TM 11-6625-493-15

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

DS, GS, AND DEPOT MAINTENANCE MANUAL

FREQUENCY COMPARATOR CM-77A/USM

This copy is a reprint which includes current pages from Changes 1 through 4.

HEADQUARTERS, DEPARTMENT OF THE ARMY

SEPTEMBER 1964

CHANGE NO. 4

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, 9 *May 1977*

Operators, Organizational, Direct Support, General Support, and Depot Maintenance Manual

FREQUENCY COMPARATOR CM977A/USM (NSN 6625-00-080-7204)

TM 11-6625-493-15, 29 September 1964, is changed as follows:

The title of the manual is changed as shown above.

Page v, The Forms and Records paragraph is superseded as follows:

0-1. Forms and Records

a. Reports of Maintenance and Unsatisfactory Equipment. Maintenance forms, records, and reports which are to be used by maintenance personnel at all maintenance levels are listed in and prescribed by TM 38-750.

b. Report of Packaging and Handling Deficiencies. Fill out and forward DD Form 6 (Packaging Improvement Report) as prescribed in AR 700-58/NAVSUPINST 4030.29/AFR 71-13/MCO P4030.29A, and DSAR 4145.8.

c. *Discrepancy in Shipment Report (DISREP) (SF 361).* Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38/NAVSUPINST 4610.33A/AFR 75-18/MCO 4610.19B and DSAR 4500.15

The Reporting of Errors paragraph is superseded as follows:

0-2. Reporting of Errors

You can help improve this manual by calling atten tion to errors and by recommending improvements and stating your reasons for the recommendations. Your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms) should be mailed direct to Commander, US Army Electronics Command, ATTN: DRSEL-MA-Q, Fort Monmouth, New Jersey 07703. A reply will be furnished direct to you. After the Reporting of Errors paragraph, add the following:

0-3. Administrative Storage

Administrative storage of equipment issued to and used by Army activities shall be in accordance with TM 740-90-1.

0-4. Destruction of Army Electronics Materiel.

Destruction of Army electronics materiel to prevent enemy use shall be in accordance with TM 750-244-2.

0-5. Reporting Equipment improvement Recommendations (EIR)

EIR's will be prepared using DA Form 2407 (Maintenance Request). Instructions for preparing EIR's are provided in TM 38-750, The Army Maintenance Management System. EIR's should be mailed direct to Commander, US Army Electronics Command, ATTN: DRSEL-MA-Q, Fort Monmouth, New Jersey 07703. A reply will be furnished direct to you.

Page 5-2, Table 5-1 is superseded as follows:

Table 5-1. Test Equipment

Nomenclature	Model/AN Type	Application	Range	Accuracy
Voltmeter, meter (ac vacuum tube voltmeter)	HP Model 400D/ME-30A/U	Measure low-frequency or low-level ac voltage	0.1 mv to 300 volts	± 2%
Multimeter (vacuum tube voltmeter)	HP Model 410B/ME-26/U	Measure dc voltage and high-frequency ac voltage	1 to 1000 vdc	
Transformer, Variable Power (variable auto-transformer)	General Radio Variac Model W2, or W5 or v-10/16/U	Supply variable power line voltage	100 to 130 volts ac, 1.25 amp	Voltmeter accurate within 1 volt
Probe "T" Connector	HP Model 455 A	In-line coaxial connection with 410B voltmeter probe	100 to 200 mc	
50-ohm Coaxial Load	HP Model AC-67A	Matched termination for Model 455A		
Counter, Electronic Digital Readout (electronic counter)	HP Model 524B/C/D with Model 525B Plug-In Converter/AN/USM-207A	Precise frequency measurement	100 to 220 mc	1/10⁶ or better
Signal Generator (Square-wave generator)	HP Model 211A/SG-299/U	Signal generator for amplifier response test	Approx. 2 kc, 0.5 volt, 0.02 s rise-time	
Oscilloscope	HP Model 160B/AN/USM-281A	Observe test waveforms	10 mc, triggered sweep	
Clip-On Dc Milliammeter	HP Model 428A	Measure direct current	3 ma to 1 amp	±3% ±0.1 ma
Generator, Signal (SHF signal generator)	HP Models 614A, 618B, and 620A/AN/URM-44A	Measure mixer sensitivity	0.8 to 11 gc	

Page 5.1-1. Section V.I is superseded as follows:

SECTION V.1
PREVENTIVE MAINTENANCE INSTRUCTIONS

5.1-1. Scope of Organizational 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 tables 5.1-1 and 5.1-2 cover routine systematic care essential to proper upkeep and operation of the equipment.

b. Preventive Maintenance Checks and Services. The preventive maintenance checks and services tables outline the functions to be performed at specific intervals. These checks and services are designed to maintain Army equipment in a combat-serviceable condition; that is, in good physical and operational condition. To assist organizational maintenance personnel in maintaining combat serviceability, the table indicate what to check, how to check, and the normal conditions. If the defect cannot be remedied by organizational maintenance personnel, higher category maintenance or repair is required. Records and reports of these checks and services must be made in accordance with TM 38-750.

5.1-2. Preventive Maintenance Checks and Services Periods

Preventive maintenance checks and services of the equipment is required on a daily, weekly, and monthly basis as indicated in *a* and *b* below. Whenever a normal indication is not observed during the performance of the daily, weekly, or monthly preventive maintenance check, necessary corrective action must be taken.

a. Daily and Weekly. Table 5.1-1 specifies the preventive maintenance checks and services that must be performed daily and weekly or when the equipment is:

(1) Initially installed.

(2) Reinstalled after return from higher category of maintenance and repairs have been performed.

(3) Maintained in a standby (ready for immediate operation) condition. Perform on a monthly schedule.

(4) Returned to service from limited storage.

b. Monthly. Table 5.1-2 specifies the preventive maintenance checks and services that must be performed monthly. A month is defined as approximately 30 calendar days of 8-hour-per-day operation. Adjustment of the monthly preventive maintenance interval must be made to compensate for any unusual operating conditions. For example, if the equipment is used 16 hours per day, the monthly preventive maintenance checks and services should be performed at 15-day intervals. ACM-77A maintained in a standby condition requires monthly preventive maintenance, but one in limited storage does not.

Table 5.1-1. Daily and Weekly Preventive Maintenance Checks and Services

D—Daily
Total Task-Hours Required: 0.3

W-Weekly
Total Task-Hours Required: 0.6

Interval and sequence No. D	Interval and sequence No. W	ITEM TO BE INSPECTED PROCEDURE	Work time (T/H)
1	1	**EXTERIOR**	
		Check for damage to knobs, power cord, and cabinet	0.1
2	2	**CONNECTORS**	
		Check tightness of all connectors.	0.1
3		**OPERATION**	
		During operation of the equipment, be alert for any unusual performance or condition. Observe that the mechanical operation of each control is smooth and free of external and internal binding and that there is no excessive looseness (para 3-6).	0.1
	3	**CLEANLINESS OF EQUIPMENT**	
		Inspect equipment for exterior cleanliness. Follow the cleaning procedure in paragraph 5-3.	0.1
	4	**CABLES**	
		Inspect cords, cables, and wires for chafed, cracked, or frayed insulation. Replace connectors that are broken, arced, stripped, or worn excessively.	0.1
	5	**HANDLES AND LATCHES**	
		Inspect handles and latches for looseness. Replace or tighten as necessary.	0.1

Table 5.1-2. Monthly Preventative Maintenance Checks and Services

M-Monthly
Total Task-Hours Required: 0.2

Sequence No.	ITEM TO BE INSPECTED PROCEDURE	Worktime (T H)
1	**JACKS AND PLUGS**	
	Inspect jacks and plugs for snug fit and good contact.	0.1
2	**METAL SURFACES**	
	Inspect exposed metal surfaces for rust or corrosion. Touch up paint as required (para 5-4 and 5-5).	0.1

5.1-3. Cleaning

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

a. Remove dust and loose dirt with a clean lint-free cloth.

WARNING

The fumes of trichloroethane are toxic. Provide thorough ventilation whenever used. DO NOT USE NEAR AN OPEN FLAME. Trichloroethane is not flammable, but exposure of the fumes to an open flame or hot metal forms highly toxic phosgene gas.

b. Remove grease, fungus, and ground-in dirt from the case; use a cloth dampened (not wet) with trichloroethane. After cleaning, wipe dry with a clean lint-free cloth.

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

CAUTION

Do not press on the face (glass) of the cathode ray tube when cleaning; the cathode ray tube may become damaged.

d. Clean the front panel and control knobs; use a soft clean lint-free cloth. If necessary, dampen the cloth with water. Mild soap may be used for more effective cleaning. Wipe dry with a clean lint-free cloth .

5.1-4. Paints and Finishes

When the CM-77A/USM requires repainting, refinishing, or touchup painting, refer to Federal Standard No. 595a for a matching color. SB 11-573 lists. painting tools and miscellaneous supplies required for painting.

5.1-5. Touchup Painting Instructions

a. Refer to TB 43-0118 for instructions on painting and preserving Electronics Command equipment. When touchup painting, a perfect match with the exact shade of the original paint surface may not be possible. This may be caused by changes such as in the original pigment because of oxidation, and differences in manufacture. The prevention of corrosion and deterioration is the most important consideration in touchup painting; appearance is secondary. This, however, should not be construed to mean that appearance of the equipment is not important. Touckup painting should be accomplished neatly and the quality of work should be good. Field inspection personnel should make allowances for slight color mismatch where minor touchup has been done, but not for neglect, poor quality, or where the need for refinishing is obvious.

b. 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.

