VARIABLE	CAL

Oscilloscope Time-Base Unit	
Time/Div	**50 ms**
Triggering	Adjusted for a free running trace

13. Check Incidental Frequency Modulation

There are no requirements for this check. It provides an indication of operational performance.

a. Equipment setup is shown in Fig. 6-25.

b. Apply a 9 kHz signal from the LF signal generator through the 600 Ω step attenuator and 600 Ω termination to the INPUT connector on the Type 3L5. Set the attenuator for 0 dB then adjust the signal generator output for a full screen (8 div) display.

c. Reduce the DISPERSION Hz/DIV to 10 while adjusting the generator frequency to keep the signal centered within the graticule area.

d. Change the sweep rate to .5 s/div. Maintain a full screen display that is centered within the graticule area.

e. Check the amount of incidental FM at the 50% or half amplitude point of the signal. It should not exceed 1.5 minor divisions (Fig. 6-26).

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

g. Change the CENTER FREQUENCY-Hz setting and the signal generator frequency to 900 kHz. Decrease the DISPERSION-Hz/DIV selector to 50. Keep the signal centered and maintain an amplitude of 8 divisions.

h. Check incidental FM at 90 kHz, 500 kHz and 10 kHz. It should not exceed 10 Hz or 1 minor division with a dispersion of 50 Hz/DIV.

14. Check Amplitude of Random Spurii

Requirement: Random spurii amplitude, from a signal that is 50 dB above 1.0 division reference level, must not exceed 1.0 division.

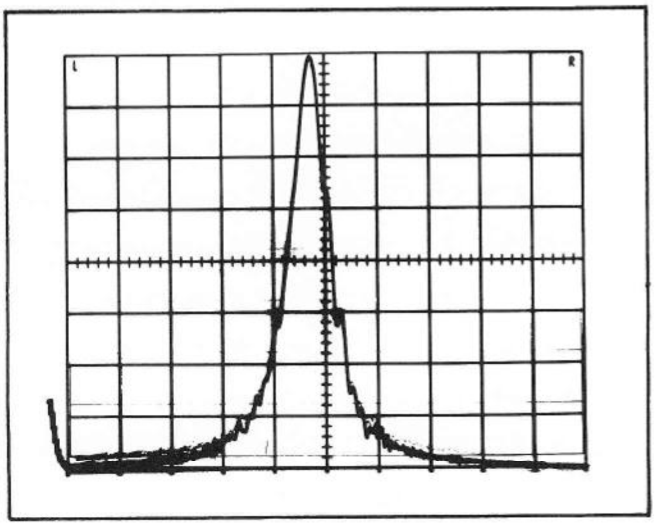


Fig. 6-26. Display illustrating the check on incidental FM.

a. Equipment setup is given in step 13.

b. Change the controls to the following settings:

CENTER FREQUENCY-Hz	**500 k**
VERTICAL DISPLAY	**LOG**
VOLTS/DIV	.005 (Inner scale)
V/DIV. ÷ 100	**Pulled out**
DISPERSION-Hz/DIV	**100 k**
RESOLUTION	**200 (uncoupled)**
Time/Div	**.5 s**

c. Apply a 500 kHz signal from the signal generator through the step attenuator and 600 Ω termination to the Type 3L5 INPUT. Set the step attenuator for 50 dB attenuation. Adjust the generator output for a display amplitude of 1.0 division.

d. Set the step attenuator for 0 dB attenuation.

e. Check—Amplitude of spurious signals should not exceed 1.0 division. Ignore the 0 Hz spur and the 2nd harmonic signal.

If an excessive spurious signal is present at approximately 300 kHz, it may be due to mis-adjustment of L270. 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

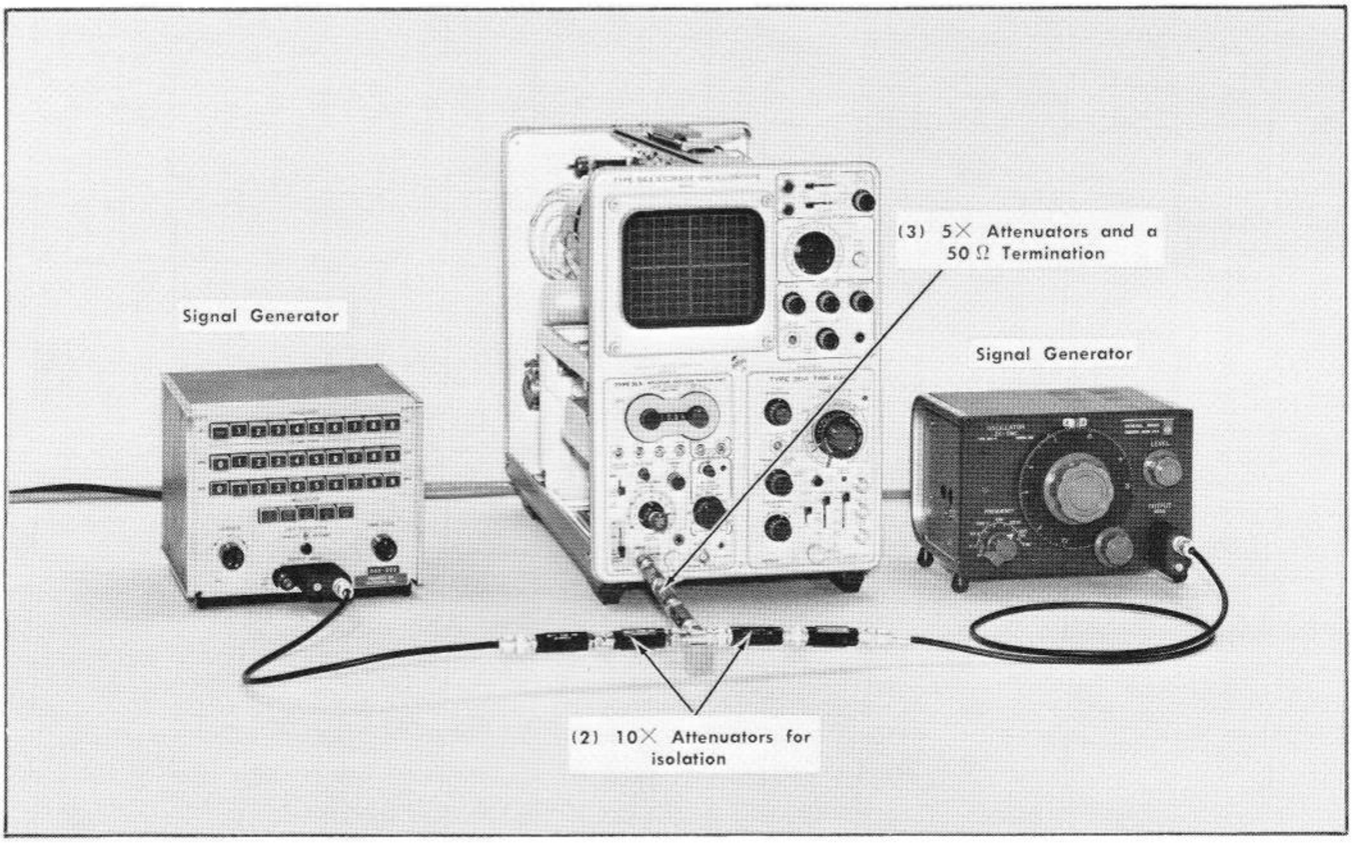


Fig. 6-27. Test equipment setup to check intermodulation distortion.

	Type 3L5
CENTER FREQUENCY-Hz	**100 k**
VARIABLE	CAL
VERTICAL DISPLAY	LOG
POSITION	**Centered trace at the bottom graticule line**
SWEEP	INT
Input Selector	AC FAST
VOLTS/DIV	.005 (Inner scale)
V/DIV ÷ 100	Pulled out
DISPERSION-Hz/DIV	**10 k**
RESOLUTION	**50**
	Oscilloscope Time-Base Unit
Time/Div	**.5 s**
Triggering	**Free running**

15. Check Intermodulation Distortion

Requirement: Intermodulation sideband amplitude must not exceed 1.0 division when signals of 8 divisions (LOG mode) are displayed.

a. Equipment setup is shown in Fig. 6-27.

b. Apply outputs from 90 kHz and 110 kHz signal generators through isolation networks consisting of two 10× attenuators, a BNC T connector, three 5× attenuators and a 50 Ω termination to the INPUT connector of the Type 3L5.

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 then adjust the output controls of the two signal generators for two signals that are 1.0 divisions above the bottom graticule line. See Fig. 6-28A.

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/DIV selector to .002 position.

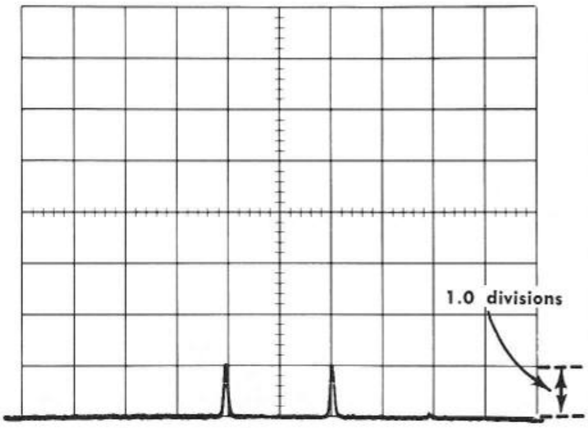
e. Check—Intermodulation distortion. The amplitude of the sidebands must not exceed 1.0 divisions. See Fig. 6-28B.

16. Check Operation of Manual Sweep

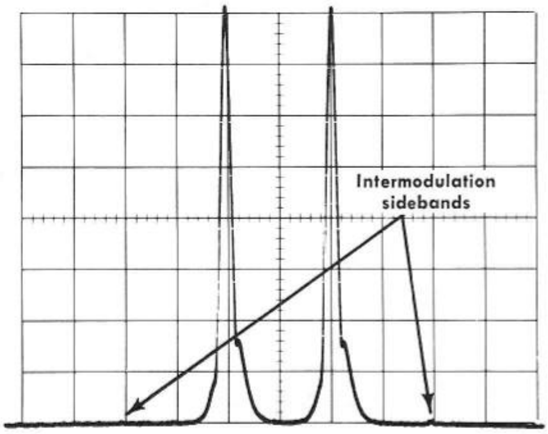
a. Connect a patch cord (banana plug to BNC) between the OUT jack and the Ext Horiz Input connector on the Time-Base Unit (Type 3B4).

b. Set the front panel controls as follows:

	Type 3L5
CENTER FREQUENCY-Hz	**10 k**
VERTICAL DISPLAY	**LIN**



(A) 90 kHz and 110 kHz signals adjusted to an amplitude of 1.0 divisions.



(B) Intermodulation sidebands less than 1.0 divisions.

Fig. 6-28. Typical display of two signals used to check intermodulation distortion.

VOLTS/DIV	**CALIBRATE**
DISPERSION	**10 k**
Input Coupling	GND
SWEEP	**MANUAL fully clockwise to 10**

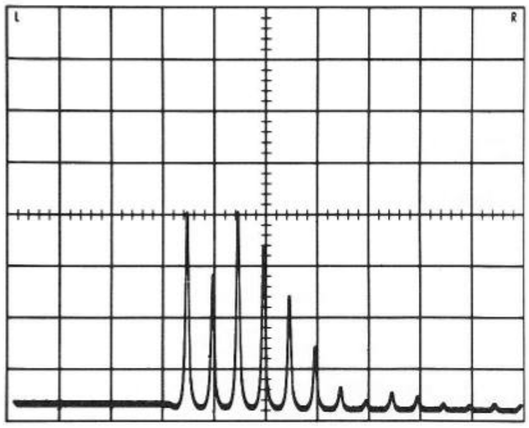


Fig. 6-29. Calibrator display when checking MANUAL sweep operation.

Time-Base Unit

Horizontal Volts/Div **(External Input)**

c. Position the beam to the left edge of the graticule with the Position control.

d. Turn the SWEEP control fully counterclockwise to 0. Adjust the VARIABLE VOLTS/DIV control to position the beam to the right edge of the graticule.

e. Rotate the SWEEP control through its range. The display should resemble Fig. 6-29.

17. Check Internal Noise Level

a. Set the front panel controls as follows:

CENTER FREQUENCY-Hz	**500 k**
VERTICAL DISPLAY	**LOG**
DISPERSION-Hz/DIV	**100** k
VOLTS/DIV	**.001**
V/DIV ÷ 100	Pull knob out
Input Selector	**GND**

b. Check—Noise level must not exceed 0.5 division.

NOTES

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	PHB	pan head brass
DE	double end	PHS	pan head steel
dia	diameter	plstc	plastic
div	division	PMC	paper, metal cased
elect.	electrolytic	poly	polystyrene
EMC	electrolytic, metal cased	prec	precision
EMT	electrolytic, metal tubular	PT	paper, tubular
ext	external	PTM	paper or plastic, tubular, molded
F & I	focus and intensity	RHB	round head brass
FHB	flat head brass	RHS	round head steel
FHS	flat head steel	SE	single end
Fil HB	fillister head brass	SN or S/N	serial number
Fil HS	fillister head steel	SW	switch
h	height or high	TC	temperature compensated
hex.	hexagonal	THB	truss head brass
HHB	hex head brass	thk	thick
HHS	hex head steel	THS	truss head steel
HSB	hex socket brass	tub.	tubular
HSS	hex socket steel	var	variable
ID	inside diameter	w	wide or width
incd	incandescent	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.
◐	Screwdriver adjustment.
▭	Control, adjustment or connector.

