

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

---

SPECTRUM ANALYZER

AN/UPM-58

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This reprint includes all changes in effect at the time of publication; changes 1 through 3.

HEADQUARTERS, DEPARTMENT OF THE ARMY

MAY 1957

CHANGE }  
No. 3 }

HEADQUARTERS  
DEPARTMENT OF THE ARMY  
WASHINGTON, D.C., 4 May 1967

**SPECTRUM ANALYZER AN/UPM-58**

TM 11-5099, 28 May 1957, is changed as follows:

*Note.* The parenthetical reference to previous changes (example: page 1 of C 2) indicate that pertinent material was published in that change.

*Page 2, paragraph 1.1, line 6 (page 1 of C 2).* Delete "(types 4, 6, 7, 8, and 9)" and substitute: (types 7, 8, and 9). Paragraph 2c (page 1 of C 2). Delete subparagraph c and substitute:

c. *Reporting of Equipment Manual Improvements.*

Report of errors, omissions, and recommendations for Improving this manual by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to DA Publications) and forwarded direct to Commanding General, U.S. Army Electronics Command, ATTN: AMSEL-MR-NMP-AD, Fort Monmouth, N.J. 07703.

*Page 77.* Add section V after section 1V.

**Section V. DEPOT OVERHAUL STANDARDS**

**95.1. Applicability of Depot Overhaul Standards**

The tests outlined in this chapter are designed to measure the performance capability of a repaired equipment. Equipment that is to be returned to stock should meet the standards given in these tests.

**95.2. Applicable References**

a. *Repair Standard.* Applicable procedures of the depots performing these tests and the general standard for repaired electronic equipment given in TB SIG 355-1, TB SIG 355-2, and TB SIG 355-3 form a part of the

requirements for testing this equipment.

b. *Technical Publications.* The technical publication applicable to the equipment to be tested is TM 11-5099.

c. *Modification Work Orders.* Perform all modification work orders applicable to this equipment before making the tests specified. DA Pam 310-4 lists all available MWO's.

**95.3. Test Facilities Required**

The following items are needed for depot testing:

Item	Technical manual	Common name
Directional Coupler CU-673/U.....	.....	Directional coupler
Frequency Comparator CM-77A/USM.....	TM 11-6625-493-15	Frequency comparator
Frequency Converter CV-394/USA-5.....	TM 11-6625-604-15	Frequency converter
Frequency Meter FR-38D/U.....	TM 11-5057	Frequency meter
Harmonic Mixer HP P932A.....	.....	Harmonic mixer
Multimeter TS-352B/U.....	TM 11-6625-366-15	Multimeter
Radar Test Set AN/UPM-60A.....	TM 11-6625-228-12	
Transformer, Power CN-16A/U.....	.....	Transformer
Variable Attenuator CN-491/G.....		
Waveguide Assembly CG-539/U.....		

TAGO 1656A-May 260-475\*-67

**95.4. General Test Conditions**

All tests will be performed under the following conditions:

- a. Input power of 115 volts, 60 cps, single phase.
- b. Normal room temperature.

**95.5. Frequency Range Test**

This test will be performed under the input power conditions outlined in the chart below.

- a. Set the AN/UPM-58 controls as follows:
  - (1) FUNCTION switch: MIXER position.
  - (2) SPECTRUM WIDTH: maximum counter-clockwise position.
  - (3) MIXER AMPLIFIER: one-third clockwise position.
  - (4) SPECTRUM CENTER: midposition.
  - (5) TUNING: midposition.
  - (6) FREQUENCY MC: Adjust.
  - (7) DB: 10.
  - (8) SWEEP RATE: to maximum clockwise position.

b. Center the bell-shaped mode with the SPECTRUM CENTER control to measure the frequency range of the klystron. Extend it to cover the width of the trace with the SPECTRUM WIDTH control. Use the MIXER AMPLIFIER control to adjust its size as desired.

c. Rotate the FREQUENCY MC control for a reading of 15,750 mcs on the dial. Vary the TUNING control and adjust the FREQUENCY MC control for a frequency meter dip. Frequency meter dip can be located in the center of the mode with the TUNING control set for correct operation.

d. Repeat the procedures given in b and c above for a reading of 16,250 mcs on the dial.

e. The frequency range input power conditions are listed below.

Line	Test condition	Result
1	<i>Input power</i> 105v/60 cps <i>Frequency</i> 15,750 mcs	Frequency meter dip in the center of mode.
2	125v/60 cps    16,250 mcs	Same as in line 1.

**95.6. Resolution Test**

- a. Connect Spectrum Analyzer AN/UPM-58 to a 115-volt 60-cps line.
- b. Set up the equipment as shown in figure 56.1.

c. Set the AN/UPM-58 operating controls as follows:

- (1) Function switch: SPECTRUM.
- (2) DB: zero.
- (3) IF SENSITIVITY: maximum clockwise position.
- (4) SPECTRUM WIDTH: Adjust.
- (5) MIXER AMPLIFIER: one-third clockwise position.
- (6) TUNING: Adjust to 16,000 ± 45 mcs.
- (7) SPECTRUM CENTER: Adjust.
- (8) SWEEP RATE: maximum counter-clockwise position.

d. At 16,000 mcs, set Radar Test Set AN/UPM-60A to a pulse width of 1 microsecond and to a repetition rate of 200 pps. Adjust the AN/UPM-60A REFLECTOR control until a spectrum is visible on Spectrum Analyzer AN/UPM-58.

e. Adjust the AN/UPM-58 DB control for an optimum display of the spectrum. Adjust the AN/UPM-58 SPECTRUM WIDTH control for optimum display. At least 20 discrete transients should be displayed.

**95.7. Sensitivity Test**

a. Connect the AN/UPM-58 to a 115-volt 60-ops line.

b. Set up the equipment as shown in figure 56.1.

c. Set the AN/UPM-58 operating controls as follows:

- (1) Function switch: SPECTRUM.
- (2) DB: zero.
- (3) IF SENSITIVITY: maximum clockwise position.
- (4) MIXER AMPLIFIER: midposition.
- (5) FREQUENCY MC: 15,795 mos.
- (6) TUNING: adjust until two pips appear at the sides of the screen.
- (7) SPECTRUM CENTER: Center two pips on the CRT.
- (8) SWEEP RATE: maximum counter-clockwise position.

d. Tune the AN/UPM-60A to 15.750 gigacycles (gc), and adjust the AN/UPM-60A DBM control until a 1-inch pip appears on the screen of the AN/UPM-58.

e. The AN/UPM-60A DBM dial (with connection) should indicate 55 dbm or more down.

f. Tune the AN/UPM-60A to 16.250 gigacycles and repeat the procedures given in c, d, and e above.

g. Tune the AN/UPM-60A to 16.00 gigacycles and repeat the procedures given in *c* and *d* above. The AN/UPM-60A DBM dial (with correction) should indicate 60 dbm or more down.

**95.8. Frequency Maker Test**

- a. Connect the equipment to a 115-volt, 60-cps line.
- b. Set up the equipment as shown in figure 56.2.
- c. Set the AN/UPM-58 operating controls as follows:
  - (1) Function switch: MIXER.
  - (2) SPECTRUM WIDTH: maximum counter-clockwise position.
  - (3) MIXER AMPLIFIER: one-third clockwise position.
  - (4) SPECTRUM CENTER: one-half clockwise position.
  - (5) DB: 30 dbm.
  - (6) FREQUENCY - MC: 15,755 mcs.
  - (7) TUNING: Adjust.
- d. Adjust the AN, UPM-58 SPECTRUM CENTER control to center the mode in the middle of the screen.
- e. Adjust the AN/UPM-58 TUNING control until the dip caused by the wavemeter appears at the center of the mode. If necessary, recenter the mode by adjusting the SPECTRUM CENTER control.
- f. Set the AN/UPM-60A output frequency to 15.80 gc as calibrated with the CM-77A/USM and the counter.

g. Set the function switch to SPECTRUM and adjust the AN/UPM-58 TUNING control until a spike is displayed on the screen. Adjust the IF SENSITIVITY control as necessary.

h. Adjust the FREQUENCY MC control for a dip in the spike amplitude. The FREQUENCY MC dial should indicate 15.755 gc ± 10 mc.

i. Adjust the TUNING control to center the upper image spike. Adjust the FREQUENCY MC control for a dip in the spike amplitude. The FREQUENCY MC dial should indicate 15.845 gc ± 10 mc.

j. Repeat the procedures given in *f* through *i* above for the following test frequencies.

AN/UPM-60A	AN/UPM-38
<i>Output frequency</i>	<i>Marker</i>
16.00 gc.....	15.955 gc ± 10 mc
	16.045 gc ± 10 mc
16.20 gc.....	16.155 gc ± 10 mc
	16.245 gc ± 10 mc

**95.9. Attenuator Accuracy Test**

- a. Connect the equipment to a 115-volt, 60-cps line.
- b. Set up the equipment as shown in figure 56.3.
- c. Set the AN/UPM-58 opening controls as follows:
  - (1) Function switch: MIXER position.
  - (2) SPECTRUM WIDTH: maximum counter-clockwise position.

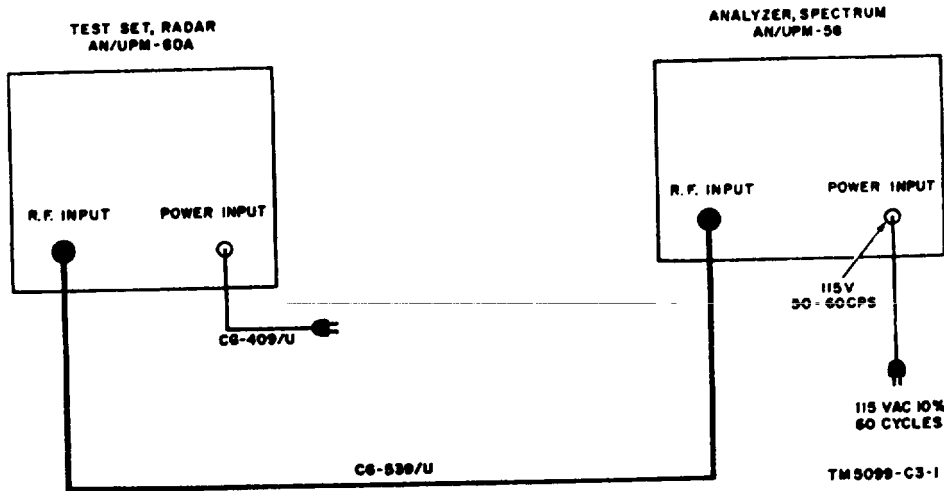


Figure 56.1. Resolution and sensitivity tests.

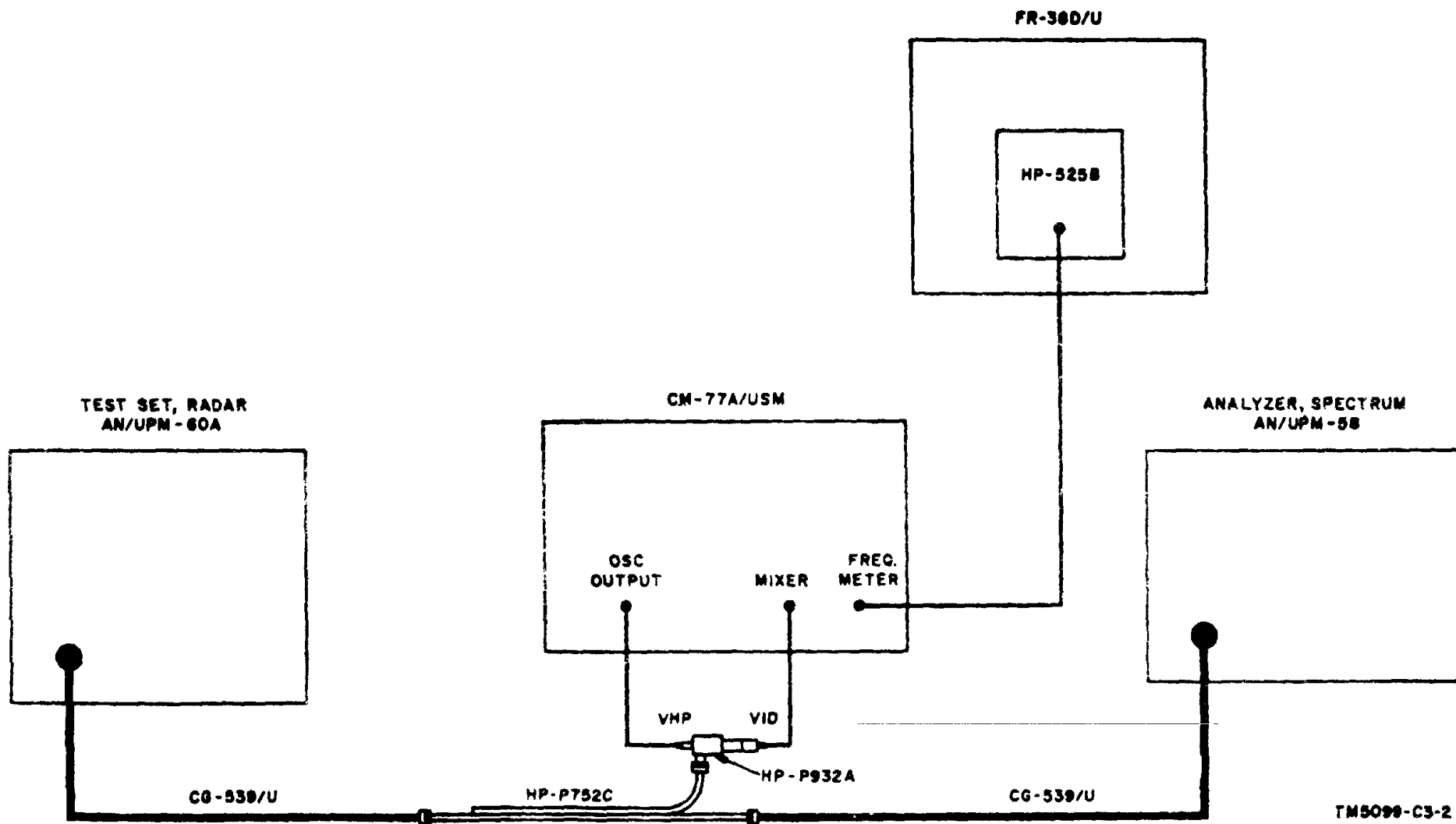


Figure 56.2. Frequency marker test.

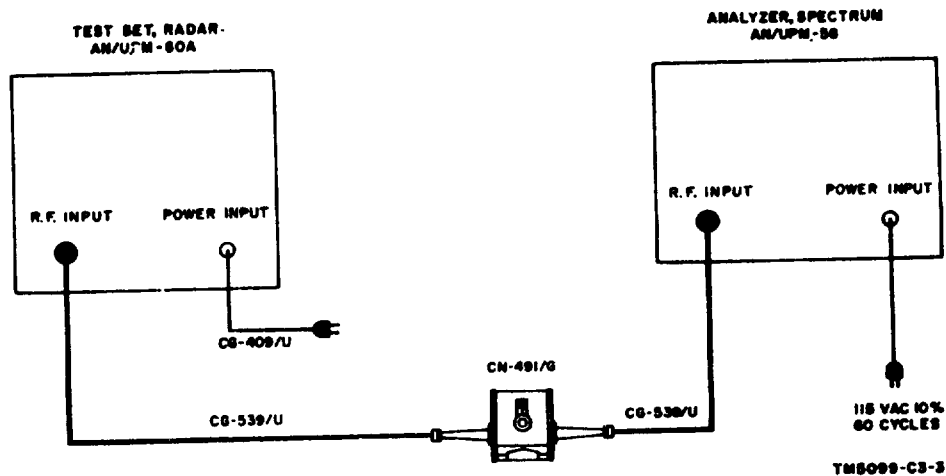


Figure 56.3. Attenuator accuracy test.

- (3) MIXER AMPLIFIER: one-third clockwise position.
- (4) SPECTRUM CENTER: Adjust.
- (5) DB: zero position.
- (6) IF SENSITIVITY: Adjust.
- (7) FREQUENCY MC: 15,795 gc.
- (8) TUNING: Adjust.

d. Adjust the AN/UPM-58 SPECTRUM CENTER control to center the mode in the middle of the screen.

e. Adjust the TUNING control until the dip caused by the initial setting of the FREQUENCY MC control appears at the center of the mode.

f. Set the AN/UPM-58 function switch to the SPECTRUM position and tune the AN/UPM60A to 15.750 gc until the right-hand spike displayed on the AN/UPM-58 screen coincides with the frequency meter dip.

g. Set the broadband variable attenuator to 50 db and adjust the AN/UPM-58 IF SENSITIVITY control to obtain a convenient reference reading on the screen.

h. Adjust the AN/UPM-58 DB control until 5 db is indicated on the dial. Decrease the external attenuator until the same signal level appears on the screen.

i. The sum of the external attenuator and the AN/UPM-58 DB settings should be  $50 \pm 3$  db and within  $\pm 1.0$  db with the aid of the calibration chart.

j. Repeat the procedures given in h and i above in 5-db increments up to and including 45 db.

k. Repeat the procedures given in c through j above at the following test frequencies.

AN/UPM-60A	AN/UPM-56
<i>Output frequency</i>	<i>Marker</i>
16.00 gc (gigacycles).....	15,955 gc or 16,045 gc
16.20 gc.....	16,155 gc or 16,245 gc

## APPENDIX

### REFERENCES

DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (types 7, 8, and 9), Supply Bulletins, Lubrication Orders, and Modification Work Orders.
TB SIG 355-1	Depot Inspection Standard for Repaired Signal Equipment.
TB SIG 355-2	Depot Inspection Standard for Refinishing Repaired Signal Equipment.
TB SIG 355-3	Depot Inspection Standard for Moisture and Fungus Resistant Treatment.
TB SIG 364	Field Instructions for Painting and Preserving Electronics Command Equipment.
TM 9-213	Painting Instructions for Field Use.
TM 11-1242	Crystal Rectifier Test Sets TS-268/U, TS-268A/U, TS-268B/U, TS-268C/U, TS-268D/U, and TS-268E/U.
TM 11-5030	Signal Generator TS497A/URR.
TM 11-5057	Frequency Meter AN/USM-26.
TM 11-5103	Oscilloscopes AN/USM-24 and AN/USM-24A.
TM 11-6625-366-15	Organizational, DS, GS, and Depot Maintenance Manual: Multimeter TS-352B/U.
TM 11-6625-228-12	Operation and Organization Maintenance: Radar Test Set AN/UPM-60A.
TM 11-6625-232-10P	Operator's Maintenance Repair Parts and Special Tool Lists: Analyzer, Spectrum AN/UPM-58.
TM 11-6625-232-20P	Organizational Maintenance Repair Parts and Special Tools List and Maintenance Allocation Chart: Analyzer, Spectrum AN/UPM-58.
TM 11-6625.-49;3-15	Operator, Organizational, Direct Support, General Support, and Depot Maintenance Manual: Comparator, Frequency CM-77A/USM.
TM 11-6625-604-15	Operator, Organizational, Direct Support, General Support, and Depot Maintenance Manual: Frequency Converter CV-394/USA-5.
TM 11-6625-700-10	Operator's Manual: Digital Readout, Electronic Counter AN/USM-207.
TM 38-750	Army Equipment Record Procedures.

By Order of the Secretary of the Army:

HAROLD K. JOHNSON,  
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*Chief of Staff.*

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KENNETH G. WICKHAM,  
*Major General, United State Army,*  
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NG: State AG (3); units - same as Active Army except allowance is one copy each.

USAR: None.

For explanation of abbreviations used, see AR 320-50.

TAGO 1656A



SPECTRUM ANALYZER AN/UPM-58

CHANGE }  
No. 2 }

HEADQUARTERS  
DEPARTMENT OF THE ARMY  
WASHINGTON, D.C., 26 December 1968

TM 11-5099, 28 May 1957, is changed as follows:

Page 2, paragraph 1. Delete subparagraph b.  
Add paragraph 1.1 after paragraph 1.

**1.1. Index of Publications**

Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to your equipment. DA Pam 310-4 is an index of current technical manuals, technical bulletins, supply manuals (types 4, 6, 7, 8 and 9), supply bulletins, lubrication orders, and modification work orders available through publications supply channels. The index lists the individual parts (-10, -20, -35P, etc.) and the latest changes to and revisions of each equipment publication.

Delete paragraph 2 and substitute:

**2. Forms and Records**

a. *Reports of Maintenance and Unsatisfactory Equipment.* Use equipment forms and records in accordance with instructions in TM 38-750.

b. *Report of Damaged or Improper Shipment.* Fill out and forward DD Form 6 (Report of Damaged or Improper Shipment) as prescribed in AR 700-58 (Army), NAVSANDA Publication 378 (Navy), and AFR 71-4 (Air Force).

c. *Reporting of Equipment Manual Improvements.* The direct reporting, by the individual user, of errors, omissions, and recommendations for improving this manual is authorized and encouraged. DA Form 2028 (Recommended changes to DA technical manual parts lists or supply manual 7, 8, or 9) will be used for reporting these improvements. This form will be completed in triplicate by the use of pencil, pen, or typewriter. The original and one copy will be forwarded direct to commanding Officer, U. S. Army Electronics Materiel Support Agency, ATTN: SELMS-MP, Fort Monmouth, N. J. 07703. One information copy will be furnished to the individual's immediate supervisor (officer, noncommissioned officer, supervisor, etc.).

Page 21, chapter 3. Take the following changes:

Delete section I and substitute:

**Section I. PREVENTIVE MAINTENANCE**

**27. Scope of Maintenance**

The maintenance duties assigned to the operator and organizational repairman of the equipment are listed below, together with a reference to the paragraphs covering the specific maintenance functions.

- a. Daily preventive maintenance checks and services (para. 30).
- b. Weekly preventive maintenance checks and services (para. 31).
- c. Monthly preventive maintenance checks and services (para. 31.1).
- d. Quarterly preventive maintenance checks and services (para. 31.2).
- e. Cleaning (para. 31.3).
- f. Touchup painting (para. 31.4).
- g. Lubrication (pars. 32 and 33).
- h. Visual inspection (para. 35).
- i. Equipment performance check (para. 37).

**28. Preventive Maintenance**

Preventive maintenance is the systematic care, servicing, and inspection of equipment to prevent the occurrence of trouble, to reduce downtime, and to assure that the equipment is serviceable.

a. *Systematic Care.* The procedures given in paragraphs 30 through : 31.4 cover routine systematic care and cleaning essential to proper upkeep and operation of the equipment.

b. *Preventive Maintenance Checks and Services.* The preventive maintenance checks and services charts (pars. 30 through 31.2) outline functions to be performed at specific intervals. These checks and services are to maintain Army electronic equipment in a combat-serviceable condition; that is, in good general (physical) condition and in good operating condition. To assist operators in maintaining combat serviceability, the charts indicate

what to check, how to check, and what the normal conditions are; the References column lists the illustrations, paragraphs, or manuals that contain detailed repair or replacement procedures. If the defect cannot be remedied by performing the corrective actions listed, higher echelon maintenance or repair is required. Records and reports of these checks and services must be made in accordance with the requirements set forth in TM 38-750.

Delete the section II heading.  
Delete paragraphs 29, 30, and 31 and substitute:

**29. Preventive Maintenance Checks and Services Periods**

Preventive maintenance checks and services of the equipment are required daily, weekly, monthly, and quarterly.

a. Paragraph 30 specifies the checks and services that must be accomplished daily (or at least once each week if the equipment is maintained in standby condition).

b. Paragraphs 31, 31.1, and 31.2 specify *additional* checks and services that must be performed on a weekly, monthly, and quarterly basis, respectively.

**30. Daily Maintenance Checks and Services Chart**

Sequence No	Item	Procedure	References
1	Completeness.....	See that the equipment is complete.....	TM 11625-232-10P.
2	Exterior surfaces.....	Clean the exterior surfaces, including the panel, synchroscope, FREQUENCY MC dial window, and DB control dial window (para. 31.3). Check all glasses and indicator lens for cracks.	
3	Connectors.....	Check the tightness of all connectors.	
4	Controls and indicators.....	While making the operating checks (sequence No. 5), observe that the mechanical action of each knob, dial, and switch is smooth, and free of external or internal binding, and that there is no excessive looseness.	
5	Operation.....	Operate the equipment according to paragraph 37....	Para. 37.

**31. Weekly Maintenance Checks and Services Chart**

Sequence No	Item	Procedure	Reference
1	Cables.....	Inspect cords and cables for chafed, cracked, or frayed insulation. Replace connectors that are broken, arced, stripped, or worn excessively.	
2	Handles and latches.....	Inspect handles and latches for looseness. Replace or tighten as necessary.	
3	Metal surfaces.....	Inspect exposed metal surfaces for rust and corrosion. touch up paint as required (para. 31.4).	

Page 22. Delete figure 15. Add paragraphs 31.1 through 31.4 after paragraph 31.  
Page 23. Delete figure 16.

**31.1. Monthly Preventive Maintenance Checks and Services Chart**

Sequence No	Item	Procedure	References
1	Pluckout items.....	Inspect the seating of pluckout items. Make certain that tube clamps grip tube bases tightly.	
2	Jack.....	Inspect the jacks for snug fit and good contact.	
3	Transformer terminals.....	Inspect the terminals on the power transformer. All nuts must be tight. There should be no evidence of dirt or corrosion	

Sequence No	Item	Procedure	References
4	Terminal blocks.....	Inspect the terminal blocks for loose connections and cracked or broken insulation.	
5	Resistors and capacitors.....	Inspect the resistors and capacitors for cracks, blistering, or other detrimental defects.	
6	Gaskets and insulators.....	Inspect the gaskets, insulators, bushings, and sleeves for cracks, chipping, and excessive wear.	
7	Interior.....	Clean the interior of chassis and cabinet.	
8	Cathode-ray tube.....	Inspect the cathode-ray tube for burned screen spots.	

### 31.2. Quarterly Preventive Maintenance Checks and Services Chart

Sequence No	Item	Procedure	References
1	Publications.....	See that all publications are complete, serviceable, and current.	DA Pam 310-4.
2	Modifications.....	Check DA Pam 310-4 to determine whether new applicable MWO's have been published. All URGENT MWO's must be applied immediately. All NORMAL MWO's must be scheduled.	TM 38-750 and DA Pam 310-4.
3	Spare parts.....	Check all spare parts (operator and organizational) for general condition and method of storage. There should be no evidence of overstock, and all shortages must be on valid requisitions.	TM 11-6625-232-10P and TM 11-6625-232-20P.
4	Lubrication.....	Lubricate the equipment.....	Pars. 32 and 33, and figs. 17 and 18.

### 31.3. Cleaning

Inspect the exterior of the equipment. The exterior surfaces should be clean, and free of dust, dirt, grease, and fungus.

a. Remove dust and loose dirt with a clean soft cloth.

**Warning: Cleaning compound is flammable and its fumes are toxic. Provide adequate ventilation. Do not use near a flame.**

b. Remove grease, fungus, and ground-in dirt from the cases; use a cloth dampened (not wet) with Cleaning Compound (Federal stock No. 79303959542).

c. Remove dust or dirt from plugs and jacks with a brush.

**Caution: Do not press on the synchroscope or**

**dial windows (glass) when cleaning; the dial windows may become damaged.**

d. Clean the front, panel, synchroscope, dial windows, and control knobs; use a soft clean cloth. If necessary, dampen the cloth with water; mild soap may be used for more effective cleaning.

### 31.4. Touchup Painting Instructions

Remove rust and corrosion from metal surfaces by lightly sanding them with fine sandpaper. Brush two thin coats of paint on the bare metal to protect it from further corrosion. Refer to the applicable cleaning and refinishing practices specified in TM 9-213.

Page 26. Redesignate section III as section II.

Page 78. Add the following appendix after chapter 6.

## APPENDIX

## REFERENCES

DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (Types 4, 6, 7, 8, and 9), Supply Bulletins,	TM 9-213	Lubrication Orders, and Modification Work Orders. Painting Instructions for Field Use.
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AGO 7814A

TM 11-1242	Crystal Rectifier Test Sets TS-268/U, TS-268A/U, TS-268B/U, TS-268C/U, TS-268D/U, and TS-268- E/U.	TM 11-6625 232-10P	Operator's Maintenance Re- pair Parts and Special Tools List for Analyzer, Spectrum AN/UPM-58.
TM 11-5030	Signal Generator TS-497A/URR.	TM 11-6625- 232-20P	Organizational Maintenance Repair Parts and Special Tools List and Maintenance Allocation Chart for Analy- zer, Spectrum AN/UPM- 58.
TM 11-5103	Oscilloscope AN/USM-24.		
TM 11-5527	Multimeters TS-352/U, TS- 352A/U, and TS-352B/U.		
TM 11-6625- 228-12	Operation and Organizational Maintenance: Radar Test Set AN/UPM-60A.	TM 38-750	The Army Equipment Record System and Procedures.

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ARADCOM Rgn (2)	Units org under fol TOE:
OS Maj Comd (2)	11-55 (2)
OS Base Comd (2)	11-56 (2)
Armies (1)	11-158 (2)
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NG: State AG (3); unite-same as Active Army except allowance is one copy to each unit.

USAR: None.

For explanation of abbreviations used, see AR 320-50.

AGO 7814A

TECHNICAL MANUAL  
SPECTRUM ANALYZER AN/UPM-58

TM 11-5099 }  
CHANGES No. 1 }

HEADQUARTERS,  
DEPARTMENT OF THE ARMY  
WASHINGTON 25, D. C., 14 March 1957

TM 11-5099, 28 May 1957, is changed as indicated so that the manual also applies to equipments procured on Order No. 36225-Phila-57.

*Page 2, paragraph 3, line 17.* After "50 decibels (db) of attenuation" add: and 65 db in equipments procured on Order No. 36225-Phila-7.

*Page 3, paragraph 4.* Add the following note at the end of subparagraph a:

*Note.* On equipments procured on Order No. 36225-Phila-57, the following technical characteristics are different:

RF input attenuation:

Uncalibrated ..... 46 to 65 db.

Sweep frequency range..... 5 to 30 c.p.s.

*Page 4, paragraph 6a, line 5.* After "four" add: or eight.

*Page 4, paragraph 7.* Add the following note after the listing:

*Note.* On equipments procured on Order No. 36225-Phila-57, type F02G3R00A fuses are used instead of type 3AG. Also preferred type tubes: 12AT7WA, 6AU6WA, and 5Y3WGTA are used instead of the 12AT7, 6AU6, and 5Y3WGT.

*Page 4.*

**8.1 Differences in Models**

(Added)

The following differences exist between the equipment procured on Order No. 36225-Phila-57 and the spectrum analyzer described in the manual:

a. The sweep frequency range is modified to operate from 5 to 30 c.p.s.

b. The uncalibrated portion of the range of RF input attenuation is from 46 to 65 db.

c. Preferred type electron tubes are used: types 12AT7WA, 6AU6WA, and 5Y38WGTA.

d. The point-to-point wiring is different (figs. 64 and 65).

e. A different type of crystal mixer is used (par. 48b1).

f. The values of the following electrical parts differ: C55, C61, C80, C81 (fig. 60).

*Page 9, paragraph 13.* Under the function column opposite DB, add the following note after "also provided."

*Note.* In equipments procured on Order No. 36225-Phila-57, an uncalibrated attenuation from 46 to 65 db is provided.

Under the function column opposite SWEEP RATE, add the following note after "sweeps per second."

*Note.* In equipments procured on Order No. 36225-Phila-57, the sweep repetition rate is variable from 5 to 30 sweeps per second.

*Page 13, paragraph 15f(2), line 3.* Delete "(a)" and substitute: (1).

*Page 34, paragraph 43a(l), line 2.* Change "H-band" to H-bend.

*Page 34, figure 22.* In the "SPECTRUM AMPL V9" block, change "6AU6" to 6AH6.

*Page 35, paragraph 43a(14), line 4.* Change "6AU6" to 6AH6.

*Page 36, paragraph 43a(16), line 6.* After "cycles per second" add:

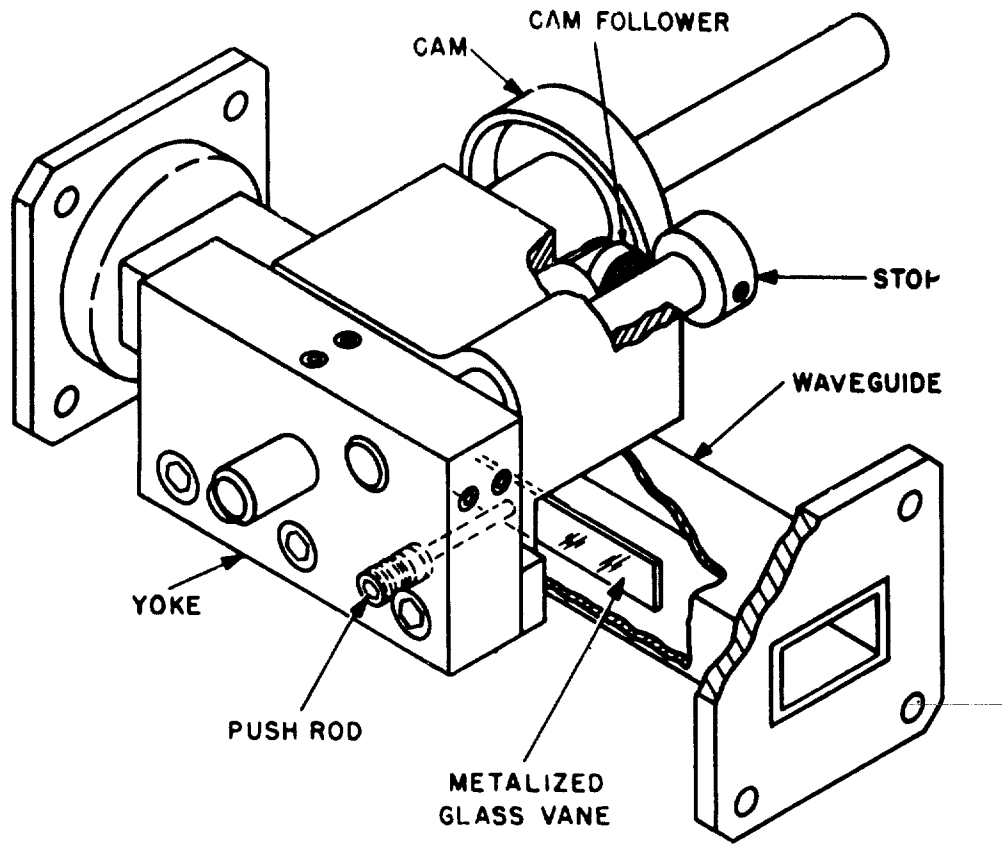
In equipments procured on Order No. 36225-Phila-57, the frequency is variable from 5 to 30 cycles per second.

*Page 37, paragraph 44.* Make the following changes: Heading. Change "(fig. 24)" to (figs. 24 and 24.1).

Subparagraph c. Add the following at the end of subparagraph c:

In equipments procured on Order No. 36225-Phila-67, the calibrated RF attenuator provides losses up to 65 db.

*Page 40, paragraph 48.* Make the following changes: Heading. (Change "fig. 27)" to (figs. 27 and 27.1).



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Figure 24.1. (Added) Calibrated RF attenuator, cutaway view, in equipments procured on Order No. 36225-Phila-57.

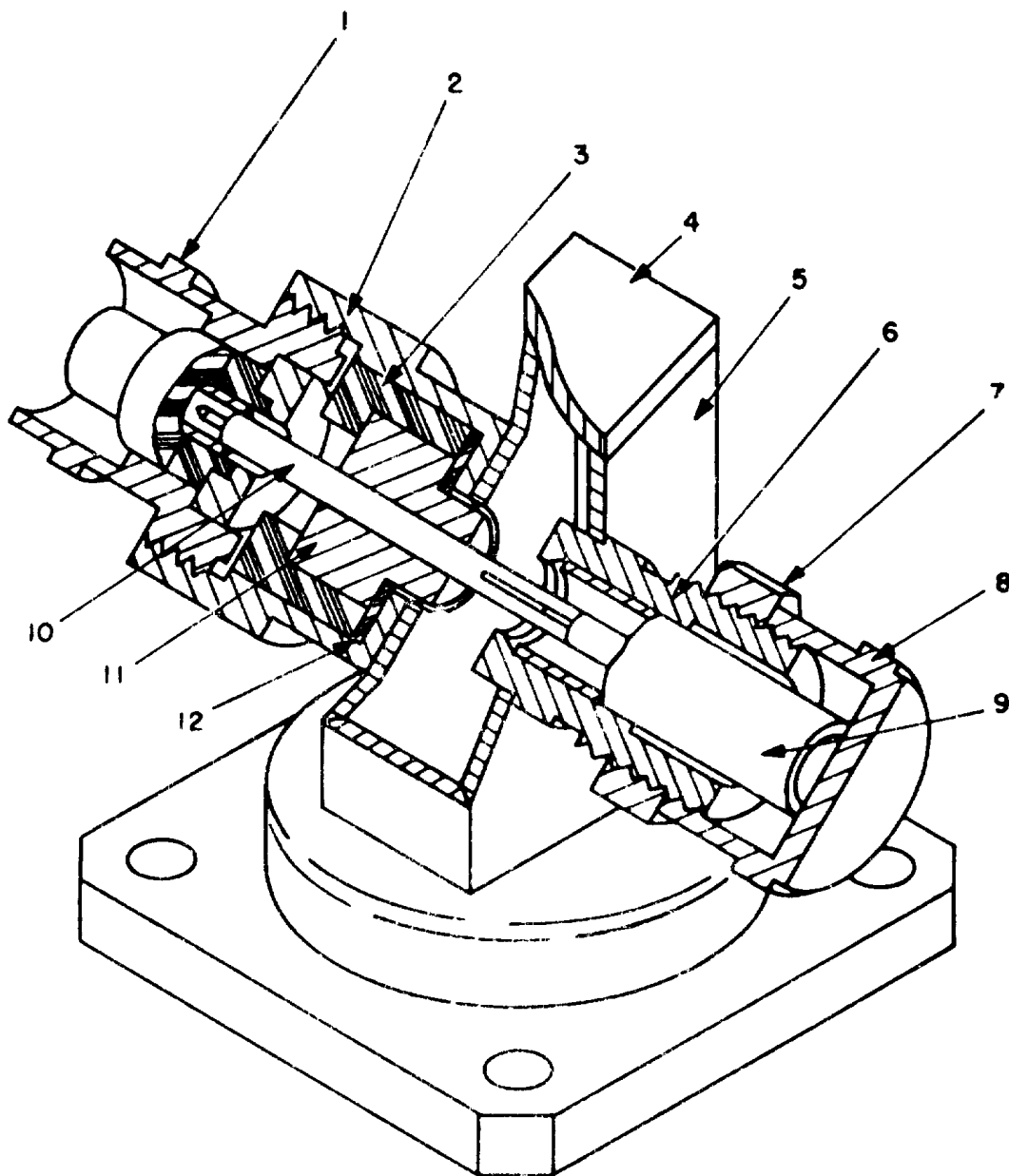
b.1. (Added) The crystal mixer used in the spectrum analyzer procured on Order No. 36225-Phila-57 is shown in figure 27.1. The crystal mixer uses an RF probe antenna (10), crystal (9) and holder (6), RF bypass capacitor (12), and a coaxial output connector (1). The RF energy in the guide (5) is picked up by the probe antenna, the two ends of which are firmly coupled to the center terminal of the mixer crystal and the center conductor of the coaxial output connector. RF energy propagated toward the output connector is shorted out through the RF bypass capacitor (12). The RF fed into the crystal is mixed in the crystal and the resultant IF energy passed back along the probe antenna to the output connector. The IF is not short-circuited by the capacitor- (12). The crystal cartridge (9) rests on a bevelled seat in the crystal holder (6) and is firmly held in place by a cap (8). The tip of the crystal center pin

fits tightly 2 between four spring fingers in the end of the probe antenna. The waveguide termination is designed to give a good impedance match of the mixer circuit to the waveguide over the entire frequency range of the analyzer, and assure efficient absorption of the RF energy by the probe antenna. The termination consists of a short-circuiting plate set at an angle to the waveguide axis and at such a position as to present effectively a quarter-wave length distance of the termination from the probe antenna over the entire frequency range.

Page 46, paragraph 56c, line 4. After "cycles per second," insert:

In spectrum analyzers procured on Order No. 36225-Phila-57, the frequency may be varied from 5 to 30 cycles per second.

Page 46. figure 33. Add the following note to figure 33:



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- |                                |                              |
|--------------------------------|------------------------------|
| 1 Receptacle connector.        | 7 Locking nut.               |
| 2 Holder                       | 8 Crystal cap.               |
| 3 Insulator.                   | 9 Coaxial crystal cartridge. |
| 4 Waveguide termination plate. | 10 RF probe antenna.         |
| 5 Waveguide.                   | 11 Antenna holder.           |
| 6 Crystal holder.              | 12 RF bypass capacitor.      |

Figure 27.1. (Added) Crystal mixer used in spectrum analyzer procured on Order No. 36225-Phila-57, cutaway view.

NOTE:

CAPACITOR C55 IS .068 UF IN SPECTRUM ANALYZERS PROCURED ON ORDER NO. 36225-PHILA-5.7.

Page 50, figure 37. Add the following note to figure 37:

NOTE:

CAPACITOR C61 IS .015 UF IN SPECTRUM ANALYZERS PROCURED ON ORDER NO. 36225-PHILA-57.

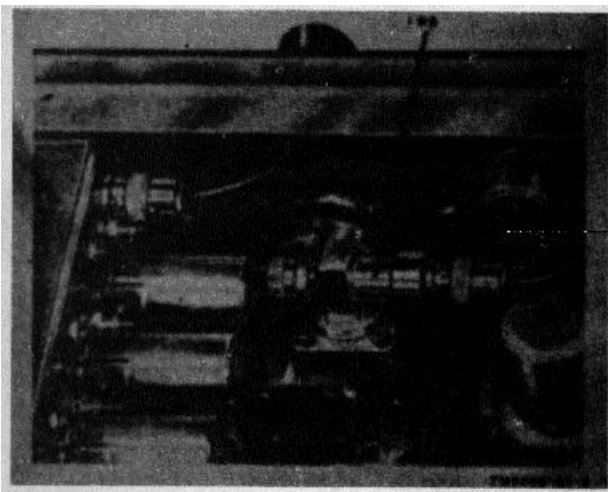
Page 55, figure 42. Add the following note to figure 12:

NOTE:

CAPACITOR C80 IS .022 UF IN SPECTRUM ANALYZERS PROCURED ON ORDER NO. 36225-PHILA-57.

Page 57, paragraph 69, last line of chart. Change "AN URM-60" to AN UPM-60.

Page 67, figure 52. Interchange the present



**Figure 50.1. (Added) Crystal mixer W9 of spectrum analyzer procured on Order No. 36225-Phila-57.**

positions of the captions SWEEP GEN V10 12AT7 and SPECTRUM AMPL V9 6AH6. Also delete 12A17 under V14 and insert: 6AH6.

*Page 73, paragraph 77d.* Change the first sentence to read: Remove the No. 3 8-24 hexagonal nut, the lockwasher, and (on some models) the square washer that secure the captive bar to the front panel.

*Page 73, paragraph 78.* Make the following changes:

Subparagraph c. Change four to eight.

After "plumbing assembly" add: Loosen the setscrews that hold the dial to the attenuator shaft.

Subparagraph d. Delete subparagraph d and substitute:

d. Slip the attenuator shaft through the opening in the panel and dial assembly and carefully remove the attenuator and dial assembly.

*Page 74, paragraph 84.* Delete subparagraph c and substitute:

c. Replace the crystal and screw on the knurled cap. On equipment procured on Order No. 36225-Phila-57, tighten the locknut. On all other equipment, be sure that the spring within the cap makes contact with the crystal.

*Figure 60 (fold-out).* Add the following to the notes:

3. IN THE EQUIPMENTS PROCURED ON ORDER NO. 36225-PHILA-57, THE VALUES OF CAPACITORS C55, C61, C80, AND C81 ARE AS FOLLOWS: C55-.068 UF; C61-015 UF; C80-022 UF; C81-015, UF.



[AG 413.44 (28 Feb 58)]

By Order of *Wilber M. Brucker*, Secretary of the Army:

MAXWELL D. TAYLOR  
*General, United States Army,  
Chief of Staff.*

Official:

HERBERT M. JONES,  
*Major General, United States Army,  
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Sig Sec, Gen Depots  
Sig Depots  
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Army Terminals  
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USA White Sands Sig Agcy  
USA Sig Eqp Spt Agcy  
Yuma Test Sta  
USA Elct PG  
Sig Fld Maint Shops  
Sig Lab  
Mil Dist  
JBUSMC  
Units org under fol TOE:  
11-7  
11-16  
11-57  
11-127  
11-125  
11-500 (AA-AE)  
11-557  
11-587  
11-592  
11-597

NG: State AG; units-same as Active Army.

USAR: None.

For explanation of abbreviations used, see AR 320-50.

TECHNICAL MANUAL }  
 No. 11-5099

HEADQUARTERS,  
 DEPARTMENT OF THE ARMY  
 WASHINGTON 25, D. C., 28 May 1957

**SPECTRUM ANALYZER AN/UPM-58**

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**CHAPTER 1**  
**INTRODUCTION**

---

**Section I. GENERAL**

**1. Scope**

a. This manual contains instructions for the installation, operation, maintenance, and repair of Spectrum Analyzer AN/UPM-58 (fig. 1).

b. Forward comments on this publication directly to: Commanding Officer, United States Army Signal Publications Agency, Fort Monmouth, New Jersey.

**2. Forms and Records**

a. *Unsatisfactory Equipment Report.* Fill out and forward DA Form 468 (Unsatisfactory Equipment Report), to Commanding Officer, U. S. Army Signal Equipment Support Agency, Fort Monmouth, N. J., as prescribed in AR 700-38.

b. *Damaged or Improper Shipment.* Fill out and

forward DD Form 6 (Report of Damaged or Improper Shipment), as prescribed in AR 700-58.

c. *Preventive Maintenance Forms.*

- (1) Prepare DA Form 11-238 (Operator First Echelon Maintenance Checklist) for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar) (fig. 15) in accordance with instructions on the back of the form.
- (2) Prepare DA Form 11-239 (Second and Third Echelon Maintenance Checklist) for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar) (fig. 16) in accordance with instructions on the back of the form.

