62090

INSTRUCTION MANUAL

Panoramic*

SPECTRUM ANALYZER

MODELS SPA-3a & SPA-3/25a

AND ACCESSORIES

Gertsch*

EMPIRE*

Sensitive Research*

Panoramic*

SINGER

Precision electrical and electronic instruments for measurement

THE SINGER COMPANY • METRICS DIVISION

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IB5001

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THE SINGER COMPANY, METRICS DIVISION, warrants each new instrument to be free from defects in material and workmanship, effective after delivery to the original purchaser as follows:

*Commander** Instruments: Potentiometers, Bridges,
Volt Ratio Boxes and Standard Resistors..................5 years
*Sensitive Research** Electrical Indicating Instruments............2 years
Other Electrical and Electronic Measuring Instruments..........1 year

Repair or replacement (at our option) without charge (F.O.B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuzes, lamps, thermoelements, and *RatioTran** potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, the warranty is void.

This warranty is in lieu of all other obligations or liabilities expressed or implied and The Singer Company neither assumes, nor authorizes any person to assume for them, any other liability in connection with sales of instruments manufactured by The Singer Company, Metrics Division.

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Instruments should be returned only on prior written authorization from the Singer Representative or the factory(1). Warranty repair will be made upon written request. Please provide the following information in order to expedite our processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
6. Approximate number of hours of use
7. Has maintenance action been previously requested?
8. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument to the factory prepaid. If requested, an estimate of charges will be made before work begins.

(1) Contact Metrics Division, Bridgeport, Connecticut for *Commander**, *Empire**, *Panoramic**, and *Sensitive Research** instruments. Contact Metrics Division, Los Angeles, California for *Gertsch** instruments.
(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

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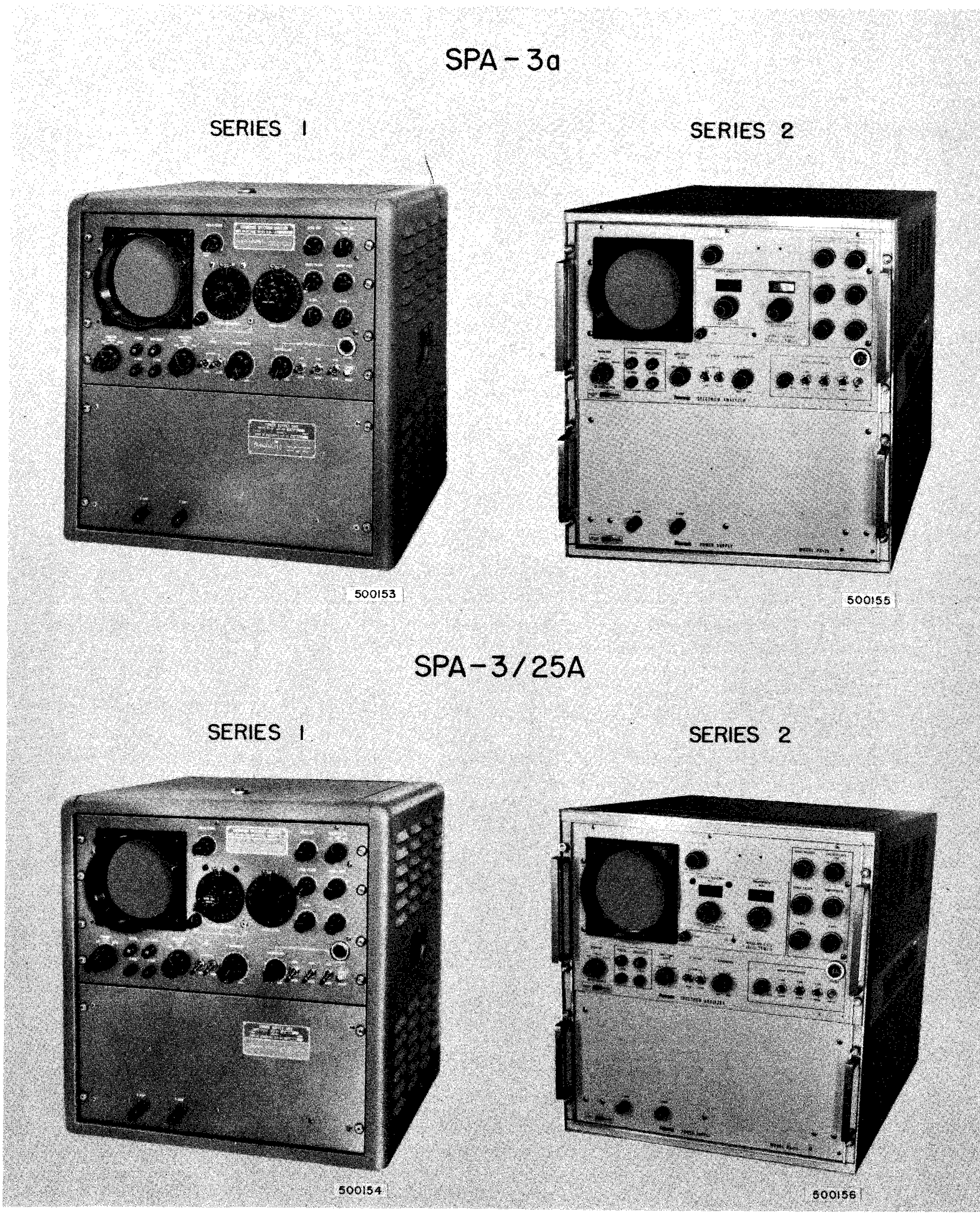

Figure 1-1. Spectrum Analyzer, Models SPA-3a and SPA-3/25a, Series 1 and Series 2

SECTION 1

GENERAL INFORMATION

1-1. GENERAL.

1-2. This instruction manual contains information concerning electrical and physical characteristics, applications, instruction and operation of the Spectrum Analyzers, Models SPA-3a and SPA-3/25a, as well as information concerning maintenance and servicing. Information is also provided for various accessory equipment which may be used with the spectrum analyzer.

1-3. No attempt to operate the equipment should be made until the user is thoroughly familiar with the information contained in Section 3, Operating Instructions. This manual provides information on two physically different versions of both the Model SPA-3a and Model SPA-3/25a. The two different physical configurations, designated series 1 and series 2, are functionally and electronically identical; the only differences are in the arrangement of the front panel and the size of the equipment. (See figure 1-1.) Both the series 1 and series 2 spectrum analyzers contain a Model PS-19 power supply.

1-4. APPLICATIONS.

1-5. The spectrum analyzers, Models SPA-3a and SPA-3/25a (with associated power supply, Model PS-19) provide a simple, reliable method for analyzing or monitoring complex discrete signals and/or noise in the frequency range of 200 cps to 15 mc (to 25 mc with Model SPA-3/25a).

1-6. The equipment provides an automatic, visual presentation (on the screen of a long-persistence cathode-ray tube) of the frequency and amplitude of signals present in the frequency region of 200 cps to 15 mc (to 25 mc with Model SPA-3/25a) for such studies as harmonic content, cross-modulation products, filter and transmission line checks, vibration measurement, and telemetry channel monitoring.

1-7. The equipment can be used to display modulated signals (am, fm, pulse, or combinations) to measure energy distributions and to provide an indication of such undesired effects as unwanted or excessive modulations, linearity of deviations, hum and noise, and otherwise undetectable parasitic oscillations. Other dynamic phenomena such as crowded communication channels, oscillator or carrier instability, and noise spectra can be studied. Both the direction and magnitude of changes caused by deliberate or random changes of circuit or operating parameters, mechanical shocks, environmental changes, and so on, can be seen instantly.

1-8. The designed versatility of the unit permits selection of center frequency, sweep width, sweep rate, intermediate-frequency bandwidth, and amplitude scale. The equipment enables the selection and detailed analysis of a narrow band which may contain signals separated by as little as 200 cps.

1-9. Once the norms for an application are established, nonprofessional personnel can use the equipment to provide a graphic visualization of spectrum content. However, the equipment is designed for laboratory investigation at the research and development levels.

1-10. In order to obtain a minute examination of modulated signals or groups of adjacent signals, the Model SPA-3a can be readily conditioned to select any 0 to 3 mc band between 200 cps and 15 mc (to 25 mc with the Model SPA-3/25a). This ability is particularly useful when the system usage involves modulated signals or closely spaced signals since an expanded presentation of just those adjacent signals being analyzed may be obtained. A display of the signals permits identification of unwanted effects at a glance, thereby affording a quick appraisal of those effects above tolerable levels. Since such observations can be employed without resorting to special and more difficult instruments and procedures, routine signal inspection with the spectrum analyzer will pinpoint difficulties and allow preventive action to be taken before important system failure is revealed.

1-11. The scope and facility of measurement with the spectrum analyzer can be extended with the use of the accessory equipment (available separately) listed in table 1-1. In addition, various outputs are provided on the spectrum analyzer for use with the accessory equipment. A listing of the outputs is provided in table 1-2.

TABLE 1-1. LIST OF ACCESSORY EQUIPMENT

Model No.	Title	Application	Characteristics
PRB-1a	High Impedance Probe	To pick up test signals from high impedance sources	Frequency Response: ±3 db from 1 kc to 23.5 mc Insertion loss: 10 db (approximate) Maximum input voltage: No attenuator head, 0.1 volt 20 db attenuator head, 1.0 volt 40 db attenuator head, 10 volts 60 db attenuator head, 100 volts
G6	Companion Sweep Generator	To determine amplitude-vs-frequency response	Frequency Range: 200 cps to 15 mc Output impedance: 72 ohms (50 ohms optional) Frequency response: ±1.5 db over entire frequency range
SW-1	Signal Alternator	To compare two signals	Frequency Range: 300 cps to 25 mc Switching rate: up to 7 cps Input impedance: unbalanced Maximum input: 500 volts rms
PDA-1	Spectral Density Analyzer	Used with spectrum analyzer and RC-3b/3 recorder to obtain spectral plot of voltage- or power-vs-frequency	Scan interval: 0.5, 1, 2, 4, 8, 16 hr or min Output level to recorder: 15 volts full scale Square-law accuracy: ±2% from 10% to 100% full scale Amplitude accuracy: ±3% (±5% with recorder) Tape loop replay: 0.7 sec minumum
RC-3b/3	Recorder and Sawtooth Wave Generator	Used with spectrum analyzer and PDA-1 spectral density analyzer to obtain spectral density plot of voltage- or power-vs-frequency	Sensitivity: 1.0 ma (15 volts) full scale Chart cycle per scan: 12 in. Pen response time: 0.25 sec for full scale deflection Chart speeds: 0.75, 1.5, 3, 6, 12, or 24 in/min or in/hr
SM-200A	Oscilloscope Camera	Polaroid-type camera for obtaining a photographic record of crt screen presentations	

1-12. GENERAL DESCRIPTION.

1-13. The spectrum analyzer is a scanning heterodyne instrument. It automatically provides a visual, two-dimensional display of the frequency components of a complex wave, in any selected 0 to 3 mc segment of the region between 200 cps and 15 mc (to 25 mc with Model SPA-3/25a). The display appears on the screen of a long-persistence, flat-faced, cathode-ray tube as vertical deflections distributed horizontally in order of component frequency. The frequency presentation is linear. The height of a given vertical deflection indicates the relative magnitude of the corresponding frequency component.

TABLE 1-2. LIST OF ANALYZER OUTPUTS

Nomenclature	Designation	Function
G-6 OUTPUT	J123	To provide sweep frequency signal to G-6 Companion Sweep Generator
AUDIO OUTPUT	J109	To provide audible monitoring of detected output at zero sweep
VERT OUTPUT	J111	To drive auxiliary slave indicators
SYNC PULSE OUTPUT	J130	To synchronize camera shutters, signal alternators and/or auxiliary slave indicators
ACCESS EQUIP	J129	To provide sweep and vertical signals to or from accessory equipment
PROBE	J103	To connect PRB-1a high impedance probe to spectrum analyzer

1-14. The spectrum analyzer consists basically of a calibrated input attenuator, an input cascode amplifier, a wide-band amplifier, a phase splitter, a sweeping oscillator, a balanced mixer, an intermediate-frequency section attenuator, a 32 mc i-f amplifier, a 29.3 mc crystal oscillator, a second mixer, variably selective intermediate-frequency amplifiers (2.7 mc), a detector, vertical and horizontal deflection amplifiers, a sawtooth generator, and a cathode-ray-tube indicator.

1-15. The sweeping oscillator progressively heterodynes, in order of frequency, with those signals at the output of the phase splitter to produce, among the mixing products, a difference frequency which is applied to the 32 mc intermediate-frequency section. A balanced modulator is employed to eliminate spurious modulation products and prevent passage of the sweeping oscillator frequency into the 32 mc i-f section. The output of the 32 mc i-f section is mixed with the output of the 29.3 mc crystal oscillator.

1-16. The 2.7 mc product of the mixing passes through a 2.7 mc variably selective i-f section. The output voltage of the 2.7 mc i-f section is proportional to the amplitude of the sampled portion of the input signal. This output is detected, amplified, and applied to the vertical deflection plates of the cathode-ray tube. The vertical deflection appears at a definite location along the horizontal axis according to signal frequency since a common sawtooth voltage source is used for both the sweeping oscillator and the horizontal deflection of the crt beam.

1-17. Oscillator sweep is obtained with a sawtooth-modulated circuit (consisting basically of a current-controlled tuning inductor) which controls the frequency of the oscillation. A calibrated SWEEP WIDTH dial varies the amplitude of the modulating sawtooth to permit selection of any sweep width from 0 to 3 mc. A calibrated CENTER FREQUENCY dial tunes the swept oscillator to permit selection of any center frequency between 0 and 13.5 mc (0 and 23.5 mc in the case of the Model SPA-3/25a).

1-18. In order to satisfy a very broad application range, the equipment incorporates independent SWEEP WIDTH, IF BANDWIDTH, and SWEEP RATE controls. For example, there are cases where high probability of signal intercept is paramount. This requires short scan intervals; the variable SWEEP RATE control and an IF BANDWIDTH control are used to obtain a suitable intermediate-frequency section bandwidth for the selected scanning velocity (product of sweep width and sweep rate). In other instances, for statistical purposes it may be necessary to scan slowly yet maintain a broad intermediate-frequency section bandwidth.

1-19. Three different amplitude scales can be selected; a linear scale calibrated in 10 divisions, a logarithmic scale calibrated from 0 db to 40 db in 5 db divisions, and a power scale wherein an approximately 2 to 1 voltage ratio provides a 4 to 1 ratio of screen deflection. The power scale is particularly useful for evaluating power levels, half-power points, and for critical amplitude comparison between signals of similar amplitude.

1-20. The Models SPA-3a and SPA-3/25a, and the companion power supply, Model PS-19, are normally supplied mounted in a cabinet. However, when removed from the cabinet, the units can be mounted in a standard, 19-inch, electrical equipment rack.

1-21. Screen observations and photography are facilitated by the flat-faced crt tube (Type 5ADP7), edge lighting for the crt scale, and a camera mounting bezel. A Polaroid-type oscilloscope camera specifically intended for use with the Models SPA-3a and SPA-3/25a mounting arrangements may be purchased from The Singer Company, Metrics Division.

1-22. The equipment is normally supplied for operation from a 95- to 130-volt, 60 cps, single-phase power source. It can also be supplied for operation from a 190- to 260-volt and/or 50 cps power source, or from a 105- to 125-volt, 47 to 420 cps power source if so ordered.

1-23. High Impedance Probe, Model PRB-1a, may be used directly with the spectrum analyzer. The probe consists of three alternate attenuator sections and a cathode follower section. Power for the high impedance probe is obtained from the PROBE connector of the spectrum analyzer. The probe is supplied with three attenuator heads: 20 db (single gold band), 40 db (double gold band), and 60 db (triple gold band).

1-24. The high impedance probe consists of a capacitive voltage divider in the attenuator head and a cathode follower output stage. The cathode follower is a triode stage whose cathode lead is the 72-ohm resistance of the spectrum analyzer input circuit.

1-25. EQUIPMENT SUPPLIED.

1-26. The following equipment is normally supplied with the Models SPA-3a and SPA-3/25a spectrum analyzers.

Description	Quantity
Analyzer section of Spectrum Analyzer, Model SPA-3a or SPA-3/25a	1
Power Supply, Model PS-19	1
Constant-Voltage Transformer, Part No. 556160-117	1
Interconnecting cable, power (SPA-3a or SPA-3/25a to PS-19) Part No. 556161-184	1
Interconnecting cable, power (PS-19 to Constant-Voltage Transformer) Part No. 556161-407	1
Line cord, ac, 3-wire (with adapter for 2-wire power line), Part No. 556161-066	1
Spare fuse, cartridge, 3 amp, 250 volts, Type 3AG (on PS-19 chassis)	2
Key for No. 4 multiple-spline socket screw	1
Key for No. 6 4-point spline socket screw	1
Key for No. 8 multiple-spline socket screw	1
Alignment Tool, Walsco Part No. 2543	1
Alignment Tool, Cambridge Thermionic Part No. X2033	1

NOTE

Keys and alignment tools are mounted on rear apron of analyzer section chassis.

1-27. ELECTRICAL CHARACTERISTICS.

1-28. The electrical characteristics of the spectrum analyzer are as follows:

a. Frequency Range:

Model SPA-3a: Any selected 0 to 3 mc portion of the range between 200 cps and 15 mc.

Model SPA-3/25a: Any selected 0 to 3 mc portion of the range between 1 kc and 25 mc (usable to 200 cps).

b. CRT Screen Calibrations:

Amplitude calibrations: The screen has a linear amplitude calibration on the right side of the scale (1.0 to 0 in divisions of 0.1) and a logarithmic amplitude calibration on the left side of the scale (0 DB to 40 DB in 5 DB divisions). When the front-panel AMPLITUDE SCALE switch is set to LOG, the logarithmic calibrations are used. When this switch is set to the LIN or the PWR (power) position, the linear calibrations are used. The linear calibrations are indicated by horizontal lines; the logarithmic calibrations by dots. (A calibrated screen with horizontal lines for the logarithmic calibrations and dots for linear calibrations can be supplied if desired.)

Frequency Calibrations: The screen has a linear frequency calibration scale, each division corresponding to one-tenth of the sweep width selected by means of the SWEEP WIDTH dial. This scale, called the SWEEP WIDTH FACTOR scale, is calibrated from +0.5 to -0.5, in divisions of 0.1.

c. CENTER FREQUENCY Dial Calibrations:

Model SPA-3a: The CENTER FREQUENCY dial is calibrated from 0 to 13.5 MC in 0.5 mc divisions.

Model SPA-3/25a: The CENTER FREQUENCY dial is calibrated from 0 to 23.5 MC in two bands. The calibrations are 0.5 mc apart.

d. SWEEP WIDTH Dial Calibrations:

The SWEEP WIDTH dial is calibrated from 0 to 3 mc (in two bands on Model SPA-3a).

e. Input Amplitude Range:

LIN scale: 25 microvolts to 1.4 volts full scale.

LOG scale: 250 microvolts to 1.4 volts full scale.

f. Relative Voltage Accuracy:

LIN scale: ±15 percent throughout the frequency range from 1.0 kc to 13.5 kc (to 23.5 kc with Model SPA-3/25a).

LOG scale: ±1.5 db throughout the frequency range from 1.0 kc to 13.5 mc (to 23.5 mc with Model SPA-3/25a).

PWR (power) scale: ±30 percent throughout the frequency range from 1.0 kc to 13.5 mc (to 23.5 mc with Model SPA-3/25a).

NOTE

Residual harmonic products of a single-frequency input of maximum allowable voltage on any input range are suppressed by at least 46 db. Maximum allowable voltages are given in Section 3.

g. Resolution:

Resolution is defined as the frequency separation of two signals of equal amplitude, whose deflections intersect 30 percent down from their peak amplitudes. Figure 1-2 includes resolution curves for various sweep rates as a function of sweep width.

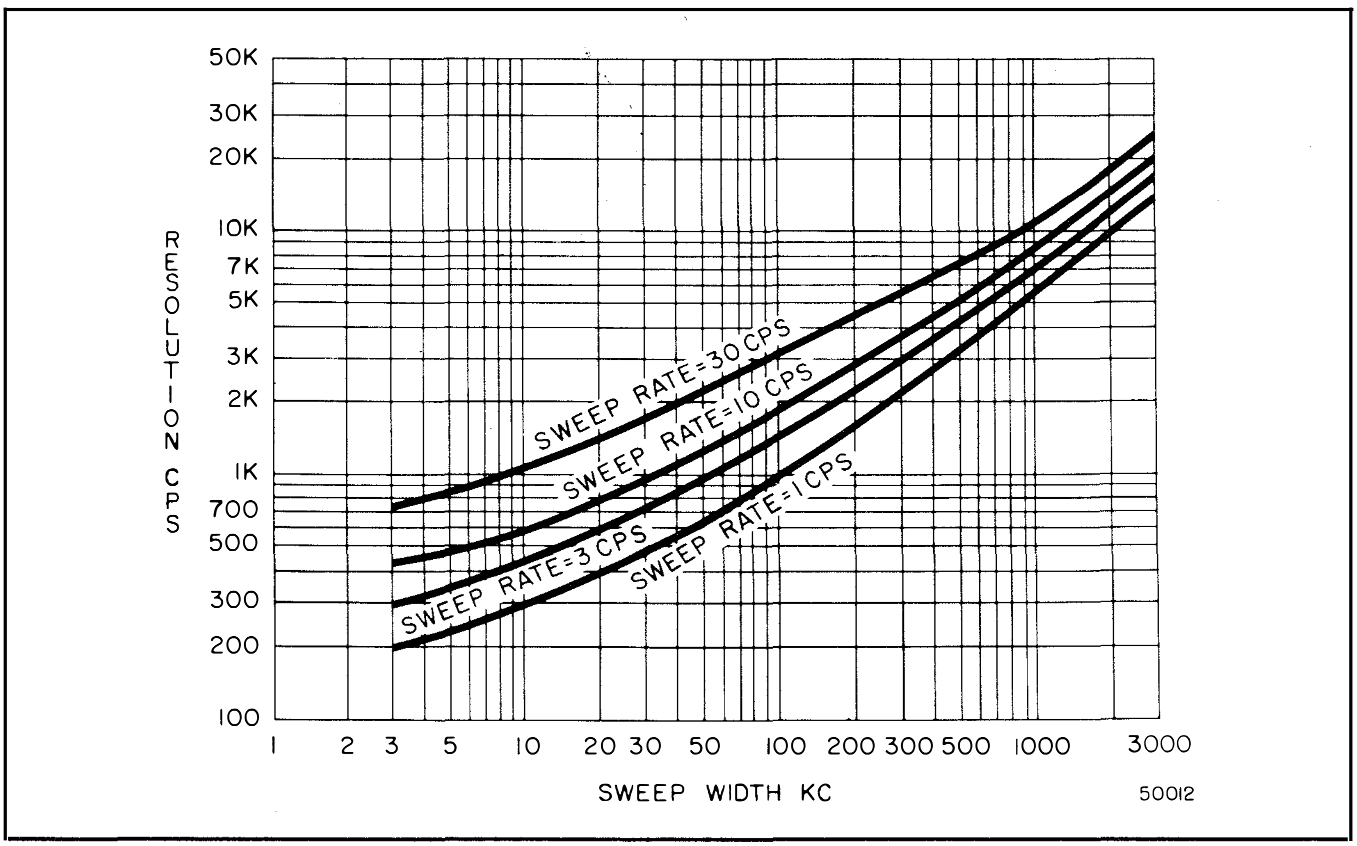

Figure 1-2. Resolution Versus Sweep Width

h. Measurement of Unequal Amplitude Signals:

Figure 1-3 indicates minimum frequency separations required to measure signals of various amplitude ratios at various scanning velocities (scanning velocity is the product of sweep rate and sweep width).

i. Sweep Rate:

The sweep rate is continuously variable, from 1 to 60 cps, by means of a single control. The sweep rate may be either free running, synchronized with the ac power line, or externally synchronized.

j. Input Impedance:

The input impedance is 72 ohms (50-ohm input impedance is available on special order). High impedance signal sources require the use of High Impedance Probe, Model PRB-1a.

k. Frequency Markers:

Internal crystal-controlled frequency markers of 500 kc and its harmonics, and 50 kc and its harmonics are provided.

l. Power Supply:

The Model PS-19 is factory-wired for operation from a 50 to 60 cps, 118-volt, ac power source. The Model PS-19 is supplied with an external constant-voltage transformer in order to maintain adequate operating stability over an input line voltage variation from 95 to 130 volts. The constant-voltage transformer supplied is rated for 250 va at 60 cps. For a 50 cps and/or 230-volt line, a suitable substitute will be furnished. The constant-voltage transformer must be used at all times; it should not be used to supply accessory or additional equipment.

1-29. PHYSICAL CHARACTERISTICS.

1-30. The physical characteristics of the spectrum analyzer are given below. The dimensions

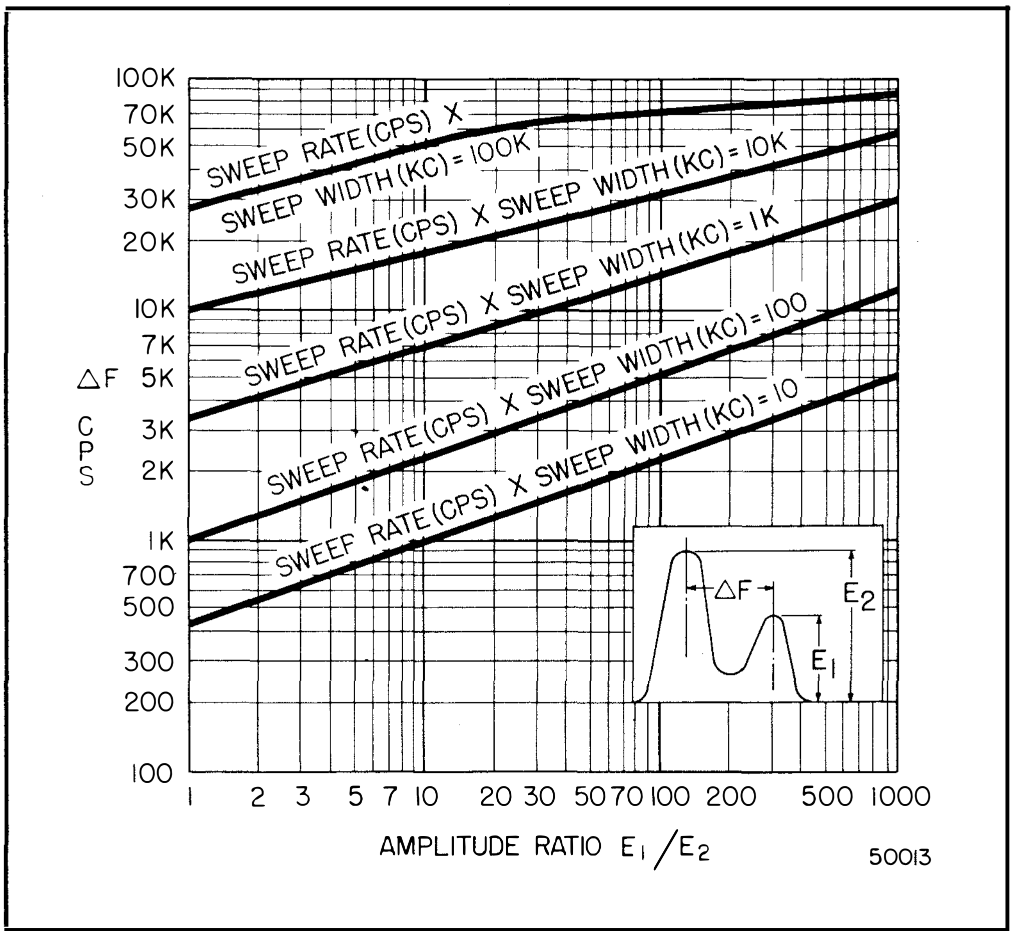

Figure 1-3. Minimum Frequency Separation Δ F Required to Measure Amplitude Ratios E_2/E_1

of the analyzer chassis, power supply chassis, and constant-voltage transformer are shown in figures 2-1 through 2-5.

a. Weights:

Equipment	Weight
Analyzer Section Chassis	33 pounds
Power Supply Chassis	27 pounds
Spectrum Analyzer and Power Supply in Cabinet	108 pounds
Constant-Voltage Transformer	24 pounds

b. Dimensions:

Equipment	Length
Series 1	
Height	21-5/8 inches
Width	22 inches
Depth	21-11/16 inches
Series 2	
Height	20-3/4 inches
Width	19-5/16 inches
Depth	23 inches
Interconnecting cable, power, Part No. 556161-184	25-1/2 in
Interconnecting cable, power, Part No. 556161-407	8 ft
Line cord, ac, with adapter, Part No. 556161-066	6 ft

1-31. TUBE COMPLEMENT.

1-32. The tube complement of the analyzer section is given in table 1-3.

TABLE 1-3. ANALYZER SECTION, TUBE COMPLEMENT

Reference Symbol	Tube Type	Function
V101	6922	Input cascode amplifier
V102	6CB6	Wide band input amplifier
V103	6J6	Phase splitter
V104	5879	Part of balanced modulator
V105	5879	Part of balanced modulator
V106	6AW8A	A: 32 mc i-f amplifier B: 29.3 mc crystal oscillator
V107	6BE6	Mixer
V108	6AB4	First crystal filter stage (2.7 mc)
V109	6AW8A	A: First 2.7 mc tuned i-f amplifier B: Second crystal filter stage (2.7 mc)
V110	6CB6	Second 2.7 mc tuned i-f amplifier
V111	6AU6	Third 2.7 mc tuned i-f amplifier
V112	12AU7	A: Detector (LIN-LOG amplitude scale) B: Audio output amplifier
V113	12AT7	A: Detector (PWR amplitude scale) B: Amplifier (PWR amplitude scale)
V114	12AU7	A: Vertical amplifier B: Vertical phase inverter and amplifier
V115	12AX7	A: 50 kc marker oscillator B: Marker harmonic generator
V117	12BY7	Sawtooth amplifier for sweeping oscillator section
V118	6BK7	Sweeping oscillator
V119	6J6	A: Sweeping oscillator output amplifier B: Sweeping oscillator output amplifier for Model G-6
V120	12AT7	Sync amplifier

TABLE 1-3. ANALYZER SECTION, TUBE COMPLEMENT (Cont)

Reference Symbol	Tube Type	Function
V121	6U8	A: Sawtooth generator B: Sawtooth output cathode follower
V122	12AU7	A: Horizontal amplifier B: Horizontal phase inverter and amplifier
V123	5ADP7	Visual indicator (crt)
V124	6AH6	500 kc marker crystal oscillator

1-33. The tube complement of the power supply section is given in table 1-4.

1-34. TERMS AND DEFINITIONS.

1-35. The following is a discussion of the various terms used in this instruction manual.

a. Panoramic* Spectrum analyzers provide simultaneous visual reception of one or several frequency sources whose frequencies are distributed over a continuous portion of the frequency spectrum. This definition distinguishes swept-band spectrum analysis reception from the conventional reception which can be called "uni-signal" reception and which can be either aural, visual, or both. The main distinction between swept-band spectrum analysis and uni-signal reception is the following: swept-band spectrum analysis is periodic reception over a wide range of the spectrum. Each signal is received at fixed, rapid intervals, for a short period of time. At higher sweep rates, these signals are received so rapidly as to appear to be continuous on the crt screen because of the persistence of the screen material and persistence of vision. Uni-signal reception is continuous reception of one signal at a time over a very narrow range of the spectrum.

b. SWEEP WIDTH is the band, measured in cycles, kilocycles, or megacycles, which can be observed and which corresponds to the range of oscillator sweep in the equipment.

c. FREQUENCY SWEEP AXIS is the horizontal line along which the signal deflections are produced and which can be calibrated in frequency according to a given frequency scale. The frequency scale used is a multiplication factor of the SWEEP WIDTH dial setting (SWEEP WIDTH FACTOR scale calibrated from -0.5 to +0.5 in divisions of 0.1).

d. CENTER FREQUENCY is the frequency of the signal received on that part of the frequency sweep axis corresponding to zero sweep width.

TABLE 1-4. POWER SUPPLY SECTION, TUBE COMPLEMENT

Reference Symbol	Tube Type	Function
V1	5U4	Full wave rectifier (B+ supply)
V2	6146	Part of series regulator (B+ supply)
V3	6146	Part of series regulator (B+ supply)
V4	12AX7	Regulator control tube (B+ supply)
V5	12AX7	Regulator control tube (B+ supply)
V6	5651 or Amperex OG3/85A2	Regulator control voltage standard
V7	5651 or Amperex OG3/85A2	Voltage regulator (B- supply)

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e. RESOLUTION is defined as the frequency difference between two signals of equal deflection amplitude, the pips of which intersect 30 percent down from their peak value. This characteristic corresponds to selectivity in ordinary receivers. The smaller this frequency difference, the better is the resolution.

f. SWEEP FREQUENCY (sweep rate) is the number of times per second that the electron beam sweeps across the cathode-ray tube.

g. DEFLECTION AMPLITUDE is the visual equivalent of signal input voltage. Deflection amplitude is the height of a given signal deflection measured from the baseline to the top of the deflection.

h. SCANNING VELOCITY is defined as the frequency band scanned by the equipment per unit time. When the frequency spectrum is scanned linearly, scanning velocity is the product of the sweep rate and the sweep width.

Scanning Velocity (cycles/sec/sec) =
Sweep Rate (sweeps/sec) x
Sweep Width (cycles/sec)

SECTION 2

INSTALLATION

2-1. UNPACKING AND INITIAL INSPECTION.

2-2. This instrument has been tested and calibrated before shipment. Only minor preparations are required to place the instrument in operation.

2-3. The equipment is shipped with all its tubes and crystals already installed. Check to see that tubes, crystals, and other "pluck-out" components are well seated.

2-4. MOUNTING.

2-5. The equipment (Model SPA-3a or SPA-3/25a with power supply) is normally supplied in an electrical equipment cabinet. The constant-voltage transformer is supplied separately. The equipment, if removed from its cabinet, can be mounted in a standard, 19-inch, electrical equipment rack.

2-6. The equipment should be located so that it will receive effective ventilation, in an area where the ambient light is not excessively bright. Locate the constant-voltage transformer so that it will receive effective ventilation and as far from the analyzer unit as possible in order to minimize hum pickup. Areas with a high level of electrical disturbance should be avoided. A convenient source of suitable ac power is required. (Refer to paragraph 2-8.)

2-7. See Figures 2-1 through 2-5 for outline dimensional drawings of the various rack-mounted units. The dimensions for cabinet-mounted units are given in Section 1.

2-8. INTERCONNECTING PROCEDURE.

2-9. The Model PS-19 power supply is factory wired for 188-volt, 50- to 60-cycle operation. In order to provide a stable power source, a constant-voltage transformer is supplied. This transformer must be considered an integral part of the instrument and must be used at all times. Do not, however, use the transformer to supply power to auxiliary or additional equipment. For satisfactory operation of the instrument, the constant-voltage transformer must be used only within the input voltage range and only at the frequency specified on the nameplate. Normally, a 95- to 130-volt, 60 cps constant-voltage transformer is supplied. The following voltage-frequency combinations are available if specified on the purchase order.

Input Voltage	Frequency	Output Voltage
95 to 130 volts	50 cps	118 volts
190 to 260 volts	60 cps	118 volts
190 to 260 volts	50 cps	118 volts
105 to 125 volts	47 to 420 cps	115 volts

NOTE

If so ordered, the equipment is supplied without the constant-voltage transformer, and is modified for operation from a well-regulated ±1 percent, 118-volt, 50 to 60 cps power source. The power source must provide the same waveform as a constant-voltage transformer or, if the power source provides a distortion-free voltage, the power supply is appropriately modified at the factory.

2-10. Interconnect the spectrum analyzer as follows:

a. The equipment is normally shipped with the interconnecting cable between the spectrum analyzer chassis and the power supply already installed. Be sure that all plugs are well seated. If the equipment is supplied without the cabinet (i.e., for rack mounting), the 14-wire interconnecting cable must be connected between the 14-contact male receptacle on the rear apron of the spectrum analyzer chassis and the 14-contact female receptacle on the rear apron of the power supply chassis.

b. Connect the constant-voltage transformer to the power supply chassis, using the 5-wire cable supplied with the equipment. The appropriate 5-contact female receptacle is located on the rear apron of the power supply chassis.

NOTE

If the equipment is modified for operation without the constant-voltage transformer (refer to paragraph 2-9), it is only necessary to connect the 3-wire line cord. Make sure that center pin of the 3-wire cord is grounded.