SECTION 7

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Bulb			
B115	150-0035-00			Neon AID T2			
				Capacitors			

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
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, Var	Air		
C4C	281-0099-00			1.3-5.4 pF, Var	Air		
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, Var	Air		
C5C	281-0099-00			1.3-5.4 pF, Var	Air		
C5D	283-0606-00			250 pF	Mica	500 V	10%
C8A	281-0099-00			1.3-5.4 pF, Var	Air		
C8C	281-0102-00			1.7-11 pF, Var	Air		
C8D	281-0505-00			12 pF	Cer	500 V	10%
C9A	281-0102-00			1.7-11 pF, Var	Air		
C9C	281-0102-00			1.7-11 pF, Var	Air		
C10	281-0100-00			1.4-7.3 pF, Var	Air		
C11	281-0500-00	B010100	B069999	2.2 pF	Cer	500 V	±0.5 pF
C11	281-0529-00	B070000		1.5 pF	Cer	500 V	±0.25 pF
C13	281-0078-00			1.4-7.3 pF, Var	Air		
C15	281-0092-00	B010100	B069999	9-35 pF, Var	Cer		
C15	281-0075-00	B070000		5-25 pF, Var	Cer		
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%
C41	281-0543-00			270 pF	Cer	500 V	10%
C43	290-0201-00			100 μF	Elect.	15 V	
C44	Selected						

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C45	281-0605-00			200 pF	Cer	500 V	
C49	283-0024-00			0.1 μF	Cer	30 V	
C51	290-0201-00			100 μF	Elect.	15 V	
C54	283-0059-00	B010100	B019999	1 μF	Cer	25 V	+80%—20%
C54	290-0323-00	B020000		270 pF	Elect.	15 V	
C70	290-0201-00			100 μF	Elect.	15 V	
C82	281-0504-00			10 pF	Cer	500 V	10%
C86	281-0081-00			1.8-13 pF, Var	Air		
C87	Selected						
C135	283-0010-00			0.05 μF	Cer	50 V	
C140	283-0008-00	XB070000		0.1 μF	Cer	500 V	
C142	283-0079-00			0.01 μF	Cer	250 V	
C153	283-0143-00			330 pF	Cer	200 V	5%
C154	283-0081-00			0.1 μF	Cer	25 V	
C155	283-0078-00			0.001 μF	Cer	500 V	
C157	283-0078-00			0.001 μF	Cer	500 V	
C158	283-0143-00			330 pF	Cer	200 V	5%
C160	281-0578-00			18 pF	Cer	500 V	5%
C161	283-0116-00			820 pF	Cer	500 V	5%
C162	283-0010-00			0.05 μF	Cer	50 V	
C168	283-0079-00			0.01 μF	Cer	250 V	
C171	283-0078-00			0.001 μF	Cer	500 V	
C175	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C176	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C178	283-0079-00			0.01 μF	Cer	250 V	
C180	283-0079-00			0.01 μF	Cer	250 V	
C184	283-0059-00			1 μF	Cer	25 V	+80%—20%
C187	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C191	283-0594-00			0.001 μF	Mica	100 V	1%
C193	283-0142-00			0.0027 μF	Cer	200 V	5%
C194	290-0136-00			2.2 μF	Elect.	20 V	
C197	281-0549-00			68 pF	Cer	500 V	10%
C204	290-0301-00			10 μF	Elect.	20 V	10%
C208	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C217	283-0059-00			1 μF	Cer	25 V	+80%—20%
C218	283-0059-00			1 μF	Cer	25 V	+80%—20%
C250	281-0523-00			100 pF	Cer	350 V	
C252	281-0044-00			80-480 pF, Var	Mica		
C253	283-0626-00			1800 pF	Mica		5%
C255	283-0115-00			47 pF	Cer	200 V	5%
C257	281-0044-00			80-480 pF, Var	Mica		
C258	283-0626-00			1800 pF	Mica		5%
C260	283-0115-00			47 pF	Cer	200 V	5%
C262	281-0044-00			80-480 pF, Var	Mica		
C263	283-0626-00			1800 pF	Mica		5%

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C265	283-0115-00			47 pF	Cer	200 V	5%
C267	281-0044-00			80-480 pF, Var	Mica		
C268	283-0626-00			1800 pF	Mica		5%
C270	283-0625-00			220 pF	Mica	500 V	1%
C273	283-0059-00			1 μF	Cer	25 V	+80%—20%
C275	283-0059-00			1 μF	Cer	25 V	+80%—20%
C280	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C281	283-0114-00	B010100	B069999	0.0015 μF	Cer	200 V	
C281	283-0624-00	B070000		1300 pF	Mica	500 V	2%
C290	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C292	283-0068-00	B010100	B069999	0.01 μF	Cer	500 V	
C292	285-0674-00	B070000		0.01 μF	PTM	100 V	
C294	283-0068-00			0.01 μF	Cer	500 V	
C297	283-0114-00			0.0015 μF	Cer	200 V	
C298	281-0580-00	B010100	B069999	470 pF	Cer	500 V	10%
C298	283-0597-00	B070000		470 pF	Mica	300 V	10%
C309	283-0079-00			0.01 μF	Cer	250 V	
C314	283-0079-00			0.01 μF	Cer	250 V	
C318	283-0111-00			0.1 μF	Cer	50 V	
C323	281-0093-00			5.5-18 pF, Var	Cer		
C327	283-0079-00			0.01 μF	Cer	250 V	
C329	281-0603-00			39 pF	Cer	500 V	5%
C332	281-0075-00			5-25 pF, Var	Cer		
C334	283-0111-00			0.1 μF	Cer	50 V	
C335	285-0685-00			0.0068 μF	PTM	100 V	10%
C336	283-0003-00			0.01 μF	Cer	150 V	
C337	283-0079-00			0.01 μF	Cer	250 V	
C338	283-0108-00			220 pF	Cer	200 V	10%
C342	283-0059-00			1 μF	Cer	25 V	+80%—20%
C343	281-0093-00			5.5-18 pF, Var	Cer		
C347	283-0079-00			0.01 μF	Cer	250 V	
C349	281-0603-00			39 pF	Cer	500 V	5%
C352	281-0075-00			5-25 pF, Var	Cer		
C354	283-0111-00			0.1 μF	Cer	50 V	
C355	285-0685-00			0.0068 μF	PTM	100 V	10%
C356	283-0003-00			0.01 μF	Cer	150 V	
C400	283-0078-00			0.001 μF	Cer	500 V	
C402	281-0617-00	XB090000		15 pF	Cer	200 V	
C404	283-0078-00			0.001 μF	Cer	500 V	
C405	281-0605-00			200 pF	Cer	500 V	
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 μF	Cer	25 V	+80%—20%
C416	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C420	283-0078-00			0.001 μF	Cer	500 V	
C421	283-0078-00			0.001 μF	Cer	500 V	
C428	283-0079-00			0.01 μF	Cer	250 V	
C432	283-0079-00			0.01 μF	Cer	250 V	
C446	290-0167-00			10 μF	Elect.	15 V	
C467	283-0003-00			0.01 μF	Cer	150 V	
C480	281-0538-00			1 pF	Cer	500 V	
C481	281-0064-00			0.25-1.5 pF, Var	Tub.		

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C490	281-0538-00			1 pF	Cer	500 V	
C491	281-0064-00			0.25-1.5 pF, Var	Tub.		
C500	285-0627-00	B010100	B069999	0.0033 μF	PTM	100 V	5%
C500	283-0627-00	B070000		0.0033 μF	Mica	500 V	5%
C506	290-0167-00			10 μF	Elect.	15 V	
C510	285-0627-00	B010100	B069999	0.0033 μF	PTM	100 V	5%
C510	283-0627-00	B070000		0.0033 μF	Mica	500 V	5%
C513	283-0059-00			1 μF	Cer	25 V	+80%—20%
C518	283-0059-00			1 μF	Cer	25 V	+80%—20%
C520	283-0059-00			1 μF	Cer	25 V	+80%—20%
C522	283-0059-00			1 μF	Cer	25 V	+80%—20%
C600	283-0059-00			1 μF	Cer	25 V	+80%—20%
C609	283-0059-00			1 μF	Cer	25 V	+80%—20%

Diodes

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
D18	*152-0185-00			Silicon	Replaceable by 1N4152	
D38	*152-0185-00			Silicon	Replaceable by 1N4152	
D42	*152-0185-00			Silicon	Replaceable by 1N4152	
D43	152-0031-00	B010100	B039999	Zener	1N718A	0.25 W, 15 V, 5%
D48	152-0243-00	B040000		Zener	1N965B	0.4 W, 15 V, 5%
D82A,B,C,D	*153-0028-00			Silicon (matched set)	Selected from 1N4244	
D108	*152-0185-00			Silicon	Replaceable by 1N4152	
D154, D157	*153-0029-00			Silicon (matched pair)	Selected from 1N4152	
D162	*152-0185-00			Silicon	Replaceable by 1N4152	
D163	*152-0185-00			Silicon	Replaceable by 1N4152	
D164	*152-0269-00			Voltage Variable Capacitance Tek Spec		
D165	152-0147-00			Zener	1N971B 0.4 W, 27 V, 5%	
D166	*152-0185-00			Silicon	Replaceable by 1N4152	
D184	*152-0185-00			Silicon	Replaceable by 1N4152	
D204	152-0243-00			Zener	1N965B	0.4 W, 15 V, 5%
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	
D420	*152-0107-00			Silicon	Replaceable by 1N647	
D422	*152-0107-00			Silicon	Replaceable by 1N647	
D428	152-0141-00	B010100	B999999	Silicon	1N4152	
D428	152-0141-02	B100000		Silicon	1N4152	
D429	152-0141-00	B010100	B999999	Silicon	1N4152	
D429	152-0141-02	B100000		Silicon	1N4152	
D430	152-0008-00			Germanium		
D432	152-0008-00			Germanium		
D434	152-0008-00	B010100	B089999	Germanium		
D434	152-0141-02	B090000		Silicon	1N4152	
D436	152-0008-00	B010100	B089999	Germanium		
D436	152-0141-02	B090000		Silicon	1N4152	
D454	*152-0185-00			Silicon	Replaceable by 1N4152	
D456	*152-0185-00			Silicon	Replaceable by 1N4152	

Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D464	*152-0185-00			Silicon	Replaceable by 1N4152
D466	*152-0185-00			Silicon	Replaceable by 1N4152
D520	*152-0185-00			Silicon	Replaceable by 1N4152

Connectors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
J1	131-0106-00			BNC, chassis mtd., 1 contact, female	
J90	131-0372-00			Coaxial	
P90[1]					
J101	*136-0139-00			Socket, Banana Jack Assembly	
J195	131-0106-00			BNC, chassis mtd., 1 contact, female	
J280	131-0372-00			Coaxial	
P280[1]					
J415	136-0094-00			Socket, Tini-Jax	

Inductors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
L120	276-0577-00	XB020000		Core, Coil Relay	
L139	*108-0443-00			25 μH	
L155	*175-0386-00	B010100	B019999	Delay Line	
L155	*175-0386-01	B020000		Delay Line	
L160	276-0577-00	XB020000		Core, Coil Relay	
L164	*114-0219-00			45-130 μH, Var	Core 276-0568-00
L190	108-0249-00			12 μH	
L191	*114-0220-00			1-3 μH, Var	Core 276-0568-00
L192	*114-0222-00			2-6 μH, Var	Core 276-0568-00
L194	*114-0222-00			2-6 μH, Var	Core 276-0568-00
L253	*108-0416-00			1.5 μH	
L258	*108-0416-00			1.5 μH	
L263	*108-0416-00			1.5 μH	
L268	*108-0416-00			1.5 μH	
L270	*114-0233-00			8.5-15.5 μH, Var	Core 276-0582-00
L280	114-0178-00			1300-3000 μH, 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	
L486	*108-0122-00			1.2 μH	
L496	*108-0122-00			1.2 μH	

Plug

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
P11	131-0149-00			Chassis mtd., 24 contact, male

[1]See Mechanical Parts List.