Page i-2. Appendix 1 is superseded as follows:

APPENDIX A
REFERENCES

The following is a list of references that are available to the operator and organizational, DS, GS, and depot maintenance personnel of Frequency Comparator CM-77A/USM:

DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (Types 7, 8 and 9), Supply Bulletins, and Lubrication Orders.
DA Pam 310-7	US Army Index of Modification Work Orders.
SB 11-573	Painting and Preservation Supplies Available for Field Use for Electronics Command Equipment.
TB 43-180	Calibration Requirements for the Maintenance of Army Materiel.
TB 43-0118	Field Instructions for Painting and Preserving Electronics Command Equipment Including Camouflage Pattern Painting of Electrical Equipment Shelters
TM 11-6625-200-15	Operator's, Organizational, DS, GS, and Depot Maintenance Manual: Multimeters ME-26A/U, ME-26B/U, ME-26C/U, and ME-26D/U.
TM 11-6625-258-14	Operator's, Organizational, Direct Support, and General Support Maintenance Manual: Signal Generators SG-299/U, SG-299A/U, SG-299B/U, SG-299C/U, SC-299D/U and SG-299E/U.
TM 11-6625-274-12	Operator's and Organizational Maintenance Manual: Test Sets, Electron Tube TV-7/U, TV-7A/U, TV-7B/U, and TV-7D/U.
TM 11-6625-316-12	Operator's and Organizational Maintenance Manual: Test Sets, Electron Tube TV-2/U, TV-2A/U, TV-2B/U, and TV-2C/U.
TM 11-6625-320-12	Operator's and Organizational Maintenance Manual: Voltmeter, Meter ME-30A/U and Voltmeters, Electronic ME-30B/U, ME-30C/U, and ME-30E/U.
TM 11-6625-366-15	Operator's, Organizational, EM, CS, and Depot Maintenance Manual: Multimeter TS-352B/U.
TM 11-6625-412-15-1	Operator, Organizational, DS, GS, and Depot Maintenance Manual, Including Repair Parts and Special Tools List: Radio Test Set AN/URM-44A.

TM 11-6625-700-14-1	Operator's, Organizational, Direct Support, and General Support Maintenance Manual Including Repair Parts and Special Tools List (Including Depot Maintenance Repair Parts and Special Tools): Digital Readout Electronic Counter AN/USM-207A (Serial Nos. 1A through 1100A).
TM 11-6625-1703-15	Operator, Organizational, DS, GS, and Depot Maintenance Manual Including Repair Parts and Special Tool Lists: Oscilloscope AN/USM-281A.
TM 38-750	The Army Maintenance Management System (TAMMS).
TM 740-90-1	Administrative Storage of Equipment
TM 750-244-2	Procedures for Destruction of Electronics Materiel to Prevent Enemy Use (Electronics Command).

Page i-3, Appendix II is superseded as follows:

APPENDIX C

MAINTENANCE ALLOCATION

Section I. INTRODUCTION

C-1. General

This appendix provides a summary of the maintenance operations for CM-77A/USM. It authorizes categories of maintenance for specific maintenance functions on repairable items and components and the tools and equipment required to perform each function. This appendix may be used as an aid in planning maintenance operations.

C-2. Maintenance Function

Maintenance functions will be limited to and defined as follows:

a. *Inspect.* To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination.

b. Test. To verify serviceability and to detect incipient failure by measuring the mechanical or electrical characteristics of an item and comparing those characteristics with prescribed standards.

c. Service. operations required periodically to keep an item in proper operating condition, i.e., to clean (decontaminate), to preserve, to drain, to paint, or to replenish fuel, lubricants, hydraulic fluids, or compressed air supplies.

d. Adjust. To maintain, within prescribed limits, by bringing into proper or exact position, or by setting the operating characteristics to the specified parameters.

e. Align. To adjust specified variable elements of an item to bring about optimum or desired performance.

f. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments or test measuring and diagnostic equipments used in precision measurement. Consists of comparisons of two instruments, one or which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

g. Install. The act of emplacing, seating, or fixing into position an item, part, module (component or assembly) in a manner to allow the proper functioning of the equipment or system.

h. Replace. The act of substituting a serviceable like type part, subassembly, or module (component or assembly) for an unserviceable counterpart.

i. Repair. The application of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions (welding, grinding, riveting, straightening, facing, remachining, or resurfacing) to restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module (component or assembly), end item, or system. This function does not include the trial and error replacement of running spare type items such as fuses, lamps, or electron tubes.

j. Overhaul. That maintenance effort (service/action) necessary to restore an item to a completely serviceable/operational condition as prescribed by maintenance standards (i.e., DMWR) in appropriate technical publications. Overhaul is normally the highest degree of maintenance performed by the

Army. Overhaul does not normally return an item to like new condition.

k. Rebuild. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild is the highest degree of materiel maintenance applied to Army equipment. The rebuild, operation includes the act of returning to zero those age measurements (hours, miles, etc.) considered in classifying Army equipments/components.

C-3. Column Entries

a. Column 1, Group Number. Column 1 lists group numbers, the purpose of which is to identify components, assemblies, subassemblies, and modules with the next higher assembly.

b. Column 2, Component/Assembly. Column 2 contains the noun names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. *Column 3, Maintenance Functions.* Column 3 lists the functions to be performed on the item listed in column 2. When items are listed without maintenance functions, it is solely for purpose of having the group numbers in the MAC and RPSTL coincide.

d. Column 4, Maintenance Category. Column 4 specifies, by the listing of a "work time" figure in the appropriate subcolumn(s), the lowest level of maintenance authorized to perform the function listed in column 3. This figure represents the active time required to perform that maintenance function at the indicated category of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different maintenance categories, appropriate "work time" figures will be shown for each category. The number of task-hours specified by the "work time" figure represents the average time required to restore an item (assembly, subassembly, component, module, end item or system) to a serviceable condition under typical field operating conditions. This time includes preparation time, troubleshooting time, and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation cha Subcolumns of column 4 are as follows:

C - Operator/Crew
O - Organizational
F - Direct Support
H - General Support
D - Depot

e. Column 5, Tools and Equipment. Column specifies by code, those common tool sets (not in dividual tools) and special tools, test, and supper equipment required to perform the designated func tion.

f. Column 6, Remarks. Column 6 contains an al phabetic code which leads to the remark in section IV, Remarks, which is pertinent to the item opposite the particular code.

C-4. Tool and Test Equipment Requirements (Sect. III)

a. Tool or Test Equipment Reference Code. The numbers in this column coincide with the numbers used in the tools and equipment column of the MAC. The numbers indicate the applicable tool or test equipment for the maintenance functions.

b. Maintenance Category. The codes in this column indicate the maintenance category allocated the tool or test equipment.

c. Nomenclature. This column lists the noun name and nomenclature of the tools and test equipment required to perform the maintenance functions.

d. National/NATO Stock Number. This column lists the National/NATO stock number of the specific tool or test equipment.

e. Tool Number. This column lists the manufacturer's part number of the tool followed by the Federal Supply Code for manufacturers (5-digit) in parentheses.

C-5. Remarks (Sect. IV)

a. Reference Code. This code refers to the appropriate item in section II, column 6.

b. Remarks. This column provides the required explanatory information necessary to clarify items appearing in section II.

SECTION II MAINTENANCE ALLOCATION CHART
FOR
FREQUENCY COMPARATOR CM-77A/USM

(1) GROUP NUMBER	(2) COMPONENT/ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY C	O	F	H	D	(5) TOOLS AND EQPT	(6) REMARKS
00	FREQUENCY COMPARATOR	Service		0.5					
		Adjust				0.5		,3,6	
		Inspect		0.5					
		Test				1.0		thru	
								3,14,1	
		Repair				1.0		0	
		Repair		0.5				1	A
		Overhaul					2.0	2	

SECTION III. **TOOL AND TEST EQUIPMENT REQUIREMENTS FOR**

FREQUENCY COMPARATOR CM-77A/USM

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
1	H,D	TRANSFORMER, VARIABLE POWER CN-16/U	5950-00-235-2086	
2	H,D	MULTIMETER ME-26/U	6625-00-360-2493	
3	H,D	VOLTMETER, ELECTRONIC ME-30A/U	6625-00-669-0742	
4	H,D	COUNTER, ELECTRONIC DIGITAL READOUT AN/USM-207A	6625-00-911-6368	
5	H,D	OSCILLOSCOPE AN/USM-281A	6625-00-228-2201	
6	H,D	CLIP-ON AMMETER, HEWLETT-PACKARD 428B (BEING NOMENCLATURED AND STANDARDIZED)	6625-00-816-9324	
7	H,D	GENERATOR, SIGNAL AN/URM-44A/U	6625-00-990-7700	
8	H,D	GENERATOR, SIGNAL SG-299/U	6625-00-808-5584	
9	H,D	MULTIMETER TS-352B/U	6625-00-553-0142	
10	H,D	TOOL KIT, ELECTRONIC EQUIPMENT TK-100/G	5180-00-605-0079	
11	O	TOOLS AND TEST EQUIPMENT NORMALLY AVAILABLE TO THE REPAIR TECHNICIAN-USER BY VIRTUE OF HIS ASSIGNED MISSION		
12	D	TEST SET, ELECTRON TUBE TV-2/U	6625-00-669-0263	
13	H,D	TEST SET, ELECTRON TUBE TV-7/U	6625-00-820-0064	
14	H,D	ADAPTER, TEST MX-455/U	6625-00-996-7561	
15	H,D	DUMMY LOAD, ELECTRICAL DA-404	5840-00-985-8913	

SECTION IV. REMARKS

REFERENCE CODE	REMARKS
A	By replacement of knobs, fuse, and lamp.

By Order of the Secretary of the Army:

BERNARD W. ROGERS
General, United States Army
Chief of Staff

Official:

PAUL T. SMITH
Major General, United *States Army*
The Adjutant General

Distribution:

Active Army

USASA (2)
COE (1)
TSG (1)
USAARENBD (1)
TECOM (2)
TRADOC (2)
OS Maj Comd (4)
USACC (4)
MDW (1)
Armies (2)
Corps (2)
Instl (2) except
Ft Gillem (10)
Ft Gordon (10)
Ft Huachuca (10)
Ft Carson (5)
SAAD (30)
LBAD (14)
TOAD (14)
SHAD (3)
HISA (Ft Monmouth) (33)
Ft Richardson (ECOM Ofc) (2)
Svc Colleges (1)
USASIGS (5)
USAICS (3)
USAADS (2)
USAFAS (2)
USAARMS (2)
USAIS (2)
USAES (2)
MAAG (1)
USARMIS (1)
USAERDAA (1)
USAERDAW (1)
Sig FLDMS (1)
Units org under fol TOE:-1 ea
11-500(AA-AC)
29-134
29-136

ARNG: State AC (3)

USAR: None

For explanation of abbreviations used, see AR310-50.