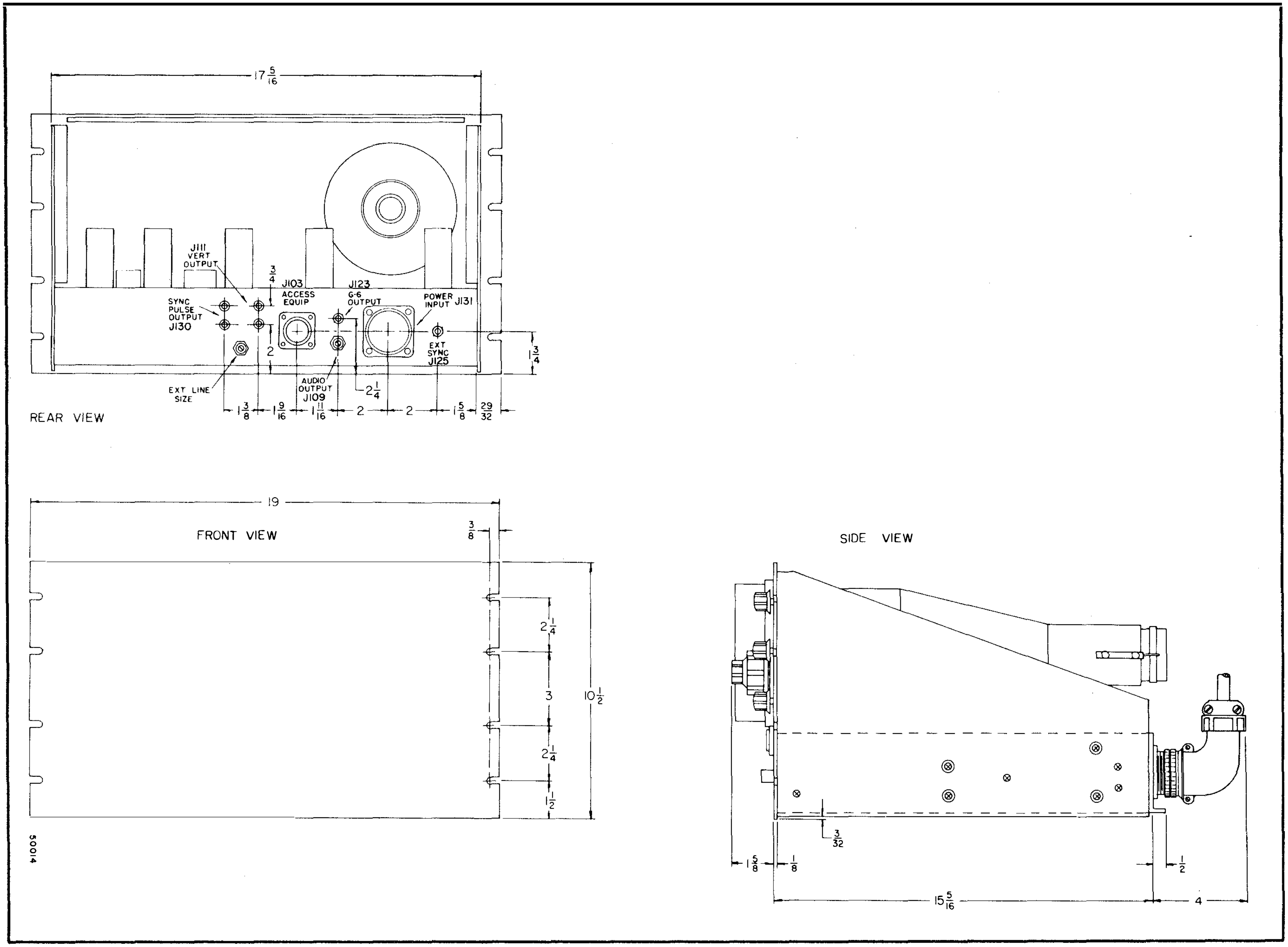


Figure 2-1. Outline Dimensional Drawing, Analyzer Section, Rack-Mounted Style, Series 1

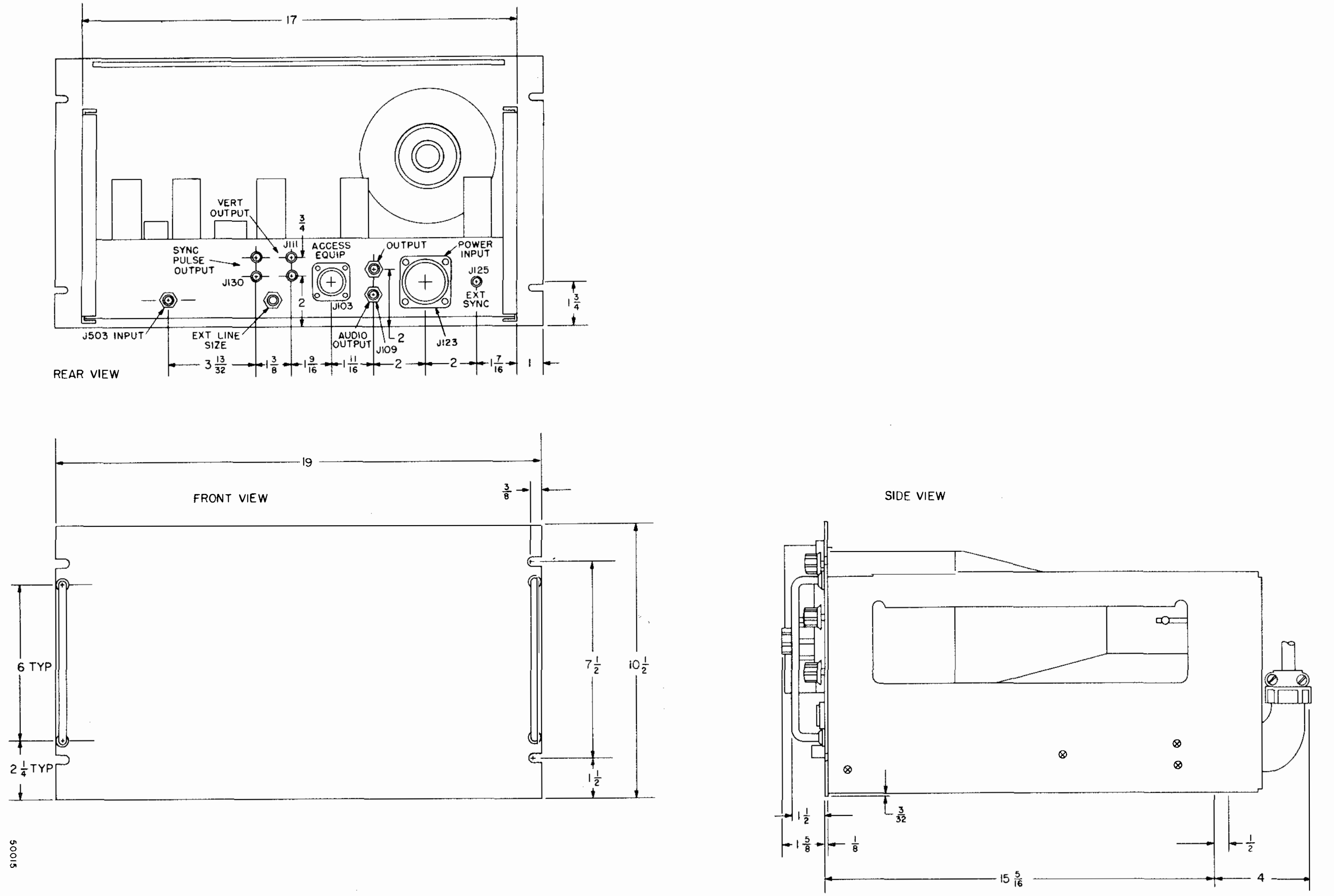


Figure 2-2. Outline Dimensional Drawing, Analyzer Section, Rack-Mounted Style, Series 2

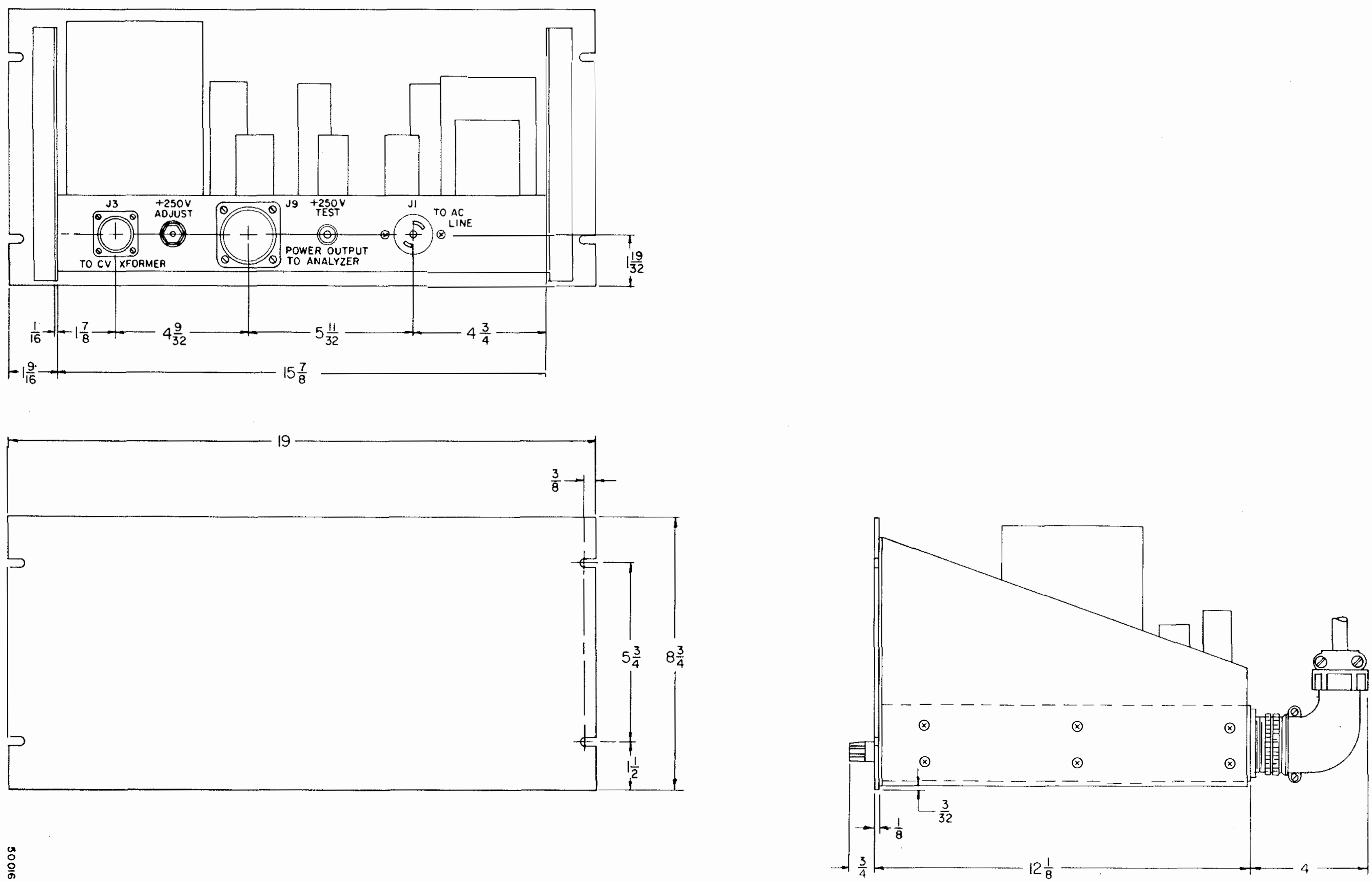


Figure 2-3. Outline Dimensional Drawing, Model PS-19, Rack-Mounted Style, Series 1

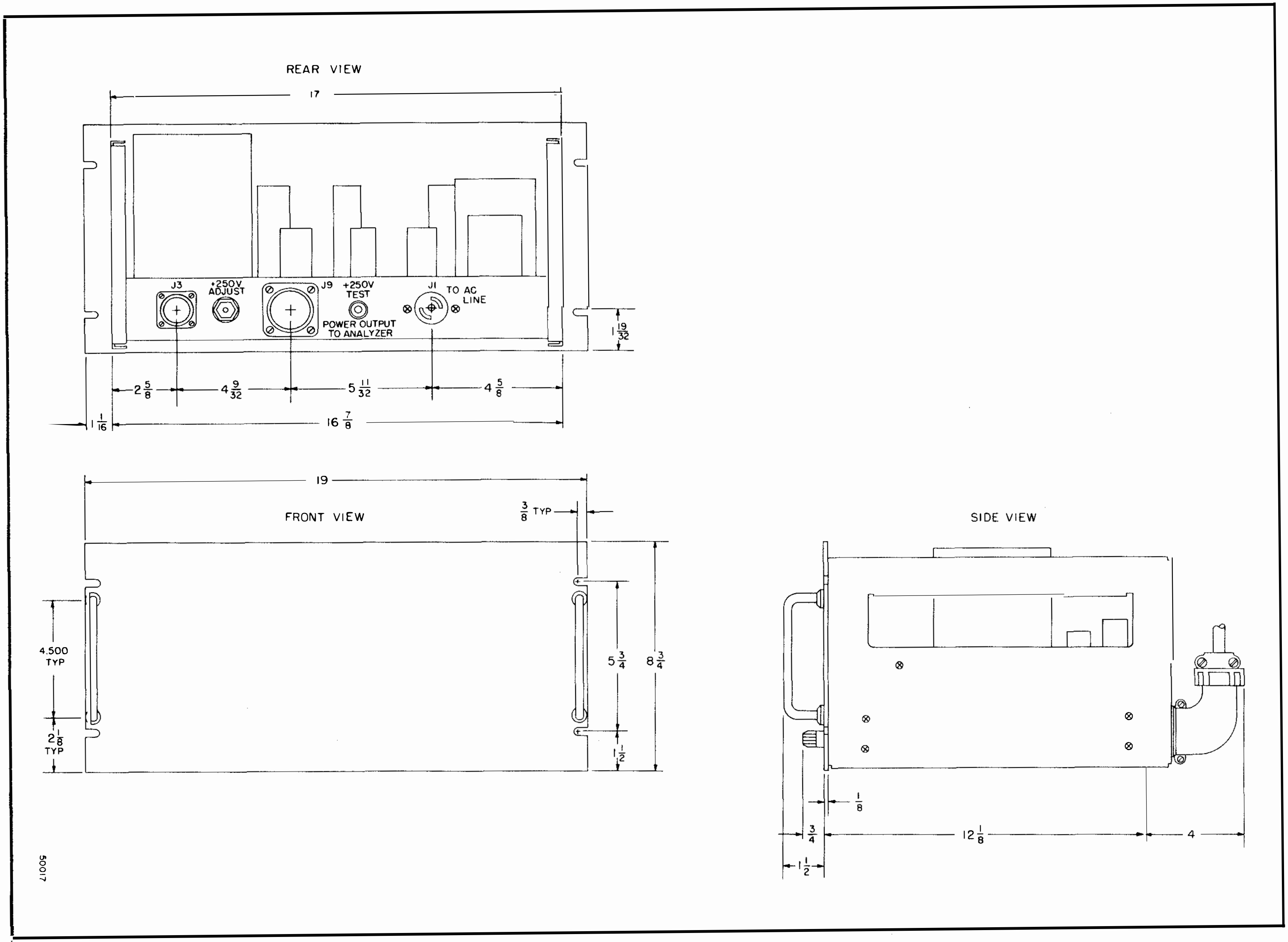


Figure 2-4. Outline Dimensional Drawing, Model PS-19, Rack-Mounted Style, Series 2

c. Connect the 3-contact, twistlock receptacle on the rear apron of the power-supply chassis to the ac power line, using the supplied three-wire, ac line cord.

CAUTION

Be sure that the power line is appropriate both as to voltage and frequency, for the constant-voltage transformer being used. Refer to the constant-voltage transformer nameplate for input requirements.

d. If the power source does not accommodate the three-wire cord (center pin grounded), then the supplied adapter should be used. If the adapter is used, the ground wire of the adapter must be connected to a suitable external ground.

e. A signal input from a 72-ohm source should be connected to the front-panel INPUT connector, through a suitable input cable. This input cable should be fabricated from RG-59/U coaxial cable and be terminated at one end with a type BNC plug to match the INPUT receptacle. The other end should be terminated with a connector suitable to the signal source.

NOTE

A 50-ohm input source should be used if the spectrum analyzer is supplied with 50-ohm input impedance.

f. To insure flatness of response, if the impedance of the source is lower than the input impedance of the spectrum analyzer, a suitable matching pad should be inserted between the signal source and the INPUT connector.

g. To connect signals from a high impedance source, the Model PRB-1a probe (supplied only if ordered) should be used. Refer to Section 6 for information relating to the probe.

2-11. INSTALLATION ADJUSTMENTS AND CHECKS.

2-12. Adjust the spectrum analyzer as follows:

NOTE

If the adjustments given in this section fail to give the indicated results, refer to Section 5 for appropriate maintenance action. Refer to Section 3 for details concerning operating techniques.

a. Set the following front-panel controls to the positions indicated:

CENTER FREQUENCY Dial	10 MC
SWEEP WIDTH Dial	3 MC
SWEEP WIDTH BAND SEL Switch	W (wide)
AMPLITUDE SCALE Switch	LOG
IF ATTEN Switches	15 DB
INPUT ATTENUATOR, Step Switches	80 DB
INPUT ATTENUATOR, CONTINUOUS	MAX
IF BANDWIDTH Control	MAX
VIDEO FILTER Control	OFF
MARKERS Switch	OFF
CAL - SYNC - SEL Switch	LINE
SYNC AMP Control	Completely counterclockwise

(SYNC ADJUST Control for Series 2)

b. Be sure that the shorting plug is securely seated in the ACCESS EQUIP receptacle at the rear of the spectrum analyzer chassis.

c. Switch on the equipment by rotating the SCALE ILLUM control fully clockwise. The crt screen edge lighting should go on immediately.

d. Within 30 seconds, a dot should appear on the screen and within a few seconds start to sweep across the screen. This moving dot is the baseline trace. If nothing appears on the screen, turn the BRILLIANCE control clockwise with a screwdriver.

CAUTION

If a stationary dot appears on the screen, turn the power off and refer to Section 5 for appropriate action.

e. The baseline trace should coincide with the baseline of the calibrated screen. If they are not parallel, rotate the cathode ray tube.

WARNING

Avoid contact with the high-voltage leads of the crt.

f. To rotate the crt, first loosen one of the two screws holding the crt socket clamp. When parallelism has been obtained, be sure that the crt is fully forward before retightening the screws.

g. If the baseline trace does not coincide with the baseline of the calibrated screen, adjust the V POS control.

h. The baseline trace should extend at least 1/8 inch beyond the calibrated portion of the crt screen at all sweep rates and should not extend past the edges of the crt screen for at least one sweep rate. See steps j through l, below, for the technique of setting sweep rate and obtaining sweep synchronization.

i. The FOCUS, BRILLIANCE (located on front panel), and ASTIG (located on analyzer chassis) controls are adjusted as required for a suitable trace. The FOCUS and ASTIG controls should be set for a clear, sharp, uniform trace. The BRILLIANCE control should be set at the minimum point of suitable visibility. Do not use the BRILLIANCE control to compete with external light falling on the crt screen; instead, reduce the external light or shield the screen.

j. Rotate the SWEEP RATE control throughout its range, noting that clockwise rotation increases the rate.

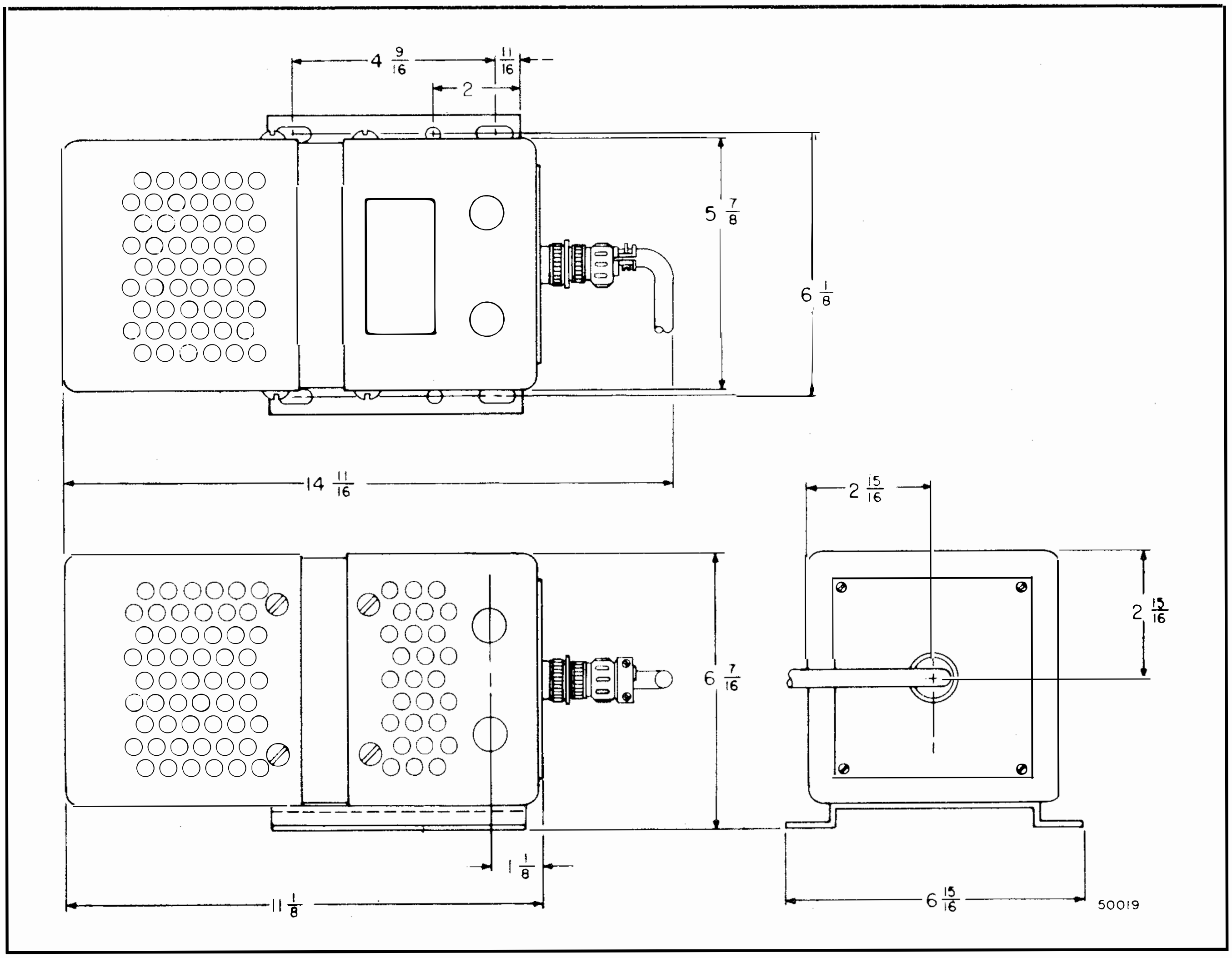


Figure 2-5. Outline Dimensional Drawing, Constant-Voltage Transformer

k. Turn CAL - SYNC SEL switch to CAL. The baseline will become a series of sine waves, the number of which indicates the sweep rate. The sweep rate is determined by dividing 60 by the number of cycles appearing on the screen. (e.g., if there are 2 cycles on the screen, the sweep rate equals 60 ÷ 2 = 30 cps.) To synchronize the sweep with the power line, adjust the SWEEP RATE control so that the appropriate number of cycles appears on the screen and is almost stationary with a slight drift to the left. Then rotate the SYNC AMP (ADJUST) control clockwise until the trace becomes stationary. If the baseline becomes too short, excessive sync (control too far clockwise) is being provided. Minimum sync amplitude consistent with good synchronization is the best setting. Note that, at low sweep rates, it is easier to count sweeps, using a stop watch for timing, than to count cycles.

NOTE

To determine the sweep rate when the power supply to the instrument is 50 cps, use 50 as the dividend in the above formula.

l. Set SWEEP RATE and SYNC AMP controls for a stable 30 cps rate (2 cycles on the screen). Return the CAL - SYNC SEL switch to the LINE position.

NOTE

The equipment must be turned on and allowed to warm up for at least one-half hour before the following checks are made.

m. Turn the CENTER FREQUENCY dial to 0. With Model SPA-3/25a, be sure that the ZERO ADJUST control is set for the LO BAND. This is done by turning the control to the extreme counterclockwise position until the switch is actuated. A rise or deflection of the baseline near the center of the screen may or may not be present. The presence of this pip indicates an unbalanced condition in the balance modulator. Manipulate the A BAL and S BAL controls alternately to minimize this deflection. Set the IF ATTEN to 0 DB and rebalance. When the IF ATTEN setting is changed from 15 DB to 0 DB, adjustment of the balance controls should become more critical, indicating increased sensitivity of the intermediate-frequency section. It may not be possible to completely eliminate the deflection, in which case proper balance is indicated by the presence of a minimum amplitude double hump that resembles an "m".

n. Change control settings as follows:

CENTER FREQUENCY Dial	2 MC
AMPLITUDE SCALE Switch	LIN
MARKERS Switch.	500 KC

o. Adjust the MARKER LEVEL control for a convenient height of marker presentation. The 2 mc marker pip should be at or near the center of the screen. Gradually reduce the sweep width to minimum, maintaining the 2 mc pip at the center of the screen with the CENTER FREQUENCY dial. Return to 3 mc sweep width and adjust the H POS control until the top of the pip coincides with the center vertical line (zero-frequency calibration) on the screen. (With the SWEEP WIDTH dial set to 3 MC and the CENTER FREQUENCY dial set to 2 MC, the 3.5 mc marker pip should fall within ±1/2 division of the -0.5 calibration mark. Note that the marker pips are 0.5 mc apart. If base line is not centered, adjust CF BAL control (on chassis).

p. Check the IF BANDWIDTH control by reducing the sweep width until the base of a centered, half-scale, 2 mc marker pip occupies approximately one-third of the screen width. Then slowly turn the IF BANDWIDTH control counterclockwise. The pip width should decrease. At the same time there may be a change in the pip height. Maintain a half-scale pip by adjusting the MARKER LEVEL control. As the IF BANDWIDTH control is turned counterclockwise, small convolutions of "ringing" will appear on the trailing edge of the pip. Optimum resolution occurs when the first convolution beyond the apex of the pip dips into the baseline. Section 3 provides a more extended discussion of the variation of screen presentation with change in the IF BANDWIDTH control setting.

q. Using the 500 kc marker pips, check the SWEEP WIDTH dial calibrations corresponding to frequencies above 0.5 mc. Adjust the MARKER LEVEL control for a convenient amplitude of marker display. Set the SWEEP WIDTH control to 3 MC and the CENTER FREQUENCY dial to 1.5 MC. The zero-frequency pip should be at or near the -0.5 calibration mark of the SWEEP WIDTH FACTOR scale. (It may be necessary to adjust the A BAL and/or S BAL controls to unbalance the equipment sufficiently to see the zero-frequency pip.) The sixth marker pip to the right of the zero-frequency pip should be at or near the +0.5 mark of the SWEEP WIDTH FACTOR scale. (Since the pips are 0.5 mc apart, the sixth pip to the right of the zero-frequency pip corresponds to a frequency of 3 mc. Since the sweep width is 3 mc, a 3 mc pip should fall at +0.5 when the zero-frequency pip falls at -0.5 on the SWEEP WIDTH FACTOR scale.) Note that it may be necessary to adjust the CENTER FREQUENCY dial to center this display of six marker pips plus the zero-frequency pip. Other SWEEP WIDTH dial calibrations in increments of 0.5 mc from 0.5 MC to 3 MC can be checked using the 500 kc marker pips. For example, if the CENTER FREQUENCY dial is set to 1.75 MC and the SWEEP WIDTH dial to 0.5 MC, marker pips should appear at +0.5 and -0.5 approximately on the SWEEP WIDTH FACTOR scale. Using the 50 kc marker pips (set the MARKERS switch to the 50 KC position), check the SWEEP WIDTH dial calibrations in increments of 0.05 mc between 0.05 and 0.5 mc.

r. To check sweep widths narrower than 0.05 mc, an amplitude modulated signal may be used. The modulating source should be set to a frequency equal to one-half the SWEEP WIDTH dial setting. The CENTER FREQUENCY dial should be set to the carrier frequency. The upper and lower side bands may then be used to determine the actual sweep width. Note that, in order to have suitable pips at narrow sweep widths, it may be necessary to reduce the sweep rate and the i-f bandwidth thereby improving resolution. Section 3 contains a more extended discussion of narrow-band techniques.

s. Check the CENTER FREQUENCY dial by setting the SWEEP WIDTH dial to 3 MC and then matching the CENTER FREQUENCY dial calibrations with the corresponding marker frequency (starting with the CENTER FREQUENCY dial set to zero). The top of the pip should appear at or near the center of the screen. Be sure that the ZERO ADJUST control is set so that the zero-frequency pip is at the center of the screen when the CENTER FREQUENCY dial is set to zero.

t. Check the amplitude scales, using a signal of variable, known amplitude and low distortion. The voltages given in these checks are approximate since the instrument measures relative amplitude rather than absolute amplitude. Any convenient fixed CENTER FREQUENCY dial and SWEEP WIDTH dial settings compatible with the generator frequency and pip readability may be used. Set the controls as follows:

AMPLITUDE SCALE Switch	LIN
IF ATTEN Switches	0 DB
INPUT ATTENUATOR, CONTINUOUS	Completely counterclockwise
INPUT ATTENUATOR, STEP	0 DB
IF BANDWIDTH Control . .	MAX
VIDEO FILTER Control . .	OFF
SWEEP RATE Control . . .	30 cps

u. A signal input amplitude of approximately 25 microvolts should result in a full-scale pip. Adjust the generator level, if necessary, for a full-scale pip. Change the INPUT ATTENUATOR, STEP to 20 DB. The signal input amplitude required for full-scale deflection should be approximately 250 microvolts. Set the INPUT ATTENUATOR, STEP to 40 DB, to 60 DB, and then to 80 DB. The signal input amplitude required for full-scale deflection should be approximately 2.5 millivolts, 25 millivolts, and 250 millivolts, respectively. With the IF ATTEN at 15 DB and the INPUT ATTENUATOR, STEP at 80 DB, an approximately 1.4-volt input should result in a full-scale deflection. Return the INPUT ATTENUATOR, STEP to 40 DB and the IF ATTEN to 0 DB. Reduce the input amplitude to approximately 2.5 millivolts in order to obtain a full-scale pip. Increase the input amplitude to 25 millivolts and rotate the INPUT ATTENUATOR, CONTINUOUS completely clockwise. The pip should be less than full scale, indicating more than a 20 db range in this control. Return the INPUT ATTENUATOR, CONTINUOUS to the full counterclockwise position and adjust the input amplitude for a full-scale pip.

v. Switch the AMPLITUDE SCALE switch to LOG. The pip amplitude should be in line with the 20 db calibration dot on the left side of the calibrated crt scale. Change the INPUT ATTENUATOR, STEP to 20 DB. The pip amplitude will again increase to full scale. Intermediate amplitude calibration points on the crt screen for the LOG position of the AMPLITUDE SCALE switch may be checked, using the IF ATTEN and the INPUT ATTENUATOR, STEP switches in 5 db steps. Intermediate amplitude calibration points on the crt screen for the LIN position of the AMPLITUDE SCALE switch may be checked against known input levels.

w. Set the AMPLITUDE SCALE switch to PWR (power). Using the INPUT ATTENUATOR, STEP and CONTINUOUS controls, obtain a full-scale pip. Decrease the input amplitude of the signal by 3 db. The pip amplitude should decrease approximately 5 linear divisions of the crt screen. Note that because of ac coupling in the circuit, this amplitude scale functions properly only with narrow pips and high sweep rates.

SECTION 3

OPERATION

3-1. GENERAL.

3-2. This section contains all the information required for operation of Spectrum Analyzers, Models SPA-3a and SPA-3/25a in both Series 1 and Series 2. Paragraph 3-3 describes the functions of all the operating controls and indicators. A separate photograph of each series is provided to illustrate the appearance and location, on the front panel, of the controls and indicators. Paragraph 3-5 describes all adjustments to be made prior to operation of the spectrum analyzer, and paragraphs 3-7 through 3-17 provide all operating instructions and interpret all indicator presentations for various types of measurements. When using the spectrum analyzers in conjunction with accessory equipment, refer to the applicable instruction manual for the equipment for appropriate operating instructions.

3-3. OPERATING CONTROLS AND INDICATORS.

3-4. The operating control and indicators of Spectrum Analyzers, Models SPA-3a and SPA-3/25a in Series 1 are illustrated in figure 3-1 and described in the chart which follows. The operating controls and indicators in Series 2 are illustrated in figure 3-2 and described in the charts which follow. These charts list the name, index number, and function of each control and indicator.

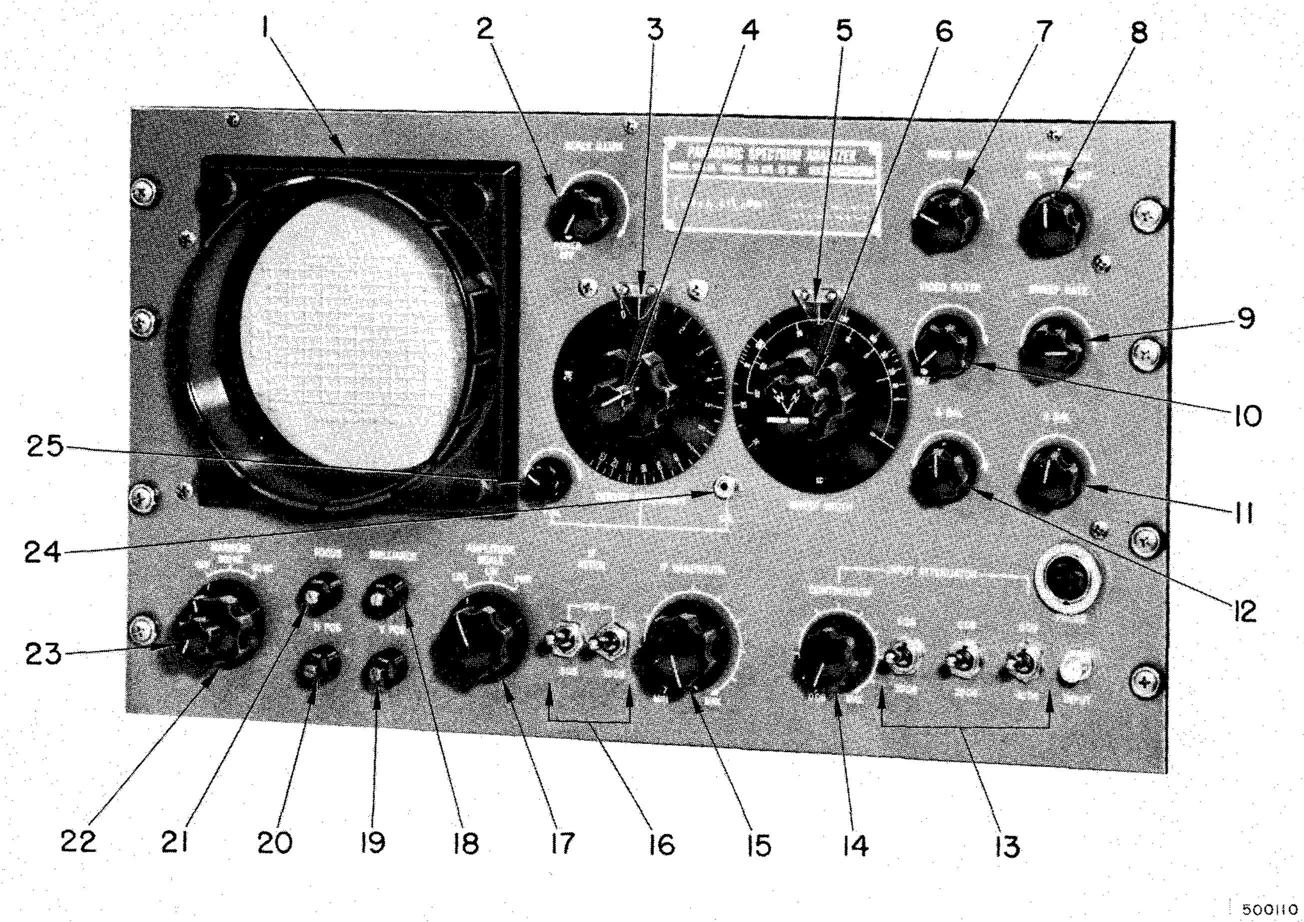


Figure 3-1. Series 1, Operating Controls and Indicators

SERIES 1, OPERATING CONTROLS AND INDICATORS

Control or Indicator	Figure 3-1 Index Number	Function
Crt Screen	1	Provides a visual indication of discrete signals or noise being monitored by spectrum analyzer.
SCALE ILLUM Control	2	Applies power to equipment when rotated clockwise, and is then used to adjust intensity of edge lighting of crt screen.
CENTER FREQUENCY Control	3	Provides a continuously adjustable selection of frequency which appears under zero marker on crt screen.
Zero Adjust Control (SPA-3a only)	4	Used to set calibration of CENTER FREQUENCY control and as a tuning control for variations on the order of 200 kc or less.
ZERO ADJ - BAND Selector (SPA-3/25a only)	4	Used to set calibration of CENTER FREQUENCY control and as a tuning control for variations on the order of 200 kc or less; also selects frequency band.
SWEEP WIDTH Control	5	Adjusts width of segment of spectrum to be analyzed; provides any sweep width from 0 to 3 mc (in two ranges on the Model SPA-3a only).
SWEEP WIDTH Range Selector (SPA-3a only)	6	Selects desired sweep range; 0 to 3 mc in wide position and 0 to 100 kc in narrow position.
SYNC AMP Control	7	Adjusts sweep-synchronizing signal to provide for proper crt beam sweep synchronism. Maximum amplitude occurs at full clockwise position. A free-running sweep is obtained when control is completely counterclockwise.
CAL - SYNC SEL Switch	8	In CAL position, a 60 cps modulation of the vertical amplifier is provided to check sweep rates and synchronization of the sawtooth generator; in LINE position, sweep rate is synchronized with power-line frequency; in EXT position, sweep rate may be synchronized externally.
SWEEP RATE Control	9	Provides continuously adjustable sweep rates between 1 and 60 cps.
VIDEO FILTER Control	10	Provides continuous adjustment of a smoothing filter located at output of detector. Filter is disconnected when control is set to OFF.
S BAL Control	11	Suppresses an internally generated deflection which may appear on crt screen when CENTER FREQUENCY control is at or near zero.