Transistors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc		Description
Q20	*151-1004-00			FET	Tek Spec
Q21	*151-0150-00			Silicon	Replaceable by 2N3440
Q30	151-0190-00			Silicon	2N3904
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
Q110	*151-0155-00			Silicon	Replaceable by 2N2925
Q120	*151-0104-00			Silicon	Dual-Replaceable by 2N2913
Q121	151-0188-00			Silicon	2N3906
Q130	151-0190-00			Silicon	2N3904
Q140	*151-0104-00			Silicon	Dual-Replaceable by 2N2913
Q160	*151-0198-00			Silicon	Replaceable by MPS-918
Q170	*151-0155-00			Silicon	Replaceable by 2N2925
Q171	151-0190-00			Silicon	2N3904
Q180	*151-0108-00			Silicon	Replaceable by 2N2501
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	B010100	B069999X	Silicon	Replaceable by 2N2923
Q300A,B	151-0254-00	XB070000		Silicon	TO-98 D16P4
Q310	*151-0153-00			Silicon	Replaceable by 2N2923
Q320	*151-0155-00			Silicon	Replaceable by 2N2925
Q330	151-0190-00			Silicon	2N3904
Q340	*151-0155-00			Silicon	Replaceable by 2N2925
Q350	151-0190-00			Silicon	2N3904
Q400	*151-0155-00			Silicon	Replaceable by 2N2925
Q401	*151-0155-00			Silicon	Replaceable by 2N2925
Q410	*151-0150-00			Silicon	Replaceable by 2N3440
Q420	151-0164-00			Silicon	2N3702
Q430	151-0164-00			Silicon	2N3702
Q441	*151-1004-00			FET	Tek Spec
Q442	151-0188-00			Silicon	2N3906
Q450	*151-0155-00			Silicon	Replaceable by 2N2925
Q460	*151-0155-00			Silicon	Replaceable by 2N2925
Q500	151-0188-00			Silicon	2N3906
Q510	*151-0155-00			Silicon	Replaceable by 2N2925
Q520	*151-0155-00			Silicon	Replaceable by 2N2925
Q600	151-0188-00			Silicon	2N3906
Q601	*151-0136-00			Silicon	Replaceable by 2N3053

Resistors

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

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R1	315-0561-00			560 Ω	1/4 W		5%
R4C	322-0621-00			900 kΩ	1/4 W	Prec	1%
R4D	321-0617-00			111 kΩ	1/8 W	Prec	1%
R5C	322-0624-00			990 kΩ	1/4 W	Prec	1%
R5D	321-0614-00			10.1 kΩ	1/8 W	Prec	1%
R7	315-0470-00			47 Ω	1/4 W		5%
R8C	322-0610-00			500 kΩ	1/4 W	Prec	1%
R8D	322-0481-00			1 MΩ	1/4 W	Prec	1%
R9C	322-0469-00			750 kΩ	1/4 W	Prec	1%
R9D	321-0628-00			333 kΩ	1/8 W	Prec	1%
R15	322-0624-00			990 kΩ	1/4 W	Prec	1%
R16	321-0289-00			10 kΩ	1/8 W	Prec	1%
R18	315-0105-00			1 MΩ	1/4 W		5%
R19	315-0101-00			100 Ω	1/4 W		5%
R21	315-0823-00			82 kΩ	1/4 W		5%
R23	315-0101-00			100 Ω	1/4 W		5%
R25	323-0318-00			20 kΩ	1/2 W	Prec	1%
R26	322-0356-00			49.9 kΩ	1/4 W	Prec	1%
R28	315-0224-00			220 kΩ	1/4 W		5%
R30	315-0101-00			100 Ω	1/4 W		5%
R31	315-0393-00			39 kΩ	1/4 W		5%
R33	315-0562-00			5.6 kΩ	1/4 W		5%
R34	315-0153-00			15 kΩ	1/4 W		5%
R35	311-0656-00			5 kΩ, Var			
R36	315-0222-00			2.2 kΩ	1/4 W		5%
R38	315-0223-00			22 kΩ	1/4 W		5%
R39	315-0474-00			470 kΩ	1/4 W		5%
R40	321-0215-00			1.69 kΩ	1/8 W	Prec	1%
R41	321-0172-00	B010100	B019999	604 Ω	1/8 W	Prec	1%
R41	321-0173-00	B020000		619 Ω	1/8 W	Prec	1%
R43	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R44	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R45	315-0101-00			100 Ω	1/4 W		5%
R46	315-0104-00			100 kΩ	1/4 W		5%
R48	308-0212-00	B010100	B010159	10 kΩ	3 W	WW	5%
R48	308-0334-00	B010160		7 kΩ	3 W	WW	5%
R49	315-0101-00	B010100	B019999	100 Ω	1/4 W		5%
R49	315-0391-00	B020000		390 Ω	1/4 W		5%
R51	321-0187-00			866 Ω	1/8 W	Prec	1%
R52	321-0193-00			1 kΩ	1/8 W	Prec	1%
R54	315-0103-00			10 kΩ	1/4 W		5%
R60	321-0161-00			464 Ω	1/8 W	Prec	1%
R64	321-0225-00			2.15 kΩ	1/8 W	Prec	1%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R70	315-0332-00			3.3 kΩ	¼ W		5%
R74	321-0097-00			100 Ω	⅛ W	Prec	1%
R80	321-0161-00			464 Ω	⅛ W	Prec	1%
R81	321-0158-00			432 Ω	⅛ W	Prec	1%
R84	321-0158-00			432 Ω	⅛ W	Prec	1%
R85	311-0433-00			100 Ω, Var			
R86	321-0161-00			464 Ω	⅛ W	Prec	1%
R90	315-0561-00			560 Ω	¼ W		5%
R91	315-0222-00			2.2 kΩ	¼ W		5%
R94	315-0222-00			2.2 kΩ	¼ W		5%
R96	315-0102-00			1 kΩ	¼ W		5%
R101	321-0431-00			301 kΩ	⅛ W	Prec	1%
R102	301-0512-00			5.1 kΩ	½ W		5%
R103[2]	311-0681-00			20 kΩ, Var			
R104	315-0105-00			1 MΩ	¼ W		5%
R105	321-0402-00	B010100	B019999	150 kΩ	⅛ W	Prec	1%
R105	321-0395-00	B020000		127 kΩ	⅛ W	Prec	1%
R106	321-0431-00			301 kΩ	⅛ W	Prec	1%
R108	315-0823-00			82 kΩ		Selected (nominal value)	
R109	321-0189-00			909 Ω	⅛ W	Prec	1%
R110	311-0485-00			250 Ω, Var			
R111	315-0101-00			100 Ω	¼ W		5%
R112	315-0103-00			10 kΩ	¼ W		5%
R113	311-0656-00			5 kΩ, Var			
R114	311-0310-00			5 kΩ, Var			
R115	321-0101-00			110 Ω	⅛ W	Prec	1%
R116A	321-0285-00			9.09 kΩ	⅛ W	Prec	1%
R116B	321-0189-00			909 Ω	⅛ W	Prec	1%
R116C	321-0166-00			523 Ω	⅛ W	Prec	1%
R116D	321-0146-00			324 Ω	⅛ W	Prec	1%
R116E	321-0097-00			100 Ω	⅛ W	Prec	1%
R116F	321-0068-00			49.9 Ω	⅛ W	Prec	1%
R116G	321-0047-00			30.1 Ω	⅛ W	Prec	1%
R116H	321-0001-00			10 Ω	⅛ W	Prec	1%
R116I	321-0001-00			10 Ω	⅛ W	Prec	1%
R117	302-0474-00			470 kΩ	½ W		
R118	321-0289-00			10 kΩ	⅛ W	Prec	1%
R120	311-0686-00			100 kΩ, Var			
R121	321-0618-00			250 kΩ	⅛ W	Prec	1%
R122	321-0331-00	B010100	B049999	27.4 kΩ	⅛ W	Prec	1%
R122	321-0354-00	B050000		47.5 kΩ	⅛ W	Prec	1%
R124	315-0101-00			100 Ω	¼ W		5%

[2]Furnished as a unit with SW103.

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R125	321-0327-00	B010100	B049999	24.9 kΩ	1/8 W	Prec	1%
R125	321-0339-00	B050000		33.2 kΩ	1/8 W	Prec	1%
R126	321-0417-00			215 kΩ	1/8 W	Prec	1%
R127	Selected	B010100	B079999				
R127	321-0210-00	B080000	B109999	1.50 kΩ		Selected (nominal value	
R127	321-0193-00	B110000		1 kΩ		Selected (nominal value	
R128	311-0463-00	B010100	B079999	5 kΩ, Var			
R128	311-0480-00	B080000		500 Ω, Var			
R129	321-0452-00			499 kΩ	1/8 W	Prec	1%
R130	315-0101-00			100 Ω	1/4 W		5%
R132	321-0339-00			33.2 kΩ	1/8 W	Prec	1%
R134	315-0103-00			10 kΩ	1/4 W		5%
R135	315-0393-00	XB100000		39 kΩ	1/4 W		5%
R136	311-0329-00	XB100000		50 kΩ, Var			
R137	315-0203-00	XB100000		20 kΩ	1/4 W		5%
R138	321-0158-00			432 Ω	1/8 W	Prec	1%
R139	322-0469-00	XB070000		750 kΩ	1/4 W	Prec	1%
R140	323-0498-00	B010100	B069999	1.5 MΩ	1/2 W	Prec	1%
R140	322-0469-00	B070000		750 kΩ	1/4 W	Prec	1%
R141	321-0385-00			100 kΩ	1/8 W	Prec	1%
R142	315-0103-00			10 kΩ	1/4 W		5%
R143	321-0385-00			100 kΩ	1/8 W	Prec	1%
R144	322-0481-00			1 MΩ	1/4 W	Prec	1%
R146	321-0147-00			332 Ω	1/8 W	Prec	1%
R147	321-0147-00			332 Ω	1/8 W	Prec	1%
R148	321-0452-00			499 kΩ	1/8 W	Prec	1%
R150	311-0465-00			100 kΩ, Var			
R151	321-0452-00			499 kΩ	1/8 W	Prec	1%
R153	322-0068-00			49.9 kΩ	1/4 W	Prec	1%
R155	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R156	311-0480-00			500 Ω, Var			
R157	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R158	322-0068-00			49.9 kΩ	1/4 W	Prec	1%
R160	301-0914-00			910 kΩ	1/2 W		5%
R161	315-0274-00			270 kΩ	1/4 W		5%
R165	315-0103-00			10 kΩ	1/4 W		5%
R168	315-0101-00			100 Ω	1/4 W		5%
R169	315-0103-00			10 kΩ	1/4 W		5%
R170	315-0272-00			2.7 kΩ	1/4 W		5%
R171	315-0431-00			430 Ω	1/4 W		5%
R173	315-0102-00			1 kΩ	1/4 W		5%
R175	315-0471-00			470 Ω	1/4 W		5%
R176	315-0101-00			100 Ω	1/4 W		5%
R178	315-0182-00			1.8 kΩ	1/4 W		5%
R180	315-0470-00			47 Ω	1/4 W		5%
R190	315-0470-00			47 Ω	1/4 W		5%
R195	315-0181-00			180 Ω	1/4 W		5%
R204	315-0222-00			2.2 kΩ	1/4 W		5%
R208	315-0151-00			150 Ω	1/4 W		5%
R210	315-0104-00			100 kΩ	1/4 W		5%
R212	321-0281-00			8.25 kΩ	1/8 W	Prec	1%
R213	323-0347-00			40.2 kΩ	1/2 W	Prec	1%
R214	311-0480-00			500 Ω, Var			

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R215	321-0210-00			1.5 kΩ	1/8 W	Prec	1%
R217	321-0289-00			10 kΩ	1/8 W	Prec	1%
R218	317-0111-00			110 Ω	1/8 W		5%
R220	317-0111-00			110 Ω	1/8 W		5%
R230	323-0281-00			8.25 kΩ	1/2 W	Prec	1%
R232	311-0443-00			2.5 kΩ, Var			
R235A-K	321-0155-00			402 Ω	1/8 W	Prec	1%
R236A-K	322-0222-00			2 kΩ	1/4 W	Prec	1%
R237	322-0239-01			3.01 kΩ	1/4 W	Prec	1/2%
R238	311-0655-00			1 kΩ, Var			
R239	311-0443-00			2.5 kΩ, Var			
R240A-J	321-0088-00			80.6 Ω	1/8 W	Prec	1%
R241A-J	321-0155-00			402 Ω	1/8 W	Prec	1%
R245	316-0101-00			100 kΩ	1/4 W		
R270	315-0102-00			1 kΩ	1/4 W		5%
R273	316-0102-00			1 kΩ	1/4 W		
R275	316-0102-00			1 kΩ	1/4 W		
R280	315-0103-00			10 kΩ	1/4 W		5%
R284	315-0101-00	B010100	B069999	100 Ω	1/4 W		5%
R284	315-0201-00	B070000		200 Ω	1/4 W		5%
R286	315-0223-00			22 kΩ	1/4 W		5%
R292	315-0101-00			100 Ω	1/4 W		5%
R294	315-0103-00			10 kΩ	1/4 W		5%
R295	315-0472-00			4.7 kΩ	1/4 W		5%
R297	315-0681-00			680 Ω	1/4 W		5%
R303	315-0101-00			100 Ω	1/4 W		5%
R306	315-0103-00	B010100	B069999	10 kΩ	1/4 W		5%
R306	315-0222-00	B070000		2.2 kΩ	1/4 W		5%
R311	315-0682-00			6.8 kΩ	1/4 W		5%
R312	315-0222-00			2.2 kΩ	1/4 W		5%
R314	307-0123-00			2.2 kΩ	1/8 W		
R316	311-0486-00	B010100	B069999	500 Ω, Var			
R316	311-0328-00	B070000		1 kΩ, Var			
R318	315-0102-00			1 kΩ	1/4 W		5%
R320	315-0682-00	B010100	B069999	6.8 kΩ	1/4 W		5%
R320	315-0273-00	B070000		27 kΩ	1/4 W		5%
R321	315-0222-00	B010100	B069999	2.2 kΩ	1/4 W		5%
R321	315-0822-00	B070000		8.2 kΩ	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 kΩ	1/4 W		5%
R329	301-0104-00			100 kΩ	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	305-0153-00			15 kΩ	2 W		5%
R335A	315-0472-00			4.7 kΩ	1/4 W		5%
R335B	315-0222-00			2.2 kΩ	1/4 W		5%
R335C	315-0102-00			1 kΩ	1/4 W		5%
R335D	315-0331-00			330 Ω	1/4 W		5%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
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	321-0289-00	B010100	B089999	10 kΩ	1/8 W	Prec	1%
R336	321-0260-00	B090000		4.99 kΩ	1/8 W	Prec	1%
R338	315-0103-00			10 kΩ	1/4 W		5%
R339	315-0222-00			2.2 kΩ	1/4 W		5%
R342	315-0102-00			1 kΩ	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 kΩ	1/4 W		5%
R349	301-0104-00			100 kΩ	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	305-0153-00			15 kΩ	2 W		5%
R355A	315-0472-00			4.7 kΩ	1/4 W		5%
R355B	315-0222-00			2.2 kΩ	1/4 W		5%
R355C	315-0102-00			1 kΩ	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	321-0289-00	B010100	B089999	10 kΩ	1/8 W	Prec	1%
R356	321-0260-00	B090000		4.99 kΩ	1/8 W	Prec	1%
R400	315-0103-00			10 kΩ	1/4 W		5%
R401	315-0224-00			220 kΩ	1/4 W		5%
R402	315-0224-00			220 kΩ	1/4 W		5%
R404	301-0473-00			47 kΩ	1/2 W		5%
R405	315-0472-00	B010100	B089999	4.7 kΩ	1/4 W		5%
R405	315-0322-00	B090000		3.3 kΩ	1/4 W		5%
R406	315-0105-00			1 MΩ	1/4 W		5%
R407	317-0473-00	XB090000		47 kΩ	1/8 W		5%
R408	315-0101-00			100 Ω	1/4 W		5%
R409	315-0103-00			10 kΩ	1/4 W		5%
R411	315-0334-00			330 kΩ	1/4 W		5%
R412	315-0754-00			750 kΩ	1/4 W		5%
R413	308-0313-00			20 kΩ	3 W	WW	
R415	316-0106-00			10 MΩ		Selected (nominal value)	
R416	315-0621-00			620 Ω		Selected (nominal value)	
R417	315-0105-00			1 MΩ	1/4 W		5%
R418	316-0106-00	B010100	B069999	10 MΩ	1/4 W	Selected (nominal value)	
R418	315-0105-00	B070000	B089999	1 MΩ	1/4 W		5%
R418	316-0106-00	B090000		10 MΩ	1/4 W		
R420	311-0552-00	XB070000		1 MΩ, Var			
R421	316-0106-00			10 MΩ	1/4 W		5%
R422	311-0637-00			2.5 MΩ, Var			
R423	315-0224-00			220 kΩ	1/4 W		5%
R425	315-0104-00	B010100	B069999	100 kΩ	1/4 W		5%
R425	315-0105-00	B070000	B089999	1 MΩ	1/4 W		5%
R425	315-0104-00	B090000		100 kΩ	1/4 W		5%