**Section II. DESCRIPTION AND DATA**

**3. Purpose and Use**

Spectrum Analyzer AN/UPM-58 (fig. 1) is a 1.87-centimeter spectrum analysis unit used to analyze power in pulsed or continuous-wave (cw) radar and beacon signals from 15,800 to 16,200 megacycles (mc). The equipment may also function as a synchroscope for large amplitude-pulsed signals. As a spectrum analyzer, it is capable of resolving into distinct transients, the spectrum resulting from the pulse modulation of radar transmitters whose modulation pulses vary in width from .2 to 2 microsecond ( $\mu$ sec) and in repetition rate from 100 to 10,000 pulses per second (pps). Spectrum Analyzer AN/UPM-58 can accommodate input radio-frequency (RF) power up to +30 decibels referred to 1 milliwatt (dbm). The desired input level is obtained by means of a variable attenuator that provides 50 decibels (db) of attenuation. The attenuator is calibrated in 1-db steps for the first 45 db and uncalibrated for the rest of its range. The frequency of a spectrum line can be 2 determined with an absolute accuracy of  $\pm 10$  mc and a relative accuracy of  $\pm 5$  mc. When functioning as a

synchroscope, large amplitude-pulsed signals can be displayed on the cathode-ray tube (crt) screen in A-scope manner. Externally triggered sweeps of approximately 5 or 150  $\mu$ sec duration may be selected for sweeping the input pulse.

**4. Technical Characteristics**

a. *Analyzer Characteristics.*

- Frequency coverage ..... 16,000 mc  $\pm 200$  mc.  
Frequency meter accuracy:  
Absolute .....  $\pm 10$  mc.  
Relative, over 100-mc range .....  $\pm 5$  mc.  
RF input attenuation:  
Calibrated ..... 0 to 45 db.  
Uncalibrated ..... 46 to 50 db.  
Measurable input pulse modulation:  
Pulse width ..... 2  $\mu$ sec or less.  
Resolution ..... At least 50 distinct transients between third minimum points.

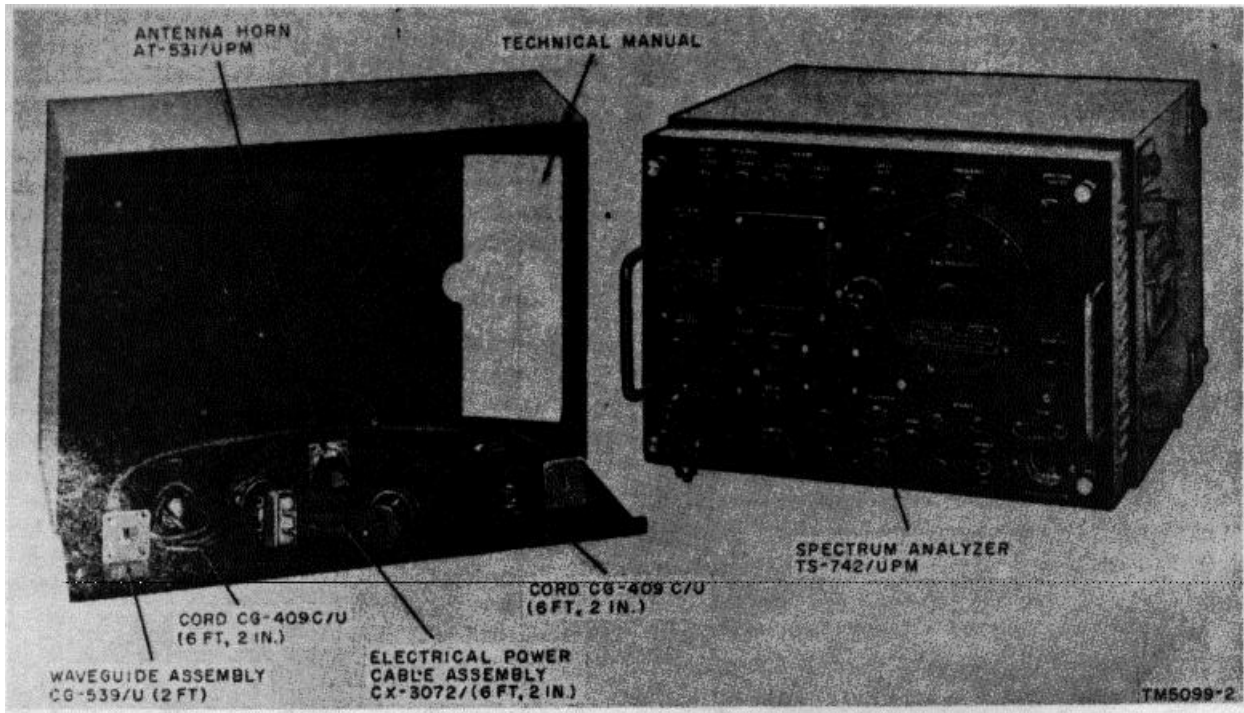


Figure 1. Spectrum Analyzer AN/UPM-8, components.

IF characteristics:

- First IF ..... 45 mc.
- Second IF ..... 5 mc.
- First IF bandwidth ..... 700 kc.
- Second IF bandwidth ..... 50 kc.
- Gain control ..... 0 to 40 db.

Sensitivity to cw:

- For 1-inch crt deflection ..... -60 dbm.
- For minimum discernible signal ... -70 dbm.

Maximum dispersion ..... 1 inch per mc.

Sweep frequency range ..... 5 to 40 cps, continuously variable.

b. Synchroscope Characteristics.

- Triggered sweep speeds ..... 5 and 150  $\mu$ sec.
- Natural deflection sensitivity ..... 115 to 160 volts per inch.

c. General Characteristics.

Power input..... 165 watts at 105 to 125 volts, 50 to 1,000 cps.

Power output:

- Plate supply..... +300 volts, electronically regulated.
- IF strip B+..... +135 volts, electronically regulated.
- Klystron reflector supply ..... -87 to -261 volts, gas diode regulated.
- Crt high voltage ..... 1,600 volts.

Number of tubes ..... 28.

Weight ..... 75 lb.

5. Table of Components

(fig. 1)

The components of Spectrum Analyzer AN/UPM-58 are listed in the table below.

Component	Read No.	Length (in.)	Depth (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Spectrum Analyzer TS-742/UPM	1	19	18 7/32	12 1/32	2.1	75
Technical manual	2	7 7/8		10 1/4		
Antenna Horn AT-531/UPM	1	3.6				
Waveguide Assembly CG-539/U (2 ft)	1	24				
Cord CG-409C/U (6 ft, 2 in.)	2	74				
Electrical Power Cable Assembly CX-3072/U (6 ft, 2 in.)	1	74				
Set of running spares (par. 7)	1					
Total						75

## 6. Description of Components

(fig. 1)

a. *Spectrum Analyzer TS-742/UPM.* The unit consists of a panel-chassis assembly inclosed in a combination dust cover and carrying case with gray enamel finish. The case is equipped with two large recessed carrying handles and four trunk-type pull-down latches. Four feet on each side, in the back, and on the bottom of the case, permit the equipment to be operated in all three planes. For operation, the case cover is removed to expose the front panel. All operating controls and receptacles for interconnecting the unit with a power source and related units are mounted on the front panel. All operating accessories are mounted on the inside surface of a hinged partition within the case cover; the circuit label appears on the outside surface. Two manuals are stored within a holder behind the hinged door.

*Note.* Throughout this manual, Spectrum Analyzer TS-742/UPM will be referred to as spectrum analyzer.

b. *Electrical Power Cable Assembly CX-3072/U.* Electrical Power Cable Assembly CX-3072/U consists of a 6-foot, 2-inch length of power cable with a Hubbell type 7084 connector at one end and Plug Connector U-120/U at the other end.

c. *Cord CG409C/U (6 ft. 2 In.).* Cord CG-409C/U (6 ft. 2 in.) consists of a 6-foot, 2-inch length of Radio Frequency Cable RG-58C/U with Radio Frequency Plug UG-88/U at each end. Two cords are provided.

d. *Waveguide Assembly CG-539/U.* Waveguide Assembly CG-539/U consists of a 2-foot length of nontwistable waveguide, encased in a molded rubber

jacket. It is terminated in a plain cover-type Waveguide Flange UG-419/U at each end.

e. *Antenna Horn AT-531/UPM.* Antenna Horn AT-531/UPM consists of a 3 1/4-inch length of Transmission Line RG-91/U flared into a horn 1 3/16 inches from one end. The other end terminates in Waveguide Flange UG-419/U.

## 7. Running Spares

Following is a list of running spares for the spectrum analyzer. Except for two fuses stored in the front panel spare fuse receptacles, these items are stored in a separate corrugated carton packed with the equipment (fig. 2).

- 1 tube 2X2A.
- 1 tube 5651.
- 2 tubes, 12AT7.
- 1 tube 6AH6.
- 1 tube 6BA7.
- 1 tube 3RP1.
- 1 tube 6 X 4W.
- 2 tubes, 6AU6.
- 1 tube 6AS7G.
- 1 tube 6005/6AQ5W.
- 1 tube 5Y3WGT.
- 1 tube 6178 (QK297).
- 1 crystal 1N26.
- 3 fuses, 250-volt, 3-ampere, type 3AGC.
- 1 panel lamp, T-3 1/4, 6- to 8-volt, .15-ampere, GE47.
- 1 panel lamp, AN3140-328.

## 8. Additional Equipment Required

A directional coupler (PRD type 405, or equivalent) is not supplied with the spectrum analyzer but is required in one of its operations.

## CHAPTER 2

### OPERATION

---

#### Section I. SERVICE UPON RECEIPT OF SPECTRUM ANALYZER AN/UPM-58

##### 9. Unpacking

a. *Packaging Data.* When packed for shipment, the components of Spectrum Analyzer AN/UPM-58 are placed in moisture-vaporproof cartons and packed in a wooden box. A typical component packed for export shipment is shown in figure 2. When packed for export shipment, the shipping container is 22 X 20 1/4 X 14 inches. It displaces approximately 3.6 cubic feet and weighs 105 pounds.

b. *Removing Contents.*

**Caution:** Be careful when handling, uncrating, and unpacking the equipment; it is easily damaged.

Perform all the steps outlined below when unpacking equipment from wooden boxes (fig. 2).

- (1) Cut and fold back the metal straps.
- (2) Remove the nails with a nail puller. Remove the top of the packing case. Do not attempt to pry off the top; you may damage the equipment.
- (3) Remove the running spares carton.
- (4) Remove the wooden braces, nailed to the sides of the wooden crate.
- (5) Remove the corrugated fiberboard carton that contains the equipment. Open the carton. Remove the five folded corrugated supports placed around the equipment, one on each side and one on top, and remove the equipment.

##### 10. Checking Unpacked Equipment

- a. The equipment should be checked as follows:
- (1) Check the contents against the packing slip.
  - (2) Place the equipment on a workbench.
  - (3) Inspect the equipment for possible damage incurred during shipment. If the equipment has been damaged, refer to paragraph 2.

b. If the equipment has been used or reconditioned, check as follows:

- (1) If the equipment has been changed by a modification work order (MWO), the MWO number will appear on the front panel. Add a note to the overall schematic diagram (fig. 60) indicating the extent of the modification.
- (2) Check the operating controls for ease of rotation. If lubrication is required, refer to paragraph 33.

##### 11. Installation and Initial Check

A 1N26 crystal and all operating tubes are installed in Spectrum Analyzer TS-742/UPM when the equipment is shipped from the factory. Check to see that all tubes are firmly seated in the proper sockets (fig. 43).

a. *Location.* The spectrum analyzer must be located within 6 feet of a source of operating power.

If the spectrum analyzer is to be connected to a directional coupler on the radar set, it must be placed within 2 feet of the directional coupler to permit connection through Waveguide Assembly CG-539/U.

b. *Power Connections.* Connect Electrical Power Cable Assembly CX-3072/U to the POWER IN receptacle on the front panel and to a 105- to 125-volt, 50- to 1,000-cps, single phase alternating current (ac) power source.

c. *Connections for Spectrum Analyzer Operation.* When used for analyzing the spectrum of a generated signal the spectrum analyzer may be connected to the signal source through a directional coupler (fig. 5) or antenna pick-up horn (fig. 6). The actual method used in connecting the spectrum analyzer will be determined by the particular tests to be performed and available equipment. The following

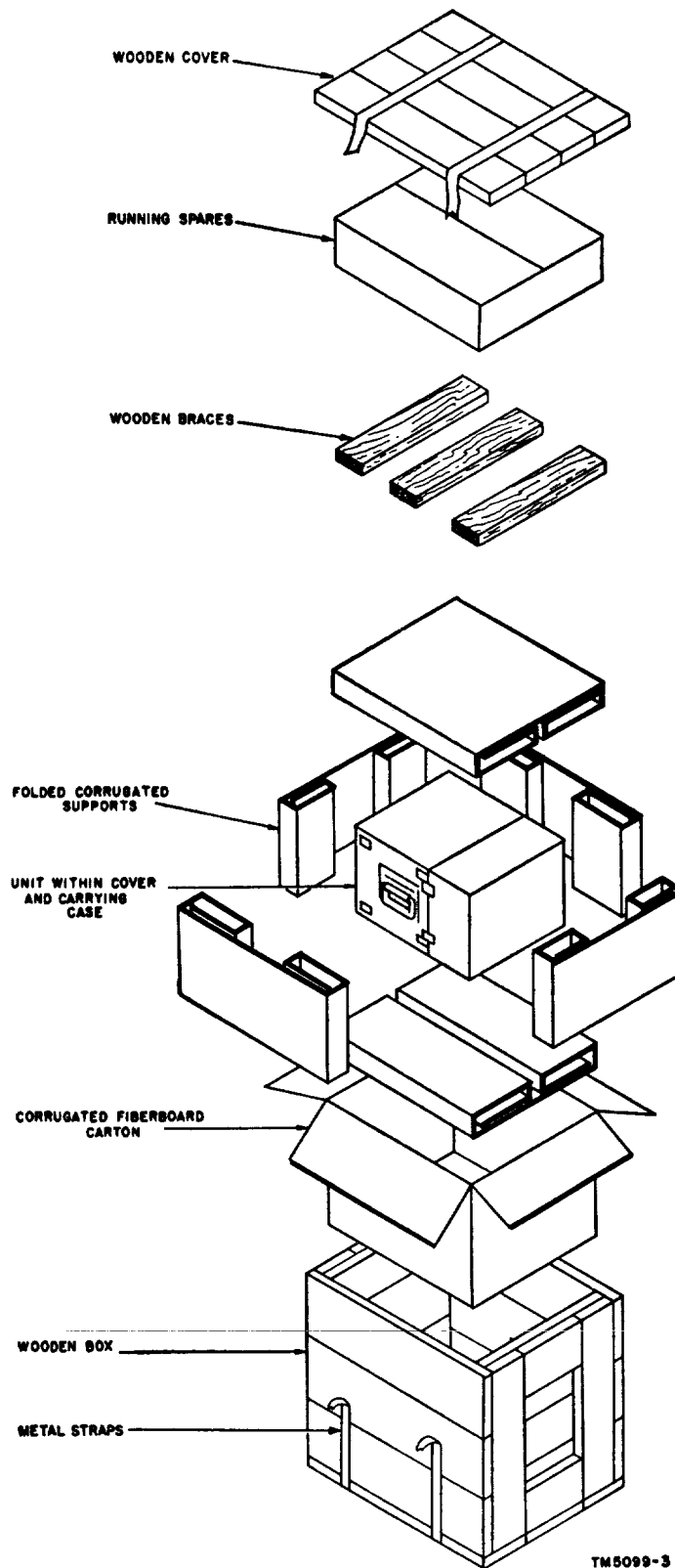


Figure 2. Spectrum Analyzer AN/UPM-58, packing and packaging diagram.

describes different procedures of connecting the equipments:

*Note.* If the input signal is coupled through the antenna horn, make sure that the coupling is not so close as to constitute a danger to the input circuits of the spectrum analyzer.

- (1) *With built-in directional coupler* (fig. 5). If the radar set to be tested has a directional coupler, connect Waveguide Assembly CG-539/U between the RF INPUT connection of the spectrum analyzer and the connection on the radar set directional coupler.
- (2) *With external directional coupler.* If the radar does not have a built-in directional coupler, but provides for insertion of a directional coupler in the radar waveguide assembly, remove the appropriate section of the radar waveguide and insert a PRD Type 405 directional coupler, or equivalent. Connect Waveguide Assembly CG-539/U between the spectrum analyzer RF INPUT connection and the directional coupler.

*Note.* A bidirectional coupler may be used to measure power in both directions in a radar set waveguide. One connection on the coupler is used to measure the radar transmitter power and to inject certain test signals in the radar system. The other connection is used to measure reflected power in the waveguide

assembly. If the spectrum analyzer is connected to the wrong connection on the coupler, the test results will be useless. The radar equipment manual should be referred to for detailed instructions on connections to a bidirectional coupler.

- (3) *With antenna horn.* Antenna Horn AT-531/UPM must be used with the waveguide as shown in figure 6. When a directional coupler or bidirectional coupler is not available, connect the end opposite the horn end of the waveguide to the RF INPUT connection on the spectrum analyzer. The antenna horn is then directed at the signal source.

*d. Connections for Synchroscope Operation.* For synchroscope operation, the spectrum analyzer is connected in the following manner:

- (1) Connect a video cable, Cord CG-409C/U, from the TRIG. IN connector on the spectrum analyzer to the trigger source on the radar set.
- (2) Connect a video cable, Cord CG-409C/U, from the PULSE IN connector on the spectrum analyzer to the signal source that is to be displayed on the synchroscope.

*e. Initial Check of Equipment.* Refer to the equipment performance checklist (par. 37) for initial checks upon receipt of equipment.

## Section II. CONTROLS AND INSTRUMENTS

### 12. General

When analyzing power in a pulsed or continuous-wave radar signal, haphazard operation or improper setting of the controls can cause damage to the spectrum analyzer. For this reason, it is important to know the function of every control and indicating dial on the equipment.

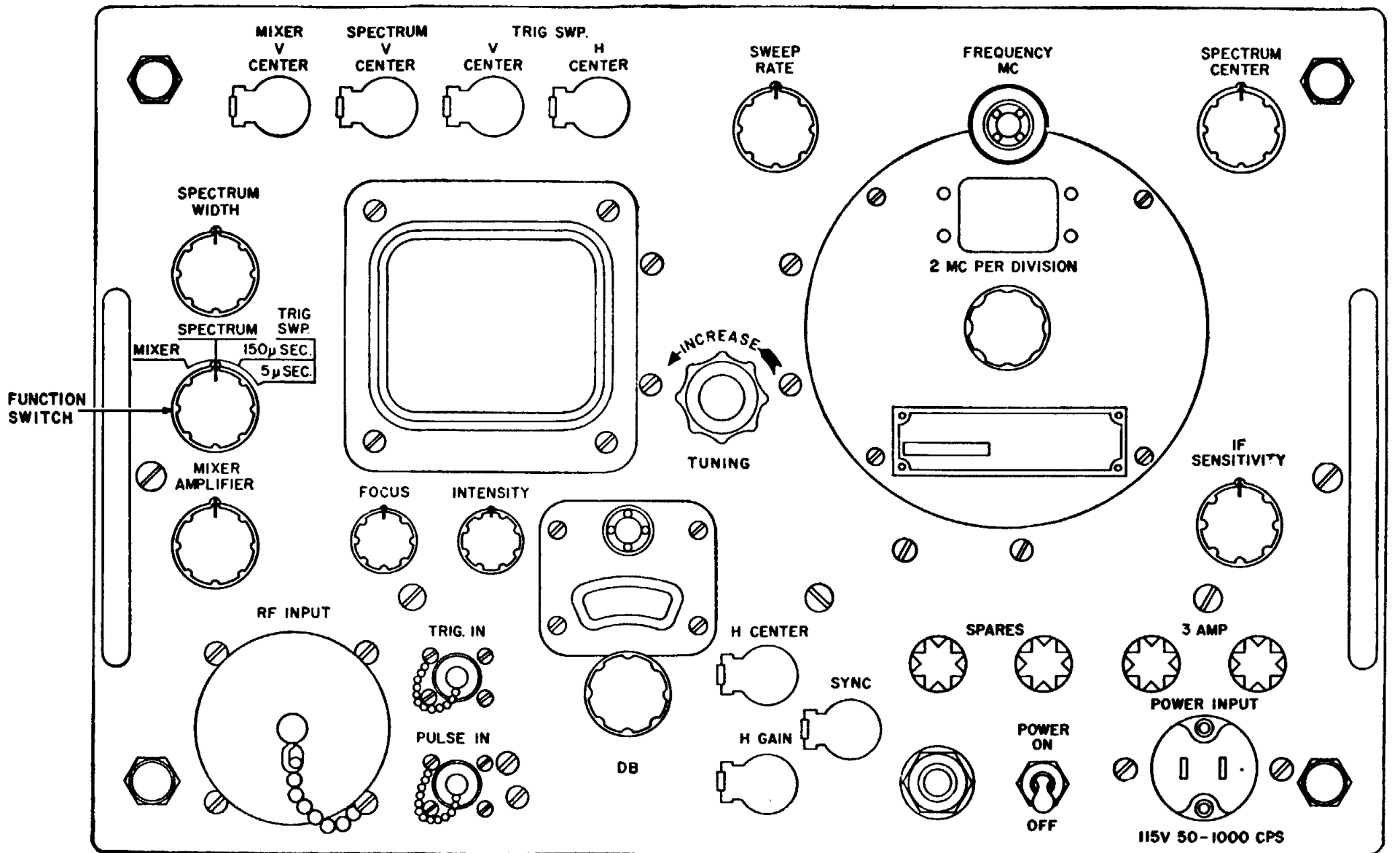
### 13. Controls and Their Uses

The following chart lists the operating controls and indicating dials of the spectrum analyzer and indicates their functions (fig. 3).

Controls	Function				
POWER switch	For turning equipment on or off.				
Function switch	Selects function of equipment. Switch positions and functions are as follows:				
	<table border="0" style="width: 100%;"> <tr> <td style="text-align: center;"><i>Position</i></td> <td style="text-align: center;"><i>Function</i></td> </tr> <tr> <td>MIXER</td> <td>Mode pattern of klystron oscillator is displayed on screen of crt.</td> </tr> </table>	<i>Position</i>	<i>Function</i>	MIXER	Mode pattern of klystron oscillator is displayed on screen of crt.
<i>Position</i>	<i>Function</i>				
MIXER	Mode pattern of klystron oscillator is displayed on screen of crt.				

Controls	Function		
	<table border="0" style="width: 100%;"> <tr> <td style="text-align: center;">Position</td> <td style="text-align: center;">Function</td> </tr> </table>	Position	Function
Position	Function		
SPECTRUM	Crt displays spectrum of rf input.		
TRIG SWP. ---	Determines sweep duration when externally triggered (approximately 150 A SEC. in this position).		
TRIG SWP. ---	Determines sweep duration when externally triggered (approximately 5 μ SEC. in this position).		
TUNING knob	Tunes klystron oscillator.		
FREQUENCY MC	Tunes absorption-type frequency meter. Dial indicates frequency in me.		
SPECTRUM WIDTH	Adjusts width of frequency band through which klystron oscillator sweeps, thereby increasing or decreasing number of me per inches displayed on crt.		





TM 5099-4

Figure 3. Spectrum Analyzer TS-742/UPM, front panel controls.

Controls	Function
IF SENSITIVITY	Adjusts gain in 45-mc intermediate-frequency amplifier stages and thereby changes amplitude of spectrum display.
MIXER AMPLIFIER	Adjusts gain of klystron mode when function switch is in MIXER position. When function switch is in SPECTRUM position, adjusts amplitude of frequency meter dips in horizontal trace.
H CENTER	When function switch is in SPECTRUM or MIXER position, positions horizontal display.
H GAIN	When function switch is in SPECTRUM or MIXER position varies width of horizontal display on screen.
FOCUS DB	Adjusts focus of display on screen. Reduces power of incoming signal to level which mixer can accommodate conveniently. Attenuation from 0 to 45 db can be read on dial of control and corrected by unit calibration curve. Uncalibrated attenuation from 46 to 50 db is also provided.

Controls	Function
SPECTRUM CENTER control	Fine frequency adjust, controls horizontal centering of spectrum or mode.
INTENSITY SWEEP RATE	Controls intensity of horizontal display. Controls sweep repetition rate from 5 to 40 sweeps per second.
SYNC	Adjusts sweep rate to submultiple of line frequency, thus permitting display to be steadied.
MIXER V CENTER	Positions display vertically when unit is operated in MIXER position.
SPECTRUM V CENTER	Positions spectrum display vertically when unit is operated in SPECTRUM position.
TRIG SWP. V CENTER	Positions trace vertically when equipment is operated in either of TRIG SWP. positions.
TRIG SWP. H CENTER	Positions trace horizontally when equipment is operated in either of TRIG SWP. positions.

### Section III. OPERATION

#### 14. Spectrum Analyzer Starting Procedure

Perform the starting procedure given below before using the analyzer operating procedure described in paragraph 15.

a. *Preliminary.* Set the front panel controls (fig. 3) as follows:

Control	Position
POWER switch	To OFF position.
Function switch	To MIXER position.
SPECTRUM WIDTH	To maximum clockwise position.
MIXER AMPLIFIER	One-third clockwise.
SPECTRUM CENTER	Midposition.
TUNING	Midposition.
FREQUENCY MC	To maximum clockwise position.
INTENSITY	Two-thirds clockwise position.

b. *Starting.*

- (1) Throw the POWER switch to the ON position. The frequency meter dial lamp, attenuator dial lamp, and pilot lamp should glow.
- (2) A bell-shaped mode pattern should appear (A, fig. 4). If the mode pattern does not appear, or if two mode patterns

appear, adjust the SPECTRUM CENTER control, to center the larger mode pattern. If the pattern is not steady, synchronize it by means of the SWEEP RATE control.

- (3) Adjust the FOCUS and INTENSITY controls to obtain a distinct pattern.
- (4) Position the display horizontally with the H CENTER control.
- (5) Position the display vertically with the MIXER V CENTER control so that it appears the same as that shown in A, figure 4.
- (6) Center the bell-shaped hump with the SPECTRUM CENTER control. Extend it almost the width of the trace with the SPECTRUM WIDTH control. Use the MIXER AMPLIFIER control to adjust its size as desired, although not to the extent of causing the top of the pattern to move off the screen.
- (7) Rotate the FREQUENCY MC control to place a frequency dip in the center of the hump (B, fig. 4).

- (8) Place the function switch in the SPECTRUM position. The mode indication should disappear and a pattern similar to C, figure 4 should appear. It may be necessary to increase the MIXER AMPLIFIER control to observe the center frequency indication. The dip at left and the rise at right indicate the outer limits of the mode and the dip midway between the end dips indicates the center frequency setting of the mode.

*Note.* If, during the starting procedure, an abnormal result is obtained, turn off the spectrum analyzer and refer to the equipment performance checklist (par. 37).

c. Set the SPECTRUM WIDTH control to its maximum counterclockwise position.

d. Set the MIXER AMPLIFIER control to its midposition.

e. Apply the signal, from the radar transmitter or other source, to the RF INPUT receptacle on the spectrum analyzer through the antenna horn or a directional coupler (figs. 5 and 6). The average power of the signal must not exceed 1 watt (+30 dbm). A spectrum pattern (B, fig. 7), or, in the case of a cw signal, a single vertical line should appear on the scope (A, fig. 7).

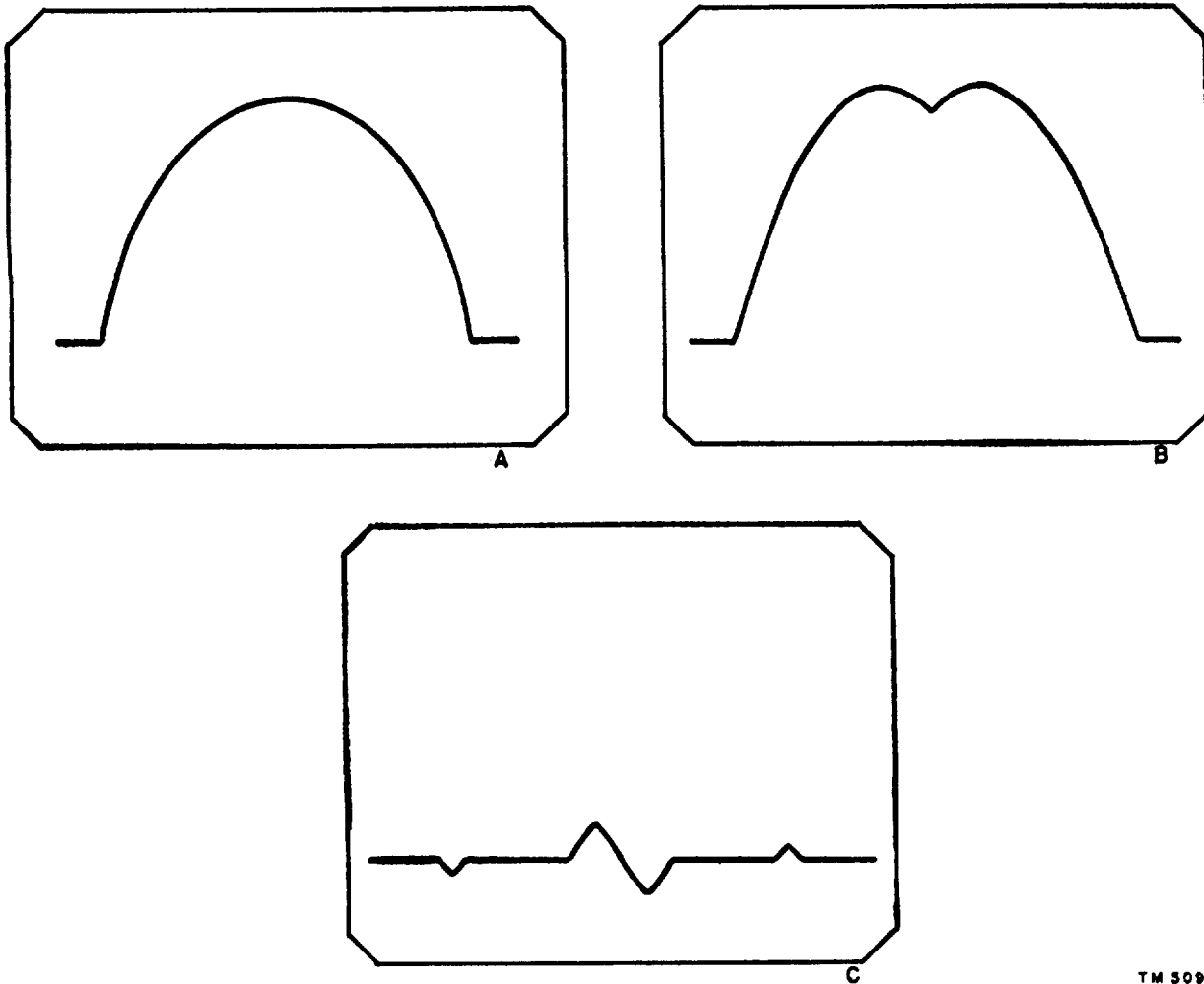
**Caution:** Avoid overcoupling the antenna horn and the equipment under test. Failure to take this precaution may damage the attenuator or the crystal mixer, even if the spectrum analyzer is turned off.

f. If neither a spectrum nor a cw indication appears on the screen, the signal may be either outside

### 15. Spectrum Analyzer Operating Procedure

a. Set the DB control to maximum.

b. Set the IF SENSITIVITY control to its maximum clockwise position.



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Figure 4. Representative displays with no signal present, SPECTRUM WIDTH full clockwise.

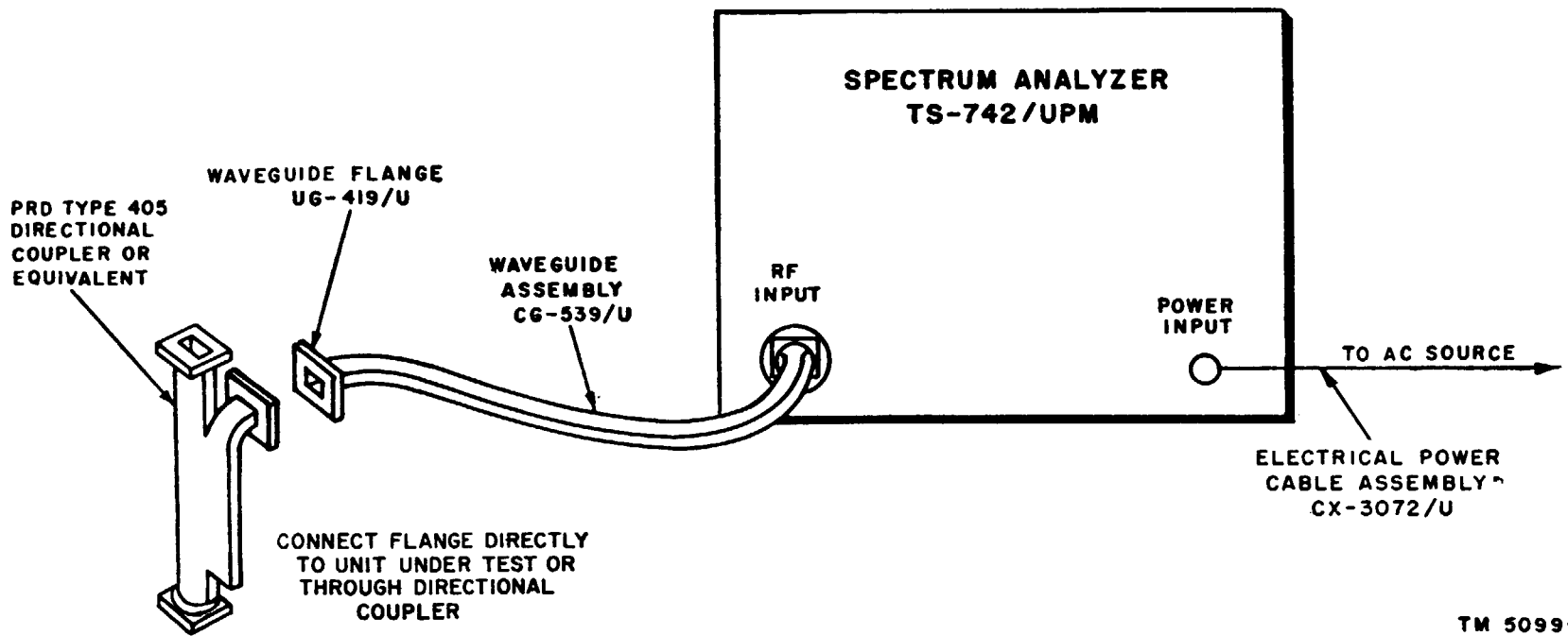
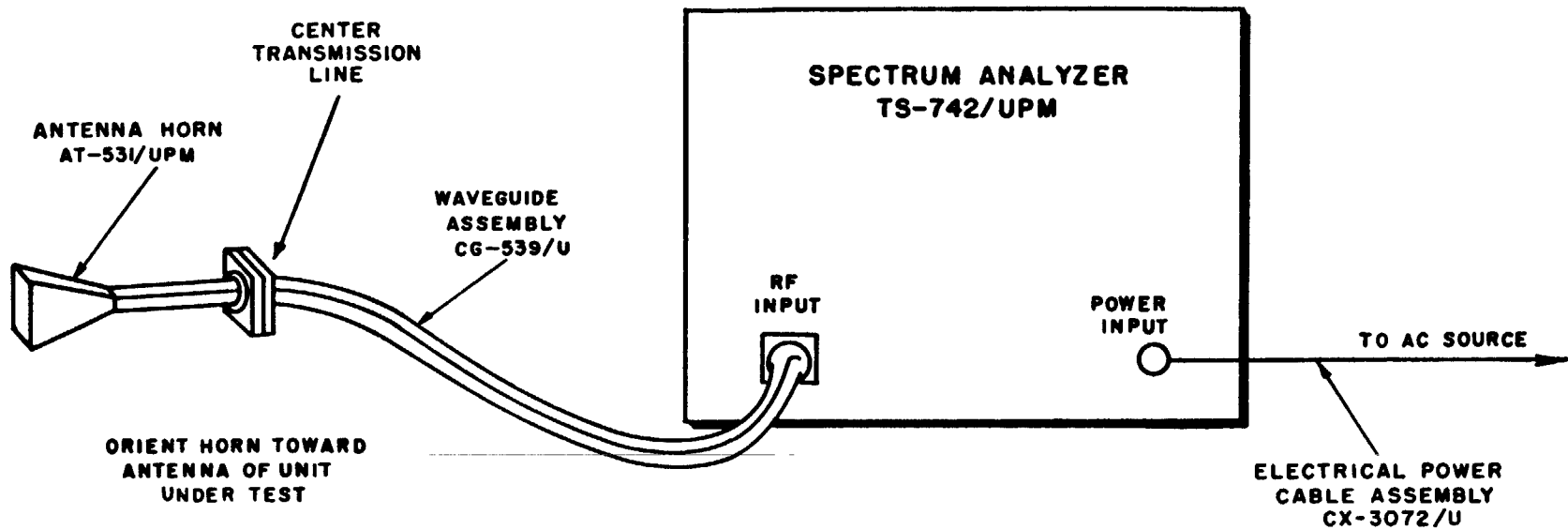


Figure 5. Interconnection diagram, directly coupled signal.

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TM5099-8  
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Figure 6. Interconnection diagram, radiated signal.

the klystron mode or there may be too much attenuation in series with the incoming signal. To check this, the following procedure should be used:

- (1) Turn the spectrum analyzer TUNING control through the entire frequency range.

If no signal appears, the DB control should be reduced from maximum attenuation to 45 db. Once again the TUNING control should be used to search the entire frequency range of the spectrum analyzer.

- (2) If the signal still does not appear on the spectrum analyzer, repeat the procedure in (a) above, decreasing the attenuation in 15-db steps until the signal appears.

g. With the radar signal present on the oscilloscope screen of the spectrum analyzer, adjust the following controls:

- (1) Adjust the SPECTRUM CENTER control so that the display is properly centered.
- (2) Adjust the DB and IF SENSITIVITY controls to obtain the desired amplitude of the display signal.
- (3) Adjust the SPECTRUM WIDTH control to obtain the desired dispersion of the display.

## 16. Measurements and Tests in Spectrum Analysis Function

a. Within the limits of its frequency range, the spectrum analyzer may be used to perform a number of tests of microwave components. These tests are made by observing the signal presented on the spectrum analyzer crt. A cw signal appears as a

single line (A, fig. 7) or two lines; a pulsed signal appears as one (B, fig. 7) or two spectrum displays. The individual lines in the spectrum represent frequency components of the pulsed signal. However, the *number* and *spacing* of these lines depend on many factors other than the frequency components of the pulsed signal: for example, the settings of the SWEEP RATE and SPECTRUM WIDTH controls. The lines have, therefore, very little significance as such. It is the *shape* of the spectrum *envelope* that yields significant information about the nature of the modulating pulse.

b. The spectrum analyzer is capable of making the following tests:

- (1) Measurement of magnetron frequencies (par. 17).
- (2) Measurement of the distribution of useful transmitted power (par. 18).
- (3) Measurement of pulse width (par. 19).
- (4) Performance tests for local oscillator tubes (par. 20).
- (5) Observation of the operation of radar local oscillators with respect to their associated magnetrons and local oscillator alignment (par. 21).
- (6) Observing and adjusting pulsed magnetron spectrums (par. 22).

## 17. Frequency Measurements

a. *General.* With the function switch in the MIXER position, the frequency dip in the bellshaped curve (B, fig. 4) represents the actual setting of the frequency meter, as indicated on the

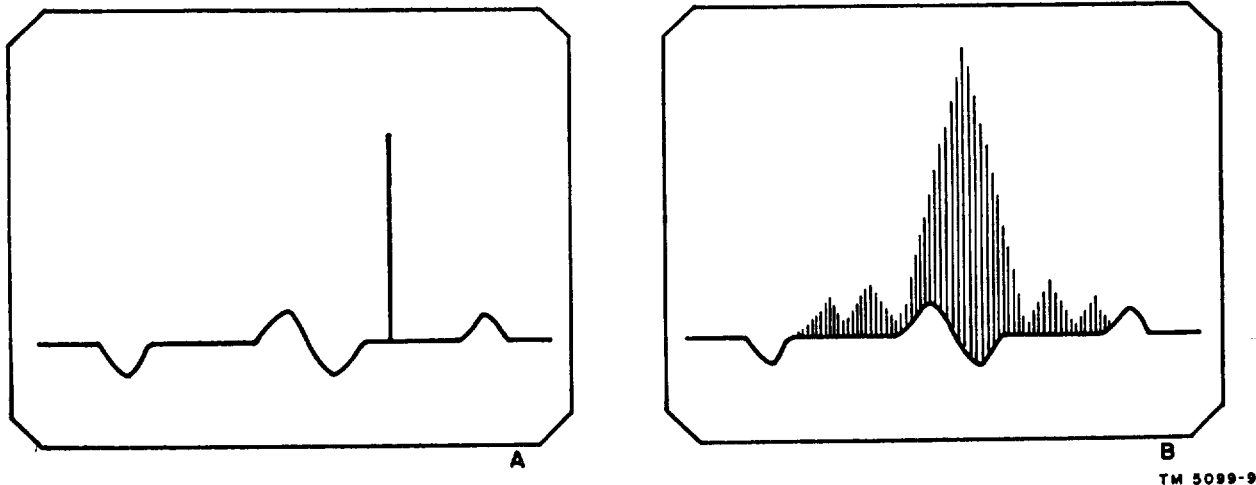


Figure 7. Representative displays with signal present, SPECTRUM WIDTH full clockwise.

FREQUENCY MC dial. When the function switch is in the SPECTRUM position, the frequency is indicated by a dip in the horizontal display. This dip may be used to compute the frequency of an unknown signal. When used in this manner, the FREQUENCY MC dial indicates the local oscillator frequency that is beating with the unknown signal to produce an IF of 45 mc rather than the unknown frequency. The unknown or signal frequency may be determined by following the procedure described below.

**Note**

**When two patterns appear, they are 90 mc apart; that is, twice the IF of the spectrum analyzer. These displays are mirror images of each other. Either one or both may be used for observations and measurements.**

b. *Both Spectrum Images on Screen.* When two images appear on the screen, one of the following methods may be used to determine the frequency of the unknown signal:

- (1) Method one:
  - (a) Adjust the FREQUENCY MC control so that the frequency meter dip is centered between the two images.
  - (b) Carefully observe both images and tune the frequency meter until the amplitude of the main lobe in both spectrums decreases simultaneously (fig. 8). The reduction of amplitude occurs because the frequency meter absorbs energy from the unknown signal.
  - (c) The reading on the frequency meter tuning dial represents the frequency of the unknown signal.

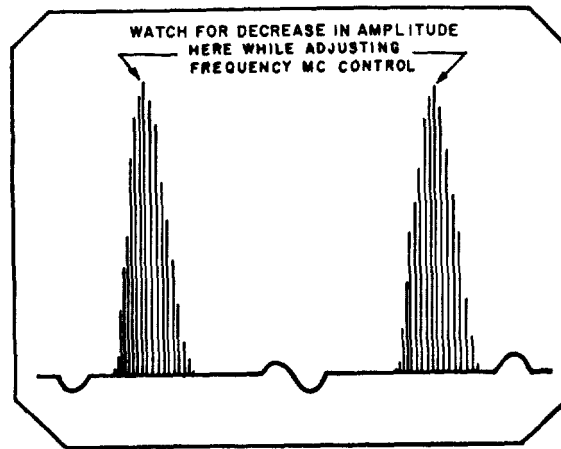
**Note**

**This method can only be used if the unknown signal is stably coupled to the spectrum analyzer via the direction coupler.**

- (2) Method two:
  - (a) Aline the frequency meter dip with the leading edge of the right-hand main lobe image. Note the reading on the frequency meter tuning dial.
  - (b) Aline the frequency meter dip with the leading edge of the main lobe of the right-hand image. Note the reading on the frequency meter tuning dial.
  - (c) Add the two frequency meter readings and divide by two.

Example:

<i>First reading</i>	<i>Second reading</i>	<i>Signal frequency</i>	
15,900 mc	+ 15,990 mc	=	15,945 mc
			2



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**Figure 8. Measuring frequency by tuning frequency meter for dips in both spectrums.**

c. *Single Spectrum Image on Screen.* When only one spectrum image can be made to appear on the screen (fig. 9), the following procedure is used to determine the frequency of the unknown signal.

- (1) Determine whether the spectrum image is a left-hand or a right-hand image by turning the TUNING control counterclockwise and noting whether another image appears on the screen. If another image appears, the image is that of a left-hand spectrum. If no image appears, the image is that of a right-hand spectrum.
- (2) Use the tuning control to center the image on the screen. Vary the FREQUENCY MC control so that the frequency meter dip coincides (causes the main lobe to decrease in amplitude) with the spectrum image.
- (3) If the frequency meter is tuned so that its dip coincides with the right-hand image, the dial reading represents the frequency of the spectrum analyzer oscillator which is 45 mc above the unknown frequency. Therefore, 45 mc must be subtracted from the dial reading to obtain the frequency of the unknown signal.
- (4) If the frequency meter is tuned so that the dip coincides with the left-hand image, the dial reading represents the frequency of the spectrum analyzer oscillator which is now 45 mc below the frequency of the unknown frequency. In this case, 45 mc must be added to the dial reading to obtain the unknown frequency.