CHANGE No. 3

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *10 December 1973*

Operator, Organizational, Direct Support, General Support, and Depot Maintenance Manual FREQUENCY COMPARATOR CM-77A/USM

TM 11-6625-493-15, 29 September 1964, is changed as follows:

Page V, Index of Equipment Publications paragraph. Delete Index of Equipment Publications paragraph and substitute:

Indexes of Publications

a. DA Pam 310-4. Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publication pertaining to the equipment.

b. DA Pam 310-7. Refer to DA Pam 310-7 to determine whether there are modification work orders (MWO's) pertaining to the equipment.

Forms and Records paragraph. Delete Forms and Records paragraph and substitute:

Forms and Records

a. Reports of Maintenance and Unsatisfactory Equipment. Maintenance forms, records, and reports which are to be used by maintenance personnel at all maintenance levels are listed in and prescribed by TM 38-750.

b. Report of Packaging and Handling Deficiencies. Fill out and forward DD Form 6 (Report of Packaging and Handling Deficiencies) as prescribed in AR 700-58 (Army)/NAVSUP PUB 378 (Navy)/AFR 71-4 (Air Force)/and MCO P4030.29 (Marine Corps).

c. Discrepancy in Shipment Report (DISREP) (SF 361). Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38 (Army)/NAVSUP PUB 459 (Navy)/AFM 75-34 (Air Force)/and MCO P4610.19 (Marine Corps).

After the Forms and Record paragraph add the following:

Reporting of Errors

The reporting of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028, Recommended Changes to Publications, and forwarded direct to Commander, US Army Electronics Command, AMSEL-MA-C, Fort Monmouth, NJ 07703.

Items Comprising the Operable Frequency Comparator CM-77A/USM

FSN	*QTY*	*Nomenclature, part No., and mfr code*
6625-788-3780		Comparator, Frequency CM-77A/USA which includes: **NOTE** The part number isfollowed by the applicable 5-digit Federal supply code for manufacturers (FSCM) identified in SB 708-42 and used to identify manufacturer, distributor, or Government agency, etc.
6150-617-1470	1	Cable Assembly, Special Purpose, Electrical: 4 ft lg, UG-88/U, connector each end, AC-16K, 28480 (Not Installed) (Not Mounted)

*This change supersedes C 2, 5 December 1966.

FSN	QTY	Nomenclature, Part No., and mfr code
5995-829-3428	2	Cable Assembly, Special Purpose, Electrical: RG-55/U cable, UG-88/U connector ea end, 6 in. lg, 540A-16M, 28480

Page 6-1. Delete section 6 and substitute the following:

SECTION 6
DEPOT OVERHAUL STANDARDS

6-1. 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.

6-2. Applicable References

a. Repair Standards. 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. Modification Work Orders. Perform all modification work orders applicable to this equ'·ment before making the tests specified. DA n 310 lists all available MWO's.

6-3. Test Facilities Required

T.. following items are required for depot inspection standards testing:

Item	Technical manual	Common name
Multimeter ME-26/U	TM 11-6625-200-12	Multimeter.
Digital Readout Electronic Counter AN/USM-207 or equal.	TM 11-6625-700-10	Frequency meter.
Signal Generator SG-299/U.	TM 11-5134-15	Square-wave generator.
Oscilloscope AN/USM-140.	TM 11-6625-535-15	Oscilloscope.
Signal Generator AN/URM-64.	TM 11-6625-299-15	Signal generator (800-2, 100mc).
Radio Test Set AN/URM-44.	TM 11-6625-412-10	Signal generator (7-11 kmc).
Signal Generator AN/URM-52A.	TM 11-6625-214-10	Signal generator (3.8-7.6 kmc).

6-4. Oscillator Output and Dial Calibration Test

a. Connect the equipment as shown in figure 6-1 and allow the equipment to warm up for 20 minutes.

b. Unscrew the cap on the end of the ac probe of the high-frequency multimeter and plug it into the tee connector. Measure the output voltage while tuning the FREQUENCY dial throughout its full frequency range. The output voltage must remain between 1.2 and 2.1 volts.

c. Set the FINE VERNIER dial to the mid-position of its travel so that the white dot is up.

d. Set the FREQUENCY dial to each major (numbered) calibration point and read the frequency meter. The frequency indicated on the frequency meter must be within 0.5 percent of the FREQUENCY dial indication.

e. Disconnect the tee connector and multimeter from the OSCILLATOR OUTPUT connector and connect them to the FREQUENCY METER connector.

f. Measure the output voltage at the FREQUENCY METER connector while tuning the FREQUENCY dial throughout its range. The voltage must be at least 0.2 volt.

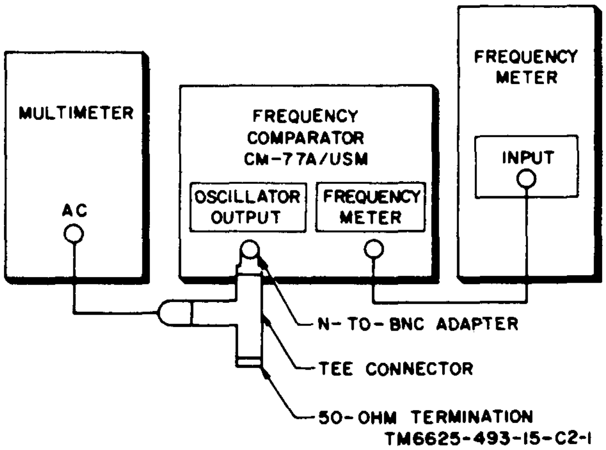


Figure 6-1. Connections for testing oscillator output and dial calibration.

6-5. Video Amplifier Gain and Response Test

a. Turn on the frequency comparator and allow 5 minutes warmup; set the three VIDEO

RESPONSE controls fully clockwise.

b. Connect the square-wave generator to the vertical input of the oscilloscope and adjust the square-wave generator to provide 0.5-volt (peak) output at 2 kc, as measured on the oscilloscope.

c. Connect the vertical input of the oscilloscope to the frequency comparator VIDEO OUTPUT connector.

d. Reduce the square-wave generator output by 40 db, and connect it to the MIXER OUTPUT connector of the transfer oscillator.

e. The waveform viewed on the oscilloscope should have an amplitude equal to or greater than that obtained in *b* above, indicating that the frequency comparator provides at least 40-db gain.

f. The overshoot on the waveform displayed on the oscilloscope must be less than 25 percent (fig. 5-2).

g. The droop of the waveform top displayed on the oscilloscope must be less than 10 percent (fig. 5-2).

h. The risetime (10 to 90 percent) of the pattern displayed on the oscilloscope (fig. 5-2) must be 0.22 microsecond or less.

6-6. Mixer Sensitivity and Frequency Response Test

Mixer sensitivity is defined as the minimum input signal power which will give an output amplitude from the mixer 6db above the noise level. Measure sensitivity and frequency response as follows:

a. Turn the three VIDEO RESPONSE controls fully clockwise.

***b.* Connect the jumper cable between the** OSCILLATOR OUTPUT connector and the LOW FREQUENCY MIXER OSCILLATOR INPUT connector (fig. 6-2).

c. Connect the multimeter to the VIDEO OUTPUT connector, to measure noise (fig. 6-2), note this reading.

d. Connect a Signal Generator AN/URM-64 to the LOW FREQUENCY MIXER SIGNAL INPUT connector (fig. 6-2).

e. Set the signal generator frequency to 1 kmc and adjust its output until the reading on the multimeter is exactly twice the voltage noted in *c* above. The input power being supplied by the signal generator is the sensitivity of the mixer at that frequency, and must be within ±10 db of the input power indicated in figure 3-2.

f. Repeat *d* and *e* above at a frequency of 4 kmc, **using Signal Generator.AN/URM-52A.**

g. Measure the frequency response of the mixer by measuring the mixer sensitivity over a range of 200 mc to 4 kmc. Use the appropriate signal generator listed in paragraph 6-3. The input power from the signal generator must be within ±10 db of the input power indicated in figure 3-2.

h. Connect the jumper cable between the OSCILLATOR OUTPUT connector and the HIGH FREQUENCY MIXER OSCILLATOR INPUT connector.

i. Repeat *d* and *e* above, using signal generators capable of measuring mixer sensitivity at frequencies of 4, 8, and 11 kmc connected to the HIGH FREQUENCY MIXER SIGNAL INPUT connector.

j. Repeat *g* above over a range of 1 to 11 kmc.

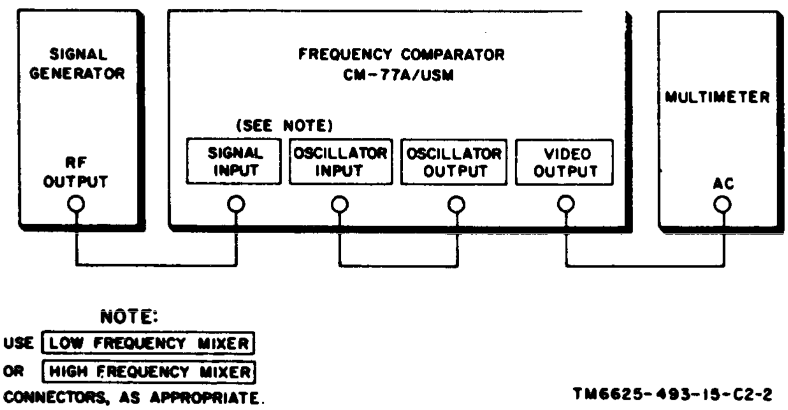


Figure 6-2. Connections for testing mixer sensitivity and frequency response.

Page i-5, appendix II. Delete appendix II.