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R426	315-0102-00			1 kΩ	¼ W		5%
R427	315-0471-00	XB090000	B109999X	470 Ω	¼ W		5%
R428	311-0496-00	B010100	B109999	2.5 kΩ, Var			
R428	311-0480-00	B110000		500 Ω, Var			
R429	317-0107-00	B010100	B069999X	100 MΩ	⅛ W		5%
R430	321-0225-00			2.15 kΩ	⅛ W	Prec	1%
R431	317-0106-00	XB090000		10 MΩ	⅛ W		5%
R432	315-0223-00	B010100	B089999	22 kΩ	¼ W		5%
R432	315-0103-00	B090000		10 kΩ	¼ W		5%
R433	315-0103-00			10 kΩ	¼ W		5%
R437	315-0472-00			4.7 kΩ	¼ W		5%
R439	315-0101-00			100 Ω	¼ W		5%
R441	315-0103-00			10 kΩ	¼ W		5%
R443	315-0105-00			1 MΩ	¼ W		5%
R445	315-0471-00			470 Ω	¼ W		5%
R446	315-0103-00			10 kΩ	¼ W		5%
R447	315-0104-00			100 kΩ	¼ W		5%
R448	315-0103-00			10 kΩ	¼ W		5%
R450	323-0356-00			49.9 kΩ	½ W	Prec	1%
R452	321-0161-00			464 Ω	⅛ W	Prec	1%
R454	323-0410-00			182 kΩ	½ W	Prec	1%
R455	322-0385-00			100 kΩ	¼ W	Prec	1%
R456	305-0104-00			100 kΩ	2 W		5%
R457	315-0103-00			10 kΩ	¼ W		5%
R460	323-0356-00			49.9 kΩ	½ W	Prec	1%
R461	321-0161-00			464 Ω	⅛ W	Prec	1%
R462	311-0091-00			1 kΩ, Var			
R464	323-0410-00			182 kΩ	½ W	Prec	1%
R465	322-0385-00			100 kΩ	¼ W	Prec	1%
R466	315-0221-00	B010100	B089999	220 Ω	¼ W		5%
R466	315-0222-00	B090000		2.2 kΩ	¼ W		5%
R467	315-0104-00	B010100	B089999	100 kΩ	¼ W		5%
R467	315-0513-00	B090000		51 kΩ	¼ W		5%
R468	311-0091-00			1 kΩ, Var			
R469	315-0562-00	B010100	B089999	5.6 kΩ	¼ W		5%
R469	315-0392-00	B090000		3.9 kΩ	¼ W		5%
R484	304-0681-00			680 Ω	1 W		
R486	308-0054-00			10 kΩ	5 W	WW	
R496	308-0054-00			10 kΩ	5 W	WW	
R500	321-0288-00			9.76 kΩ	⅛ W	Prec	1%
R501	321-0282-00			8.45 kΩ	⅛ W	Prec	1%
R502	311-0496-00			2.5 kΩ, Var			
R504	321-0193-00			1 kΩ	⅛ W	Prec	1%
R506	315-0333-00			33 kΩ	¼ W		5%
R508	315-0103-00			10 kΩ	¼ W		5%
R510	315-0562-00			5.6 kΩ	¼ W		5%
R513	321-0228-00			2.32 kΩ	⅛ W	Prec	1%
R516	315-0102-00			1 kΩ	¼ W		5%
R518	315-0222-00			2.2 kΩ	¼ W		5%
R520	321-0289-00			10 kΩ	⅛ W	Prec	1%
R522	311-0480-00			500 Ω, Var			

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R524	321-0385-00			100 kΩ	1/8 W	Prec	1%
R526	315-0103-00			10 kΩ	1/4 W		5%
R600	323-0393-00			121 kΩ	1/2 W	Prec	1%
R602	321-0289-00			10 kΩ	1/8 W	Prec	1%
R605	315-0103-00			10 kΩ	1/4 W		5%
R620	308-0008-00			10 kΩ	5 W	WW	
R622	308-0442-00			1.8 kΩ	10 W	WW	
R624	308-0421-00			3 kΩ	3 W	WW	

Switches

Unwired or Wired

Ckt. No.		Tektronix Part No.	Description	
SW1		260-0621-00	Lever	AC-GND-DC FAST
SW5	wired	*262-0814-00	Rotary	VOLTS/DIV
SW5		260-0809-00	Rotary	VOLTS/DIV
SW10		260-0723-00	Slide	VOLTS/DIV ÷ 100
SW75		260-0807-00	Lever	VERTICAL DISPLAY
SW103[3]				
SW115[4]	wired	*262-0783-00	Rotary	DISPERSION Hz/DIV
SW115		260-0814-00	Rotary	DISPERSION Hz/DIV
SW120	wired	*262-0786-00	Rotary	CENTER FREQUENCY Hz (Multiplier)
SW120		260-0810-00	Rotary	CENTER FREQUENCY Hz (Multiplier)
SW235A, SW235B	wired	*262-0785-00	Rotary	(Units) CENTER FREQUENCY Hz (Tens)
SW335[4]				COUPLED RESOLUTION

Transformers

Ckt. No.	Tektronix Part No.	Description	
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	*120-0484-00	Toroid	3 windings, bifilar
T290	*114-0223-00	6-12 μH, Var	Core 276-0506-00

Electron Tube

Ckt. No.	Tektronix Part No.	Description
V480	154-0413-00	8416

Crystals

Ckt. No.	Tektronix Part No.	Description
Y135	119-0103-01	Crystal Discriminator
Y297	158-0026-00	3.1 MHz
Y325	158-0022-00	100 kHz
Y345	158-0022-00	100 kHz

[3]Furnished as a unit with R103.

[4]SW115 and SW335 furnished as a unit.

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear on the pullout pages immediately following the Diagrams section of this 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)

SECTION 8

MECHANICAL PARTS LIST

FIG. 1 FRONT & SWITCHES

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	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	210-0001-00			2	LOCKWASHER, internal, #2
-7	210-0405-00			2	NUT, hex., 2-56 x $^{3}/_{16}$ inch
-8	407-0331-00			1	BRACKET, switch mounting
	- - - - - -			-	mounting hardware: (not included w/bracket)
-9	211-0008-00			2	SCREW, 4-40 x $^{1}/_{4}$ inch, PHS
-10	210-0801-00			2	WASHER, flat, 0.140 ID x 0.281 inch OD
-11	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-12	210-0940-00			1	WASHER, flat, $^{1}/_{4}$ ID x $^{3}/_{8}$ inch OD
-13	210-0583-00			1	NUT, hex., $^{1}/_{4}$-32 x $^{5}/_{16}$ inch
-14	366-0369-00			1	KNOB, red—CAL—VARIABLE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^{3}/_{16}$ inch, HSS
-15	366-0370-01			1	KNOB, charcoal—MULTIPLIER
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^{3}/_{16}$ inch, HSS
-16	262-0786-00			1	SWITCH, wired—MULTIPLIER
	- - - - - -			-	switch includes:
-	260-0810-00			1	SWITCH, unwired
-17	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-18	210-0046-00			1	LOCKWASHER, internal, $^{1}/_{4}$ ID x 0.400 inch OD
-19	210-0583-00			2	NUT, hex., $^{1}/_{4}$-32 x $^{5}/_{16}$ inch
-20	376-0050-00			1	ASSEMBLY, coupling
	- - - - - -			-	assembly includes:
	213-0022-00			4	SCREW, set, 4-40 x $^{3}/_{16}$ inch, HSS
-21	354-0251-00			2	RING, coupling
-22	376-0046-00			1	COUPLING, plastic, 0.375 x 0.424 inch
-23	384-0418-00			1	SHAFT, extension
	- - - - - -			-	mounting hardware: (not included w/switch)
-24	210-0419-00			1	NUT, hex., shouldered, $^{3}/_{8}$-32 x 0.500 inch

FIG. 1 FRONT & SWITCHES *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-25	406-0757-00			1	BRACKET, spacer
-26	200-0374-00	B010100	B070429	1	COVER, dial
	200-0368-01	B070430		1	COVER, dial
	- - - - - -			-	mounting hardware: (not included w/cover)
-27	211-0541-00			2	SCREW, 6-32 x 1/4 inch, 100° csk, FHS
-28	366-0215-01			1	KNOB, charcoal—VERTICAL DISPLAY
-29	260-0807-00			1	SWITCH, lever—VERTICAL DISPLAY
	- - - - - -			-	mounting hardware: (not included w/switch)
-30	220-0413-00			2	NUT, hex., 4-40 x 3/16 x 0.562 inch long
-31	366-0215-01			1	KNOB, charcoal—AC GRD AC FAST
-32	260-0621-00			1	SWITCH, lever—AC GRD AC FAST
	- - - - - -			-	mounting hardware: (not included w/switch)
-33	220-0413-00			2	NUT, hex., 4-40 x 3/16 x 0.562 inch long
-34	366-0365-03			1	KNOB, red—VARIABLE—CAL
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-35	366-0322-00			1	KNOB, charcoal—VOLTS/CM
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-36	262-0814-00			1	SWITCH, wired—VOLTS/DIV
	- - - - - -			-	switch includes:
	260-0809-00			1	SWITCH, unwired
	337-1028-00	XB070000		1	SHIELD
-37	386-1107-00			1	PLATE
-38	131-0344-00			8	CONNECTOR, feed thru
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-39	358-0241-00			1	BUSHING, plastic
-40	- - - - - -			9	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
-41	214-0456-00			1	FASTENER, plastic
-42	348-0031-00			1	GROMMET, plastic, 3/32 inch diameter
-43	441-0686-00			1	CHASSIS
	- - - - - -			-	mounting hardware: (not included w/chassis)
-44	210-0001-00			2	LOCKWASHER, internal, #2
-45	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-46	131-0371-00			6	CONNECTOR, single contact, female
-47	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-48	210-0583-00			2	NUT, hex., 1/4-32 x 5/16 inch
-49	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD

FIG. 1 FRONT & SWITCHES *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-50	214-0813-00			1	ACTUATOR, disk
-51	376-0065-00			1	ASSEMBLY, coupling
	- - - - - -			-	assembly includes:
-52	376-0064-00			2	COUPLING, shaft
-53	354-0251-00			2	RING, coupling
-54	213-0048-00			4	SCREW, set, 4-40 x 1/8 inch, HSS
-55	384-0654-00			1	SHAFT, extension
	- - - - - -			-	mounting hardware: (not included w/switch)
-56	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
-57	210-0801-00			2	WASHER, flat, 0.140 ID x 0.281 inch OD
	210-0486-00			2	NUT, keps, 4-40 x 1/4 inch (not shown)
-58	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-59	210-0840-00			1	WASHER, flat, 0.170 ID x 3/8 inch OD
-60	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-61	366-0153-00			1	KNOB, charcoal—SWEEP INT
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-62	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-63	210-0223-00			1	LUG, solder, 1/4 inch
-64	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-65	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-66	179-1172-00			1	CABLE HARNESS, switch
	- - - - - -			-	cable harness includes:
	131-0371-00			11	CONNECTOR, single contact, female
-67	366-0410-00			1	KNOB, charcoal—POSITION
	- - - - - -			-	knob includes:
	214-0949-00			1	SPRING
-68	366-0410-00			1	KNOB, charcoal—DISPERSION
	- - - - - -			-	knob includes:
	214-0949-00			1	SPRING
-69	366-0422-00	B010100	B059999	1	KNOB, charcoal—COUPLED RESOLUTION
	366-0422-01	B060000		1	KNOB, charcoal—COUPLED RESOLUTION
	- - - - - -			-	knob includes:
	213-0153-00			2	SCREW, set, 5-40 x 0.125 inch, HSS
-70	366-0423-00			1	KNOB, charcoal—DISPERSION Hz/CM
	- - - - - -			-	knob includes:
	213-0153-00			2	SCREW, set, 5-40 x 0.125 inch, HSS
-71	262-0783-00			1	SWITCH, wired—DISPERSION Hz/CM
	- - - - - -			-	switch includes:
	260-0814-00			1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
-72	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
-73	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-74	352-0084-00			1	HOLDER, neon light, 0.450 diameter x 0.650 inch long
-75	378-0541-00			1	FILTER, lens neon
-76	200-0609-00			1	CAP, lamp holder
-77	333-0982-01	B010100	B059999	1	PANEL, front
	333-0982-03	B100000		1	PANEL, front