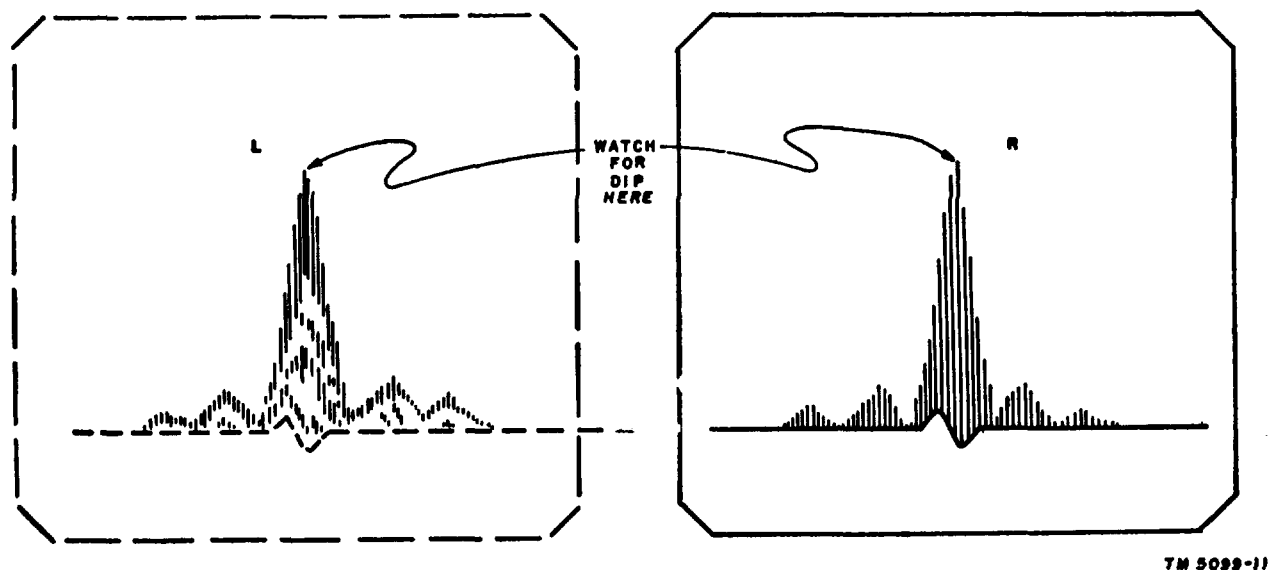


Figure 9. Measuring frequency by tuning frequency meter for dip in each spectrum.

## 18. Power Distribution and Relative Power Measurement

a. *General.* The amplitude of the lines or pulses within the spectrum envelope represents the voltage of the frequency components. Therefore, the spectrum envelope illustrates graphically the power versus frequency distribution within the signal pulse. The relationships may be expressed in db by means of the DB control.

b. *Measurement of Main Lobe Power Versus Side Lobe Power.* To compare the power of the main lobe to that of the side lobe, use the following procedure:

- (1) Place the function selector switch in the SPECTRUM position.
- (2) Adjust the FREQUENCY MC dial so that the wave meter pips do not coincide with main or side lobe peaks of the spectrum display.
- (3) Mark the amplitude of the side lobe and note the setting of the DB control.
- (4) Increase the db dial setting until the amplitude of the main lobe is reduced to the former amplitude of the side lobe. Note the db dial setting.
- (5) The difference between the two settings represents the power relationship between these lobes in db.
- (6) *Example:* If the db setting must be increased from 15 to 25 db, then the power

level of the signal frequency represented by the center line of the main lobe is 10 db higher than that of the center frequency in the side lobe.

c. *Correction Factor.* The readings obtained from the db dial are approximate since they do not take into account the frequency sensitivity of the attenuator. Figure 10 shows a typical db correction curve in which attenuation is given as a function of frequency. The calibration curve provided with the unit should be used for actual db correction. For purposes of illustration, reference is made to a typical db correction chart fig. 10). Make the db correction as follows:

- (1) Assume that the FREQUENCY MC dial is at 16,000 mc.
- (2) Enter the chart at 15 db (the first db dial setting) along the horizontal axis. Read the correction for the 16,000-mc curve on the vertical scale; it is -2.25 db. Add this reading algebraically to the original reading.  
*Example:*  $15 + (-2.25) = 12.75$  db.
- (3) Enter the chart at 25 db (the second db dial setting) and read the correction for the 16,000-mc curve on the vertical scale; it is -.6 db. Add this reading algebraically to the original reading.  
*Example:*  $25 + (-.6) = 24.44$  db.



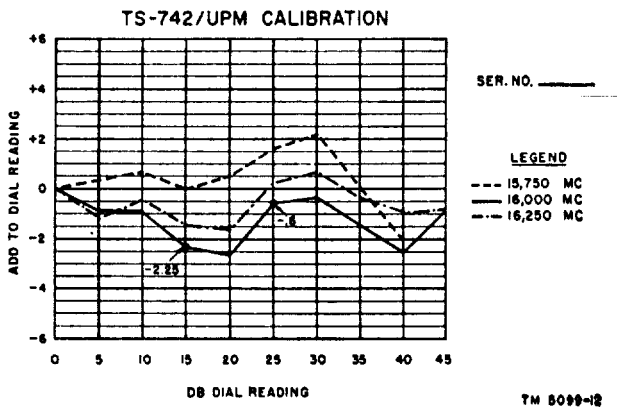


Figure 10. Typical db correction curve.

- (4) Obtain the difference between the corrected readings. It is 11.69 db. This represents the correct power relationship between the two lobes.

### 19. Measurement of Pulse Width

a. The significance of pulse width measurements is that the band pass of a radar receiver is usually designed to be slightly less than the frequency difference between the first two spectrum minima for the shortest pulses used. For example, the band pass of a typical receiver for a .5  $\mu$ sec pulse is about 3 to 6 mc. For efficient operation, it is essential that most of the power output of the transmitter be included in a frequency band that is equal to, or less than, the receiver band pass. This is the case when the transmitter output approximates the ideal, as illustrated in figure 11. Such a spectrum is produced by a perfect rectangular square wave. In practice, however, the keying pulses obtained are not perfectly rectangular. They have measurable rise and decay times and their tops are not flat. The shape of the keying pulse affects both the frequency and power of the transmitter signal and consequently the response and range of the receiver.

b. To make pulse width measurements, proceed as follows:

- (1) Adjust the spectrum analyzer controls for a spectrum as nearly as possible approximating the spectrum shown in figure 11.
- (2) Measure the frequency difference between the first two minima with the FREQUENCY MC control (par. 17).

- (3) Use the table in figure 11 to determine the pulse width. Figures therein are based on the following simplified formula:

$$\tau = \frac{2}{\Delta f}$$

$\tau$  = pulse width in  $\mu$ sec.

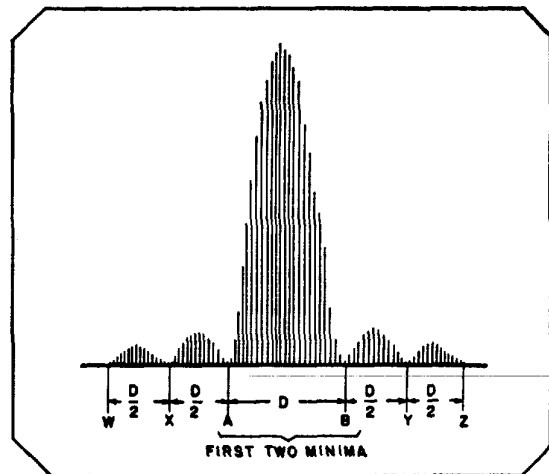
$\Delta f$  = difference in wavemeter dial readings in mc.

#### Note

When the spectrum cannot be broadened sufficiently to measure the frequency difference between the first two minima accurately, take readings between several minima. The distance between any two adjacent minima is one-half the distance between the minima bounding the main lobe.

### 20. Performance Tests for Local Oscillator Tubes

The spectrum analyzer may be used to check type 6178 local oscillator klystrons by substituting them for the klystron tube in the spectrum analyzer, turning the function selector switch to the MIXER position, and adjusting the controls until the characteristic hump or mode curve appears on the screen. Discontinuity in frequency, low power output, and lack of oscillation at particular frequencies then can be readily observed.



PULSE WIDTH	D= DIST. IN MC/S BETWEEN FIRST TWO MINIMA
1/10 USEC	20 MC
1/4 USEC	8 MC
1/2 USEC	4 MC
1 USEC	2 MC

EXAMPLE: IF THE PULSE WIDTH IS 1 USEC, THE FREQUENCY DIAL SHOULD SHOW 2 MC/S BETWEEN A AND B OR 4 MC BETWEEN X AND Y

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Figure 11. Relationships between pulse width and spectrum minima.

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## 21. Radar Local Oscillator Alinement

The operation of a radar local oscillator and the accuracy with which it tracks a magnetron can be checked with the spectrum analyzer.

a. Connect Antenna Horn AT-531/UPM to the RF INPUT receptacle on the spectrum analyzer.

b. Position the horn so that the signals are picked up simultaneously from the radar local oscillator and magnetron.

### Note

**The antenna horn should be positioned away from the magnetron thus attenuating the magnetron signal.**

c. The spectrums of both the magnetron and local oscillator should appear on the screen. Proper adjustment of controls (par. 16a) may be necessary. The magnetron spectrum should approximate the spectrum shown in figure 11. The radar local oscillator may be either a straight line (a *cw* indication), or a single lobe, if the automatic frequency control is operative.

d. The magnetron and local oscillator spectrums should be separated by the radar IF; that is, 30 or 60 mc depending on the type of radar equipment being alined.

e. Normally, the local oscillator frequency is above the magnetron frequency and its spectrum will therefore appear to the right of the left-hand magnetron spectrum. However, it is necessary to determine which images, left-hand or right-hand, of the respective spectrums are being observed (par. 17c(1)).

### Note

**Always position either two left-handed or two right-handed images.**

f. The actual frequency between the magnetron and local oscillator frequency, and consequently the accuracy with which the local oscillator is tracking the magnetron may be determined as follows:

- (1) Position the frequency meter pip in the center of local oscillator spectrum, note the value presented on the FREQUENCY MC dial.
- (2) Position the frequency meter pip in the center of the magnetron spectrum, note the value presented on the FREQUENCY MC dial.
- (3) The frequency difference between the magnetron and local oscillator can be determined by subtracting one value from the other.

g. The frequency relationships between images when the local oscillator frequency is 60 mc and 30 mc above the magnetron frequency are shown in A and B, figure 12, respectively. The dotted portion of the illustrations indicate the image that will appear when the TUNING control is varied. When the local oscillator is tuned below the magnetron frequency and two similar images (right- or left-handed) are viewed, the local oscillator spectrum will appear to the left of the magnetron spectrum.

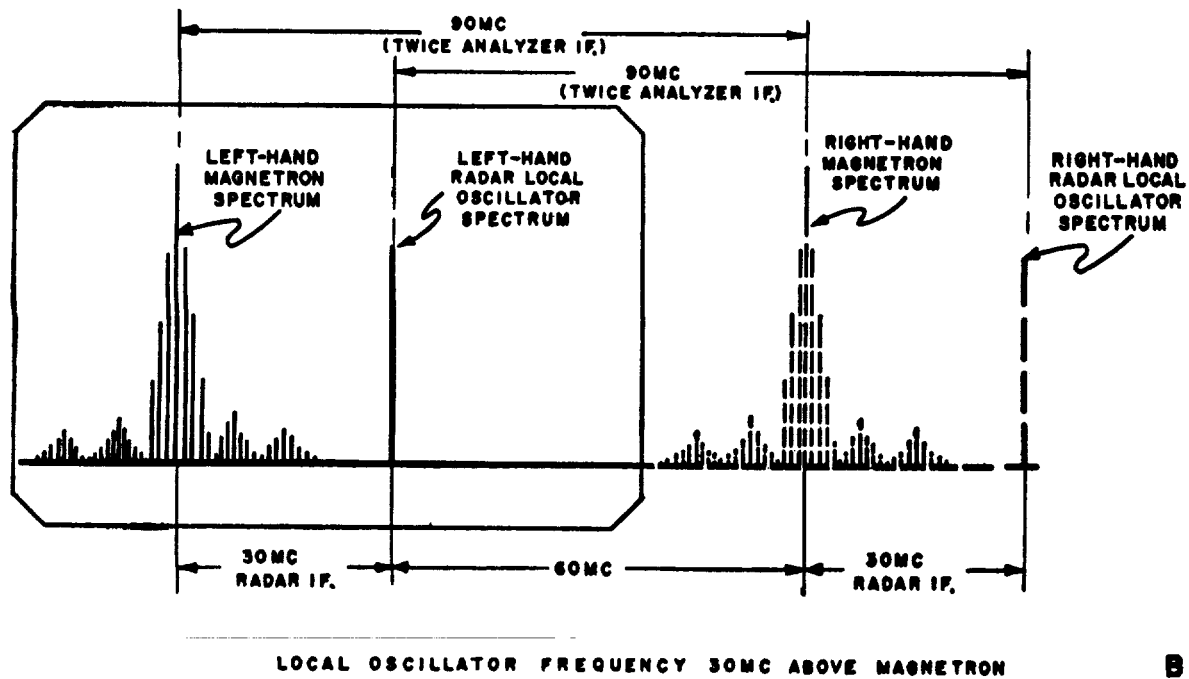
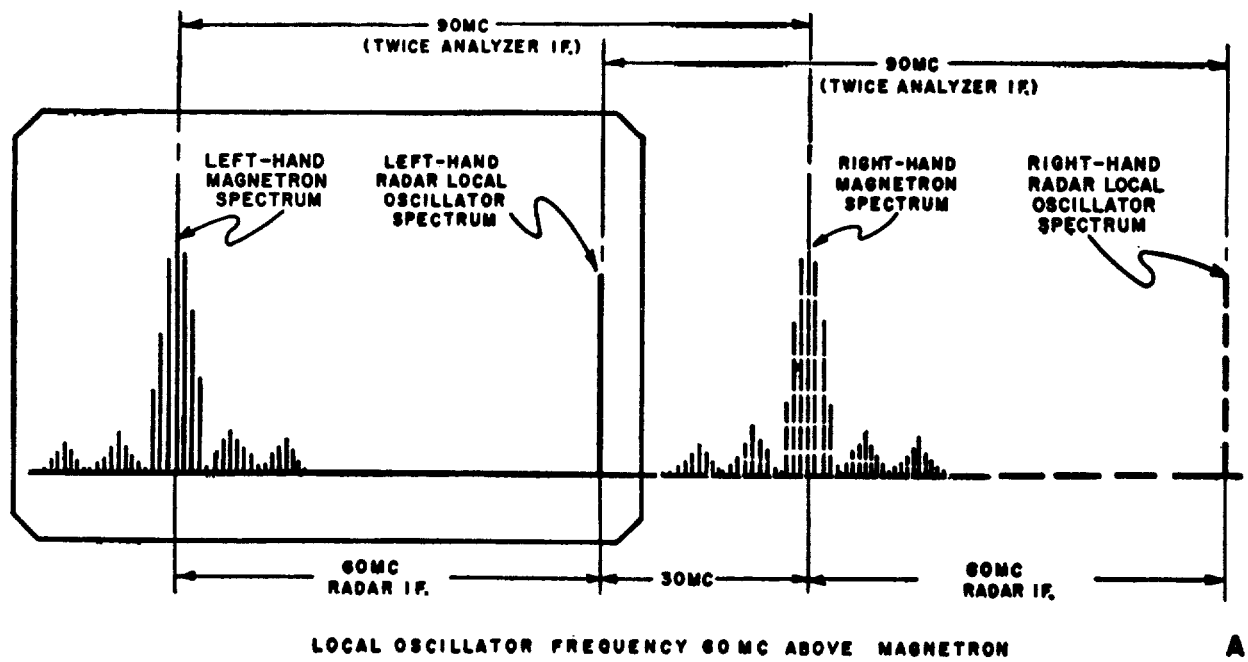
## 22. Observing and Adjusting Pulsed Magnetron Spectrums

a. *General.* The spectrum of the transmitted signal yields important information about the shape of the pulse that is used to key it. Different pulse shapes produce characteristic spectrums that deviate from the perfect spectrum shown in A, figure 13. A careful interpretation of imperfect spectrums will, therefore, disclose the manner in which the pulse shape differs from the normal. Two types of imperfection, namely, those produced by linear frequency modulation and by amplitude modulation are discussed in *b* and *c* below. Adjustment of the magnetron spectrum is discussed in *d* below.

b. *Frequency Modulation.* Frequency modulation of the pulsed signal is seen as an increase in the amplitude of the side lobes (B, fig. 13) which build up as shoulders on the main lobe. In such a case, a smaller percentage of total power is contained between the first two minimums than is the case when the minimums are deep. When frequency modulation is of a high order, for example, 3 mc per  $\mu$ sec, the side lobes may exceed the spectrum center in amplitude that produces a double-moded spectrum (C, fig. 13). If the received RF pulse has a linear frequency distortion of 1, 2, or 3 mc per  $\mu$ sec, the response of the receiver will be 90, 65, or 50 per cent, respectively. In addition, the range of the radar equipment is reduced to 97, 90, or 78 per cent for the values given.

c. *Amplitude Modulation.* Amplitude modulation of the pulse results in an increase in the number of side lobes. When frequency modulation is also present, distortion of the spectrum is noticed (D, fig. 13). In either case, the proportion of useful power in the signal is diminished.

d. *Magnetron Adjustment.* When the spectrum envelope falls significantly short of the ideal pattern, and if double-moding is present or if the pulse width or bandwidth does not approximate the values



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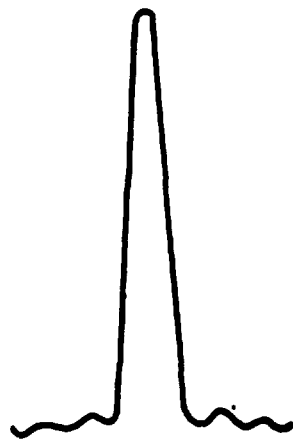
Figure 12. Measuring radar local oscillator frequency.

in figure 11, it may be possible to improve the spectrum by adjusting the output voltage of the modulator. This is the only adjustment that can be made on most equipments. If the adjustment is made while watching the spectrum analyzer scope, the spectrum will be seen to go through a number of shapes until, at the proper adjustment, the ideal spectrum appears. If an adjustment of the output voltage of the modulator does not produce a good spectrum, tests must be made to

determine the cause of trouble. Test the modulator or pulse transformers, the magnetron tubes, and the waveguides that are associated with the magnetron.

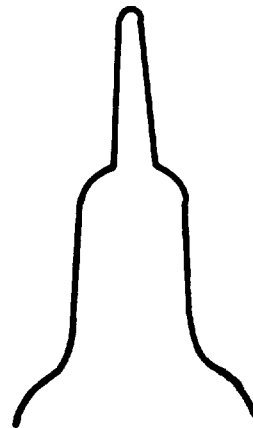
**Note**

**Adjustment of the modulator output voltage is sensitive on the longer pulse widths and should be done carefully.**



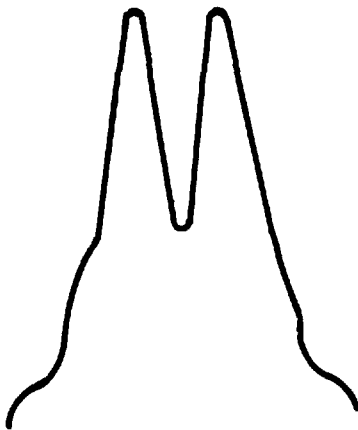
AMPLITUDE MODULATION = 0.  
FREQUENCY MODULATION = 0.

**A**



AMPLITUDE MODULATION = 0.  
FREQUENCY MODULATION = 2 MC PER USEC.

**B**



AMPLITUDE MODULATION = 0  
FREQUENCY MODULATION = 3 MC PER USEC.  
(DOUBLE MODING).

**C**



AMPLITUDE MODULATION = ABOUT 50% CAUSING  
DISTORTION.  
FREQUENCY MODULATION = 1 MC PER USEC.

**D**

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Figure 13. Representative magnetron spectrums.

### 23. Spectrum Analyzer Stopping Procedure

- a. Turn the INTENSITY control to reduce brightness of trace.
- b. Throw the POWER switch in the OFF position.

### 24. Synchroscope Starting Procedure

a. *General.* The spectrum analyzer may be used as a synchroscope when it is desired to inspect periodic or repetitive pulses of short duration. High amplitude pulses of the signal to be inspected are fed to the PULSE IN receptacle and applied directly to the vertical deflection plate of the cathode-ray tube. The pulses are displayed on the crt screen in A-scope manner. The horizontal sweep is developed by applying an external trigger to the TRIG IN receptacle. The trigger input initiates a positive sweep of 150 or 5 microsecond duration, depending on the setting of the function selector switch.

b. *Starting.*

- (1) Apply the trigger pulse to the TRIG. IN receptacle as shown in figure 14. The trigger should be of positive polarity, 30volt peak, with a pulse width of .5 to 10  $\mu$ sec and a pulse repetition rate not to exceed 2,500 pps.
- (2) Turn the function switch to the TRIG. SWP. 150  $\mu$ SEC. or TRIG SWP. 5  $\mu$ SEC. position, depending on the sweep time desired.
- (3) Throw the POWER switch to the ON position. The frequency dial lamp, pilot light, and attenuator dial light should go on.
- (4) After sufficient warm up, a horizontal trace should appear. Adjust the TRIG SWP. V

CENTER and TRIG SWP. H CENTER controls to center the trace vertically and to position it below the horizontal center axis.

**Note**

**If, during the starting procedure, an abnormal result is obtained, refer to the equipment performance checklist (par. 37).**

### 25. Synchroscope Operating Procedure

- a. Apply the pulse to be inspected to the PULSE IN receptacle (fig. 14).
- b. A pulse should appear on the spectrum analyzer screen. Position the display by using the TRIG SWP. V CENTER and TRIG SWP. H CENTER controls.
- a. Adjust the FOCUS and INTENSITY controls in the conventional manner to obtain the desired quality of the display.

### 26. Synchroscope Stopping Procedure

- a. Turn the INTENSITY control to reduce brightness of trace.
- b. Place the POWER switch in the OFF position.

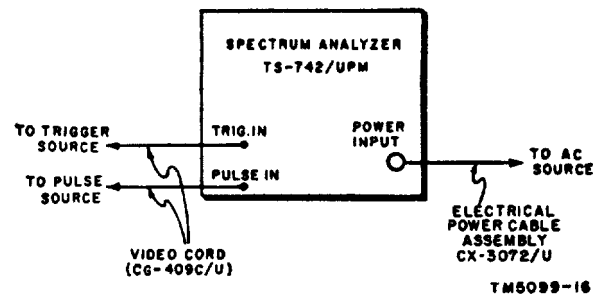


Figure 14. Interconnection diagram, spectrum analyzer used as synchroscope.

**CHAPTER 3  
ORGANIZATIONAL MAINTENANCE**

**Section I. ORGANIZATIONAL TOOLS AND MAINTENANCE**

**27. General**

a. The tools, parts, supplies, and test equipment necessary to perform organizational maintenance are authorized by appropriate publications.

b. The actual allowable organizational maintenance that can be performed on Spectrum Analyzer AN/UPM-58

depends on the spare parts issued and on the tools and other test equipment available.

**28. Tools and Materials**

Tools and materials required in the organizational maintenance of Spectrum Analyzer AN/UPM58 are listed in *a* and *b* below. The items contained in Tool Equipment TE-113 are listed in Department of the Army Supply Manual SIG 6-TE-113.

a. *Tools.*

1 Tool Equipment TE-113.

b. *Materials.*

Orange stick.

Cheesecloth, bleached, lint-free.

Cleaning Compound (Federal stock No. 7930-395-9542).

Sandpaper, No. 000.

**Section II. PREVENTIVE MAINTENANCE SERVICES**

**29. Definition of Preventive Maintenance**

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working order so that breakdowns and needless interruptions will be kept to a minimum. Preventive maintenance differs from troubleshooting and repair since its object is to prevent certain trouble from occurring.

**30. Operator's Preventive Maintenance**

a. *DA Form 11-238.* DA Form 11-238 (fig. 15) is a preventive maintenance checklist to be used by the operator. Items not applicable to the spectrum analyzer are lined out in the figure. References in the ITEM block in the figure are to paragraphs that contain additional information pertinent to the particular item. Instructions for the use of the form appear on the back of the form.

b. *Items.* The information shown in this subparagraph is supplementary to DA Form 11-238. The item numbers correspond to the ITEM numbers on the form.

Item	Maintenance procedures
3	Use a clean cloth to remove dust, dirt, moisture, and grease from the carrying case, front panel, power receptacle, the RF INPUT receptacle, front panel controls, flexible waveguide assembly, and antenna horn. If necessary, wet the cloth with cleaning compound* then wipe the parts dry with a clean cloth.
4	Inspect seating of fuses F1 and F2 and Lamps I 1, I 2, and I 3. Inspect spare fuses in the spare fuse holders on the front panels, replace if necessary.
9	Repair any cuts in the insulation by covering them with rubber tape and then with friction tape. Replace or repair all broken cords and cables. Inspect the antenna horn, and flexible waveguide assembly for discontinuities, breaks, bends, etc.
8	Remove all rust from components and touch up bare spots with paint.

\* Cleaning compound is flammable and its fumes are toxic. Do not use near a flame and provide adequate ventilation.

**31. Repairman's Preventive Maintenance**

a. *DA Form 11-239.* DA Form 11-239 (fig. 16) is a preventive maintenance checklist to be used by the repairman. Items not applicable to the equip-

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OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT											
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR											
<i>INSTRUCTIONS: See other side</i>											
EQUIPMENT NOMENCLATURE <b>SPECTRUM ANALYZER AN/UPM-5B</b>						EQUIPMENT SERIAL NO. <b>25</b>					
LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; ① Defect corrected. NOTE: Strike out items not applicable.											
DAILY											
NO.	ITEM	CONDITION									
		S	M	T	W	T	F	S			
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT ( <del>receiver, transmitter, carrying cases, wire and cable, microphone, tubes, spare parts, technical manuals and accessories</del> ).		✓	✓							
2	<del>LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.</del>										
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, SPEAKERS, KEYS, JACKS, PLUGS, TELEPHONES, <del>BATTERY BAGS, COMPONENT PANELS.</del> PAR. 30		✓	✓							
4	INSPECT SEATING OF READILY ACCESSIBLE <del>"LOCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, INDICATORS, PLUG-IN COILS AND RESISTORS.</del> PAR. 30		✓	✓							
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION.		✓	✓							
6	CHECK FOR NORMAL OPERATION.		✓	✓							
WEEKLY											
NO.	ITEM	COND- ITION	NO.	ITEM	COND- ITION						
						COND- ITION					
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, <del>WASH MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.</del>	✓	13	<del>INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.</del>							
8	INSPECT CASES, <del>MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE.</del> PAR. 30	✓	14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.	✓						
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 30	✓	15	<del>INSPECT METERS FOR DAMAGED GLASS AND CASES.</del>							
10	<del>INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.</del>		16	<del>INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHER-PROOFING.</del>							
11	<del>INSPECT CANVAS ITEMS, LEATHER, AND GEARING FOR WILDER, TEARS, AND FRAYING.</del>		17	<del>CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.</del>							
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWER STAYS, RELAYS, SELECTING MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES.		18	<del>CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.</del>							
19	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.										

DA FORM 11-238  
1 MAY 51

REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM5099-17

Figure 15. DA Form 11-238.

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SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR			
INSTRUCTIONS - See other side			
EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.		
SPECTRUM ANALYZER AN/UPM-50	26		
LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; ✕ Adjustment, repair, or replacement required; ⊕ Defect corrected. NOTE: Strike out items not applicable.			
NO.	ITEM	NO.	ITEM
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (antenna, mounting, carrying case, wire and cable, microphones, tubes, spare parts, technical manuals, and accessories).	19	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS, INSUFFICIENT SOCKET SPRING TENSION, CLEAN DUST AND DIRT CAREFULLY, CHECK CONDITION OF RECEIVER TYPED TUBES.
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.	20	INSPECT PULL-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT, AND CORROSION.
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, SPEAKERS, WIRE, JACKS, PLUGS, VIEWFINDERS, BATTERY AND BATTERY COMPARTMENT PANELS. (PAR 31)	21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION.
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIEWFINDERS, PHOTOGRAPHS, AND RECEPTS.	22	INSPECT RELAY AND SWITCH ASSEMBLIES FOR LOOSE CONTACTS, WEAR, BURNT CONTACTS, CORROSION, CONTACTS, INSUFFICIENT SPRING TENSION, BENDING OF PLUNGERS AND WIPER PARTS.
5	INSPECT CONTROLS FOR BINDING, SCRAMING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. (PAR 31)	23	INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND WORN MOUNTINGS.
6	CHECK FOR NORMAL OPERATION.	24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION, AND MOISTURE.
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, BUSHINGS, BUSHINGS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.	25	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT, AND LOOSE CONTACTS.
8	INSPECT CABLE, MOUNTING, SPRING, POWER, AND EXPOSED METAL SURFACES FOR RUST, CORROSION, AND MOISTURE.	26	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. (PAR 31)
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN.	27	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS, AND BREAKS.
10	INSPECT ANTENNA FOR IDENTIFICATION, CORROSION, LOOSE FIT, DAMAGED INSULATORS, AND REPLACEMENT.	28	CHECK SETTINGS OF ADJUSTABLE RELAYS.
11	INSPECT BATTERY TRAYS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.	29	LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER. (PAR 31)
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWER TRANSFORMERS, BATTERIES, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. (PAR 31)	30	INSPECT GENERATORS AND BATTERIES FOR BUSHING WEAR, SPRING TENSION, CRANK, AND FITTING OF COMMUTATOR.
13	INSPECT STORAGE BATTERIES FOR SHIT, LOOSE TERMINALS, BATTERY CASES, LEAKS, AND EXCESSIVE GRAVITY, AND DAMAGED CASES.	31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS. (PAR 31)
14	CLEAN AIR FILTERS, BRASS NAMEPLATE, DIAL AND VIEWER WINDOWS, JEWEL ASSEMBLIES.	32	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL LEAKAGE.
15	INSPECT VIEWERS FOR DAMAGED GLASS AND SHEETS.	33	BEFORE SHIPPING OR STORING - REMOVE BATTERIES.
16	INSPECT CASE, TRAY AND COVER FOR ADEQUACY OF WEATHER PROOFING.	34	INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.
17	CHECK ANTENNA CRY WIRE FOR LOOSENESS AND PROPER TENSION.	35	INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.
18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT, AND DRAGS.	36	INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.
19		37	MOISTURE AND FUNGIPROOF.
20 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.			

DA FORM 11-239  
MAY 51

Replaces DA 400 Form 419, 1 Dec 48, which is obsolete.

16-4889-1

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Figure 16. DA Form 11-239.



ment are lined out in the figure. References in the ITEM block in the figure are to paragraphs that contain additional information pertinent to the particular item. Instructions for the use of the form appear on the back of the form.

*b. Items.* The information shown in this subparagraph is supplementary to DA Form 11-239. The item numbers correspond to the ITEM numbers on the form.

**Warning**

**Disconnect all power from the spectrum analyzer. When power to the equipment is disconnected, some capacitors still may retain voltage of dangerous potential. Before touching exposed electrical parts, short circuit the part to ground. When maintenance is completed, replace the equipment in its carrying case, reconnect the power, and check for satisfactory operation (par. 37).**

Item	Maintenance procedures
3	Remove dirt, oil, and moisture from complete waveguide assembly (fig. 18) and Klystron tube (fig. 50). If necessary moisten the cloth with cleaning compound, then wipe the parts with a clean cloth.
5, 12	Clean and tighten the detent switch S2. If necessary use cleaning compound.
26, 31	Inspect the complete waveguide assembly (fig. 18) for rigidity. Tighten all mountings and support brackets (fig. 50). Be sure that the entire waveguide assembly is fastened firmly. Do not tighten connections too tight, threads on bolts may be stripped.
29	Lubricate equipment according to information in paragraph 33.

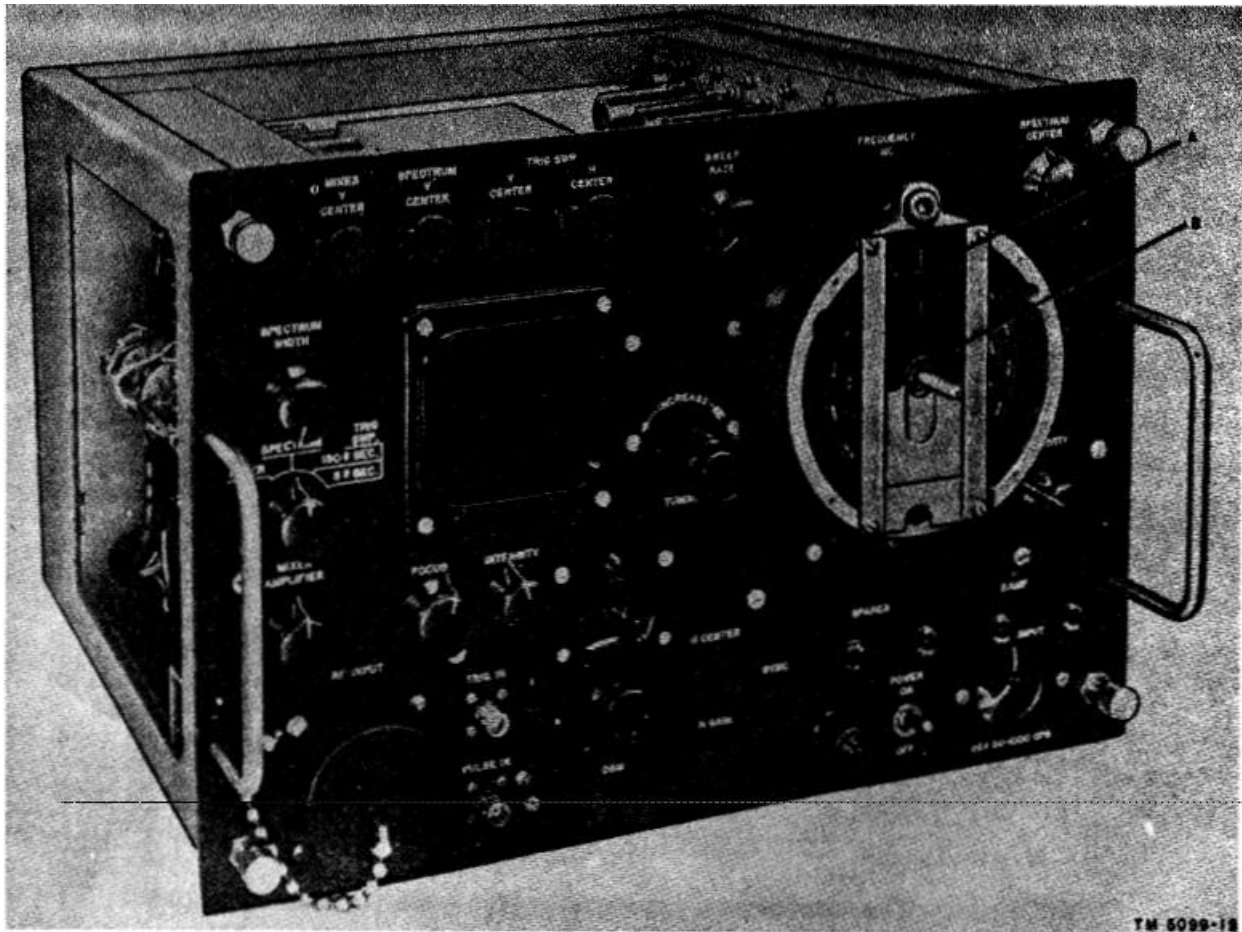


Figure 17. Lubrication of frequency drive assembly.

### 32. General Lubricating Instructions

a. Gasoline will not be used -as a cleaning fluid for any purpose. When the spectrum analyzer is overhauled or repairs are made, parts should be cleaned with cleaning compound.

b. Do not use excessive amounts of oil.

c. Be sure that lubricants and points to be lubricated are clean and free from sand, grit, or dirt. Before lubrication, clean all surfaces to be lubricated; use a lint-free cloth dampened with cleaning compound. Keep cleaning compound off surrounding parts.

d. Lubrication intervals designated are for an 8-hour period of operation. For longer periods of operation, intervals should be shortened. For example, if the equipment is operated 16 hours a day instead of 8, the equipment will have to be lubricated every 2 months instead of every 3 months.

### 33. Specific Lubricating Instructions

The type of lubricant to be used is Oil, Lubricating, Aircraft Instrument (OA1) per MIL-6085A. The interval is quarterly (every 3 months).

a. *Lubrication of Frequency Drive Assembly* (figs. 17, 45, and 50).

(1) *Removal of frequency meter cover.* Remove the frequency meter cover as follows:

(a) Unscrew the dial light from the dial light assembly.

(b) Loosen the two set screws on the frequency meter dial knob and remove the knob.

(c) Remove the four NO. 4-40 bindinghead screws that hold the frequency meter cover to the frequency meter.

(2) *Dial slide (A).* Cover with a thin film of oil (OA1).

(3) *Plunger shaft (B).* Put 1 or 2 drops of oil (OA1) on the shaft.

(4) *Replacement of frequency meter cover.* Reverse the procedures described in (a) above.

b. *Lubrication of RF Plumbing Assembly* fig. 18). Remove the spectrum analyzer from the cover and lubricate the RF plumbing as follows:

(1) Guide shaft of calibrated attenuator (A). Put 1 or 2 drops of oil (OA1) along the shaft.

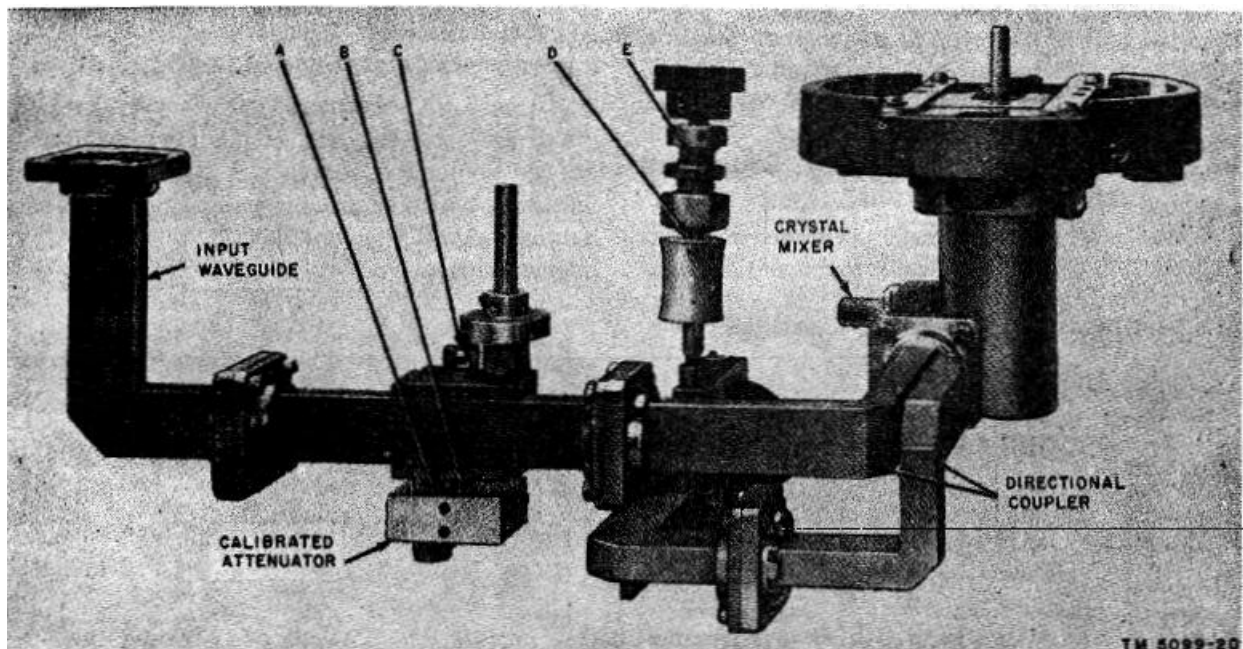


Figure 18. Lubrication of RF plumbing assembly.

- (2) *Cam follower shaft (B)*. Place 1 or 2 drops of oil (OA1) along the shaft.
- (3) *Cam follower (C)*. Put 1 or 2 drops of oil (OA1) on the cam follower wheel and shaft.

- (4) Retainer ring (D). Place 1 or 2 drops of oil (OA1) on the ring.
- (5) Stop washers of *klystron tuning shaft (E)*. Place 1 or 2 drops of oil (OA1) on the washers.

**Section III. TROUBLESHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL**

**34. General**

a. The troubleshooting and repair work that can be performed at the organizational maintenance level is necessarily limited in scope by the tools, test equipment, and replaceable parts issued.

b. Paragraphs 35 through 37 help to determine which of the circuits is at fault and in localizing the fault in the circuit to the defective stage or item, such as a tube or fuse.

**35. Visual Inspection**

a. Failure of this equipment to operate properly usually will be caused by one or more of the following faults:

- (1) Worn, broken, or disconnected cords or plugs.
- (2) Burned-out fuses.
- (3) Broken wires.
- (4) Defective tubes.
- (5) Inactive crystal diode.

b. When failure is encountered and the cause is not immediately apparent, check as many of these items as is practicable before starting a detailed examination of the component parts of the system.

**36. Troubleshooting by Using Equipment Performance Checklist**

a. *General*. The equipment performance checklist (par. 37) will help to locate trouble in the equipment.

**37. Equipment Performance Checklist**

The list gives the item to be checked, the conditions under which the item is checked, the normal indications and tolerance of correct operation and the corrective measures the operator can take. *To use this list, follow the items in numerical sequence.* Items 1 through 11 are preparatory steps; items 12 through 18 are steps used to start the equipment; items 19 through 21, equipment performance, are steps used for spectrum analysis operation while items 22 through 26 are for synchroscope operation; and items 27 and 28 are steps used to stop the equipment.

b. *Action or Condition*. For some items, the information given in the Action or condition column consists of various switch and control settings under which the item is to be checked. For other items it represents an action that must be taken to check the normal indication given in the Normal indications column.

c. *Normal Indications*. The normal indications listed include the visible and audible signs that should be perceived when the items are checked.

If the indications are not normal, the recommended corrective measures should be applied.

d. *Corrective Measures*. The corrective measures listed are those that can be made without turning in the equipment for repairs. If the corrective measures indicated do not restore the equipment to normal operation troubleshooting is required by a higher echelon.

Unit No.	Item	Action or condition	Normal indication	Corrective measures
P R E P A R T O R Y	1 Fuses F1 and F2.	Correct size (3 amp) for line voltage.		
	2 Power input receptacle (J7).	Power cord connected.		
	3 Function switch (S2).	Set to MIXER position.		
	4 SPECTRUM WIDTH control (R57).	Set to full counterclockwise position.		
	5 MIXER AMPLIFIER control (R123).	Set about one-third clockwise position.		

Unit No.	Item	Action or condition	Normal indication	Corrective measures	
P R E P A R A T O R Y	6	SPECTRUM CENTER control (R122).	Set to about midposition.		
	7	TUNING control.	Set to about midposition.		
	8	FREQUENCY MC control.	Set to full clockwise position.		
	9	SWEEP RATE (R44).	Set to about two-thirds clockwise position.		
	10	SYNC control (R40).	Set to full counterclockwise position.		
	11	INTENSITY control (R109).	Set to two-thirds clockwise position.		
	S T A R T	12	POWER switch (S1).	Turn to ON.	Pilot light (I 3), frequency dial light (I 2), and attenuator dial light (I 1) light.  Horizontal trace and a single bell-shaped mode curve appear on screen.
13		H CENTER (R49) H GAIN (R50) FOCUS (R 17) INTENSITY (R109)	Adjust each for optimum presentation.	Pattern can be centered, increased in amplitude, and focused; intensity can be varied.	Higher echelon repair required.
14		MIXER V CENTER (R127).	Adjust to shift trace below center axis.	Trace can be lowered.	Higher echelon repair required.
15		SPECTRUM CENTER (R122).	Adjust to center mode pattern.	Pattern moves to center.	Higher echelon repair required.
16		MIXER AMPLIFIER control (R123).	Adjust to increase amplitude of pattern.	Amplitude of pattern increases.	Higher echelon repair required.
17		FREQUENCY MC control.	Rotate to place frequency dip in center of hump.	Frequency dip appears in center of hump.	Higher echelon repair required.
18		Function switch (82).	Set to SPECTRUM position.	Mode indication should disappear and two small dips appear at limits of mode. Dip midway in trace appears.	Higher echelon repair required.
E P Q U R I F P O M R E M N A T I O N C E		19	RF INPUT receptacle.	Connect antenna horn or directional coupler, depending on method of coupling desired. Do not overcouple analyzer to equipment under test.	Spectrum pattern appears on screen for modulated signal; signal line appears for cw signal.
	20	DB control and IF SENSITIVITY control (R39).	Adjust to increase amplitude of signal.	Amplitude of pattern on screen increases.	Higher echelon repair required.
	21	SPECTRUM WIDTH control (R57).	Adjust to cause desired dispersion of signal on screen.	Number of mc per inch displayed increased.	Higher echelon repair required.

Unit	No.	Item	Action or condition	Normal indication	Corrective measures
<b>E P Q E U R I F P O M R E M N A T N C E</b>	22	Function switch (S2).	Set to TRIG SWP. position (150 $\mu$ SEC. or 5 $\mu$ SEC. as desired).		
	23	TRIG. IN receptacle (J5).	Connect video cable to analyzer receptacle and to source of +30-volt pulse.	Horizontal trace appears on screen.	Check for good connection between video cable and TRIG. IN receptacle. Check cable and plugs.
	24	PULSE IN receptacle (J6).	Connect video cable to analyzer receptacle and to equipment under test.	Pulse envelope appears on screen.	Check connection between video cable and PULSE IN receptacle. Check cable and plugs.
	25	TRIG SWP. V CENTER (R66).	Adjust to position trace.	Trace moves vertically.	Higher echelon repair required.
	26	TRIG SWP. H CENTER (R81).	Adjust to position trace.	Trace moves horizontally.	Higher echelon repair required.
<b>S T O P</b>	27	INTENSITY control (R109).	Adjust for minimum intensity.	Display dims.	
	28	POWER ON-OFF switch (S1).	Turn to OFF.	Display disappears.	

Section I. INTRODUCTION

**38. General**

Spectrum Analyzer TS-742/UPM is a test instrument that displays, on an oscilloscope, a pattern representative of the distribution of energy among the various frequencies in the output of a pulsed or cw radar beacon. The spectrum of a pulsed or cw signal consists of energy distributed among many different frequencies. Spectrum Analyzer TS-742/UPM presents on the oscilloscope a pattern in which the relative amplitude of the various frequencies of the spectrum are plotted on the vertical axis while the frequencies themselves are plotted on the horizontal axis. The overall pattern of the display may be interpreted to indicate the proportion of power present at the various frequencies within the spectrum. It is also used for synchroscope operation where large amplitude signals are displayed on an oscilloscope. The synchroscope requires an external trigger synchronized with the signal to be displayed on the oscilloscope. The trigger is required to synchronize the sweep on the oscilloscope with the signal. This results in a stationary pattern being viewed on the oscilloscope.