By Order of the Secretary of the Army:

CREIGHTON W. ABRAMS
General, United States Army
Chief of Staff

Official:
VERNE L. BOWERS
Major General, United States Army
The Adjutant General

Distribution:

Active Army

USASA (2)
CNGB (1)
ACSC-E (2)
Dir of Trans (1)
COE (1)
TSG (1)
USAARENBD (1)
USAMB (10)
AMC (1)
TRADOC (2)
ARADCOM (2)
ARADCOM Rgn (2)
OS Maj Comd (4)
LOGCOMD (3)
MICOM (2)
TECOM (2)
USACC (4)
MDW (1)
Armies (2)
Corps (2)
HISA (ECOM) (21)
Svc Colleges (1)
USASESS (5)
USAADS (2)
USAFAS (2)
USAARMS (2)
USAIS (2)
USAES (2)
USAINTS (3)
WRAMC (1)
USACDCEC (10)
ATS (1)
Instl (2) except
  Fort Gordon (10)
  Fort Huachuca (10)
  WSMR (1)
  Fort Carson (5)
  Ft Richardson (ECOM Ofc) (2)
Army Dep (2) except
  LBAD (14)
  SAAD (30)
  TOAD (14)
  ATAD (10)
USA Dep (2)
Sig Sec USA Dep (5)
Sig Dep (5)
Sig FLDMS (1)
USAERDAA (1)
USAERDAW (1)
MAAG (1)
USARMIS (1)
Units org under fol TOE:
  (1 copy of each unit)
  11-158
  11-500 (AA-AC)
  29-134
  29-136

NG: State AG (3)
USAR: None
For explanation of abbreviations used, see AR 310-50.

CHANGE No. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *22 August 1966*

Operator, Organizational, Direct Support, General Support, and Depot Maintenance Manual

COMPARATOR, FREQUENCY CM-77A/USM

TM 11-6625-493-15, 29 September 1964, is changed as follows:

1. The title of this manual is changed as shown above.

2. Remove old pages and insert new pages as indicated below.

Remove pages	Insert pages
v	v
6-1 through 6-9	----------
i-0 through i-4	i-1 through i-12
69 and 70	----------

3. This transmittal sheet will be filed in the front of the publication for reference purposes.

By Order of the Secretary of the Army:

HAROLD K. JOHNSON,
General, United States Army,
Chief of Staff.

Official:
KENNETH G. WICKHAM,
Major General, United States Army,
The Adjutant General.

Distribution:

Active Army:

CNGB (1)
Dir of Trans (1)
CofEngrs (1)
TSG (1)
CofSptS (1)
OCC-E (2)
USCONARC (2)
USAMC (2)
USAMICOM (2)
USAECOM (2)
USASTRATCOM (2)
ARADCOM (2)
ARADCOM Rgn (2)
OS Maj Comd (2)
USACDCEC (10)
1st LOGCOMD (10)
9th LOGCOMD (10)
Armies (1)
Sig Fld Maint Shops (1)
USASCS (2)
USASA (2)
USACDCCEA (1)
USACDCCEA Ft Huachuca (1)
Army Depots (2) except
LBAD (6)
SAAD (6)
TOAD (6)
LEAD (7)
FTWOAD (5)
SHAD (3)
NAAD (5)
CHAD (1)
SVAD (5)
Svc Colleges (1)
1st Cav Div (5)
GENDEP (1)
Sig Sec GENDEP (4)
Sig Dep (6)
USACRREL (2)
Fort Monmouth (10)
Fort Huachuca (1)
WSMR (1)
Fort Carson (7)
Fort Knox (12)
Units org under fol TOE
(2 copies each):
11-155
11-157
11-158
11-587
11-592
11-597

NG: None.

USAR: None.

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

TECHNICAL MANUAL)
)
NO. 11-6625-493-15)

HEADQUARTERS,
DEPARTMENT OF THE ARMY
Washington, D.C. 29 September 1964

DS, GS, and Depot Maintenance Manual
Frequency Comparator CM-77A/USM

Page

Section		Page

LIST OF ILLUSTRATIONS

LIST OF TABLES

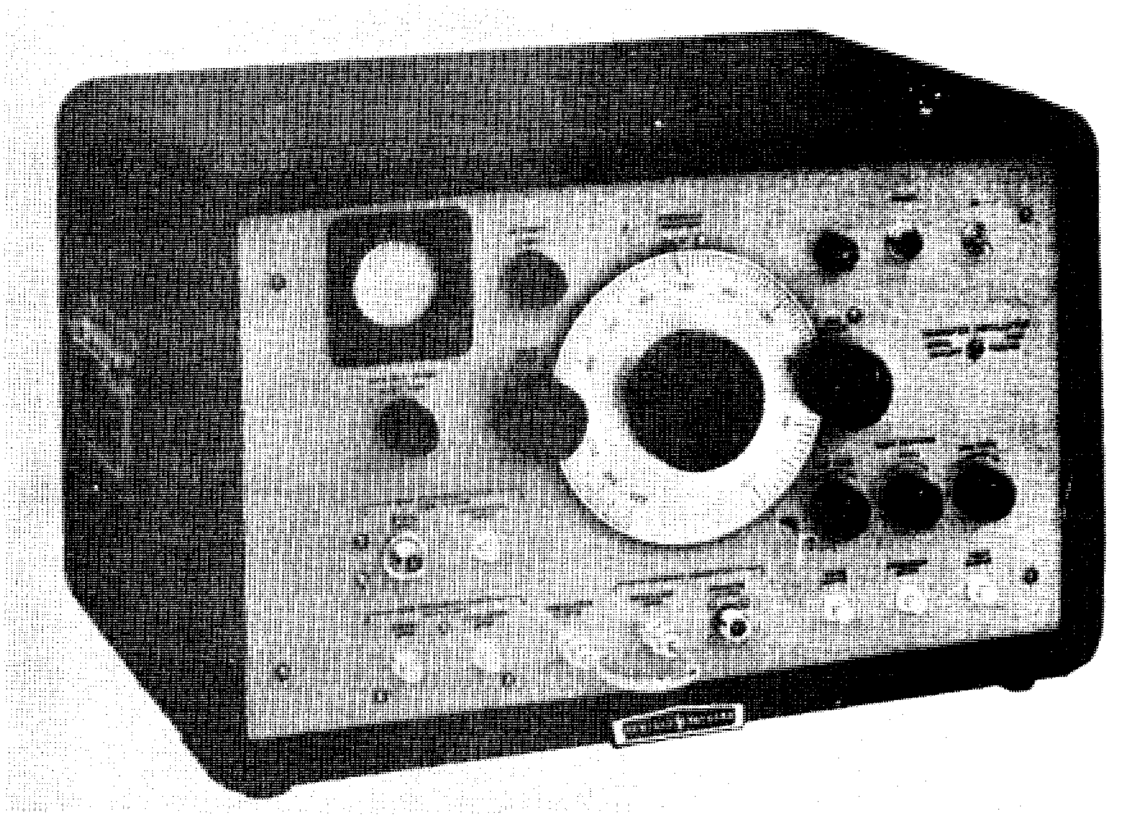


Figure 1-1. Model 540B, Front View

FOREWORD

Throughout this manual, reference is made to Model 540B Transfer oscillator which is a commercial designation and is identical with Frequency comparator CM-77A/USM. This is a first-edition manual containing preliminary and unreviewed information compiled by the manufacturer of the equipment. Judicious caution should be exercised in using the information in this manual until it is replaced by a revised edition.

Index of Equipment Publications

Refer to the latest issue of DA Pam 31C-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment. Department of the Army Pamphlet No. 310-4 is an index of current technical manuals, technical bulletins, supply manuals, 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.

Forms and Records

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

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

Reporting of Equipment Manual Improvements. The direct reporting, by the individual user, of errors, omissions, and recommendations for improving this equipment manual is authorized and encouraged. DA Form 2028 till be used for reporting these improvements. This form may be completed by using pencil, pen, or typewriter. DA Form 2028 will be completed in triplicate and forwarded by the individual using the manual. The original and one copy will be forwarded direct to: Commanding General, U. S. Army Electronics Command, ATTN: AMSEL-MR-(NMP)-MA, Fort Monnouth, New Jersey 07703.

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. PURPOSE AND USE. The Hewlett - Packard Model 540B Transfer Oscillator is an electronic frequency-measuring instrument which, extends the frequency measurement range of the Hewlett - Packard 524 and 5243 series of electronic frequency counters into the microwave region. The transfer oscillator - frequency counter combination measure frequencies up to 12.4 gigacycles (gc), or with an external mixer, up to 18 gc, with near-counter accuracy. The Model 540B can also be used without a frequency counter to measure frequency below 4 gc within about ± 1/2%.

1-3. The method used in the Model 540B Transfer Oscillator to determine frequency is to zero-beat the unknown input signal with a harmonic of an extremely-stable signal generated in the 540B, and to measure the 540B fundamental frequency on a counter. Multiplying the counter readout by the number of the harmonic causing the zero-beat gives the input signal frequency. The harmonic number is determined either from previous knowledge of the input frequency or by computation. The zero-beat is displayed on the 540B internal oscilloscope. Typical difference-frequency displays obtained are shown in figures 3-4 and 3-5.

1-4. The visual dieplay of the difference frequency between two signals permits reading microwave carrier frequencies to very close tolerance while the signal is being amplitude- or frequency-modulated, or when it contains troublesome e amounts of noise. It also permits measuring the incidental frequency modulation in amplitude-modulated carriers, the residual frequency modulation in cw signals and the center fre*quency and* Iimits of deviation in frequency-modulated signals. When the 540B is used in conjunction with an external oscilloscope, the carrier frequency of rf pulses can also be measured to high accuracy. Typical beat-frequency displays of pulse-modulated carriers are shown in figures 3-10 and 3-11.

1-5. ACCURACY OF MEASUREMENT. The stability of the transfer oscillator and the precision with which it can be adjusted are sufficient that the high accuracy and resolution of the electronic counters used for readout are utilized over the entire frequency range. Accuracies up to 1 part per million may be expected with cw signals that are very stable and noise-free. Few radio-frequency (rf) signals are stable enough to be measured with such accuracy. Thus, the instability of the signal being measured is usually the greatest accuracy-limiting factor.

1-6. When measuring pulsed signals, accuracy depends to some extent *on* pulse length because measurement can take place only during the pulse. Typical accuracy obtainable when measuring a stable, pulsed carrier of 1000 mc is approximately 3 parts per million for a 10-microsecond pulse duration and 10 parts per million for a 2. 5-microsecond pulse.