FIG. 1 FRONT & SWITCHES *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-78	386-1204-00			1	PLATE, sub-panel front
	- - - - - -			-	plate includes:
-79	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch, HSS
-80	366-0109-00			1	KNOB, plug-in securing
	- - - - - -			-	knob includes:
	213-0005-00			1	SCREW, set, 8-32 x 1/8 inch, HSS
-81	131-0106-00			1	CONNECTOR, coaxial, 1 contact, BNC, w/hardware
-82	136-0094-00			1	SOCKET
	- - - - - -			-	mounting hardware: (not included w/socket)
-83	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-84	210-0202-00			1	LUG, solder, SE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
-85	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-86	136-0139-00			1	SOCKET, banana jack
	- - - - - -			-	mounting hardware: (not included w/socket)
-87	210-0894-00			1	WASHER, plastic, 0.190 ID x 7/16 inch OD
-88	210-0465-00			2	NUT, hex., 1/4-32 x 3/8 x 3/16 inch
-89	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-90	131-0106-00			1	CONNECTOR, coaxial, 1 contact, BNC, w/hardware
	- - - - - -			-	mounting hardware: (not included w/connector)
-91	210-0255-00			1	LUG, solder, 3/8 inch
-92	214-0053-00			1	FASTENER
	- - - - - -			-	mounting hardware: (not included w/fastener)
-93	210-0004-00			2	LOCKWASHER, internal, #4
-94	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-95	- - - - - -			3	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-96	210-0471-00			1	NUT, hex., 1/4-32 x 5/16 diameter x 19/32 inch long
-97	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-98	358-0054-00	B010100	B059999	1	BUSHING, banana jack
	358-0054-02	B060000		1	BUSHING, banana jack
-99	384-0615-00			1	ROD, frame
	- - - - - -			-	mounting hardware for each: (not included w/rod)
	212-0044-00			1	SCREW, 8-32 x 1/2 inch, RHS

FIG. 1 FRONT & SWITCHES *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-100	- - - - - -	B010100	B099999	2	RESISTOR, variable
	- - - - - -	B109999		3	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-101	210-0471-00			1	NUT, hex., $1/4$-32 x $5/16$ diameter x $19/32$ inch long
-102	358-0054-00	B010100	B059999	1	BUSHING, banana jack
	358-0054-02	B060000		1	BUSHING, banana jack
-103	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-104	220-0484-00			1	NUT, hex., 0.250-32 x 0.375 inch long
-105	358-0054-00	B010100	B059999	1	BUSHING, banana jack
	358-0054-02	B060000		1	BUSHING, banana jack

FIG. 2 CHASSIS & REAR

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-1	670-0139-01	B010100	B089999	1	ASSEMBLY, circuit board—DISCRIMINATOR & OUTPUT
	670-0139-05	B090000		1	ASSEMBLY, circuit board—DISCRIMINATOR & OUTPUT
	- - - - - -			-	assembly includes:
	388-0849-00			1	BOARD, circuit
-2	214-0506-00			72	PIN, connecting, straight, male
-3	136-0183-00			2	SOCKET, transistor, 3 pin
-4	136-0235-00			2	SOCKET, transistor, 6 pin
-5	136-0220-00			22	SOCKET, transistor, 3 pin
-6	214-0565-00			2	FASTENER, pin
-7	214-0668-00			1	HEAT SINK
-8	214-0693-00			2	HEAT SINK
-9	337-0944-00			1	SHIELD, coil
-10	- - - - - -			1	CRYSTAL
	- - - - - -			-	mounting hardware: (not included w/crystal)
-11	210-0849-00			2	WASHER, fiber, shouldered, #4
-12	210-0994-00			2	WASHER, flat, 0.125 ID x 0.250 inch OD
-13	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
	- - - - - -			-	mounting hardware: (not included w/assembly)
-14	211-0116-00			7	SCREW, sems, 4-40 x 5/16 inch, PHB
-15	386-1203-00			1	PLATE, rear
-16	136-0015-00			1	SOCKET, 9 pin, w/ground lugs
	- - - - - -			-	mounting hardware: (not included w/socket)
-17	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-18	351-0037-00			1	GUIDE, shoe
	- - - - - -			-	mounting hardware: (not included w/guide)
-19	211-0013-00			1	SCREW, 4-40 x 3/8 inch, RHS
-20	210-0586-00			1	NUT, keps, 4-40 x 1/4 inch
-21	131-0149-00			1	CONNECTOR, 24 contact
	- - - - - -			-	mounting hardware: (not included w/connector)
-22	211-0097-00			2	SCREW, 4-40 x 5/16 inch, PHS
-23	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-24	670-0138-00	B010100	B069999	1	ASSEMBLY, circuit board—VARIABLE RESOLUTION AMPLIFIER
	670-0138-01	B070000	B089999	1	ASSEMBLY, circuit board—VARIABLE RESOLUTION AMPLIFIER
	670-0138-02	B090000		1	ASSEMBLY, circuit board—VARIABLE RESOLUTION AMPLIFIER
	- - - - - -			-	assembly includes:
	388-0854-00			1	BOARD, circuit
-25	214-0506-00			15	PIN, connector, straight, male
-26	136-0183-00			6	SOCKET, transistor, 3 pin
-27	352-0096-00			2	HOLDER, crystal
-28	136-0234-00			4	RECEPTACLE
	- - - - - -			-	mounting hardware: (not included w/assembly)
-29	211-0116-00			5	SCREW, sems, 4-40 x 5/16 inch, PHB

FIG. 2 CHASSIS & REAR *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-30	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
-31	211-0553-00			1	SCREW, 6-32 x 1½ inches, RHS
-32	210-0601-00			1	EYELET
-33	210-0478-00			1	NUT, hex., 5/16 x 21/32 inch long
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS (not shown)
-34	386-1205-00			1	SUPPORT
	- - - - - -			-	support includes:
-35	211-0094-00			2	SCREW, 4-40 x ½ inch, PHS
-36	670-0137-00			1	ASSEMBLY, circuit board—INPUT
	- - - - - -			-	assembly includes:
	388-0853-00			1	BOARD, circuit
-37	214-0506-00			19	PIN, connecting, straight, male
-38	136-0183-00			9	SOCKET, transistor, 3 pin
-39	136-0220-00			1	SOCKET, transistor, 3 pin
-40	214-0565-00			2	FASTENER, pin
-41	260-0723-00			1	SWITCH, slide
	343-0159-00	XB030000		1	RETAINER, slide switch
	- - - - - -			-	mounting hardware: (not included w/assembly)
-42	211-0116-00			6	SCREW, sems, 4-40 x 5/16 inch, PHB
-43	- - - - - -			2	COIL
	- - - - - -			-	mounting hardware for each: (not included w/coil)
-44	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-45	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
-46	211-0544-00			1	SCREW, 6-32 x ¾ inch, THS
-47	210-0478-00			1	NUT, hex., 5/16 x 21/32 inch long
-48	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-49	441-0723-00			1	CHASSIS
	- - - - - -			-	mounting hardware: (not included w/chassis)
-50	211-0507-00			7	SCREW, 6-32 x 5/16 inch, PHS
-51	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch
-52	376-0063-00			1	COUPLER, slide switch to disk
-53	343-0088-00			1	CLAMP, cable, plastic, small
-54	343-0089-00			2	CLAMP, cable, plastic, large
-55	407-0330-00			1	BRACKET, filter
	- - - - - -			-	mounting hardware: (not included w/bracket)
-56	211-0008-00			2	SCREW, 4-40 x ¼ inch, PHS
-57	210-0586-00			1	NUT, keps, 4-40 x ¼ inch

FIG. 2 CHASSIS & REAR *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
2-	610-0194-00	B010100	B069999	1	ASSEMBLY, FILTER & MIXER
	610-0194-01	B070000		1	ASSEMBLY, FILTER & MIXER
	- - - - - - -			-	assembly includes:
-58	136-0153-00			1	HOLDER, crystal
	- - - - - - -			-	mounting hardware: (not included w/holder)
-59	213-0055-00			1	SCREW, thread forming, 2-32 x 3/16 inch, PHS
-60	136-0218-00			2	SOCKET, transistor, 3 pin
	- - - - - - -			-	mounting hardware for each: (not included w/socket)
-61	354-0285-00			1	RING, socket mounting
-62	131-0157-00			2	CONNECTOR, terminal, standoff
-63	131-0161-00			2	CONNECTOR, terminal, feed thru
-64	131-0372-00			2	CONNECTOR, coaxial, 1 contact, w/hardware
-65	352-0101-00			4	HOLDER, plastic
	- - - - - - -			-	mounting hardware for each: (not included w/holder)
-66	361-0008-00			1	SPACER, plastic, 0.281 inch long
-67	441-0692-00			1	CHASSIS, plug-in converter
	- - - - - - -			-	mounting hardware: (not included w/chassis)
-68	211-0005-00			4	SCREW, 4-40 x 1/8 inch, PHS
-69	441-0685-00			1	CHASSIS
-70	407-0269-00			1	BRACKET
-71	131-0371-00			2	CONNECTOR, single contact, female
	- - - - - - -			-	mounting hardware: (not included w/assembly)
-72	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
-73	337-0867-00			1	SHIELD
	- - - - - - -			-	mounting hardware: (not included w/shield)
-74	211-0065-00			2	SCREW, 4-40 x 3/16 inch, PHS
	175-0386-00	B010100	B019999	1	ASSEMBLY, cable
	175-0386-01	B020000		1	ASSEMBLY, cable
	- - - - - - -			-	assembly includes:
-75	380-0049-00			1	HOUSING
-76	200-0482-00			1	COVER
-77	211-0513-00			2	SCREW, 6-32 x 5/8 inch, PHS
-78	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-79	131-0371-00			4	CONNECTOR, single contact, female
	- - - - - - -			-	mounting hardware: (not included w/assembly)
-80	211-0018-00			3	SCREW, 4-40 x 7/8 inch, RHS
-81	210-0994-00			3	WASHER, flat, 0.125 ID x 0.250 inch OD
-82	175-0423-00			2	ASSEMBLY, cable, 4 1/2 inches
	- - - - - - -			-	each assembly includes:
-83	131-0371-00			2	CONNECTOR, single contact, female

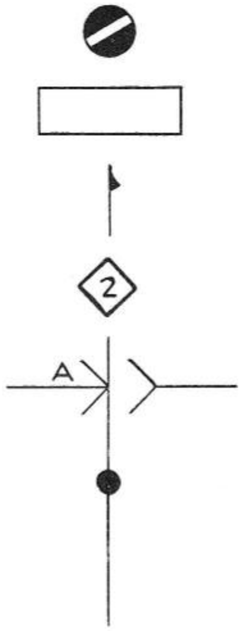
Ⓑ

FIG. 2 CHASSIS & REAR *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-84	179-1171-00			1	CABLE HARNESS, chassis
	- - - - - - -			-	cable harness includes:
-85	131-0371-00			63	CONNECTOR, single contact, female
-86	179-1173-00			1	CABLE HARNESS, connector
	- - - - - - -			-	cable harness includes:
-87	131-0371-00			7	CONNECTOR, single contact, female