**39. Formation of a Spectrum**

a. A common conception of the output of a pulsed oscillator is a single frequency that is turned on and off for periods of standard duration, similar to the output of a conventional cw telegraph transmitter. The output of the radar oscillator does not consist of a fundamental frequency that is turned on and off but must be considered as a fundamental frequency that is modulated by the wave form of the pulse.

b. It must be understood that any fundamental frequency, when modulated by another frequency, will produce a fundamental frequency with sideband frequencies that are collectively called a spectrum. In other words, *the output will appear on more than one frequency*. The distribution of the power on

these frequencies is a function of the modulation and is also called a spectrum. Normally, modulation is plotted on an amplitude and time basis, as shown in part 1 of figure 19. Part 2 of this figure shows the spectrum produced by a fundamental frequency when it is modulated by frequencies  $F_{p1}$ ,  $F_{p2}$  and  $F_{p3}$ .

c. Assume  $F$  to be the fundamental frequency of an oscillator. A wave form of this fundamental frequency, plotted as amplitude against time, is shown in A in part 1 of figure 19. The number of periods  $1/(F)$  occurring within one second determines the frequency of the oscillation. The amplitude is represented as proportional to the distance between the negative and positive peak of one cycle of oscillation.

d. In a spectrum pattern, this same frequency and amplitude would be represented as  $F$  in part 2 of figure 19. Points along the horizontal coordinate represent frequency, which increases from left to right, while distances along the vertical coordinate above the base line represent amplitude. Parts 1 and 2 of figure 19 represent two methods of diagramming the results of amplitude-modulating a carrier frequency.

e. Assume  $F_{p1}$  is a modulation frequency applied to the fundamental frequency,  $F$ . This is normally represented on an amplitude versus time basis as B in part 1 of figure 19. This same type of modulation is represented by two lines on the spectrum pattern. These lines are marked  $F+F_{p1}$  and  $F-F_{p1}$  in part 2 of the figure. The reason for this is that the modulated wave actually represents the results of *heterodyning*, two different frequencies. In other words, the modulation produces the same envelope that would be produced by heterodyning the side band and fundamental frequencies shown in figure 19. It follows that these frequencies are effectively

present in the modulated envelope and can be detected by suitable receivers. The two frequencies producing the portion of the spectrum previously mentioned are  $F$  and  $F_{p1}$  the fundamental and modulating frequency, respectively. The result is the production of two additional frequencies as stated previously. One of these is the sum of the two frequencies, while the other is the difference between them. The amplitudes of the new frequencies are each half of the amplitude of the modulating frequency.

f. Assume also, that a second harmonic of the modulating frequency also exists. This is usually of a

lower degree of amplitude than the fundamental of the modulating frequency. Call this frequency  $F_{p2}$ . Another set of waves is developed, as shown in parts 1 and 2 in figure 19. The amplitude of the two new frequencies created is less than that created by  $F_{p1}$ .

g. Additional modulating frequencies will produce additional sideband frequencies. Since these frequencies are normally present in a harmonic relationship, the net result is a number of different frequencies above and below the carrier. The difference between any two adjacent frequencies is equal to the fundamental modulating frequency.

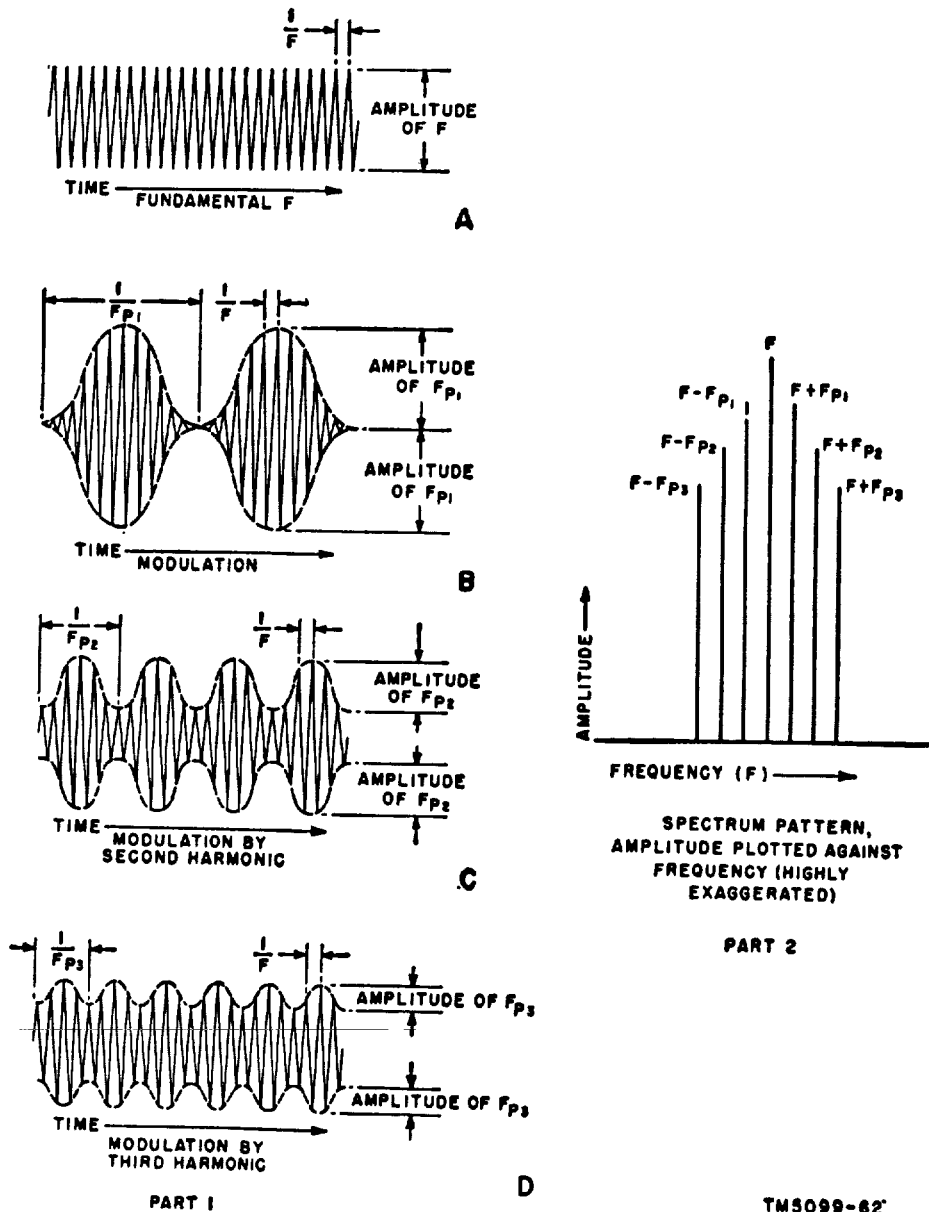


Figure 19. Comparison of a plot of amplitude versus time with a plot of amplitude against frequency.

## 40. Spectrum of a Pulsed Oscillator

a. Usually a pulse modulated oscillator is pulsed by the application of a rectangular wave of voltage to an oscillator circuit. A narrow rectangular wave of voltage contains an exceedingly wide range of harmonics, including harmonics of a very high order. A rectangular wave of voltage can be considered as a summation of a sine wave fundamental of the repetition frequency plus an infinite number of sine wave harmonics. Consequently a pulsed oscillator may be assumed to be an oscillator modulated by a modulation frequency that is exceedingly rich in harmonics. A pulsed oscillator, turned on and off as in figure 20, produces an output similar to that which would be produced by a sine wave repetition frequency and its harmonics phased so that their summation would produce a wave form similar to the modulating pulses.

b. In figure 20, the pulse frequency and the basic frequency of the pulsed oscillator are shown on a time and amplitude graph. From this, it might appear that the output was simply a pure cw wave, of constant amplitude and frequency turned on for brief intervals of time. This cannot be true because of the presence of the modulation frequency  $F_p$  and the very large number of harmonics of the modulation frequency,  $F_{p1}$ ,  $F_{p2}$ , etc. The fundamental modulation frequency and its many harmonics may be considered to modulate the oscillator to produce a fundamental frequency with many sidebands. The net result is a spectrum such as was developed in figure 19, except that it is extended to a very large number of frequencies above and below the fundamental frequency. Such a spectrum is shown in part A of figure 21. The pulse frequency that produces this spectrum is shown in part B of figure 21. The output of the oscillator consists of an infinite number of lines representing different frequencies. However, due to the harmonic relationship between the modulation frequency and its harmonics, these lines will always be separated by a distance on the base line that is equal to the fundamental modulation frequency,  $F_p$ .

c. From the above discussion, it may be deduced that the amplitude versus frequency plot, will provide an envelope which is of value in estimating the power distribution in the output of a pulsed oscillator. This spectrum, as plotted on the spectrum analyzer is a power spectrum due to the square law characteristics of the analyzer's detector. The true power spectrum, which represents the voltage (or

amplitude), squared ( $E^2$ ) is shown in part D of figure 21. This power spectrum emphasizes even more forcefully than the voltage spectrum in part A in the same figure, the importance of confining the majority of the power at the fundamental frequency of the pulsed oscillator. Actually the spectrum analyzer pattern, as shown in part C of figure 21 represents only a sample of the spectrums. Each of the separated lines seen on the spectrum represents a section of the spectrum. The explanation of this pattern is given later in this section.

d. The actual power amplitude of any frequency may be computed by mathematics using Fourier's formula for harmonic analysis. This formula may be found in any standard calculus book. Part D of figure 21 effectively shows the results of this calculation for a standard oscillator when pulsed by a standard pulsing circuit. The spectrum analyzer, by providing a power spectrum, provides an effective means of approximating the power components of the spectrum. It can be of great value in tuning up a pulsed oscillator so as to provide the greatest range of power output in the band-pass circuits of the receiver.

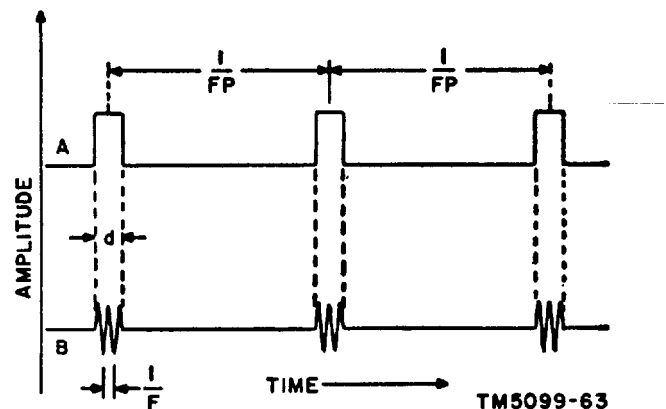


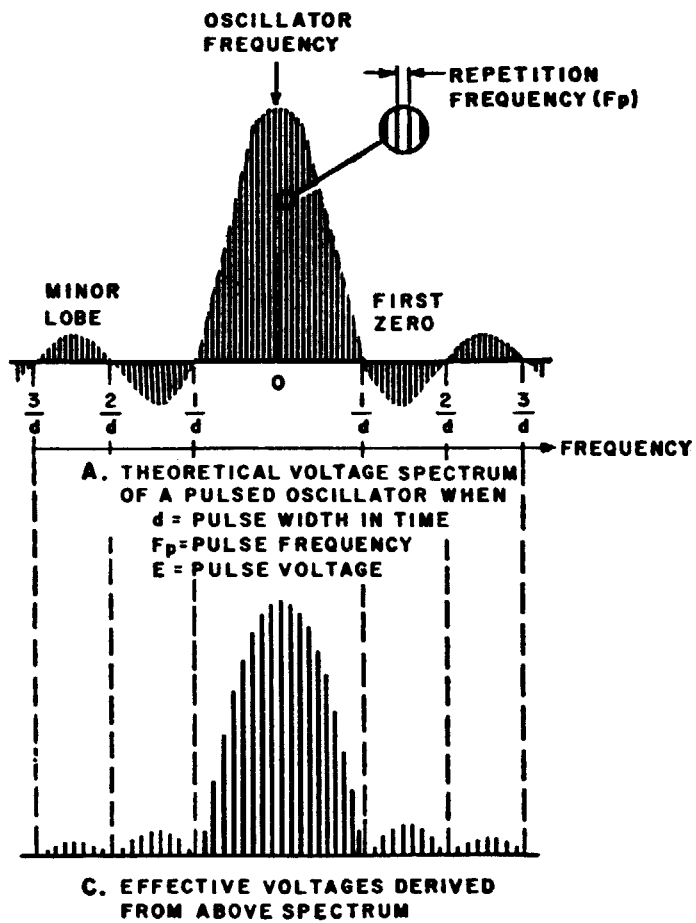
Figure 20. Output of pulsed oscillator.

## 41. Practical Analysis of a Spectrum

a. The following analysis of a spectrum assumes a fundamental oscillator frequency of 16,000 megacycles per second (mcs) or 16,000,000 kilocycles per second (kcs), and a pulse repetition frequency of 2,000 cps (or 2 kcs). Two sidebands would be produced. One of these would be a frequency representing the fundamental plus the modulation frequency (16,000,002 kcs) while the other would be a frequency equivalent to the difference (15,999,998 kcs) between the two frequencies. Therefore, if this

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Figure 21. Relationship between a voltage spectrum and a power spectrum.

were the only frequency modulating the fundamental frequency, the output would appear on three frequencies; namely, the fundamental frequency, a frequency equal to the fundamental plus 2 kcs, and the fundamental frequency minus 2 kcs. The difference between any two adjacent frequencies would be 2 kcs, or the repetition frequency.

b. The second harmonic of the pulse frequency is 4 kcs and it produces two additional frequencies that are 4 kcs above and 4 kcs below the fundamental frequency of the oscillator. The third harmonic produces two more frequencies that are 6 kcs above and below the oscillator frequency. It can be seen that all of these frequencies are 2 kcs apart, which is the fundamental pulsing frequency. Consequently the spectrum produced by a pulsed oscillator is formed by the amplitude of various frequencies that are separated on the base line by a distance that represents the frequency of the repetition rate.

c. This condition occurs only when a true rectangular pulse is applied to the oscillator. In actual practice, the pulse applied to the oscillator is not a true rectangular wave. The flat top usually has a negative or positive slope. The trailing edge is not vertical, but droops. In addition, certain transients are present in the pulse. These transients have a harmonic family of frequencies of their own, all of which are present in the pulse. These additional frequencies of the rectangular wave cause both amplitude and frequency modulation of the oscillator. The effect of amplitude modulation is to increase the number of sidebands in the spectrum, while the effect of frequency modulation is to increase the amplitude of the side lobes, since the actual fundamental frequency of the oscillator is

shifted back and forth between points on each side of its true fundamental frequency.

d. Certain spectra showing the effects of frequency modulation are shown in figure 13 and the causes of unusual spectra are described with the various parts of this figure. Some general conclusions may be drawn from the spectra shown in these figures. These conclusions are as follows:

- (1) The width of the center lobe of an ideal spectrum should not greatly exceed the bandwidth of the receiving section of the radar set, otherwise power will be wasted which will result in a reduced output from the receiver.
- (2) A spectrum without deep minimum points adjacent to the main lobe indicates frequency modulation of the oscillator.
- (3) If two distinct peaks are observed on the spectrum, the transmitting oscillator is operating in two modes, or is being pulled in frequency by some external force, such as a poorly matched rotating antenna or fluctuating voltages.
- (4) The frequency difference between two peaks indicates the amount of frequency pulling, or scattering. The height of each of these peaks represents the proportional amount of power at the frequency of each of the peaks.
- (5) The width of the modulating pulse may be determined by measuring the distance between the minimum on each side of the main portion of a good spectrum. The measurement of pulse width and the conclusions which may be drawn are described in paragraphs 19 and 22 respectively.

## Section II. BLOCK DIAGRAM

### 42. General

Spectrum Analyzer TS-742/UPM is a dual purpose type test equipment. It functions either as a spectrum analyzer or a synchroscope.

a. *Spectrum Analyzer* fig. 22). Spectrum Analyzer TS-742/UPM when functioning as a spectrum analyzer consists of a dual conversion superheterodyne receiver with a klystron local RF oscillator, frequency-modulated by a sawtooth voltage. As the frequency of the local oscillator is varied, it beats with the incoming cw or pulsed signal to produce an IF signal for the various frequency components

present in the spectrum of the received signals. The IF signal is detected and the resultant displayed on the crt screen vertical axis. The klystron local RF oscillator modulating sawtooth voltage controls the horizontal sweep. Therefore, the height of the display represents the signal amplitude and the horizontal position represents the frequencies of the input cw or pulsed signal.

b. *Synchroscope* fig. 23). Spectrum Analyzer TS-742/UPM when functioning as a synchroscope consists of a trigger amplifier, a triggered sweep generator, and a horizontal amplifier that operates

in conjunction with the sweep generator in a pushpull circuit to provide a linear horizontal sweep on the crt. An external signal to be observed is applied to the trigger amplifier. This results in a horizontal scope sweep that is synchronized with the external signal applied to the vertical deflection plates of the crt.

### 43. Analysis of Block Diagram

A block diagram of signal paths in the spectrum analysis function of Spectrum Analyzer TS-742/UPM is shown in figure 22. The signal path in the synchroscope operation of the unit is shown in figure 23. For more detailed overall circuit information, refer to the schematic diagram fig. 60).

a. *Spectrum Analysis Operation* (fig. 22). The video display of a spectrum is developed within the spectrum analyzer as follows:

- (1) *Input waveguide.* The input waveguide is the length of an H-band rectangular waveguide that terminates in a choke flange at each end. It is used to couple the input signal into the calibrated RF attenuator. The average power of the RF signal applied to the waveguide is not to exceed 1 watt (30 dbm).

- (2) *Calibrated RF attenuator.* The calibrated RF attenuator consists of a rectangular resistance element mounted in the portion of waveguide that joins the input waveguide at one end and the directional coupler at the other end. Varying the position of the resistance element across the inside area of the attenuation waveguide varies the degree of maximum attenuation. Maximum attenuation is obtained when the element is displaced towards the center of the waveguide. The attenuator controls the amplitude of the signal that enters the analyzer.

- (3) *Directional coupler.* The directional coupler consists of two branches of aperture coupled waveguide, with one termination joining the calibrated RF attenuator, another mating with the frequency meter and a third connected to the klystron oscillator via the fixed attenuator. The purpose of the directional coupler is to permit signal and klystron oscillator voltages to be fed into the crystal, at the same time preventing the oscillator from feeding back to the input.

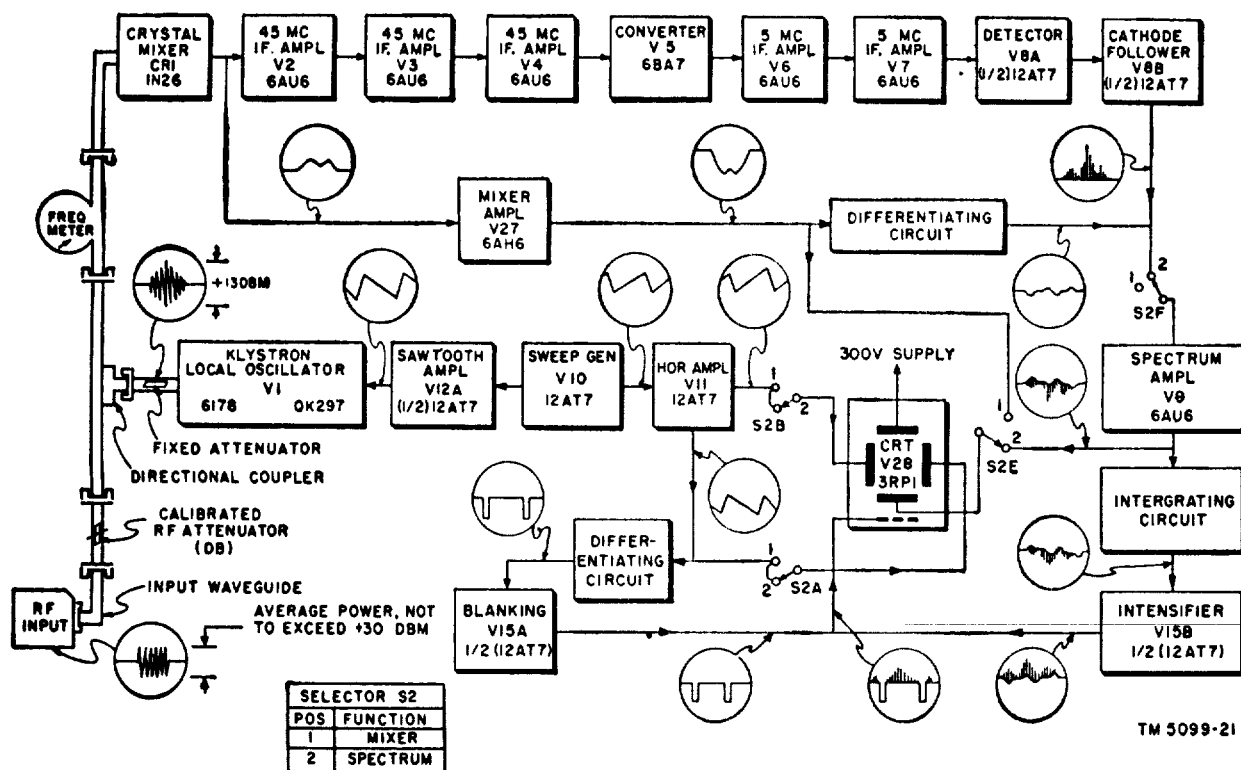


Figure 22. Mt. Spectrum Analyzer TS-742/UPM, block diagram of signal paths, spectrum analysis function. TAGO 6709-A. June

- (4) *Klystron local oscillator.* The analyzer local RF oscillator is a reflex-type velocity modulated klystron 6178 (QK297). It is frequency-modulated by a portion of the sweep voltage that is applied to the oscilloscope. Modulation voltage is obtained from the output of the sweep amplifier, and provides a frequency swing of 60 to 100 mc.
- (5) *Fixed attenuator.* The fixed attenuator is a portion of waveguide that connects the klystron to the directional coupler. It contains a resistive attenuator card. The fixed attenuator provides for an impedance match between the klystron and the crystal and, at the same time, reduces the klystron power.
- (6) *Frequency meter.* The frequency meter is an absorption-type meter. It consists of a cavity that can be tuned by means of a noncontacting shorting plunger, controlled by the TUNING knob on the front panel. This control is geared to a direct reading dial. Each time the frequency of the klystron local oscillator passes through the resonant frequency to which the cavity is tuned, the meter absorbs some of the RF energy, causing a sharp decrease in the amplitude of the signal. This decrease in amplitude is made to appear on the oscilloscope screen as a sharp pip and is used as a frequency marker.
- (7) *Crystal mixer.* Crystal mixer, CR1, consists of a 1N26 type crystal mounted in a portion of the waveguide. Both the klystron local oscillator and the RF input signals are mixed at the crystal producing various frequencies. When the difference frequency equals the 45-mc IF frequency, it is passed by the IF amplifiers. The crystal current is also used as an indication of the klystron oscillator output as it varies with repeller voltage. This is the klystron mode signal that is fed to the mixer amplifier.
- (8) *Mixer amplifier.* The klystron mode that appears at the output of the crystal is filtered and fed to V27, the mixer amplifier, a type 6AH6 vacuum tube. The output, an amplified klystron mode pattern, is fed either directly to one of the vertical plates of the cathode-ray tube or through a differentiating network to the spectrum amplifier (V9), depending on the setting of the function selector switch. In the MIXER position of the switch, the klystron mode appears on the crt screen and is used to center the klystron oscillator mode. In the SPECTRUM setting, the differentiated mode curve is applied to the spectrum amplifier and appears at the output as nicks in the base line which represent the two ends and the center of the klystron mode curve.
- (9) *45-mc IF amplifiers.* The output of the crystal mixer is amplified by three stages of IF amplification that are resonant at 45 mc. These stages use 6AU6 pentodes, V2 through V4. The output of the 45-mc IF amplifiers is applied to the converter.
- (10) *Converter.* The converter uses stage V5, a 6BA7 as a local oscillator and a mixer. The converter is used to convert the 45-mc IF signal to 5 mc. The converter local oscillator generates a frequency of 50 mc, which, when beat with the incoming 45-mc IF produces a difference frequency of 5 mc. The output is applied to two 5-mc IF amplifiers.
- (11) *5-mc IF amplifiers.* The two 5-mc IF amplifiers consist of V6 and V7, type 6AU6 pentodes. These stages amplify the converter output. The output of the 5-mc IF amplifiers is applied to a detector.
- (12) *Detector.* The detector stage V8A consists of one-half of a 12AT7 dual-triode. The tube functions as a diode detector by having the grid and plate tied together. The rectified output of the detector is applied to a cathode follower.
- (13) *Cathode follower.* Cathode-follower stage V8B is a conventional cathode follower that uses one-half of a 12AT7 dual-triode. The cathode follower provides a high-to-low impedance path for the video signal that appears on the output of the RF amplifier. The signal that appears on the cathode of this stage is fed to the spectrum amplifier through the function switch.
- (14) *Spectrum amplifier.* The spectrum amplifier, V9, amplifies the voltage pulses from the cathode follower. This stage consists of a type 6AU6 vacuum tube. The output of the spectrum amplifier is applied to one of the vertical deflection plates of the cathode-ray tube. A portion

- of the signal is applied to the intensifier.
- (15) *Intensifier.* The function of the intensifier stage, which comprises the B section of V15, a type 12AT7 dual-triode, is to amplify the individual pulses that make up the negative signal from the spectrum amplifier and to apply the positive output to the grid of the cathode-ray tube. In this way, the individual pulses of the signal on the vertical plate are intensified by corresponding increases in the beam current of the cathode-ray tube.
  - (16) *Sweep generator.* Sweep generator V10, a type 12AT7 vacuum tube, is a cathodecoupled, free-running multivibrator. This stage produces a sawtooth sweep voltage with a frequency variable from 5 to 40 cycles per second. The output of the sweep generator is applied to the reflector of the klystron oscillator through the sawtooth amplifier and to the horizontal deflection plates of the cathode-ray tube through the horizontal amplifier. In addition, the sawtooth wave from the horizontal amplifier is differentiated and applied as a square wave to the blanking tube. Therefore, the klystron modulating signal and the crt time base are synchronized.
  - (17) *Sawtooth amplifier.* The sawtooth amplifier consists of one-half of a type 12AT7 vacuum tube. The sawtooth voltage from the sweep generator is amplified in the conventional amplifier and the output is applied to the reflector of the klystron oscillator; frequency modulating the klystron oscillator.
  - (18) *Horizontal amplifier.* The sawtooth voltage from the sweep generator is amplified by VII, the horizontal amplifier. This stage provides push-pull deflection voltages for the horizontal plates of the crt. It also feeds the negative portion of the sawtooth voltage through a differentiating circuit that converts it into a positive pulse. The positive pulse corresponds to the sweep retrace time.
  - (19) *Blanking.* The positive square wave is amplified by V15A, the blanking amplifier, one-half of V15, a type 12AT7 vacuum tube. The resultant negative pulse is ap-

plied to the grid of the crt to cut off the tube. Inasmuch as the negative pulse coincides with the retrace portion of the sweep, the blanking pulse serves to eliminate the retrace that would otherwise appear on the scope.

b. *Synchroscope Operation* (fig. 23). High amplitude pulses are fed through the PULSE IN receptacle J6 and applied directly to one of the vertical plates of the cathode-ray tube. The horizontal sweep is developed as follows:

- (1) *Trigger amplifier.* The external triggering pulse is applied through TRIG. IN receptacle J4 and amplified by V12B, one-half of a type 12AT7 dual-triode. The negative output signal is fed to the trigger sweep generator.
- (2) *Triggered sweep generator.* The trigger pulse from the trigger amplifier is applied to the triggered sweep generator that consists of V13A and V14, one-half of a 12AT7 and a 6AH6 pentode connected as a multivibrator. The trigger initiates the multivibrator action of this stage. The output is a positive sweep of 150 or 5,sec duration, depending on the setting of the function selector switch. A portion of the output sweep is applied directly to one of the horizontal plates of the crt. Another portion is applied to the triggered sweep horizontal amplifier. In addition, a square pulse output is differentiated and applied to the spectrum amplifier to be used for blanking.
- (3) *Triggered sweep horizontal amplifier.* The positive sweeps from the triggered sweep generator is amplified by V13B, the triggered sweep horizontal amplifier, and the negative output is fed to the other horizontal deflection plate of the crt.
- (4) *Intensifier.* The square wave output from the triggered sweep generator is differentiated, and the negative pulse is amplified by V9, the spectrum amplifier. The resultant positive signal is applied to intensifier V15B, one-half of a type 12AT7 vacuum tube. The negative output of this stage, a negative blanking signal, is fed to the grid of the crt and coincides with the retrace portion of the display.

**Note**

The intensifier described above is used as a blanking tube in synchroscope operation.

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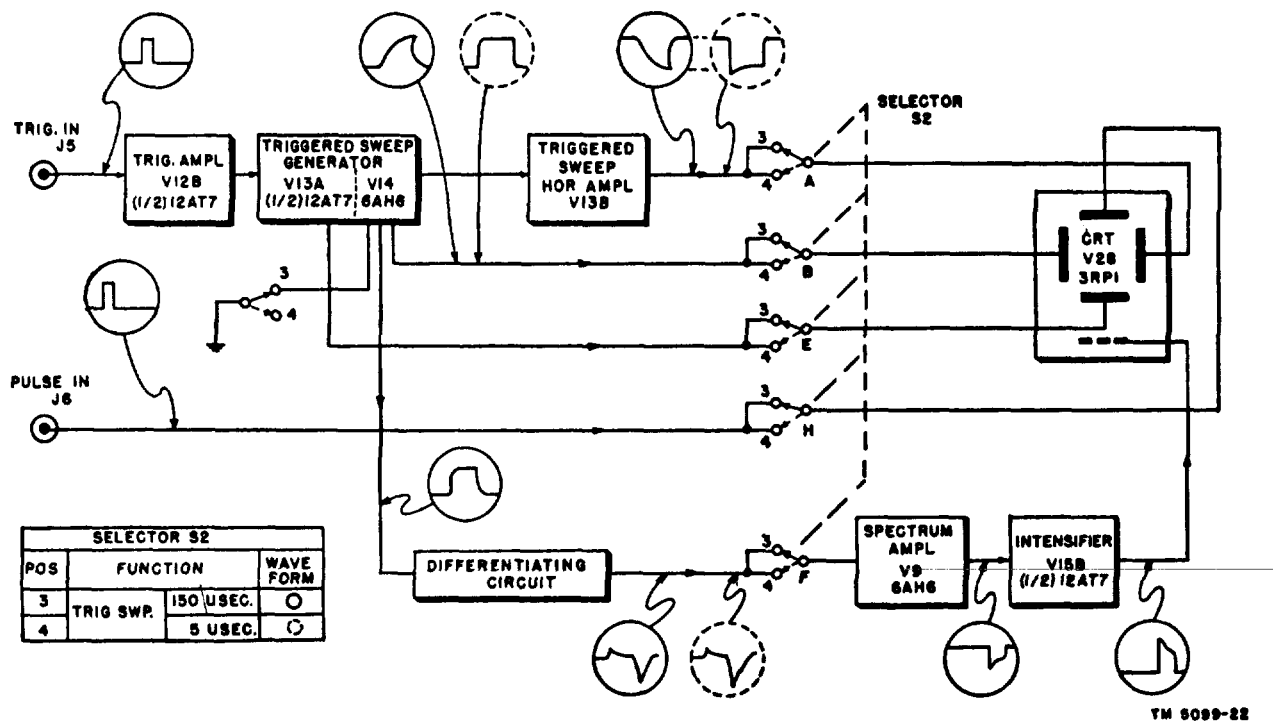


Figure 23. Spectrum Analyzer TS-742/UPM, block diagram of signal paths, syncroscope function.

### Section III. DETAILED FUNCTIONING OF CIRCUITS

#### 44. Calibrated RF Attenuator AT1 fig. 24)

a. The calibrated RF attenuator reduces the input power to a level suitable for the operation of the crystal. The RF signal enters the RF circuit through the input waveguide and passes the calibrated RF attenuator before reaching the crystal mixer. Consequently, the RF attenuator controls the amplitude of the pattern on the screen.

b. Calibrated RF attenuator AT1 consists of a thin metalized film strip or vane inserted into a portion of the rectangular waveguide so that it lies parallel with the narrow dimension of the guide. The strip is attached to a yoke with two push rods and is driven by the shaft through a cylindrical cam and cam follower. The vane is parallel to the electrical field in the waveguide. Because the field strength increases from zero at the side of the guide to maximum at the center, the loss caused by the attenuator increases as the vane is moved toward the center of the guide.

c. A direct-reading front panel dial, mounted on the attenuator shaft indicates attenuation in db. Since the attenuator is frequency-sensitive, attenuator readings must be corrected by means of the db

correction curve provided with the unit (par. 18c). The curve gives attenuation readings as a function of frequency. The calibrated RF attenuator provides losses up to 50 db; however, only the first 45-db of attenuation is calibrated.

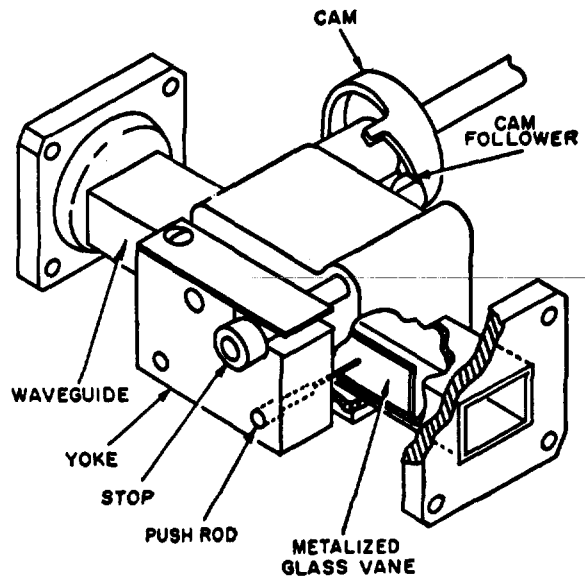


Figure 24. Calibrated RF attenuator, cutaway view. TAGO 6709-A. June

#### 45. Klystron Local Oscillator (figs. 25 and 60)

Klystron local oscillator V1 utilizes a type 6178 (QK297) velocity-modulated klystron to produce a frequency-modulated signal of known and adjustable frequency and power level. This signal is used as a test signal in the MIXER position of function selector switch S2 and indicates whether or not the klystron is functioning. When the function selector switch is in the SPECTRUM position, the same frequency-modulated signal is used to beat with the incoming RF signal, producing the 45-mc IF frequency. When the difference frequency is equal to the IF to which the IF amplifier is tuned, it passes through the IF amplifier to be displayed on the crt. The swept klystron mode is also differentiated and the resultant pips are used as frequency markers on the crt display. Oscillations are produced in the following manner:

a. The tube elements consist of a reflector electrode, resonator grids, and a cathode. The cathode is at ground potential, the resonator grids are supplied with a positive 300 volts from the +300-volt supply, and the reflector is maintained at a negative voltage between -87 and -261-volts as determined by the setting of SPECTRUM CENTER control R122. This voltage is obtained from a voltage divider across the negative end of the high-voltage supply.

b. The electron gun produces a focused electron beam of uniform velocity. A reentrant cavity resonator, tunable by varying the spacing of the resonator grids and the volume of the resonator cavity, is an integral part of the tube. A varying RF field exists at the resonator, while a strong negative field exists at the reflector electrode. The varying RF field acts on the electron beam as it passes the resonator slowing up the electrons when the field is negative and speeding up the electrons when the field is positive. This process, known as velocity modulation, causes a bunching of electrons around the electrons that pass the RF field at the moment of zero voltage. When the electrons arrive at the reflector, they are slowed to a stop and reflected back to the resonator by the negative reflector voltage. This voltage is adjusted so that electrons are reflected back when the phase of the RF field is slowing down the electrons and, therefore, energy is delivered to the resonator.

c. The TUNING control, located on the front panel, is mechanically coupled to the resonator

grids. By varying the spacing of the resonator grids, the frequency of the local oscillator is also varied. When the distance between the grids is decreased, the capacitance of the resonator cavity is increased; this decreases the natural frequency of oscillation.

d. The frequency-modulating voltage used to sweep the klystron signal is developed by the same sweep generator that supplies the horizontal sweep for the CRT (par. 58b). This sawtooth voltage, coupled through capacitors C60 and C1 to the reflector of the klystron, causes the frequency of the klystron oscillator to deviate to either side of center. The amplitude of this voltage as controlled by SPECTRUM WIDTH control R57 determines the width of the frequency band through the klystron sweeps.

e. The frequency-modulated output is fed through a waveguide that contains a fixed attenuator. The fixed attenuator reduces the power of the klystron output and matches its impedance to that of directional coupler DC1.

f. Test jack J8 is used to measure klystron current. When a meter plug is inserted into jack J8 the cathode of the klystron is returned to ground through the millimeter.

#### 46. Directional Coupler DC1

The incoming RF and local oscillator signals are fed in through the separate branches of directional coupler DC1. A step-matched polyiron termination is incorporated at the end of the local oscillator branch of the coupler near the junction with the RF input branch. This pad serves as an impedance matching device which reduces reflections and increases

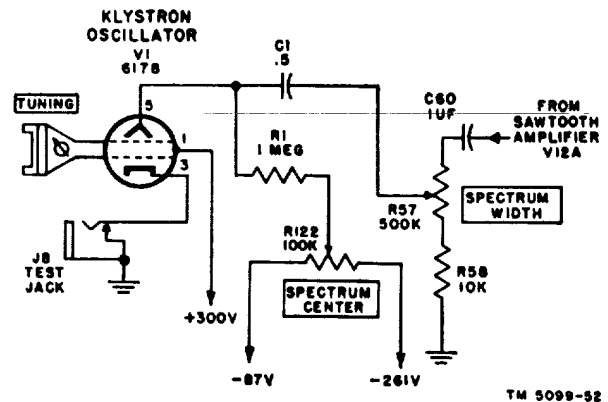


Figure 25. Klystron oscillator, simplified schematic diagram.

the directivity of the signal. The section connected to the local oscillator branch provides approximately 10 db of decoupling of the klystron signal. Additional loss is provided by fixed attenuator waveguide AT2. By means of these attenuating devices, the klystron signal level is reduced in the directional coupler to approximately 1 milliwatt (0 dbm). Both signals, properly attenuated, maintain a forward direction through the directional coupler. The output of the directional coupler is applied to frequency meter Z1.

**47. Frequency Meter Z1 fig. 26)**

a. Frequency meter Z1 is an iris-coupled right circular cylinder operating in the  $TE_{011}$  mode. The meter barrel is coupled to the broad face of the waveguide. Tuning is accomplished by means of a noncontracting plunger ganged to a direct-reading dial on the front panel. The frequency meter is designed so that no other modes can become simultaneously resonant with the desired mode.

b. The frequency meter absorbs energy at the local oscillator frequency as the oscillator is swept through the frequency to which the frequency meter is tuned. This absorption causes a sharp drop in the local oscillator component of the crystal current. When the function selector switch is in the MIXER position, this energy absorption appears as a dip in the klystron mode display. The frequency at which the absorption occurs is indicated by the setting of the frequency meter. When in the SPECTRUM position, an absorption marker corresponding to that absorption appears on the base line and indicates the klystron local oscillator frequency rather than the signal frequency. The two dips that appear in the base line equidistant from the center dip indicate the frequency limits of the klystron mode. At the same time, the resonant frequency of the frequency meter can be read directly on the front panel FREQUENCY MC scale. This dial is calibrated for frequencies between 16,000 mc -F-250 mc and 16,000 mc -250 mc in 2- mc divisions.

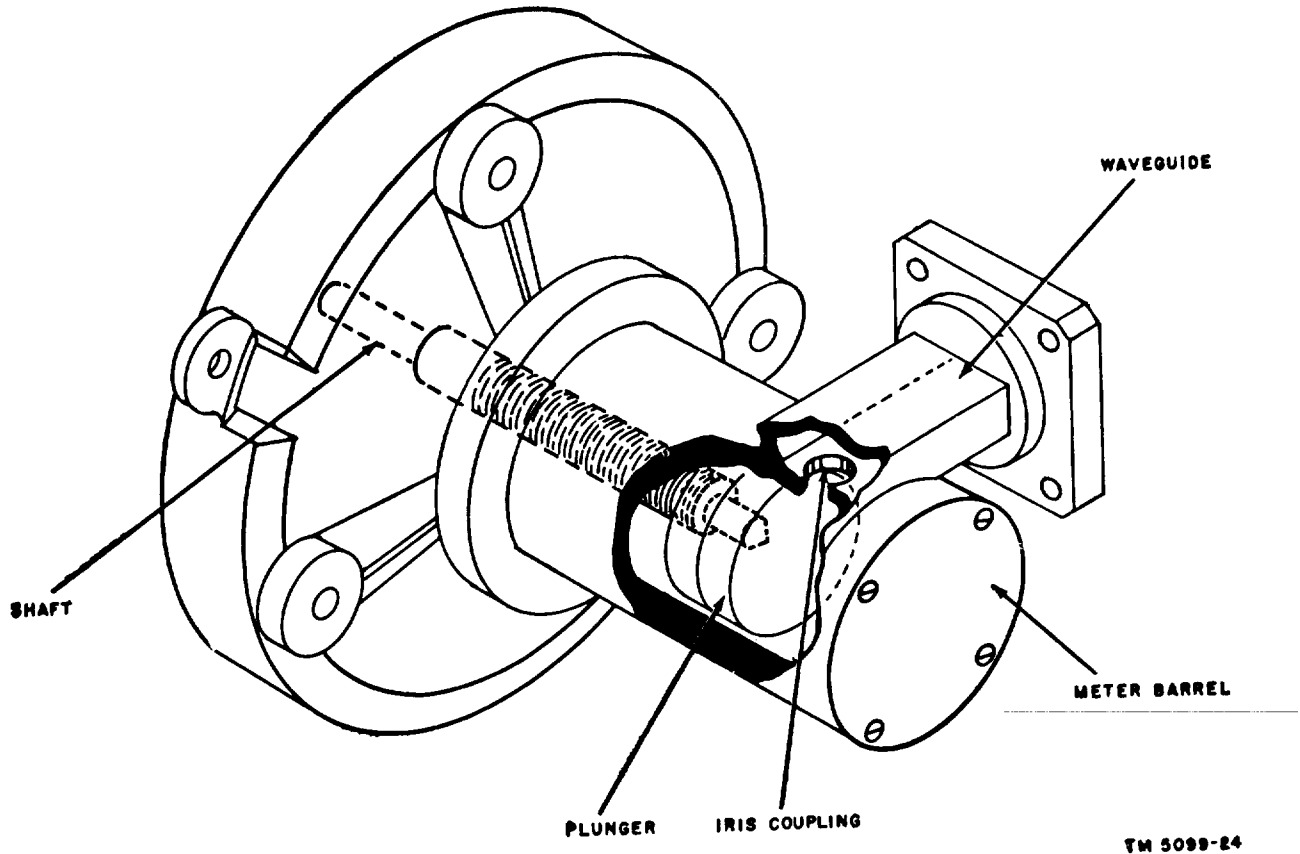


Figure 26. Frequency meter, cutaway view.



#### 48. Crystal Mixer W9 fig. 27)

a. The crystal mixer consists of a portion of waveguide incorporating a IN26 coaxial cartridge crystal mounted parallel to the electrical field within the guide. The crystal mixer is fixed tuned.

b. The crystal mount incorporates an RF choke and an IF filter. The local oscillator and input RF signals are fed into the mixer by means of a waveguide-to-coaxial transformer (13) shown dotted in the cutaway illustration fig. 27). This provides a gradual tapering impedance match. At the end of the taper, there is a quarter wave transformer section (14). This further reduces the dimension of the waveguide to match its impedance to that of the crystal. The local oscillator and input RF signals are therefore applied to the crystal mixer without any appreciable loss of power. The RF is then picked up by a probe antenna (6) which forms part of the spring finger contact for one end of the crystal. From this point, the RF can go in two directions: toward the IF filter or the RF choke. In the RF choke branch of this T, the RF encounters a near short circuit. In the opposite direction, provision is made for good RF coupling to the crystal by means of good contacts at both the inner and outer conductors of the coaxial crystal cartridge (10). The edge of the crystal cartridge, shown cut away in the illustration, rests on a beveled seat having the same size opening as the inside diameter of the cartridge. The tip of the crystal center pin slips into spring fingers cut in the end of a beryllium copper pin, insuring a tight fit. Thus, the inner conductor of the crystal is continued to the inner conductor of the coaxial connector. The outer conductor is pressed against the beveled seat by the spring (12) inside the crystal cap (11). A noncontacting short is used to continue the outer conductor of the crystal cartridge to the outer conductor of the coaxial connector; at the same time, it prevents RF leakage at that point. Good RF coupling at the seat is obtained by means of a choke incorporated in the crystal mount. This consists of a low impedance quarter wave section (8) surrounding the crystal cartridge and a folded high impedance quarter wave section (9) outside of that. By means of this choke, a short is reflected at the point of contact between the crystal outer conductor and the mount. The choke is backed up by a damping ring of powdered iron (7) to maintain the broadband characteristics of the mixer. To prevent RF from

entering the IF line, an IF filter is used. This consists of three sections of coaxial line: One is a section of low impedance a quarter wave long (5). The second is a quarter wave section of much higher impedance (4). The third is a longer section filled with powdered iron (3) which terminates the filter and provides high attenuation of RF energy.