SERIES 1, OPERATING CONTROLS AND INDICATORS (Cont)

Control or Indicator	Figure 3-1 Index Number	Function
A BAL Control	12	Suppresses an internally generated deflection which may appear on crt screen when CENTER FREQUENCY control is at or near zero.
INPUT ATTENUATOR Step Switches	13	Provide attenuation of 80 db in three increments: 20 db, 20 db, and 40 db.
INPUT ATTENUATOR - CONTINUOUS Control	14	Provides a variable attenuation from 0 to more than 20 db.
IF BANDWIDTH Control	15	Adjusts bandwidth of intermediate-frequency section.
IF ATTEN Switches	16	Provide attenuation of 15 db in 5 db increments for any given setting of INPUT ATTENUATOR. Should only be used when AMPLITUDE SCALE selector is in LIN or PWR position; when selector is in LOG position, IF ATTEN switches must be set to zero db to avoid inadvertent overloading.
AMPLITUDE SCALE Selector	17	Selects logarithmic voltage-amplitude scale, linear voltage-amplitude scale, or power amplitude scale.
BRILLIANCE Control	18	Adjusts intensity trace.
V POS Control	19	Adjusts vertical position of trace on crt screen.
H POS Control	20	Adjusts horizontal position of trace on crt screen.
FOCUS Control	21	Adjusts sharpness of trace.
MARKERS - FREQUENCY Selector	22	Turns off markers or selects a frequency of 500 kc or 50 kc.
MARKERS - LEVEL Control	23	Adjusts amplitude of markers.
CAL Control	24	Adjusts range of CENTER FREQUENCY control.
FINE Control	25	Used as a fine tuning control for variations on the order of 20 kc or less.
ASTIG Control	(Located on (chassis)	Provides uniform focus throughout the trace.
LINE SIZE Control	(Located on (chassis)	Adjusts horizontal line size.

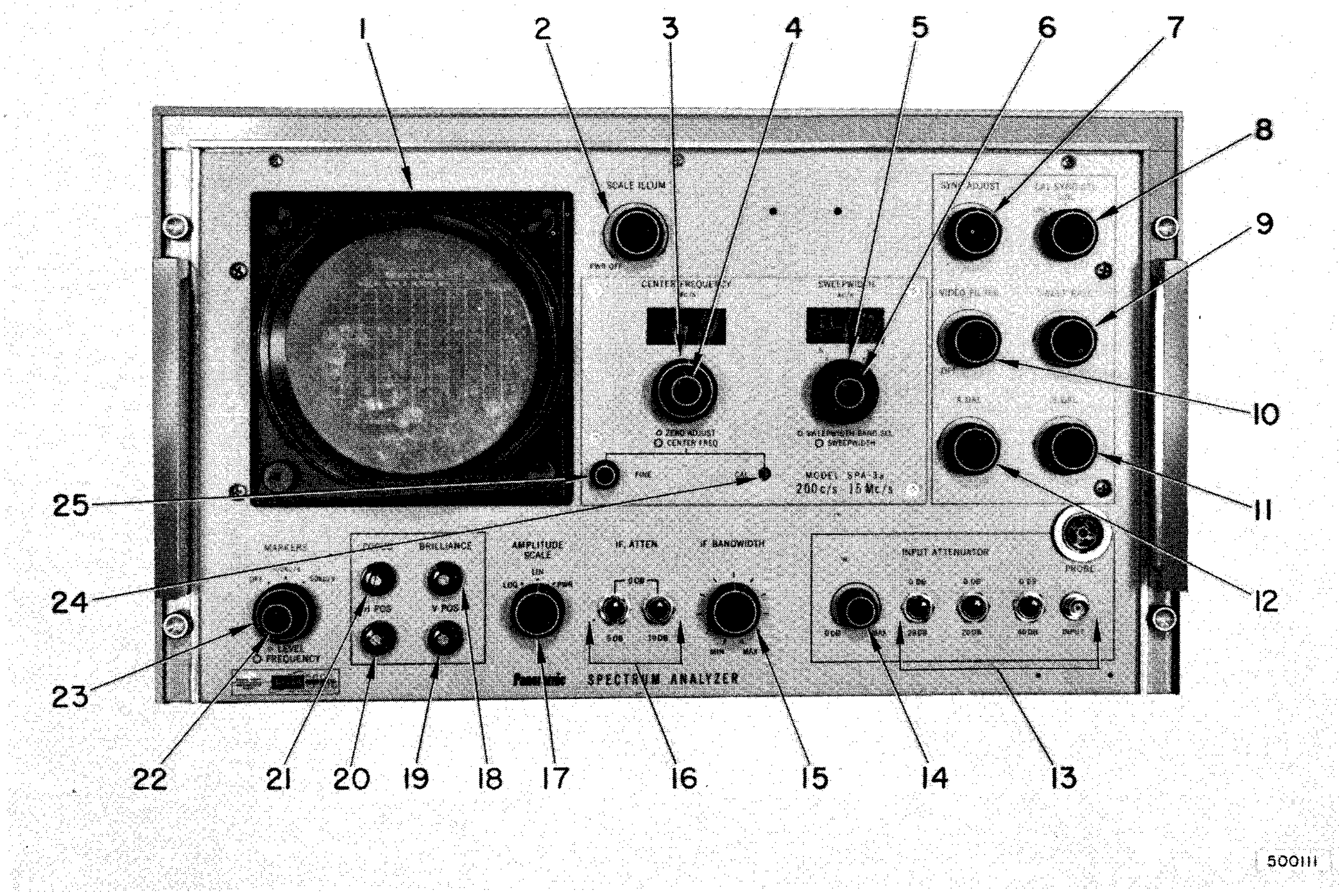


Figure 3-2. Series 2, Operating Controls and Indicators

SERIES 2, OPERATING CONTROLS AND INDICATORS

Control or Indicator	Figure 3-2 Index Number	Function
Crt Screen	1	Provides a visual indication of discrete signals or noise being monitored by spectrum analyzer.
SCALE ILLUM Control	2	Applies power to equipment when rotated clockwise, and is then used to adjust intensity of edge lighting of crt screen.
CENTER FREQ Control	3	Provides a continuously adjustable selection of frequency which appears under zero marker on crt screen.
ZERO ADJUST Control (SPA-3a only)	4	Used to set calibration of CENTER FREQ control and as a tuning control for variations on the order of 200 kc or less.

SERIES 2, OPERATING CONTROLS AND INDICATORS (Cont)

Control or Indicator	Figure 3-2 Index Number	Function
ZERO ADJUST Band Selector Control (SPA-3/25a only)	4	Used to set calibration of CENTER FREQUENCY control and as a tuning control for variations on the order of 200 kc or less; also selects frequency band.
SWEEPWIDTH Control	5	Adjusts width of segment of spectrum to be analyzed; provides any sweep width from 0 to 3 mc in two ranges.
SWEEPWIDTH BAND SEL Switch (SPA-3a only)	6	Selects desired sweep range; 0 to 3 mc in wide position and 0 to 100 kc in narrow position.
SYNC ADJUST Control	7	Adjusts sweep-synchronizing signal to provide for proper crt beam sweep synchronism. Maximum amplitude occurs at fully clockwise position. A free-running sweep is obtained when control is completely counterclockwise.
CAL-SYNC SEL Switch	8	In CAL position, a 60 cps modulation of the vertical amplifier is provided to check sweep rates and synchronization of the sawtooth generator; in LINE position, sweep rate is synchronized with power-line frequency; in EXT position, sweep rate may be synchronized externally.
SWEEP RATE Control	9	Provides continuously adjustable sweep rates between 1 and 60 cps.
VIDEO FILTER Control	10	Provides continuous adjustment of a smoothing filter located at output of detector. Filter is disconnected when control is set to OFF.
S BAL Control	11	Suppresses an internally generated deflection which may appear on crt screen when CENTER FREQUENCY control is at or near zero.
A BAL Control	12	Suppresses an internally generated deflection which may appear on crt screen when CENTER FREQUENCY control is at or near zero.
INPUT ATTENUATOR Step Switches	13	Provides attenuation of 80 db in three increments; 20 db, 20 db, and 40 db.
INPUT ATTENUATOR Variable Control	14	Provides a variable attenuation from 0 to more than 20 db.
IF BANDWIDTH Control	15	Adjusts bandwidth of intermediate-frequency section.
IF ATTEN Switches	16	Provides attenuation of 15 db in 5 db increments for any given setting of INPUT ATTENUATOR. Should only be used when AMPLITUDE SCALE selector is in LIN or PWR position; when selector is in LOG position, IF ATTEN switches must be set to zero db to avoid inadvertent overloading.

SERIES 2, OPERATING CONTROLS AND INDICATORS (Cont)

Control or Indicator	Figure 3-2 Index Number	Function
AMPLITUDE SCALE Selector	17	Selects logarithmic voltage-amplitude scale, linear voltage-amplitude scale, or power amplitude scale.
BRILLIANCE Control	18	Adjusts intensity trace.
V POS Control	19	Adjusts vertical position of trace on crt screen.
H POS Control	20	Adjusts horizontal position of trace on crt screen.
FOCUS Control	21	Adjusts sharpness of trace.
MARKERS - FREQUENCY Selector	22	Turns off markers or selects a frequency of 500 kc or 50 kc and their harmonics.
MARKERS - LEVEL Control	23	Adjusts amplitude of markers.
CAL Control	24	Adjusts range of CENTER FREQ control.
FINE Control	25	Used as a fine tuning control for variations on the order of 20 kc or less.
ASTIG Control	(Located on chassis)	Provides uniform focus throughout the trace.
LINE SIZE Control	(Located on chassis)	Adjusts horizontal line size.

3-5. PRELIMINARY ADJUSTMENTS.

3-6. Preliminary adjustments of the spectrum analyzers should be made with care and exactness each time the equipment is to be used. Before applying primary power, set the controls in accordance with the preliminary control adjustment chart, table 3-1; then proceed with the following steps:

NOTE

Make certain that the shorting plug is securely plugged into the ACCESS EQUIP receptacle at the rear of the spectrum analyzer chassis.

a. Turn power on by rotating the SCALE ILLUM control clockwise. The crt screen edge lighting should go on immediately. Within 30 seconds, a dot should appear on the screen and within a few seconds start to sweep across the screen. If nothing appears on the screen, turn the BRILLIANCE control clockwise. The BRILLIANCE control should be set at a point of suitable visibility and the FOCUS control for the finest clear line. A later adjustment of the FOCUS and BRILLIANCE controls may be required, since the appropriate settings are partially dependent upon the signal density. Do not use the BRILLIANCE control to compete with external light falling on the crt screen but instead reduce the external light or shield the screen.

b. Adjust the A BAL control and/or the S BAL control so that the zero-frequency pip (figure 3-3) is visible. With the Model SPA-3/25a, be sure that the ZERO ADJ - BAND selector is set to LO. This is done by turning selector to extreme counterclockwise position until the switch is actuated. Adjust the selector (concentric with the CENTER FREQUENCY control) so that the zero-frequency pip is at the center of the screen. Then adjust the A BAL control and the S BAL control to minimize the zero-frequency pip.

TABLE 3-1. PRELIMINARY CONTROL ADJUSTMENT CHART

Operating Control	Setting
SWEEPWIDTH Control	3 MC
CENTER FREQ Control	0 MC
IF BANDWIDTH Control	MAX
AMPLITUDE SCALE Selector	LOG
IF ATTEN Switches	0 DB
VIDEO FILTER Control	OFF

c. Set the CENTER FREQUENCY dial to 10 MC. Set the MARKERS - FREQUENCY selector to 500 KC. Adjust the MARKERS - LEVEL control for a convenient height of marker presentation. A 10 mc marker pip should be at or near the center of the screen. Gradually reduce the sweep width to minimum, maintaining the 10 mc pip at the center of the screen with the CENTER FREQUENCY control. Return to 3 mc sweep width and adjust the H POS control until the top of the pip coincides with the center vertical line. (See figure 3-4.)

NOTE

All other operating control settings are dependent upon input signal characteristics and type of measurements to be made.

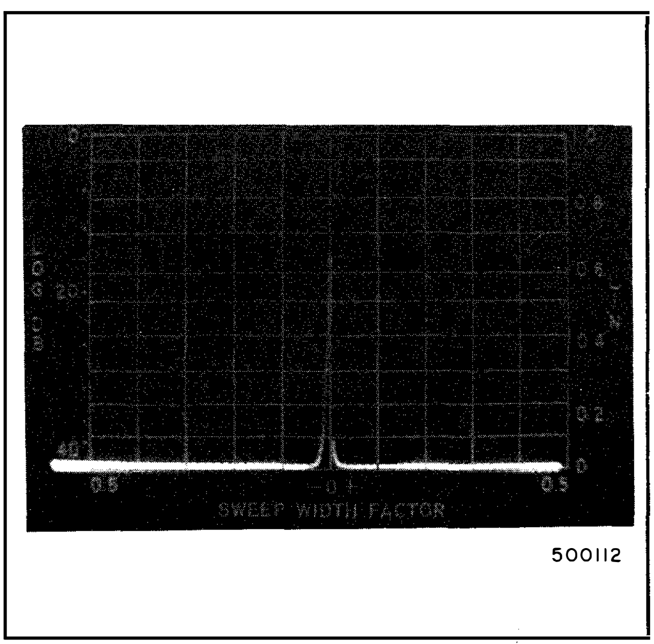


Figure 3-3. Zero-Frequency Pip

3-7. OPERATING PROCEDURES AND INTERPRETATION OF INDICATOR PRESENTATIONS.

3-8. GENERAL. Input signals to the spectrum analyzer can be divided into two types: discrete and non-discrete. Discrete signals are in the form of periodic waveforms with frequency contents which do not vary appreciably with time. The internal markers of the equipment are typical of such a signal. Although there are several frequency components, each frequency is discernible as a separate pip provided that the resolution of the spectrum analyzer is adequate for the frequency differences encountered. In practice, discrete signals are typical of periodic oscillation such as signal generator and oscillator outputs and transducer outputs if a periodic vibration is encountered; for example, constant-speed rotating machinery with a well-defined resonant vibration. Non-discrete signals are typified by a random noise in which the input frequency distribution must be considered as spread out over a band of the spectrum, rather than consisting of line spectra. Random signals vary with time but usually have a definable means (rms) level. Non-discrete signals are shown on the spectrum analyzer as a varying envelope of amplitude at each spectrum sample. Several scans through the noise input signal usually are adequate to establish a meaningful relative amplitude-versus-frequency analysis. The amplitude scales are equally valid for both random and discrete signals. However, the equipment sensitivity for discrete signals is

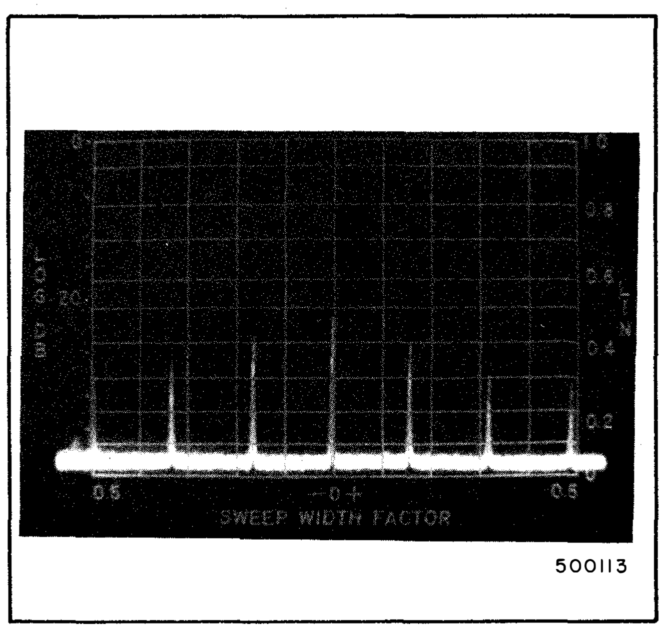


Figure 3-4. Marker Presentation, 3 Mc Sweep Width and 10 Mc Center Frequency

different from that for random signals. Discrete signal levels should be compared to other discrete signal levels and random to other random signal levels when relative signal strengths are being determined. In a generally complex signal where both random and discrete signals are present, the spectrum analyzer will show, on average, the levels of the noise and the levels of the discrete signals correctly. That is, the random and discrete deflections, on average, would not change if one or the other were removed from the input signal. Paragraphs 3-9 through 3-14 provide the operating instructions for discrete signal measurements, paragraphs 3-15 and 3-16 provide instructions for noise analysis, and paragraph 3-17 provides an interpretation of typical crt screen presentations.

3-9. RELATIVE-VOLTAGE MEASUREMENTS OF DISCRETE SIGNALS. Obtain the relative-voltage measurements by performing the following instructions:

a. Set the following controls to the listed positions.

Control	Setting
SWEEP WIDTH Dial	3 MC
CENTER FREQUENCY Dial	0 MC
IF BANDWIDTH Control	MAX
IF ATTEN Switches	0 DB
AMPLITUDE SCALE Selector	LOG
VIDEO FILTER Control	OFF

b. Connect the test signals to the spectrum analyzer. The method of connection depends upon the nature of the signal source.

c. For correct results, the limits on the instantaneous peak voltage of signals connected to the input receptacle must be observed. (Refer to table 3-2.) Failure to limit the level to the indicated voltages may result in incorrect amplitude readings and indications of frequency components which are not present in the input signal. It should be noted, however, that even if large amplitude bursts do occur, if they are of very short time duration they can be ignored. They will cause spurious response for a very brief period of time and thus will not appear on the crt for any significant length of time.

d. When evaluating the input level, it is necessary to measure the total amplitude present at the input, whether related or extraneous, whether in the frequency range of the equipment (200 cps to 15 mc or 200 cps to 25 mc) or outside of the frequency range. The input amplitude should be measured with a broadband, fast-responding, peak-level indicator such as an oscilloscope. If the presence of signals not related to the signals of interest are of sufficient amplitude to overload the equipment, it is advisable to use appropriate filters to eliminate the unrelated signals. In the case of noise analysis (noise being defined as randomly fluctuating signals), unless it is definitely known that the level of signal present above the spectrum of interest is negligible, it is good practice to use a low-pass filter in order to attenuate signals above the spectrum of interest.

NOTE

Amplitude overloading of the input is determined by the instantaneous peak voltage of the input signal. However, in cases in which the peak amplitudes are no greater than 1.4 times the rms amplitude, a broadband true rms voltmeter may be used instead of an oscilloscope.

TABLE 3-2. INPUT SIGNAL INSTANTANEOUS PEAK VOLTAGE CHART

Total Attenuation of INPUT ATTENUATOR step switches and CONTINUOUS control	0 DB	20 DB	40 DB	60 DB	80 DB
Maximum instantaneous peak voltage	300 uv	3 mv	30 mv	0.3 v	3 v
(LOG position of AMPLITUDE SCALE selector may only be used when IF ATTEN switches are set to 0 DB.)					

e. As a rough check for overload, it should be noted that overload can be assumed to occur if, with the AMPLITUDE SCALE selector set to LOG and the IF ATTEN switches set to 0 DB, deflections greater than full scale result. This does not mean that if the deflections are less than full scale, overload is not occurring.

f. With the CENTER FREQUENCY dial set to 0 and the AMPLITUDE SCALE selector set to LOG adjust the A BAL and S BAL for maximum suppression of the zero-frequency pip. It should be noted that it is perfectly normal for the amplitude of the zero-frequency pip to vary with time. If the frequency region being examined is sufficiently removed from zero so that the zero-frequency pip is not on the screen, it is only necessary to be sure that the zero-frequency pip is less than full scale on the LOG scale when the IF ATTEN switches are set to 0 DB. It is good practice to confirm this degree of suppression occasionally. If the equipment is used near enough to zero so that the zero-frequency pip is on the screen, greater care in suppression may be required. If the zero-frequency pip is below full scale on the LOG scale with the IF ATTEN switches set to 0 DB and the signal pips do not tend to ride on the zero-frequency pip, the suppression is satisfactory. If the signal pip amplitudes are being influenced by the zero-frequency pip, adjust the equipment, if possible, to improve the resolving capabilities (reduce the sweep width, reduce the sweep rate, and/or narrow the i-f bandwidth). If improvement of the resolving capabilities does not sufficiently separate the zero-frequency pip from the signal pips, adjust the A BAL and S BAL controls for a suppression of the zero-frequency pip that is sufficient to prevent influence on the amplitude of the signal pips.

g. Adjust the CENTER FREQUENCY dial to bring the desired test signals on the screen. With the Model SPA-3/25a, be sure that the ZERO ADJ - BAND selector is set for the appropriate band. If a closer examination is required, the sweep width may be reduced. The ZERO ADJ - BAND selector (concentric with the CENTER FREQUENCY control) may be used as a fine tuning adjustment. However, this use puts the CENTER FREQUENCY dial out of calibration. The dial may be restored to correct calibration by setting it so that the zero-frequency pip is at the center of the screen when the CENTER FREQUENCY dial is set to 0.

h. The spectrum analyzer can be adjusted to provide any sweep rate from 1 to 60 cps. The spectrum analyzer sweep rate can be adjusted for synchronism to the power line, synchronism to an external signal, or non-synchronism. When the CAL - SYNC SEL switch is set to EXT, the sweep can be synchronized to a suitable signal connected to the EXT SYNC receptacle (on the rear apron of the spectrum analyzer chassis). When the switch is set to LINE, the sweep can be synchronized to the power line. When the SYNC AMP (ADJUST) control is turned completely counterclockwise, the sweep operates without synchronism. The technique of adjusting the sweep rate is given in Section 2.

i. The choice of appropriate sweep rate and mode of sweep synchronism of the spectrum analyzer is determined by the nature of the signals being studied. For example, when the test signals are sporadic in occurrence, it is desirable to operate the equipment at high sweep rates to increase the probability of intercepting the signal. One way to obtain better resolution is to decrease the sweep rate. When examining pulse spectra, increasing the sweep rate will reduce the number of pulse lines per scan. Thus, a high synchronous sweep rate permits determination of the pulse repetition frequency and also permits examination for missing pulse lines. On the other hand, a low sweep rate will increase the number of pulse lines per scan, thus giving better definition to the shape of the spectral distribution envelope. Examination of distributed spectra (for example, random noise) requires low sweep rates to obtain good definition.

j. In most applications, the unsynchronized sweep mode of operation provides more information than does the synchronized mode. However, it is often more convenient for viewing purposes to synchronize the sweep. For example, when examining a signal, unresolved modulations may be revealed as amplitude bobbing of the screen presentation when the sweep is not synchronous with the modulation frequency. Synchronizing the sweep to the modulation frequency will stop the bobbing. When viewing pulsed rf signals, unsynchronized sweep will result in the continuous shifting of the pulse lines across the screen. This results in better definition of the spectral envelope. However, if examination for missing pulsed repetition frequency lines or determination of the pulse repetition frequency is desired, it is more convenient to synchronize the sweep to the pulse, thereby causing a stationary pattern on the crt screen. Note that if the pulse is synchronized to the power line, synchronism is more easily provided by synchronizing the spectrum analyzer to the power line rather than to the pulse.

k. The relative heights of the pip deflections on the crt screen are proportional to the relative amplitudes of the corresponding frequency components being analyzed, within the limits of flatness of response of the spectrum analyzer in the range of 1 kc to 13.5 mc (to 23.5 mc with the Model SPA-3/25a). The specified flatness of response will be applicable only if neither the SWEEP WIDTH nor IF BANDWIDTH controls are changed. Changing the setting of these two controls may change the height of crt deflections. Best accuracy of amplitude ratio measurement is provided by the PWR (power) position of the AMPLITUDE SCALE selector, least accuracy by the LOG position.

NOTE

It is permissible to exceed full-scale pip height to permit examination of low-level signals, provided that the equipment is not overdriven.

l. To observe signals of comparable amplitude, the AMPLITUDE SCALE selector should be set to LIN. The LIN scale of the crt screen is calibrated into ten divisions. The horizontal calibration lines are read at the right side of the screen. Simultaneous examination of signals of wide divergence of amplitude will require the log setting of this switch. In this position, the calibration range is from 0 db to 40 db in 5 db divisions, as indicated by the dots on the left side of the screen. Note that the LOG calibration is not valid when narrow pulses are measured. To convert from voltage to decibels, see figure 3-5. This illustration presents an example using a voltage ratio of 500 mv to 5 mv.

m. To measure power differences directly, use the PWR position of the AMPLITUDE SCALE selector. Adjust the largest pip of interest to full scale. Relative deflections are approximately proportional to the square of the input voltage or power and are read on the linear scale calibration. Should the lower pip measure 1/4 scale, the input voltage ratio is $1:\sqrt{4}$ or 1:2. The power calibration is accurate from 1.0 to 0.25 approximately; therefore, it is limited to a 4:1 full-scale power ratio. Note that the power scale deflection circuit includes a time constant which adversely affects its accuracy at low tracing rates. For example, signal pip at slow sweep rates and narrow sweep widths should not be measured on the power scale.

n. Figure 1-4 indicates the minimum frequency separation required to measure signals of unequal amplitude at various scanning velocities (scanning velocity being the product of sweep width and sweep rate). When there is a large difference in amplitude and the signals are close together, visual beats may interfere with measurement unless properly evaluated. To obtain the measurement, the center of the beat is used. This is illustrated in figure 3-6. The amplitude ratio in a is greater than that in b, resulting in a somewhat different presentation.

o. If noise, beats between adjacent signals, and so on, make observations difficult, the VIDEO FILTER control can be used to suppress such unwanted effects. However, if measurements permit, it is better to keep the control in the OFF position and adjust the equipment for better resolution (refer to paragraph 3-11) to eliminate beats between adjacent signals. Clockwise rotation of the VIDEO FILTER control increases the amount of filtering. Excessive filtering will decrease the amplitude of pips on the screen and worsen resolution. The control, if used, should be adjusted for the clearest picture with minimum loss of amplitude. It should be noted that the control has greatest useful effect at low sweep rates. At high sweep rates, the effect on the signal pips is too great for the control to be helpful. Figure 3-7 shows typical screen presentations obtained when the VIDEO FILTER control is used. In a, a typical case of beating between signals is illustrated; the control is in the OFF position. In b, the control has been adjusted for a clear picture with minimum loss of amplitude. In c, excessive filtering is illustrated; note the loss of amplitude and broadening of the pips.

3-10. FREQUENCY MEASUREMENTS OF DISCRETE SIGNALS. Obtain the frequency measurements by performing the following instructions:

a. Use the same technique for placing the signals to be studied on the crt screen as is given in paragraph 3-9. Since the pip shape is sharper on the LIN and PWR than the LOG position of the AMPLITUDE SCALE selector, the LIN and PWR positions provide better frequency-measurement capabilities than does the LOG position.

b. The CENTER FREQUENCY dial setting indicates the frequency of a pip at the center of the screen. (Refer to paragraph 3-9, step g, for a discussion of the ZERO ADJUST control.) Adding the reading of the SWEEP WIDTH dial times the crt screen sweep width factor calibration point (preserving sign) over which the pip appears to the reading of CENTER FREQUENCY

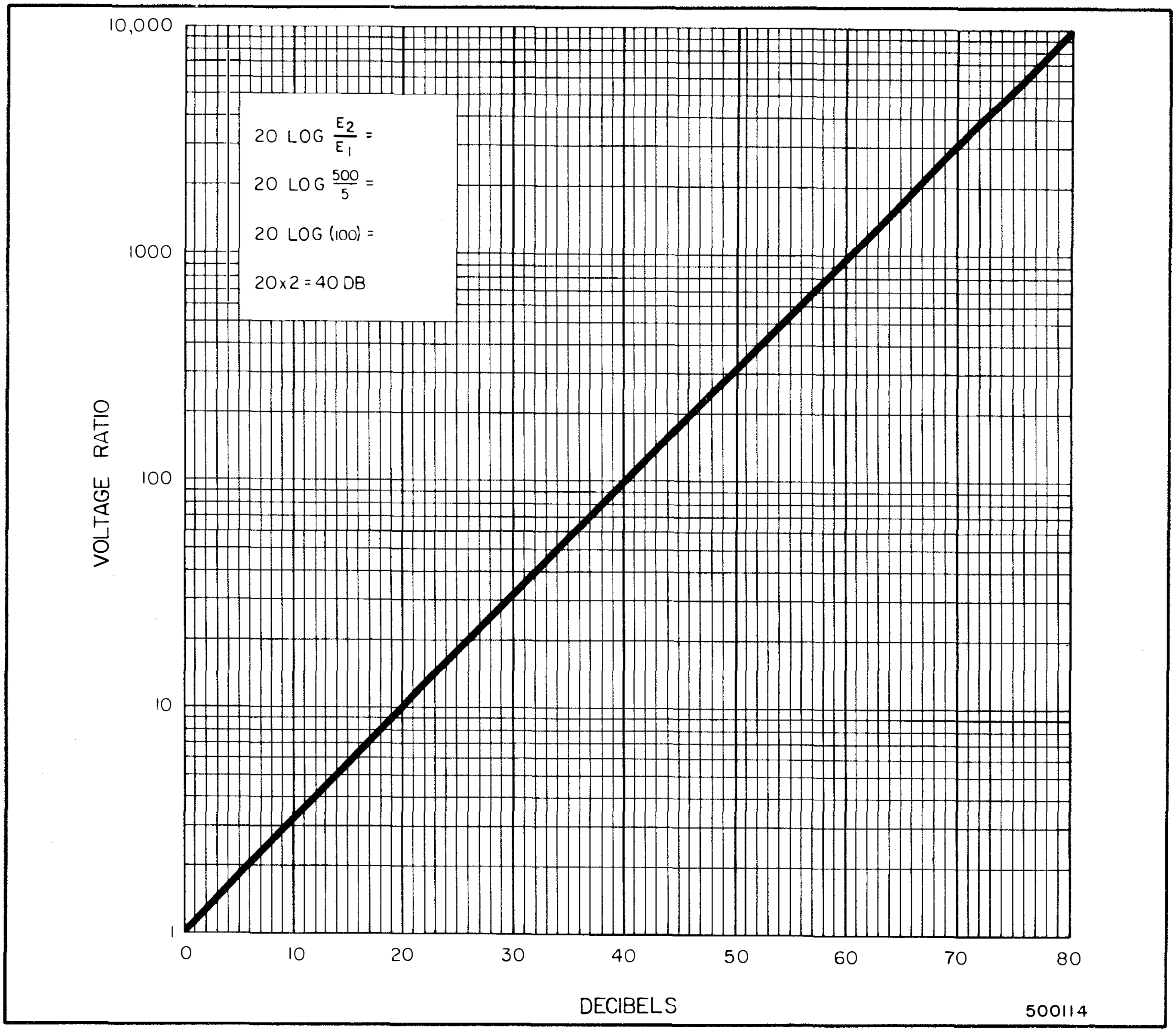


Figure 3-5. Voltage Ratio to Decibel Conversion

dial represents the frequency of the component to which the pip corresponds. For example:

CENTER FREQUENCY Dial Reading = 10 MC
SWEEP WIDTH Dial Reading = 2 MC
Pip appears over -0.2 division on crt screen
Pip Frequency = 10 MC + (2 MC x -0.2) =
= 10 MC -0.4 MC = 9.6 MC

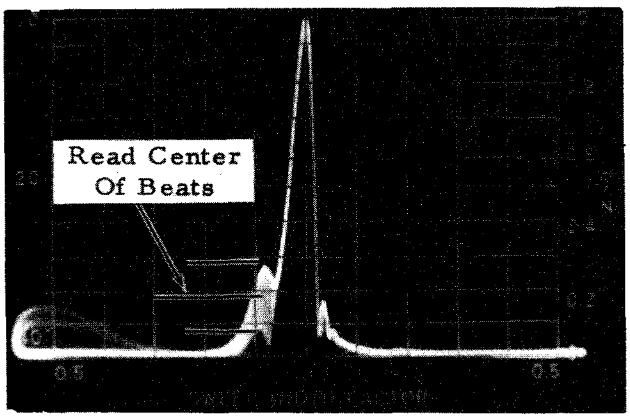
NOTE

The internal frequency markers can be used to obtain more precise determinations of sweep width and center frequency than is possible with the calibrated dials.

c. It should be noted that if frequency measurements of greater accuracy than that permitted by the calibration accuracy of the SWEEP WIDTH and CENTER FREQUENCY dials are required, a signal of known frequency may be connected to the input of the spectrum analyzer to determine the exact location of interesting frequencies. To do this, it is first necessary to remove the signals being measured or to isolate them properly. More conveniently, the Panoramic Signal Alternator, Model SW-1, may be used to alternate the test signal and the calibration signal at the input of the spectrum analyzer, thereby avoiding interference between the two and permitting an exact optical overlay of the two signals.

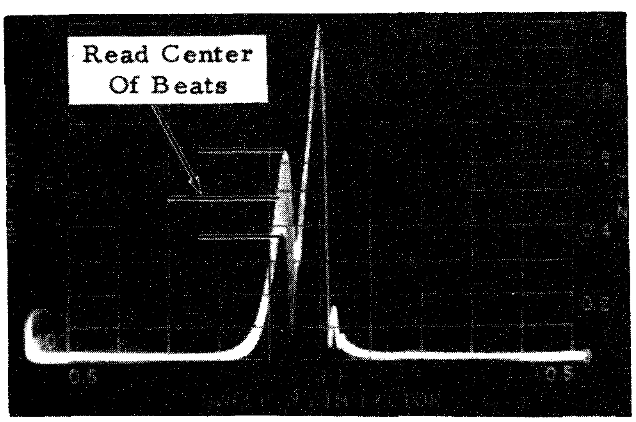
d. If noise, beats between adjacent signals, and so on, make observations difficult, the VIDEO FILTER control can be used to suppress such unwanted effects. The technique of adjusting the VIDEO FILTER control is given in paragraph 3-9, step o.

3-11. MEASUREMENT OF SIGNALS CLOSELY SPACED IN FREQUENCY. At full sweep width, test signals, or a carrier and its sidebands, having a small frequency difference, tend to have their corresponding deflections merge into and mask each other. The ability of the equipment to separate individual signals (resolution) depends upon two factors: the scanning velocity



500115

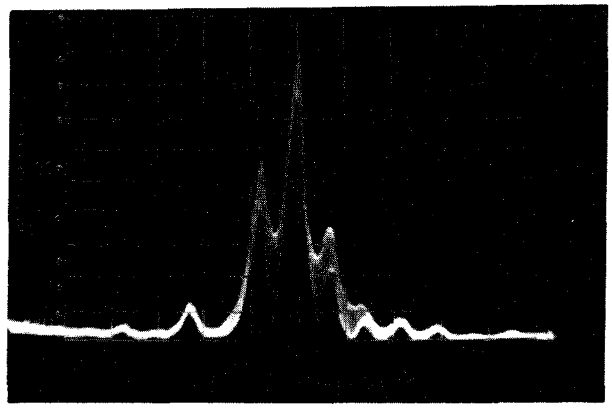
A



500116

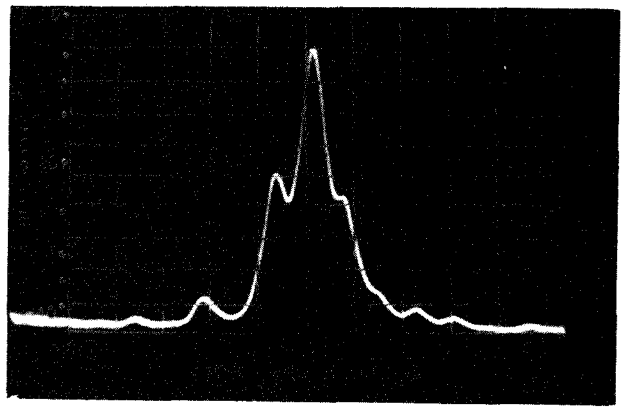
B

Figure 3-6. Measurement of Closely Spaced Unequal Amplitude Signals



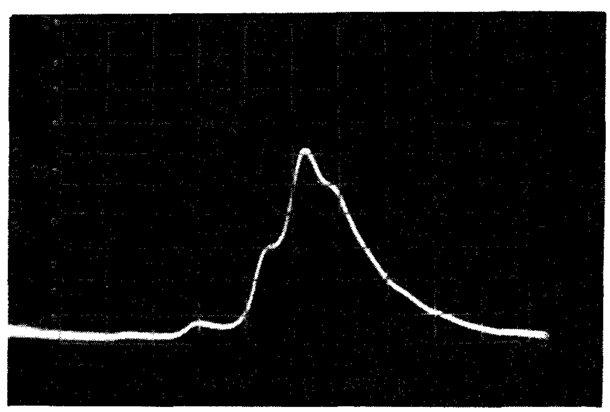
500117

A. Typical presentation.
FILTER in OFF position.



500118

B. Suitable Degree of Filtering.



500119

C. Excessive Filtering.

Figure 3-7. Typical Screen Presentations, Illustrating Adjustment of VIDEO FILTER Control (product of sweep rate and sweep width) and the bandwidth of the intermediate-frequency section of the equipment. For any given scanning velocity, there is a complementary i-f bandwidth for optimum resolution. The scanning velocity is diminished by increasing the sweep period (reducing the sweep rate) and/or decreasing the spectrum width scanned within a given time (reducing the sweep width). Reducing the scanning velocity improves resolution (improves the ability of the equipment to separate closely spaced frequency components).