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

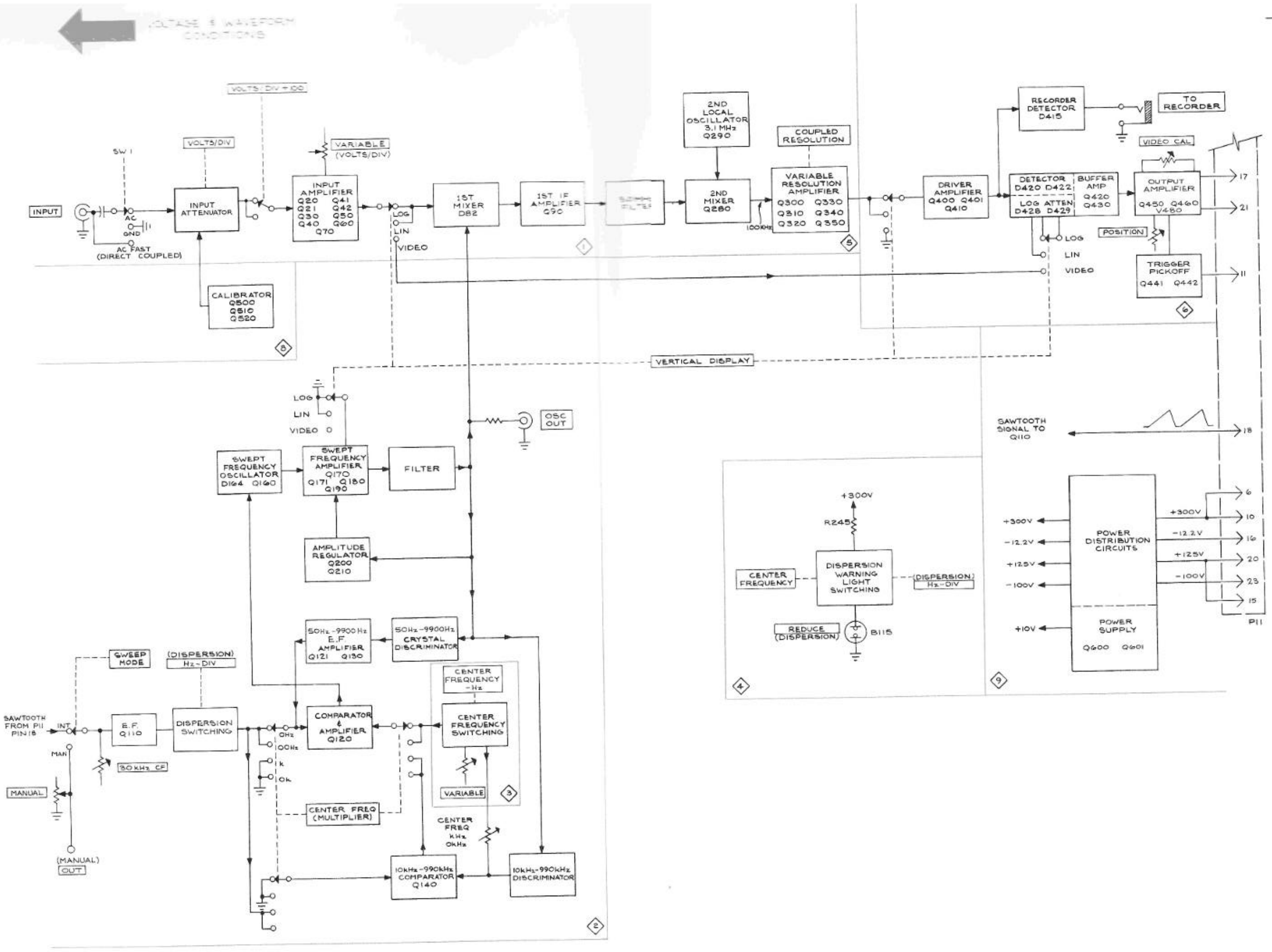
IMPORTANT

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.

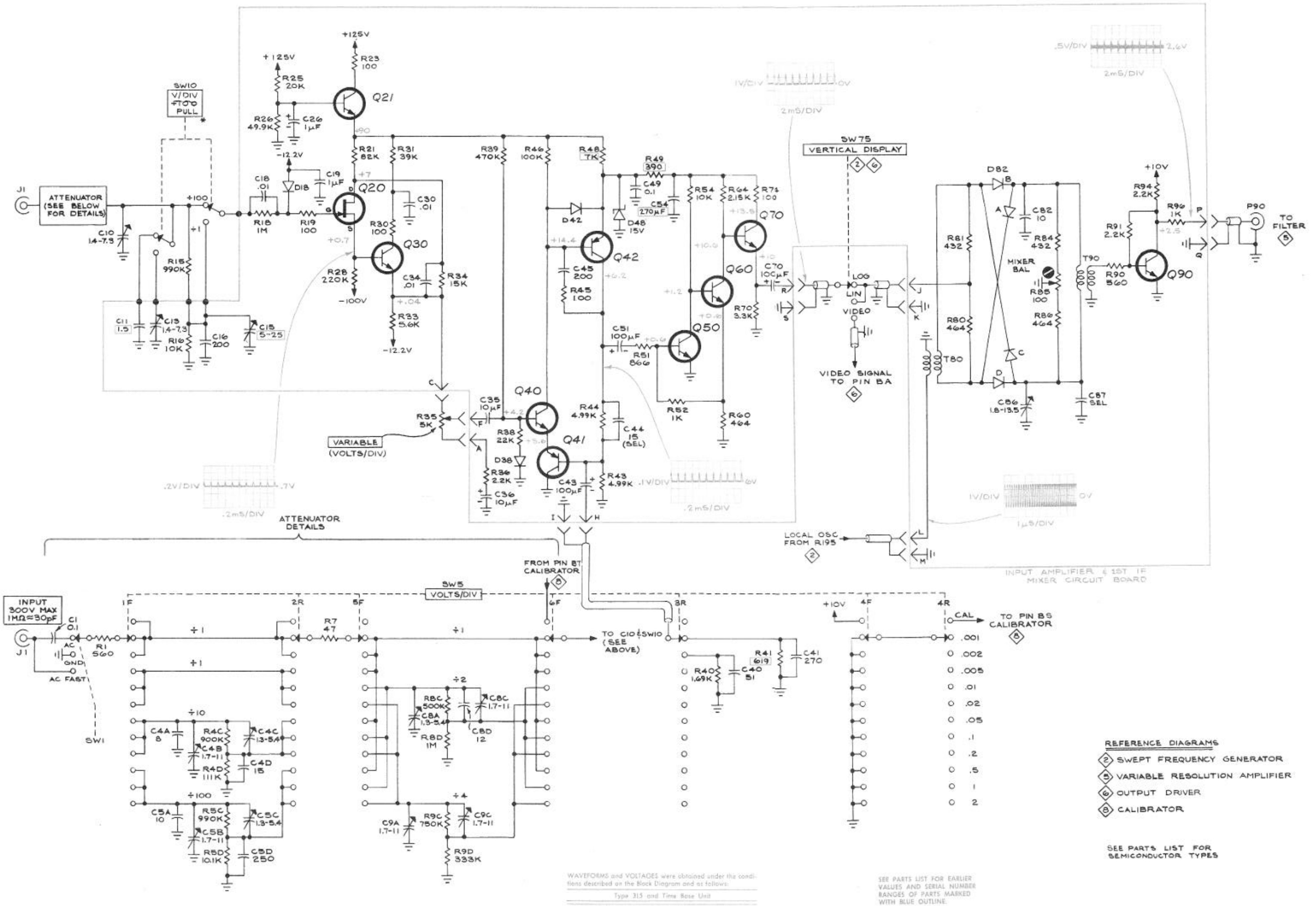
Waveforms shown are actual waveform photographs, taken with a Tektronix Oscilloscope Camera System mounted on a Type 545B Oscilloscope with a Type 1A1 vertical plug-in unit.

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 3L5 SPECTRUM ANALYZER



WAVEFORMS and VOLTAGES were obtained under the conditions described on the Block Diagram and as follows:

Type 3L5 and Time Base Unit	
CENTER FREQUENCY Hz	500 k
VERTICAL DISPLAY	LIN
VOLTS/DIV	CALIBRATE
V/DIV ÷ 100	Pulled out
VARIABLE	CAL
Hz/DIV	10 K
Time Div	.2 s
Test Oscilloscope	
Triggering	Auto, +, Int

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

E1

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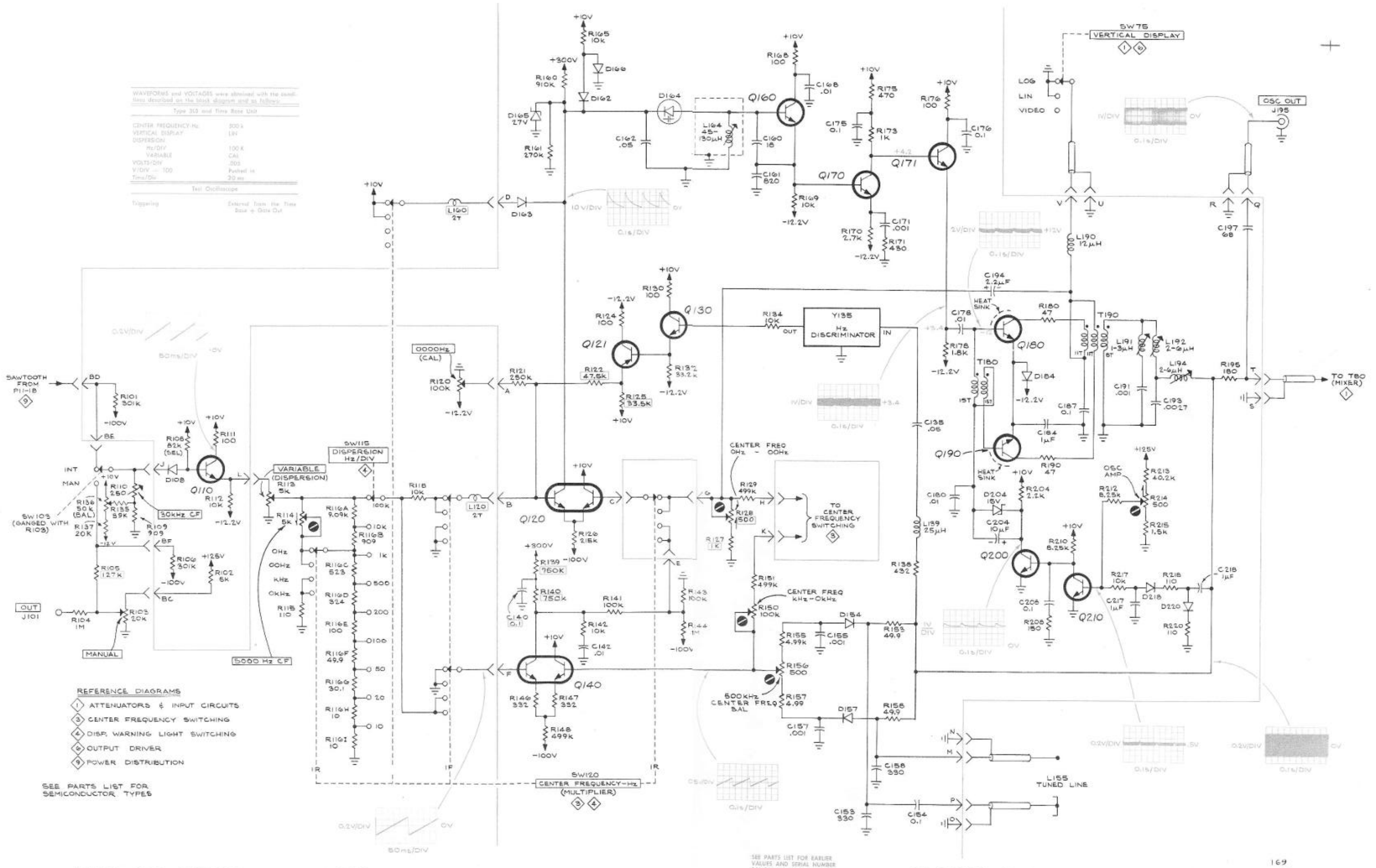
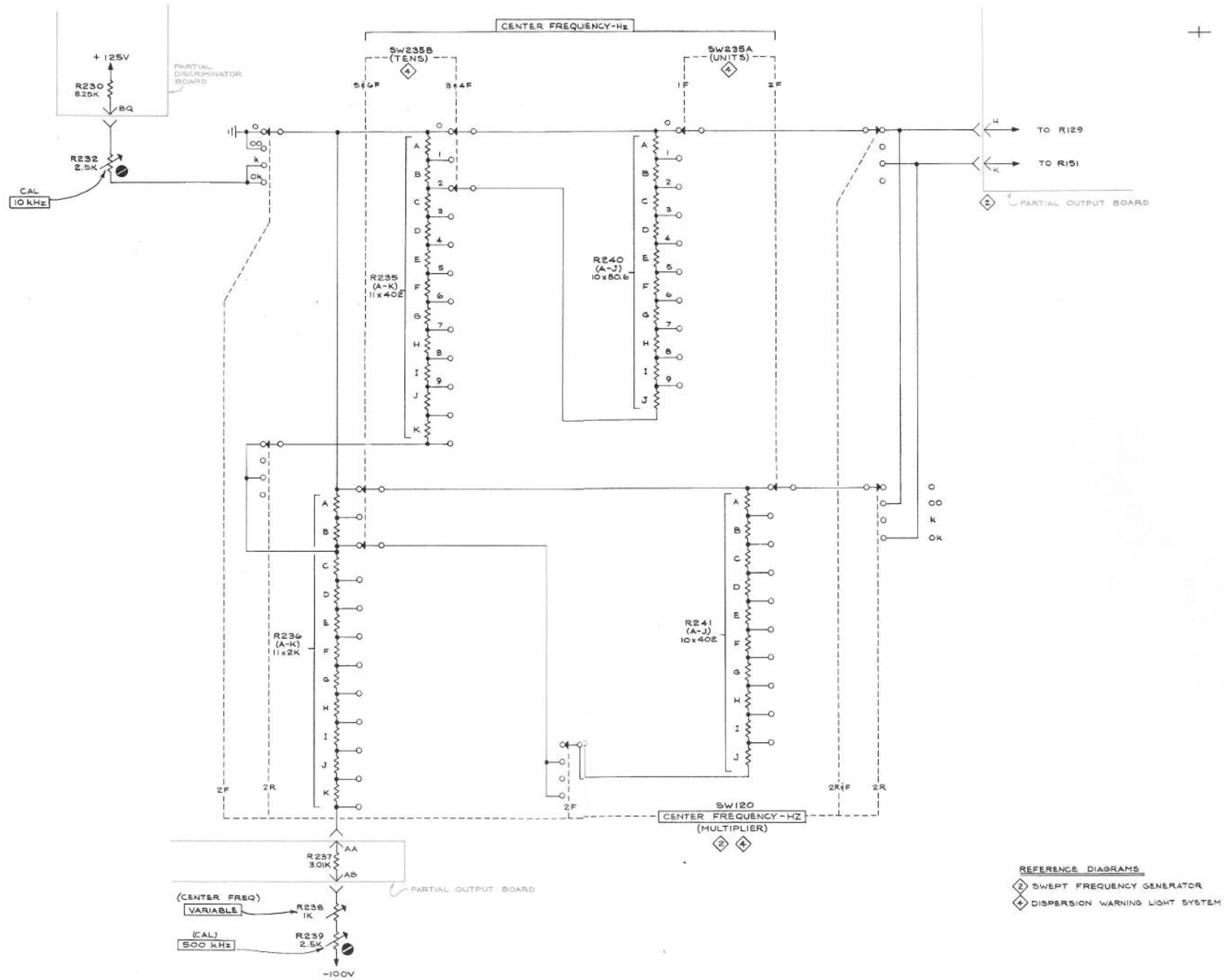
TYPE 3L5 SPECTRUM ANALYZER