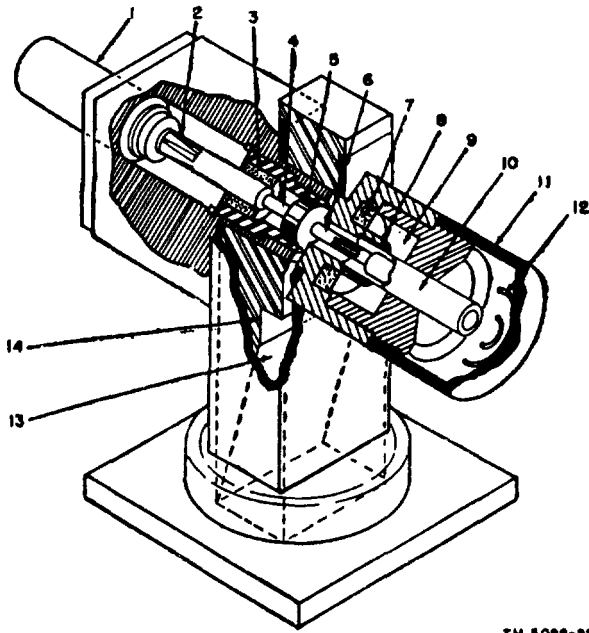
c. The crystal unit heterodynes the input RF signal with the frequency-modulated output of the klystron local oscillator. Whenever the RF input signal is 45 me above or below the frequency of the RF local oscillator, the IF amplifier responds to the output of the crystal. The IF component of the crystal output appearing at BNC connector J2 is fed via coaxial cable (W1) to the IF amplifier.

d. The output of the crystal also contains a large dc current proportional to the power output of the klystron oscillator as it sweeps through its mode. When the function selector switch is in the MIXER position, this component is fed to the mixer amplifier and displayed on the crt screen. The display is used to check the operation of the klystron oscillator or to set various controls described in paragraphs 12 and 13. It is also used to ascertain whether the klystron oscillator is tuned to the desired frequency range. The frequency meter dips described in paragraph 47 are also present in the crystal output. In the SPECTRUM position of the function selector switch, the klystron mode curve is also applied to the mixer amplifier. However, it is differentiated by an rc network and amplified by the spectrum amplifier before being displayed on the screen as markers for the spectrum display.

#### 49. Mixer Amplifier (figs. 28 and 60)

a. The mixer amplifier uses V27, a type 6AH6 vacuum tube, to amplify the amplitude envelope of the klystron local oscillator. When the function switch is in SPECTRUM position, the output of V27 is differentiated to produce frequency markers.

b. The output of the crystal is applied (through coaxial cable) through receptacle J1 to an L-type filter network consisting of coils L1, L2, L3, and L4 in combination with C3, C4, C5, and C6 to ground. Resistors R2, R3, R4, and R5 serve to prevent the coils from setting up parasitic oscillations. The filter network offers a high impedance to the RF and IF, thus allowing only the crystal current to be applied to the monitoring circuit. The signal applied to the grid of V27 is the rectified voltage represent



TM 5099-23

- 1 Receptacle UG-290/U, BNC connector.
- 2 IF and dc outputs.
- 3 Lossy termination.
- 4 High impedance one-quarter wave length coaxial section.
- 5 Low impedance one-quarter wave length coaxial section.
- 6 Probe antenna.
- 7 Damping ring.
- 8 Low impedance one-quarter wave length choke section.
- 9 High impedance one-quarter wave length choke section.
- 10 Coaxial crystal cartridge.
- 11 Crystal cap.
- 12 Crystal cap spring.
- 13 Waveguide-to-coaxial transformer.
- 14 One-quarter wave length transformer section.

Figure 27. Crystal mixer, cutaway view.

ing the amplitude envelope of the klystron local oscillator. MIXER AMPLIFIER control R123, a 5,000-ohm potentiometer, serves to complete the circuit to ground. The voltage developed across R123 varies directly with the power output of the klystron local oscillator. This voltage, of parabolic wave shape, represents the klystron mode pattern as a function of swept reflector voltage. The grid, pin 1 of V27, is tied to the wiper of R123. Thus the mode pattern is amplified and appears inverted at plate load R124.

c. The plate, pin 5 of V27, is tied to contact 1 of the E section of function selector switch S2. The wiper of this section is tied directly to pin 6, one of the vertical

deflection plates of the crt. Therefore when the function selector switch is in the MIXER TAGO 6709-A. June position of S2 the klystron mode appears on the crt screen.

d. When the function selector switch is in the SPECTRUM position, the mode curve appearing at the plate load is applied to a differentiating rc network consisting of R131 and C83. The resultant wave form consists of three differentiated pulses: one for the frequency meter dip and the other two for the ends of the mode. These marker pulses are fed to contact 2 of the F section of function selector switch S2. At the same time, a spectrum signal originating in the IF section is fed in from P3 through resistor R131 and is similarly fed to contact 2 of the F section of S2. The two signals are coupled out by the wiper to the grid, pin 1, of spectrum amplifier V9 (para. 55), where they are amplified and fed via the E section to pin 6, one of the vertical deflection plates of the crt. Therefore, the spectrum appears with frequency markers along the base line. For analyses of the spectrum amplifier refer to paragraphs 55 and 65 b.

e. Resistor R125 serves as the screen dropping resistor. When the function selector switch is in the MIXER position, resistors R.125, R126, and R127 form a voltage divider network for the screen. In the SPECTRUM position, resistor R136 is added to the circuit, altering the operating voltages of V27. Potentiometer R127, the MIXER V CENTER control, is used to develop cathode bias and therefore serves to adjust the plate voltage. The setting of R127, consequently, determines the dc voltage on the vertical plates of the crt which, in turn, determine the vertical position of the trace. Potentiometer R123, the MIXER AMPLIFIER control, determines the amplitude of the signal applied to the grid of the tube.

## 50. IF Amplifier (45-mc)

(figs. 29 and 60)

The spectrum analyzer uses three 45-mc IF amplifiers: V2, V3, and V4. The amplifiers are identical except for the input coupling of V2, the first 45-mc IF amplifier. V2 is described in a and b below; circuit details apply to the other two stages and can be understood by substituting the proper reference symbols for those of V2.

a. The output of the crystal mixer is applied to the grid of V2 through inductor L5 and capacitor C2. These form a series resonant circuit, tuned to 45 me, and offer little impedance to the IF signal. The voltage developed across grid return inductor L6 is applied to the grid.

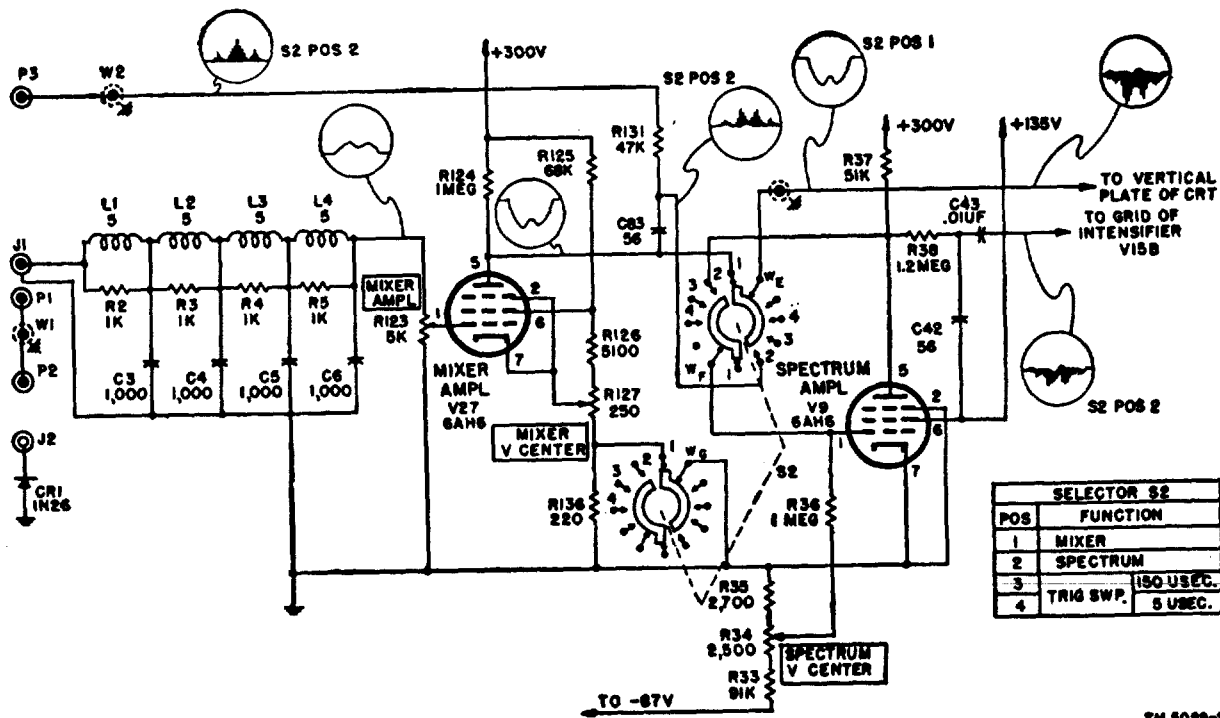


Figure 28. Mixer and spectrum amplifiers, simplified schematic diagram.

Resistor R2 and inductor L1 form part of the 45-me isolation network in the input to mixer amplifier V27. The signal developed across the plate load, R7 and L7, is coupled through C9 to grid tank coil L1 and C10 to the grid of the second IF amplifier. The tank circuit is sharply tuned to 45 megacycles. The cathode is returned to ground through the biasing network, R6 and C7, through decoupling filter, L8 and R9, and through IF SENSITIVITY control R39. Since the cathode currents of the three 45-mce IF amplifiers flow through R39, varying the resistance of R39 will vary the bias of the three 45-me IF amplifiers and hence their gain. Inductor L10, resistor R10, and capacitor C11 form the plate decoupling network, isolating this stage from all other stages in the analyzer.

b. The IF signal is amplified through the 45-mc IF stages and appears at the output as a series of pulses of 45 mc. Each pulse represents a section of the spectrum of the signal being observed. These are fed to converter V5 through capacitor C19.

### 51. Converter V5

(figs. 30 and 6n)

A type 6BA7 pentagrid converter is used as the second mixer in the IF circuit. The 45-mc signal 42

from the third IF amplifier is heterodyned with a locally generated 50-me signal. The output frequencies are fed to the first 5-me IF amplifier.

a. The oscillator that generates the 50-me signal is a shunt-fed Colpitts oscillator, with the screen grid, pin 1, serving as the plate, and the first grid, pin 2, serving as the grid. Capacitors C23 and C24 form the feed-back capacitance voltage divider necessary to sustain oscillations. The feed-back capacitors with inductor L22 form the oscillator tank circuit and are tuned to 50 me. Capacitor C25 serves two functions: It couples the signal generated at the tank circuit to the grid and, with resistor R23, provides grid leak bias for the oscillator. Inductor L20 provides the cathode dc return path. The oscillator section of the converter forms a virtual cathode which controls the current through the tube.

b. The 45-mc IF signal is applied to the third grid of the converter through coupling capacitor C19. Capacitor C20 and inductor L17 form the 45-me grid tank circuit. The 45-mc signal from the third 45-mc IF amplifier and the 50-mc signal from the local oscillator are mixed in the tube and the resultant frequencies are passed on to the next stage through coupling capacitor C29. The first 5-me IF amplifier selects the difference frequency (5 mc) and feeds it through the and feeds it

through the remaining 5-mc IF amplifiers.

c. Inductor L19 is the plate load, resistor R21 is the screen dropping resistor, and capacitor C28 keeps the screen at an RF ground potential. Capacitor C27, inductor L23, and resistor R24 form a plate supply decoupling network isolating any IF energy in this stage from the power supply.

## 52. IF Amplifiers (5 Mc)

(figs. 31 and 60)

a. The spectrum analyzer uses two tubes type 6AU6 as 5-mc IF amplifiers. V6, the first 5-mc IF amplifier, is described in b and c below. Circuit details, however, apply to both and can be understood by substituting the proper reference symbol for those of the V6 circuit.

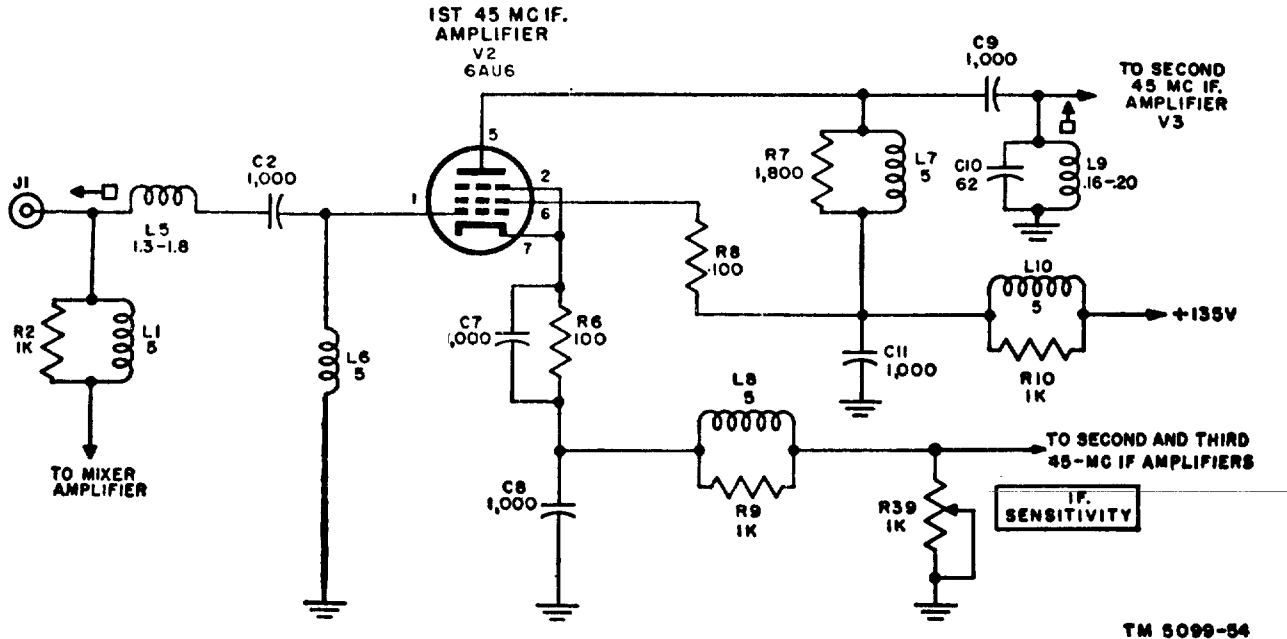


Figure 29. First 45-mc IF amplifier, simplified schematic diagram.

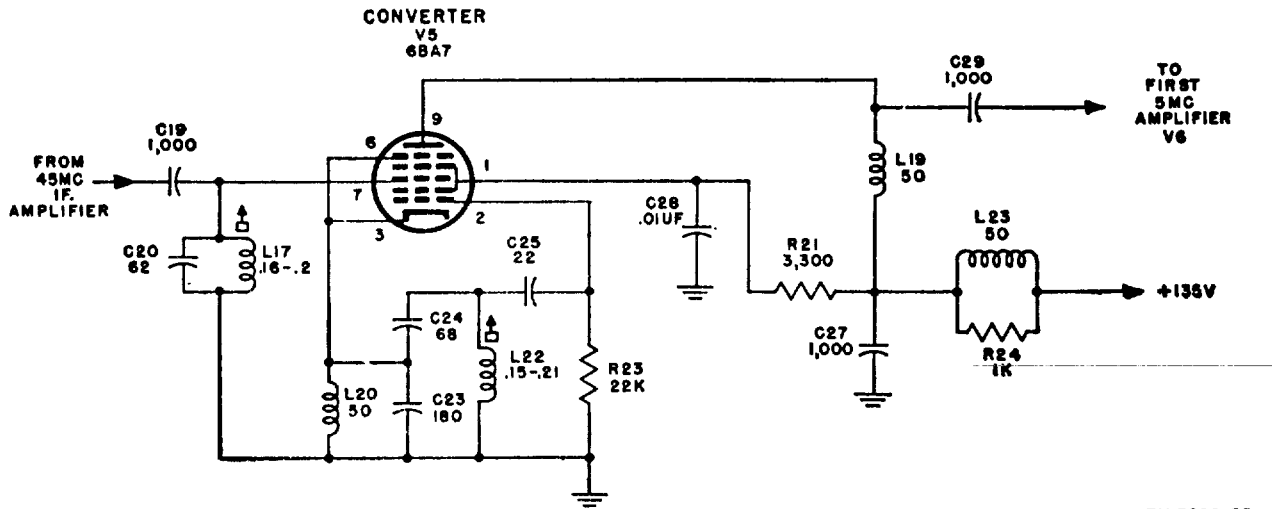


Figure 30. Converter, simplified schematic diagram.

b. The frequencies developed in the converter plate are fed through coupling capacitor C29 and are applied across the grid tank, C30 and L24. The tank circuit is sharply tuned; this allows only the frequency to which it is tuned to be applied to the grid. The signal is amplified in the conventional manner. The output is developed across plate load inductor L25 and is applied to the second 5-mc IF amplifier through C33.

c. Resistors R25 and capacitor C32 provide the cathode bias for this stage. Screen resistor R26 is a parasitic suppressor. Capacitor C31, inductor L26, and resistor R27 are the plate supply decoupling network.

### 53. Detector

(figs. 32 and 60)

a. The detector utilizes one-half of type 12AT7 dual-triode tube (V8) to convert the 5-mc IF signal to a video signal. The grid and plate are tied together, forming a diode. Inductor L29 and capacitor C38 and the tube capacitance to ground form a resonant circuit tuned to the 5-mc IF signal. The capacity consists of the total output capacity of V7 in addition to the input and stray capacitance of V8A.

b. The unidirectional characteristics of the diode will permit plate current to flow only on alternate half-cycles. When the 5-mc input signal is such that the voltage at the plate and grid is positive with respect to the cathode, the diode will conduct and charge capacitors C39 and C41. This places a positive charge

on the cathode equal to the peak voltage of the incoming positive half cycle. During the remainder of the positive half cycle, when the positive charge on the cathode becomes greater than the incoming positive voltage applied to the grid plate combination, the diode stops conducting and capacitors C39 and C41 will discharge exponentially through resistor R32, lowering the voltage placed on the cathode. On the alternate half-cycle, when the incoming signal drives the grid plate combination negative with respect to the cathode, no current will flow. This allows capacitors C39 and C41 to discharge further. The following cycle will act in a similar manner. Resistors R31 with capacitors C39 and C41 function as a pi-type filter. The resulting video signal appearing across R32, the diode load resistor, is fed directly to the grid, pin 2, of cathode follower V8B.

### 54. Cathode Follower

(fig. 60)

a. A cathode follower stage using the other half of V8, a 12AT7 dual-triode, is used to provide a high-to-low impedance match between the output of the IF amplifier and video cable W2.

b. With no signal applied, the grid, pin 2 of V8B, is negative with respect to the cathode. The positive video signal developed across diode resistor R32 is applied directly to the grid of cathode follower V8B. Cathode current through R30, the unbypassed cathode resistor,

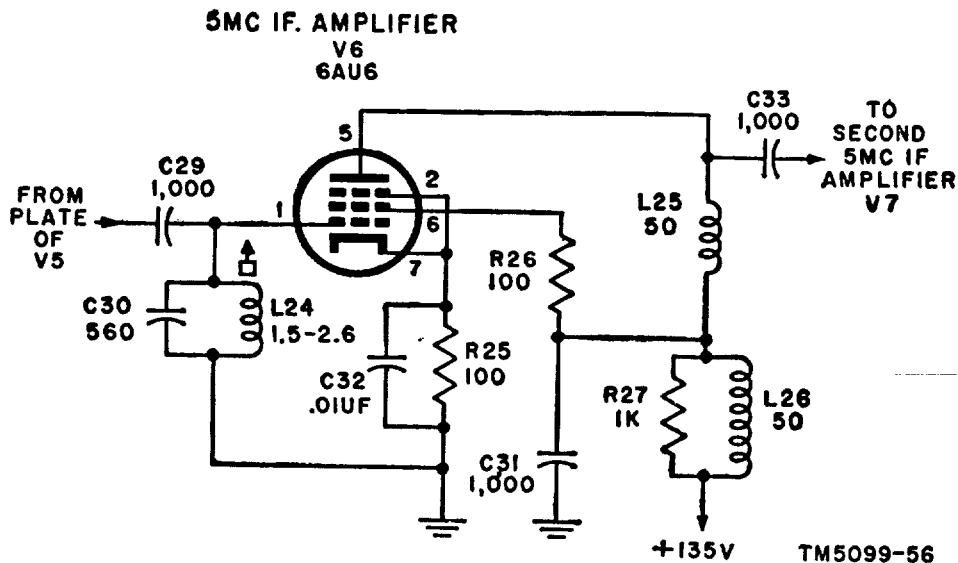


Figure 31. First 5-mc IF amplifier, simplified schematic diagram.

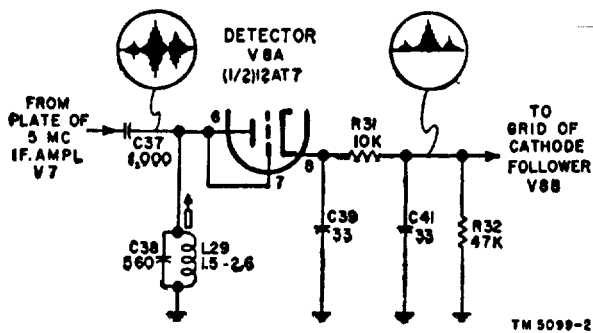


Figure 32. Detector, simplified schematic diagram.

rises. This causes a greater drop across the cathode resistor and makes the cathode more positive. Thus the voltage across the cathode resistor tends to reduce the grid to cathode voltage. Any change in the input signal appears in part as a change in cathode voltage. The output voltage, taken from the cathode is a signal with the same polarity as that of the signal applied to the grid. The signal appearing at J3 is fed to video cable W2 and is then applied along with the differentiated marker pulses from V27 to contact 2 of the F section of function selector switch S2.

## 55. Spectrum Amplifier

(figs. 28 and 60)

a. The spectrum amplifier consists of a type 6AH6 vacuum tube, V9, and its associated circuitry. In this stage, resistor R36 serves as a grid return resistor. The voltage divider network, R33, R34, R35, supplies the bias voltage. Resistor R37 is the plate load. When the function switch is in the SPECTRUM position, SPECTRUM V CENTER resistor R34 determines the grid bias of the spectrum amplifier and therefore serves to adjust the plate voltage. Consequently, the setting of R34 determines the dc voltage on the vertical plates of the crt tube which, in turn, determines the vertical position of the trace.

b. The video signal appearing at the grid (para. 47d) is amplified in the plate circuit and coupled to contact 2 on the E section of the function selector switch. Wiper WE then picks up the signal and feeds it into pin 6, one of the vertical deflection plates of V28, the crt. At the same time, signals are coupled through the integrating network, R38 and C42, and coupling capacitor C43 to the grid, pin 2, of intensifier V15B. This tube delivers an intensifying voltage to the grid for each transient of the spectrum signal (para. 59).

## 56. Sweep Generator

(figs. 33 and 60)

a. The sweep generator stage utilizes V10, a type 12AT7 dual-triode. The two sections of the tube are connected as a cathode-coupled free-running multivibrator with common cathode resistor R41. Resistors R42, R44A, and R43 are the plate load resistors for the respective halves of the tube. The time constant of potentiometer R44B, resistors R42 and R45, and capacitor C55 determines the repetition rate of the multivibrator. The grid, pin 7, of the tube is grounded through R40, a potentiometer designated SYNC, which is used to control the amplitude of the synchronizing pulse fed from the high-voltage power supply. This signal is used to lock the sweep repetition rate of the multivibrator to a submultiple of the line frequency. Hence, greater stability in sweep rate is achieved (d below).

b. With no plate voltage applied to V10, both grids, pins 7 and 2, are at ground potential. When plate voltage is applied, both halves of V10 conduct. The plate current of both halves flows through R41, the common cathode resistor, causing the cathode potentials to rise above ground. This causes a negative bias voltage to be applied to both tubes which tends to limit the current in the two sections. The current through R42, the plate load of the B section, reduces the voltage at the plate, pin 6. The voltage drop at the plate of the B section is coupled via C55 to the grid of the A section, further reducing the current through this half. The reduction in current decreases the voltage across R41, thereby increasing the current in the B section. This causes the plate voltage in this section to drop even more and the A section to conduct less. This cumulative action continues until the plate current in the A section is cut off while in the B section it has reached its maximum. The A section of V10 is held beyond cutoff during the time C55 discharges through R45 and R44B. The discharge current through R45 and R44B produces a negative voltage with respect to ground at the grid, pin 2, of the A section. This negative voltage decreases exponentially as the capacitor discharges. The grid voltage continues to decrease until it reaches cutoff. At this time, the A section conducts. The current drain by the A section of the tube increases the voltage across R41, causing the bias of the B section to go more negative. Less plate current flows in this half of the tube; therefore, the voltage at plate pin 6 increases. The grid of the A section is therefore driven more

positive, increasing the plate current in this half of V10. As a result of the reciprocal action between the two halves of the tube, the current in the B section is now reduced to zero as the current through the A section reaches maximum.

c. The time constant of potentiometer R44B, together with R45, R42, and C55 controls the frequency of this multivibrator. The frequency may be varied from 5 to 40 cycles per second. When the A section of V10 is cut off, capacitor C56 charges through R43 and potentiometer R44A toward B+ along the linear portion of the exponential charging curve. Potentiometer R44A adjusts the rate of climb of the resultant sawtooth rising slope so that it reaches approximately the same maximum voltage regardless of the sweep frequency. Potentiometers R44A and R44B are ganged together and comprise the SWEEP RATE control. By varying the two potentiometers simultaneously, the amplitude of the sawtooth voltage generated across C56 is maintained constant in spite of changes of sweep frequency.

d. The sync signal appearing across R40 is obtained from R108 in the filter of the high-voltage rectifier circuit (para. 66c(1) and fig. 43). Each time capacitor C78 charges up to the peak of the ac being rectified by V23, a negative voltage at a 60-cycle rate appears across R108. These negative pulses are used to synchronize the sweep repetition rate of the sweep generator with the line frequency.

e. The sawtooth voltage generated by V10 is

coupled through capacitor C57 to V11, the horizontal amplifier for the crt horizontal sweep. The same sawtooth voltage is coupled through C59 and resistor R59 to sawtooth amplifier V12A for the klystron modulating voltage. By feeding the same sweep voltage to these two stages, the klystron modulation voltage and the crt time base are synchronized.

### 57. Horizontal Amplifier

(figs. 34 and 60)

a. The horizontal amplifier consists of vacuum tube V11, a type 12AT7 dual-triode, with the two halves connected as a phase inverter circuit. Potentiometer R50 is the grid resistor for V11A and is connected to the arm of potentiometer R49 which, with resistor R48, constitutes a voltage divider network. Resistor R56 is the grid resistor for the grid of V11B and is tied to a point on the voltage divider consisting of resistors R47, R46, and R48. Resistors R53 and R52 constitute the plate load of the V11A, while R54 is the plate load of V11B. Resistors R51 and R55 are the cathode biasing resistors.

b. The sawtooth voltage is fed to the grid, pin 2 of V11A, and is amplified. A portion of the signal is taken off part of the plate load and fed through capacitor C58 to the grid of V11B, where it is amplified. The negative sawtooth voltage on the plate of V11A, pin 1, branches off at this point. It is coupled directly to contacts 1 and 2 of the A section of the function selector switch, the wiper

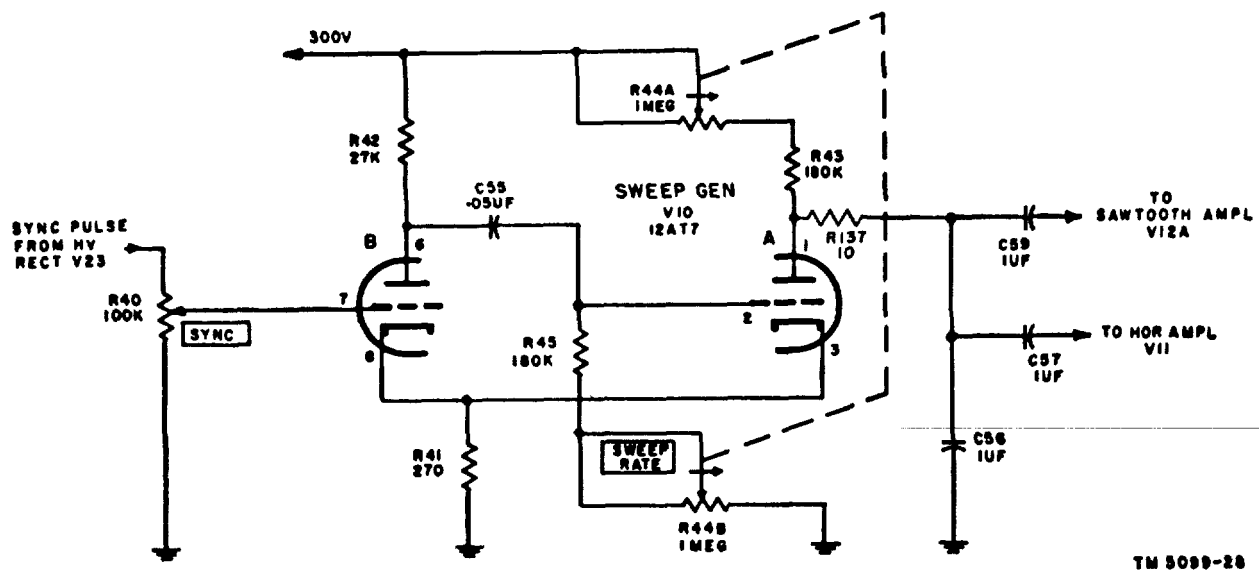
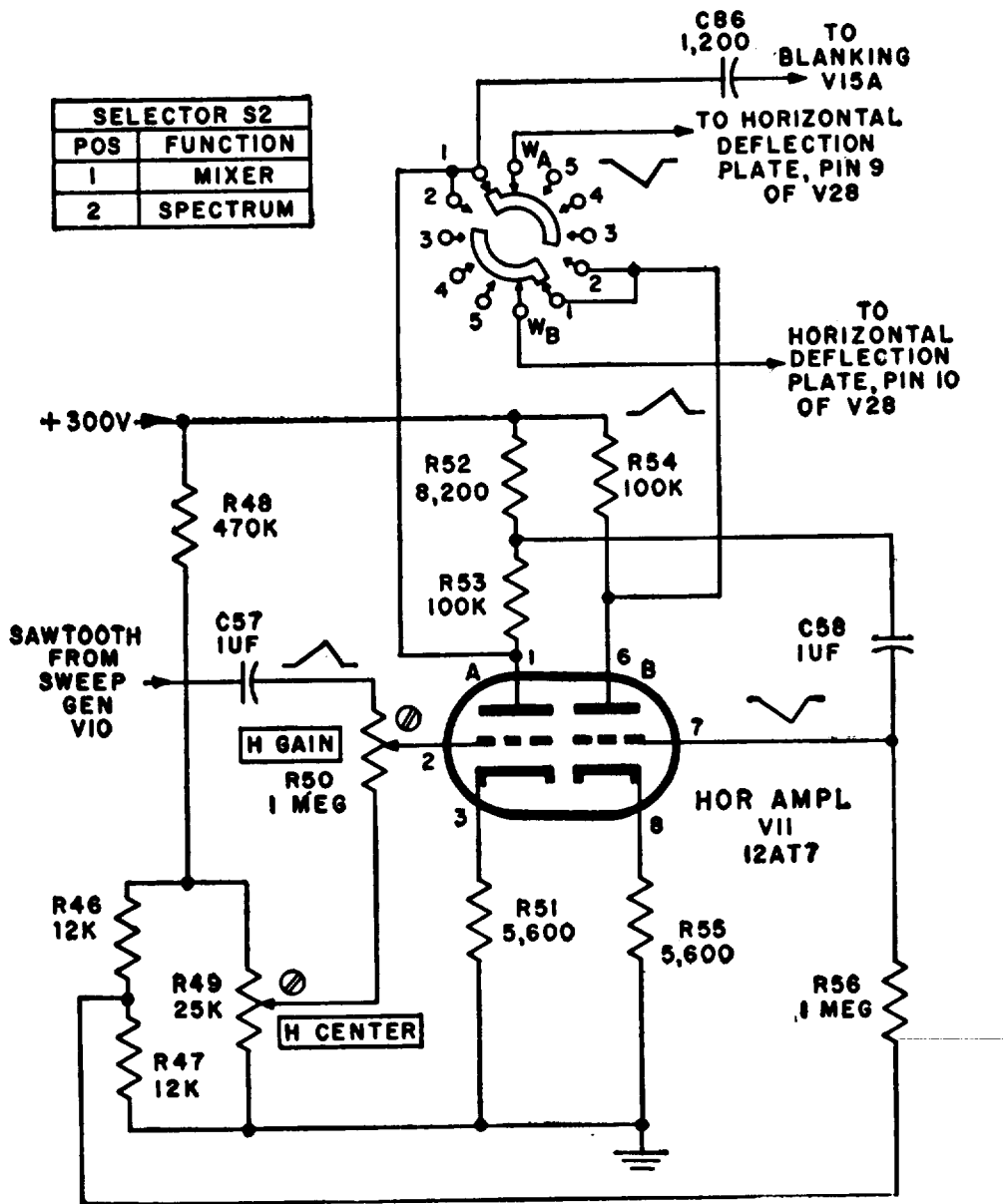


Figure 33. Sweep generator, simplified schematic diagram.

of which is tied to pin 9, one of the horizontal deflection plates of V28 (the crt). It is also fed through a differentiating network consisting of capacitor C86 and resistor R85 (fig. 60) to the grid of blanking tube V15A. The signal at the plate of V11B, which is 180° out of phase with the signal at the plate of V11A, is coupled to contacts 1 and 2 of the B section of the function selector switch. The wiper is tied to the other horizontal deflection plate, pin 10 of the crt.

c. Potentiometer R49, the H CENTER control, permits manual adjustment of the relative bias between pins 2 and 7, the grids of the phase inverter amplifier. Changes in the relative bias cause the plate voltage in the A and B sections to shift in relation to one another. Consequently, R49 can be used to center the horizontal sweep. Potentiometer R50, designated H GAIN, controls the amplitude of the input to the A section and is therefore the horizontal sweep gain control for the crt.



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Figure 34. Horizontal amplifier, simplified schematic diagram.



## 58. Sawtooth Amplifier

(figs. 35 and 60)

a. One-half of a type 12AT7 dual-triode, V12A, is used as the modulating sawtooth voltage amplifier. In this stage, resistor R62 is the plate load and R61 is the cathode resistor.

b. The sawtooth is applied to the grid, pin 2, and amplified at the plate load. The signal is coupled by capacitor C60 to the load consisting of potentiometer R57 and resistor R58 and fed through the arm of R57 to the reflector, pin 5 of the klystron, through capacitor C1. SPECTRUM WIDTH control R57 determines the amount of output sweep voltage applied to the reflector of the klystron. In turn, this controls the width of the frequency band through which the klystron sweeps, since the frequency of the klystron varies directly with the amplitude of the modulating voltage.

## 59. Spectrum Blanking-Intensifier

(figs. 36 and 60)

a. Retrace blanking and intensification of the trace are accomplished by V15A and V15B respectively, the halves of a type 12AT7 dual-triode.

b. In blanking tube V15A, resistor R86 is the biasing resistor. Resistor R89 is a plate load resistor common to the blanking and intensifier tubes. The positive pulse from the differentiating network (R85 and C86) is applied to the grid, pin 7 of V15A. This tube is normally near cutoff. The positive pulse from the plate

of the horizontal amplifier acts as a trigger, allowing the tube to conduct heavily. The tube produces a negative pulse at the plate. This pulse coincides with the retrace portion of the sweep wave form on the crt, cutting off the crt during the retrace portion of the sweep.

c. In V15B, the intensifier stage, R90 is an unbypassed cathode resistor and R91 and C70 form the grid return network.

d. A portion of the output of V9 is applied to the grid of V15B. This negative spectrum signal appearing at the plate of V15B consists of positive spikes of voltage coinciding with each positive signal delivered to the vertical deflection plate of the crt. The intensifying signals are coupled through capacitor C82 to the control grid, pin 2 of the crt. The action of the intensifying signals on the crt grid during the sweep time can be considered as intensity modulation because it causes the individual transients of the crt display to be intensified. The two halves of the blanking-intensifier stage operate in synchronization to brighten the individual transients during sweep time and to blank the retrace during retrace time.

## 60. Cathode-Ray Tube

(fig. 60)

a. A type 3RP1 crt (V28) is used to display the output of the spectrum analyzer. Voltages applied to the horizontal and vertical deflection plates as well as voltages applied to the control grid control the trace.

b. The cathode, pin 3, is connected to the -1,600-volt supply through resistor R115. The cathode is kept at a high negative potential with respect to ground. Resistor R109, the INTENSITY control, is connected between the grid and the cathode. The INTENSITY control varies to the grid-to-cathode potential, thereby varying the intensity of the electron beam reaching the screen. Voltages from the intensifier and blanking tube are also applied to the grid. These voltages intensify the beam during the trace and blank it out (taking the grid beyond cutoff) during the retrace period.

c. The first anode, pin 4, is connected to the FOCUS control. Varying the FOCUS control varies the potential on pin 4; this varies the electrostatic field set up between the accelerating anode and the first anode. The accelerating anode, pin 8, is connected to a voltage divider network consisting of R132, R133 (the ASTIG control), and R134. Varying the ASTIG control varies the accelerating anode voltage and thus, to a finer degree, the electrostatic field between the first and

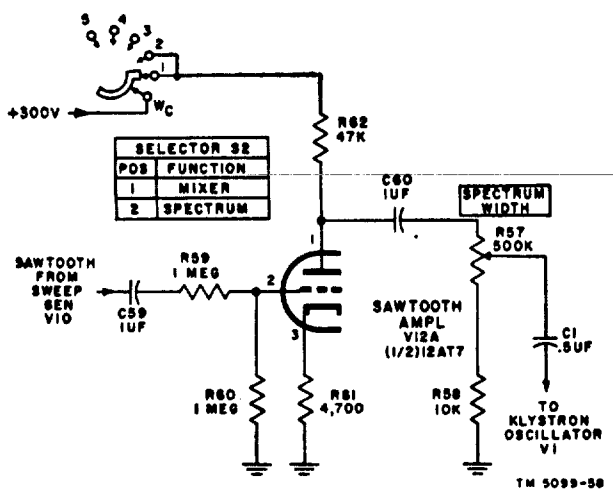


Figure 35. Sawtooth amplifier, simplified schematic diagram.

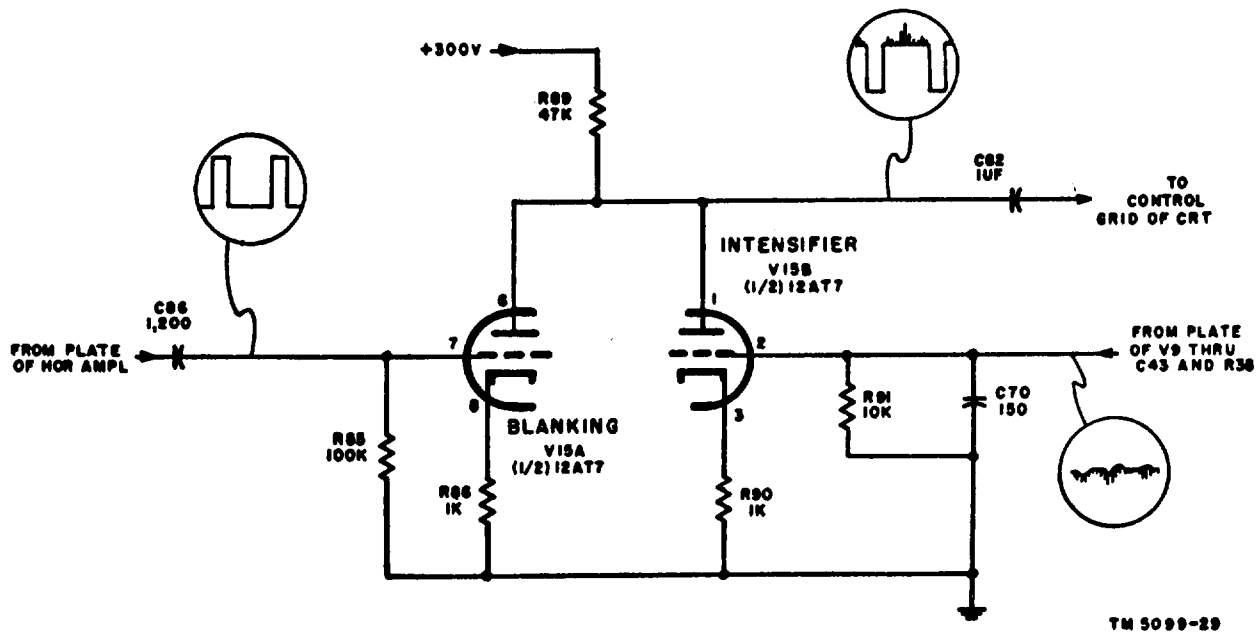


Figure 36. Spectrum blanking intensifier, simplified schematic diagram.

second anodes. This voltage is normally around +150 volts.

d. The vertical deflection plates, pin 7 and 6, are used to deflect the electron beam. When the function switch is in the MIXER or SPECTRUM position, pin 7 is connected to a fixed potential coming from the 300-volt supply through R130. The voltage divider network consisting of R128 and R129 develops the fixed dc voltage for pin 7. When the function switch is in either TRIG SWP. position, pin 7 is connected to the PULSE IN receptacle. Pin 6 is connected to the variable input signal through the function selector switch. The horizontal deflection plates are connected to the horizontal amplifier through section 1 of function selector switch S2. Voltages from the sawtooth oscillator and other sweep voltages are applied to these plates.

### 61. Synchroscope Input Circuit

(fig. 60)

During synchroscope operation, vertical signals are fed into the analyzer through PULSE IN connector J6 and are coupled by capacitor C85 to contacts 3 and 4 of the H section of switch S2. The wiper of this section is tied to one of the vertical deflection plates, pin 7 of the crt. External triggers are fed in through TRIG. IN connector J5 and are coupled by C61 into the grid, pin 7, of V12B, the trigger amplifier.

### 62. Trigger Amplifier

(figs. 37 and 60)

a. One-half of a type 12AT7 dual-triode tube (V12B) is used to amplify the input triggers. In this stage, resistor R64 is the grid resistor, R63 is the cathode resistor, and R71 is a common plate load resistor with V13A.

b. The positive input signal applied to the grid is amplified and appears as a negative-going signal on the plate, pin 6, of triggered sweep generator V13A. This negative signal is coupled by C64 into the grid, pin 1 of V14, which together with V13A forms the triggered sweep generator.

### 63. Triggered Sweep Generator

(figs. 38 and 60)

a. The triggered sweep generator consists of V14 (a type 6AH6 pentode) and V13A (the A section of a type 12AT7 dual-triode), which are connected as a one-shot multivibrator. Regeneration occurs as a result of the feed-back circuit between the screen, pin 6 of V14, and the grid, pin 7 of V13A; capacitor C63 serves as the coupling capacitor. The plate circuit of V14 is thus free to generate the sweep wave forms.

b. Normally, V14 is conducting because its grid is connected to B+ through R72. However, V13A is cut off as a result of the bias obtained from R68 and R70.

SELECTOR S2		
POS	FUNCTION	
3	TRIG	150 USEC.
4	SWP.	5 USEC.

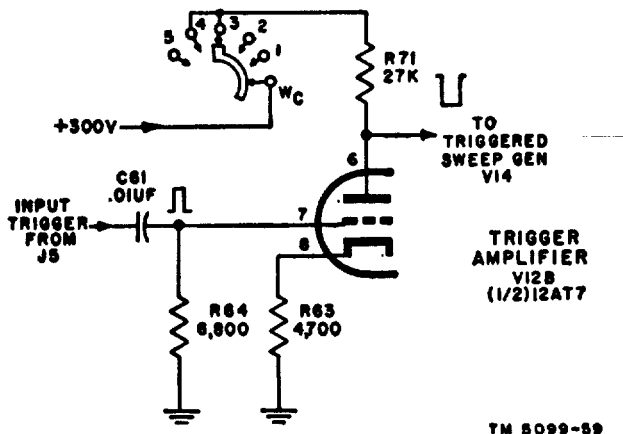


Figure 37. Trigger amplifier, simplified schematic.

When a negative signal appears at the grid, the current flow-through tube V14 decreases. As the current flow through the tube decreases, the plate and screen voltages increase. The positive signal appearing at the screen is fed back to the grid of V13A, causing the tube to conduct and the plate voltage to decrease. The decreasing plate voltage is coupled through C64 to the grid of V14 and appears as a negative voltage. Regenerative action continues until V13A reaches saturation and V14 is cut off.

c. The width of the sawtooth wave form obtained at the plate of V14 is determined by an re network consisting of plate load resistors R75 through R79 and capacitor C66, when S2H is in the TRIG SWP. 150  $\mu$ SEC. position. In the TRIG SWP. 5  $\mu$ SEC. position, C66 is switched out of the circuit and the tube stray capacitance is used to determine the re time constant. Variable capacitor C87, 5  $\mu$ sec adjustment, serves as a trimmer to adjust the 5  $\mu$ sec sweep time. A wave form with a steep exponential rising slope for the 5- $\mu$ sec sweep and a more gradual one for the 150- $\mu$ sec sweep are therefore generated by this circuit. A portion of the sawtooth wave form appears across the bank of plate load resistors R76 through R79 and another portion across resistor R75. The portion across the resistor network is coupled through capacitor C67 and fed to contacts 3 and 4 of the B section of S2, where it is

picked up by the wiper and applied directly to pin 10, one of the horizontal deflection plates of the crt. The dc level at pin 10 is determined by the voltage set by potentiometer R81, the TRIG SWP. H CENTER control and R80, the load resistor across which the signal is developed. The other portion of the sawtooth voltage is taken off R75 and coupled by capacitor C68 to the grid, pin 2 of V13B, the triggered sweep horizontal amplifier.

d. The components of the triggered sweep generator circuit include resistors R69 and R72, the grid return resistors for V13A and V14 respectively, resistors R75 through R79, the plate load resistors of V14, and screen dropping resistors R73 and R74 of V14.

e. A positive square pulse appears on the screen of V14 equal to the pulse width of the multivibrator. This pulse is fed to a differentiating network consisting of C65 and R135. The resultant wave form consists of a positive pip of the leading edge and a negative pip of the trailing edge. The positive pip coincides with the beginning of the sweep and the negative pip with the retrace. This differentiated wave form is fed to contacts 3 and 4 of the F section of S2, coupled into the wiper, and fed to the grid of V9. The negative pip is used to blank the crt during the retrace period.