1-7. DESCRIPTION *OF* EQUIPMENT. The transfer oscillator is a single-unit, cabinet-mounted instrument. The electronic circuitry haa four main groups which can be interconnected by front panel jumpers for a variety *of* measurement applications. The four groups are shown in the block diagram in figure 1-2, and listed below:

a. Oscillator Section. An internal oscillator generates a frequency from 100 to 220 mc, which is continuously adjustable by front panel controls. This frequency is applied to frequency mixers and to an external frequency counter for accurate frequency indication.

b. Frequency Mixers. There are two mixers, a low frequency mixer for input signals from about 10 mc to 5 gc and a high frequency mixer for input signals from 1 gc to 12.4 gc. The oscillator output is connected to the proper mixer through a front panel jumper. The mixer generates harmonics of the oscillator signal which beat with the input signal and produce low-frequency beat signals which constitute the mixer output.

c. Amplifier-Oscilloscope Section The amplifier amplifies the mixer output to display the beat frequency on the built-in oscilloscope. The amplified mixer output is also available for display on an external oscilloscope. With the mixer output being displayed on the oscilloscope, the frequency of the oscillator can be adjusted until one of its harmonica produces a zero-beat indication. The zero-beat indication on the oscilloscope differs in shape as different types of signals having varying amounts of modulation or noise are measured.

d. Harmonic Generator. This separate harmonic generator section may be used to produce higher-order harmonics of the oscillator frequency for external amplification and use.

1-8. ACCESSORIES FURNISHED. The Model 540B Transfer Oscillator includes as part of the equipment a 6-inch coaxial cable jumper with type BNC connectors for use in programming connections between the jacks on the front panel, and a 4-foot coaxial cable with type BNC connectors for connecting the transfer oscillator to the electronic counter.

1-9. DIFFERENCES IN INSTRUMENTS.

1-10. This manual applies directly to 540B Transfer Oscillators having the serial-number prefix 234. The manual with the following changes aleo applies to 540B Transfer Oscillators having serial-prefix numbers 128, 046, 015, 008, and the earlier prefix 129 for serials between 101 and 597.

Table 1-1. Specifications

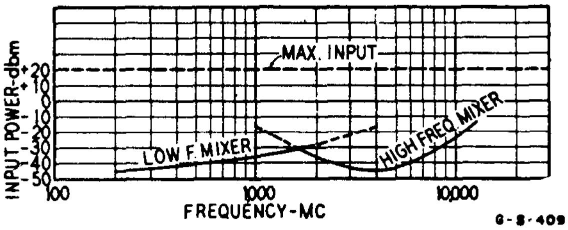
GENERAL

Frequency Range: 10 mc to at least 12.4 gc

Type of Input Signal: CW, AM, FM, or pulse

Maximum Input: 100 mw

Typical Sensitivity:



Accuracy: Depends on character of unknown signal, accuracy of comparison, and accuracy with which fundamental is measured. See discussion in text.

Auxiliary Equipment:
- ⓗⓟ Model 524 Sertes Electronic Counter
- ⓗⓟ Model 525B Frequency Converter Unit
- ⓗⓟ Model 150A Oscilloscope (for pulse measurement)

OSCILLATOR

Fundamental Frequency Range: 100 mc to 220 mc

Harmonic Frequency Range: Above 12.4 gc

Stability: Less than 0.002% change per minute after 30 minutes warmup

Dial: Six-inch diameter, calibrated in l-me increments. Accuracy ± 1/2%

Vernier Dial:
- Mechanical - approximately 9:1
- Electrical - approximately ± 125 parts/million

Output: Approximately 2 volts into 50 ohms. Adjusted for optimum crystal harmonic generation.

AMPLIFIER

Gain: Adjustable, 40 db maximum

Bandwidth: 100 cycles to 2 megacycles

High Frequency Control: 3-db point adjustable from below 1 kc to above 2 mc

Low Frequency Control: 3-db point switched from 100 cycles to below 10 kc, then continuously adjustable to above 400 kc

Maximum Undistorted Output: 1 volt rms usable signal across 1000-obm load

OSCILLOSCOPE

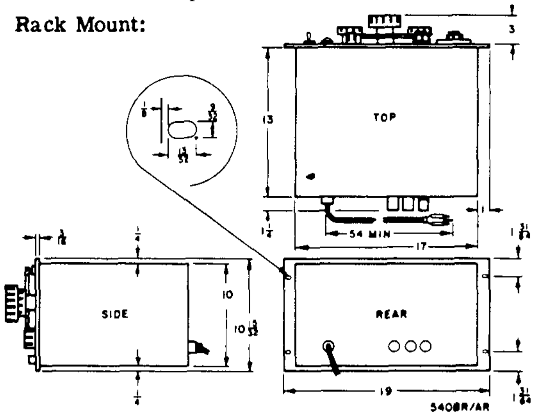
Frequency Range: 100 cps to 200 kc

Vertical Deflection Sensitivity: 5 mv rms per inch

Horizontal Sweep:
- External, 1 volt per inch, 20 cps to 5 kc
- Internal, power supply frequency with phase control

MISCELLANEOUS

Dimensions:
- Cabinet Mount: 20-3/4 in. wide, 12-1/2 in. high, 15-1/4 in. deep
- **Rack Mount:**



Weight: Cabinet Mount: 42 lb, shipping 53 lb
Rack Mount: 35 lb, shipping 50 lb

Power Supply: 115 or 230 volts ± 10%, 50 to 1000 cps, approximately 110 watts

Accessories Furnished: ⓗⓟ AC-16K Cable Assem-bly, 3 ft of RG-58/U 50-ohm coaxial cable terminated at each end with UG-88/U type BNC male connectors

Accessories Available:

ⓗⓟ AC-16C Cable Assembly, 6 ft of RG-9A/U 50-ohm coaxial cable terminated at one end with a UG-21B/U type male connector and with a UG-23 B/U type N female connector at the other. (For use at frequencies below 4000- mc.)

ⓗⓟ AC-16D Cable Assembly, 44 in. of RG-58/U 50-ohm coaxial cable terminated at one end only with a UG-88/U type N BNC male connector

ⓗⓟ AC-16F Cable Assembly, 6 ft of RG-9A/U 50-ohm coaxial cable terminated at each end with UG-21B/U type N male. connectors. (For use at frequencies; below 4000 mc.)

ⓗⓟ AC-16Q Cable Assembly, 6 ft of specially treated RG-9A/U 50-ohm coaxial cable terminated at each end with UG-21B/U type N male connectors. Each cable is tested and selected for minimum vswr at frequencies above 4000 mc.

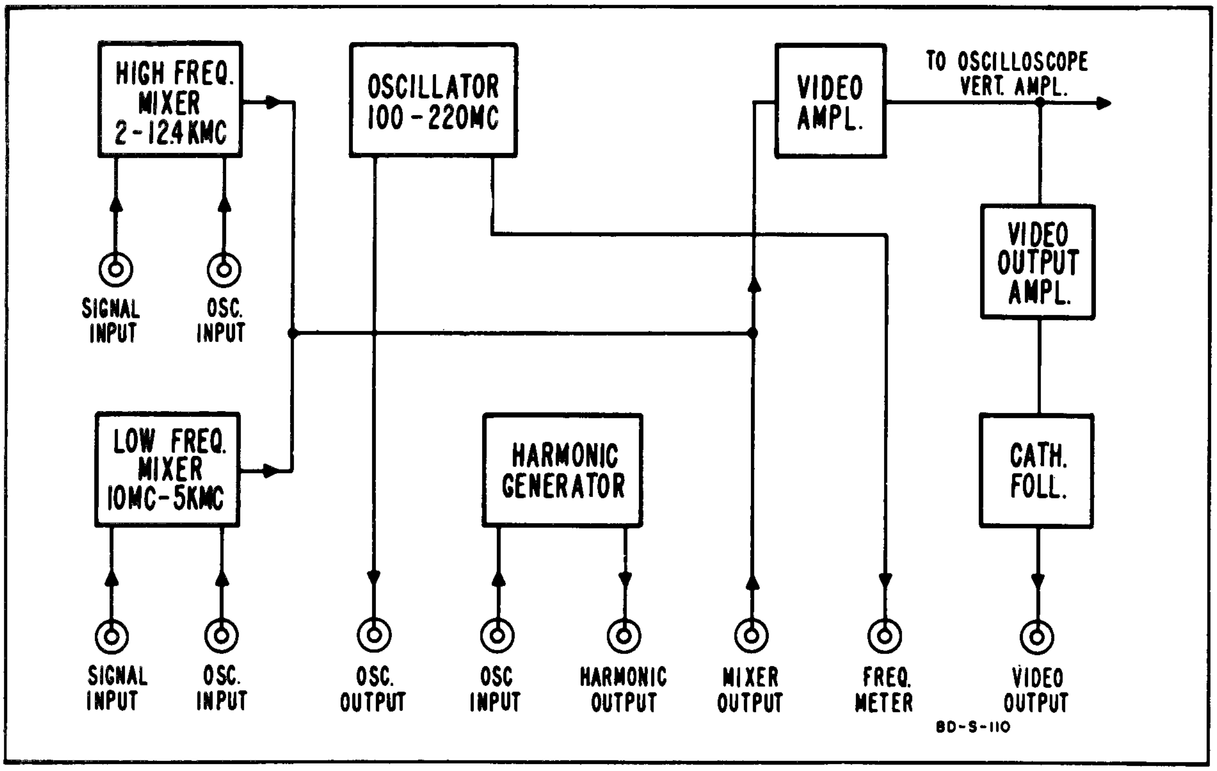


Figure 1-2. Diagram of Panel Connections and Functional Groups

1-11. To adapt this manual to instruments with other instrument serials, make changes as follows:

Instrument Serial No.	Change No.
129-01577 to 128-02701	1, 2
046-01191 to 046-01516	1, 2
015-00698 to 015-01190	1, 2, 3
008-598 to 008-697	1, 2, 3
129-00101 to 128-00597	1, 3, 4

1. S4. Delete slide switch from schematic diagram, parts lists, table 3-1. Refer to paragraph 2-9 for details.

   Q1, R76, R77, C49. Delete these parts from schematic diagram, parts lists, and replace with R2, Resistor, fixed, composition, 1200 ohms ± 10%, **1/2 watt, ⓗ stock No. 0687-1221, Mfr 01121.**

2. Gear, frequency drive, large driving; change stock number in parts lists to G36-H.

   Gear, frequency drive, large spring loading; change stock number in parts lists to G24-G.