ATTENUATORS & INPUT CIRCUITS ⟨1⟩



TYPE 3L5 SPECTRUM ANALYZER

SWEPT FREQUENCY GENERATOR ②

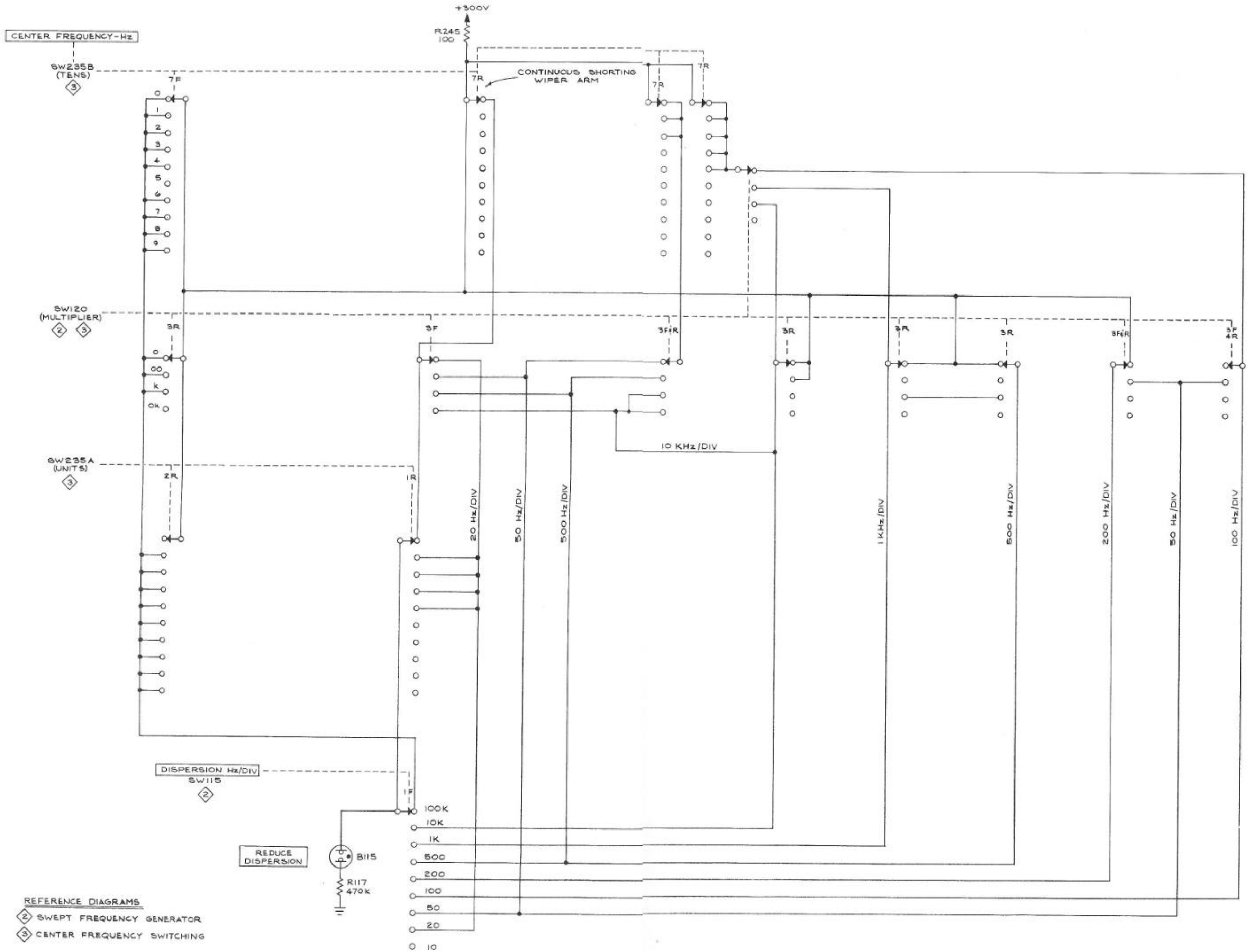


TYPE 3L5 SPECTRUM ANALYZER

A

CENTER FREQUENCY SWITCHING 3

367

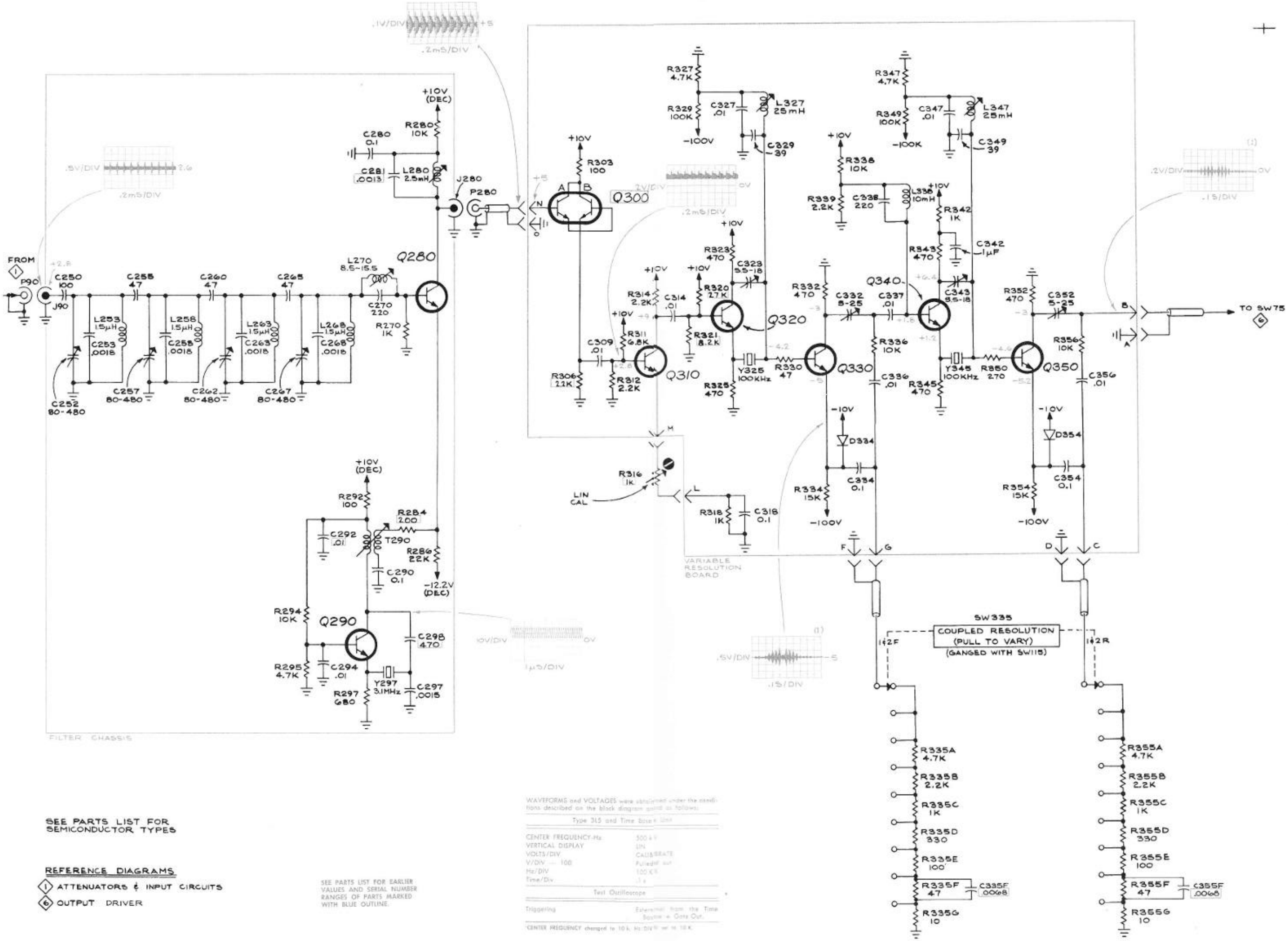


TYPE 3L5 SPECTRUM ANALYZER

A3

DISPERSION
WARNING LIGHT SWITCHING 4

367



SEE PARTS LIST FOR
SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS

1 ATTENUATORS & INPUT CIRCUITS

6 OUTPUT DRIVER

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 3L5 and Time Base Unit	
CENTER FREQUENCY-Hz	500 k
VERTICAL DISPLAY	LIN
VOLTS/DIV	CALIBRATE
V/DIV — 100	Pulled out
Hz/DIV	100 K
Time/Div	.1 s
Test Oscilloscope	
Triggering	External from the Time Base + Gate Out.

CENTER FREQUENCY changed to 10 k, Hz/DIV set to 10 K.

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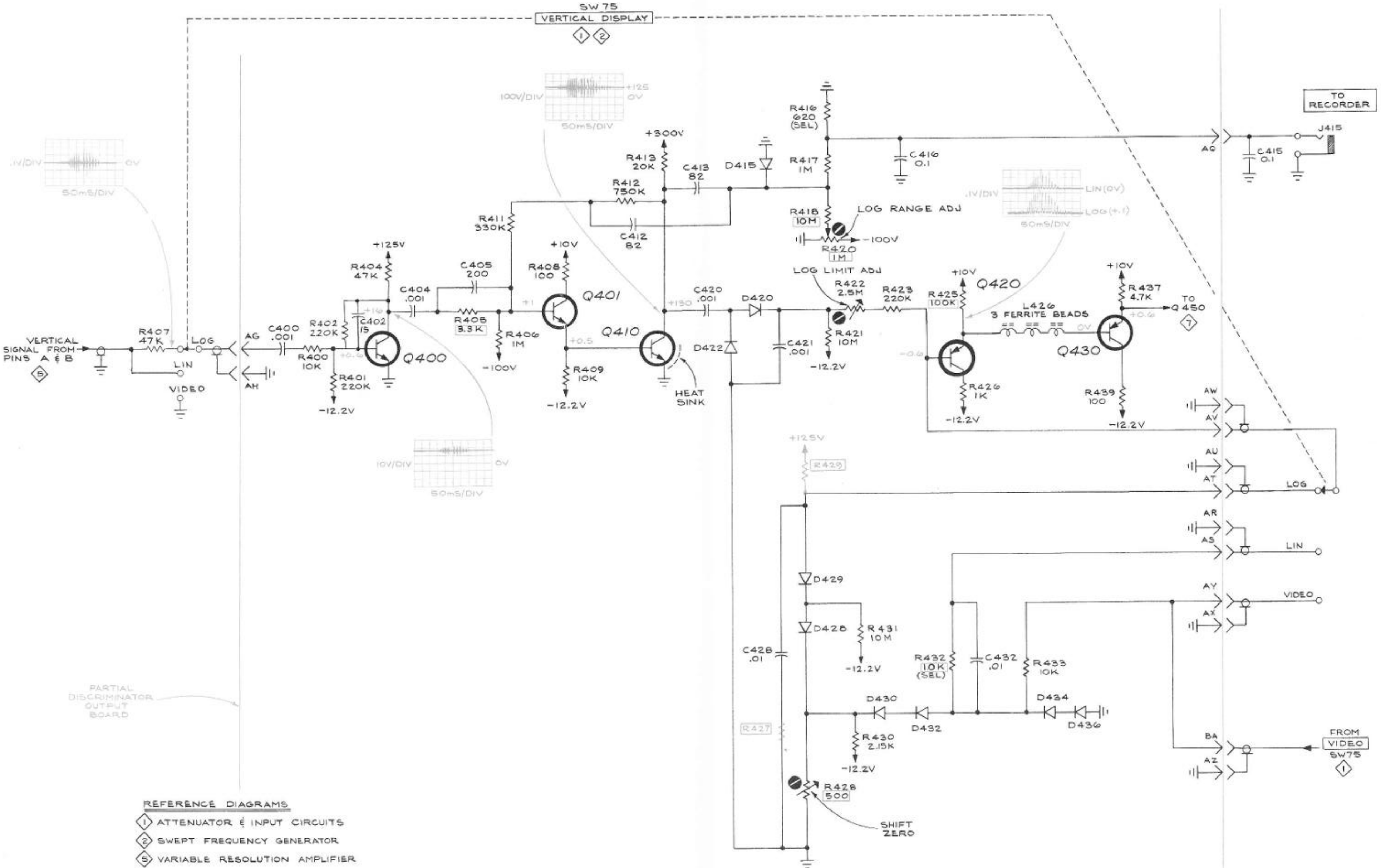
TYPE 3L5 SPECTRUM ANALYZER