#### 64. Triggered Sweep Horizontal Amplifier

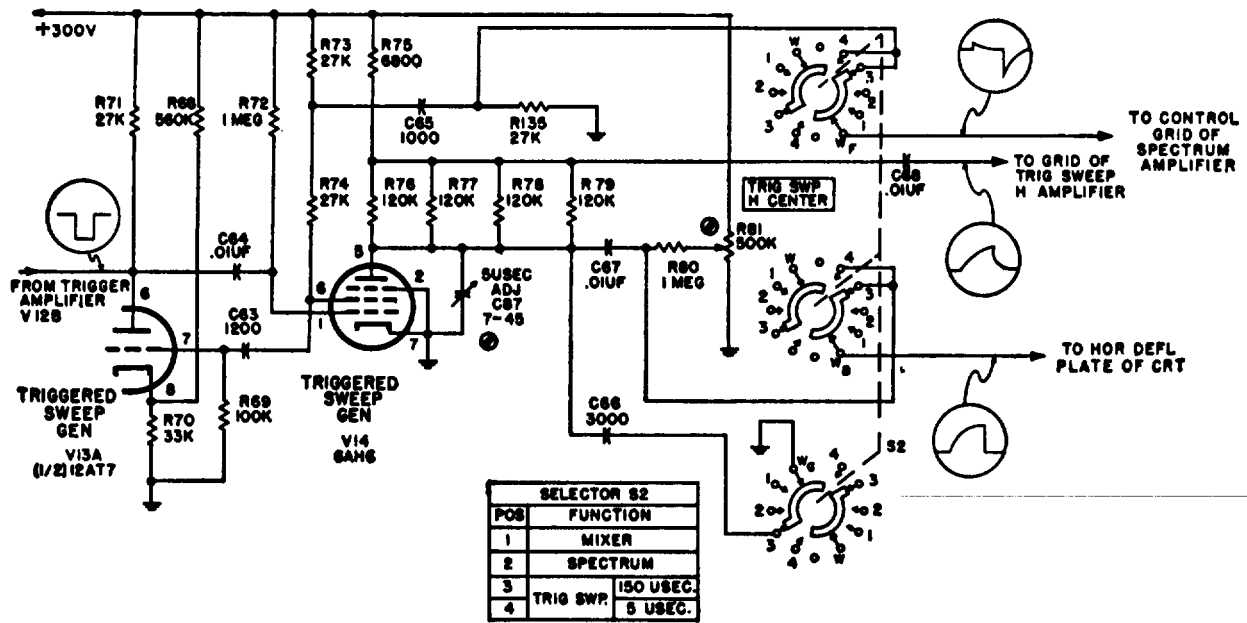
(fig. 60)

Triggered sweep horizontal amplifier V13B utilizes one-half of a type 12AT7 in a circuit which includes cathode bypass capacitor C69, cathode resistor R84, grid resistor R82, and plate load resistor R83. The positive sawtooth wave form is amplified in this stage in a conventional way and appears at the plate load as the negative counterpart of the sawtooth. The output is applied directly to pin 10 of the crt. Thus, the output of V14 and V13B is in push-pull, providing deflection voltage 180° out of phase for sweeping the cathode-ray beam horizontally. The negative-going sawtooth wave form is applied to contacts 3 and 4 of the A section of S2, picked up by the wiper, and fed to pin 9 which is the other horizontal deflection plate of the crt.

#### 65. Synchroscope Intensifier

(figs. 39 and 60)

a. In the synchroscope function of the analyzer, intensification of the trace is accomplished in a manner quite different from that employed in the spectrum



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Figure 38. Triggered sweep generator, simplified schematic diagram.

analysis function (para. 59). The differentiated square wave output of V14 (para. 63c) consists of a positive pulse followed by a negative pulse which is applied through contacts 3 and 4 and the wiper of the F section of S2 to the grid of V9, the spectrum amplifier. In the TRIG SWP. (synchroscope) position of 82, V9 is connected as a triode amplifier; the plate, pin 5, and the screen, pin 6, are tied together through the switch. The negative supply which normally biases the grid through R36 is shunted to ground through R135. The tube having no cathode resistor runs heavily. During the positive portion of the input signal, the grid attempts to swing positive. Grid current flows through R36, developing a drop across it of a polarity that will oppose the positive input voltage. Since the resistance of R36 is very large compared with the grid-to-cathode resistance of the circuit when grid current flows, the voltage on the grid is limited to near that of the cathode. During the negative half-cycle, however, no grid current flows and the negative pip causes a large positive pulse to appear across load resistor R37.

b. The large positive pulse developed at the plate of V9 is coupled through the re filter, C42 and R38, and coupling capacitor C43 to grid resistor R91 of V15B. The voltage developed across the resistor is applied to the grid. The input pulse is amplified and appears as a large negative pulse across plate resistor R89; this occurs during the retrace time of the sweep. The

blanking pulse is then coupled through capacitor C82 to the grid, pin 2, of the crt. The effect of this blanking pulse is to cut off the crt during the retrace time and thus prevent the retrace line from appearing. This blanking of the retrace is to intensify the trace resistor. R90 is the unbypassed cathode biasing resistor.

## 66. Power Supplies

Three regulated power supplies arranged in cascade are incorporated in the analyzer to furnish the necessary operating voltages. The -87-volt supply determines the overall regulation in the +300-volt and the +135-volt supplies by providing them with a reference voltage.

a. *Regulated +135-volt Supply* (figs. 40 and 60). The regulated +135-volt power supply consists of full-wave rectifier tube V17, series regulator tube V21, de amplifier tube V22, voltage regulator tube V26, and the circuit elements associated with these tubes. The power supply is regulated electronically to keep the de output constant with changes in input voltage or load current. It furnishes a regulated +135 volts for operation of the spectrum analyzer.

- (1) When POWER switch S1 is placed in the ON position, power is applied to the primary of transformer T1 through fuses F1 and F2 (fig. 60). The primary input voltage is stepped up to 550 volts

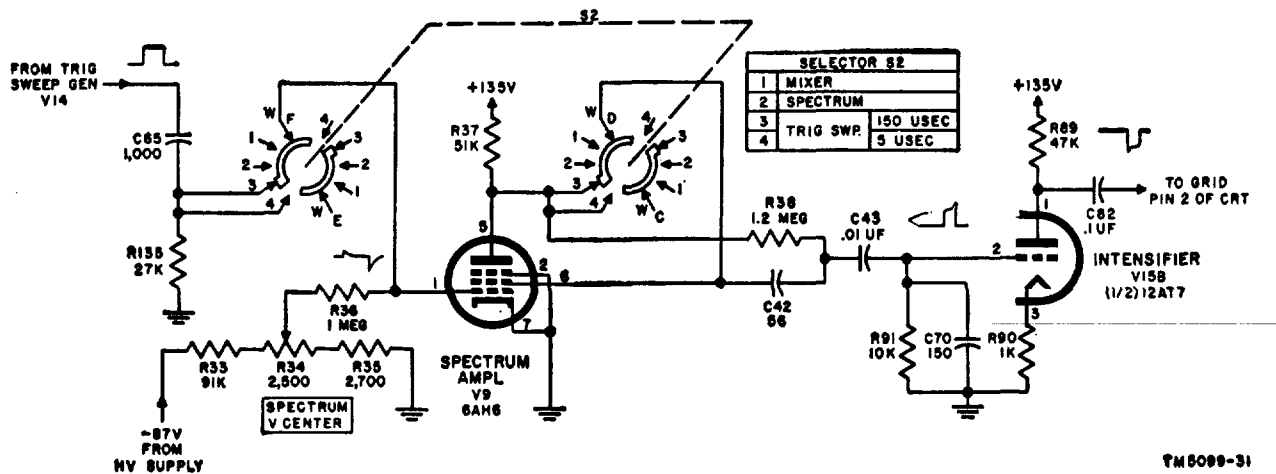


Figure 39. Synchroscope intensifier circuit, simplified schematic diagram.

ac, center-tapped. Half of this voltage is applied to each plate of full-wave rectifier V17 on alternate cycles. A secondary winding supplies 5 volts ac to the filaments of the rectifier. A third winding supplies 6 volts ac to the filaments of the remaining tubes of the regulated +135-volt supply. The 550-volt output of the transformer secondary is rectified by V17 and a pulsating dc appears at the common filament. The rectified voltage is applied to a pi-type filter network, consisting of capacitors C74 and C75 and choke L38. The filter network reduces the ripple content in the pulsating dc output of the rectifier. The output of the rectifier is applied to the regulator circuit.

- (2) The regulator action is described as follows: Assume that the line voltage increases or that load current decreases. In either case, the output voltage would tend to increase. This makes the grid of de amplifier V22 (pentode type 6AU6) more positive with respect to ground because grid resistors R106 and R107 and voltage regulator V26 are part of the bleeder network. Resistors R104 and R105 are also part of this network. Capacitor C76, across R104, R105, and R106, bypasses all instantaneous changes. The cathode of the de amplifier is grounded and the grid is connected to the -87-volt supply through R106, the voltage adjust potentiometer, 52 and

R107. This places the grid at a negative potential with respect to the cathode. Plate voltage is applied to the plate of the dc amplifier through resistor R99. When the grid goes positive, plate voltage decreases. This decreasing positive voltage is applied to the grid of voltage control amplifier V21 through resistors R97 and R103; the tubes draw less current and the output cathode voltage decreases. This decreasing cathode voltage overcomes the increase caused by the line voltage increase, and the output voltage remains constant. If the line voltage decreases or the circuit load increases, the plate voltage of V22 will increase. The voltage applied to the grids of the series regulator will increase in a positive direction. The tube draws more current, causing the cathode voltage to increase. This overcomes the decrease caused by a line voltage decrease so that the output voltage remains constant.

- (3) Other components of the circuit include plate parasitic suppressors R100 and R101, grid suppressors R97 and R103, and cathode suppressors R98 and R102.

*b. Regulated +300-volt Supply* (figs. 41 and 60)  
The +300-volt supply consists of full-wave rectifier V16, a type 6X4W vacuum tube, series regulators V18 and V19 (both type 6005), and dc amplifier V20, type 6AU6.

- (1) Rectification of the ac on the plates, pins 1 and 6, of V16 causes a pulsating dc

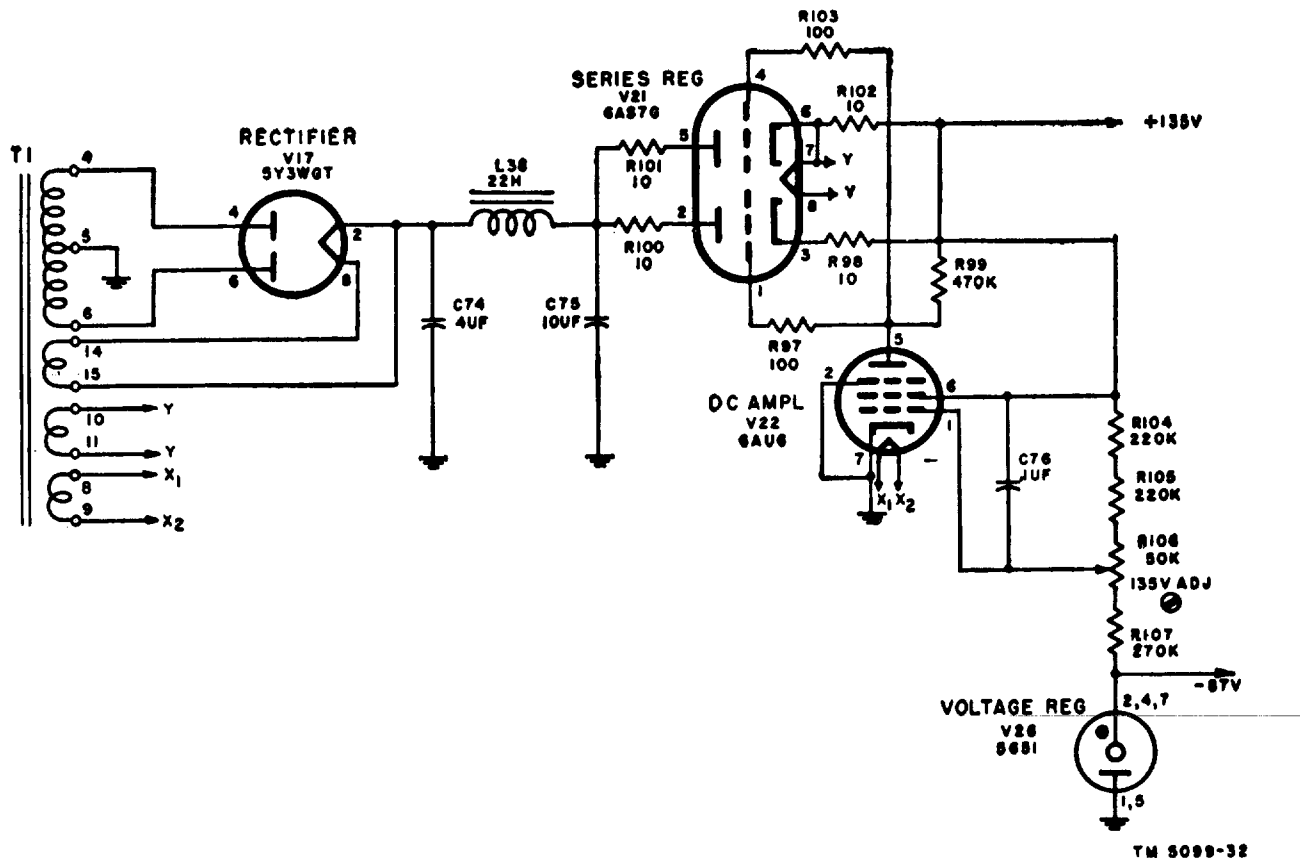


Figure 40. Regulated +165-volt supply, simplified schematic diagram.

voltage to appear on cathode. This is fed to a pi-filter network consisting of C71, L37, and C72. The filtered dc is fed to the plates, pins 5 of series regulators V18 and V19. These tubes are connected as triodes. A +300-volt output appears at the cathodes, pins 2 of these tubes. The output is regulated as follows: The control grids, pin 1 of the series regulators, are tied to the plate, pin 5 of the dc amplifier. The dc amplifier obtains bias from the bleeder across this supply consisting of resistors R93, R95, and R96 and 300-volt adjustment potentiometer R94. The grid is biased slightly negative with respect to cathode. The cathode, pin 7, is referenced to the +135 regulated power supply.

- (2) Variations in output voltage appearing across the bleeder are coupled into the grid, pin 1 of V20. Because the plate, pin 5, of this tube is connected to the control grids of the series regulators, the resistance represented by these tubes will

be varied to restore the voltage at the cathodes to the proper level. For a detailed analysis of voltage regulation, refer to a above.

- (3) The 300-volt adjustment potentiometer, R94, part of the voltage divider, is used to adjust the grid voltage of V20 and thereby sets the positive 300 volts at the cathode of V18. Resistor R92 is the plate load resistor for V20; capacitor C73 is used to couple the fast changes in the +300 volts to the grid.

c. *High-Voltage Supply* (figs. 42 and 60). The negative high-voltage supply is a conventional halfwave rectifier circuit employing a type 2X2A tube, V23, and three type 5651 voltage regulator tubes, V24, V25, and V26.

- (1) The rectified voltage at the plate of V23 is filtered by a pi-type filter made up of C78, L39, and C79. The 60-cycle sync signal used to synchronize the sweep repetition rate of the sweep generator with the

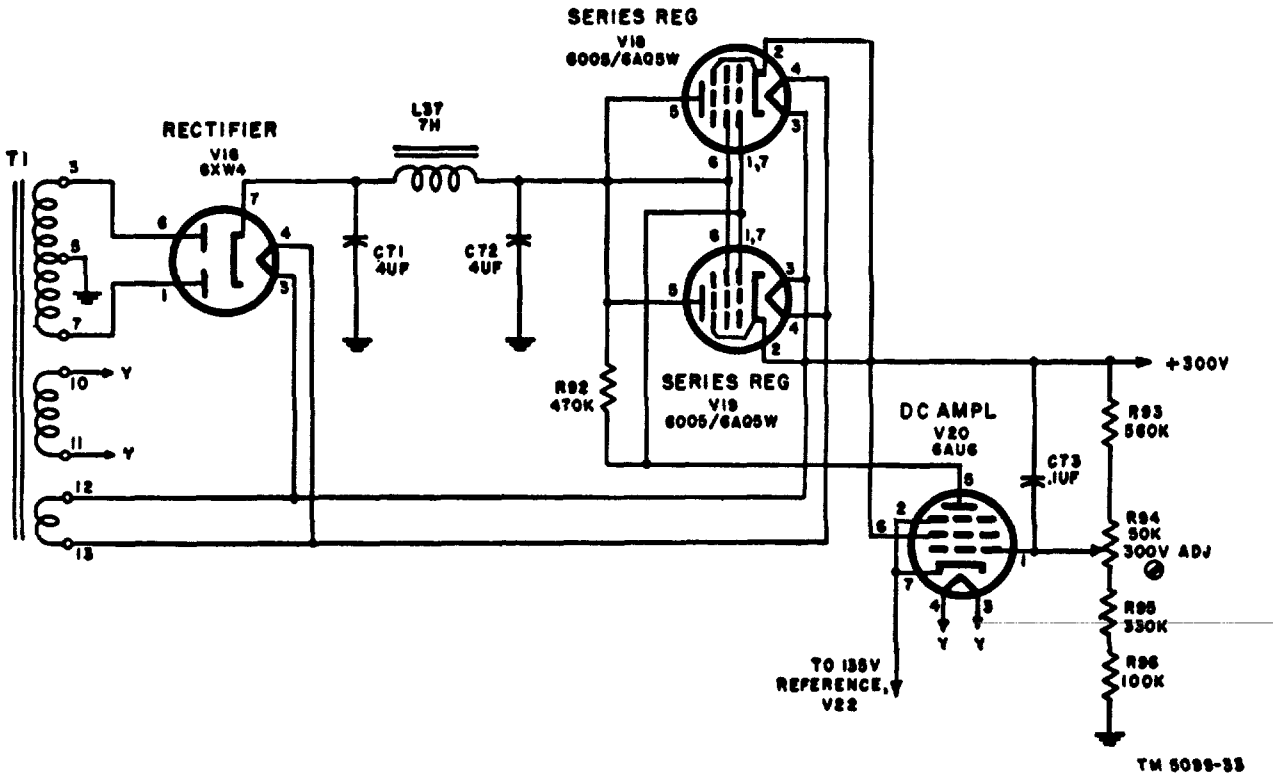
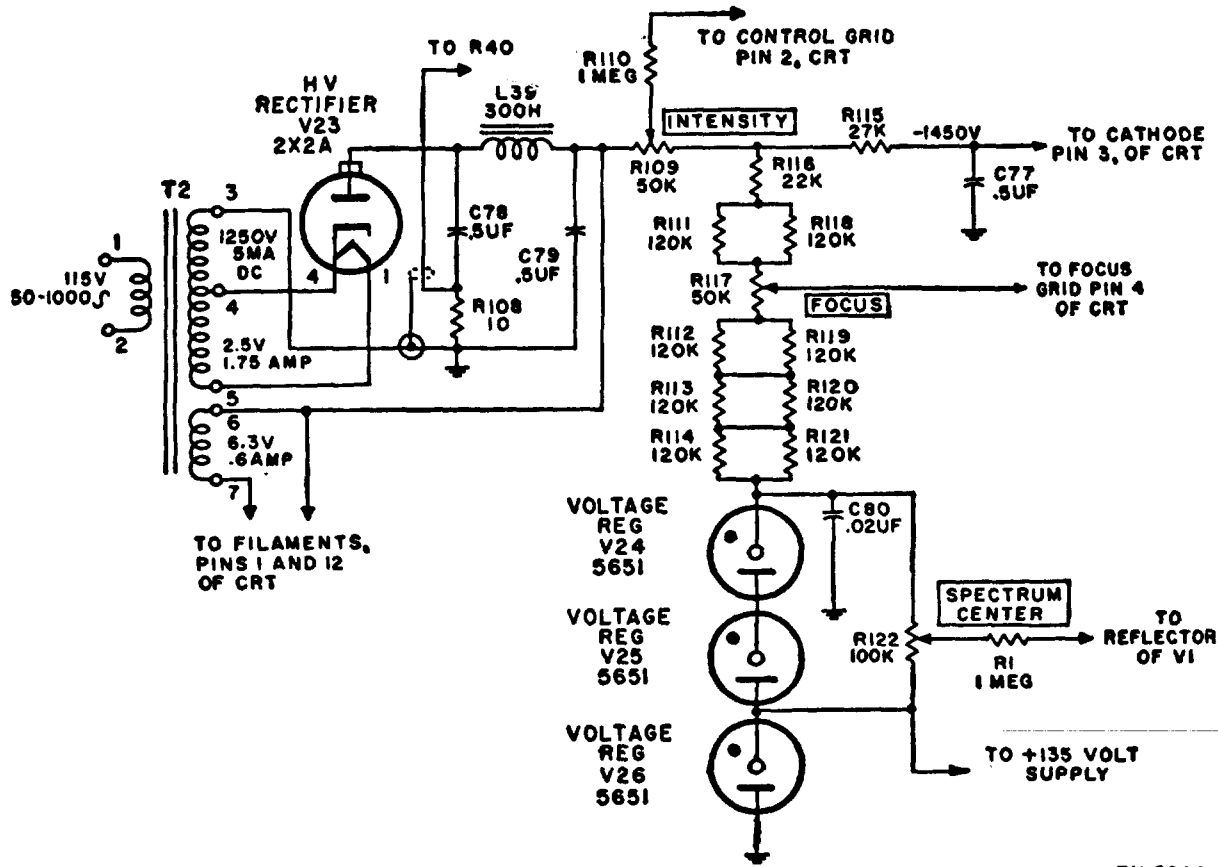


Figure 41. Regulated +0-volt supply, simplified schematic diagram.

line frequency (para. 56d) is developed across resistor R108. A bleeder network consisting of resistors R109 through R121 in series with voltage regulating tubes V24 through V26 is connected across the output.

- (2) INTENSITY control R109 permits adjustment of the control grid voltage of the crt for intensifying the trace. FOCUS control R117, a part of the voltage divider,

provides voltages to the focusing grid of the crt for focusing the electron beam. The crt cathode voltage is filtered by R115 and C77. Potentiometer R122, designated SPECTRUM CENTER, is connected across voltage regulator tubes V24 and V25. This potentiometer provides a means of adjusting the reflector voltage of the klystron between -87 and -261 volts.



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Figure 42. High-voltage supply, simplified schematic diagram.



## CHAPTER 5 FIELD MAINTENANCE

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### Section I. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

#### **Warning:**

**High voltages (1,600 volts) are used in the operation of this equipment. Death on contact may result if operating personnel fail to observe safety precautions.**

#### **67. Troubleshooting Procedures**

*a. General.* The first step in servicing a defective spectrum analyzer is to sectionalize the fault. Sectionalization means tracing the fault to the major component or circuit responsible for abnormal operation. The second step is to localize the fault. Localization means tracing the fault to the defective part responsible for the abnormal condition. Some faults, such as burned-out resistors, arcing, and shorted transformers, often can be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking voltages and resistances.

*b. Component Sectionalization and Localization.* Listed below is a group of tests arranged to simplify and reduce unnecessary work and aid in tracing a trouble to a specific component. The simple tests are used first. Those that follow are more complex. Follow the procedures in the sequence given. In general, the trouble is traced to a section of the analyzer, and the faulty component in that section is located; then the trouble is remedied. The service procedure is summarized as follows:

- (1) *Visual inspection.* Through visual inspection (para. 35) alone, the repairman frequently may discover the trouble or determine the circuit in which the trouble exists. This inspection is valuable in avoiding additional damage to the analyzer which might occur through improper servicing methods and in forestalling future failures.
- (2) *Operational tests.* The operational test (para. 37) is important because it frequently indicates the general location of trouble. In many instances, the

information gained will determine the exact nature of the fault. To use this information fully, all symptoms must be interpreted in relation to one another.

- (3) *Troubleshooting chart.* The trouble symptoms listed in this chart (para. 72) will aid greatly in localizing trouble if visual and operational tests fail to localize the trouble.
- (4) *Signal substitution* and stage gain data. Signal substitution generally is not used for troubleshooting in an item of test equipment. However, if the proper signal generators are available, it is possible to use signal substitution to an advantage in some cases. Often equipment, though operative, may not perform at peak level. To measure the efficiency of the RF amplifier, all outside variable factors must be eliminated except the efficiency of the section under test. External signals may not exist in a particular range, their strength may vary, or the strength of one signal may vary over a period of time: The siting and orientation of the equipment are other variable factors. Consequently, the most certain method of localizing trouble and particularly of measuring circuit efficiency is signal substitution. This method is discussed in detail in paragraph 74.
- (5) *Intermittents.* In all these tests, the possibility of intermittent conditions should not be overlooked. If present, this type of trouble often may be made to appear by tapping or jarring the equipment. It is possible that some external connection may cause the trouble. Test wiring for loose connections by moving wires and components with an insulated tool such as a fiber rod. This may show where a faulty connection or component is located.

## 68. Troubleshooting Data

### Caution:

**Always check the circuit label, since the schematic diagram in the manual may not include circuit changes made during equipment production.**

Fig. or para. No.	Title
Fig. 43	Tube location diagram.
Fig. 44	Spectrum Analyzer TS-742/UPM, chassis controls.
Fig. 45	Spectrum Analyzer TS-742/UPM, top view
Fig. 46	Spectrum Analyzer TS-742/UPM, bottom view.
Fig. 47	Spectrum Analyzer TS-742/UPM, side view.
Fig. 48	IF amplifier AR1, top view.
Fig. 49	IF amplifier AR1, bottom view.
Fig. 50	Spectrum Analyzer TS-742/UPM, RF plumbing assembly, location of parts.
Fig. 51	Voltage and resistance diagram, main chassis.
Fig. 52	Voltage and resistance diagram, indicator chassis.
Fig. 53	Voltage and resistance diagram, IF amplifier.
Fig. 54	Voltage and resistance diagram, terminal boards.
Fig. 55	MIL-STD resistor color codes.
Fig. 56	MI-STD capacitor color codes.
Fig. 57	Wave form chart, main chassis.
Fig. 58	Wave form chart, indicator chassis, spectrum analysis position.
Fig. 59	Wave form chart, indicator chassis, synchroscope position.
Fig. 60	Spectrum Analyzer TS-742/UPM, schematic diagram.
Fig. 61	Spectrum Analyzer TS-742/U, B+ distribution diagram.
Fig. 62	Spectrum Analyzer TS-742/U, wiring diagram (bottom).
Fig. 63	Spectrum Analyzer TS-742/U, wiring diagram (sides).
Para. 73	Dc resistance of transformers and coils.

## 69. Test Equipment Required for Troubleshooting

The items of test equipment required for troubleshooting Spectrum Analyzer TS-742/UPM are listed below. Technical manuals associated with each item also are listed.

Test equipment	Technical manual
Multimeter TS352/U	TM 11-5527
Signal Generator TS-497A/URR	TM 11-5030
Crystal Rectifier Test Set TS-268/U	TM 11-1242
Oscilloscope AN/USM-24	TM 11-5103
Radar Test Set AN/URM-60	

## 70. General Precautions

Observe the following precautions carefully whenever servicing the spectrum analyzer:

- a. Be careful when the analyzer is removed from the dust cover; dangerous voltages are exposed.
- b. If the analyzer has been operating for some time, use a cloth when removing the metal tube shields and a tube puller to remove the tubes to prevent burning the hand or fingers.
- c. Handle the crt carefully. Because of its high vacuum and the large surface area of its face, it may break with enough force to endanger nearby personnel.
- d. Avoid disturbing any of the fixed adjustments of the calibrated assemblies.
- e. When removing or replacing a crystal, be careful to avoid burn-out caused by static discharges. Such discharges may be caused by accumulated static charges on the operator or on the equipment. Ground the equipment chassis. Be careful to avoid mechanical strain on the body or contacts.
- f. Avoid bumping or straining the plumbing assembly.
- g. Do not overtighten screws when assembling mechanical couplings.
- h. When changing a component that is held by screws, always replace the lockwashers.
- i. Do not disturb any of the alinement adjustments unless it definitely has been determined that the trouble is caused by an adjustment.

## 71. Checking B+ Circuits for Shorts

a. *General.* If the B+ is low for any position of the function selector switch or if there is no B+ voltage, the trouble may be in the power supply circuits. This may be due to a faulty rectifier, a series regulator, a dc amplifier tube, an open filter choke, or a shorted filter capacitor. When the defect that causes an abnormal B+ voltage is in some other circuit, it probably will show up only in one position of function selector switch S2. The methods to be used for checking the circuits will be outlined in b through d. Refer to figure 60, the overall schematic diagram. By using this diagram in conjunction with the voltage and resistance measurements found in figures 51 through 54, the typical causes for trouble can be checked easily.

b. *Sectionalizing B+ Shorts.* A trouble in any circuit will be noticed when following the operating procedures in paragraphs 14 through 26. These troubles will be indicated in the equipment performance checklist (para. 37). Normally, using this procedure will narrow down the location to a section of the spectrum analyzer or perhaps even to one particular stage. Sometimes, if the B+ circuit is shorted in the decoupling network of one stage, it may drop voltage so that several stages are affected. Most of the checking can be accomplished from the bottom and side of the chassis; however, to check the IF strip B+, the IF subchassis must be removed (para. 77).

c. *Regulated +135-volt Supply.* The regulated B+ voltage for the IF section leaves the cathodes, pins 3 and 6, of series regulator V21 at the high end of the bleeder and appears at pin H of receptacle J4. Pin H of mating plug P4 carries the voltage into the IF strip. This voltage is also fed to pins 1 and 2 of the D section of function selector switch S2, the wiper of which is connected to the screen grid, pin 6, of spectrum amplifier V9.

d. *Regulated +300-volt Supply.* The regulated B+

voltage for the klystron local oscillator, the sweep, and the blanking-intensifier and mixer amplifier stages leaves the cathodes, pins 2, of series regulators V18 and V19 at the high end of the voltage divider and goes directly to the interaction grids, pin 1, of the klystron. It also supplies mixer amplifier V27, blanking-intensifier V15, and spectrum amplifier V9., Function selector switch S2 distributes the 300 volts to the analyzer sweep section in positions 1 and 2 and to the synchroscope triggered sweep section in positions 3 and 4.

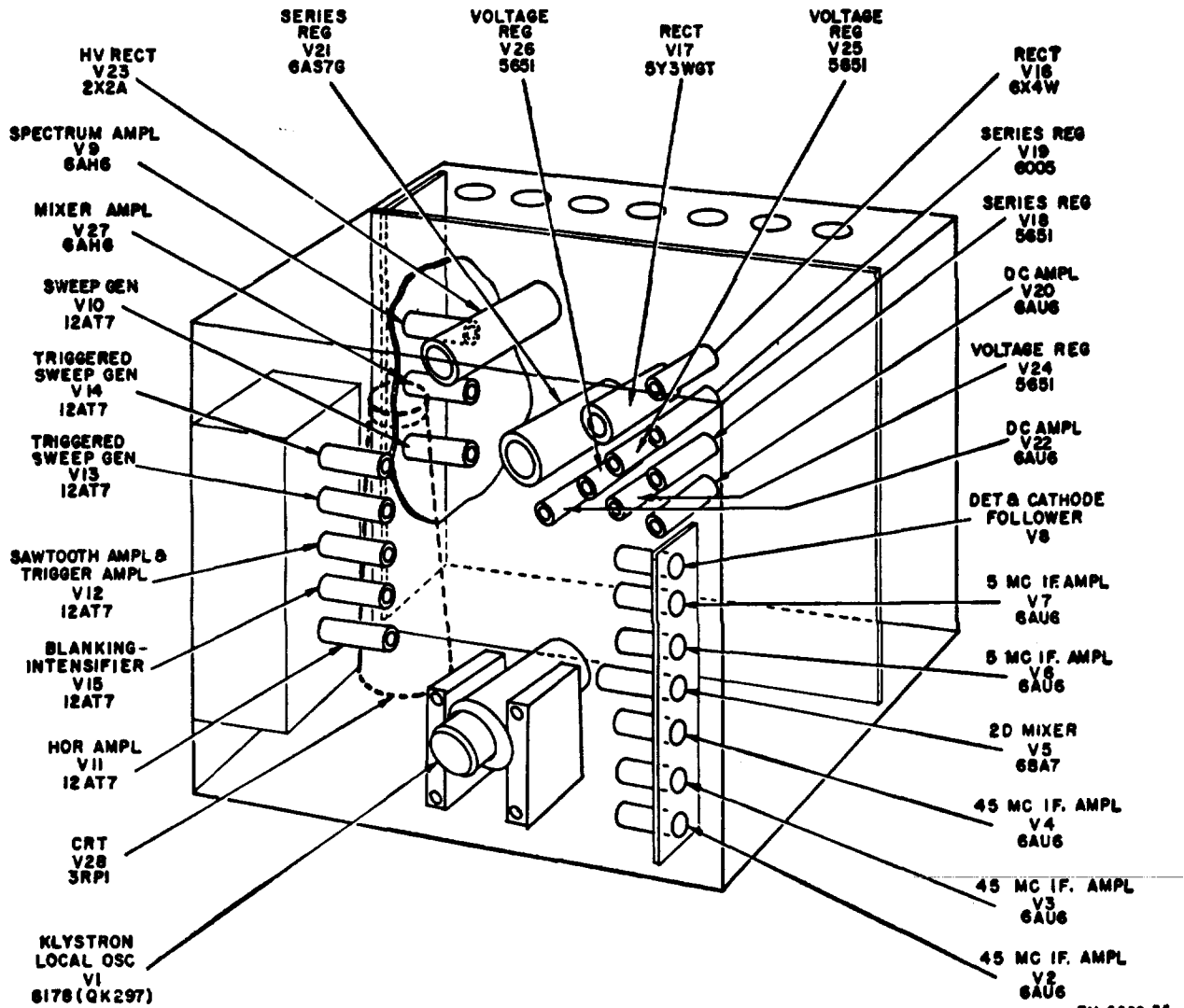
## 72. Troubleshooting Chart

The following chart is supplied as an aid in locating trouble in the analyzer. It lists the symptoms which the repairman observes while making a few simple tests. The chart also indicates how to localize trouble quickly to the klystron oscillator, the IF amplifier, the sweep circuits, or the power supply. After the trouble has been localized to a stage or circuit, a tube check and voltage and resistance measurements of this stage or circuit ordinarily should be sufficient to isolate the defective parts. Normal voltage and resistance readings are given in figures 51 through 54.

Item	Symptom	Probable trouble	Correction
1	Power cord connected to power source and POWER switch in ON position. Instrument dead; no voltage.	Defective power cord or plugs. Defective receptacle J7.	Replace defective component.
2	Instrument dead. Voltage at fuse test points normal.	Blown fuses F1 and F2. Open POWER switch.	Replace fuses with SPARES. If replaced fuse blows, refer to paragraph 71. Replace switch.
3	Indicating lamps do not light.	Defective lamp I 1, I 2, or I 3.	Replace defective lamp.
4	No indication on crt in any position of function selector switch S2.	Defective rectifier tube V23 or high-voltage supply components. Defective crt.	Make voltage and resistance checks Replace defective component  <b>Caution: If voltage regulator tube V24, V25, or V26 is not lighted, turn equipment off and remove socket from klystron tube before proceeding with trouble shooting. Failure to take this precaution may result in burning out the klystron.</b>
5	No mode pattern obtainable with function selector switch in MIXER position but trace appears on crt. Spectrum and cw displays obtainable in SPECTRUM position, but no frequency markers appear.	Filter capacitors C3, C4, C5, C6, C47 shorted to ground.	Replace defective component.

Item	Symptom	Probable trouble	Correction
6	No sweep in MIXER position. Spectrum and cw displays obtainable in SPECTRUM position but no frequency markers. MIXER V CENTER control appears inoperative.	Defective mixer amplifier tube V21 or circuit components. Replace defective	Check tube and replace if defective. Make voltage and resistance checks. component.
7	No mode curve when in MIXER position and no spectrum when in SPECTRUM position. However, there is a horizontal sweep in these positions (vertical position of sweep in MIXER position will vary with setting of MIXER AMPLIFIER control). No sweep when in TRIG SWP. positions.	Defective sawtooth and trigger amplifier tube V12 or circuit components.	Replace defective tube or components.
8	No mode curve when in MIXER position. No spectrum when in SPECTRUM position. However, there is a horizontal sweep in this position. Normal operation in TRIG SWP. positions. klystron socket. If these voltages are abnormal, check the power supplies. Replace klystron if defective (paras. 81 and 82).	Defective cableW1, defective crystal CR1, defective klystron V1, or defective test jack J8.	Check cable for continuity. Replace if defective. Check crystal in crystal checker. Replace if defective. Check klystron cathode return at test jack J8. If there is no current, check the voltages at the
9	No spectrum obtainable when in SPECTRUM position, however markers are present. Normal operation in MIXER and TRIG SWP. positions.	Failure of IF strip B + supply or if strip faulty.	Remove analyzer from case, disconnect P4 and J4, and take a voltage reading at pin H of J4. If no voltage is obtainable, check +135-volt supply. Signal trace through strip. Replace faulty component.
10	No base line when in SPECTRUM position, SPECTRUM V CENTER control appears inoperative. Normal operation in MIXER position. Higher setting of INTENSITY control required to produce signal in TRIG SWP. position.	Defective spectrum amplifier tube V9 or circuit components.	Check V9. Make voltage and resistance measurements. Replace faulty component or tube.
11	No horizontal trace obtainable when in MIXER and SPECTRUM positions. However, sharply focused spot is seen on crt screen. Operation normal when in TRIG SWP. positions.	Defective sweep generator tube V10 or circuit components.	Replace tube or defective components.
12	Vertical sweep in MIXER position. Spot with vertical signal deflection in SPECTRUM position. Normal operation in TRIG SWP. positions.	Defective horizontal amplifier tube V11 or its circuit components.	Replace VII or defective components.
13	Display will not sync when in MIXER and SPECTRUM positions.	SYNC control R40 or resistor R108 defective.	Replace defective component.
14	Normal operation in MIXER and SPECTRUM positions. No horizontal trace appears on crt in TRIG SWP. position with positive trigger input on J5.	Defective tube V13 or V14 or circuit components.	Replace defective tube or components.

Item	Symptom	Probable trouble	Correction
15	TRIG SWP. V CENTER control is inoperative but no vertical deflection can be obtained in TRIG SWP. positions.	Defective cable W4. Defective capacitor C85.	Replace cable or defective capacitors.
16	Retrace lines are visible in all positions of function selector switch.	Defective tube V15 or circuit components.	Replace defective tube or components.



TM 5099-35

Figure 43. Tube location diagram.

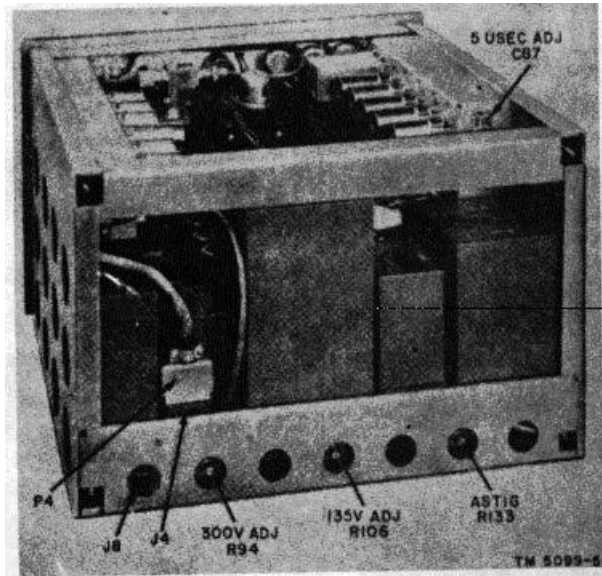


Figure 44. Spectrum Analyzer TS-742/UPM, chassis controls.

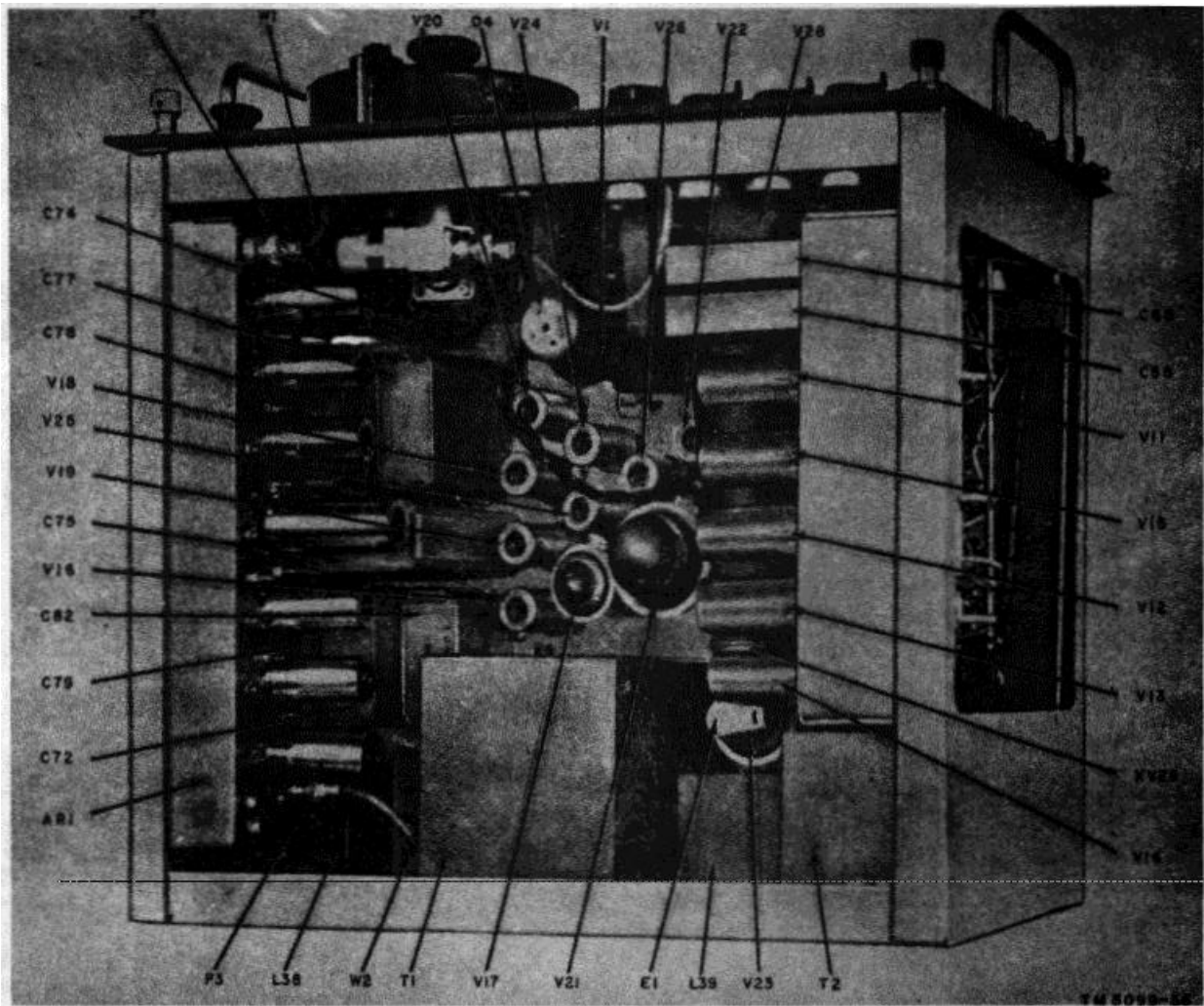


Figure 45. Spectrum Analyzer TS-742/UPM, top view.

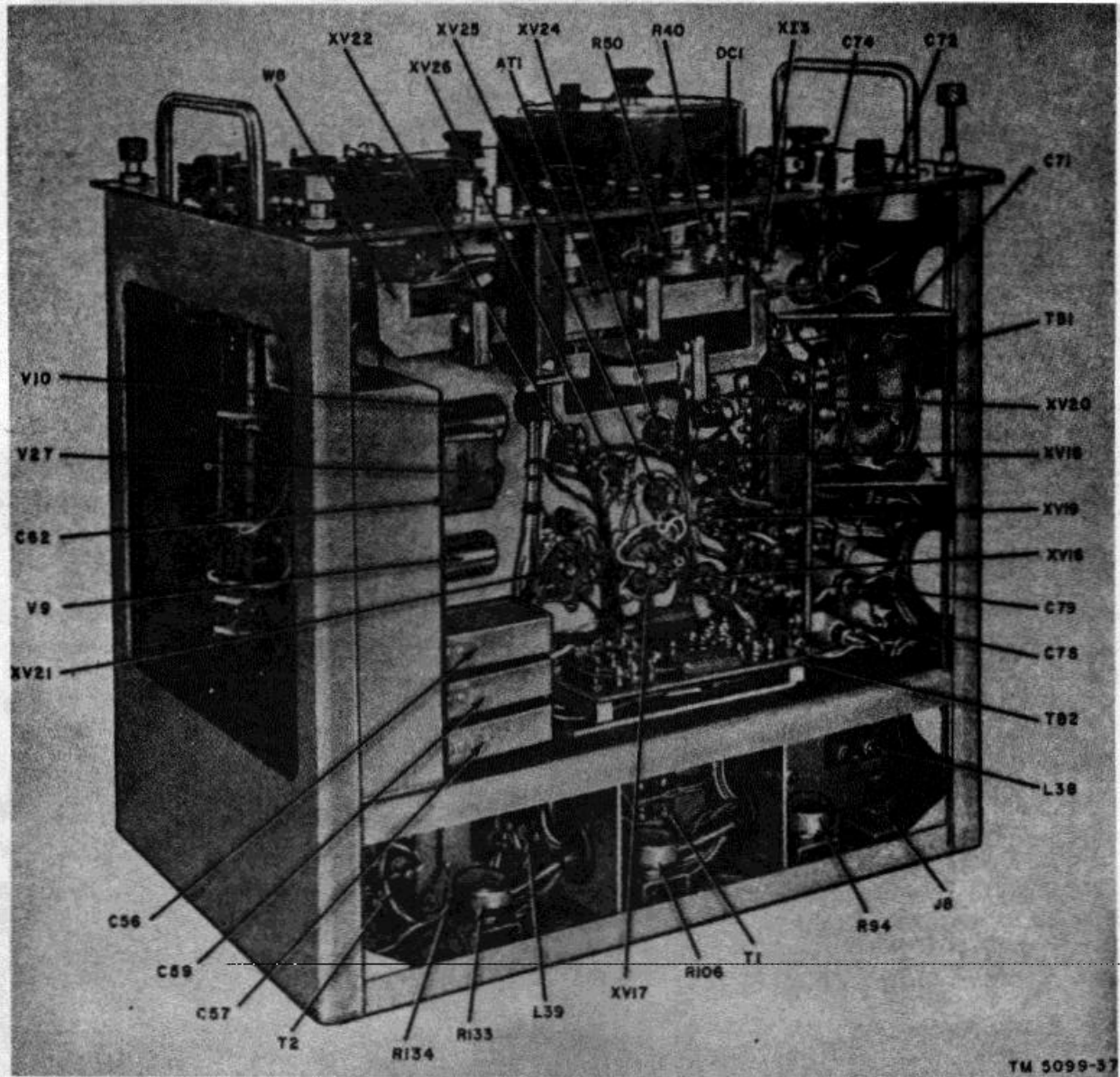


Figure 46. Spectrum Analyzer TS-742/UPM, bottom view.