   Window, frequency dial; change stock number in parts lists to G99-H.

3. L8. Delete choke from schematic diagram and parts Mats. Replace with wire jumper connected to junction of J13 and L5.

4. Regulated B+ at Vll pins 3 and 6; change to +225 volts, Decrease by about 7% the values of all tube socket voltages listed for all tubes except V6, V8, V10, Vll, V12, and V13.

   R12. Change value to 27,000 ohms, **ⓗ stock No.** 0690-2731.

   R17. Change value to 1800 ohms, **ⓗ stock No.** 0687-1821.

   C47. Change value to 470 pf,**ⓗ stock No. 0140-** 0027,

   Gear, frequency drive, large driving; changeⓗ stock No. in parts lists to 200AB-36B.

   Gear, frequency drive, large spring loading; change ⓗ stock No. in parts lists to 200AB-36C.

SECTION II

INSTALLATION

2-1. UNPACKING AND INSPECTION

2-2. Unpack the Transfer Oscillator upon receipt and inspect it for signs of physical damage such as scratched or dented surfaces, bent or broken projections, etc.

When possible, also attempt operation of the instrument as a further check for damage in shipment. Preserve the packing materials and case for future reshipment. The materials are designed to give best protection against normal shipping hazards.

2-3. REPACKING FOR SHIPMENT.

2-4. If possible use original packing materials and carton for repacking. If it is not available, first wrap instrument in plastic of smooth, heavy paper to protect surface against scratching. Use liberal quantity of “stuffing” between entire instrument and heavy shipping carton or box. The stuffing materials should be firm, should prevent motion of the instrument in the container, and absorb vibration as much as possible. Seal the shipping carton with steel bands or heavy tape. Mark the shipping box “FRAGILE” - "DELICATE INSTRUMENT”.

2-5. POWER CABLE.

2-6. The Transfer Oscillator is equipped with a three-conductor power cable which, when plugged into the appropriate receptacle, grounds the instrument chassis. The offset round pin on the plug is the ground connection. To preserve the ground connection when using a three-pin to two-pin adapter in a two-pin receptacle, connect the green pigtail lead on the adapter to ground (the receptacle mounting box may provide a good ground connection).

2-7. OPERATION FROM 115- OR 230-VOLT LINE.

2-8. The Transfer Oscillator may be operated on either 115- or 230-volt line as selected by a slide switch on the rear of the instrument chassis (earlier models were not equipped with this switch and required rewiring of the power transformer primary winding as described below). The slide switch can be operated with a screwdriver; for operation on 115 volts, slide switch down so that “115” is exposed; use a 1.25-amp fuse. For 230-volt operation, slide switch down so that “230” is exposed; use a O. 75-amp fuse.

2-9. For Transfer Oscillators having serial number prefixes 129, 048, 015, and 008, the power transformer primary winding was connected as shown in figure 2-1 for 115-volt operation. To connect for 230-volt operation remove the jumpers marked “115 v“ and install the jumper marked “230 v“. The connections are easily made on a tie strip mounted next to the power transformer.

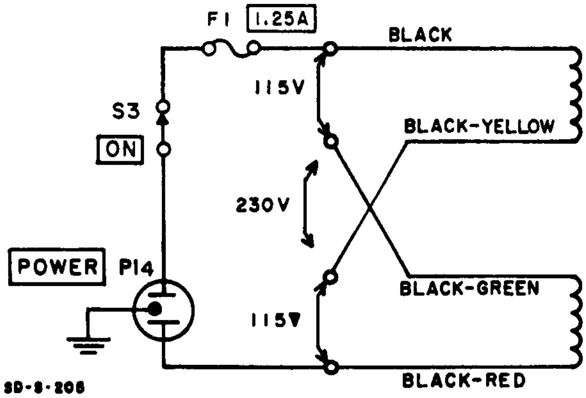


Figure 2-1. Power Transformer Primary Winding

2-10. OPERATION ON LINE FREQUENCIES HIGHER THAN 120 CYCLES PER SECOND

2-11. The Transfer Oscillator can be operated on any frequency from 50 to 1000 cycles per second. The internal sweep for the front-panel oscilloscope gives adequate phase control with line frequencies up to 120 cps. Above this line frequency, the proper degree of phase control can still be obtained by decreasing the value of C24 according to the following equation:

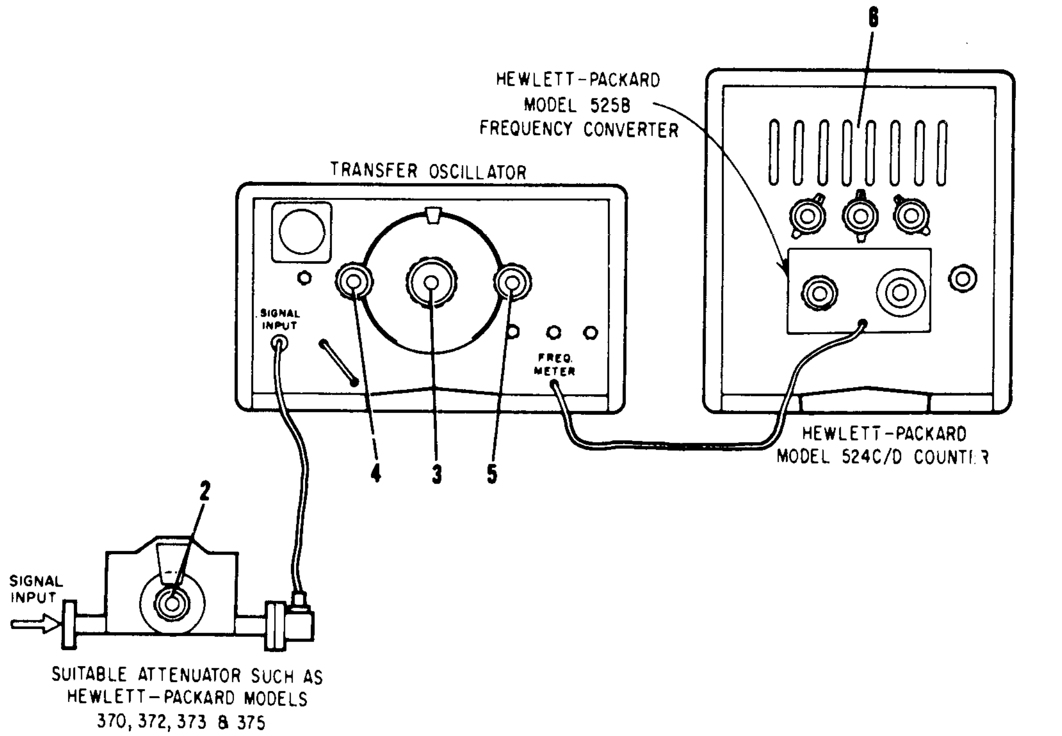
$$C\ (\text{in}\ \mu f) = \frac{13.2}{f\ \text{line}\ (\text{in cps})}$$

For example: with 400 cps line frequency,

$$C = \frac{13.2}{400} = 0.033\ \mu f$$

2-12. INSTALLATION

2-13. No special operating precautions are necessary for installing the Transfer Oscillator except when it is to be operated near vibrating machinery. Even though the precision oscillator in the Model 540B is not prone to microphonics, its extreme resolution makes very small frequency changes readily observable, and the effects of vibration may become apparent. If vibrating machines disturb frequency measurements, shock-mount the Transfer Oscillator by placing the cabinet model on shock-absorbing material When rack-mounted, the mass of the rack is often sufficient to reduce vibration to tolerable amounts. Details of rack-mounting the Transfer Oscillator are given in Table 1-1, Specifications.



1. Connect transfer oscillator as shown, using the appropriate mixer.
2. Adjust input signal to below 100 milliwatts.
3. Set FREQUENCY dial to approximate fundamental frequency.
4. Adjust COARSE VERNIER to obtain a pattern on the oscilloscope.
5. Adjust FINE VERNIER to obtain a stable pattern.
6. Read fundamental frequency on electronic counter.
7. Multiply the fundamental frequency by the harmonic number. This is the frequency being measured.

Figure 3-1. Measuring CW and FM Signals

SECTION III

OPERATING INSTRUCTIONS

3-1. INTRODUCTlON.

3-2. This section gives step-by-step procedures for measuring the frequency of the three most common types of microwave signals, continuous wave, frequency modulated and pulsed signals. The instructions for measuring c-w signals are basic to all measurements made with the Transfer oscillator and must be understood before proceeding with any other measurement technique. Instructions are aleo included for special uses of the Transfer oscillator.

CAUTION

Apply no more than 100 milliwatt r-f power to the Transfer oscillator Input connectors. To do so will damage the mixer crystal diodes.

3-3. MEASURING FREQUENCY.

3-4. GENERAL. To measure the frequency of an unknown signal applied to the input of the Transfer Oscillator, tune the 540B fundamental frequency until a harmonic of this fundamental beate with the input signal, then measure the fundamental frequency on an electronic counter (or read it from the FREQUENCY dial) and multiply the fundamental by the number of the harmonic which beat with the input signal; the product is the frequency of the input signal. When measuring an input signal for the first time, one of two conditions exists: 1) the frequency of the input signal is known approximately and the number of the harmonic causing the beat can be determined by dividing the approximate input signal frequency by the fundamental and rounding off the answer to the nearest whole number; 2) the input signal frequency is completely unknown and the number of the harmonic that beats with it must be determined by tuning the 540B to two adjacent fundamental frequencies whose harmonics zero beat with the input signal, and computing the number of the harmonic, and the input frequency.

3-5. To measure the frequency of an input signal refer to figures 3-1, 3-3 and Table 3-1, and proceed as follows:

a. Plug in power cable and turn power switch to the ON position.

b. Select the mixer section which includes the frequency of the signal to be measured. Connect the jumper cable between the OSCILLATOR OUTPUT and OSCILLATOR INPUT connectors of this mixer.