3-12. The IF BANDWIDTH control is used to adjust the intermediate-frequency-section bandwidth. Counterclockwise rotation of this control narrows the width of the i-f section. It should be noted that, as this control is adjusted, there will be some degree of change in the sensitivity of the equipment. Narrowing the i-f bandwidth improves resolution until the point of optimum resolution. Beyond this point, further narrowing of i-f bandwidth worsens resolution.

3-13. Figure 1-3 indicates resolution versus sweep width for various sweep rates; it should be used as a guide to determine whether or not a given set of signals can be resolved and, if they can, at what control settings. For example, if a given number of equal amplitude sidebands, each a fixed frequency apart, are to be measured, the product of number of sidebands times frequency separation determines the sweep width required. The frequency separation of the sidebands determines the poorest resolution that can be used and still maintain separation of the sidebands. Figure 1-3 can then be used to determine the fastest sweep rate that will provide the necessary resolution at the required sweep width. Figure 1-4 is a graph which indicates the minimum frequency separation that is required to measure amplitude ratios E_2/E_1 at various scanning velocities (scanning velocity being the product of sweep rate and sweep width). If a signal of small amplitude is close in frequency to a signal of large amplitude, the pip of the small signal will be influenced by the presence of the large pip. In effect, the small pip will ride on the skirt of the large pip (the amplitude-versus-frequency response of the intermediate-frequency section being bell-shaped). As the signals are separated in frequency, the error becomes less. The curves in Figure 1-4 indicate the separation required for negligible error at the given scanning velocities.

3-14. To increase the resolution capabilities by reducing sweep width, narrowing the i-f bandwidth, and increasing scanning time, use the following procedure.

a. Set the IF BANDWIDTH control completely clockwise, the position for the broadest i-f bandwidth.

b. Adjust the CENTER FREQUENCY dial so that the desired band of signals is at the center of the screen.

c. Spread the band of signals across the screen by turning the SWEEP WIDTH dial counterclockwise. Note that at reduced sweep width each frequency calibration mark of the screen represents a frequency separation equal to one-tenth of the reduced sweep width.

d. Turn the IF BANDWIDTH control counterclockwise until individual signals are most clearly resolved. If the signals are not resolved, a slower sweep rate will have to be used. Optimum resolution can be recognized by the nature of the ringing pulses that will appear on the trailing edge of the signal pip as optimum resolution is approached. See Figure 3-7 and step e. Ringing can be seen more easily with the VIDEO FILTER control in the OFF position.

NOTE

Rotation of the IF BANDWIDTH control may result in increased or decreased pip height. Pip amplitude may be returned to suitable level with the step switches and CONTINUOUS INPUT ATTENUATOR control. Turning the IF BANDWIDTH control counterclockwise after optimum resolution is reached will decrease the resolving power and result in greatly reduced sensitivity.

e. Maximum resolution can be recognized by the presence of ringing pulses on the trailing edge of the pip.

f. Waveforms a to f of Figure 3-8 indicate progressive variations in pip width effected by counterclockwise rotation of the IF BANDWIDTH control. In a and b the intermediate-frequency bandwidth is broad for particular scanning velocity (product of sweep rate and sweep width). Waveform c shows the beginning of ringing. On the LIN or PWR (power) amplitude scale, with a full-scale or smaller pip, the notch between the signal pip and the ringing pip nearest the signal pip extends into the baseline when the equipment is at optimum resolution. This is illustrated in waveform d. On the LOG amplitude scale, with

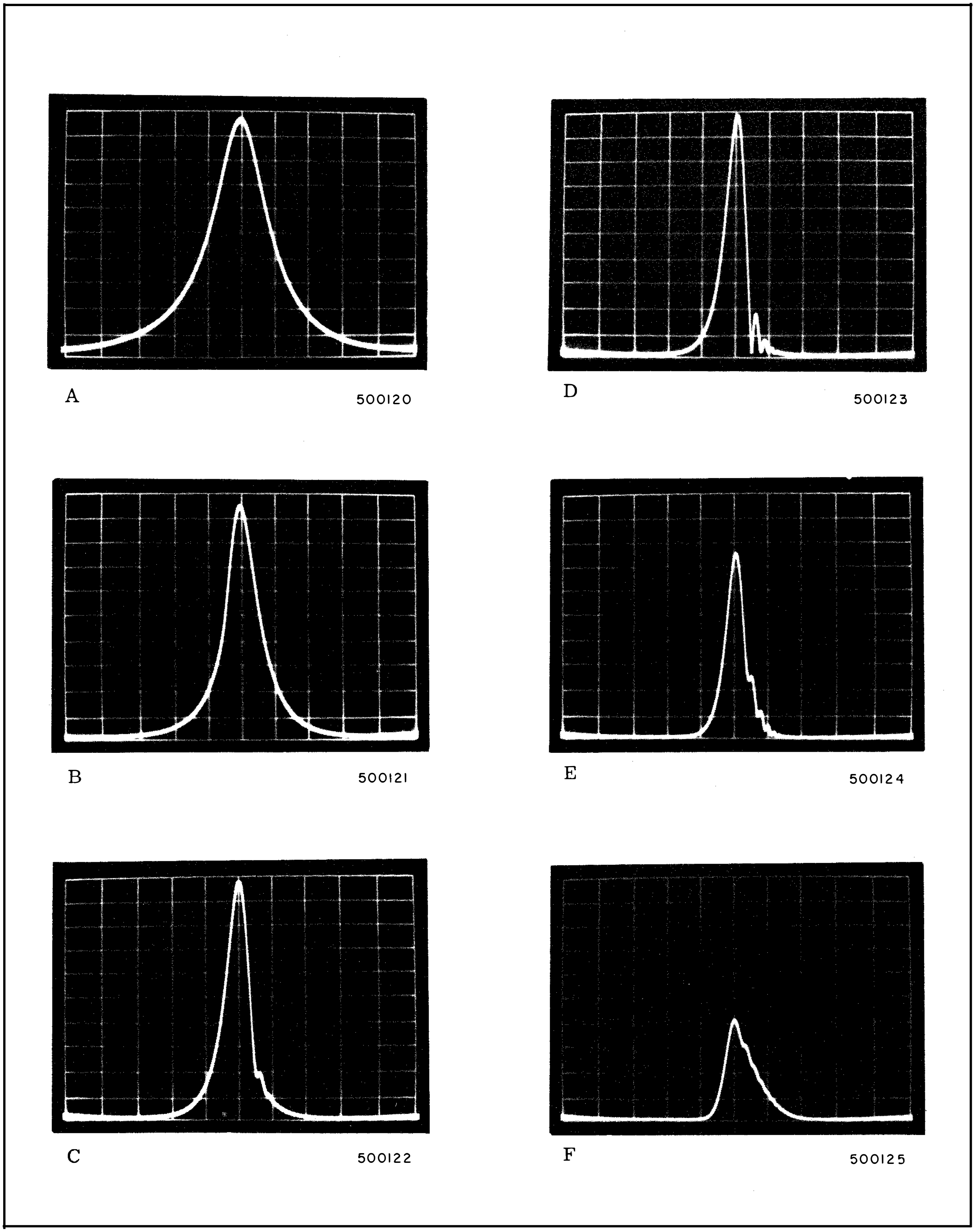


Figure 3-8. Screen Presentations for Different Settings of IF BANDWIDTH Control

a greater than half-scale pip, the notch may not go to the baseline. In this case, optimum resolution is the point at which the notch is nearest the baseline. As the i-f section is made narrower, excessive ringing widens the signal pip and decreases the pip amplitude, thus reducing the resolving power. Further counterclockwise rotation of the IF BANDWIDTH control causes a reduction in amplitude and a tendency of remerging of the pips. This is shown in waveforms e and f.

g. To separate the signals better, the sweep width, i-f bandwidth, and/or sweep rate can be reduced further.

h. If it is mandatory to observe a given sweep width at one time and the signals contained therein are so closely spaced that they cannot be completely resolved, maximum resolution is recognized by the appearance of the clearest picture. Further counterclockwise rotation of the IF BANDWIDTH control will result in lessened resolution and a bobbing presentation. Better resolution can be obtained by looking at a narrower sweep width than that of interest, and then shifting the center frequency to cover the spectrum segment of interest.

3-15. NOISE ANALYSIS. In noise analysis (noise being defined as randomly fluctuating signals), the same general techniques are used for setting the equipment for the spectrum of interest as are used for discrete signals. If the input spectrum is broadband, it is very important to monitor the input level to prevent equipment overload. Refer to paragraph 3-9, step c.

3-16. The following special techniques should be noted:

a. In general, a fairly wide i-f bandwidth is preferred for noise analysis. This permits relatively rapid scans since a wide i-f bandwidth gives better noise envelope averaging than does a narrow i-f bandwidth. However, if the noise source is highly selective (for example, influenced by a structural resonance), an i-f bandwidth which is narrow compared to the bandwidth of the resonance is required. This permits presentation of fine detail of the noise characteristics. When a narrow i-f bandwidth is used, a low sweep rate is necessary for correct amplitude presentation. The appropriateness of the sweep rate can be determined by changing the sweep rate slightly and noting whether or not there is any change in the envelope amplitude. (The portion of envelope having the greatest slope should be watched since the greatest change in envelope will occur here.) The sweep rate should be slow enough so that a small change in sweep rate does not result in an amplitude change. If the sweep rate is at minimum, the sweep width should be reduced and/or the i-f bandwidth increased until it is possible to make a small change in sweep rate without changing the amplitude. Once a sweep which is slow enough to provide correct results has been established, a slower sweep can be set if improved envelope averaging is required.

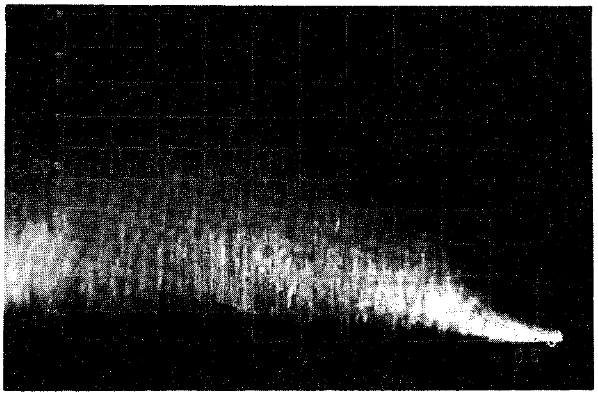
b. In noise analysis, video filtering can be used to obtain averaging of the noise spectrum envelope. It is usually desirable to rotate the VIDEO FILTER control clockwise until a single-line presentation is obtained. The video filtering should not be too great (control too far clockwise) for the setting of i-f bandwidth. This can be checked by changing the sweep rate slightly and noting whether or not there is a change in the steepest portion of the presentation.

c. In a general sense, the i-f bandwidth, VIDEO FILTER control setting, sweep width, and sweep rate should be such that a slight change in sweep rate does not change the slope of the steepest portion of the presentation. If this is not the case, it may be necessary to reduce the sweep rate, sweep width, or video filtering, or to increase the i-f bandwidth.

d. As an alternate to envelope averaging by video filtering, photographic averaging can be used. This is simply a matter of taking a composite photograph of a number of successive scans, thereby obtaining an average presentation.

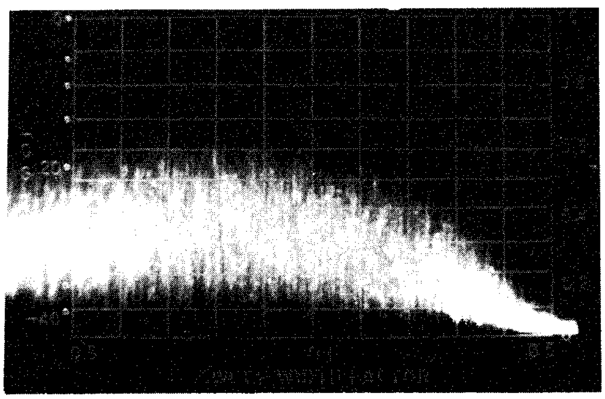
e. The equipment sensitivity listed in Section 1 is applicable only to discrete signals. If absolute noise amplitude measurements are required, a calibration of the spectrum analyzer using a known noise amplitude should be made. Such a calibration must be made at the same scanning velocity (product of sweep width and sweep rate) and i-f bandwidth used for measurement since change in scanning velocity and/or i-f bandwidth changes the amplitude. It is convenient to use the Panoramic Signal Alternator, Model SW-1, to display on alternate scans the calibration presentation and the analysis presentation.

f. Typical screen presentations with different control settings and different photograph exposure times of the same noise spectrum are shown in figure 3-9. To obtain a convenient



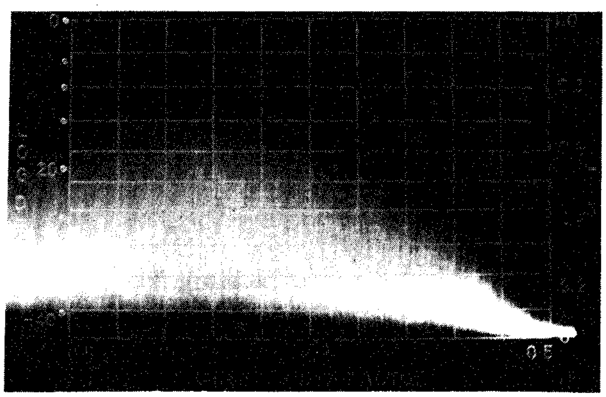
500126

A. LINear Amplitude Scale. Narrow IF Bandwidth. One Scan.



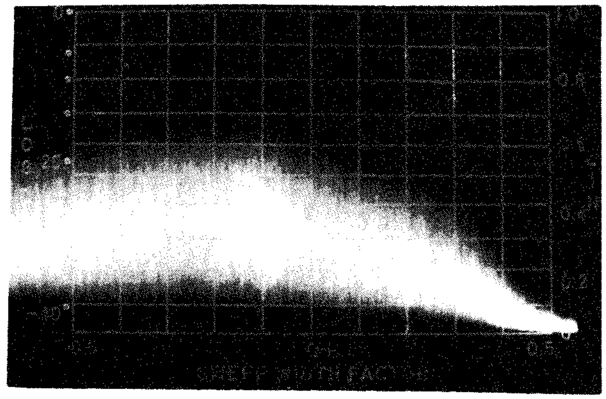
500127

B. Same as "A" on LOGarithmic Amplitude Scale. (Input attenuation adjusted for convenient amplitude presentation.)



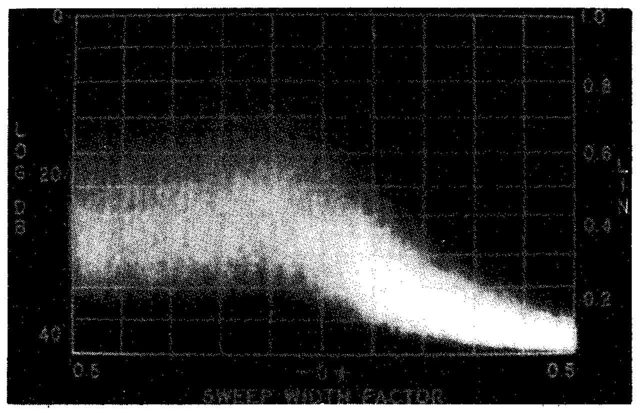
500128

C. Same as "A" with extended photographic exposure.



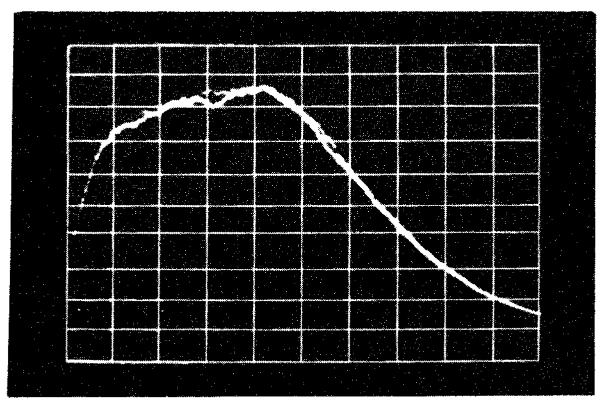
500129

D. Same as "B" with extended photographic exposure.



500130

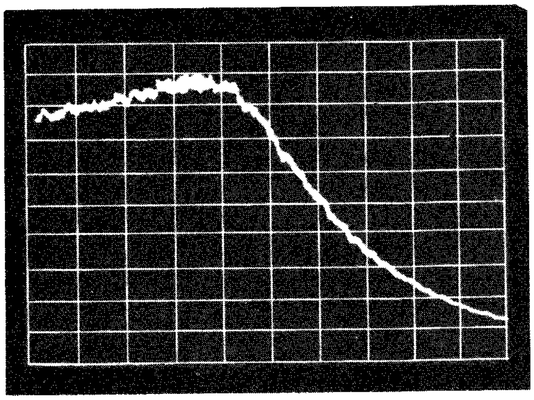
E. LOGarithmic Amplitude Scale. Broad IF Bandwidth. One Scan.



500131

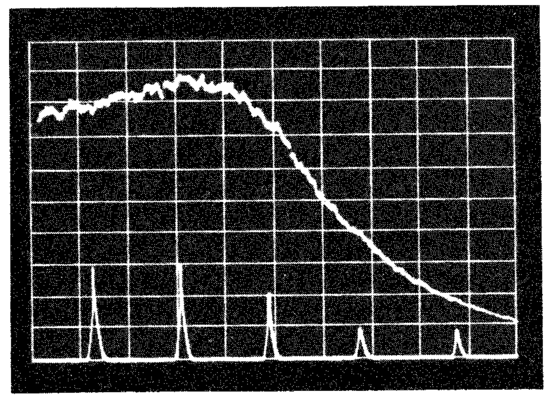
F. Same as "E". Video filtering used to obtain single line presentation. Sweep rate too fast.

Figure 3-9. Typical Screen Presentations for Noise Signals (Sheet 1 of 2)



500132

G. Same as "F" with sweep rate adjusted for correct presentation.



500133

H. Same as "G" with marker presentation used to define frequency points.

Figure 3-9. Typical Screen Presentations for Noise Signals (Sheet 2 of 2)

presentation amplitude, the input level and/or input attenuators have been adjusted as required.

g. In figure 3-9 the i-f bandwidth is narrow. The amplitude scale is linear. Since the scale is linear, the range of amplitude variation is emphasized compared to a logarithmic scale. (See figure 3-9b.) The use of a narrow i-f bandwidth also tends to emphasize the range of amplitude variation. The narrow bandwidth increases the likelihood of the equipment response at any given point being caused by a significantly higher or lower than average noise amplitude. If the i-f bandwidth is wide, it is more likely that the equipment response will be caused by a more typical noise amplitude. The result of using a wide i-f bandwidth and a logarithmic amplitude scale is illustrated in figure 3-9e.

h. Figures 3-9c and d illustrate the use of extended photographic exposure to provide a better averaging of the noise spectra. Figure 3-9c is an extended photograph (many scans) of the spectra photographed for one scan in figure 3-9a while figure 3-9d is an extended photograph of the spectra photographed for one scan in figure 3-9b.

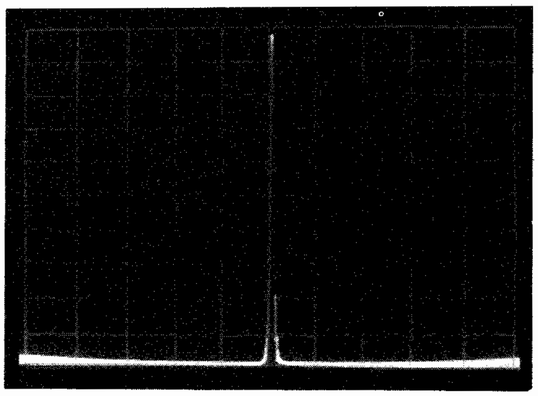
i. The use of video filtering to obtain averaging of the noise spectra is illustrated in figures 3-9f and g. With the equipment settings used for f, a slight change of sweep rate caused a significant change in the presentation, thus indicating the unsuitability of the settings. The sweep rate was reduced until no change in the presentation was noted. This is the correct response and is shown in figure 3-9g.

3-17. INTERPRETATION OF TYPICAL SCREEN PRESENTATIONS. With a little experience, the operator will be able to recognize visually the character of the various types of signals.

a. An unmodulated constant signal appears as a pip of fixed height and fixed horizontal position. Reducing the sweep width widens the pip. See figures 3-10a and b.

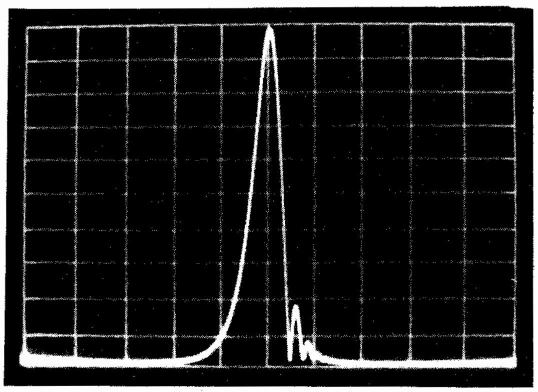
b. Two unmodulated constant signals which are close enough in frequency will appear as a single pip, varying in height as does an amplitude-modulated signal. Reducing the sweep width, reducing the sweep rate, and/or narrowing the i-f bandwidth may result in separation into two distinct pips. See figures 3-10c and d.

c. An amplitude-modulated signal with a modulating frequency which is lower than the resolution capability of the equipment will appear as a deflection of variable height. Non-constant tone modulation of low frequency will produce a series of convolutions varying in height, their number being determined by the modulation frequency. The nature of the presentation will depend upon the sweep width, the sweep rate, and the bandwidth of the intermediate-frequency section.



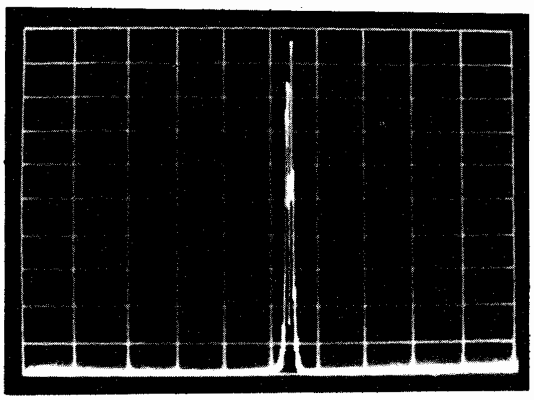
500134

A. Constant carrier signal at approximately maximum sweep width.



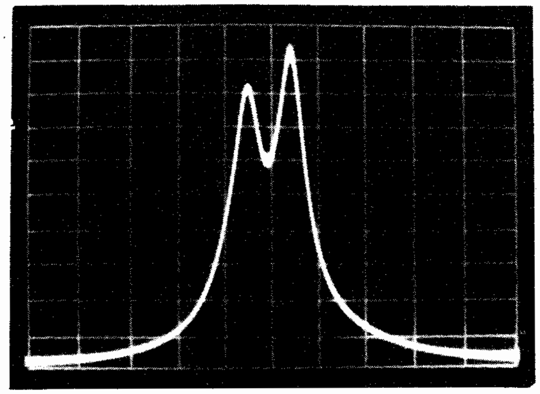
500135

B. Appearance of constant carrier at reduced sweep width.



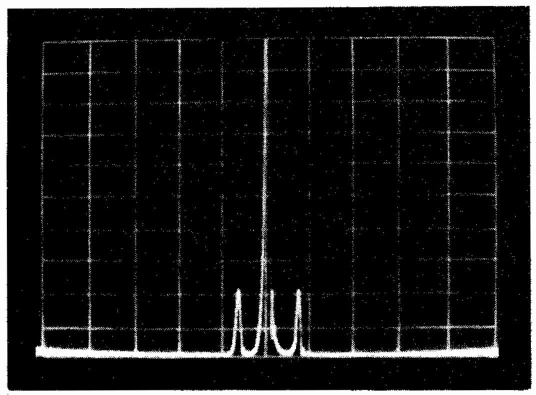
500136

C. Two interfering carriers depicted at maximum sweep width.



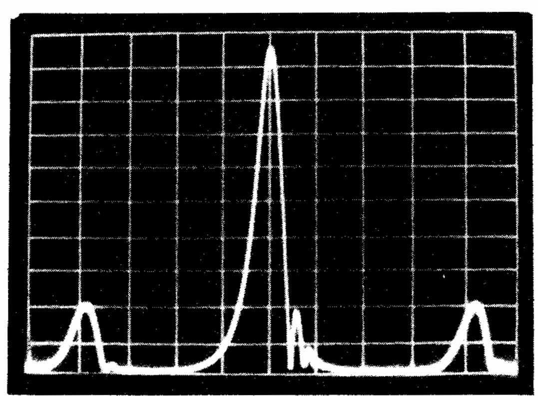
500137

D. Same signals as in "C", sweep width reduced resulting in improved separation (resolution) of signals.



500138

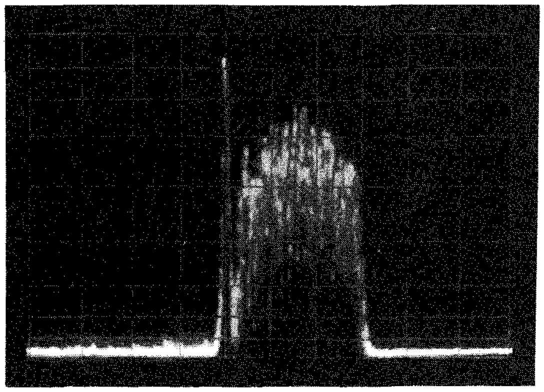
E. Amplitude-modulated signal showing carrier at the center and two sidebands.



500139

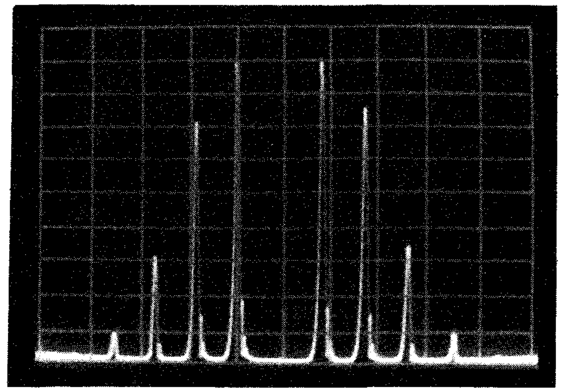
F. Same am signal as in "E" at reduced sweep width. Carrier remains at center of screen.

Figure 3-10. Typical Screen Presentations for Discrete Signals (Sheet 1 of 2)



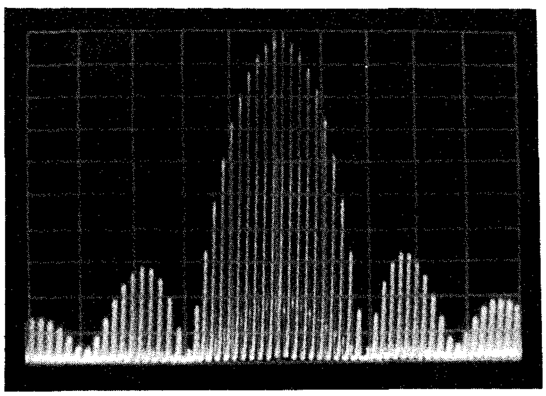
500140

G. Single-sideband signal without carrier suppression.



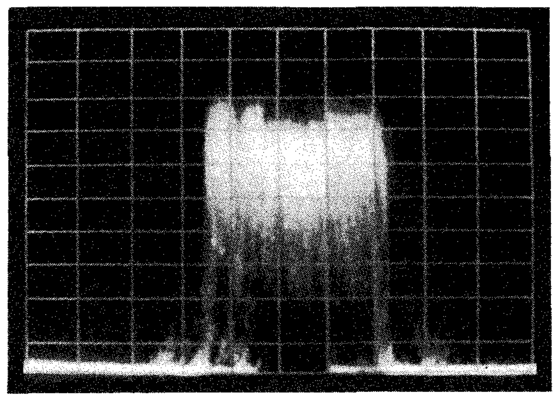
500142

I. Frequency-modulated signal with carrier null.



500141

H. Spikes indicating distribution of a pulsed r-f signal.



500143

J. Typical sideband energy of fm signal, speech modulated. Slow sweep and/or extended exposure photography are used to display envelope averages.

Figure 3-10. Typical Screen Presentations for Discrete Signals (Sheet 2 of 2)

d. As the modulation frequency increases, the convolutions move toward the two sides of the deflection and the sidebands tend to become visible. When the modulation frequency is increased, it becomes possible to separate the sidebands by reducing the sweep width, reducing the sweep rate, and/or narrowing the i-f bandwidth. (See figures 3-10e and f.) The higher the frequency of modulation, the farther away those sidebands will move from the center deflections, representing the carrier. In evaluating the level of the sidebands, the flatness of response of the spectrum analyzer over the band of frequencies involved must be taken into account.

e. A typical screen presentation of an amplitude-modulated single sideband signal without carrier suppression is shown in figure 3-10g.

f. A pulse-modulated signal (figure 3-10h) will consist of a pattern of vertical spikes. The number of spikes is dependent on the pulse repetition rate and the sweep rate of the equipment. The amplitude of each spike represents the amount of energy present at that particular frequency during one of the pulses. The peak envelope of all the spikes represents the energy-distribution pattern of the signal. When analyzing this type of signal, both synchronous and asynchronous displays should be viewed in order to determine the complete pattern.

g. Typical screen presentations of frequency-modulated signals are shown in figure 3-10i and j.

h. Transient disturbances, generally examined, are of two types: periodic and aperiodic transients. Periodic transients, such as produced by motors, vibrators, buzzers, and so forth, appear as signals moving along the frequency-sweep baseline in one direction or another. Thus, an engine which is accelerating will produce a set of deflections which may move first in one direction, slow down, stop and then move in an opposite direction. This is caused by the fact that the analyzer is sweeping at a fixed rate, whereas the transient occurs at a variable rate. The images stand still on the screen when there is synchronism between the two. If the transient disturbance is synchronized with the analyzer horizontal sweep, the "noise" appears as a fixed signal which, however, does not move on the screen when the center frequency is changed, but only varies in height. Such deflections may appear like amplitude-modulated signals or like a steady carrier. Aperiodic transients, such as static, appear as irregular deflections and flash along the entire frequency sweep axis.

i. Diathermy or other apparatus using an unfiltered or ac power supply will produce a periodic disturbance which will cause a deflection to appear only on certain portions of the screen when the analyzer horizontal sweep is synchronized with the power line. This is because such equipment emits a signal pulsating in synchronism with the power line. On the other hand, the analyzer, too, is sweeping the spectrum in synchronism with the line, but at a lower frequency; only when a proper phase relationship exists is it possible for the spectrum analyzer to receive those periodic pulses.

SECTION 4

THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. The spectrum analyzer is a scanning heterodyne instrument which automatically provides a visual, two-dimensional display of the frequency components of a complex wave, in any selected 0 to 3 mc segment of the region between 200 cps and 15 mc (between 200 cps and 25 mc with Model SPA-3/25a). The display appears on the screen of a long-persistence, flat-faced, cathode-ray tube, as vertical deflections distributed horizontally in order of component frequency. The frequency presentation is linear. The height of a given vertical deflection indicates the relative magnitude of its corresponding frequency component. (See figure 4-1 for a block diagram of the spectrum analyzer.)

4-3. The spectrum analyzer consists basically of a calibrated input attenuator, an input cascode amplifier, a wide-band amplifier, a phase splitter, a sweeping oscillator, a balanced mixer, an intermediate-frequency-section attenuator, a 32 mc i-f amplifier, a 29.3 mc crystal oscillator, a second mixer, variably selective intermediate-frequency amplifiers (2.7 mc), a detector, vertical and horizontal deflection amplifiers, a sweep generator, and a cathode-ray-tube indicator.

4-4. In the balance mixer, the sweeping oscillator signal progressively heterodynes, in order of frequency, with those signals at the output of the phase splitter. Oscillator signal and even-order modulation products are balanced out in the mixer, leaving only the input signal and sum and difference terms of the input and oscillator frequencies. Whenever the difference frequency is 32 mc, it is passed by the sharply tuned 32 mc intermediate-frequency section. The output of the 32 mc i-f section is mixed with the output of the 29.3 mc crystal oscillator.

4-5. The 2.7 mc product of this mixing passes through a 2.7 mc variably selective i-f section. The output voltage of the 2.7 mc i-f section is proportional to the amplitude of the sampled portion of the input signal. This output is detected, amplified, and applied to the vertical deflection plates of the cathode-ray tube. The vertical deflection appears at a definite location along the horizontal axis according to signal frequency, since a common sawtooth voltage source is used for both the sweeping oscillator and the horizontal deflection of the crt beam.

4-6. Oscillator sweep is obtained with a sawtooth-modulated circuit (consisting basically of a current-controlled tuning inductor) which controls the frequency of the swept oscillation. A calibrated SWEEP WIDTH control varies the amplitude of the modulating sawtooth signal to permit selection of any sweep width from 0 to 3 mc. A calibrated CENTER FREQUENCY control capacitively tunes the swept oscillator to permit selection of any center frequency between 0 and 13.5 mc (0 and 23.5 mc in the case of Model SPA-3/25a).

4-7. CIRCUIT DESCRIPTION, MODELS SPA-3a AND SPA-3/25a, ANALYZER SECTION.

4-8. INPUT CIRCUIT.

4-9. The input circuit consists of an INPUT ATTENUATOR, an input cascode amplifier (V101), a wide-band input amplifier (V102), and a phase splitter (V103).

4-10. The INPUT ATTENUATOR has two separate functions. A step function of 80 db attenuation in 20 db increments is provided by switches S501, S503, and S505. Input attenuation is provided by varying CONTINUOUS control (R521). This control has a range of at least 20 db.

4-11. An input signal is directly connected to the INPUT connector (J501) if the signal is derived from a 72-ohm source. If the signal is derived from other than a 72-ohm source, matching pads are required, or the signal may be connected to the INPUT connector through a cathode-follower probe. (Refer to Section 6.)

4-12. The signal at the INPUT connector passes through the step INPUT ATTENUATOR switches and through the CONTINUOUS ATTENUATOR control to the grid of V101B, part of the input cascode amplifier.

4-13. The output of the cascode amplifier is connected to the wide band amplifier (V102) which is connected to the phase splitter. Two outputs approximately 180 degrees out of phase are produced by the phase splitter. These outputs are coupled to the control grids of V104 and V105.

4-14. Shunt peaking networks in the plates of V101, V102, and V103 improve the high-frequency amplitude response of the input circuit.

4-15. FREQUENCY MARKERS.

4-16. The frequency markers consist of a 50 kc and a 500 kc signal and their harmonics. The 500 kc signal is generated by the crystal oscillator (V124). The 50 kc oscillator (V115A) is locked to the 500 kc crystal oscillator. Both oscillator outputs are coupled to a diode-connected tube (V115B) in order to produce rich harmonics.

4-17. The MARKER LEVEL control (R337) forms the cathode resistor of the harmonic generator. The marker output is coupled to the grid of one section of the input cascode amplifier (V101).

4-18. SWEEPING OSCILLATOR.

4-19. The sweeping oscillator (V118) is a tuned-plate, push-pull oscillator. The frequency discriminatory circuit of the oscillator consists basically of the secondary of a voltage-controlled tuning inductor (L127) and the CENTER FREQUENCY control (a dual tuning capacitor, C265 A, B).

4-20. The inductance of the secondary of the current-controlled tuning inductor depends upon the current applied to its primary. A linear sawtooth is applied to the primary. The inductance of the secondary varies with this sawtooth current, thus changing linearly from one inductance value to another inductance value and then snapping back to the original value. Thus the frequency of the oscillator changes linearly from one frequency to another frequency and then snaps back to the original frequency.

4-21. The sawtooth drive to the tuning inductor is derived from the sawtooth generator (V121). The maximum amplitude of sawtooth signal available to the tuning inductor, and thus the maximum sweep width of the instrument, is determined by the setting of the SWEEP LIMIT control (R421). Changing the setting of the front-panel SWEEP WIDTH control (R349) changes the amplitude of the sawtooth current drive to the tuning inductor. This varies the extent of inductance change and controls the extent of oscillator-frequency change. The sawtooth voltage output from the SWEEP WIDTH control is amplified by a sawtooth amplifier (V117) and then connected to the tuning inductor. The mid-frequency of the oscillator is changed by changing the setting of the front-panel CENTER FREQUENCY control, a dual capacitor, which is part of the frequency discriminatory circuit of the oscillator. A variable capacitor (C267), in parallel with one section of the CENTER FREQUENCY control, serves as a means for calibrating the center frequency dial and also can be used as a tuning control for variations on the order of 200 kc or less.

4-22. As the center frequency is increased, the inductance change of the tuning indicator required for any particular fixed sweep width becomes less. A SWEEP WIDTH TRACK variable resistor (R345), mechanically linked to the CENTER FREQUENCY control, reduces the sawtooth current drive to the tuning inductor as the center frequency is increased. This maintains a nominally constant sweep width as center frequency is changed.

4-23. Model SPA-3a has a Wide and Narrow SWEEP WIDTH range selector. In the Narrow range position, L128 is switched across the signal winding of L127. This parallel combination is placed in series with L129. The change in inductance of the tuning inductor (maintaining a constant sweep width voltage) now causes a much smaller change in the total circuit inductance. The center-frequency range of the sweeping oscillator in the Narrow range position is set by means of L129 and C264. Variable inductance L129 is used to set the zero-frequency end of the CENTER FREQUENCY dial. The OSC trimmer (C264) is used to set the high end of the dial. In the W (wide) position the CAL trimmer is used to set the high frequency end of the dial.