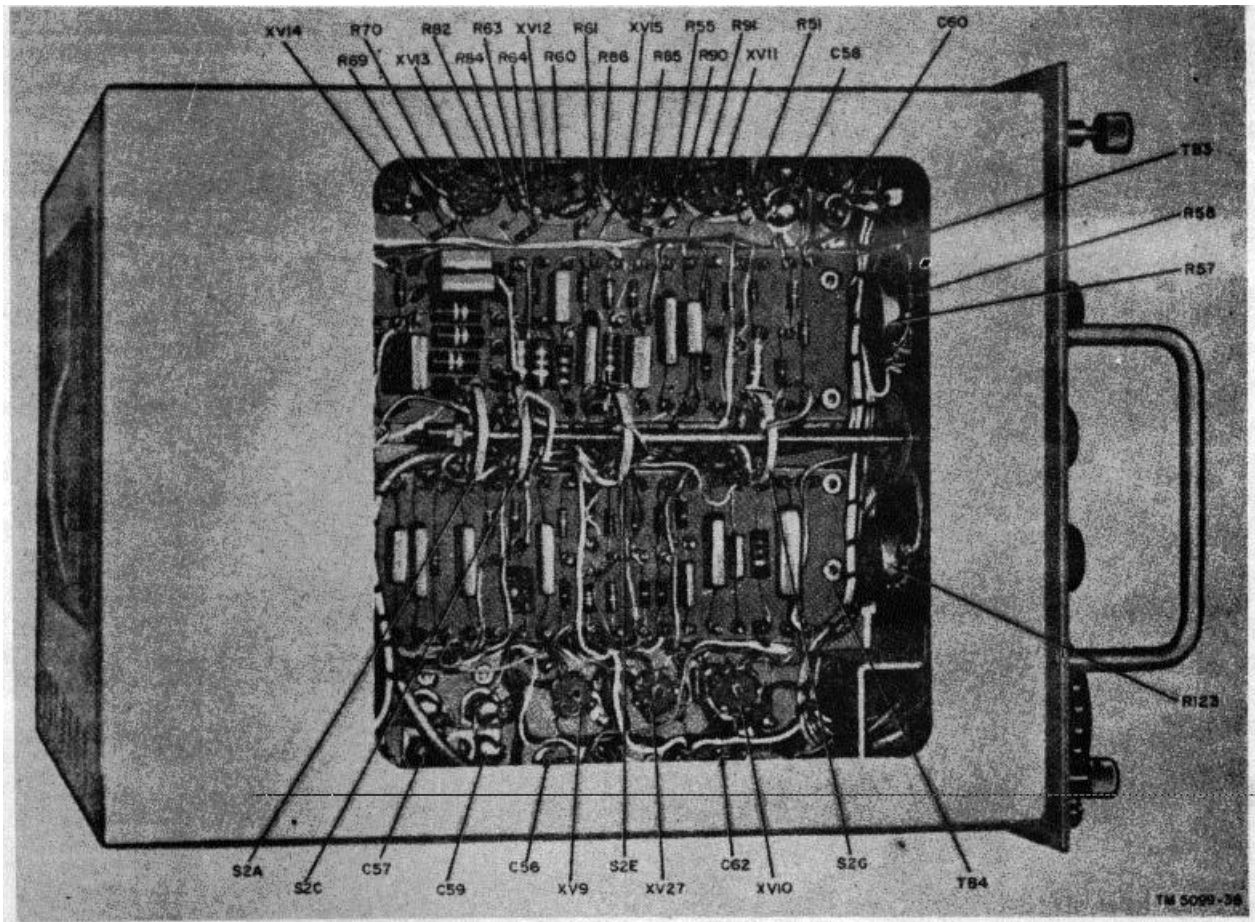


Figure 47. Spectrum Analyzer TS-742/UPM, side view.

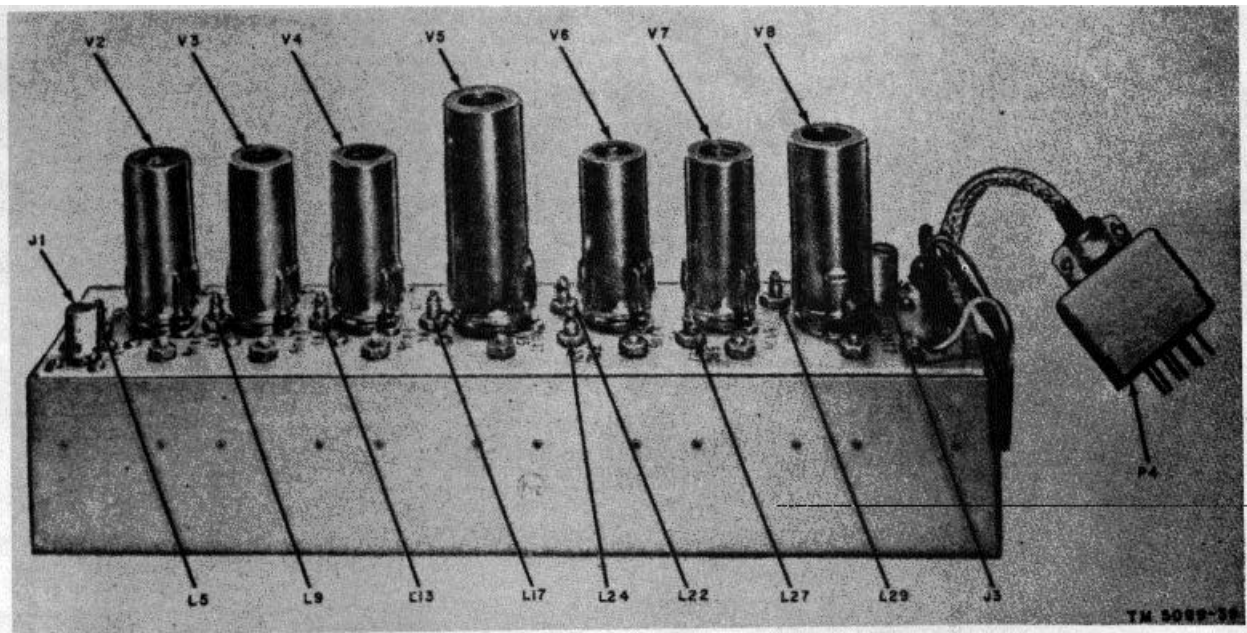


Figure 48. IF amplifier AR1, top view.



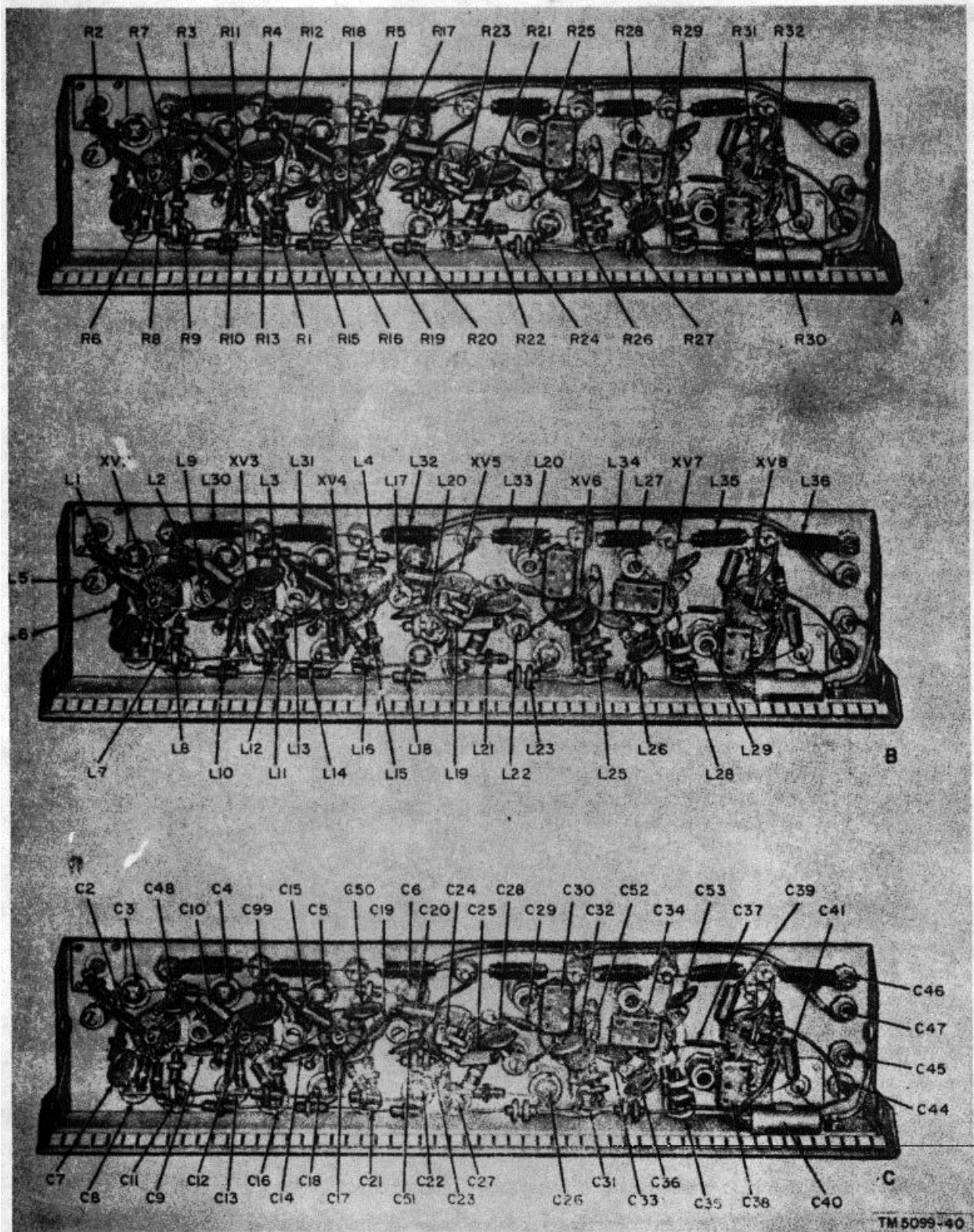


Figure 49. IF amplifier AR1, bottom view.

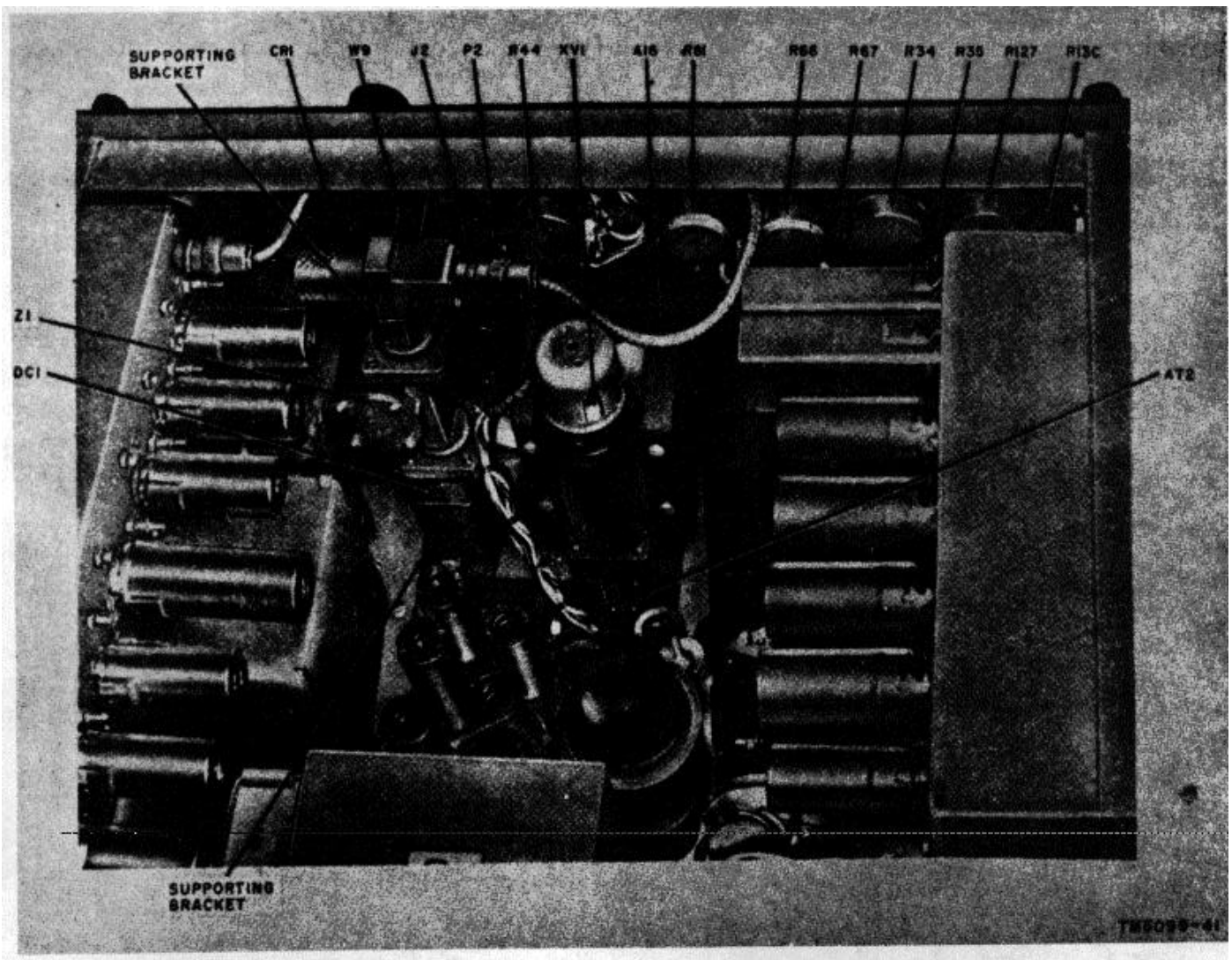
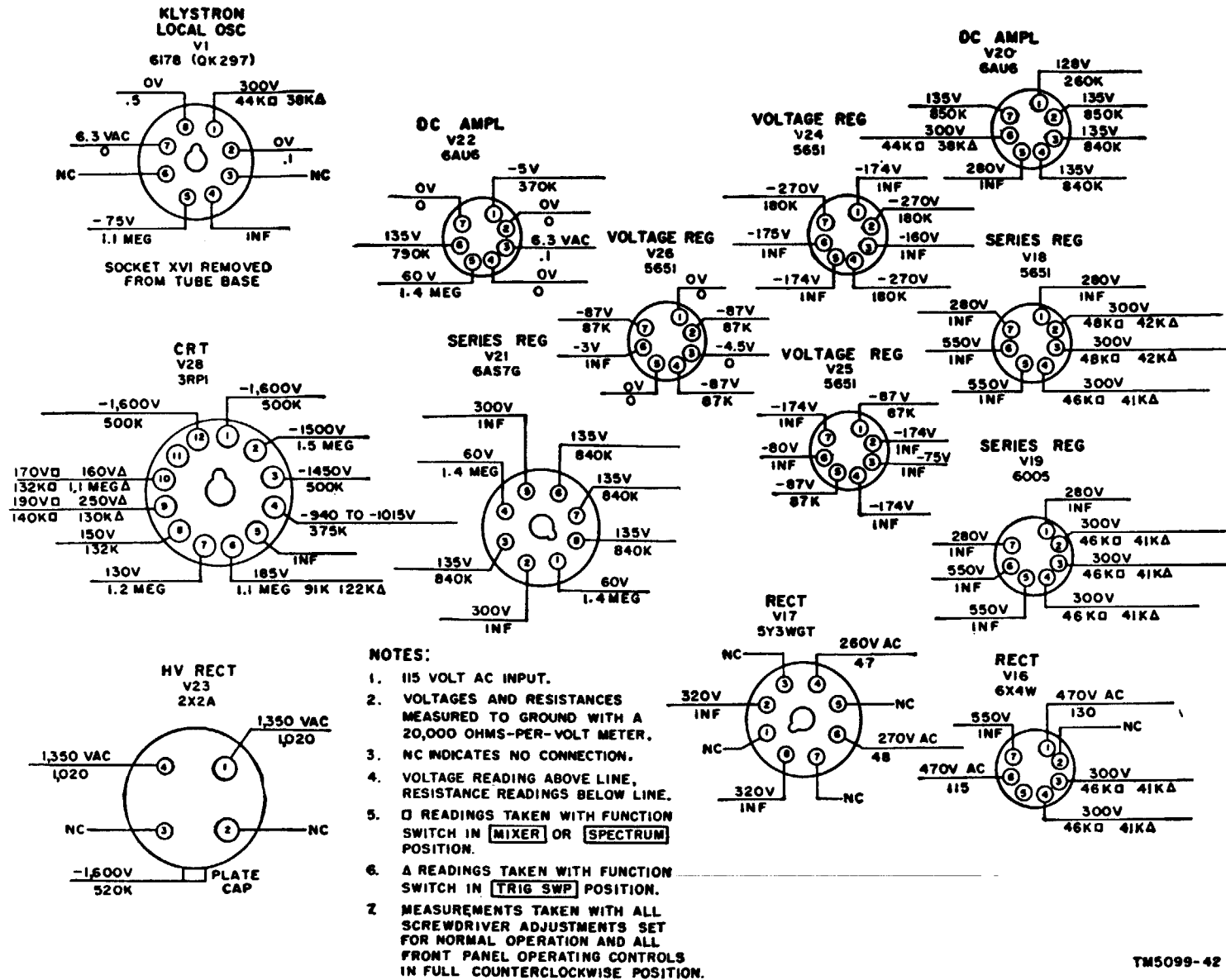


Figure 50. Spectrum Analyzer TS-742/UPM, RF plumbing assembly, location of parts.

TAGO 5709-A. June



TM5099-42

Figure 51. Voltage and resistance diagram, main chassis.

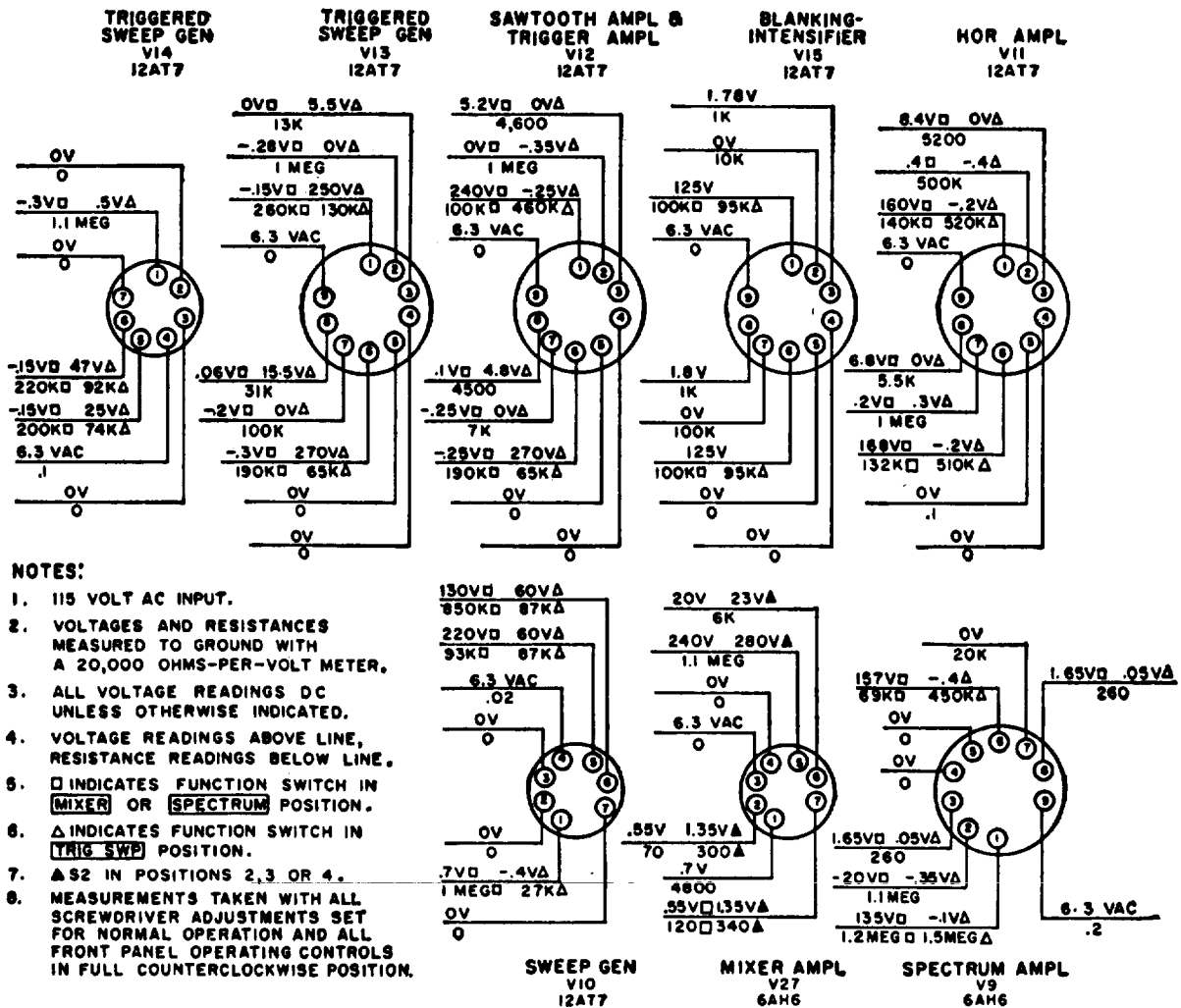
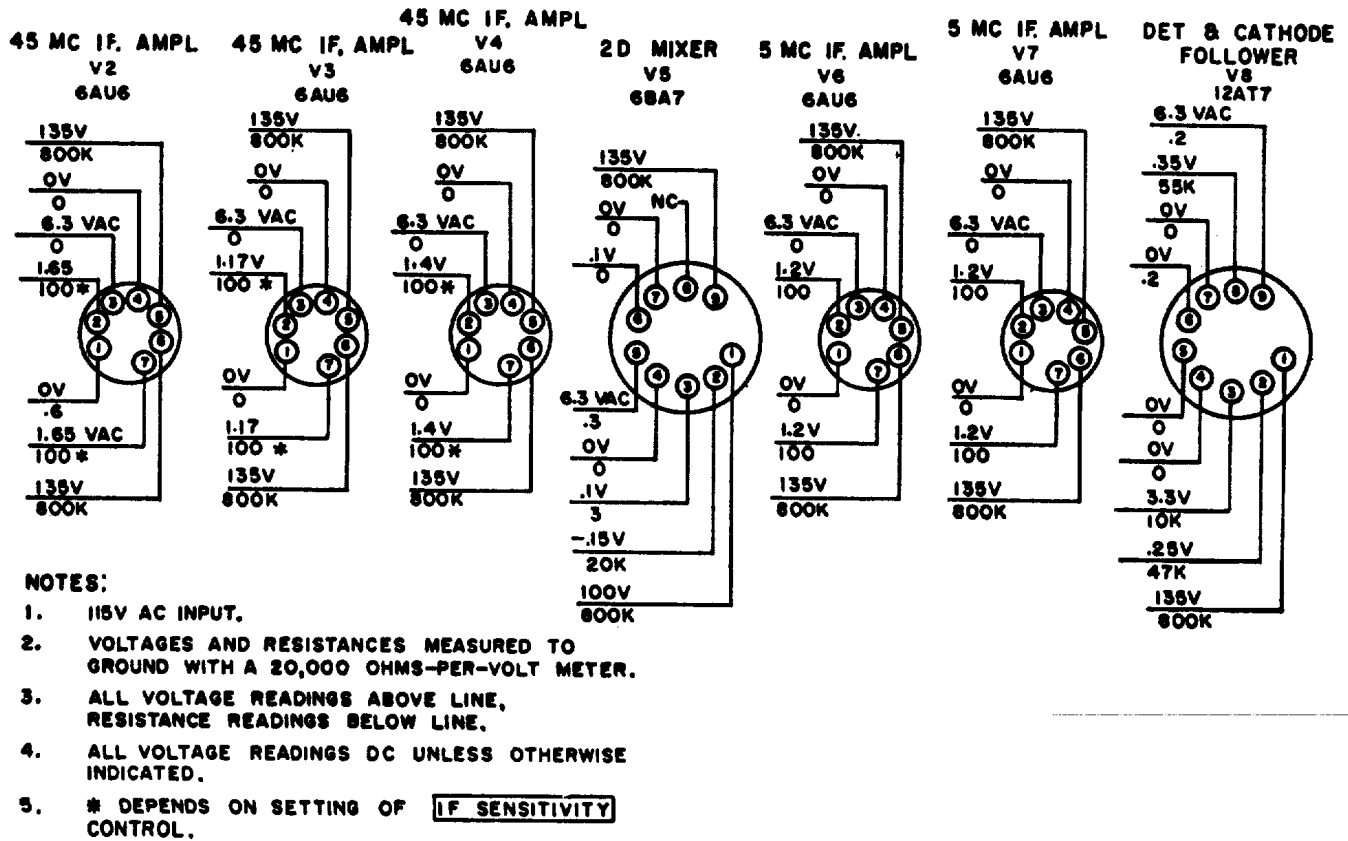


Figure 52. Voltage and resistance diagram, indicator chassis

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TM 5099-44

Figure 53. Voltage and resistance diagram, IF amplifier.

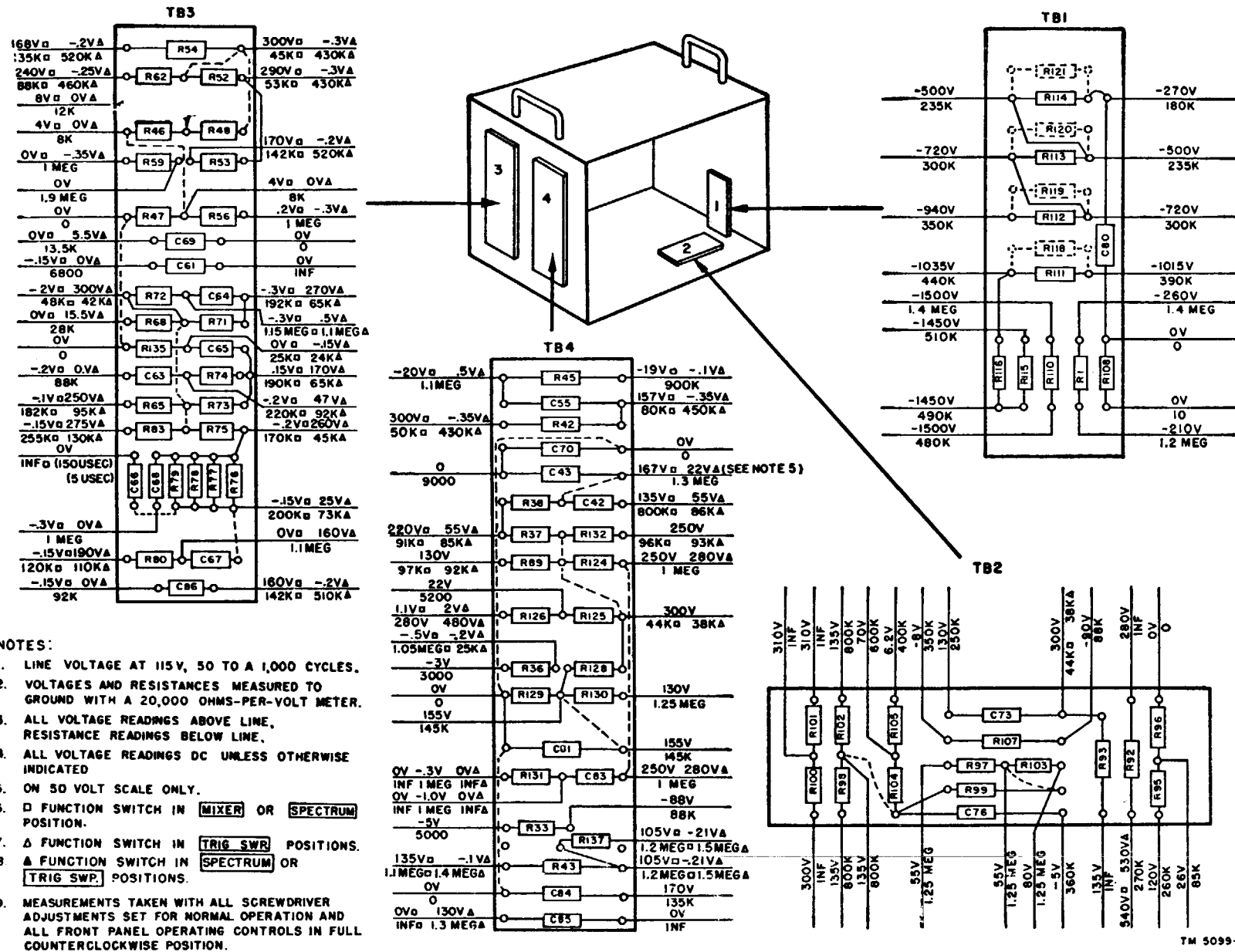
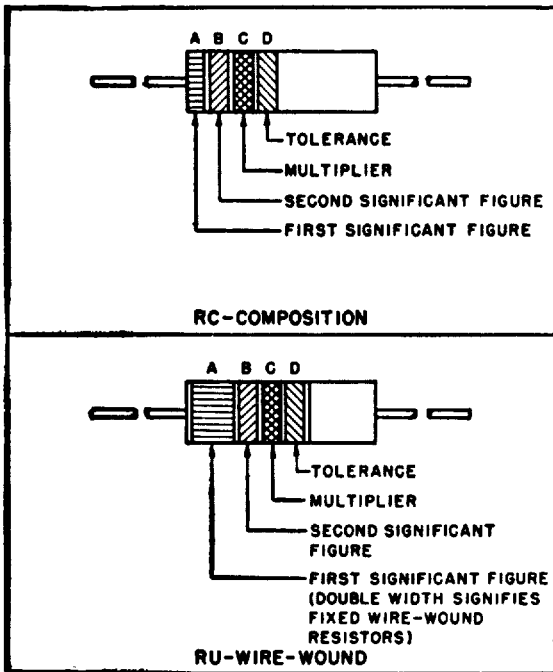


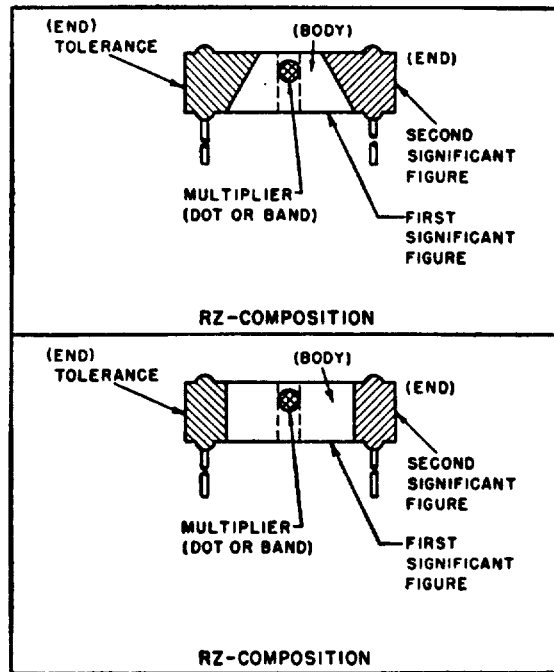
Figure 54. Voltage and resistance diagram, terminal boards.

**RESISTOR COLOR CODE MARKING  
(MIL-STD RESISTORS)**

**AXIAL-LEAD RESISTORS  
(INSULATED)**



**RADIAL-LEAD RESISTORS  
(UNINSULATED)**



**RESISTOR COLOR CODE**

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

\* FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

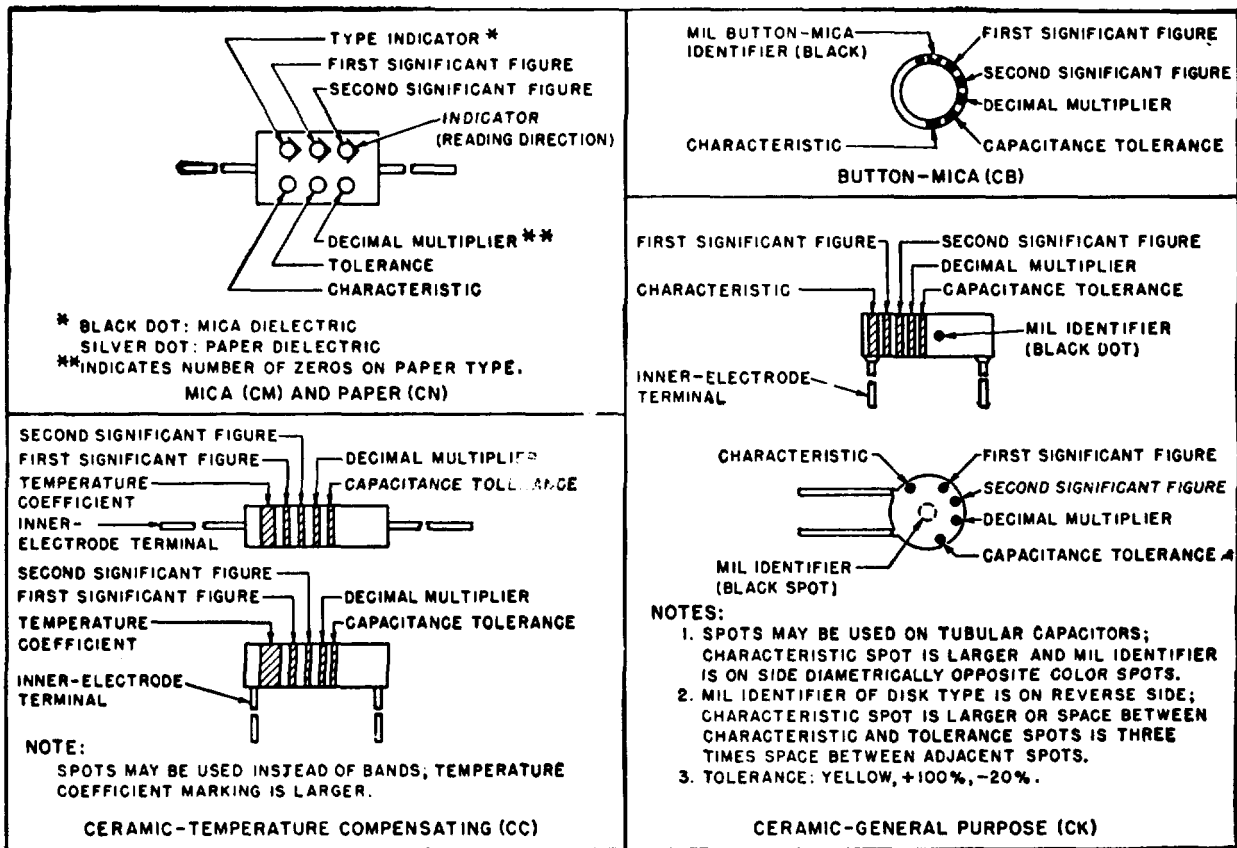
**EXAMPLES (BAND MARKING):**  
 10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.  
 4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

**EXAMPLES (BODY MARKING):**  
 10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.  
 3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END, RED DOT OR BAND; SILVER END.

STD-RI

Figure 55. MIL-STD resistor color codes.

## CAPACITOR COLOR CODE MARKING (MIL-STD CAPACITORS)



### CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC <sup>1</sup>				TOLERANCE <sup>2</sup>				TEMPERATURE COEFFICIENT (UUF/BF/°C)	
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF		10UUF OR LESS
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330 (±500) <sup>3</sup>
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.  
 2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.  
 3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

Figure 56. MIL-STD capacitor color codes.



### 73. Dc Resistances of Transformers and Coils

The dc resistances of transformers and coils in Spectrum Analyzer TS-742/UPM are listed below:

Transformer or coil	Terminals	Ohms
T1	1-2	2.4
	3-5	135
	5-7	135
	5-4	45
	5-6	45
	3-7	270
	8-9	.065
	10-11	.09
	12-13	.16
	14-15	.10
T2	1-2	8.1
	3-4	1,100
	4-5	.2
	3-5	1,100
	6-7	.3
L1, L2, L3, L4, L6, L7, L8, L10, L11, L12, L14, L15, L16, L18, and L21. L9, L13, L17 L19, L20, L23, L25, L26, L28. L22 L24, L27, L29 L30 through L36 L8,7 L88 L89		.75
		.005
		3.25
		.01
		.16
		.04
		200
		400
		5,500

### 74. Signal Substitution Notes

General notes on signal substitution and signal tracing are as follows:

a. A signal generator is required to develop a signal of proper voltage and frequency that is to be substituted in or traced through the equipment.

b. The wave form at the output of the circuit may be observed on a suitable oscilloscope. A vacuum-tube voltmeter (vtvm) is used to measure the voltage.

**Caution:**

**Do not remove shield cans or other shielding until the trouble has been traced to a particular unit. Do not, push wiring out of place. Pushing wiring back and forth may cause broken connections, change the frequency of an oscillator, or alter the characteristics of a circuit.**

c. When connecting a signal generator to the grid of a tube, be sure that the low-impedance output of the

signal generator does not short the grid voltage in the circuit under test. It is advisable to connect a capacitor in series with the output (high side) of the signal generator.

d. The output impedance of the signal generator must be matched to the input impedance of the circuit under test.

e. Once the signal is traced to a stage or circuit, disconnect the test equipment and make voltage and resistance measurements to locate the defective part.

### 75. Signal Substitution and Waveform Procedure and Data

a. *Testing IF Amplifiers by Signal Substitution.*

The reasons for using an external signal when servicing the equipment are included in paragraph 67b (4). The equipment used in connection with signal substitution is listed in paragraph 69. To gain access to the underchassis, follow instructions in paragraph 77.

- (1) Use Signal Generator TS-497A/URR. Set it for the correct IF frequency, modulated as indicated in the chart (*b* below). Set the amplitude of the test signal as indicated in the chart.
- (2) Connect the signal generator to the proper pin of the stage under observation. (Col. 2 of the chart.)
- (3) To observe the signal; use either the spectrum analyzer scope or an oscilloscope (par. 66).
- (4) Mark the signal amplitude on the scope screen for the final stage output signal (that is, first item of chart).
- (5) Apply the signal indicated in the chart for each stage; note the amplitude of the signal generator output signal required to bring the signal on the scope up to the level marked on the screen. This figure should correspond for each stage to the signal generator output listed in the chart.

b. *Stage Gain Data.*

Signal generator frequency (mc)	Signal generator output connection	signal generator output (microvolt)	deflection
5	Pin 1 of V7	45,000	.5
5	Pin 1 of V6	7,000	1
45	Pin 7 of V5	4,000	1
45	Pin 1 of V4	700	1
45	Pin 1 of V3	150	1
45	Pin 1 of V2	30	1

\*Modulated 30 percent by 400 cps.

c. *Wave Forms.* Figures 57 through 59 contain wave forms which should be obtained at various points in the analyzer with no RF input. These can be used to

locate troubles within a stage or circuit after a decision has been made as to where the trouble exists.

## Section II. REPAIRS

### 76. Replacement of Parts

#### Note

**Several electrical parts used in the spectrum analyzer have close tolerances. If these parts require replacement, use parts of the same tolerance as those removed. RF attenuator AT1 and frequency meter Z1 are calibrated assemblies which, if defective, must be replaced with calibrated units rather than be repaired.**

a. The majority of the components of Spectrum Analyzer TS-742/UPM are readily accessible and are replaced easily if found faulty. The sockets, capacitors, filter chokes, and inductors and transformers are mounted securely to the chassis with hexagonal nuts and binding head screws.

b. If any of the switch wafers require replacement, carefully mark the wires connected to the wafer with tags to avoid misconnection when the new switch is installed. Follow this practice whenever replacement requires the disconnection of numerous wires.

### 77. Removal of IF Strip

To remove the IF strip from the chassis, proceed as follows:

- a. Disconnect plug P4 from receptacle J4.
- b. Disconnect plug P1 from receptacle J1.
- c. Disconnect plug P3 from receptacle J3.
- d. Remove the No. 3/8-24 hexagonal nut and lockwasher that secure the captive bar to the front panel. Slip the captive out of the panel.
- e. Remove the four No. 6-32 flat-head screws that hold the IF strip to the main chassis.
- f. Slowly lift the IF strip from the main chassis; work it carefully so that it does not strike the plumbing assembly.

### 78. Removal of Calibrated RF Attenuator AT1

To remove the calibrated RF attenuator from the plumbing assembly, proceed as follows:

- a. Loosen the two setscrews on the attenuator knob. Remove the knob.

b. Remove the two No. 6-32 binding head screws on the front panel that holds the support bracket (fig. 46) to the rear of the panel.

c. Remove the four No. 6-32 cap screws that hold the attenuator to the plumbing assembly.

d. Slip the attenuator shaft clear of the opening in the panel and carefully remove the attenuator.

e. Replace the calibrated RF attenuator by following the removal steps in the reverse order.

### 79. Removal of Frequency Meter Z1

To remove the frequency meter from the plumbing assembly, proceed as follows:

a. Unscrew the frequency dial light from the dial light assembly. The dial light cover comes off with the removal of the lamp.

b. Loosen the two setscrews on the frequency meter knob and remove the knob.

c. Remove the four No. 4-40 binding head screws that hold the frequency meter cover to the frequency meter. Remove the cover.

d. Remove the three No. 8-32 binding head screws that hold the frequency meter to the panel. The dial is notched to facilitate removal of these screws. Rotate the dial until the screw head appears in the notch and then remove the screws.

e. Turn the spectrum analyzer over. Remove the two No. 6-32 cap screws that fasten the crystal diode assembly clamp to the supporting bracket and remove the clamp (fig. 50).

f. Remove connector P2 from jack J2.

g. Remove the four No. 6-32 cap screws that attach the frequency meter to the crystal diode assembly. Remove the crystal diode assembly.

h. Turn the set over. Remove the four No. 6-32 cap screws that attach the frequency meter to the plumbing assembly and remove the frequency meter assembly. A long handle allen wrench is necessary for the removal of the cap screws.

i. Remove the frequency meter.

j. Replace the frequency meter by following the removal steps in the reverse order.

### 80. Removal of Cathode-Ray Tube

To remove the crt, proceed as follows:

- a. Slip off the socket.

- b. Loosen the base clamp.
- c. Unscrew the four No. 6-32 flat-head screws that hold the bezel to the front panel. Remove the bezel with the window. Remove the gasket.
- d. Slip the crt out of its shield and through the front panel opening.
- e. Replace the crt by following the above steps in reverse order.

**Note**

**Check the crt operation in the usual manner after replacement. If the horizontal trace is not properly positioned, turn off the power, loosen the base clamp, and rotate the tube to position the trace properly. Refasten the base clamp after positioning the tube.**

**81. Removal of Klystron Tube**

To remove the klystron tube, proceed as instructed below.

**Warning**

**Voltages dangerous to life appear on the klystron tube envelope and tuning shaft. Turn the power to the OFF position before attempting to remove the klystron.**

- a. Slip off the klystron socket.
- b. Remove the four No. 6-32 binding head screws that hold the phenolic support to the rear of the front panel.
- c. Remove the four No. 6-32 cap screws that connect the klystron tube to the flange of the fixed attenuator waveguide. Remove the unit from the waveguide assembly; slide the shaft out of the nylon coupling.
- d. Remove the four screws that hold the klystron tube to the phenolic support.
- e. Remove the tuning shaft from the tube.

**82. Replacement of Klystron Tube**

To replace the klystron tube, proceed as follows:

- a. Remove the tuning shaft of the new klystron tube. Insert the shaft of the defective klystron tube into the new klystron tube; turn it until it bottoms in the tube.

**Caution:**

**Do not force the shaft beyond the point at which it bottoms; failure to observe this precaution may mean the destruction of the tube.**

- b. Loosen the two No. 6-32 setscrews on the shaft coupling.
- c. Turn the TUNING knob to its extreme clockwise position.
- d. Replace the klystron tube; align the pin in the shaft with the slot in the coupling. Tighten the setscrews in the coupling.
- e. Reverse the steps given in paragraph 81a through d.
- f. Refer to paragraph 85 for instructions on checking the oscillating range of a klystron replacement.

**83. Replacing Fixed Attenuator Card**

To replace a defective fixed attenuator card, remove the six No. 2-56 roundhead screws and the six lockwashers that hold the attenuator card brackets to the fixed attenuator and pull the defective card out of the waveguide. Replace the card by reversing this procedure. Remove any broken pieces of the attenuator card which remain in the waveguide.

**Note**

**When replacing the attenuator card bracket be sure to replace all lockwashers.**

**84. Replacing Defective Crystal**

If crystal CR1 becomes defective because of the effect of duty and load variations, replace it as follows:

- a. Unscrew the knurled cap on the crystal.
- b. Withdraw the defective crystal from the crystal mount.
- c. Replace the crystal and screw on the knurled cap. Be sure that the captive spring within the cap makes contact with the crystal.