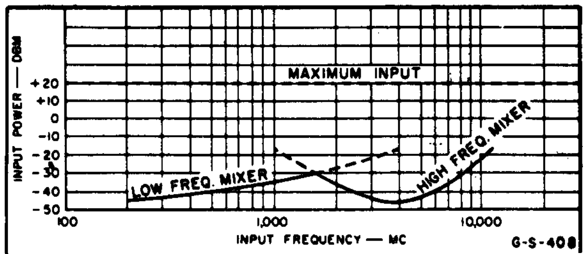
c. Set the HORIZ SWEEP INPUT switch on the rear of the chassis to INT; set the line voltage selector to the line voltage to be ueed.

d. Set the VIDEO RESPONSE-GAIN and HIGH FREQUENCY controls to maximum clockwise position.

e. Determine if the input signal level is above 100 milliwatts. If it ie, provide attenuation as shown in figure 3-1.

CAUTION

DO NOT EXCEED 100 milliwatts to either SIGNAL INPUT connector. Higher power will destroy the crystal diodes in the mixer. The minimum signal input power required to make measurements at various frequencies is shown in figure 3-2.



The values obtainable with a particular mixer may vary from the average values shown due to different crystal efficiencies, etc. Generally variations as great as ± 10 db from tbe curves may occur at some frequencies. *DBM means decibels referred to one milliwatt.

Figure 3-2. Typical Mixer Input Sensitivity

f. Connect the input signal to be measured to the SIGNAL INPUT connector of the selected mixer.

g. Connect the electronic counter (Hewlett-Packard Model 524 C/D or equivalent) to the FREQUENCY METER connector.

h. If the input frequency is known approximately, divide it by a harmonic number that gives a fundamental frequency in the range of the FREQUENCY dial. Set the FREQUENCY dial to this frequency.

i. Using a 0.01 second counter gate time and minimum display time, tune the COARSE VERNIER control until a vertical deflection is obtained on the oscilloscope. This deflection indicatee that some harmonic of the transfer oscillator's fundamental frequency is sufficiently close to the input signal to produce a difference-frequency within the bandwidth of the oscilloscope. If more than one such beat frequency is obtainable, use the highest fundamental. Tune as close to zero beat as is convenient with the COARSE control.

j. Using a 0.01 second counter gate time and infinite dieplay time, tune the FINE VERNIER control to reduce the difference-frequency to as close to zero as the stability of the measured signal will allow. Press the counter RESET bution at the instant an exact zero beat is obtained. This allows the electronic counter

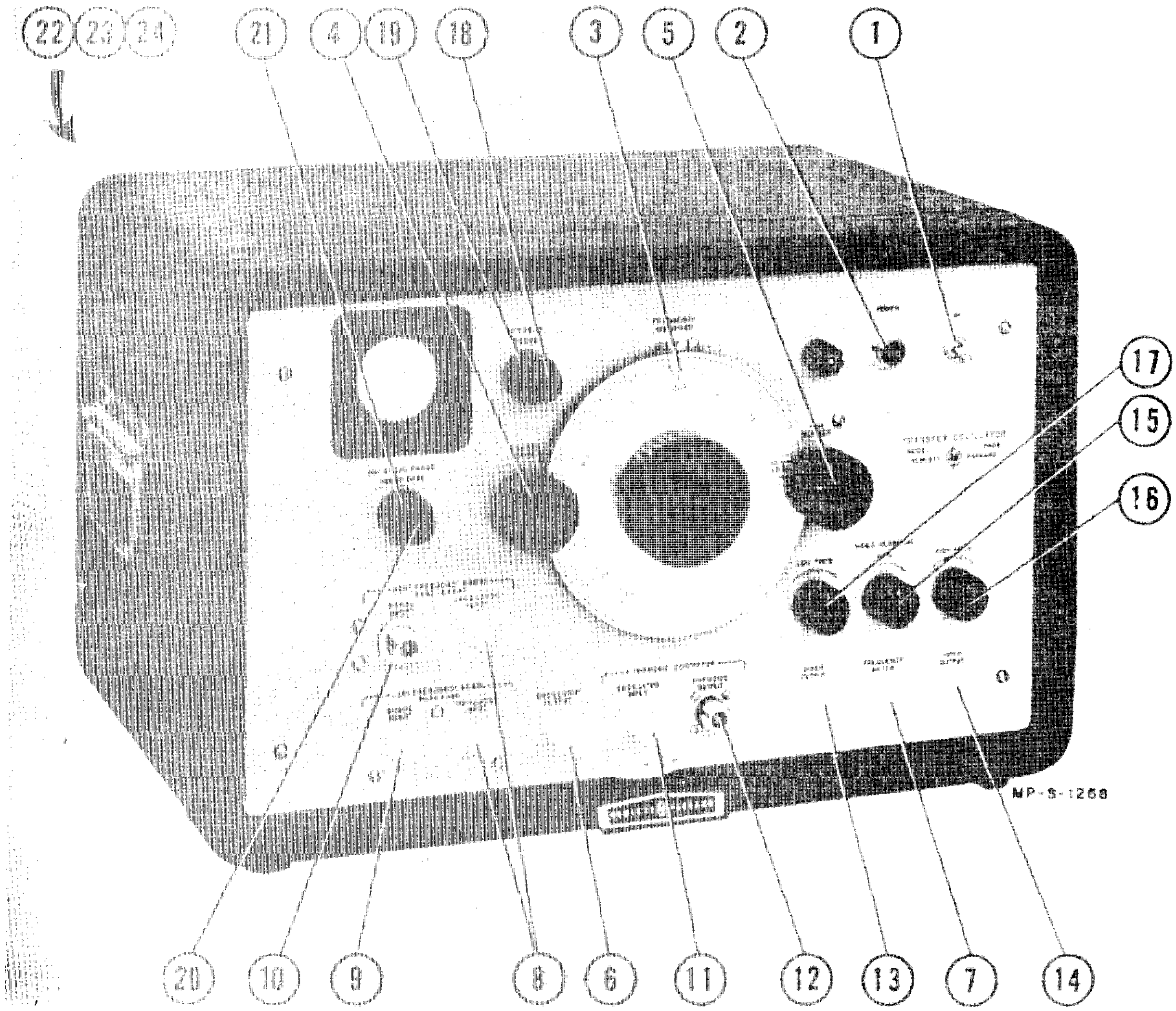


Figure 3-3. Controls. Indicators. and Connectors

Table 3-1. Function of Controls, Indicators, and Connectors (Sheet 1 of 2)

1. ON switch. In ON position, applies power to instrument. In down position, removes power from instrument.

2. POWER indicator light. Glows when power is applied to instrument.

3. FREQUENCY dial. Adjusts and indicates the fundamental frequency generated by the internal oscillator, in MEGACYLES, within 1/2 percent.

4. COARSE VERNIER dial. Adjusts the FREQUENCY dial at reduced speed.

5. FINE VERNIER dial. Adjusts the oscillator frequency electrically +125 cycles per megacycle from the frequency indicated by the FREQUENCY dial.

6. OSCILLATOR OUTPUT connector. Supplies the fundamental frequency for connection tothe Low Frequency or High Frequency Mixer, or Harmonic Generator.

7. FREQUENCY METER connector. Supplies an output of the oscillator frequency for connection to an external electronic counter.

Table 3-1. Function of Controls, Indicators, and Connectors (Sheet 2 of 2)

8. HIGH FREQUENCY MIXER OR LOW FREQUENCY OSCILLATOR INPUT connectors. Accepts the fundamental frequency from the OSCILLATOR OUTPUT connector.

9. LOW FREQUENCY MIXER SIGNAL INPUT connector. Accepts an input signal of 5 gc or less whose frequency is to be measured. This signal is mixed with harmonics of the oscillator frequency and the resultant signal is supplied at the MIXER OUTPUT connector.

10. HIGH FREQUENCY MIXER SIGNAL INPUT connector. Accepts an input signal between 1 and 12.4 gc whoee frequency is to be measured. This signal is mixed with harmonics of the oscillator frequency and the resultant signal is supplied at the MIXER OUTPUT connector.

11. HARMONIC GENERATOR OSCILLATOR INPUT connector. Accepts the signal from the OSCILLATOR OUTPUT connector for generation of higher-order harmonics obtainable at the HARMONIC OUTPUT connector. When the transfer oscillator is used for frequency measurement, the necessary harmonics are generated in the mixer, and this harmonic generator section is not used.

12. HARMONIC GENERATOR HARMONIC OUTPUT connector. Provides high-order harmonics of the signal applied to the HARMONIC GENERATOR OSCILLATOR INPUT connector. These harmonics are for mixing with input signal frequencies above 12.4 gc using an external mixer. The output of the external mixer is then applied to the MIXER OUTPUT connector for display.

13. MIXER OUTPUT connector. Supplies the output signal from the Low or High Frequency Mixer for use by external equipment these mixer outputs are internally connected to the amplifier-oscilloscope section for display). This connector may also receive the output of an external mixer for display on the internal oscilloscope.

14. VIDEO OUTPUT BNC connector. Supplies the amplified output of the mixers for use by external equipment. Gain and bandwidth are controlled by the three VIDEO RESPONSE controls.

15. VIDEO RESPONSE-GAIN control. Controls amplification of the output from either internal mixer or from an external mixer connected to the MIXER OUTPUT jack, which drives the oscilloscope sod is available at the VIDEO OUTPUT connector.

16. VIDEO RESPONSE-HIGH FREQ control. *Ad*justs the frequency of the upper 3 db point of the amplified mixer output signal to the oscilloscope and the VIDEO OUTPUT connector from below 1 kc to above 2 mc.

NOTE: Although the signal available at the VIDEO OUTPUT connector has a 2 mc bandwidth the oscilloscope responds only to frequencies up to approximately 200 kc.

17. VIDEO RESPONSE-LOW FREQ control. Adjusts the frequency of the lower 3 db point of the mixer signal at the MIXER OUTPUT jack; does not affect the bandwidth of the oscilloscope. At the extreme clockwise position, the 3 db point is switched to 100 cps. Moving off the extreme CW position the 3 db point is switched from 100 CPS to 10 kc, and then is continuously adjustable to above 400 kc as the control is turned counterclockwise.