4-24. The center-frequency range of the sweeping oscillator (SPA-3/25a only) is set by means of L129 and C263 (the CAL trimmer). Variable inductance L129 is used to set the zero-frequency end of the CENTER FREQUENCY dial. The CAL trimmer is used to set the high-frequency end of the dial on the LO BAND of Model SPA-3/25a.

4-25. The temperature stability of the inductance of the current-controlled tuning inductor

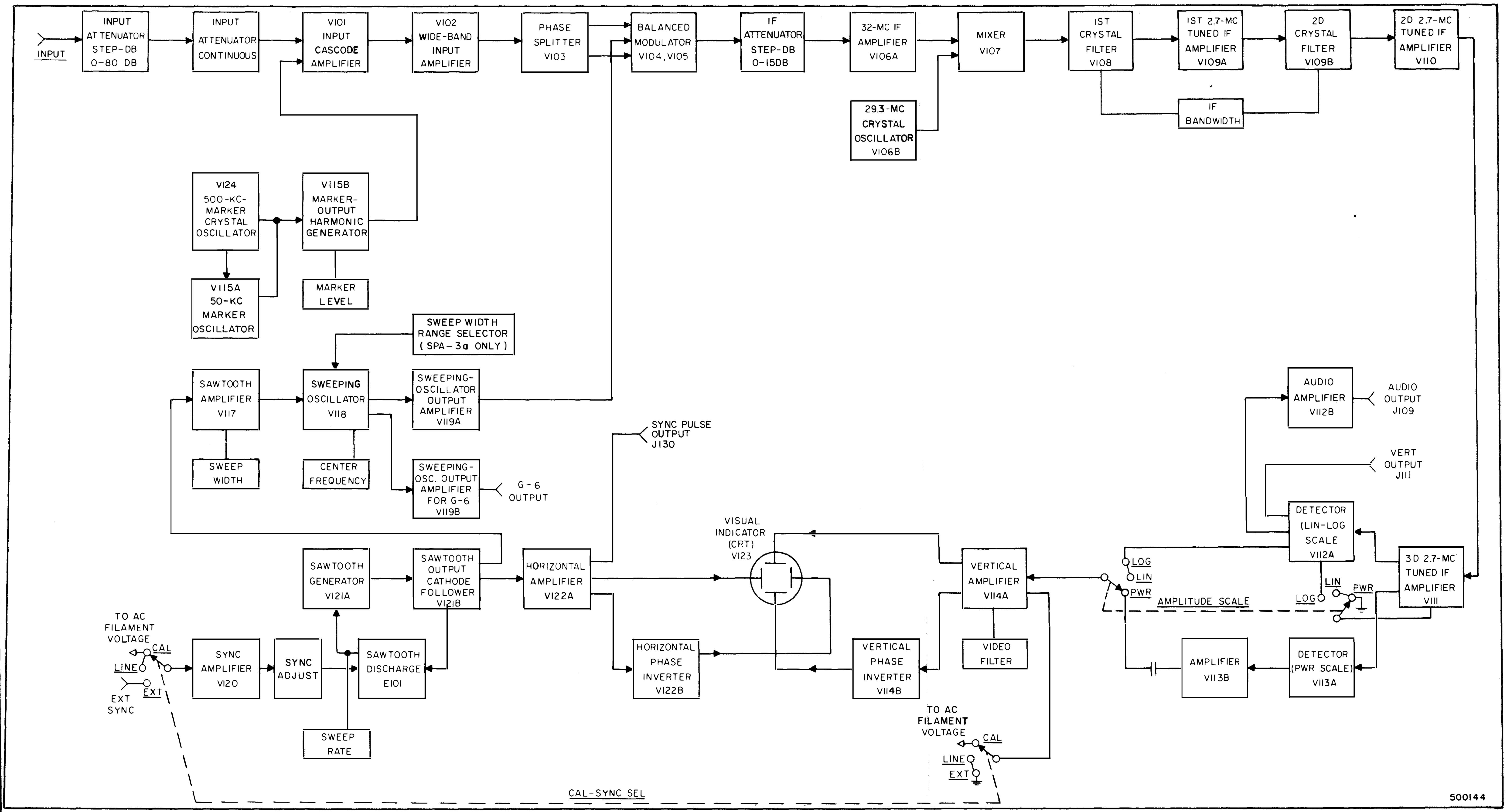


Figure 4-1. Block Diagram, Analyzer Section

depends upon the current flow through the inductor. The BIAS control (R353) is used to set the center-frequency current flow for minimum inductance-versus-temperature drift, thereby minimizing the center frequency-versus-temperature drift of the sweeping oscillator.

4-26. Output from the sweeping oscillator is coupled to the control grids of two oscillator output amplifiers (V119A, V119B). The output from V119A is coupled to the common cathode of the balanced modulator. The output from V119B is coupled to the G-6 OUTPUT connector which is located on the rear of the chassis. This connector provides the source of sweeping oscillator signal necessary to drive the auxiliary Companion Sweep Generator Model G-6.

4-27. To provide a stable B+ voltage for sawtooth amplifier V117, a zener diode (CR103) is used.

4-28. In Model SPA-3/25a, switch S106 (the BAND selector switch) selects parameters appropriate to the two center-frequency bands.

4-29. BALANCED MODULATOR.

4-30. The two out-of-phase outputs from V103A and V103B (the phase splitter) are coupled to the control grids of V104 and V105 (the balanced modulator), respectively. The sweeping oscillator signal is coupled to the common cathode of the two balanced-modulator tubes.

4-31. Sum and difference products of the mixing of the input signals with the sweeping oscillator signal, as well as the input signals themselves, appear at the output of the balanced modulator. The sweeping oscillator signal balances out in the output circuit of the balanced modulator. To compensate for any imbalance of the balanced modulator tubes and circuitry, three controls are employed to maximize the cancellation of the sweeping oscillator signal. The front-panel controls, A BAL and S BAL, have a differential effect on the output of the balanced modulator: A BAL by changing differentially the plate load of the balanced-modulator tubes and S BAL by changing differentially the screen voltages and thus the gain of the balanced-modulator tubes. Variable capacitor C131, located on the chassis, is used to obtain suitable phase balance between the outputs of the two sections of the balanced modulator.

4-32. 32 MC INTERMEDIATE-FREQUENCY SECTION, 29.3 MC CRYSTAL OSCILLATOR, AND MIXER.

4-33. The 32 mc i-f section consists of three 32 mc bandpass filters (T101, T102, and T103). An IF ATTEN with a step function of 15 db of attenuation in 5 db increments is provided by switches S102 and S109.

4-34. The balanced modulator output is connected to an intermediate-frequency section which is tuned sharply to 32 mc. Each time a 32 mc mixing product is produced in the balanced modulator, a pulse will pass through the 32 mc i-f section. This pulse corresponds to a particular input signal. All other frequencies are attenuated greatly. The front-panel IF ATTEN switches permit the selection of 0 db to 15 db of attenuation of the pulse which in effect is 0 db to 15 db of additional attenuation of the input signal. The IF GAIN chassis control in the cathode of V106A permits adjusting the gain of this 32 mc i-f amplifier to set the input sensitivity of the analyzer.

4-35. The output from the 32 mc i-f section is mixed with the 29.3 mc crystal-controlled oscillator in V107. This mixer output consists of 2.7 mc and other outputs. They are fed to the input bandpass filter (T104) of the 2.7 mc variably selective i-f section.

4-36. 2.7 MC VARIABLY SELECTIVE INTERMEDIATE-FREQUENCY SECTION.

4-37. The 2.7 mc variably selective i-f section consists of a 2.7 mc bandpass filter (T104), a first 2.7 mc crystal filter stage (V108, Y102), a first 2.7 mc tuned amplifier (V109A), a second 2.7 mc crystal filter stage (V109B, Y103), a second 2.7 mc tuned i-f amplifier (V110, T105), and a third 2.7 mc tuned i-f amplifier (V111, T106).

4-38. The input to the 2.7 mc i-f section is a bandpass filter tuned to 2.7 mc which passes 2.7 mc products appearing at the output of mixer V107 and greatly attenuates all other frequencies. The i-f signal passes through the five-stage i-f section (V108, V109A, V109B, V110, V111) which includes two identical 2.7 mc crystal filters (Y102, Y103). Associated with each crystal filter is an LC tuned circuit (C169, L111; C189, L117) and associated with each tuned circuit is one section of a dual potentiometer (R225A, R228B) which is the front-panel IF BANDWIDTH control. The bandwidth of the i-f section is determined by the bandwidth of the two combinations of tuned circuit and crystal filter. The bandwidth of the tuned circuits is determined by the setting of the IF BANDWIDTH control.

4-39. The frequency resolution, or ability to separate individual frequency components, is a function of the scanning velocity (frequency scanned per unit time) and the bandwidth of the intermediate-frequency stages.

4-40. The presence of "ringing" on the trailing edge of the pip indicates that the equipment is close to or at optimum resolution. Assuming a fixed scanning velocity, the illustrations in Figure 3-8 show the changes in the screen presentation of a single frequency input when the i-f bandwidth is made progressively narrower.

4-41. In waveforms a and b of Figure 3-8, the i-f bandwidth is broad for the particular scanning velocity. Waveform c shows the beginning of "ringing". The extent of "ringing" in waveform d indicates optimum resolution. Note that the "ringing" pip closest to the signal pip extends to the baseline. As the i-f section is made narrower, excessive "ringing" widens the pip and the signal pip amplitude decreases.

4-42. The output from the last 2.7 mc tuned i-f amplifier (V111, T106) is connected to the detector (V112) and the PWR detector (V113A).

4-43. In the LOG position of the AMPLITUDE SCALE selector switch, section S103A connects the output from the lin-log detector through the secondary of T105 to the grid of V111. This negative feedback, the amplitude of which is determined by the setting of the 0 DB LOG ADJ control (R279), causes the effective output of V111 to vary logarithmically with signal input. In the LIN and PWR (power) positions, the point of connection of the feedback voltage is grounded, and the output of V111 is linearly proportional to signal input. Section S103B of the AMPLITUDE SCALE selector switch changes the cathode bias and screen voltage of V111, and thus the gain, appropriate for the amplitude scale selected. In the LOG position of AMPLITUDE SCALE selector switch, the 20 DB LOG ADJ control (R261) is used to adjust the cathode bias and screen voltage of V111 (and thus the gain of V111) so that a full-scale deflection on LIN and PWR (power) appears at the 20 db crt calibration point on the LOG position. The 20 DB LOG ADJ control sets the feedback amplitude for a 20 db difference in amplitude between a pip of 0 db deflection and a pip of 20 db deflection on the crt screen.

4-44. DETECTORS.

4-45. The 2.7 mc output from the i-f section is connected to the lin-log detector (V112), for the linear logarithmic amplitude scale. The detector is a triode whose plate and grid are connected to form a diode. The output from the detector is connected to section S103C of the AMPLITUDE SCALE selector switch.

4-46. The 2.7 mc output from the i-f section is also connected to the grid of V113A, the square-law detector for the PWR (power) amplitude scale.

4-47. The output from the square-law detector passes through an amplifier (V113B) to section S103C of the AMPLITUDE SCALE selector switch.

4-48. Switch selector S103C determines whether output from the lin-log detector or the output from the square-law detector is connected to the grid of the vertical amplifier (V114A).

4-49. The output from the lin-log detector is connected through the audio amplifier (V112B) to the AUDIO OUTPUT connector. This output connector permits aural monitoring when the equipment is set for zero sweep width.

4-50. VERTICAL PUSH-PULL AMPLIFIER.

4-51. The output from either the lin-log detector or the amplified output from the square-law detector (selected by section S103C of the AMPLITUDE SCALE selector switch) is connected to the grid of the vertical amplifier (V114A).

4-52. An RC video filter is connected to the grid of the vertical amplifier. The resistive element of the filter is VIDEO FILTER control (R307). A switch (part of the VIDEO FILTER control) permits disconnection of the video filter from the circuit.

4-53. Output from the vertical amplifier is directly coupled to one vertical deflection plate of the cathode-ray tube and is connected to the vertical phase inverter and amplifier (V114B).

4-54. The output from the phase inverter (which is 180 degrees out of phase with the output from the vertical amplifier) is directly coupled to the other vertical deflection plate of the cathode-ray tube. The setting of the V POS control (R325) determines the cathode voltage and thus the plate voltage of V114B. This determines the vertical position of the crt beam.

4-55. In the CAL position of the CAL - SYNC SEL switch, switch section S105B connects heater voltage into the cathode circuit of the vertical phase inverter. This permits calibration of the sweep rate.

4-56. SAWTOOTH GENERATOR.

4-57. The sawtooth sweep voltage is derived from the sawtooth generator and sawtooth output cathode follower (V121) and E101 (an NE16 neon lamp). The pentode section of V121 acts as a Miller sweep generator. Resistors R401A (one section of the SWEEP RATE control) and R399 and capacitor C289 in the grid circuit provide a time constant which controls the negative-going voltage on the grid. This change in grid voltage is amplified in the pentode section and is fed back 180 degrees out of phase through the triode cathode-follower section of the same tube. This amplified positive-going voltage tends to slow down the rate of negative change of the grid of the pentode section. This results in a linear, positive sawtooth voltage at the output of the cathode follower. When this voltage reaches a predetermined amplitude, E101 conducts, restoring the grid of the pentode section of V121 to its initial condition. (The conduction time for E101 is the retrace time of the sawtooth.)

4-58. R401B (the other section of the SWEEP RATE control), which is in the crt negative voltage bleeder string, determines the level of the negative-going voltage applied to the grid of the pentode section of V121. This negative-going voltage determines the amplification of the pentode section of V121 which in effect amplifies the time constant.

4-59. When the negative grid bias voltage of the pentode section of V121 is at a minimum, the amplification of the time constant will be the greatest. At the same time, the second section of the dual potentiometer is at greatest resistance or highest time constant. Rotation of the SWEEP RATE control in a clockwise direction results in a higher sweep rate; in the fully clockwise position, the sweep rate is approximately 60 cps; in the fully counterclockwise position, the sweep rate is approximately 1 cps.

4-60. To synchronize the sawtooth generator, the differentiated output from the sync amplifier is connected through the SYNC AMP control (SYNC ADJUST control in Series 2 units) to the conductive coating of E101.

4-61. The electrostatic effect of voltage pulses appearing on this coating will change the voltage required to cause E101 (the sawtooth discharge tube) to conduct. A pilot lamp (DS101) is located adjacent to E101. The function of DS101 is to maintain a constant ionization level in E101 by photoelectric effect, thereby maintaining a constant conducting voltage. (If DS101 is not lit, erratic operation of the sweep circuit may occur.)

4-62. In the CAL or LINE position of the CAL - SYNC SEL switch, switch section S105A connects ac heater voltage to the grid of the sync amplifier (V120), thereby synchronizing the sawtooth generator to the power line.

4-63. The EXT position of the CAL - SYNC SEL switch permits synchronization with external voltages which may be connected to the EXT SYNC connector (J125).

4-64. Turning the SYNC AMP (ADJUST) control completely counterclockwise removes synchronizing voltage from E101, allowing the sawtooth generator to be free running.

4-65. The output from the sawtooth generator is connected to both the sweeping oscillator (refer to paragraph 4-21) and the horizontal push-pull amplifier.

4-66. To provide a sawtooth voltage of zero average dc level, a negative voltage, whose level is determined by the setting of the CF BAL control (R411), is connected at the output of the sawtooth generator to cancel the normally positive average dc level of sawtooth output. This permits correct baseline centering.

4-67. HORIZONTAL PUSH-PULL AMPLIFIER.

4-68. Sawtooth voltage derived from V121B is connected to the grid of the horizontal amplifier (V122A). Output from the horizontal amplifier is directly coupled to one horizontal deflection plate of the cathode-ray tube. The setting of the H POS control (R431) determines the cathode bias and thus the plate voltage of V122A. This determines the horizontal position of the crt beam.

4-69. Output from the horizontal amplifier is also connected to the horizontal phase inverter and amplifier (V122B). The output from the phase inverter (which is 180 degrees out of phase with the output from the horizontal amplifier) is directly coupled to the other horizontal deflection plate of the cathode-ray tube.

4-70. The LINE SIZE control (R415) determines the level of sawtooth connected to the horizontal amplifier and thus the extent of the horizontal deflection of the crt beam. When an external sweep source is used, the EXT LINE SIZE control (R417) is adjusted so that the same baseline length is obtained with either the internal sawtooth generator or the external sweep voltage generator.

4-71. The sawtooth signal from V121A is connected to the SYNC PULSE OUTPUT receptacle (J130) through an RC differentiating circuit which shapes the sawtooth wave into a sharp pulse. This pulse may be used to synchronize to the spectrum analyzer sweep, the Signal Alternator, Model SW-1, camera shutters, and/or auxiliary indicators.

4-72. VISUAL INDICATOR.

4-73. A type 5ADP7 cathode-ray tube is used as a visual indicator. A voltage doubler high-voltage system is used to drive the crt. Negative high voltage is connected to the electron gun. Positive high voltage is connected to the post accelerator anode. The FOCUS and BRILLIANCE controls are located in the negative voltage bleeder string. The ASTIG control is used to adjust the crt trace for uniform focus.

4-74. ACCESSORY EQUIPMENT RECEPTACLE AND SHORTING PLUG.

4-75. The ACCESS EQUIP receptacle (J129) is provided to permit the convenient connection of accessory equipment to the spectrum analyzer. The shorting plug (P129) must be connected when normal operation is required.

4-76. When the shorting plug is connected, the jumper wire between contacts G and F connects the sawtooth generator (V121) to B+. The jumper wire between contacts D and A connects the output of the sawtooth generator to the sweeping oscillator and horizontal circuits.

4-77. When the shorting plug is disconnected, the internal sawtooth generator is turned off. A 250-volt regulated B+ supply is available at contact F. A -85-volt regulated B- supply is available at contact H. An external sweep source may be connected at contact B. Contact C is a ground connection. Contact J provides detected vertical output.

4-78. CIRCUIT DESCRIPTION, MODEL PS-19.

4-79. The Power Supply, Model PS-19, furnishes all necessary power for the analyzer section at the indicated contact of connector J7 as follows:

+250 volts dc, regulated	Contact H
-1650 volts dc	Contact L
+1650 volts dc	Contact N
-85 volts dc, regulated	Contact D
6.3 volts ac	Contacts P-M
6.4 volts ac	Contacts A-B
6.3 volts ac	Contacts E-F

NOTE

Dc voltages are from contact to chassis. Ac voltages are between indicated contacts.

4-80. The power input to the Model PS-19 is derived from a constant-voltage transformer which provides a stable source of 118-volt, 60 cps power when connected to a 60 cps power source (95-130 volts). (Constant-voltage transformers for other power sources are available on special order, refer to Section 2.)

4-81. The +250 volts dc is provided by a full-wave rectifier (V1). Filtering is introduced by C5 and C7. Regulation is accomplished by V2, V3, V4, V5, and V6. The voltage regulator tube (V6) provides a reference voltage for the regulator control tube (V5). The regulator control tubes serve as a dc amplifier which amplifies and feeds back to the grids of the series regulator (V2, V3) any voltage change in the +250-volt line. This feedback changes the cathode-to-plate voltage drop across V2, V3 so as to oppose the change in the +250-volt line. The +250 Volt ADJ control (R39) is used to set the grid voltage of V5B so that regulation produces a nominal voltage of +250 volts dc.

4-82. Negative high voltage for the cathode-ray tube is provided by a half-wave rectifier (CR3). Filtering is introduced by R51 and C19A, C19B.

4-83. Positive high voltage for the cathode-ray tube is provided by a half-wave rectifier (CR5). Filtering is introduced by R57 and C21A, C21B.

4-84. The -85-volt dc supply is provided by a half-wave rectifier (CR1). Filtering is provided by C15, R47 and C17. V7 serves as a voltage regulator for the negative supply.

SECTION 5

SERVICE AND MAINTENANCE

5-1. GENERAL.

5-2. This section is divided into five parts to facilitate its use in aligning, adjusting, or repairing the equipment. The five parts are described in the following paragraphs.

NOTE

If an equipment trouble cannot be corrected by using the procedures outlined in this section, it is recommended that the equipment be returned to The Singer Company, Metrics Division, for servicing. Before returning the instrument, fill out and mail the Repair and Maintenance Form bound in the back of this manual. Upon receipt of the information, The Singer Company will supply the necessary servicing data or shipping instructions. After receiving the shipping instructions, forward the equipment prepaid to the factory. If requested, an estimate of charges will be made before work is started.

5-3. The first part of this section is a guide to troubleshooting. The troubleshooting chart lists principal trouble symptoms and the corrective measures. As an aid to troubleshooting, voltage and resistance charts and a stage gain chart are provided.

5-4. The second part of this section describes the alignment that may be required due to aging or replacement of any of the tubes (and/or associated components) of the equipment.

5-5. The third part of this section indicates the function of the service controls.

5-6. The fourth part of this section is a complete field alignment procedure. This procedure would only be used in its entirety under the most unusual circumstances. Most of the alignment problems encountered in the field can be solved by using the applicable adjustment techniques given in the second part of this section.

5-7. The fifth part of this section is a final testing procedure which may by used to determine if the equipment is operating within specifications after it has been repaired.

5-8. TROUBLESHOOTING.

5-9. Troubleshooting information is provided in paragraphs 5-10 through 5-17. The information includes a troubleshooting chart, table 5-1, voltage and resistance charts, tables 5-2 through 5-5, and a stage gain chart, table 5-6, to be used to localize the fault to defective stages and components responsible for the abnormal condition.

5-10. TROUBLESHOOTING CHART. This chart, table 5-1, lists the principal trouble symptoms which may be observed during tests. For each symptom, corrective measures are indicated. When a check of a tube is listed, the tube and its associated circuits should be investigated. The voltage and resistance charts and the stage gain chart can be used to help locate the trouble.

WARNING

High voltage is used in this equipment. To avoid contact with lethal voltage, personnel should observe proper safety precautions.

5-11. VOLTAGE AND RESISTANCE CHARTS. The charts, tables 5-2 through 5-5, were made with the spectrum analyzer, power supply, and constant-voltage transformer interconnected for normal operation.

5-12. Unless otherwise specified, all voltage and resistance values were taken between the indicated point and chassis ground. All measurements were taken with an RCA VTVM, Model WV-98B.

TABLE 5-1. TROUBLESHOOTING CHART

Symptom	Corrective Measures
No scale illumination. Not corrected by adjusting SCALE ILLUM control.	Check power connections.
	Check 3-ampere fuses (F1, F2).
	Check output voltage from constant-voltage transformer. Low output may be caused by defective constant-voltage transformer, or by a short circuit in the power supply or spectrum analyzer.
3-ampere fuse (F1, F2) fails when replaced.	Check T1, T2 and loads. If fuse fails immediately, check for shorted power transformer.
	Check for ac filament short.
	If fuse fails after approximately 30 seconds, check for B+ supply short circuit.
No crt illumination. Not corrected by adjustment of FOCUS and BRILLIANCE controls.	Check seating of anode contact of crt.
	Check seating of shorting plug in ACCESS EQUIP receptacle.
	If removal of V111 from its socket results in crt illumination, check intermediate-frequency section for oscillation and swept oscillator section for failure.
	Check high voltage. If high voltage is incorrect, check CR3, CR5 and associated filter circuits.
	Check V121 (including neon lamp E101, mounted under the chassis) and V122. Note that the mid-point of the sawtooth swing should be approximately the same at the two horizontal deflection plates of the crt.
	Check V114. Note that there should be approximately a 60-volt difference between the two vertical deflection plates of the crt.
	Check V123.
Crt illumination observed but baseline not obtained. (Stationary dot on crt screen.)	Check seating of shorting plug in ACCESS EQUIP receptacle.
	Check B+ supply at J5. If necessary, adjust +250V ADJUST potentiometer. Check V1 through V6.
	Check V121 (including neon lamp E101, mounted under the chassis) and V122.

TABLE 5-1. TROUBLESHOOTING CHART (Cont)

Symptom	Corrective Measures
Baseline length and/or horizontal position incorrect. Not corrected by turning SYNC AMP control counterclockwise.	If baseline is too long and sensitivity too great, check for insufficient high voltage. If high voltage is incorrect, check CR3, CR5, and associated filter circuits.
	Check V121 (including neon lamp E101, mounted under the chassis) and V122. Reset LINE SIZE, H POS, and CF BAL controls as given in paragraph 5-28.
Baseline cannot be synchronized.	Check to see that lamp DS101 (under the chassis near E101) is lit.
	Check V120.
SWEEP RATE control does not vary the sweep rate from 1 cps to 60 cps.	Check V121 (including neon lamp E101, mounted under the chassis).
No signal pips appear on the screen. Marker pips do not appear. Zero-frequency pip does not appear when CENTER FREQUENCY dial is set to 0 (may require adjustment of A and/or S BAL controls).	Check balanced modulator stages (V104, V105), i-f stages (V106, V107, V108, V109, V110, V111), and sweeping oscillator, (V117, V118, V119). Use stage gain chart to help isolate failure.
Zero-frequency pip cannot be balanced.	Adjust C131 as given in paragraph 5-23.
	Check V104, V105.
No signal pips appear on crt screen. Zero-frequency pip appears when CENTER FREQUENCY dial is set to 0 (may require adjustment of A and/or S BAL controls).	Check connections between signal source and input to analyzer. Check to see that attenuators, SWEEP WIDTH, and CENTER FREQUENCY controls are correctly set for level and frequency of input signals.
	Check V101, V102, V103.
Marker pips do not appear on crt screen. Signal pips do appear.	Check V115.
	Check V124 (including Y104).
Insufficient signal sensitivity.	Check signal channel from crt to input V123, V114, V112A, V111, V110, V109, V108, V107, V106, V105, V104, V103, V102, V101). Check sweeping oscillator output V119A.
LIN amplitude scale calibrations incorrect.	Check V112A.
LOG amplitude scale calibrations incorrect.	Check V111, V112A.
PWR (power) amplitude scale does not function correctly.	Check V113.

TABLE 5-1. TROUBLESHOOTING CHART (Cont)

Symptom	Corrective Measures
The pip height of a constant amplitude signal varies more than ±15% as the frequency is varied from 1 kc to 13.5 mc (to 23.5 mc with the SPA-3/25a) with AMPLITUDE SCALE selector set to LIN.	Check V101, V102, V103, V104, V105. Check V118, V119.
Input attenuator step switches function correctly.	Check resistors and capacitor associated with each of switches S501, S503, S505.
INPUT ATTENUATOR - CONTINUOUS control has incorrect range.	Check the following resistors and capacitor: R519, R521, R523, and C505.
IF ATTEN switches function incorrectly.	Check resistors associated with switches S102 and S109.
SWEEP WIDTH and CENTER FREQUENCY dial calibrations incorrect.	Check CR103, V117, V118, V119.
SWEEP WIDTH dial calibrations incorrect. CENTER FREQUENCY dial correct.	If sweep width is insufficient and baseline too short, check V121 (including neon lamp E101, mounted under the chassis). Reset LINE SIZE, POS and CF BAL controls as given in paragraph 5-28. Reset SWEEP LIMIT control and/or R342 (SPA-3/25a only) as given in paragraph 5-26. Check V117, V118.
Sweep width changes more than ±15% as CENTER FREQUENCY control is changed from 0 to 13.5 mc (to 23.5 mc in the case of SPA-3/25a).	Check the gearing associated with the CENTER FREQUENCY control (variable capacitor). If this gearing has loosened, refer to paragraph 5-40 for Model SPA-3/25a and to paragraph 5-41 for Model SPA-3a. Redetermine value of R341 as given in paragraph 5-29 (SPA-3a). Redetermine values of R343 and R344 as given in paragraph 5-30 (SPA-3/25a).
CENTER FREQUENCY dial setting incorrect. SWEEP WIDTH dial correct.	Check V118. Adjust L129 and CAL potentiometer as given in paragraph 5-27.
Resolution poor.	Check crystals Y102, Y103. NOTE If it is necessary to replace the crystals, the replacement crystals should be obtained in matched pairs.
Range of resolution incorrect. (I-f bandwidth cannot be broadened sufficiently.)	Check V108 and V109B. Realign crystal-filter circuits as given in paragraph 5-39.

5-13. The following front-panel control settings were used to obtain the voltage and resistance readings.

Control	Setting
SWEEP WIDTH Control	3 MC
CENTER FREQUENCY Control	0
IF BANDWIDTH Control	MAX
AMPLITUDE SCALE Selector	LIN
IF ATTEN Switches	15 DB
INPUT ATTENUATOR Switches	0 DB
MARKER - FREQUENCY Selector . .	500 KC
VIDEO FILTER Control	OFF
SWEEP RATE Control	30 CPS
CAL SYNC SEL Switch	LINE

5-14. STAGE GAIN CHART. The stage gain chart is used as a standard to check the gain of each stage when troubleshooting.

5-15. The stage gain chart was made using a Measurements Corporation Standard Signal Generator, Model 82, with a Microlab 50-72 ohm matching pad and an RG59/U coaxial cable terminated in 75 ohms. This is illustrated in figure 5-1.

5-16. Unless otherwise indicated, the listed input voltages are required for full-scale deflection on the screen of the spectrum analyzer.

NOTE

For input measurement, use RG59/U cable with BNC connectors at each end.

5-17. The stage gain measurements were made with the following front-panel control settings:

Control	Setting
SWEEP WIDTH Control	MAX
CENTER FREQUENCY Dial	2 MC
IF BANDWIDTH Control	MAX
IF ATTENUATOR Switches	0 DB
AMPLITUDE SCALE Selector	LIN
INPUT ATTENUATOR Control	0 DB
INPUT ATTENUATOR Switches	0 DB
VIDEO FILTER Control	OFF
MARKER - FREQUENCY Selector . . .	OFF

5-18. TOUCH-UP ALIGNMENT.

CAUTION

These adjustments should not be attempted unless suitable instruments and sufficiently skilled, experienced personnel are available.

5-19. This section indicates adjustments that may be needed when tubes or the associated components age or are changed. The charts, tables 5-7 and 5-8, indicate possible procedures; they do not imply that any or all of the adjustments need be made. When a tube or associated component is changed, check equipment operation before any adjustments are attempted in order to determine if there is a need for adjustment. Before any adjustments of chassis controls are made, the entire procedure should be read to determine the expected result. Whenever possible, the equipment should then be checked to see if it is already providing the desired result. Only if the equipment does not yield the desired result should the adjustment be made. Equipment requirements are listed in paragraph 5-20.

5-20. Before beginning any touch-up alignment, follow the interconnection and adjustment procedures outlined in Section 2. Allow at least a half-hour warmup period. After the warmup period, connect a voltmeter (whose accuracy is known to be ±3 percent or better, at 250 (volts) to the +250 V TEST jack on the rear apron of the Model PS-19 and, if necessary, adjust the +250 V ADJUST chassis control of the Model PS-19 for a B+ supply reading on the voltmeter of +250 volts dc.

5-21. ADJUSTMENT PROCEDURES.

5-22. IF GAIN CONTROL. If the equipment sensitivity is incorrect, adjust the IF GAIN control, using the following procedure.

606 A

a. Set the CENTER FREQUENCY dial to 2 MC and the SWEEP WIDTH dial to 3 mc. Set the other front-panel controls to the positions given in paragraph 2-12, step t. Connect a 2 mc, 25 uv voltage to the INPUT connector.

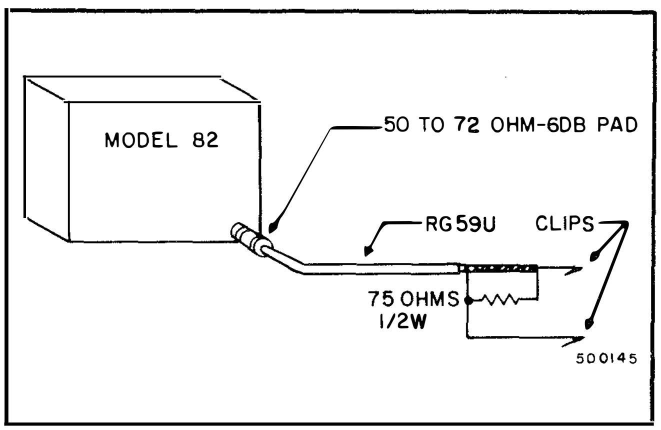


Figure 5-1. Stage Gain Measurement Circuit

TABLE 5-2. VOLTAGE CHART (MODELS SPA-3a AND SPA-3/25a)

Circuit Reference Symbol	Type	Pin Numbers 1	2	3	4	5	6	7	8	9
V101	6922	111	0	2.25	5.3*	5.3*	190	110	111	0
V102	6CB6	0	1.5	6.3*	6.3*	187	148	1.5	-	-
V103	6J6	190	190	5.0*	5.0*	45	45	49	-	-
V104	5879	-0.2	NC	0.75	5.5*	5.5*	NC	25	195	0
V105	5879	-0.15	NC	0.75	5.3*	5.3*	NC	24	195	0
V106	6AW8A	0	-0.6	110	5.4*	5.4*	6.2	0	165	235
V107	6BE6	-1.55	1.4	5.4*	5.4*	245	62	0	-	-
V108	6AB4	245	NC	5.5*	5.5*	245	0.6	3.1	-	-
V109	6AW8A	2.55	0.52	245	5.4*	5.4*	2.3	0	75	250
V110	6CB6	0	1.7	5.6*	5.6*	240	96	0	-	-
V111	6AU6	0	0	5.5*	5.5*	230	80	1.15	-	-
V112	12AU7	145	-0.65	4.2	(connected) 5.4*		-13	-13	0.3	5.4*
V113	12AT7	27	2.7	3.0	(connected) 5.2*		250	-9.5	4.3	5.2*
V114	12AU7	150	-13	1.8	(connected) 5.2*		85	17	19.5	5.2*
V115	12AX7	-72	-72	0.75	(connected) 5.1*		150	-41	0	5.1*
V117	12BY7	3.0	0	3.0	6.0	-6.3	0.3	145	150	3.0
V118	6BK7	65	-2.8	0	0	6.0	62	-2.4	0	0
V119	6J6	135	140	-6.3	0	-5.7	-5.7	2.0	-	-
V120	12AT7	90	-4.6	0.18	(connected) 5.1*		95	-46	2.4	5.1*
V121	6U8	260	-1.48	41	5.1*	5.1*	128	0	130	128
V122	12AU7	146	0.6	9.8	(connected) 5.1		150	12.8	20	5.1*
V123	5ADP7	-1900‡	-1800	-1800	NC	-1300	NC	150	150	160
			10	11	12	13	14			
			85	165	NC	NC	-1900‡			

All voltages DC unless otherwise specified.

* Measurement between indicated pins not to ground. Voltage is ac, rms.

NC No connection.

‡ Do not measure unless high voltage power supply is disabled by removing rectifiers from power supply. With rectifiers removed voltage is 6.3V ac (rms) between pins.

Tolerance on all voltages is ±10 percent.

TABLE 5-3. RESISTANCE CHART (MODELS SPA-3a AND SPA-3/25a)

Circuit Reference Symbol	Type	Pin Numbers								
		1	2	3	4	5	6	7	8	9
V101	6922	50K	100K	220	0	0	12K	50K	50K	0
V102	6CB6	220K	91	*	*	12K	26K	91	-	-
V103	6J6	12K	12K	*	*	100K	100K	2.3K	-	-
V104	5879	200K	NC	875	*	*	NC	100K	14K	0
V105	5879	200K	NC	875	*	*	NC	70K	14K	0
V106	6AW8A	0	100K	35K	*	*	2.2K‡	12	40K	15K
V107	6BE6	3.8K	220	*	*	16K	48K	22	-	-
V108	6AB4	11.5K	NC	*	*	11.5K	48K	490	-	-
V109	6AW8A	490	100K	11.5K	*	*	1.15K	3.5	85K	10.5K
V110	6CB6	3.5	320	*	*	12.5K	130K	0	-	-
V111	6AU6	100K	0	*	*	15.5K	21K	200	-	-
V112	12AU7	30	1MEG	750	*	*	110K	110K	120	*
V113	12AT7	250K	6.8K	2.1K	*	*	12.2	300K	4.7K	*
V114	12AU7	100K	300K	725	*	*	110K	140K	5.2K	*
V115	12AX7	100K	100K	1K	*	*	21K	22K	0	*
V117	12BY7	175‡‡	0.60K†	175‡‡	**	**	**	13K	13K	175‡‡
V118	6BK7	32K	50K	0	**	**	32K	50K	0	∞
V119	6J6	21K	21K	**	**	400K	400K	240K	-	-
V120	12AT7	1MEG	1.1MEG	1K	*	*	220K	1MEG	3K	*
V121	6U8	10.5K	1MEG-5.5MEG††	16K	*	*	470K	0	27K	470K
V122	12AU7	200K	430K	3.2K	*	*	220K	160K	5.1K	*
V123	5ADP7	1.5MEG	1.5MEG	2MEG	NC	1.1MEG	NC	220K	200K	38K
			10	11	12	13	14	ANODE CAP		
			110K	100K	NC	NC	1.5MEG	20MEG		

NC No connection.

* Very low resistance.

** Do not measure resistance.

‡ Resistance varies with setting of IF GAIN potentiometer.

‡‡ Resistance varies with setting of BIAS potentiometer and FINE control.

† Resistance varies with setting of SWEEPWIDTH control and the sweep width tracking potentiometer (R345).

†† Resistance varies with setting of SWEEP RATE control.