**85. Checking Oscillating Range of Klystron Tubes**

To check the oscillating range of the newly installed klystron tube, proceed as follows:

- a. Observe the proper safety precautions and turn the power to the ON position.
- b. Measure the frequency of the klystron (par. 17) at the low end of the FREQUENCY MC dial. If it is less than 15,800 mc, proceed with the steps given in c and d below; if it is not, reject the tube and replace the tube with another new one; follow the procedure given in paragraph 82.
- c. Turn the TUNING control to its extreme counterclockwise position. Check the frequency with the FREQUENCY MC control. If it is over 16,200 mc, the klystron can be used for the spectrum analyzer; if it is not, proceed with the step given in d below.
- d. Determine if the klystron is still tuning by turning the TUNING control slightly clockwise and

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observe the mode curve to see if there is any change. If there is no effect, reject the klystron. If, however, there is some effect, equalize the low and high end overtravel by getting more travel at the high end and less at the low end. This is done as follows:

- (1) Turn the TUNING control to its extreme clockwise position.
- (2) Set the FREQUENCY MC control for a reading of 15,800 mc.

**Warning:**

**Dangerous voltages are found on the klystron envelope and the tuning shaft. When turning the insulated coupling, be very careful not to contact the high voltage.**

- (3) Loosen the two No. 6-32 setscrews on the TUNING shaft coupling. Turn the coupling counterclockwise; observe the mode

pattern. When the frequency meter pip appears centered on the curve, turn the power to the OFF position.

- (4) Tighten the setscrews on the coupling; be careful not to disturb the setting of the knob.
- (5) Throw the POWER switch to the ON position.
- (6) Set the TUNING control to its extreme counterclockwise position.
- (7) Check the frequency. If it is over 16,200 mc, determine if the klystron is still tuning by turning the TUNING control slightly clockwise to see if there is any indication of tuning in the display. If there is none, reject the tube because it requires an excessive amount of overtravel to cover its oscillating range.

### Section III. CALIBRATION AND ALINEMENT

#### 86. Test Equipment for Calibration and Alinement

Multimeter TS-352/U (TM 11-5527) and Radar Test Set AN/UPM-60 are required for calibration and alinement of Spectrum Analyzer TS-742/UPM. A signal generator with the following technical characteristics is also required for the calibration and alinement of Spectrum Analyzer TS-742/UPM.

- a. 5- to 45-mc signal output.
- b. High frequency signal modulated 30 per cent by a 400-cps signal.

#### 87. Calibration of Spectrum Analyzer TS-742/UPM

To calibrate and aline the analyzer properly, proceed as follows in the sequence given.

a. *Regulated B+ Voltages.* The regulated B+ voltages (+300 and +135 volts) provide a part of the stability of the analyzer; therefore, it is important that these voltages be set correctly as instructed before further adjustments are made.

- (1) Clip the negative multimeter prod to the chassis and the positive prod to pin 6 of V22.
- (2) Throw the POWER switch to ON.
- (3) Allow the set to become temperature established.

- (4) Adjust 135 V ADJ potentiometer R106 on the back of the unit for a reading of +135 volts on the meter.
- (5) Turn the POWER switch to OFF.
- (6) Clip the positive prod to pin 6 of V20.
- (7) Adjust 300-volt adjustment potentiometer R94 on the back of the unit for a reading of +300 volts on the meter.

b. *Alinement of IF Amplifier.* All the IF alinement controls are located on the IF subchassis where they can be reached for peaking (figs. 45 and 48). To reach the underchassis for complete IF alinement, remove the IF subchassis as instructed in paragraph 77d through f. Then proceed as follows:

- (1) Remove the four No. 6-32 binding head screws and lockwashers that hold the L-bracket to the IF chassis.
- (2) Pull the bracket away from the IF chassis. The underchassis is now accessible for alinement.
- (3) Connect the signal generator output leads to pin 7 of V5 and to ground.
- (4) Turn the function selector switch to the SPECTRUM position.
- (5) Set the signal generator control for a 5-mc signal at a 7,000-microvolt level, modulated 30 per cent by a 400-cycle signal.

- (6) Turn the analyzer and signal generator on. Allow both units to become temperature-stabilized. (A 400-cycle sine wave will appear on the analyzer scope.)
- (7) Tune coils L24, L27, and L29 for maximum amplitude of the display.
- (8) Set the signal generator output for a 45-me signal, and tune coil L22 for maximum amplitude of the display. This coil sets the frequency of the local oscillator circuit in V5, a pentagrid converter, at 50 me. This is a sensitive adjustment and should be made carefully.
- (9) Disconnect PI from J1. Turn the IF SENSITIVITY control clockwise as far as it will go (maximum sensitivity). Apply a 45-mc signal, modulated as above but at a

22-microvolt level to J1. Set the signal generator output level for a good display on the scope.

- (10) Tune coils L9, L13, and L17 for maximum amplitude of the display.
- (11) Reconnect P1 and J1 and apply the output of Radar Test set AN/UPM-60 directly to the RF INPUT of the analyzer without attenuation in either unit. Set the radar test set for cw operation. Adjust the controls for a good cw display on the scope.
- (12) Tune coil L5 for maximum amplitude of the display. If steps given in (4) through (13) above have been followed carefully, the IF strip should be alined properly.

**Section IV. FINAL TESTING**

**88. General**

This section is intended as a guide to be used in determining the quality of a repaired Spectrum Analyzer AN/UPM-58. The minimum test requirements outlined in paragraphs 89 through 94 may be performed by maintenance personnel with adequate test equipment and the necessary skills. Repaired equipment meeting these requirements will furnish uniformly satisfactory operation.

**89. Test Equipment Required for Final Testing**

The following items of test equipment are required for final testing of Spectrum Analyzer AN/UPM-58:

Item	Technical manual
Radar Test Set AN/UPM-60 Signal Generator TS-497B/URR or equal PRD type 567-A wavemeter or equal PRD type 187 calibrated attenuator or equal	TM 11-5030

**90. Overall Sensitivity**

- a. Connect the RF output waveguide receptacle of Radar Test Set AN/UPM-60 to the RF INPUT waveguide receptacle of the spectrum analyzer by means of the flexible waveguide component. Turn on both units.
- b. Set the controls of Radar Test Set AN/UPM-60 to produce a cw signal at 16,000 me.

c. Set the controls of the spectrum analyzer for a cw signal display as described in paragraph 15. Tune the spectrum analyzer to approximately 16,000 me. A cw signal should appear on the scope.

d. Set the analyzer DB dial to zero and the IF SENSITIVITY control to its maximum clockwise position.

e. Vary the DBM control of the radar test set to get a minimum discernible signal. Note the DBM dial reading at this point. Correct the reading by means of the unit db correction curve. A reading of about -70 db should be obtained for sensitivity to a minimum discernible cw signal.

f. Vary the DBM control to cause a 1-inch vertical deflection of the cw signal. Note the DBM dial reading now. Correct this reading by means of the radar test set unit db correction curve.. the result is the sensitivity to cw of the analyzer for 1-inch crt deflection. This should be about -60 db.

**91. IF Bandwidth**

- a. Connect Signal Generator TS-497A/URR to J1 on the IF subchassis.
- b. Set the function selector switch to the SPECTRUM position.
- c. Set the controls of the signal generator for a 45-mc output modulated 30 per cent by 400 cycles.
- d. Turn on both units. A 400-cycle sine wave should appear on the scope. Turn the H GAIN control to compress the display until a single vertical

line appears on the scope. Mark the signal amplitude on the scope.

e. Increase the voltage output of the signal generator by 1.4 times its previous reading. The amplitude of the display will increase.

f. Increase the signal generator frequency until the signal on the screen decreases to its original level. Note the frequency at this point.

g. Return the signal generator frequency to 45 mc. Decrease the signal generator frequency from this point until the signal decreases to its original level. Note the frequency at this point.

h. Subtract the two frequency readings. The result should be about 50 kc, the overall bandwidth of the IF amplifier.

## 92. Receiver Gain

a. Perform the steps given in paragraph 92a through c

(IF bandwidth final test).

b. Turn on both units. An expanded 400-cycle signal should appear on the scope. Vary the H GAIN control until a single vertical line appears on the screen.

c. Set the signal generator output to obtain a signal 1 inch in amplitude peak to peak.

d. Note the signal generator output. A reading of approximately 15 microvolts should be obtained. This corresponds to an overall receiver gain of approximately 100 db.

## 93. Frequency Meter Accuracy

a. Place the wavemeter specified in paragraph 89 in series with the frequency meter in the spectrum analyzer.

b. Connect the other end of the calibrated wavemeter to the RF receptacle of Radar Test Set AN/UPM-0. Detune the wavemeter.

c. Set the controls of the test set for a cw signal at a given frequency.

d. Set the controls of the analyzer for SPECTRUM operation. Detune the analyzer frequency meter.

e. Measure the frequency of the cw signal first with the wavemeter standard and then with the analyzer frequency meter. The analyzer frequency meter reading should correspond to the wavemeter standard reading within  $\pm 10$  mc.

## 94. RF Calibrated Attenuator Accuracy

a. Connect the calibrated attenuator specified in paragraph 89 to the RF INPUT receptacle of the analyzer. This places it in series with the spectrum analyzer attenuator. Set both attenuator controls at zero.

b. Connect the other end of the attenuator to the RF receptacle of the test set.

c. Set the radar test set controls for a cw signal output.

d. Set the analyzer controls for spectrum operation.

e. Mark the level of the cw signal on the analyzer screen.

f. Increase the attenuation of the analyzer attenuator by 1 db. This is done by first calculating the db correction for 1 db as described in paragraph 18c and then setting the DB dial at the corrected setting. Mark the signal level on the screen. Decrease the attenuation until the cw signal level rises to its original amplitude.

g. Increase the attenuation of the external attenuator until the cw signal is at the level marked for 1 db of attenuation. Note the reading on the external calibrated attenuator. It should read 1 db.

## 95. Pulse Spectrum

a. Connect Radar Test Set AN/UPM-0 to the analyzer.

b. Set the controls of the radar test set for a pulsed signal. Set the spectrum analyzer controls for spectrum operation.

c. The spectrum obtained should approximate the spectrum shown in figure 11. At least 50 discrete spikes should be seen in the spectrum between third minimum points (W-Z).

## CHAPTER 6

### SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

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#### Section I. SHIPMENT AND LIMITED STORAGE

##### 96. Disassembly

The following instructions are recommended as a general guide for preparing Spectrum Analyzer AN/UPM-58 for transportation and storage.

a. Remove all cables that connect the spectrum analyzer to the power source and to the external trigger or pulse sources.

b. Remove the coupling device (the directional coupler, antenna horn or flexible waveguide) from the front panel waveguide receptacle.

c. Check the equipment against the table of components (par. 5).

##### 97. Repacking for Shipment or Limited Storage

Figure 2 illustrates one method of repacking the equipment. Specific directions for repacking Spectrum Analyzer AN/UPM-58 are as follows:

a. Place all the items listed in the table of components (par. 5) in their proper places as shown in

figure 1. Place the cover on the case and close the case securely.

b. Place a folded corrugated support inside a corrugated fiberboard carton and place the equipment into the carton on top of the support.

c. Position a corrugated support between each side of the equipment and on each side of the carton which it faces.

d. Seal the carton with gummed tape and place the sealed carton in a cleated wooden box.

e. Place the wooden braces on top of the carton inside the wooden box and nail them to the side of the box.

f. Pack the running spares in a flat corrugated carton. Seal the carton with gummed tape and place this carton inside the box on top of the braces.

g. Put the box cover on the box and nail it in place.

h. Staple two metal straps around the sealed box.

#### Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

##### 98. General

The demolition procedure outlined in paragraph 99 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon order of the commander.

##### 99. Methods of Destruction

a. *Smash.* Smash the controls, tubes, frequency meter, coils, switches, capacitors, transformers, and waveguide pieces; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or heavy tools.

b. *Cut.* Cut the power cord and the video cables; use axes, handaxes, or machetes.

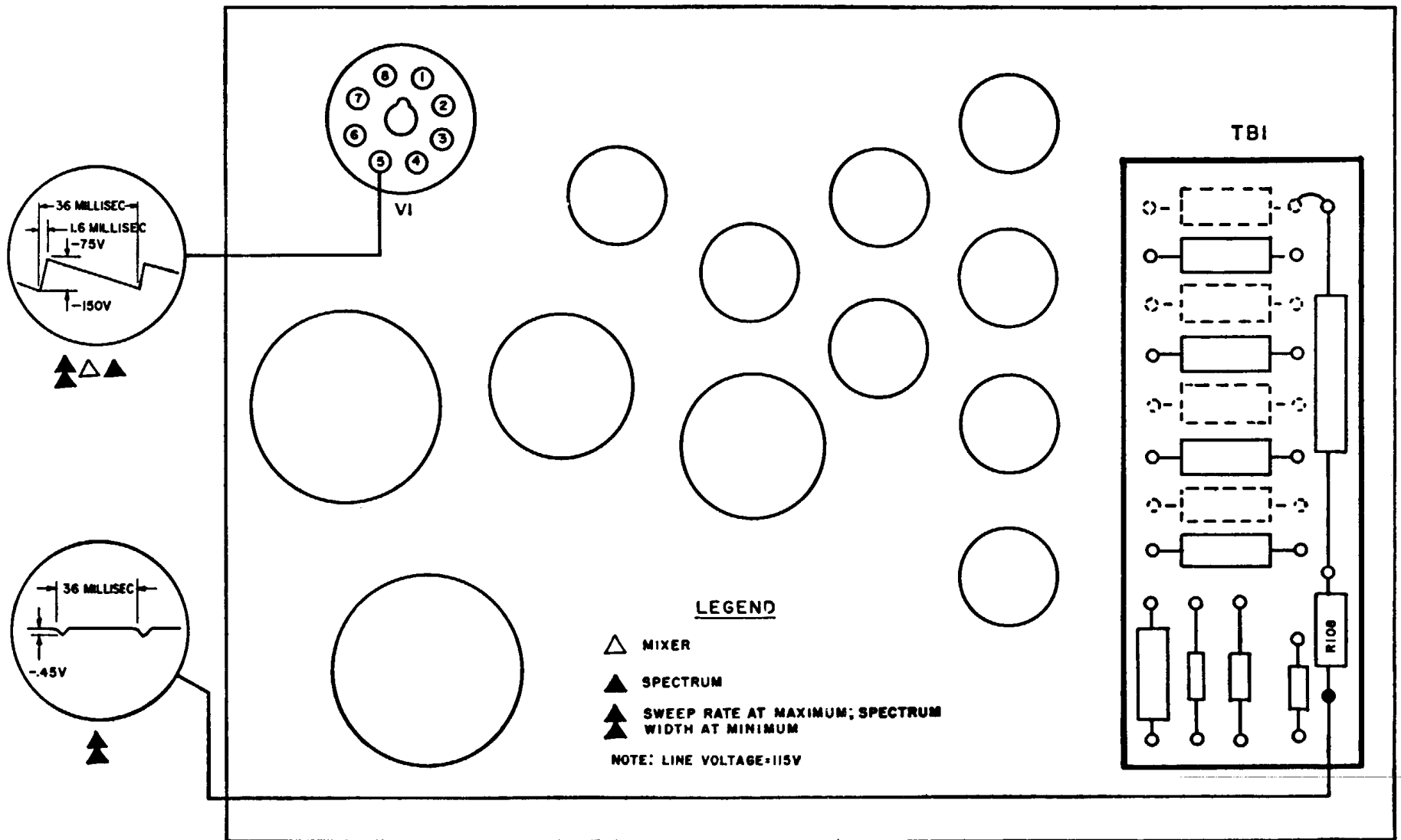
c. *Burn.* Burn cords and technical manuals; use gasoline, kerosene, oil, flamethrowers, or incendiary grenades.

d. *Bend.* Bend waveguides, panel, and cabinet.

e. *Explode.* If explosives are necessary, use firearms, grenades, or TNT.

f. *Dispose.* Bury or scatter the destroyed parts in slit trenches, foxholes, or throw them into streams.

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Figure 57. Wave form chart, main chassis.



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AFIP	

NG: State AG; units same as Active Army.

USAR: None.

For explanation of abbreviations used, see SR 320-51.

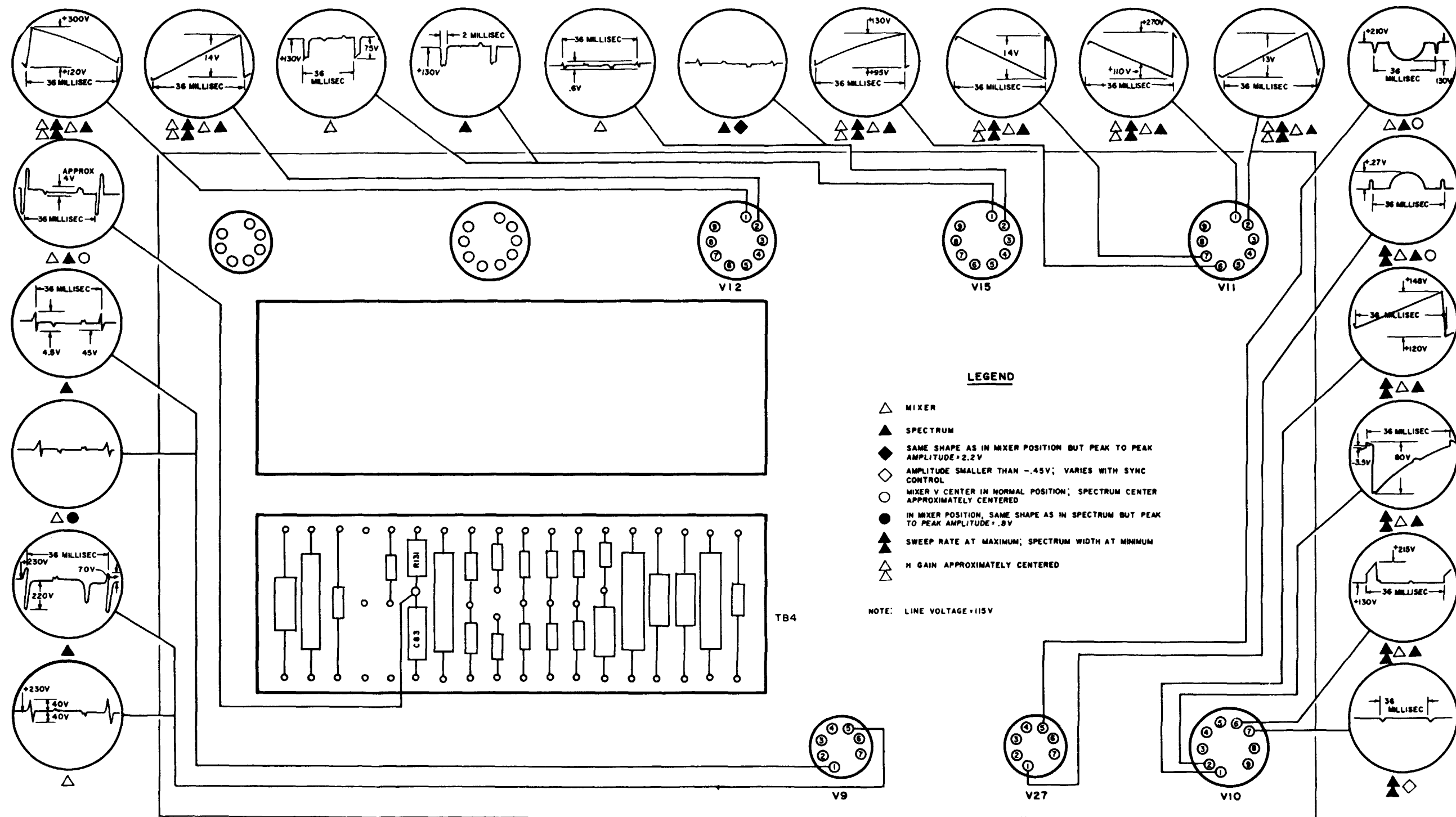


Figure 58. Wave form chart, indicator chassis, spectrum analysis positions.

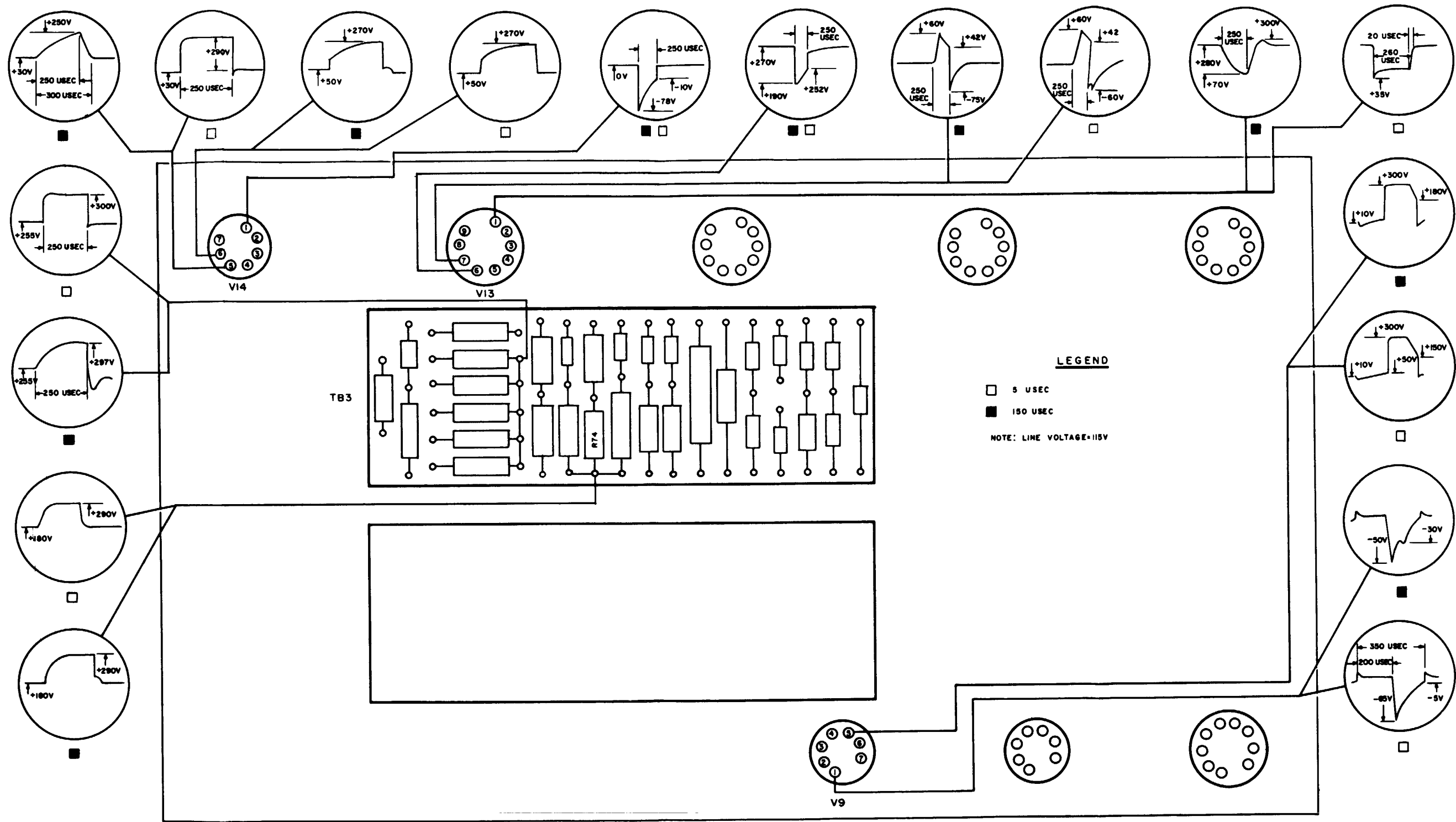


Figure 59. Wave form chart, indicator chassis, synchroscope positions.

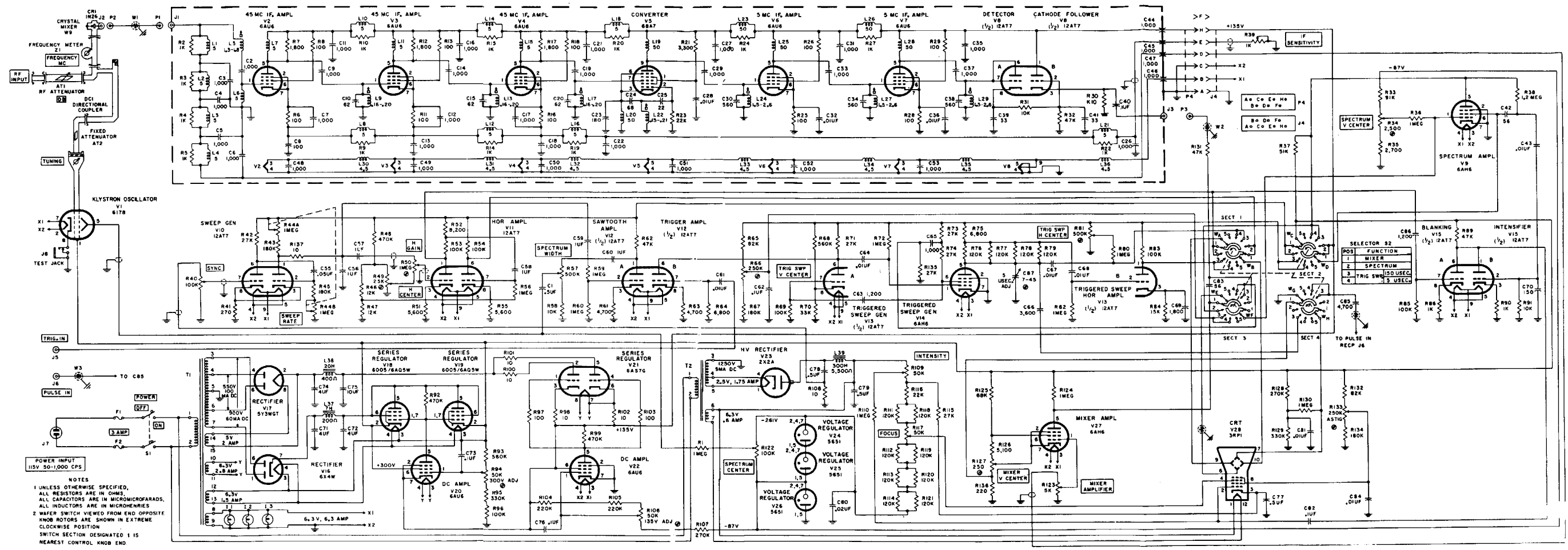
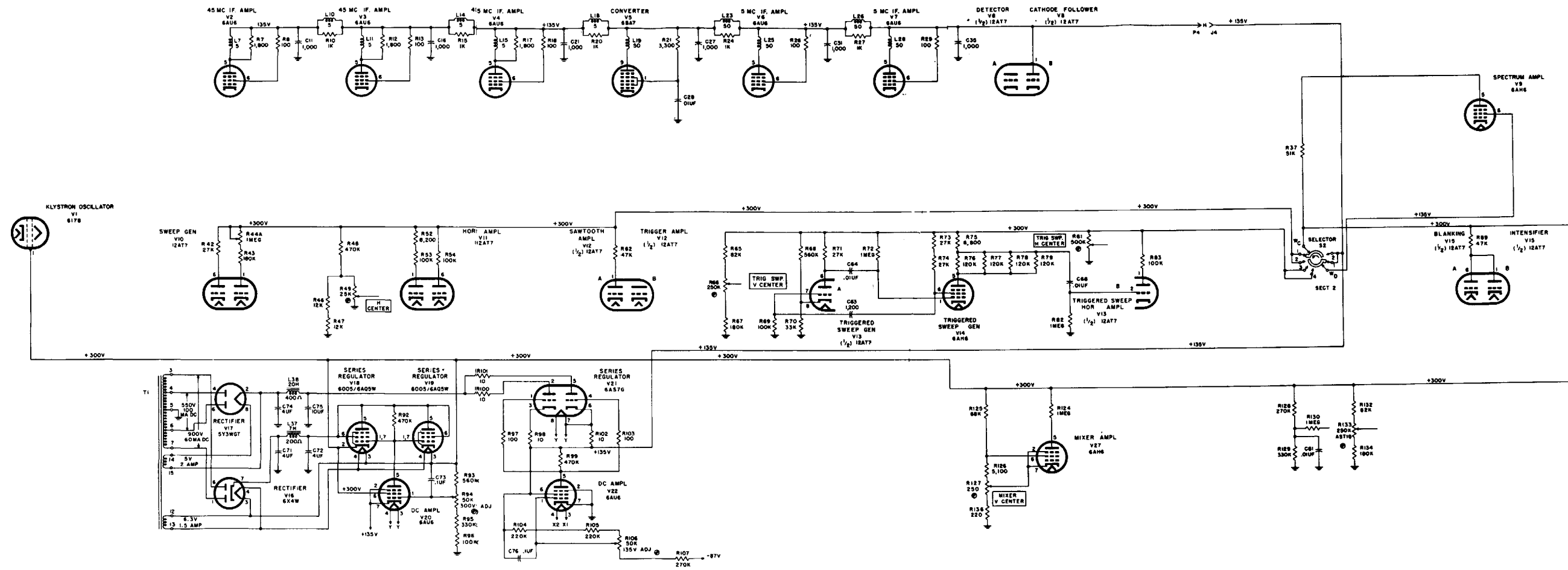


Figure 60. Spectrum Analyzer TS-742/upm, schematic diagram.



TM 5099-62

Figure 61. Spectrum Analyzer TS-742/U, B+ voltage distribution diagram.

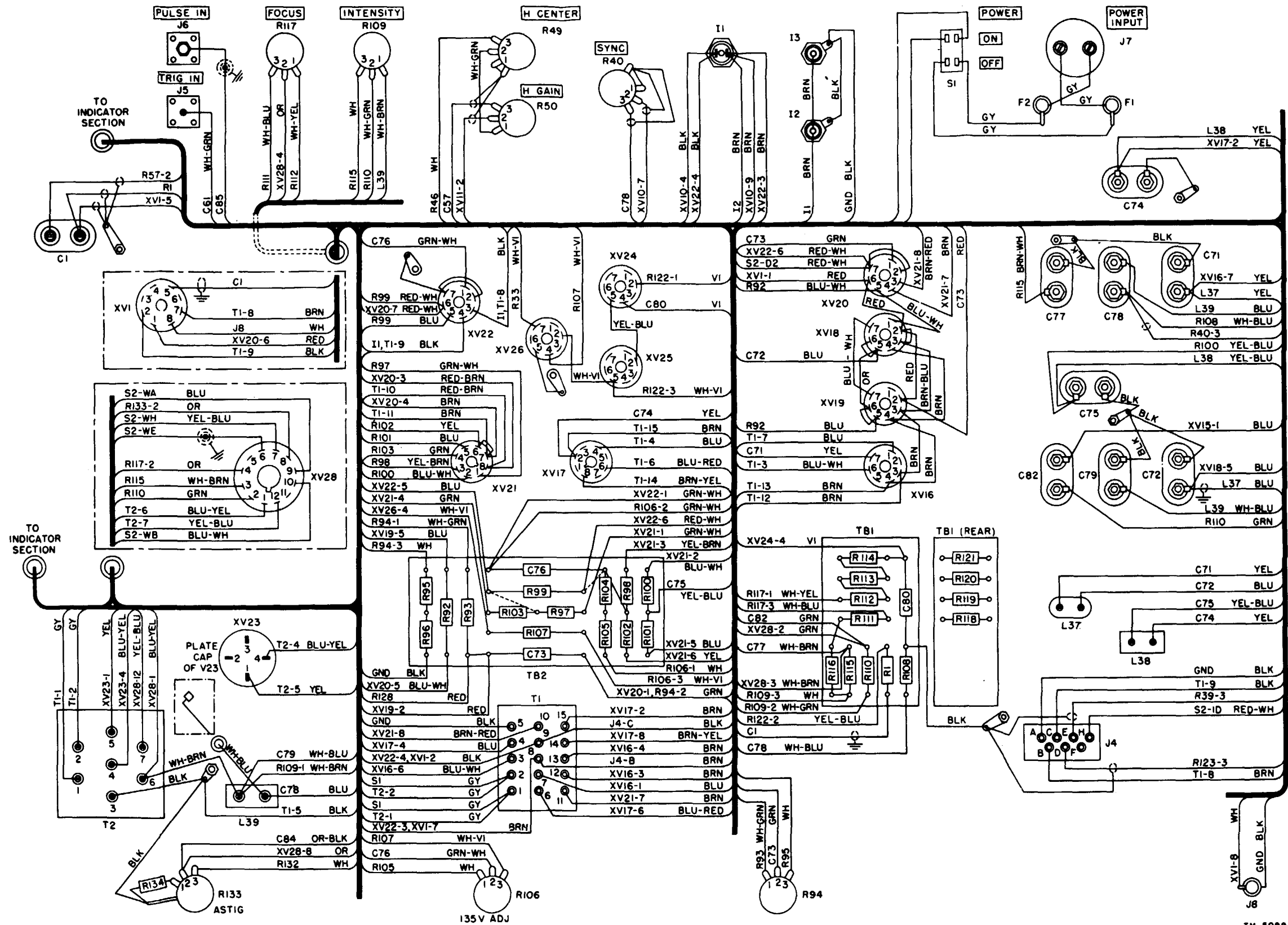


Figure 62. Spectrum Analyzer TS-742/U, wiring diagram (bottom).



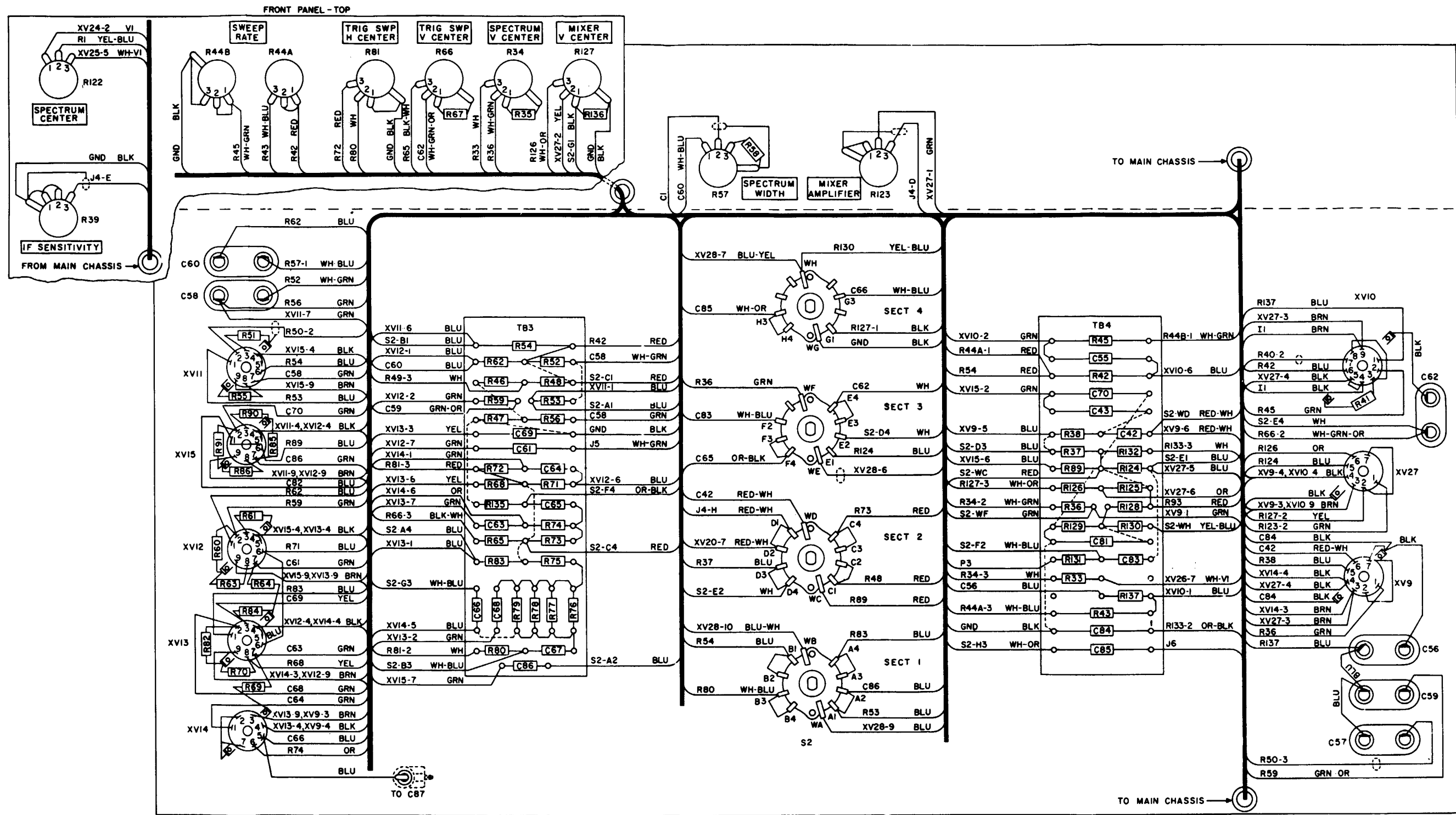


Figure 63. Spectrum Analyzer TS-742/U, wiring diagram (sides).

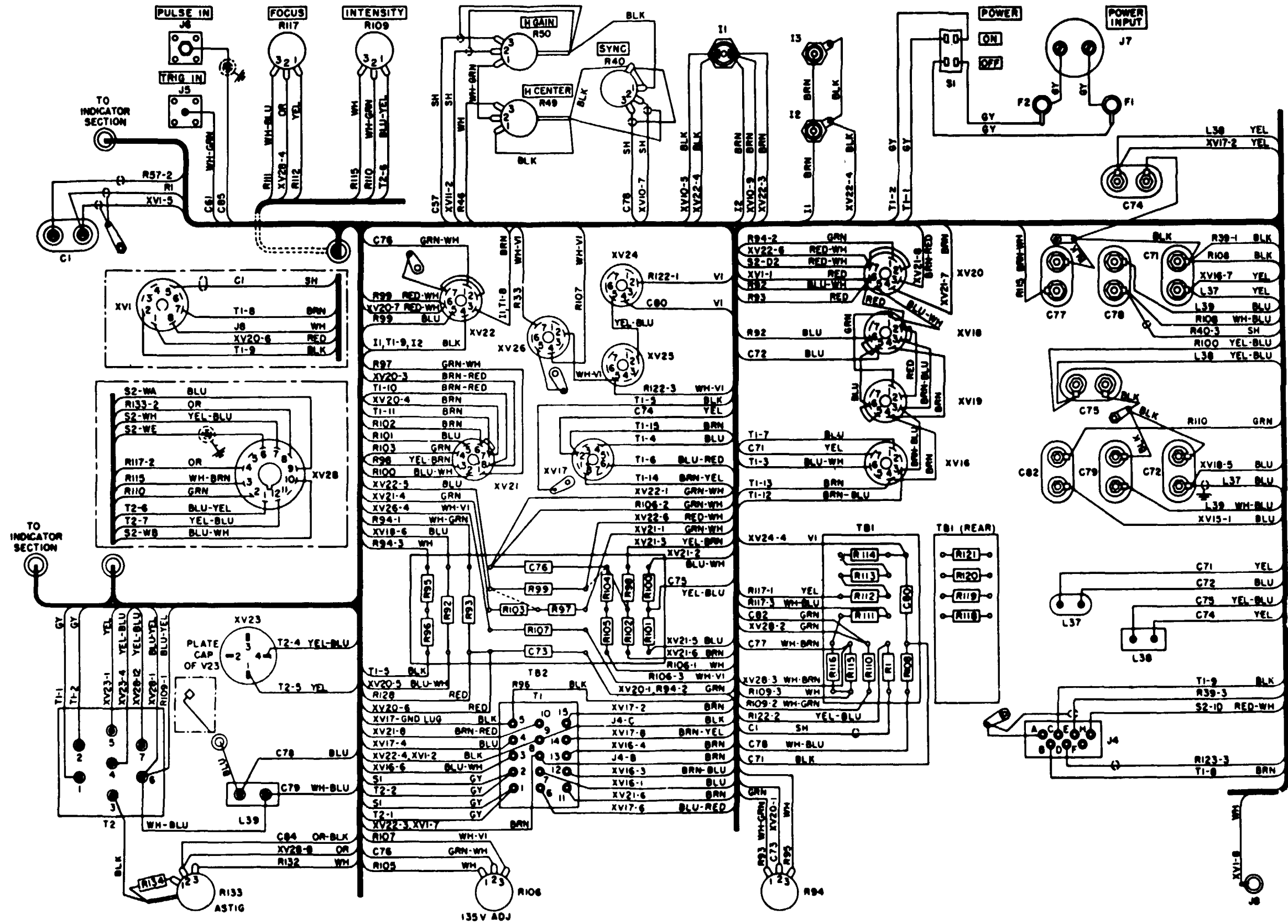


Figure 64. (Added) Spectrum Analyzer TS-742/UPM procured under Order No. 36225-Phila-57, wiring diagram (bottom).

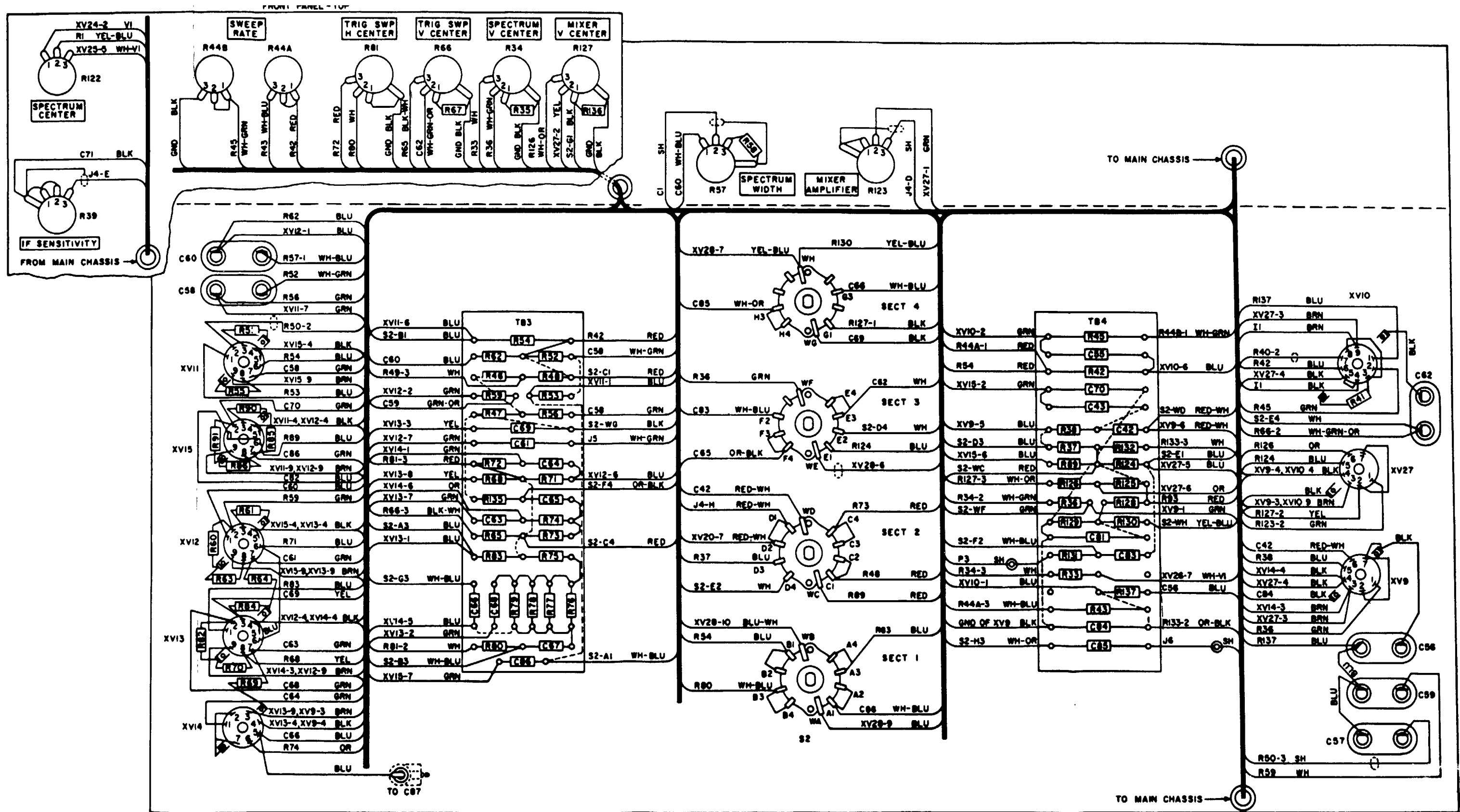



Figure 65. (Added) Spectrum analyzer TS 742/UPM procured under Order No. 36225-Phila-57, wiring diagram (sides).

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS

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## The Metric System and Equivalents

### Linear Measure

1 centimeter = 10 millimeters = .39 inch  
 1 decimeter = 10 centimeters = 3.94 inches  
 1 meter = 10 decimeters = 39.37 inches  
 1 dekameter = 10 meters = 32.8 feet  
 1 hectometer = 10 dekameters = 328.08 feet  
 1 kilometer = 10 hectometers = 3,280.8 feet

### Weights

1 centigram = 10 milligrams = .15 grain  
 1 decigram = 10 centigrams = 1.54 grains  
 1 gram = 10 decigrams = .035 ounce  
 1 decagram = 10 grams = .35 ounce  
 1 hectogram = 10 decagrams = 3.52 ounces  
 1 kilogram = 10 hectograms = 2.2 pounds  
 1 quintal = 100 kilograms = 220.46 pounds  
 1 metric ton = 10 quintals = 1.1 short tons

### Liquid Measure

1 centiliter = 10 milliliters = .34 fl. ounce  
 1 deciliter = 10 centiliters = 3.38 fl. ounces  
 1 liter = 10 deciliters = 33.81 fl. ounces  
 1 dekaliter = 10 liters = 2.64 gallons  
 1 hectoliter = 10 dekaliters = 26.42 gallons  
 1 kiloliter = 10 hectoliters = 264.18 gallons

### Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch  
 1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches  
 1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet  
 1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet  
 1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres  
 1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

### Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch  
 1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches  
 1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

## Approximate Conversion Factors

<i>To change</i>	<i>To</i>	<i>Multiply by</i>	<i>To change</i>	<i>To</i>	<i>Multiply by</i>
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29.573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

## Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C
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