VARIABLE RESOLUTION AMPLIFIER 5



REFERENCE DIAGRAMS

- ① ATTENUATOR & INPUT CIRCUITS
- ② SWEPT FREQUENCY GENERATOR
- ⑤ VARIABLE RESOLUTION AMPLIFIER
- ⑦ OUTPUT AMPLIFIER

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

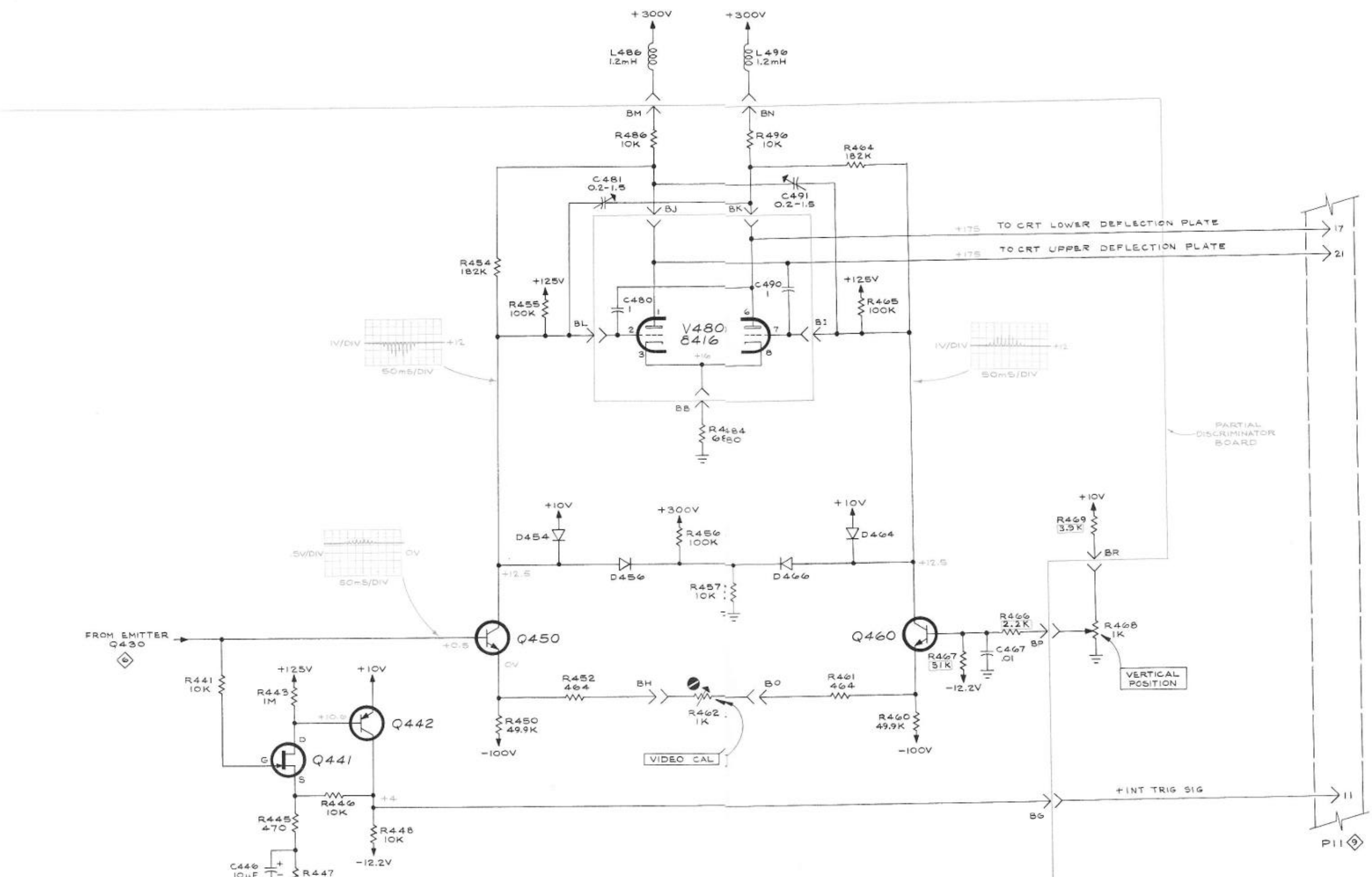
WAVEFORMS and VOLTAGES were obtained under the conditions described on the block diagram and as follows:

Type 3L5 and Time Base Unit	
CENTER FREQUENCY-Hz	10 k
VERTICAL DISPLAY	LIN
VOLTS/DIV	CALIBRATE
V/DIV — 100	Pulled out (except as noted)
Hz/DIV	10 K
Time/Div	50 ms
Test Oscilloscope	
Triggering	External from the Time Base + Gate Out.

TYPE 3L5 SPECTRUM ANALYZER

D

OUTPUT DRIVER ⑥



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS
⑥ OUTPUT DRIVER
⑨ POWER DISTRIBUTION

WAVEFORMS and VOLTAGES were obtained under the conditions described on the block diagram and as follows:

Type 3L5 and Time Base Unit	
CENTER FREQUENCY-Hz	10 k
VERTICAL DISPLAY	LIN
VOLTS/DIV	CALIBRATE
V/DIV ÷ 100	Pushed in
Hz/DIV	10 K
Time/Div	50 ms
POSITION	Adjusted to center the trace.
Test Oscilloscope	
Triggering	External from the Time Base + Gate Out.

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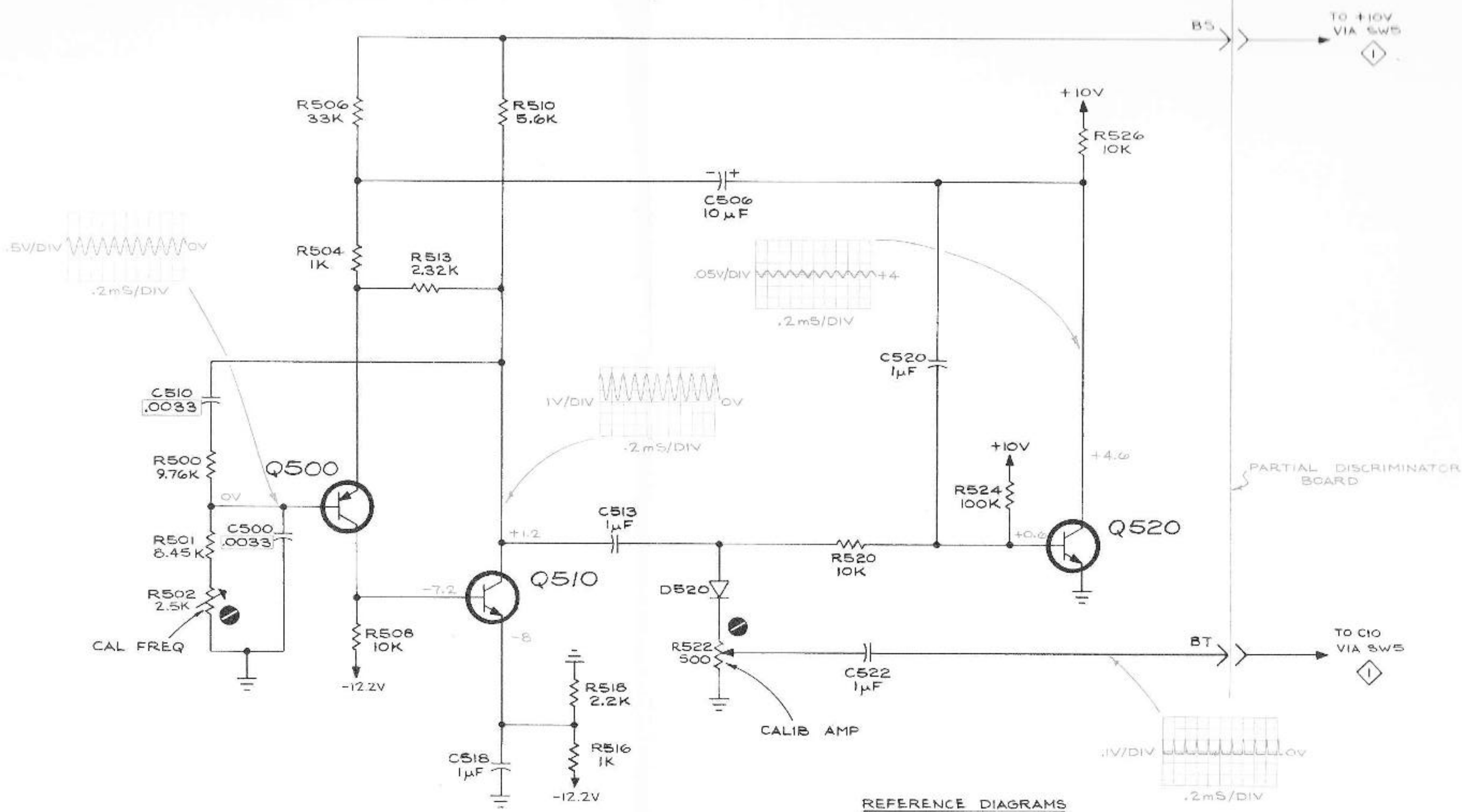
TYPE 3L5 SPECTRUM ANALYZER

B 3

OUTPUT AMPLIFIER ⑦



REFERENCE DIAGRAMS

(1) ATTENUATORS & INPUT CIRCUITS

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TYPE 3L5 SPECTRUM ANALYZER

B

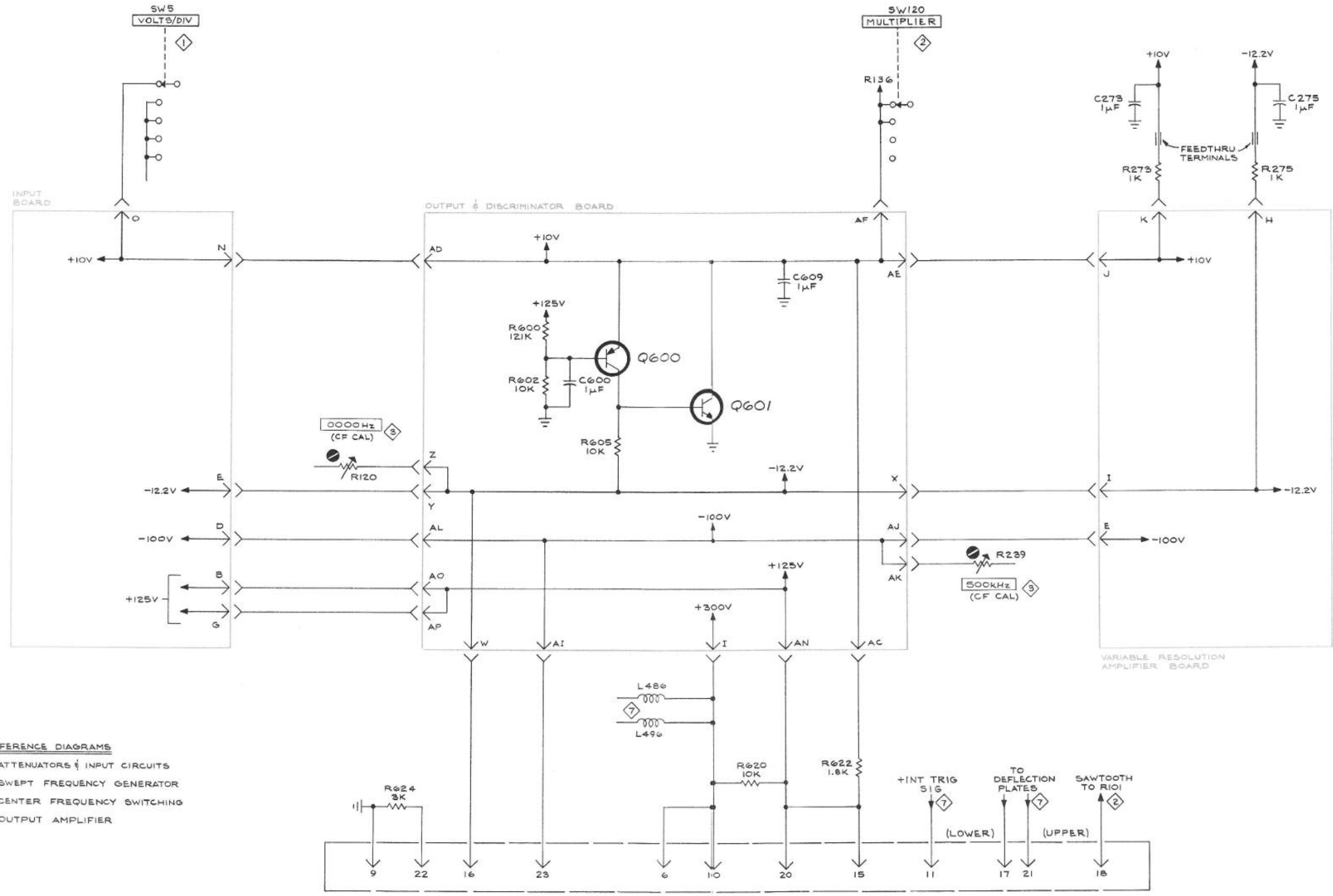
WAVEFORMS and VOLTAGES were obtained under the conditions described on the block diagram and as follows:

Type 3L5 and Time Base Unit	
CENTER FREQUENCY-Hz	10 k
VERTICAL DISPLAY	LIN
VOLTS/DIV	CALIBRATE
V/DIV ÷ 100	Pushed in
Hz/DIV	10 K
Time/Div	50 ms
POSITION	Adjusted to center the trace.
Test Oscilloscope	
Triggering	External from the Time Base + Gate Out.

W 568

CALIBRATOR (8)

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



REFERENCE DIAGRAMS

- ⟨1⟩ ATTENUATORS & INPUT CIRCUITS
- ⟨2⟩ SWEPT FREQUENCY GENERATOR
- ⟨3⟩ CENTER FREQUENCY SWITCHING
- ⟨7⟩ OUTPUT AMPLIFIER

SEE PARTS LIST FOR SEMICONDUCTOR TYPES