TABLE 5-4. VOLTAGE CHART (MODEL PS-19 POWER SUPPLY)

Circuit Reference Symbol	Type	Pin Numbers									
		1	2	3	4	5	6	7	8	9	Cap
V1	5U4	500*	500V*	NC	430(RMS)	NC	430(RMS)	NC	500*	-	-
V2	6146	250	6.3(RMS)**	500	250	100	250	6.3(RMS)**	NC	-	500
V3	6146	250	6.3(RMS)**	500	250	100	250	6.3(RMS)**	NC	-	500
V4	12AX7	250	66	72	(connected) 6.3**		100	65	72	6.3**	-
V5	12AX7	138	51	52	(connected) 6.3**		136	50	52	6.3**	-
V6	5651	84	0	NC	0	84	NC	0	-	-	-
V7	5651	0	-84	NC	-84	0	NC	-84	-	-	-

NC No connection.

All voltages are dc unless otherwise specified.

* 5 V ac (RMS) measured between pins 2 and 8.

** Measurement between indicated pins not to ground. Voltage is ac, rms.

TABLE 5-5. RESISTANCE CHART (MODEL PS-19 POWER SUPPLY)

Circuit Reference Symbol	Type	Pin Numbers									
		1	2	3	4	5	6	7	8	9	Cap
V1	5U4	NC	*	NC	28	NC	26	NC	*	-	-
V2	6146	NC	∞	*	NC	8.2M	11K	∞	NC	-	*
V3	6146	NC	∞	*	NC	8.2M	11K	∞	NC	-	*
V4	12AX7	11K	1.6M	230K	∞	∞	8M	1.6M	230K	∞	-
V5	12AX7	850K	65K	230K	∞	∞	755K	64K	230K	∞	-
V6	5651	NC	0	NC	NC	66K	NC	NC	-	-	-
V7	5651	0	NC	NC	NC	NC	NC	90K			

NC No connection.

* Leakage, do not measure resistance.

TABLE 5-6. STAGE GAIN CHART

Circuit Reference Symbol	Type	Pin	Frequency	Input Voltage
V101	6922	2	2 mc	20 uv
V102	6CB6	1	2 mc	37 uv
V103	6J6	6	2 mc	240 uv
V104	5879	1	2 mc	510 uv
V105	5879	1	2 mc	590 uv
V104	5879	1	32 mc	260 uv
V105	5879	1	32 mc	240 uv
V106A	6AW8A	7	32 mc	80 uv
V107	6BE6	7	32 mc	455 uv
V107	6BE6	7	2.7 mc	1200 uv
V108	6AB4	6	2.7 mc	3.7 K uv
V109A	6AW8A	7	2.7 mc	1.1 K uv
V109B	6AW8A	2	2.7 mc	8 K uv
V110	6CB6	1	2.7 mc	2.5 K uv
V111	6AU6	1	2.7 mc	100 K uv
V112	12AU7	7	DC	-7 volts
V114	12AU7	2	DC	-6.7 volts
V114	12AU7	1	DC	+135 volts*
V114	12AU7	6	DC	+78 volts*
V114	12AU7	7	DC	+16 volts*

*DC voltages for -7 volts input at pin 7 of V112.

b. Set the IF GAIN control for a full-scale indication on the crt screen.

5-23. CAPACITOR C131. If good suppression of the zero-frequency pip cannot be obtained, reset capacitor C131, using the following procedure:

a. Set the CENTER FREQUENCY dial to zero, and the other front-panel controls to the positions given in paragraph 2-12, step a.

b. Set A BAL and S BAL controls to the center of their operational range. Adjust C131 for best suppression of the zero-frequency pip.

c. Trim C131, A BAL and S BAL controls for best suppression of the zero-frequency pip.

d. Set IF ATTEN switches for 0 DB and trim C131, A BAL, and S BAL controls for best suppression of the zero-frequency pip.

5-24. INDUCTORS L111, L117. If resolution is unsatisfactory (i-f bandwidth cannot be broadened sufficiently), adjust L111 and/or L117 in accordance with the following procedure:

a. Connect a 2 mc signal to the INPUT connector. Set the SWEEP WIDTH dial to 3 mc, the SWEEP WIDTH range selector (SPA-3a) to W, and the CENTER FREQUENCY dial for a centered 2 mc pip.

b. Adjust SWEEP WIDTH dial, while maintaining the pip at the center of the screen by means of the CENTER FREQUENCY dial, so that the base of the pip occupies approximately one-third of the baseline.

TABLE 5-7. GUIDE TO ADJUSTMENT

Analyzer Section

Reference Symbol	Tube Type	Required Procedure
V101	6922	Reset i-f gain.
V102	6CB6	Reset i-f gain.
V103	6J6	Reset i-f gain.
V104	5879	Reset C131.
V105	5879	Reset i-f gain.
V106	6AW8A	Reset i-f gain.
V107	6BE6	Reset i-f gain.
V108	6AB4	Reset i-f gain, L111 if required.
V109	6AW8A	Reset i-f gain, L117 if required.
V110	6CB6	Reset i-f gain.
V111	6AU6	Reset 20 DB LOG ADJ and 0 DB LOG ADJ potentiometers. Reset i-f gain.
V112	12AU7	Check LIN and LOG scale settings.
V113	12AT7	Check PWR (power) amplitude scale. Refer to Section 3.
V114	12AU7	Reset V POS control and check amplitude settings on crt screen.
V115	12AX7	Reset T108 if required.
V117	12BY7	If the voltage at J115 is not 0.95 volt, reset BIAS control. Reset SWEEP LIMIT potentiometer and/or R342 (SPA-3/25a).
V118	6BK7	Check SWEEP WIDTH and CENTER FREQUENCY dial setting. Reset CAL trimmer capacitor C263, C264 (SPA-3a), and L129 if required.
V119	6J6	Reset i-f gain.
V120	12AT7	None.
V121	6U8	Reset LINE SIZE CF BAL controls.
V122	12AU7	Reset H POS control and LINE SIZE control.
V123	5ADP7	Reset BRILLIANCE, FOCUS, V POS, H POS and IF GAIN controls. Check amplitude settings on crt screen.
V124	6AH6	None.

TABLE 5-8. GUIDE TO ADJUSTMENT

Power Supply Section

Reference Symbol	Tube Type	Required Procedure
V1	5U4	Check for +250 volts at J5. Reset +250 V ADJUST chassis control. Use a voltmeter which is known to be accurate to ±3%.
V2	6146	
V3	6146	
V4	12AX7	
V5	12AX7	
V6	5651	

c. Remove crystal Y102.

d. Trim L117 for minimum deflection and broadest pip, adjusting the INPUT ATTENUATOR and SWEEP WIDTH controls to keep the sides of the pip visible. If the pip moves across the screen, center the pip by using the CENTER FREQUENCY dial or by shifting the input frequency.

NOTE

When the coil is correctly set, a condition of minimum height and broadest pip will be achieved. As the coil is tuned away from the correct setting, the pip will increase in amplitude, become narrower, and shift horizontally.

e. After L117 is correctly set, replace crystal Y102.

f. Remove crystal Y103, and repeat the above procedure, using L111 in place of L117. When L111 is correctly set, replace crystal Y103.

5-25. 20 DB LOG ADJ, 0 DB LOG ADJ CONTROLS. If the logarithmic amplitude scale calibrations are incorrect, refer to paragraph 5-43 for alignment procedure.

5-26. SWEEP LIMIT CONTROL AND RESISTOR R342. If the sweep width does not correspond to the SWEEP WIDTH dial setting, proceed as follows:

a. For the Model SPA-3a, set the CENTER FREQUENCY dial to 1.5 mc, set the SWEEP WIDTH dial to 3 MC and the SWEEP WIDTH range selector to W. Adjust the SWEEP LIMIT control until marker pips are aligned with the crt scale, as described in Section 2.

b. For the Model SPA-3/25a, set the CENTER FREQUENCY dial to 1.5 mc and the SWEEP WIDTH dial to 3 MC. Adjust the SWEEP LIMIT control for the low band and R342 for the high band, until the marker pips are aligned with the crt scale, as described in Section 2.

5-27. CAL TRIMMER (C263 - SPA-3/25a, C264 - SPA-3a), L129. If the CENTER FREQUENCY dial settings are incorrect, proceed as follows:

a. Make certain that the ZERO ADJUST control is correctly set, in accordance with the procedure given in Section 3, before proceeding.

b. Set the BIAS control for 0.95 volt at the BIAS TEST jack on the top of the oscillator chassis and set the ZERO ADJUST control to the midpoint of its operational range.

c. Adjust CAL trimmer capacitor (C263 or C264) and L129 in accordance with the procedures of paragraph 5-40 or 5-41.

5-28. LINE SIZE, CF BAL CONTROLS. If the size of the baseline is not correct or if the line cannot be centered by using the H POS control as described in Section 2, adjust the LINE SIZE control and CF BAL control. Refer to paragraph 5-37 step c for the adjustment instructions.

5-29. RESISTOR R341 (SPA-3a). If the sweep width change is greater than 15 percent as the CENTER FREQUENCY control is varied between 0 mc and 13.5 mc, redetermine the proper value for resistor R341.

NOTE

First verify that the gears associated with the CENTER FREQUENCY control have not become loosened.

With the SWEEP WIDTH control set to the 3 mc position, check for proper sweep width at several center frequencies between 1.5 mc and 13.5 mc, using the frequency markers. Choose a value for resistor R341 that provides the smallest change in sweep width over the entire range of the CENTER FREQUENCY control.

5-30. RESISTORS R343 AND R344 (SPA-3/25a). Resistors R343 and R344 serve the same function provided by resistor R341 in the Model SPA-3a. Redetermine the proper values for resistors R343 and R344 as described in paragraph 5-29. First determine the value for resistor R344 in the low band and then the value for resistor R343 in the high band.

5-31. SERVICE CONTROLS.

5-32. The controls that are adjusted during maintenance appear in the list of service controls and are illustrated in figure 5-2. These controls should be operated only by service personnel in accordance with the instructions in the troubleshooting and alignment procedures.

5-33. FIELD ALIGNMENT.

5-34. The field alignment procedures are detailed instructions that are performed only under unusual circumstances. Before performing these procedures, attempt to correct any troubles by means of the adjustment procedures in paragraph 5-18. Before performing any alignment procedure, read the entire procedure to determine the expected result. Wherever possible, check to see if the equipment is already providing the expected result. Perform the procedure only if the desired result cannot be obtained.

5-35. TEST EQUIPMENT REQUIRED. The following test equipment is required:

Dc voltmeter; 3 percent accuracy at 250 volts dc.

Fm signal generator; low harmonic content in output, level indicators, range 200 cps to 15 mc (to 25 mc for SPA-3/25a).

5-36. PRELIMINARY PROCEDURES. Proceed as follows:

a. Follow test setup instructions provided in Section 2.

NOTE

Allow 30-minute warmup period before proceeding.

b. Connect dc voltmeter between +250V TEST jack on rear of Model PS-19 and ground. Check to see that voltmeter indicates 250 volts dc.

c. If voltmeter indication is incorrect, adjust +250V ADJUST potentiometer for a 250-volt dc indication.

5-37. BASELINE ADJUSTMENT. Baseline adjustment is performed as follows:

a. Adjust FOCUS, BRILLIANCE (located on front panel), and ASTIG controls (located on analyzer chassis) for a clear, sharp, uniform trace. BRILLIANCE control should be set at the minimum point of suitable visibility.

CAUTION

Do not use the BRILLIANCE control to compete with external light falling on the crt screen; instead, shield the screen from the external light.

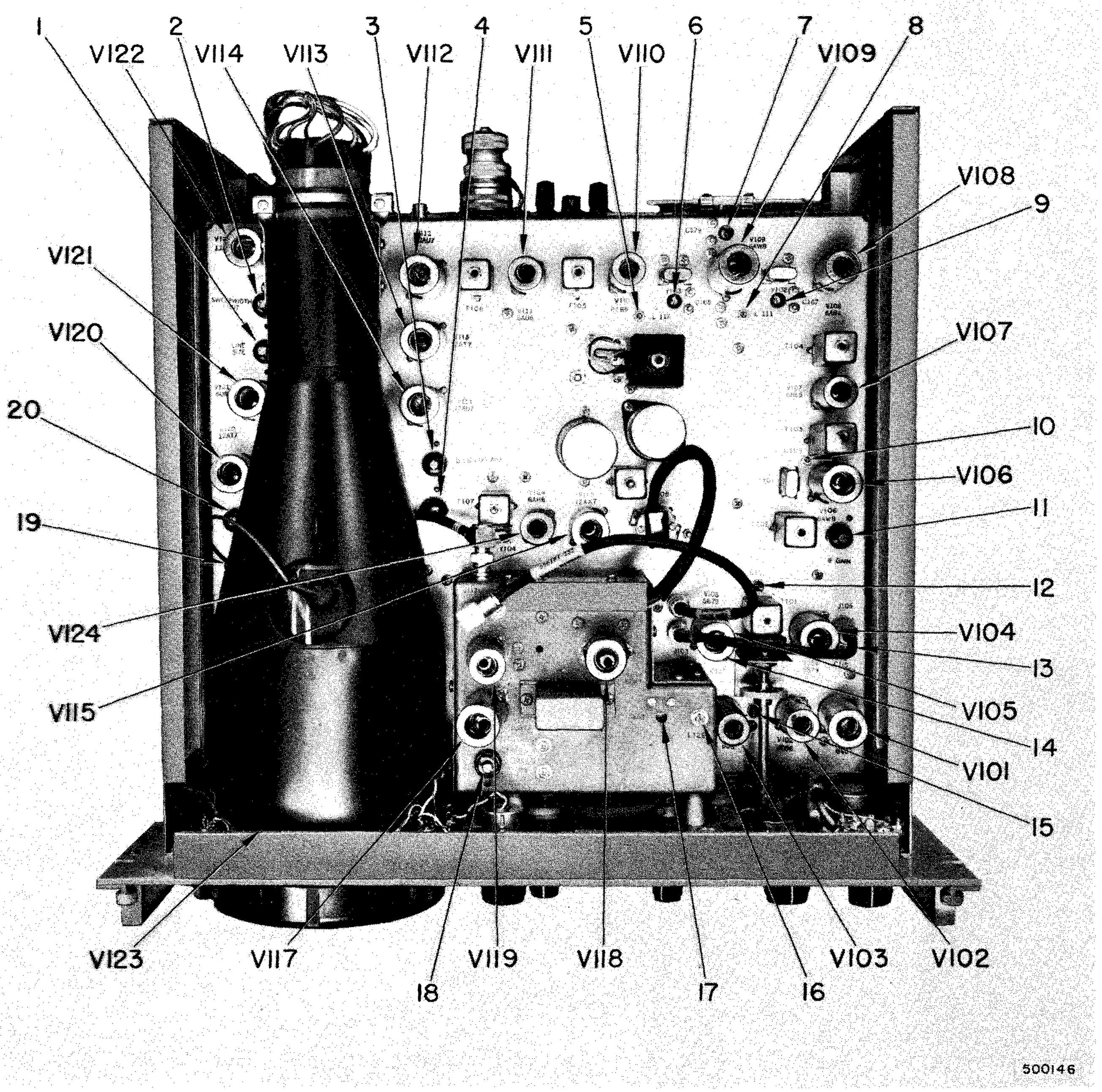


Figure 5-2. Models SPA-3a and SPA-3/25a, Top Internal View

SERVICE CONTROLS

Name	Reference Designation	Figure 5-2 Index Number	Function
IF GAIN potentiometer	R187	11	Adjusts gain of V106A for correct equipment sensitivity.
20 DB LOG ADJ potentiometer	R261	4	Adjusts last i-f stage and detector circuit for proper LOG amplitude scale calibration.
0 DB LOG ADJ potentiometer	R279	3	Operates in conjunction with 20 DB LOG ADJ potentiometer R261 to adjust last i-f stage and detector circuit.
BIAS potentiometer	R353	18	Determines current flow through inductor L127 to minimize the sweeping oscillator center-frequency drift caused by temperature changes.
CF BAL potentiometer	R411	20	Adjusts sawtooth voltage applied to V122 in order to maintain a 0-volt dc average level, thereby, permitting correct baseline centering.
LINE SIZE potentiometer	R415	1	Controls size of crt baseline.
EXT. LINE SIZE potentiometer	R417	19	Adjusts size of crt baseline when an external sweep source is used.
SWEEP WIDTH LIMIT potentiometer	R421	2	In the Model SPA-3a, potentiometer R421 adjusts the maximum sweep width. On the Model SPA-3/25a, potentiometer R421 controls the maximum sweep width for the low band and resistor R342 controls the maximum sweep width for the high band.
Variable capacitors	C107, C115, C117	15 13 14	Adjust frequency response of input frequency compensation network.
Variable capacitor	C131	12	Adjusts phase balance between the two outputs from balanced modulator V104, V105.
Variable capacitor	C167	9	Neutralizing capacitor for crystal Y102.
Variable capacitor	C179	7	Tunes output of i-f amplifier V109A.

SERVICE CONTROLS (Cont)

Name	Reference Designation	Figure 5-2 Index Number	Function
Variable capacitor	C185	6	Neutralizing capacitor for crystal Y103.
CAL trimmer variable capacitor	C263	17	Adjusts range of CENTER FREQUENCY control (with variable inductor L129 on the Model SPA-3/25a). Adjusts frequencies in the 13.5 mc range on the Model SPA-3a and adjusts the high frequency signals of the low band on the Model SPA-3/25a. Capacitor C270 adjusts the high frequency signals of the high band on the Model SPA-3/25a.
Variable capacitor	C264 (SPA-3a)		Operates in conjunction with variable inductor L129 to set range of CENTER FREQUENCY control when SWEEP WIDTH selector is set to N (narrow).
Variable inductor	L109	10	Adjusts output of 29.3 mc crystal oscillator V106B.
Variable inductor	L111	8	Provides load for crystal filter Y102.
Variable inductor	L117	5	Provides load for crystal filter Y103.
Variable inductor	L129	16	Operates in conjunction with CAL trimmer capacitor C263 to set range of the CENTER FREQUENCY control on the Model SPA-3/25a. Operates in conjunction with capacitor C264 to set range of CENTER FREQUENCY control when sweep width band switch on the Model SPA-3a is set to N (narrow).

NOTE

If the baseline trace does not coincide with the baseline of the calibrated screen, adjust the V POS control. If there is a lack of parallelism, rotate the crt in accordance with the procedures given in Section 2.

b. Adjust the SWEEP RATE control so that the sweep rate of the crt beam is 30 cps and set the CAL - SYNC SEL switch to LINE. (Refer to Section 2.)

c. Adjust the LINE SIZE, CF BAL, and H POS controls in accordance with the following procedure.

(1) Set H POS control to the center of its rotational range.

(2) Set LINE SIZE control until the baseline length is approximately that of the calibrated portion of the crt screen. If the line is not centered, use the CF BAL control to obtain a centered line.

(3) Set CENTER FREQUENCY control to 10 MC, SWEEP WIDTH control to 3 mc, SWEEP WIDTH RANGE selector to W (SPA-3a only), IF ATTEN to 0 DB, and AMPLITUDE SCALE control to LIN. Set MARKERS - FREQUENCY selector to 500 KC.

(4) Adjust MARKER LEVEL control for a convenient height of marker presentation. The 10 mc marker pip should be at or near the center of the screen.

(5) Gradually reduce sweepwidth to minimum, maintaining the 10 mc pip at the center of the screen with the CENTER FREQUENCY control.

(6) Return to 3 mc sweep width and adjust H POS control until the top of the pip coincides with the center vertical line on the screen.

(7) Adjust LINE SIZE and CF BAL controls until a centered line of the correct length is obtained. The length of the baseline is correct if it extends at least 1/8 inch beyond the calibrated portion of the crt screen at all sweep rates and does not extend past the edges of the crt screen during at least one sweep rate.

5-38. I-F ALIGNMENT. Perform the i-f alignment procedure as follows:

NOTE

It may be necessary to adjust the input signal levels to keep the baseline trace on the screen.

All coils may be tuned from the top of the chassis. Bottom core adjustments are made by passing the black end of the supplied Walsco No. 2543 alignment tool through the hollow top core until the end of the tool engages the bottom core. Care must be taken, when removing the tool, not to disturb the setting of the top core. For this reason, wherever possible, it is better to adjust the bottom core before the top core is adjusted. The top core can be adjusted with either the black or blue end of the tool.

a. Set AMPLITUDE SCALE selector to LIN. Set IF ATTEN switches to 0 DB. Set CENTER FREQUENCY control to 2 MC. Set SWEEP WIDTH control to 0. Set IF BANDWIDTH control to MAX. Set VIDEO FILTER control to OFF. Set SWEEP RATE control to 30 cps. Set IF GAIN potentiometer to 3/4 maximum clockwise rotation.

b. Couple a 2.7 mc voltage through a 0.01 uf capacitor to pin 1 of V111. Adjust the top and bottom cores of T106 for a maximum baseline rise.

NOTE

The 0.01 uf capacitor should also be used in the following steps.

c. Connect the 2.7 mc voltage to pin 1 of V110. Adjust the top and bottom cores of T105 for a maximum baseline rise.

d. Connect the 2.7 mc voltage to pin 7 of V107. Adjust the top and bottom cores of T104 for a maximum baseline rise. Adjust C179 for a maximum baseline rise.

e. Couple a 32.0 mc voltage through a 0.01 uf capacitor to pin 7 of V106. Adjust the top and bottom cores of T103 for a maximum baseline rise.

f. Connect the 32.0 mc voltage to pin 1 of V104. Adjust the bottom cores of T102 and T101 for maximum baseline rise.

5-39. ADJUSTMENT OF CRYSTAL FILTER CIRCUITS.

NOTE

If it is necessary to replace crystals, the replacement crystals should be obtained in matched pairs from The Singer Company, Metrics Division.

a. Set the SWEEP WIDTH control to 3 mc and for the Model SPA-3a, set the SWEEP WIDTH range selector to W.

b. Connect a 2 mc signal to the INPUT connector.

c. Set the CENTER FREQUENCY control so that the 2 mc pip is in the center of the screen. Trim the top and bottom cores of T106, T105, T104, and T103 for maximum pip deflection. Trim C179 and the bottom cores of T102 and T101 for maximum pip deflection.

d. Tune L109 for maximum pip deflection.

NOTE

If pip should disappear (oscillator fails) before or at maximum height, back up tuning slug until pip reappears. If, at maximum pip deflection, pip tends to disappear, back up tuning slug until pip height is reduced by 10 percent of full scale.

e. Adjust the SWEEP WIDTH control, while maintaining the pip at the center of the screen with the CENTER FREQUENCY control, so that the base of the pip occupies approximately one-third of the baseline.

f. Remove crystal Y102. Adjust the INPUT ATTENUATOR step switches to any convenient position other than 0 DB.

g. Set the signal generator output level for a full-scale pip. Rotate C185 through 360 degrees, noting the change in pip shape. At some point of rotation, the pip should approximate the shape shown in a of figure 5-3 or its mirror image.

NOTE

As rotation is continued, the rejection slot should sharpen and disappear into the side of the pip. Continued rotation should cause the rejection slot to appear on the other side of the pip. Reverse the rotation and choose a point at which pip symmetry is best and no rejection slot is present. This is illustrated in b of figure 5-3. This point should be approximately halfway between the two positions at which the rejection enters the pip from the sides.

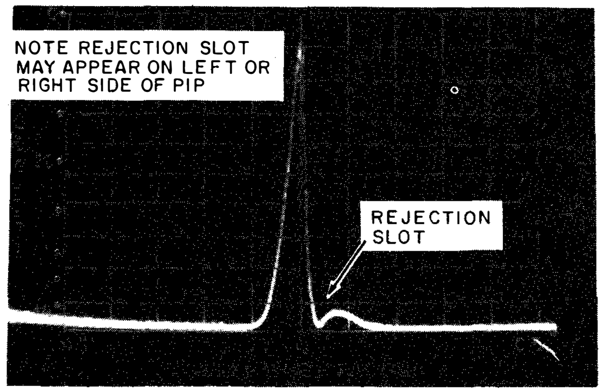
h. Reset the INPUT ATTENUATOR step switches for 20 db less attenuation, thereby causing the pip to go over full scale. If necessary, adjust sweep width so that the sides of the pip go into the baseline. Trim C185 for absence of rejection slot and best pip symmetry.

i. Adjust the INPUT ATTENUATOR as necessary to give a full-scale pip.

j. Adjust L117 for minimum deflection and broadest pip, adjusting the INPUT ATTENUATOR and SWEEP WIDTH controls to keep the sides of the pip visible.

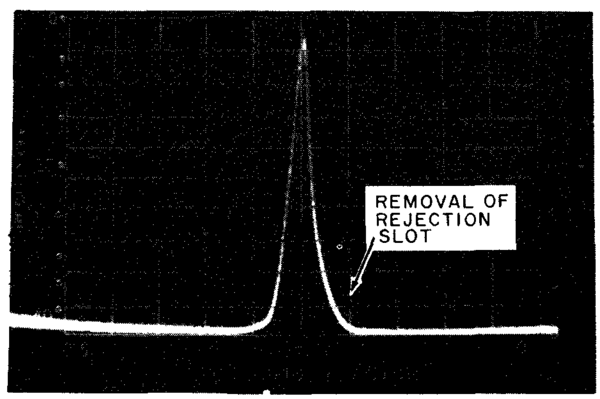
NOTE

If the pip moves across the screen, keep it centered by using the CENTER FREQUENCY control or by shifting the input frequency. Note that when the coil is correctly adjusted, a condition of minimum height and broadest pip will be achieved. As the coil is tuned away from the correct position, the pip will increase in amplitude, become narrower, and shift horizontally.



500147

A. Illustration of Rejection Slot.



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B. Illustration of Complete Rejection Slot Removal.

Figure 5-3. Crystal Rejection Slot Removal

k. Repeat steps f, g, h, i, and j.

l. Replace crystal Y102.

m. Remove crystal Y103.

n. If necessary, readjust the INPUT ATTENUATOR control for a full-scale pip.

o. Repeat steps f through k using C167 and L111 in place of C185 and L117.

p. Replace crystal Y103.

q. Adjust controls for a full-scale broad pip as in step e.

r. Adjust the IF BANDWIDTH control counterclockwise until optimum resolution is obtained. Refer to Section 3.

s. Adjust the following transformers, coils, and capacitor for maximum pip height: T106, T105, C179, T104, T103, T102, and T101.

5-40. OSCILLATOR ALIGNMENT (SPA-3/25a). Oscillator alignment of Model SPA-3/25a is performed as follows:

a. Adjust the BIAS control R353 for 0.95 volt dc measured at the BIAS TEST jack.

b. Set the CAL trimmer capacitor to the center of its range.

c. If the gear coupling between the center-frequency capacitor and the sweep width track potentiometer has been disturbed (if the gearing associated with the CENTER FREQUENCY control loosens), proceed as follows:

(1) With the power off; in series 1, remove fiducial, knobs, and CENTER FREQUENCY dial plate. In series 2, remove knobs and oscillator front panel plate.

(2) Disconnect all cables from oscillator.

(3) Remove oscillator chassis.

(4) Tighten setscrews on capacitor drive gear. Loosen setscrews on sweep width track potentiometer gear. Turn sweep width track potentiometer to the maximum counterclockwise position.

(5) Turn the CENTER FREQUENCY capacitor counterclockwise until the plates have fully meshed. Then turn the capacitor approximately 5 degrees further.

(6) Tighten setscrews on sweep width track potentiometer gear.

(7) Install oscillator chassis and parts removed in step (1).

(8) Connect all cables to oscillator chassis.

(9) Turn power on.

(10) Set SWEEP WIDTH control to 3 mc. (Set SWEEP WIDTH range selector to W for Model SPA-3a.)

(11) Repeat step a.

d. Connect a 10.5 mc signal to the spectrum analyzer. Set the ZERO ADJUST control to the center of its range on low band. Set the SWEEP WIDTH dial to 0.5 mc. Turn the CENTER FREQUENCY dial to 10.5 MC. Adjust the CAL trimmer capacitor C263, located on the front panel, so that the 10.5 mc pip is in the center of the screen.

e. Turn the CENTER FREQUENCY dial to 0. Adjust L129 so that zero-frequency pip is in the center of the screen.

f. Repeat steps d and e until 0 mc and 10.5 mc calibration has been accurately accomplished.

g. Connect a 23.5 mc signal to the spectrum analyzers. Set the CENTER FREQUENCY dial to 23.5 mc. (Be sure the equipment is set for the high band.) If necessary, change the value of C270 so that the 23.5 mc pip is in the center of the screen.

h. The CENTER FREQUENCY dial settings can be checked by using the internal markers. Set the MARKERS FREQUENCY selector to the 500 KC position. Adjust the MARKERS LEVEL control for a convenient height of marker presentations. If required, construct an error chart for the dial or calibrate a new dial.

i. With the SWEEP WIDTH control set to 3 mc, center a 2 mc pip on the screen. Using the markers as an indication, set the SWEEP WIDTH range selector so that the sweep is 3 mc. The sweep is 3 mc when the third marker pip on either side of the 2 mc pip is ±1/2 division from the either edge of the calibrated crt screen. If equipment is the Model SPA-3/25a, after the SWEEP WIDTH range selector has been set on the center frequency low band, change R342, if necessary, for a 3 mc sweep at a 10.5 mc center frequency (high band).

j. Check the SWEEP WIDTH dial calibrations as given in Section 2. If required, construct an error chart for the dial or calibrate a new dial.

5-41. OSCILLATOR ALIGNMENT (SPA-3a). Oscillator alignment of Model SPA-3a is performed as follows:

a. Repeat steps a through c of paragraph 5-40.

b. Set the ZERO ADJUST control to the center of its range.

c. Connect a 13.5 mc voltage to the spectrum analyzer. Turn the CENTER FREQUENCY dial to 13.5 mc. Adjust the CAL trimmer capacitor so that the 13.5 mc pip is in the center of the screen.

d. Turn the CENTER FREQUENCY dial to 0. The zero-frequency pip should appear in the center of the screen. If necessary, adjust R353, BIAS control, measured at the BIAS TEST JACK. Bias voltage shall be 0.95 ±0.1 volts.

e. Repeat steps c and d until 0 and 13.5 on the CENTER FREQUENCY dial are calibrated correctly. If required, construct an error chart for the dial or calibrate a new dial.

f. Check and adjust, if necessary, the SWEEP WIDTH dial as directed in paragraph 5-40, step i.

g. Set the SWEEP WIDTH dial to 3 mc. Set the SWEEP WIDTH range selector to W. Turn the CENTER FREQUENCY dial to 0. The zero-frequency pip should appear in the center of the screen.

h. Set the SWEEP WIDTH range selector to N. The zero-frequency pip should appear on the screen. If necessary, adjust L129. The pip will appear wider in the N position because of reduced sweep width.

i. Set the SWEEP WIDTH range selector to W. Turn the CENTER FREQUENCY dial until a 13.5 mc pip appears in the center of the screen. Set the SWEEP WIDTH range selector to N. The pip should still appear on the screen. If necessary, adjust C264.

j. Repeat steps h and i until the 0 and 13.5 mc pips remain on the screen while alternating between W to N sweep widths.

5-42. FLATNESS ADJUSTMENTS. Be sure that the inputs are connected correctly to the spectrum analyzer.

a. Connect a 25 uv, 2 mc signal to the spectrum analyzer. Set all attenuators to minimum attenuation. Set the CENTER FREQUENCY control to 2 MC. Set the SWEEP WIDTH control to 3 MC. Set the AMPLITUDE SCALE selector to LIN. Adjust the IF GAIN potentiometer so that the 25 uv, 2 mc pip is of full-scale amplitude.

b. Connect a 25 uv, 13.5 mc signal (23.5 mc for Model SPA-3/25a) to the input connector. Tune C107, C115, and C117 for maximum pip height and then for flatness.

c. Check amplitude flatness over the frequency range of the equipment. If the high frequency end drops off excessively, slightly reduce the values of factory selected resistors R137 and R142. Repeat steps a and b. If the high frequency end rises excessively, slightly increase the value of the factory selected resistors R137 and R142. Repeat steps a and b.

5-43. ADJUSTING LIN LOG AMPLITUDE SCALES AND STANDARD SENSITIVITY.

a. Set the CENTER FREQUENCY dial to 2 MC, the SWEEP WIDTH dial to 0.5 MC, the IF ATTEN switches to 0 DB, and the AMPLITUDE SCALE selector to LIN. Connect a 2 mc signal to the spectrum analyzer and adjust the voltage level for a full-scale crt deflection.

b. Set the AMPLITUDE SCALE selector to LOG.

c. Adjust the 20 DB LOG ADJ potentiometer for a 20 db pip height on the DB amplitude scale of the crt screen.

d. Increase the input voltage amplitude 10 times.

e. Adjust the 0 DB LOG ADJ potentiometer for a full-scale pip.

f. Repeat steps a through e until the LOG amplitude scale is correct.

g. Set the AMPLITUDE SCALE selector to LIN and the SWEEP WIDTH dial to 3 mc. Set all attenuation controls to minimum. Adjust the IF GAIN potentiometer so that a 25 uv, 2 mc pip is of full-scale amplitude.

h. Check the calibration points on the crt amplitude scales and, if necessary, construct an error chart or calibrate a new crt screen.

5-44. FINAL TEST PROCEDURE.

5-45. The spectrum analyzer should be tested after it has been repaired. Repaired equipment, meeting the standards indicated in the test procedures of this section, will furnish uniformly satisfactory operation.

5-46. MOUNTING, INTERCONNECTION, AND INITIAL ADJUSTMENTS. Mount and interconnect the equipment in accordance with the instructions given in Section 2. Perform the initial adjustments given in Section 2.

5-47. SWEEP RATE. Turn the SYNC AMP(ADJUST) control completely counterclockwise. Set the CAL - SYNC SEL switch to CAL. Set the SWEEP RATE control completely clockwise. Turn the SYNC AMP control clockwise and, if necessary, trim the SWEEP RATE control until a one-cycle sine wave appears stationary on the crt screen. This demonstrates that the minimum sweep rate is at least 60 cps. Turn the SWEEP RATE control completely counterclockwise. Using a watch, count the number of sweeps that occur in 20 seconds. There should be 20 or fewer sweeps in 20 seconds, demonstrating that the minimum sweep rate is one cps or less.

5-48. This test demonstrates that the range of the SWEEP RATE control is at least 1 to 60 cps.

5-49. SENSITIVITY.

a. Adjust the sweep rate to approximately 30 cps in accordance with instructions given in Section 2.

b. Set the front-panel controls as follows:

Control	Setting
AMPLITUDE SCALE Selector	LIN
IF ATTEN Switches	0 DB
INPUT ATTENUATOR, - CONTINUOUS Control	Completely counterclockwise
INPUT ATTENUATOR Step Switches	0 DB
IF BANDWIDTH Control	MAX
VIDEO FILTER Control	OFF
SWEEP WIDTH Control	3 MC

c. Connect a signal generator to the spectrum analyzer. Set the CENTER FREQUENCY dial and the signal generator to 2 mc. Set the generator level for a full-scale pip on the crt screen.

NOTE

An approximately 25-microvolt input to the equipment indicates correct sensitivity.

d. Note that in the absence of a suitable signal generator, a rough check of sensitivity correctness is the presence of noise on the screen when the INPUT ATTENUATOR step switches are set to 80 DB and the I-F ATTEN switches are set to 0 db.

5-50. IF ATTEN SWITCHES.

a. With the sweep rate set to 30 cps and the front-panel controls set as in paragraph 5-49, set the signal generator input for full-scale deflection on the crt and note the input amplitude. Set the IF ATTEN switches to 15 DB. Reset the signal generator input level for full-scale deflection. Note the required level.

b. If the IF ATTEN switches are working correctly, the generator input at 15 DB should be 5.4 to 5.8 times that at 0 DB.

5-51. INPUT ATTENUATOR CONTROLS.

a. With the sweep rate set to 30 cps and the front-panel controls set as in paragraph 5-49, set the signal generator input for full-scale deflection on the crt and note the input amplitude. Set the INPUT ATTENUATOR step switches to 20 DB, 40 DB, 60 DB, and 80 DB, resetting and noting the generator level for a full-scale deflection on the crt at each position.

b. If the INPUT ATTENUATOR step switches are working correctly, the level required at each switch position is greater than at the 0 DB position; at the 20 DB position 20 ±1 db, at the 40 DB position 40 ±2 db, at the 60 DB position 60 ±3 db, and at the 80 DB position 80 ±4 db.

c. Set the generator for full-scale deflection on the crt. Increase the generator input 10 times. Turn the INPUT ATTENUATOR - CONTINUOUS control completely clockwise.

d. If the INPUT ATTENUATOR - CONTINUOUS control is working correctly, the crt deflection should be full scale or less.

5-52. BALANCE. Set the CENTER FREQUENCY dial to 0 and the other front-panel controls as in paragraph 5-49. At several sweep rates between 1 cps and 60 cps and several sweep widths between 0 and 3 mc, it should be possible to cause the zero-frequency pip to go through a minimum point using the A BAL and S BAL controls.

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5-53. MARKERS AND CENTER FREQUENCY DIAL.

a. Set the INPUT ATTENUATOR step switches to 80 DB and the other front-panel controls as in paragraph 5-49. Note that, at higher frequencies, the IF ATTEN switches must be set to 0 DB to obtain a suitable marker presentation. Set the CENTER FREQUENCY dial to 2 MC and the MARKERS switch to 500 KC.

b. Adjust the MARKERS - LEVEL control for a convenient height of marker presentation. The 2 mc marker pip should be at or near the center of the screen. Gradually reduce the sweep width, noting the change in the 2 mc pip.

c. If the top of the pip moves to either side of its original position as sweep width is reduced, adjust the CENTER FREQUENCY dial slightly to keep the pip at the center of the screen.

d. Return to 3 mc sweep width and adjust the H POS control until the top of the pip with the center vertical line (zero-frequency calibration) is on the screen. Marker pips should be present every 0.5 mc from 0.5 mc to 15 mc on the Model SPA-3a and to 25 mc on the Model SPA-3/25a.

e. Check the CENTER FREQUENCY dial by setting the SWEEP WIDTH dial to 3 mc, then set the CENTER FREQUENCY dial to corresponding marker frequency, starting with the CENTER FREQUENCY dial set to 0. The top of the pip should appear at or near the center of the screen. Be sure that the ZERO ADJUST control is set so that the zero-frequency pip is at the center of the screen when the CENTER FREQUENCY dial is set to 0 MC.

5-54. SWEEP WIDTH DIAL. Refer to paragraph 2-12.

5-55. FREQUENCY LINEARITY. With the SWEEP WIDTH dial set accurately for a 3 mc sweep width (use the markers) and the other front-panel controls set as in paragraph 5-49, center a convenient input pip on the screen. Change the input frequency in five steps of 300 kc above and below the frequency of the center pip. Each signal pip should fall within one-half division of its appropriate marking. Note that this test can be performed conveniently by using a harmonically rich 300 kc signal source to place on the crt screen 11 pips which are equally spaced in frequency.

5-56. RESOLUTION. Representative points on the resolution graph may be checked by using the following procedure:

a. Set the front-panel controls as indicated in paragraph 5-49, step b.

b. Connect an fm signal generator to the analyzer input and set the CENTER FREQUENCY dial to match the generator output.

c. Adjust the IF BANDWIDTH control for optimum resolution.

d. Frequency modulate the signal generator carrier with a frequency-calibrated oscillator. (A range of approximately 200 cps to 20 kc is required to check the full range of resolution.)

e. Adjust the fm signal generator and the modulating oscillator so that the carrier and the closest modulation product are both full-scale pips whose point of intersection is 30 percent down from the top of the pips. The frequency setting of the modulating oscillator is the resolution of the spectrum analyzer.

5-57. AMPLITUDE RESPONSE.

a. Set the front-panel controls as in paragraph 5-49, step b. Set the SWEEP WIDTH dial to 3 mc and the CENTER FREQUENCY dial to 0.5 MC. Set the generator frequency to 0.5 mc and adjust the level for a full-scale deflection on the crt. Be sure that the generator is connected in accordance with paragraph 2-10 steps e and f since mismatching will affect amplitude response. If the Model PRB-1a is used, refer to paragraph 5-60.

b. While maintaining a constant-amplitude input to the equipment, vary the frequency of the generator from 0.5 mc to 13.5 mc (to 23.5 mc with an SPA-3/25a), keeping the pip at the center of the crt screen with the CENTER FREQUENCY dial. The variation of pip amplitude should not be greater than ±15 percent.

NOTE

It normally is unnecessary to check the amplitude response at the low-frequency end of the range since it is unusual for failure to occur at this end of the range. If failure is suspected, measurements must be made at reduced sweep width, reduced sweep rate, and narrow i-f bandwidth. (Refer to Section 3 for narrow-band measurement techniques.) Since adjustment of sweep width, sweep rate, and i-f bandwidth changes sensitivity, in order to measure amplitude-versus-frequency response down to 1 kc, it is necessary to correlate sensitivites at various sweep widths, sweep rates, and i-f bandwidths.

5-58. CRT AMPLITUDE SCALE. Check the amplitude scales using a voltage of variable known amplitude and low distortion. The voltages given in these checks are approximate since the instrument measures relative amplitude rather than absolute amplitude. Any convenient fixed CENTER FREQUENCY and SWEEP WIDTH dial settings compatible with the generator frequency and pip readability may be used.

a. Set the controls as follows:

Control	Setting
AMPLITUDE SCALE Selector	LIN
IF ATTEN Switches	0 DB
INPUT ATTENUATOR - CONTINUOUS Control	Completely counterclockwise
INPUT ATTENUATOR Step Switches	20 DB
IF BANDWIDTH Control	MAX
VIDEO FILTER Control	OFF
SWEEP RATE Control	30 cps

b. Adjust the generator level for a full-scale crt deflection. Switch the AMPLITUDE SCALE selector to LOG. The pip amplitude should be in line with the 20 DB calibration dot on the left side of the calibrated crt scale. Change INPUT ATTENUATOR step switches to 0 DB. Pip amplitude will again increase to full scale. Intermediate-amplitude calibration points on the crt screen for the LOG position of the AMPLITUDE SCALE selector may be checked, using the IF ATTEN and INPUT ATTENUATOR step switches in 5 db steps. Intermediate-amplitude calibration points on the crt screen for the LIN position of the AMPLITUDE SCALE selector may be checked against known input levels.

c. Switch the AMPLITUDE SCALE selector to PWR (power). Using the INPUT ATTENUATOR step switches and CONTINUOUS control, obtain a full-scale pip. Decrease the input amplitude of the signal 3 db. The pip amplitude should decrease approximately 5 linear divisions of the crt screen. Note that because of the ac coupling in the circuit, the PWR (power) scale functions properly only with narrow pips and high sweep rates.

5-59. OPERATION WITH MODEL SW-1. If the Model SPA-3a or SPA-3/25a is supplied with a Model SW-1, interconnect the two units in accordance with the Model SW-1 instruction manual. Turn on the power switch of the Model SW-1. The SW-1 relay should switch at the end of each analyzer sweep.

5-60. PROBE OPERATION. If the Model SPA-3a or SPA-3/25a is supplied with a Model PRB-1a probe, perform the following checks:

a. Set the front-panel control as in paragraph 5-49, step b.

b. Set the CENTER FREQUENCY dial to 2 MC and the signal generator frequency to 2 mc.

c. Connect the probe, without any attenuator head, to the spectrum analyzer in accordance with instructions given in Section 6.

d. Connect the signal generator to the input of the probe through the normal output termination of the generator. Set the generator level for a full-scale deflection on the crt and note the generator level.

e. Using the 20 db attenuator head, adjust the generator output for full-scale deflection on the crt. If the probe is working correctly, the generator output should be approximately 10 times that required for direct input to the spectrum analyzer.

f. Using the 40 db attenuator head, adjust the generator for full-scale deflection. The level should be approximately 100 times that required for direct input.

g. Using the 60 db attenuator head, adjust the generator for full-scale deflection. The level should be approximately 1000 times that required for direct input.

h. Set the generator output for full-scale deflection on the crt. Maintaining a constant amplitude input to the probe, vary the generator frequency from 0.5 mc to 13.5 mc (to 23.5 mc with the Model SPA-3/25a), using the CENTER FREQUENCY dial to keep the pip at the center of the screen. The amplitude variation of the pip should not be greater than ±3 db.

5-61. SPARE FUSES AND TOOLS. Check to see that two 3-ampere, 250-volt cartridge fuses are mounted on the rear apron of the Model PS-19 chassis. Check to see that the following tools are mounted on the rear apron of the spectrum analyzer chassis:

1 - No. 4 Key for multiple-spline socket screw.
1 - No. 6 Key for 4-point-spline socket screw.
1 - No. 8 Key for multiple-spline socket screw.
1 - Walsco No. 2543 alignment tool.
1 - Cambridge Thermionic No. X2033 alignment tool.

SECTION 6

ACCESSORY EQUIPMENT

6-1. INTRODUCTION.

6-2. This section contains information regarding the Cathode Follower Probe, Model PRB-1a (Figure 6-1), which can be used with the Spectrum Analyzer, Models SPA-3a and SPA-3/25a. There should be no attempt made to operate the probe until the user is thoroughly familiar with the operating procedure.

6-3. GENERAL DESCRIPTION.

6-4. The Cathode Follower Probe, Model PRB-1a, permits connection of signals from a high-impedance source to the Spectrum Analyzer, Model SPA-3a or SPA-3/25a. The complete probe consists of a cathode-follower section (with attached rf and power cables), a uhf-to-BNC adapter (usually shipped attached to the rf cable), three attenuator heads (a 20 db head, a 40 db head, and a 60 db head), and three test points (a straight point, a hooked point, and an alligator-clip point).

6-5. SPECIFICATIONS.

6-6. The specifications of the cathode follower probe are listed in the specification chart.

SPECIFICATION CHART

Frequency response, 1 kc to 23.5 mc (without attenuator head) . . . . ±3 db

Insertion loss . . . . . . 10 db (approximately)

Input impedance (without attenuator head) . . . . 12 megohms shunted by 5 uuf

NOTE

Low-frequency response drops off appreciably at low frequency when using an attenuator head. The input impedance depends on the attenuator head being used.

Maximum permissible total rms input voltage:

Probe without attenuator head . . . . 0.1 volt

20 db attenuator head (single gold band) . . . . 1 volt

40 db attenuator head (double gold band) . . . . 10 volts

60 db attenuator head (triple gold band) . . . . 100 volts

6-7. INSTALLATION.

6-8. Connect the 4-contact plug to the PROBE receptacle on the Model SPA-3a or SPA-3/25a front panel. The rf cable is attached to the BNC connector of the input receptacle on the spectrum analyzer front panel using the uhf-to-BNC adapter supplied. As determined by the signal levels involved (refer to paragraph 6-5), the probe is used without attenuator head or with one of the three supplied attenuator heads. The attenuator heads screw on to the cathode-follower section. Note that to indicate attenuation, the attenuator heads are banded. The single-gold-banded head has an attenuation of 20 db. The double-gold-banded head has an attenuation of 40 db. The triple-gold-banded head has an attenuation of 60 db. For convenience, three different test points are supplied. They screw on to the cathode-follower section (when used without an attenuator head) or the attenuator head. The probe test tip is connected to the signal source. Be sure to connect the ground clip of the probe to the ground side of the signal source.

CAUTION

Be sure that the maximum input-signal levels to the probe are not exceeded or harmonics of the input signal will be generated.

The normal overload conditions for the Models SPA-3a and SPA-3/25a apply when the probe is connected. Refer to Section 3.

6-9. CIRCUIT DESCRIPTION.

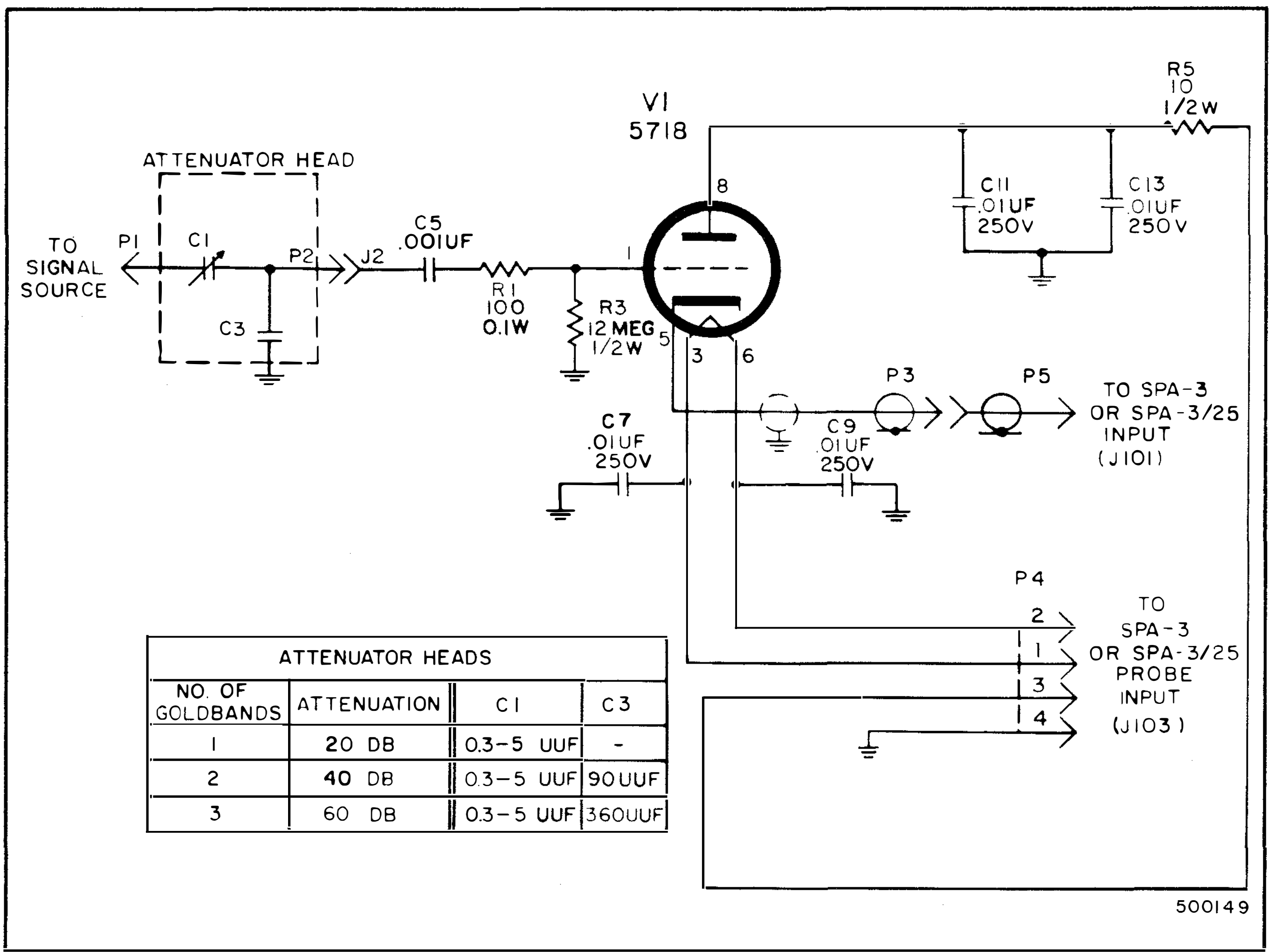
6-10. The cathode follower is a type 5718 triode whose cathode load is the 72-ohm resistance of the spectrum analyzer input circuit. Plate and heater voltages for the tube are provided through the 4-contact plug which is connected to the spectrum analyzer. The attenuator heads are simple capacitive divider attenuators.

6-11. SERVICE AND MAINTENANCE.

6-12. TROUBLESHOOTING. The troubleshooting procedures are contained in the troubleshooting chart.

TROUBLESHOOTING CHART

Symptom	Corrective Measures
No output	If probe does not get warm: a. Check voltages at J103. b. Check filament of probe tube for continuity. c. Check probe plug for broken leads.
No output using attenuator head	Remove head; apply voltage directly to probe to determine whether or not the head is defective.
Incorrect output using attenuator head	Realign head in accordance with paragraph 6-13.



ATTENUATOR HEADS			
NO. OF GOLDBANDS	ATTENUATION	C1	C3
1	20 DB	0.3-5 UUF	-
2	40 DB	0.3-5 UUF	90UUF
3	60 DB	0.3-5 UUF	360UUF

Figure 6-1. Cathode-Follower Probe, Model PRB-1a, Schematic Diagram

6-13. ALIGNMENT. The alignment procedures are contained in the following steps:

a. The 20 db attenuator head is aligned as described below.

(1) Adjust the spectrum analyzer controls for maximum sensitivity and the CENTER FREQUENCY dial to 2 MC. Connect the probe, without any attenuator head, to the input of the analyzer.

(2) Connect a signal generator (with accurate means of changing and measuring relative level) to the input of the probe. Set the generator frequency to 2 mc. Be sure the generator is connected to the probe through the normal generator output termination. Adjust the generator level for a full-scale pip on the spectrum analyzer and note the generator level.

(3) With the 20 db attenuator head installed, increase the generator output 10 times. If required, adjust the probe for a full-scale pip on the crt of the spectrum analyzer. This is done by an adjusting screw in the tip of the attenuator head. A jeweler's screwdriver is required and is supplied with the probe.

b. The 40 db attenuator head is aligned as described below.

(1) Replace the 20 db attenuator head with the 40 db attenuator head.

(2) Increase the generator output to 100 times the output required for full-scale deflection without an attenuator head. If required, adjust the probe for a full scale pip on the crt of the spectrum analyzer.

c. The 60 db attenuator head is aligned as described below.

(1) Replace the 40 db attenuator head with the 60 db attenuator head.

(2) Increase the generator output to 1000 times the output required for full-scale deflection without an attenuator head. If required, adjust the probe output for a full-scale pip on the crt of the spectrum analyzer.

6-14. VOLTAGE AND RESISTANCE MEASUREMENTS. The voltage and resistance measurements are obtained using an RCA Volt-Ohmyst WV-77A (or equivalent), and are listed in the voltage and resistance chart, table 6-1.

TABLE 6-1. VOLTAGE AND RESISTANCE CHART

Pin	1	2	3	4
Voltage	4.6 volts ac	zero	90 volts dc (with probe connected) 250 volts dc (without probe)	zero
Resistance	Less than 0.1 ohm	Less than 0.1 ohm	20,000 ohms	zero

SECTION 7

LIST OF REPLACEABLE PARTS

7-1. INTRODUCTION.

7-2. This list is divided into two parts; the first part covers the Models SPA-3a and SPA-3/25a analyzers, and the second part covers the Model PS-19 power supply.

7-3. The total quantity for each item appears in the list only once, and is given in the "Quantity In Set" column the first time it appears in the list.

7-4. A list of manufacturers' codes, as used in the "Manufacturer's Code" column of the list, is given at the end of this section.

7-5. In some cases, the values, ratings, and source (manufacturer) shown are nominal, and variations may be found. Satisfactory replacement may be made with either the listed component, or an exact replacement for the part removed from the equipment.

7-6. When ordering parts from The Singer Company, Metrics Division, be sure to include the following information:

Instrument Model Number

Instrument Serial Number

Circuit Reference Symbol

Description of Part

Singer Part Number

List of Replaceable Parts For Models SPA-3a and SPA-3/25a

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
C103	CAPACITOR: fixed, electrolytic, 10 uf, 15V	556074-041	56289 CE71X105	2	
C104	CAPACITOR: fixed, electrolytic, 10 uf, 15V	556074-041	56289 CE71X100E		
C106	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556120-026	14655 PJ4P25	2	
C107	CAPACITOR: variable, piston type, 1 to 18 uuf	556122-027	J. F. D. ELECTRONICS VC-4G	3	
C108	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0	16	
C109	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C110	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C111	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C115	CAPACITOR: variable, piston type, 1 to 18 uuf	556122-027	J. F. D. ELECTRONICS VC-4G		
C116	CAPACITOR: fixed, electrolytic, tubular, 4 uf, 350V	556074-028	56289 CE71X040P-1	1	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
C117	CAPACITOR: variable, piston type, 1 to 18 uuf	556122-027	J. F. D. ELECTRONICS VC-4G	1	
C119	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C121	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C123	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z	33	
C125	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C127	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C129	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C131	CAPACITOR: variable, piston type, 1 to 5 uuf	556122-012	J. F. D. ELECTRONICS VC-5	1	
C133	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C136	CAPACITOR; fixed, ceramic, feedthru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000	11	
C137	CAPACITOR: fixed, electrolytic, twistlock, 4x4 uf, 450V	556066-004	56289 TUL4775	1	
C139	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C141	CAPACITOR: fixed, ceramic disc, 0.01 uf ±20%, 500V	556060-073	55814 CD16XD103Z		
C143	CAPACITOR: fixed, ceramic disc, 0.65 uf, 500V	556060-081	72982 827200Z5V0		
C145	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C147	CAPACITOR: fixed, composition, 2.2 uuf, ±10%, 500V	556060-008	72653 TYPE GA	1	
C149	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C151	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C153	CAPACITOR: fixed, silvered mica, 15 uf, ±5%, 300V	556070-009	72136 TYPE N750 CM15C100J	1	
C155	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
C157	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C159	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C161	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C162	CAPACITOR: fixed, ceramic feedthru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C163	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C164	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C165	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C167	CAPACITOR: variable, ceramic trimmer, 8 to 50 uuf	556122-009	71590 TYPE N-650, 822AN	3	
C169	CAPACITOR: fixed, silvered mica, 15 uuf, ±5%, 300V	556078-007	72136 CM15C150J	1	
C171	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C173	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187A	24	
C175	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C177	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C179	CAPACITOR: variable, ceramic trimmer, 8 to 50 uuf	556122-009	71590 TYPE N-650, 822AN		
C181	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C183	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C185	CAPACITOR: variable, ceramic trimmer, 8 to 50 uuf	556122-009	71590 TYPE N-650, 822AN		
C187	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C189	CAPACITOR: fixed, silvered mica, 20 uuf, ±5%, 300V	556078-004	72136 CM15C200J		
C191	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		

List of Replaceable Parts for Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
C193	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C195	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C197	CAPACITOR: fixed, silvered mica, 47 uuf, ±5%, 300V	556079-025	72136 CM15C470J	2	
C199	CAPACITOR: fixed, silvered mica, 100 uuf, ±5%, 300V	556079-001	72136 CM15C101J	2	
C203	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C204	CAPACITOR: fixed, silvered mica, 470 uuf, ±5%, 300V	556079-026	72136 CM15C471J	3	
C207	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C209	CAPACITOR: fixed, silvered mica, 100 uuf, ±5%, 500V	556082-014	72136 CM20C101J	2	
C211	CAPACITOR: fixed, ceramic disc, 0.65 uf, 500V	556060-081	72982 827200Z5V0		
C213	CAPACITOR: fixed, mylar, 1000 uuf, 400V	556120-079	72928 338E102M	1	
C215	CAPACITOR: fixed, silvered mica, 100 uuf, ±5%, 500V	556082-014	72136 CM20C101J		
C217	CAPACITOR: fixed, ceramic disc, 0.65 uf, 500V	556060-081	72982 827200Z5V0		
C219	CAPACITOR: fixed, ceramic disc, 0.65 uf, 500V	556060-081	72982 827200Z5V0		
C220	CAPACITOR: fixed, ceramic disc, 0.65 uf, 500V	556060-081	72982 827200Z5V0		
C221	CAPACITOR: fixed, silvered mica, 240 uuf, ±5%, 500V	556082-011	72136 CM20C241J	1	
C223	CAPACITOR: fixed, silvered mica, 75 uuf, ±5%, 300V	556079-033	72136 CM15E750J	2	
C225	CAPACITOR: fixed, silvered mica, 750 uuf, ±5%, 300V	556081-041	72136 CM20C751J	1	
C227	CAPACITOR: fixed, mylar, 0.22 uf, 400V	556120-107	72928 338E224M	1	
C229	CAPACITOR: fixed, molded tubular, 0.1 uf, 200V	556120-037	56289 2TM-P1	1	
C231	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		

List of Replaceable Parts for Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
C233	CAPACITOR: fixed, silvered mica, 10 uuf, ±5%, 500V	556082-018	72136 CM20C100J	1	
C235	CAPACITOR: fixed, silvered mica, 75 uuf, ±5%, 300V	556079-033	72136 CM15E750J		
C237	CAPACITOR: fixed, silvered mica, 5100 uuf, ±5%, 500V	556088-008	72136 CM30B512J	1	
C239	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C241	CAPACITOR: fixed, silvered mica, 2700 uuf, ±5%, 500V	556089-003	72136 CM30C272J	1	
C242	CAPACITOR: fixed, silvered mica, 100 uuf, ±5%, 300V	556079-001	72136 CM15C101J	1	
C245	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C247	CAPACITOR: fixed, silvered mica, 2200 uuf, ±5%, 500V	556087-015	72136 CM30E222J	2	
C249	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C251	CAPACITOR: fixed, silvered mica, 2200 uuf, ±5%, 500V	556087-015	72136 CM30E222J		
C253	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C255	CAPACITOR: fixed, silvered mica, 180 uuf, ±5%, 300V	556079-007	72136 CM15E181J	1	
C257	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C259	CAPACITOR: fixed, silvered mica, 470 uuf, ±5%, 300V	556079-026	72136 CM15C471J		
C261	CAPACITOR: fixed, silvered mica, 470 uuf, ±5%, 300V	556079-026	72136 CM15C471J		
C262	CAPACITOR: fixed, silvered mica, 330 uuf, ±5%, 300V	556079-019	72136 CM15E331J	1	
C263	CAPACITOR: variable air dual, trimmer section	556168-146	74868 160-121	1	
C264 (Model SPA-3/25a)	CAPACITOR: variable, ceramic NPO trimmer, 1.5 to 7 uuf	556122-037	71590 822-E2	1	
C265 (Model SPA-3/25a)	CAPACITOR: dual, variable, air dielectric, 8.3 to 81 uuf each section	556122-072	80583 HFAD75A	1	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
C265 A, B (Model SPA-3/25a)	CAPACITOR: dual, variable, air dielectric, 6.5 to 51 uuf	556122-008	74970 167-52	1	
C267 (Model SPA-3/25a)	CAPACITOR: adjustable, air trimmer, 3 to 6 uuf	556168-084	71313 PL6000	1	
C267 (Model SPA-3a)	CAPACITOR: adjustable, air trimmer, 3 to 6 uuf	556168-085	71313 PL6000	1	
C269	CAPACITOR: fixed, silvered mica, 20 uuf, ±5%, 300V	556078-004	72136 CM15C200J		
C270 (Model SPA-3/25a)	CAPACITOR: fixed, silvered mica, 20 uuf, ±5%, 300V	556078-004	72136 CM15C200J	1	
C271	CAPACITOR: fixed, silvered mica, 20 uuf, ±5%, 300V	556078-004	72136 CM15C200J		
C273	CAPACITOR: fixed, silvered mica, 47 uuf, ±5%, 300V	556079-025	72136 CM15C470J		
C275	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C277	CAPACITOR: fixed, silvered mica, 1000 uuf, ±5%, 300V	556081-004	72136 CM20C102J	3	
C279	CAPACITOR: fixed, silvered mica, 1000 uuf, ±5%, 300V	556081-004	72136 CM20C102J		
C281	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C283	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C285	CAPACITOR: fixed, mylar, 4700 uuf, 400V	556120-104	72928 338E472M	1	
C287	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C289	CAPACITOR: fixed, molded tubular, 0.022 uf, 400V	556120-111	56289 4TM-S22	1	
C291	CAPACITOR: fixed, silvered mica, 91 uuf, ±5%, 500V	556081-044	72136 CM20C910J	1	
C292	CAPACITOR: fixed, silvered mica, 1000 uuf, ±5%, 300V	556081-004	72136 CM20C102J		
C293	CAPACITOR: fixed, molded tubular, 0.25 uf, 400V	556120-026	14655 PJ4P25		

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
C295	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C297	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C299	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C301	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C303	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C305	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C307	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C309	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C311	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C313	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C315	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C317	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C318	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C319	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C320	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C321	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C323	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C325	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C326	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C327	CAPACITOR: fixed, electrolytic, twistlock, 2000 uf, 15V	556062-003	56289 TVL1168		

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
C328	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C329	CAPACITOR: fixed, silvered mica, 200 uuf, ±5%, 300V	556079-008	72136 CM15E201J		
C331	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C333	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C335	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C337	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C338	CAPACITOR: fixed, ceramic disc, 0.02 uf, ±20%, 500V	556060-023	56289 29C187-A		
C339	CAPACITOR: fixed, ceramic disc, 0.01 uf, ±20%, 500V	556060-073	55814 CD16XD103Z		
C340	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C341	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C342	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C343	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C344	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C345	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C346	CAPACITOR: fixed, ceramic feed thru, 1000 uuf, ±20%, 500V	556060-071	72982 327-1000		
C501	CAPACITOR: fixed, silvered mica, 62 uuf, ±5%, 300V, test selected	556081-038	72136 CM15C620J	1	
C505	CAPACITOR: fixed, ceramic disc, 0.05 uuf, 500V	556060-081	72982 827200Z5V0		
CR101	RECTIFIER: selenium, bridge, 1.5 amp, 26 VAC, 4 cell	556118-021	77638 C11S1B1S1G	1	
CR102	DIODE: germanium	556118-045	77638 IN128		
CR103	DIODE: zener, 150V, 10W, ±20%	556118-140	81483 IN3011	1	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
DS101	LAMP: incandescent	556002-006	24446 47	1	
DS102	LAMP: miniature, type No. 349, 6.3V, 0.206 amp	556002-130	24446 349	3	
DS103	LAMP: miniature, type No. 349, 6.3V, 0.206 amp	556002-130	24446 349		
DS104	LAMP: miniature, type No. 349, 6.3V, 0.206 amp	556002-130	24446 349		
DS105	LAMP: miniature, type No. 349, 6.3V, 0.206 amp	556002-130	24446 349		
DS106 (Model SPA-3/25a)	LAMP: indicator, miniature, light yellow, neon, hot stamp "LO"	556002-103	72619 38-1536	1	
DS107 (Model SPA-3/25a)	LAMP: indicator, miniature, red neon, hot stamp "H"	556002-104	72619 38-1581	1	
E101	LAMP: neon, 1/4W, double contact, bayonet, candelabra	556002-034	16665 Type NE-16, C1-9064	1	
J103	CONNECTOR: receptacle, 4 contact, female, microphone type	556010-077	02660 91PC4F	1	
J105	CONNECTOR: receptacle, BNC D type, MIL type UG-1094/U	556010-038	02660 31-221	8	
J107	CONNECTOR: receptacle, BNC D type, MIL type UG-1094/U	556010-038	02660 31-221		
J109	CONNECTOR: jack, telephone, two conductor, open circuit	556010-067	71002 257	1	
J111	CONNECTOR: post, binding	556010-041	74970 111-103	4	
J113	CONNECTOR: receptacle, 12 pin, female	556010-069	71313 M12S-LS12-N	1	
J115	CONNECTOR: jack, tip, red	556024-085	98291 SKT-8	1	
J117	CONNECTOR: receptacle, BNC D type, MIL type UG-1094/U	556010-038	02660 31-221		
J119	CONNECTOR: receptacle, BNC D type, MIL type UG-1094/U	556010-038	02660 31-221		
J121	CONNECTOR: receptacle, BNC D type, MIL type UG-1094/U	556010-038	02660 31-221		
J123	CONNECTOR: receptacle, BNC D type, MIL type UG-1094/U	556010-038	02660 31-221		

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
J125	CONNECTOR: receptacle, BNC D type, MIL type UG-1094/U	556010-038	02660 31-221		
J129	CONNECTOR: receptacle, 10 pin, female	556010-030	02660 MS3102A-18-15	1	
J130	CONNECTOR: post, binding	556010-041	74970 111-103		
J131	CONNECTOR: receptacle, 14 pin, male	556016-011	02660 MS3012A-28-2P	1	
J501	CONNECTOR: receptacle, BNC D type, MIL type UG-1094/U	556010-038	02660 31-221		
J502	CONNECTOR: receptacle, BNC, MIL type UG-1098/U, right angle	556010-078	02660 31-222	1	
L101	CHOKE: r-f, 2.7 uh, ±10%	556012-043	99849 210-11	1	
L102	CHOKE: r-f, 6.8 uh, ±10%	556012-044	99849 215-11	1	
L103	CHOKE: r-f, 3.3 uh, ±10%	556012-028	99849 211-11	2	
L104	CHOKE: r-f, 10 uh, ±10%	556012-045	99849 217-21	1	
L105	CHOKE: r-f, 3.3 uh, ±10%	556012-028	99849 211-11		
L107	CHOKE: r-f, 100 uh	556012-001	81279 CH-3-3	6	
L109	COIL: oscillator, 29.3 mc	556026-204	16665 Z2-8376A	1	
L110	CHOKE: r-f, 100 uh	556012-001	81279 CH-3-3		
L111	COIL: crystal loading, 2.7 mc	556026-205	16665 Z2-8377B	2	
L113	CHOKE: r-f, 100 uh	556012-001	81279 CH-3-3		
L115	CHOKE: r-f, 100 uh	556012-001	81279 CH-3-3		
L117	COIL: crystal loading, 2.7 mc	556026-205	16665 Z2-8377B		
L119	CHOKE: r-f, 100 uh	556012-001	81279 CH-3-3		
L121	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A	10	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
L123	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A		
L125	CHOKE: r-f, 100 uh	556012-001	81279 CH-3-3		
L127 (Model SPA-3/25a)	INDUCTOR: Vari-L	556012-038	05375 SD-36A	1	
L127 (Model SPA-3a)	INDUCTOR: Vari-L	556012-114	05375 SD-36D	1	
L128 (Model SPA-3a)	CHOKE: r-f, 24 uh, 300 ma, 0.28 ohm	556012-042	76493 4626	4	
L129 (Model SPA-3a)	COIL: oscillator, variable	556026-203	16665 Z2-8375A	2	
L129 (Model SPA-3/25a)	COIL: oscillator, variable	556026-203	16665 Z2-8375A		
L130	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A		
L131	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A		
L132	CHOKE: r-f	556026-328	16665 ZN-8495	2	
L133	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A		
L134	CHOKE: r-f	556026-328	16665 ZN-8495		
L135	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A		
L137	CHOKE: r-f, 24 uh, 300 ma, 0.28 ohm	556012-042	76493 4626		
L139	CHOKE: r-f, 24 uh, 300 ma, 0.28 ohm	556012-042	76493 4626		
L141	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A		
L143	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A		
L145	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A		

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
L147	CHOKE: r-f, 0.75 uh	556026-472	16665 Z1-10998A		
L148	CHOKE: r-f, 24 uh, 300 ma, 0.28 ohm	556012-042	76493 4626		
K149	CHOKE: r-f, 100 uh	556012-001	81279 CH-3-3		
P105	CONNECTOR: plug, r-f, MIL type UG-260/U	556016-015	02660 31-102	5	
P107	CONNECTOR: plug, r-f, MIL type UG-260/U	556016-015	02660 31-102		
P113	CONNECTOR: plug, 12 contact, male, with shell	556016-112	71313 M12P and M12H	1	
P117	CONNECTOR: plug, r-f	556016-060	74868 8575	1	
P119	CONNECTOR: plug, r-f, MIL type UG-260/U	556016-015	02660 31-102		
P121	CONNECTOR: plug, r-f, MIL type UG-260/U	556016-015	02660 31-102		
P129	CONNECTOR: plug, 10 pin, male	556016-045	02660 MS3106A18-1P	1	
P502	CONNECTOR: plug, r-f, MIL type UG-260/U	556016-015	02660 31-102		
R119	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045	13	
R121	RESISTOR: fixed, composition, 220 ohms, ±5%, 1/2W	151-1003-221J	01131 EB2215	2	
R131	RESISTOR: fixed, composition, 68,000 ohms, ±5%, 1/2W	151-1003-683J	01131 EB6835	2	
R132	RESISTOR: fixed, composition, 33,000 ohms, ±5%, 2W	151-1005-333J	01131 HB3335	2	
R133	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2W	151-1003-102J	01131 EB1025	8	
R134	RESISTOR: fixed, composition, 33,000 ohms, ±5%, 2W	151-1005-333J	01131 HB3335		
R135	RESISTOR: fixed, composition, 200,000 ohms, ±5%, 1/2W	151-1003-204J	01131 EB2045	4	
R136	RESISTOR: fixed, composition, 240,000 ohms, ±5%, 1/2W	151-1003-244J	01131 EB2445	6	
R137	RESISTOR: fixed, composition, 560 ohms, ±5%, 1/2W, test selected	151-1003-561J	01131 EB5615	1	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R138	RESISTOR: fixed, composition, 91 ohms, ±5%, 1/2W	151-1003-910J	01131 EB9105	1	
R139	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R140	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015	10	
R141	RESISTOR: fixed, composition, 2200 ohms, ±5%, 1W	151-1004-222J	01131 GB2225	6	
R142	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2W, test selected	151-1003-102J	01131 EB1025		
R143	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R144	RESISTOR: fixed, composition, 15, 000 ohms, ±5%, 1W	151-1004-153J	01131 GB1535	2	
R145	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R147	RESISTOR: fixed, composition, 620 ohms, ±5%, 1/2W	151-1003-621J	01131 EB6215	3	
R149	RESISTOR: fixed, composition, 620 ohms, ±5%, 1/2W	151-1003-621J	01131 EB6215		
R151	RESISTOR: fixed, composition, 200, 000 ohms, ±5%, 1/2W	151-1003-204J	01131 EB2045		
R152	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1004-101J	01131 EB1015		
R153	RESISTOR: fixed, composition, 200, 000 ohms, ±5%, 1/2W	151-1003-204J	01131 EB2045		
R154	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1004-101J	01131 EB1015		
R155	RESISTOR: fixed, composition, 1800 ohms, ±5%, 1/2W	151-1003-182J	01131 EB1825	2	
R157	RESISTOR: fixed, composition, 1800 ohms, ±5%, 1/2W	151-1003-182J	01131 EB1825		
R159	RESISTOR: fixed, composition, 75, 000 ohms, ±5%, 1/2W	151-1003-753J	01131 EB7535	2	
R161	RESISTOR: variable, composition, linear, 50, 000 ohms, ±10%, 2W	556052-035	16665 RV2-22035	1	
R163	RESISTOR: fixed, composition, 24, 000 ohms, ±5%, 1/2W	151-1003-243J	01131 EB2435	1	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R165	RESISTOR: fixed, composition, 13,000 ohms, ±5%, 1/2W	151-1003-133J	01131 EB1335	1	
R167	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R169	RESISTOR: fixed, composition, 2200 ohms, ±5%, 1/2W	151-1003-22J	01131 EB2225	5	
R171	RESISTOR: fixed, composition, 510 ohms, ±5%, 1/2W	151-1003-511J	01131 EB5115	2	
R173	RESISTOR: variable, composition, linear, 10,000 ohms, ±10%, 2W	556052-005	16665 RV2-22005	1	
R175	RESISTOR: fixed, composition, 510 ohms, ±5%, 1/2W	151-1003-511J	01131 EB5115		
R177	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R178	RESISTOR: fixed, composition, 120 ohms, ±5%, 1/2W, test selected	151-1003-121J	01131 EB1215	2	
R179	RESISTOR: fixed, composition, 1000 ohms, ±5%, 2W	151-1005-102J	01131 HB1025	1	
R183	RESISTOR: fixed, composition, 12 ohms, ±5%, 1/2W	151-1003-120J	01131 EB1205	1	
R185	RESISTOR: fixed, composition, 360 ohms, ±5%, 1/2W	151-1003-361J	01131 EB3615	1	
R187	RESISTOR: variable, composition, linear, 10,000 ohms, ±10%, 2W	151-1005-103K	16665 RV2-22005	1	
R189	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2W	151-1003-154J	01131 EB1545	4	
R191	RESISTOR: fixed, composition, 47,000 ohms, ±5%, 1W	151-1004-473	01131 GB4735	1	
R193	RESISTOR: fixed, composition, 5600 ohms, ±5%, 1/2W	151-1003-562J	01131 EB5625	4	
R195	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R196	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R197	RESISTOR: fixed, wirewound, 4.7 ohms, ±10%, 1/2W	556036-003	75042 Type BW-1/2	1	
R199	RESISTOR: fixed, composition, 6200 ohms, ±5%, 1/2W	151-1003-622J	01131 EB6225	1	

List of Replaceable Parts for Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R201	RESISTOR: fixed, composition, 18,000 ohms, ±5%, 1W	151-1004-183J	01131 GB1835	1	
R203	RESISTOR: fixed, composition, 22 ohms, ±5%, 1/2W	151-1003-220J	01131 EB2205	3	
R205	RESISTOR: fixed, composition, 3900 ohms, ±5%, 1/2W	151-1003-392J	01131 EB3925	1	
R207	RESISTOR: fixed, composition, 220 ohms, ±5%, 1/2W	151-1003-221J	01131 EB2215	1	
R211	RESISTOR: fixed, composition, 39,000 ohms, ±5%, 2W	151-1003-393J	01131 HB3935	1	
R213	RESISTOR: fixed, composition, 5600 ohms, ±5%, 1/2W	151-1003-562J	01131 EB5625		
R215	RESISTOR: fixed, composition, 470,000 ohms, ±5%, 1/2W	151-1003-474J	01131 EB4745	3	
R217	RESISTOR: fixed, composition, 390 ohms, ±5%, 1/2W	151-1003-391J	01131 EB3915	2	
R219	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R221	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R223	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2W	151-1003-102J	01131 EB1025		
R225 A, B	RESISTOR: variable, dual cw log taper, 10,000 ohms, ±10%	556057-013	16665 RV2-22512	1	
R227	RESISTOR: fixed, composition, 200,000 ohms, ±5%, 1/2W	151-1003-204J	01131 EB2045		
R228	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 1/2W, test selected	151-1003-103J	01131 EB1035	2	
R229	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2W	151-103-154J	01131 EB1545	2	
R230	RESISTOR: fixed, composition, 5100 ohms, ±5%, 1/2W	151-1003-512J	01131 EB5125	1	
R231	RESISTOR: fixed, composition, 160 ohms, ±5%, 1/2W	151-1003-161J	01131 EB1615	3	
R233	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2W	151-1003-102J	01131 EB1025		
R235	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R237	RESISTOR: fixed, composition, 390 ohms, ±5%, 1/2W	151-1003-391J	01131 EB3915		

List of Replaceable Parts for Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R239	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R241	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R243	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2W	151-1003-102J	01131 EB1025		
R245	RESISTOR: fixed, composition, 10, 000 ohms, ±5%, 1/2W, test selected	151-1003-103J	01131 EB1035		
R247	RESISTOR: fixed, composition, 2200 ohms, ±5%, 1/2W	151-1003-222J	01131 EB2225		
R249	RESISTOR: fixed, composition, 120, 000 ohms, ±5%, 1/2W	151-1003-124J	01131 EB1245	1	
R251	RESISTOR: fixed, composition, 160 ohms, ±5%, 1/2W	151-1003-161J	01131 EB1615		
R253	RESISTOR: fixed, composition, 160 ohms, ±5%, 1/2W	151-1003-161J	01131 EB1615		
R255	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R257	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R259	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R261	RESISTOR: variable, composition, linear, 100, 000 ohms, ±10%, 2W	556052-025	16665 RV2-22025	3	
R263	RESISTOR: fixed, composition, 15, 000 ohms, ±5%, 1W, test selected	151-1004-153J	01131 GB1535	1	
R265	RESISTOR: fixed, composition, 33, 000 ohms, ±5%, 1W	151-1004-333J	01131 GB3335	1	
R267	RESISTOR: fixed, composition, 5600 ohms, ±5%, 1W	151-1004-562J	01131 GB5625	2	
R269	RESISTOR: fixed, composition, 47, 000 ohms, ±5%, 2W	151-1005-473J	01131 HB4735	1	
R271	RESISTOR: fixed, composition, 5600 ohms, ±5%, 1W	151-1004-562J	01131 GB5625		
R273	RESISTOR: fixed, composition, 20, 000 ohms, ±5%, 1W	151-1004-203J	01131 GB2035	1	
R275	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2W	151-1003-105J	01131 EB1055	6	

List of Replaceable Parts for Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R277	RESISTOR: fixed, composition, 750 ohms, ±5%, 1/2W	151-1003-751J	01131 EB7515	1	
R278	RESISTOR: fixed, composition, 68,000 ohms, ±5%, 1/2W	151-1003-683J	01131 EB6835		
R279	RESISTOR: variable, composition, linear, 100,000 ohms, ±10%, 2W	556052-025	16665 RV2-22025		
R281	RESISTOR: fixed, composition, 11,000 ohms, ±5%, 1/2W	151-1003-113J	01131 EB1135	1	
R283	RESISTOR: fixed, composition, 220,000 ohms, ±5%, 1/2W	151-1003-224J	01131 EB2245	5	
R285	RESISTOR: fixed, composition, 680,000 ohms, ±5%, 1/2W	151-1003-684J	01131 EB6845	1	
R287	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R289	RESISTOR: fixed, composition, 2200 ohms, ±5%, 1/2W	151-1003-222J	01131 EB2225		
R291	RESISTOR: fixed, composition, 4700 ohms, ±5%, 1/2W	151-1003-472J	01131 EB4725	3	
R293	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R295	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2W	151-1003-154J	01131 EB1545		
R297	RESISTOR: fixed, composition, 2200 ohms, ±5%, 1/2W	151-1003-222J	01131 EB2225		
R299	RESISTOR: fixed, composition, 2200 ohms, ±5%, 1/2W	151-1003-222J	01131 EB2225		
R301	RESISTOR: fixed, composition, 220,000 ohms, ±5%, 1/2W	151-1003-224J	01131 EB2245		
R303	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2W	151-1003-105J	01131 EB1055		
R305	RESISTOR: fixed, composition, 4300 ohms, ±5%, 1/2W	151-1003-432J	01131 EB4325	1	
R307	RESISTOR: variable, composition, linear, 5 megohms, ±20%, 2W (includes switch S107)	556056-005	16665 RV2-22704	1	
R309	RESISTOR: fixed, composition, 4.7 megohms, ±5%, 1/2W	151-1003-475J	01131 EB4755	1	
R311	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1W	151-1004-104J	01131 GB1045		

List of Replaceable Parts for Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R313	RESISTOR: fixed, composition, 620 ohms, ±5%, 1/2W	151-1003-621J	01131 EB6215		
R315	RESISTOR: fixed, composition, 120 ohms, ±5%, 1/2W	151-1003-121J	01131 EB1215	1	
R317	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1W	151-1004-104J	01131 GB1045		
R319	RESISTOR: fixed, composition, 1.2 megohms, ±5%, 1/2W	151-1003-125J	01131 EB1255	1	
R321	RESISTOR: fixed, composition, 160, 000 ohms, ±5%, 1/2W	151-1003-164J	01131 EB1645	1	
R323	RESISTOR: fixed, composition, 5600 ohms, ±5%, 1/2W	151-1003-562J	01131 EB5625		
R325	RESISTOR: variable, composition, linear, 500, 000 ohms, ±10%, 2W	556052-015	16665 RV2-22015	3	
R327	RESISTOR: fixed, composition, 68, 000 ohms, ±5%, 1W	151-1004-683J	01131 GB6835	1	
R329	RESISTOR: fixed, composition, 150, 000 ohms, ±5%, 1W	151-1004-154J	01131 GB1545	1	
R331	RESISTOR: fixed, composition, 51, 000 ohms, ±5%, 1/2W	151-1003-513J	01131 EB5135	1	
R333	RESISTOR: fixed, composition, 22, 000 ohms, ±5%, 1/2W	151-1003-223J	01131 EB2235	1	
R335	RESISTOR: fixed, composition, 27, 000 ohms, ±5%, 1/2W	151-1003-273J	01131 EB2735	1	
R337	RESISTOR: variable, composition, linear, 1000 ohms, ±10%, 2W (includes switch S104)		16665 RV2-22703	1	
R339	RESISTOR: fixed, wirewound, radial leads, 2000 ohms, ±10%, 10W	556045-041	94310 FRL-10	1	
R340	RESISTOR: fixed, wirewound, 7 K, ±5%, 10W	556045-019	56289 RW10X702R-1	1	
R341 (Model SPA-3a)	RESISTOR: fixed, composition, 150, 000 ohms, ±5%, 1/2W, test selected	151-1003-154J	01131 EB1545		
R342 (Model SPA-3/25a)	RESISTOR: fixed, composition, 47 K, ±5%, 1/2W, test selected	151-1003-473J	01131 EB4735	3	
R343 (Model SPA-3/25a)	RESISTOR: fixed, composition, 120 K, ±5%, 1/2W, test selected	151-1003-124J	01131 EB1245		

List of Replaceable Parts for Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R344 (Model SPA-3/25a)	RESISTOR: fixed, composition, 180 K, ±5%, 1/2W, test selected	151-1003-184J	01131 EB1845		
R345	RESISTOR: variable, composition, linear, 250,000 ohms, ±10%, 2W	556052-024	16665 RV2-22024	1	
R347	RESISTOR: fixed, composition, 240,000 ohms, ±5%, 1/2W	151-1003-244J	01131 EB2445	1	
R349 (Model SPA-3a)	RESISTOR: variable, composition, cw log A taper, 100,000 ohms, ±10%, 2W (includes switch S108)	556052-060	16665 RV2-22058	1	
R349 (Model SPA-3/25a)	RESISTOR: variable, composition, cw log A taper, 100,000 ohms, ±10%, 2W	556168-127	16665 RV2-22058	1	
R350	RESISTOR: variable, composition, 10,000 ohms, ±10%, 1/2W	556055-013	16665 RV2-22412	1	
R352	RESISTOR: fixed, composition, 120,000 ohms, ±5%, 1/2W	151-1003-124J	01131 EB1245	1	
R353	RESISTOR: variable, composition, linear, 300 ohms, ±10%, 2W	556052-008	16665 RV2-22008	1	
R355	RESISTOR: fixed, composition, 51 ohms, ±5%, 1W	151-1004-510J	01131 GB5105	1	
R357	RESISTOR: fixed, composition, 15,000 ohms, ±5%, 1/2W	151-1003-153J	01131 EB1535	1	
R359	RESISTOR: fixed, composition, 51,000 ohms, ±5%, 1/2W	151-1003-513J	01131 EB5135	3	
R361	RESISTOR: fixed, composition, 51,000 ohms, ±5%, 1/2W	151-1003-513J	01131 EB5135		
R363	RESISTOR: fixed, composition, 22 ohms, ±5%, 1/2W	151-1003-220J	01131 EB2205	3	
R365	RESISTOR: fixed, composition, 390,000 ohms, ±5%, 1/2W	151-1003-394J	01131 EB3945	1	
R367	RESISTOR: fixed, composition, 240 ohms, ±5%, 1/2W	151-1003-241J	01131 EB2415	1	
R369	RESISTOR: fixed, composition, 3300 ohms, ±5%, 1/2W	151-1003-332J	01131 EB3325	2	
R371	RESISTOR: fixed, composition, 22 ohms, ±5%, 1/2W	151-1003-220J	01131 EB2205		

List of Replaceable Parts for Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R373	RESISTOR: fixed, composition, 3300 ohms, ±5%, 1/2W	151-1003-332J	01131 EB3325		
R375	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R377	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2W	151-1003-105J	01131 EB1055		
R379	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2W	151-1003-105J	01131 EB1055		
R381	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2W	151-1003-102J	01131 EB1025		
R385	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2W	151-1003-105J	01131 EB1055		
R386	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2W	151-1003-101J	01131 EB1015		
R387	RESISTOR: fixed, composition, 220, 000 ohms, ±5%, 1/2W	151-1003-224J	01131 EB2245		
R389	RESISTOR: fixed, composition, 3000 ohms, ±5%, 1/2W	151-1003-302J	01131 EB3025	1	
R391	RESISTOR: variable, composition, linear, 50, 000 ohms, ±10%, 2W	556052-035	16665 RV2-22035	1	
R393	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1W	151-1004-104J	01131 GB1045		
R395	RESISTOR: fixed, composition, 20, 000 ohms, ±5%, 1/2W	151-1003-203J	01131 EB2035	1	
R397	RESISTOR: fixed, composition, 470, 000 ohms, ±5%, 1/2W	151-1003-474J	01131 EB4745		
R399	RESISTOR: fixed, composition, 820, 000 ohms, ±5%, 1/2W	151-1003-824J	01131 EB8245	1	
R401 A, B	RESISTOR: variable, dual, linear, 50, 000 ohms/5 megohms, ±10%, 2W	556057-003	16665 RV2-22502	1	
R403	RESISTOR: fixed, composition, 4700 ohms, ±5%, 1/2W	151-1003-472J	01131 EB4725	1	
R405	RESISTOR: fixed, composition, 15, 000 ohms, ±5%, 1W	151-1004-153J	01131 GB1535	2	
R407	RESISTOR: fixed, composition, 15, 000 ohms, ±5%, 1W	151-1004-153J	01131 GB1535		
R409	RESISTOR: fixed, composition, 51, 000 ohms, ±5%, 1/2W	151-1003-513J	01131 EB5135		

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R411	RESISTOR: variable, composition, linear, 100,000 ohms, ±10%, 2W	556052-025	16665 RV2-22025		
R413	RESISTOR: fixed, composition, 30,000 ohms, ±5%, 1/2W	151-1003-303J	01131 EB3035	1	
R415	RESISTOR: variable, composition, linear, 500,000 ohms, ±10%, 2W	556052-015	16665 RV2-22015		
R417	RESISTOR: variable, composition, linear, 2 megohms, ±20%, 2W	556052-017	16665 RV2-22017	1	
R419	RESISTOR: fixed, composition, 750,000 ohms, ±5%, 1/2W	151-1003-754J	01131 EB7545	1	
R420	RESISTOR: fixed, composition, 510,000 ohms, ±5%, 1/2W	151-1003-514J	01131 EB5145	1	
R421	RESISTOR: variable, composition, linear, 1 megohm, ±20%, 2W	556052-002	16665 RV2-22002	1	
R422	RESISTOR: fixed, composition, 910,000 ohms, ±5%, 1/2W	556033-092	01131 EB9145	1	
R425	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2W	151-1003-105J	01131 EB1055		
R427	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1W	151-1004-104J	01131 GB1045		
R429	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 1/2W	151-1003-103J	01131 EB1035	1	
R431	RESISTOR: variable, composition, linear, 5000 ohms, ±10%, 2W	556052-012	16665 RV2-22012	1	
R433	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2W	151-1003-102J	01131 EB1025		
R435	RESISTOR: fixed, composition, 220,000 ohms, ±5%, 1/2W	151-1003-224J	01131 EB2245		
R437	RESISTOR: fixed, composition, 1.8 megohms, ±5%, 1/2W	151-1003-185J	01131 EB1855	1	
R439	RESISTOR: fixed, composition, 180,000 ohms, ±5%, 1/2W	151-1003-184J	01131 EB1845	1	
R441	RESISTOR: fixed, composition, 75,000 ohms, ±5%, 2W	151-1005-753J	01131 HB7535	1	
R443	RESISTOR: fixed, composition, 5600 ohms, ±5%, 1/2W	151-1003-562J	01131 EB5625		

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R444	RESISTOR: fixed, composition, 47,000 ohms, ±5%, 1/2W	151-1003-473J	01131 EB4735	2	
R445	RESISTOR: fixed, composition, 220,000 ohms, ±5%, 1/2W	151-1003-224J	01131 EB2245		
R446	RESISTOR: fixed, composition, 47,000 ohms, ±5%, 1/2W	151-1003-473J	01131 EB4735		
R447	RESISTOR: fixed, composition, 24,000 ohms, ±5%, 1W	151-1004-243J	01131 GB2435	1	
R449	RESISTOR: variable, composition, linear, 50,000 ohms, ±10%, 2W	556052-014	16665 RV2-22014	2	
R451	RESISTOR: fixed, composition, 75,000 ohms, ±5%, 1W	151-1004-753J	01131 GB7535	1	
R453	RESISTOR: fixed, composition, 430,000 ohms, ±5%, 1/2W	151-1003-434J	01131 EB4345	1	
R455	RESISTOR: variable, composition, linear, high voltage, 100,000 ohms, ±30%, 2W	556059-014	16665 RV2-22913	1	
R457	RESISTOR: fixed, composition, 270,000 ohms, ±5%, 1W	151-1004-274J	01131 GB2745	1	
R459	RESISTOR: variable, composition, linear, high voltage, 5000,000 ohms, ±30%, 2W	556059-013	16665 RV2-22912	1	
R461	RESISTOR: fixed, composition, 470,000 ohms, ±5%, 1W	151-1004-474J	01131 GB4745	2	
R463	RESISTOR: fixed, composition, 470,000 ohms, ±5%, 1W	151-1004-474J	01131 GB4745		
R465	RESISTOR: fixed, composition, 2000 ohms, ±5%, 1/2W	151-1003-202J	01131 EB2025	2	
R467	RESISTOR: fixed, composition, 2000 ohms, ±5%, 1/2W	151-1003-202J	01131 EB2025		
R469	RESISTOR: variable, wire-wound, linear, 6 ohms, ±10%, 2W, (includes switch S110)	556056-001	16665 RV2-22700	1	
R470	RESISTOR: fixed, wirewound, radial leads, 10,000 ohms, ±10%, 5W	556043-020	56289 RW5X103R-1	1	
R471	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045		
R472	RESISTOR: fixed, composition, 51,000 ohms, ±5%, 1/2W	151-1003-513J	01131 EB5135		

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R475	RESISTOR: fixed, composition, 96.5 ohms, ±1%, 1/2W	556029-217	05794 RC20A296P5F	2	
R476	RESISTOR: fixed, composition, 71.3 ohms, ±1%, 1/2W	556029-314	05794 RC20A291P3F	1	
R477	RESISTOR: fixed, composition, 96.5 ohms, ±1%, 1/2W	556029-217	05794 RC20A296P5F		
R478	RESISTOR: fixed, composition, 178.7 ohms, ±1%, 1/2W	556029-280	05794 RC20A2178P7F	2	
R479	RESISTOR: fixed, composition, 30.4 ohms, ±1%, 1/2W	556029-228	05794 RC20A230P4F	1	
R480	RESISTOR: fixed, composition, 178.7 ohms, ±1%, 1/2W	556029-280	05794 RC20A2178P7F		
R501	RESISTOR: fixed, precision, 73.4 ohms, ±1%, 1/2W, customer option	556029-052	05794 Type C1/2C	2	
R501	RESISTOR: fixed, precision, 51 ohms, ±1%, 1/2W, customer option	556029-045	05794 Type C1/2C	2	
R503	RESISTOR: fixed, composition, 3600 ohms, ±1%, 1/2W, customer option	556029-119	05794 Type C1/2C	1	
R503	RESISTOR: fixed, composition, 2500 ohms, ±1%, 1/2W, customer option	556029-114	15794 Type C1/2C	1	
R505	RESISTOR: fixed, composition, 73.4 ohms, ±1%, 1/2W, customer option	556029-052	05794 Type C1/2C		
R505	RESISTOR: fixed, composition, 51 ohms, ±1%, 1/2W, customer option	556029-045	05794 Type C1/2C		
R507	RESISTOR: fixed, composition, 88 ohms, ±1%, 1/2W, customer option	556029-153	05794 Type C1/2C	5	
R507	RESISTOR: fixed, composition, 61.1 ohms, ±1%, 1/2W, customer option	556029-134	05794 Type C1/2C	4	
R509	RESISTOR: fixed, composition, 356.4 ohms, ±1%, 1/2W, customer option	556029-080	05794 Type C1/2C	2	
R509	RESISTOR: fixed, composition, 247.5 ohms, ±1%, 1/2W, customer option	556029-072	05794 Type C1/2C	2	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R511	RESISTOR: fixed, composition, 88 ohms, ±1%, 1/2W, customer option	556029-153	05794 Type C1/2C		
R511	RESISTOR: fixed, composition, 61.1 ohms, ±1%, 1/2W, customer option	556029-134	05794 Type C1/2C		
R513	RESISTOR: fixed, composition, 88 ohms, ±1%, 1/2W, customer option	556029-153	05794 Type C1/2C		
R513	RESISTOR: fixed, composition, 61.1 ohms, ±1%, 1/2W, customer option	556029-134	05794 Type C1/2C		
R515	RESISTOR: fixed, composition, 356.4 ohms, ±1%, 1/2W, customer option	556029-080	05794 Type C1/2C		
R515	RESISTOR: fixed, composition, 247.5 ohms, ±1%, 1/2W, customer option	556029-072	05794 Type C1/2C		
R517	RESISTOR: fixed, composition, 88 ohms, ±1%, 1/2W, customer option	556029-153	05794 Type C1/2C		
R517	RESISTOR: fixed, composition, 61.1 ohms, ±1%, 1/2W, customer option	556029-134	05794 Type C1/2C		
R519	RESISTOR: fixed, composition, 200 ohms, ±1%, 1/2W, customer option	556029-723	05794 Type C1/2C	1	
R519	RESISTOR: fixed, composition, 88 ohms, ±1%, 1/2W, customer option	556029-153	05794 Type C1/2C		
R521	RESISTOR: variable, composition, linear, 100 ohms, ±10%, 2W	556052-028	16665 RV2-22028	1	
R523	RESISTOR: fixed, composition, 5.6 ohms, ±1%, 1W, customer option	556034-331	05794 Type C1/2C	1	
R523	RESISTOR: fixed, composition, 3.9 ohms, ±1%, 1W, customer option	556034-332	05794 Type C1/2C	1	
S102	SWITCH: toggle, DPDT, bat handle	559019-114	04009 83054	5	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
S103	SWITCH: rotary, phenolic wafer, single section, 3 pole, 3 throw	556019-178	16665 S1-9395B	2	
S104	SWITCH: concentric rotary, phenolic wafer, single section, 2 pole, 3 throw (included in resistor R337)	556014-191	16665 S2-14336	1	
S105	SWITCH: rotary, ceramic wafer, single section, 3 pole, 3 throw	556019-178	16665 S1-9395B		
S106 (Model SPA-3/25a)	SWITCH: rotary, ceramic, 5 pole, 1 section, 2 section	556019-198	16665 S2-11714	1	
S108 (Model SPA-3a)	SWITCH: concentric, rotary, ceramic wafer, single section, 3 pole, 2 throw (included in resistor R349)	556019-209	16665 S2-14169A	1	
S109	SWITCH: toggle, DPDT, bat handle	559019-144	14009 83054		
S501	SWITCH: toggle, DPDT, bat handle	556019-144	04009 83054		
S503	SWITCH: toggle, DPDT, bat handle	556019-144	04009 83054		
S505	SWITCH: toggle, DPDT, bat handle	556019-144	04009 83054		
T101	TRANSFORMER: i-f, 32 mc	556026-329	16665 Z2-8373	1	
T102	TRANSFORMER: i-f, 32 mc	556026-201	16665 Z2-8374	1	
T103	TRANSFORMER: i-f, 32 mc	556026-206	16665 Z2-8378	1	
T104	TRANSFORMER: i-f, 2.7 mc	556026-207	16665 Z2-8379B	2	
T105	TRANSFORMER: i-f, 2.7 mc	556026-207	16665 Z2-8379B		
T106	TRANSFORMER: i-f, 2.7 mc	556026-300	16665 Z2-8473	1	
T107	TRANSFORMER: r-f, 500 kc	556026-310	16665 ZN-8504	1	
T108	TRANSFORMER: osc, 50 kc	556026-311	16665 ZN-8505	1	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
V101	ELECTRON TUBE: 6922, dual triode	556027-135	Any E.I.A. manufacturer	1	
V102	ELECTRON TUBE: 6CB6A, pentode	556027-095	Any E.I.A. manufacturer	2	
V103	ELECTRON TUBE: 6J6, dual triode	556027-101	Any E.I.A. manufacturer	2	
V104	ELECTRON TUBE: 5879, pentode	556027-059	Any E.I.A. manufacturer	2	
V105	ELECTRON TUBE: 5879, pentode	556027-159	Any E.I.A. manufacturer		
V106	ELECTRON TUBE: 6AW8A, dual section, triode, pentode	556027-079	Any E.I.A. manufacturer	2	
V107	ELECTRON TUBE: 6BE6, converter	556027-082	Any E.I.A. manufacturer	1	
V108	ELECTRON TUBE: 6AB4, triode	556027-064	Any E.I.A. manufacturer	1	
V109	ELECTRON TUBE: 6AW8A, dual section, triode, pentode	556027-079	Any E.I.A. manufacturer		
V110	ELECTRON TUBE: 6CB6A, pentode	556027-095	Any E.I.A. manufacturer		
V111	ELECTRON TUBE: 6AU6, pentode	556027-074	Any E.I.A. manufacturer	1	
V112	ELECTRON TUBE: 12AU7, dual triode	556027-020	Any E.I.A. manufacturer	3	
V113	ELECTRON TUBE: 12AT7, dual triode	556027-017	Any E.I.A. manufacturer	2	
V114	ELECTRON TUBE: 12AU7, dual triode	556027-020	Any E.I.A. manufacturer		
V115	ELECTRON TUBE: 12AX7, dual triode	556027-022	Any E.I.A. manufacturer	1	
V117	ELECTRON TUBE: 12BY7A, pentode	556027-026	Any E.I.A. manufacturer	1	
V118	ELECTRON TUBE: 6BK7A, dual triode	556027-188	Any E.I.A. manufacturer	1	
V119	ELECTRON TUBE: 6J6, dual triode	556027-101	Any E.I.A. manufacturer		
V120	ELECTRON TUBE: 12AT7, dual triode	556027-017	Any E.I.A. manufacturer		
V121	ELECTRON TUBE: 6U8, dual section, triode, pentode	556027-118	Any E.I.A. manufacturer	1	

List of Replaceable Parts For Models SPA-3a and SPA-3/25a (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
V122	ELECTRON TUBE: 12AU7, dual triode	556027-020	Any E.I.A. manufacturer		
V123	ELECTRON TUBE: 5ADP7, cathode ray tube, flat face	556027-037	Any E.I.A. manufacturer	1	
V124	ELECTRON TUBE: 6AH6, pentode	556027-067	Any E.I.A. manufacturer	1	
Y101	CRYSTAL: quartz, 29.300 mc, ±0.005%	556025-021	16665 Y-3014	1	
Y102	CRYSTAL: quartz, 2.700 mc, ±0.005%	556025-022	16665 2Y-3015M	2	
Y103	CRYSTAL: quartz, 2.700 mc, ±0.005%	556025-022	16665 2Y-3015M		
Y104	CRYSTAL: quartz, 500 kc, ±0.01%	556025-020	16665 Y-3013	1	
	List of Replaceable Parts for Model PS-19 Power Supply				
C1	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0	2	
C2	CAPACITOR: fixed, ceramic disc, 0.05 uf, 500V	556060-081	72982 827200Z5V0		
C5	CAPACITOR: fixed, electrolytic, tubular, axial leads, 80 uf, 450V	556074-021	56289 TVA-1716	2	
C7	CAPACITOR: fixed, electrolytic, tubular, axial leads, 80 uf, 450V	556074-021	56289 TVA-1716		
C9	CAPACITOR: fixed, mylar, 0.1 uf, 400V	556120-099	72928 338E104M	1	
C11	CAPACITOR: fixed, paper, molded, tubular, 0.5 uf, 400V	556120-163	53021 330405	1	
C13	CAPACITOR: fixed, electrolytic, twistlock, 40 uf, 450V	556060-006	56289 TVL-1725	1	
C15	CAPACITOR: fixed, electrolytic, tubular, axial leads, 20 uf, 450V	556074-011	56289 TVA-1709	2	
C17	CAPACITOR: fixed, electrolytic, tubular, axial leads, 20 uf, 450V	556074-011	56289 TVA-1709		
C19 A, B	CAPACITOR: fixed, paper dielectric, 2 x 0.25 uf, 2500V, with ground lug	556115-003	72928 7125-2X-25	2	

List of Replaceable Parts for Model PS-19 Power Supply (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
C21 A, B	CAPACITOR: fixed, paper dielectric, 2 x 0.25 uf, 2500V, with ground lug	556115-003	72928 7125-2X-25		
CR1	RECTIFIER: selenium, cartridge, 5 ma, 1000V	556118-008	75042 V50HF	1	
CR3	RECTIFIER: selenium, cartridge, 5 ma, 2000V	556118-005	75042 V100HF	2	
CR5	RECTIFIER: selenium, cartridge, 5 ma, 2000V	556118-005	75042 V100HF		
F1	FUSE: instantaneous, glass cartridge, 3 amp, 250V	556006-012	16665 F-2009	2	
F2	FUSE: instantaneous, glass cartridge, 3 amp, 250V	556006-012	16665 F-2009		
J3	CONNECTOR: receptacle, 5 pin, male contacts	556010-019	02660 AN3102A-14S-5P	1	
J5	CONNECTOR: tip jack, black	556010-080	71002 407	1	
J7	CONNECTOR: receptacle, 14 pin, female contacts	556010-014	02660 AN3102A-28-2S	1	
P1	CONNECTOR: plug, electric, 3 wire, AC power, twistlock type	556016-062	74545 7485	1	
R1	RESISTOR: fixed, composition, 330, 000 ohms, ±10%, 1W	151-1004-334K	01131 GB3341	2	
R3	RESISTOR: fixed, composition, 330, 000 ohms, ±10%, 1W	151-1004-334K	01131 GB3341		
R5	RESISTOR: fixed, composition, 10 megohms, ±5%, 1/2W	151-1003-106J	01131 EB1065	1	
R7	RESISTOR: fixed, composition, 120 ohms, ±5%, 1/2W	151-1003-121J	01131 EB1215	2	
R9	RESISTOR: fixed, composition, 120 ohms, ±5%, 1/2W	151-1003-121J	01131 EB1215		
R11	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2W	151-1003-102J	01131 EB1025	2	
R13	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2W	151-1003-102J	01131 EB1025		
R15	RESISTOR: fixed, composition, 8.2 megohms, ±5%, 1/2W	151-1003-825J	01131 EB8255	1	
R17	RESISTOR: fixed, composition, 3 megohms, ±5%, 1/2W	151-1003-305J	01131 EB3055	4	

List of Replaceable Parts For Model PS-19 Power Supply (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R19	RESISTOR: fixed, composition, 3 megohms, ±5%, 1/2W	151-1003-305J	01131 EB3055		
R21	RESISTOR: fixed, composition, 240, 000 ohms, ±5%, 1/2W	151-1003-244J	01131 EB2445	2	
R23	RESISTOR: fixed, composition, 3 megohms, ±5%, 1/2W	151-1003-305J	01131 EB3055		
R25	RESISTOR: fixed, composition, 3 megohms, ±5%, 1/2W	151-1003-305J	01131 EB3055		
R27	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1/2W	151-1003-104J	01131 EB1045	1	
R29	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2W	151-1003-105J	01131 EB1055	2	
R31	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2W	151-1003-105J	01131 EB1055		
R33	RESISTOR: fixed, composition, 240, 000 ohms, ±5%, 1/2W	151-1003-244J	01131 EB2445		
R35	RESISTOR: fixed, composition, 68, 000 ohms, ±5%, 1/2W	151-1003-683J	01131 EB6835	1	
R37	RESISTOR: fixed, composition, 330, 000 ohms, ±5%, 1/2W	151-1003-334J	01131 EB3345	1	
R39	RESISTOR: variable, composition, linear, 50, 000 ohms, ±10%, 2W	556052-014	16665 RV2-22014	1	
R41	RESISTOR: fixed, composition, 56, 000 ohms, ±5%, 1/2W	151-1003-563J	01131 EB5635	1	
R43	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1W	151-1004-104J	01131 GB1045	3	
R45	RESISTOR: fixed, composition, 3000 ohms, ±5%, 1W	151-1004-302J	01131 GB3025	1	
R47	RESISTOR: fixed, composition, 30, 000 ohms, ±5%, 1W	151-1004-303J	01131 GB3035	2	
R49	RESISTOR: fixed, composition, 30, 000 ohms, ±5%, 1W	151-1004-303J	01131 GB3035		
R51	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1W	151-1004-104J	01131 GB1045		
R53	RESISTOR: fixed, composition, 10 megohms, ±5%, 2W	151-1005-106K	01131 HB1065	4	
R55	RESISTOR: fixed, composition, 10 megohms, ±5%, 2W	151-1005-106K	01131 HB1065		
R57	RESISTOR: fixed, composition, 100, 000 ohms, ±5%, 1W	151-1004-104J	01131 GB1045		

List of Replaceable Parts For Model PS-19 Power Supply (Cont)

REFERENCE DESIGNATION	DESCRIPTION	SINGER PART NO.	MANUFACTURER'S CODE & PART NO.	QTY IN SET	
R59	RESISTOR: fixed, composition, 10 megohms, ±5%, 2W	151-1005-106K	01131 HB1065		
R61	RESISTOR: fixed, composition, 10 megohms, ±5%, 2W	151-1005-106K	01131 HB1065		
T1	TRANSFORMER: power, low voltage, primary: 115V, 50-60 cps; secondary: 880 VTC, 200 ma dc; 5.0V, 3.0 amp; 6.3V, 3.0 amp; 6.3V, 1.2 amp; 6.3V, 6.0 amp	556020-110	16665 T3-10791B	1	
T2	TRANSFORMER: power, high voltage, primary: 115/230V, 50-60 cps, secondary: 1200V, 4 ma; 6.4V, 0.6 amp; 6.3V, 6 amp	556020-146	16665 T3-9875B	1	
V1	ELECTRON TUBE: 5U4GB, dual diode rectifier	556027-043	Any E.I.A. manufacturer	1	
V2	ELECTRON TUBE: 6146, beam power triode	556027-129	Any E.I.A. manufacturer	2	
V3	ELECTRON TUBE: 6146, beam power triode	556027-129	Any E.I.A. manufacturer		
V4	ELECTRON TUBE: 12AX7, dual triode	556027-022	Any E.I.A. manufacturer	2	
V5	ELECTRON TUBE: 12AX7, dual triode	556027-022	Any E.I.A. manufacturer		
V6	ELECTRON TUBE: 5651, regulator	556027-048	Any E.I.A. manufacturer	2	
V7	ELECTRON TUBE: 5651, regulator	556027-048	Any E.I.A. manufacturer		

LIST OF MANUFACTURERS' CODES

CODE	MANUFACTURER
01131	Allen-Bradley Company Milwaukee, Wisconsin
02660	Amphenol-Borg Electronics Corporation Broadview (Chicago), Illinois
04009	Arrow-Hart and Hegeman Electric Company Hartford, Connecticut

CODE	MANUFACTURER
04202	Winchester Electronics Company, Incorporated New Milford, Connecticut
05375	Vari-L Company, Incorporated Stamford, Connecticut
05794	Kidco Inc. Somerset, Kentucky

LIST OF MANUFACTURERS' CODES (Cont)

CODE	MANUFACTURER
12697	Clarostat Manufacturing Company, Incorporated Dover, New Hampshire
14655	Cornell-Dubilier, Electric Corporation South Plainfield, New Jersey
16665	Singer Metrics Division Bridgeport, Connecticut
24446	General Electric Company Schenectady, New York
53021	Sangamo Electric Company Springfield, Illinois
55814	Sola Electric Company Cicero, Illinois
56289	Sprague Electric Company North Adams, Massachusetts
71002	Birnbach Radio Company New York, New York
71313	Cardwell Condenser Corporation Plainville, Connecticut
71590	Centralab Division of Globe-Union, Incorporated Milwaukee, Wisconsin
72136	Electro Motive Manufacturing Company Willimantic, Connecticut
72619	Dialight Corporation Brooklyn, New York
72653	Stackpole Division G.C. Electronics Manufacturing Company Rockford, Illinois
72928	Gudeman Manufacturing Company Chicago, Illinois
72982	Erie Resistor Corporation Erie, Pennsylvania
74545	Harvey, Hubbell, Incorporated Bridgeport, Connecticut
74868	Industrial Products Danbury, Connecticut
74970	E. F. Johnson Company Waseca, Minnesota
75042	International Resistance Company Philadelphia, Pennsylvania
76493	J.W. Miller Company Los Angeles, California
77638	Radio Receptor, Incorporated Brooklyn, New York
80583	Hammarlund Company, Incorporated New York, New York
81279	Teleradio Engineering Corporation New York, New York
81483	International Rectifier Corporation El Segundo, California
94310	Tru-Ohm Products Division Model Engineering and Manufacturing, Incorporated Chicago, Illinois
98291	Sealectro Corporation Mamaroneck, New York
99849	Wilco Corporation Indianapolis, Indiana

SECTION 8

SCHEMATIC DIAGRAMS