18. FOCUS control. Adjusts the focus of the oscilloscope trace.

19. INTENSITY control. Adjusts the intensity of the oscilloscope trace.

20. HORIZ GAIN control. Adjusts speed to compress or widen the presentation.

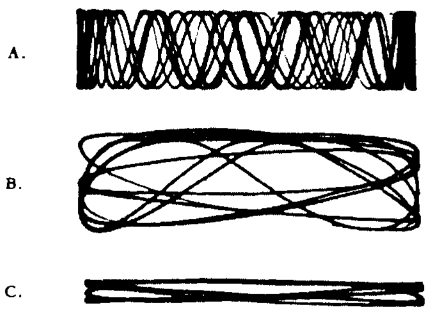
21. 60 CYCLE PHASE control. Adjusts the phase of the internal, power line frequency sweep to position the zero-beat frequency indication in the center of the screen.

22. HORIZ SWEEP INPUT toggle switch (on rear panel). In INT. position, provides a line-frequency sine-wave sweep for the oscilloscope, with phase adjustable by the front panel 60 CYCLE PHASE control. In EXT. position, allows a sweep signal to be provided from an external source connected to HORIZ SWEEP INPUT connector, and disables the front panel 60 CYCLE PHASE control.

23. HORIZ SWEEP INPUT BNC connector (on rear panel). Accepts an external sweep signal. External sweeps must have an external phase control to position the zero-beat indication. This is used to synchronize the sweep when the carrier being measured is modulated at a rate different from the power line frequency.

24. FREQUENCY CONTROL BNC connector (on rear panel). Receives an externally-genetated, adjustable voltage or resistance to adjust the oscillator output frequency. The maximum frequency variation from this control ie less than 0. 1%.

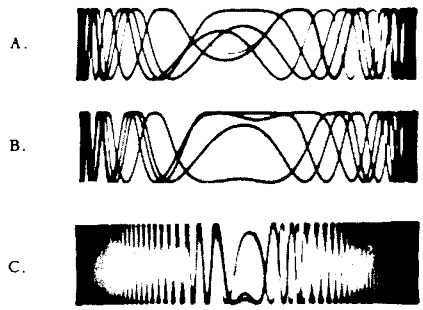
to measure the, transfer oscillator fundamental frequency at a precise moment, then hold the display. On stable signals the oscilloscope trace will resemble figure 3-4. Absolute zero-beat will be obtained when the oscilloscope trace collapses into the horizontal line. Since the frequency of most signals measured is not stable enough to achieve this indication completely, various looped patterne are obtained as the measured frequency drifts about the exact point of zero-beat. Patterns such as illustrated in figure 3-5 are sufficiently close to zero-beat for most measurements, and are more practical to use than attempting to obtain a perfect zero-beat. Adjust the characteristic of the pattern by adjusting the VIDEO RESPONSE-GAIN and HIGH FREQ. controls as desired.



When a very stable cw signal is being measured, the operator can initially adjust the transfer oscillator frequency until a beat-frequency presentation similar to A is obtained. As the operator refines the adjustment wfth the FINE VERNIER control, the oscilloscope pattern changes as shown in B and then collapses to almost-straight hortzontal lines, as shown in C when the true zero-beat is obtained. In practice, few signals are sufficiently stable to permit the simple pattern of C to be obtained. If the signal being measured has some residual frequency modulation the beat frequency patterns shown in figure 3-5 will be obtained.

Figure 3-4. Typical Sequence of Oscilloscope Patterns Obtained as Difference Frequency is Reduced to Zero, with a Stable CS Input Signal

k. The 60 CYCLE PHASE control can be adjusted to position the zero beat point in the center of the screen, provided the residual frequency modulation occure at the power line frequency. If the zero beat cannot be positioned with the 60 CYCLE PHASE control, frequency of the residual modulation on the carrier is different from the power line frequency. In thie case the zero-beat point is determined from the wideet zero-beat indication obtainable in the pattern that will sweep across the screen. If it ie necessary to etop the pattern in one place f or adequate measurement, apply to the rear HORIZ SWEEP INPUT connector a signal of the same frequency as the residual modulation of the cw input. Switch the HORIZ SWEEP INPUT switch to the EXT. position. The oscilloscope horizontal sweep will now be synchronized with the residual modulation of the cw input signal, and the pattern will be stable. If the residual frequency-



When the frequency of the unknown signal vanes slightly (has some residual frequency modulation), the difference or beat frequency viewed on the oscilloscope also varies, and the exact zero-beat indication till be in the center of a band of difference frequencies all shown simultaneously on the oscilloscope screen. This figure shows examples of zero-beat indications obtained with signals with varying amounts of residual frequent y modulation. Parts A and B show two typical beat-frequency responses from signals containing very minor amounts of frequency deviation; part C is the result obtained with a signal having a larger amount of frequency deviation. The exact zero-beat point is where the lines in the pattern become expanded horizontally. When such responses are obtained, notice first, that a low-beat frequency is approached, and then the exact zero-beat point begins to appear. This point moves about on the screen presentation and then disappears. Note that the zero-beat is traced twice per sweep, once in each direction, because the oscilloscope sweep is a sine wave. The 60 CYCLE PHASE control can be used to superimpose the two zero-beat traces in the center of the screen, if the residual frequency modulation occurs at power line frequency. If the zero-beat traces cannot be stopped in one place, refer to paragraph 3-5 k for instructions for connecting an external synchronizing signal.

Figure 3-5. Typical Oscilloscope Patterns Obtained when CW Input Signal has some Frequency Deviation

modulation is accompanied bv the amplitude modulation, the amplitude of the overall pattern on the oscilloscope will be altered without affecting readability or resolution. Amplitude modulation is indicated by a difference in amplitude of the pattern at the forward and backward traces on the oscilloscope. If the amplitude modulation occurs at the power line frequency, the phase control can be adjusted to superimpose the two traces and produce the familiar trapezoid associated with amplitude modulation. To measure the residual or the incidental frequency modulation, see paragraph 3-9.

1. Record the reading on the FREQUENCY dial, or the number displayed on the Model 524 C/D Frequency Counter (add the mixing frequency indicated on the Model 525B Frequency Converter, in accordance with the frequency converter instruction manual). The

counter reading is a more exact measurement of the fundamental frequency being generated by the transfer oscillator.

m. If the input frequency is known well enough that there can be no ambiguity between harmonics, divide it by the transfer oscillator fundamental frequency and round off the answer to the nearest even number. This is the number of the harmonic that beats with the input signal. If there is any ambiguity about the harmonic number, determine the exact harmonic in steps o through s.

n. Multiply the FREQUENCY dial reading or the counter indication by the harmonic number to obtain the exact frequency of the input signal.

o. Slowly increase or decrease the fundamental frequency until the next adjacent fundamental is found whose harmonic produces a zero-beat indication. Watch the oscilloscope closely to assure that a weak indication of a zero-beat is not passed unnoticed, Record this fundamental frequency.

p. Using the appropriate nomograph in figures 3-6 and 3-7, locate the higher fundamental frequency recorded in steps 1 and o on the left column and the lower fundamental frequency recorded above on the center column.

q. Place a straight-edge across the two points and intersecting the right hand column. The point of intersection on the right-hand column indicates the number of harmonic that beats with the input signal when the FREQUENCY dial is tuned to the higher of the two fundamental frequencies used.

r. If further assurance of accuracy is required, such as with input signals containing large amounts of noise, or if the input frequency is above or below those included in the nomography, use the first of the following equations to determine the input frequency, and the second or third equations to determine the harmonic.

Equation 1:

$$f_x = \frac{f_1 \times f_2}{f_1 - f_2}$$

Equation 2:

$$N_1 = \frac{f_2}{f_1 - f_2}$$

Equation 3:

$$N_2 = \frac{f_1}{f_1 - f_2}$$

where f_x = frequency of unknown input signal

f_1 = two adjacent fundamental frequencies whose harmonics produce zero beat with f_x; f_1 = higher fundamental,
f_2 = lower fundamental

N_1 = harmonic number of f_1

N_2 = harmonic number of f_2

Note

To obtain accurate answers with the above equations, the fundamental frequencies must be read to 0.01% or better. In case the input signal being measured does not have this order of stability, it may be necessary to take the average of several fundamental frequency readings for each beat-producing harmonic. With the fundamental frequencies read to 0.01% or better, the necessary division or multiplication can be carried out in longhand if highest accuracy is required, or with a slide rule if this degree of accuracy is satisfactory.

s. To check the calculation performed in the step above, measure the next adjacent fundamental whose harmonic produces a zero-beat indication. Recalculate, using the previously measured adjacent fundamental frequency.

3-6. Figures 3-6 and 3-7 are nomography of the equations given in step r of paragraph 3-5. They are useful if the input frequency is between 400 and 5000 megacycles and can be determined from two adjacent transfer oscillator fundamental frequencies which produce zero-beat indications. In the nomograph, f_x is the unknown frequency, f_1 is the higher of two adjacent transfer oscillator frequencies whose harmonics produce zero-beat indications; f_2 is the lower frequency. To use the nomograph, locate two adjacent fundamental frequencies which zero-beat with the unknown input signal. Find the higher of these two frequencies in left-hand column, the lower in the center column; place a straight-edge across these two points. The point where the straight-edge intersects the right-hand column ie the number of the harmonic which beats with f_x when the transfer oscillator is tuned to f_1, Multiply f_1 by the harmonic number to obtain the frequency of the input signal (f_x).

3-7. Transfer oscillator fundamental frequency can be read directly from the FREQUENCY dial with 1/2% accuracy. The dial reading can be used in the above equations for frequencies up to about 2000 megacycles, where low-order harmonics are used and the multiplied inaccuracy is reduced. To use the equations above 2000 mc the electronic counter must be used to read the fundamental frequency with sufficient accuracy to identify adjacent harmonics. However, if the harmonic which produces a beat frequency is already identified, unknown frequencies above 2000 megacycles can be measured to 1/2% accuracy by reading the fundamental frequency directly from transfer oscillator FREQUENCY dial.

3-8. The beat frequencies produced by the mixers in thie instrument are suitable only for frequency measurement as described in this manual. These outputs are not suitable for amplitude measurements because the mixers are designed for best frequency coverage rather than calibrated amplitude responses. A suitable external mixer must be used for applications where mixer output amplitude measurements are made.

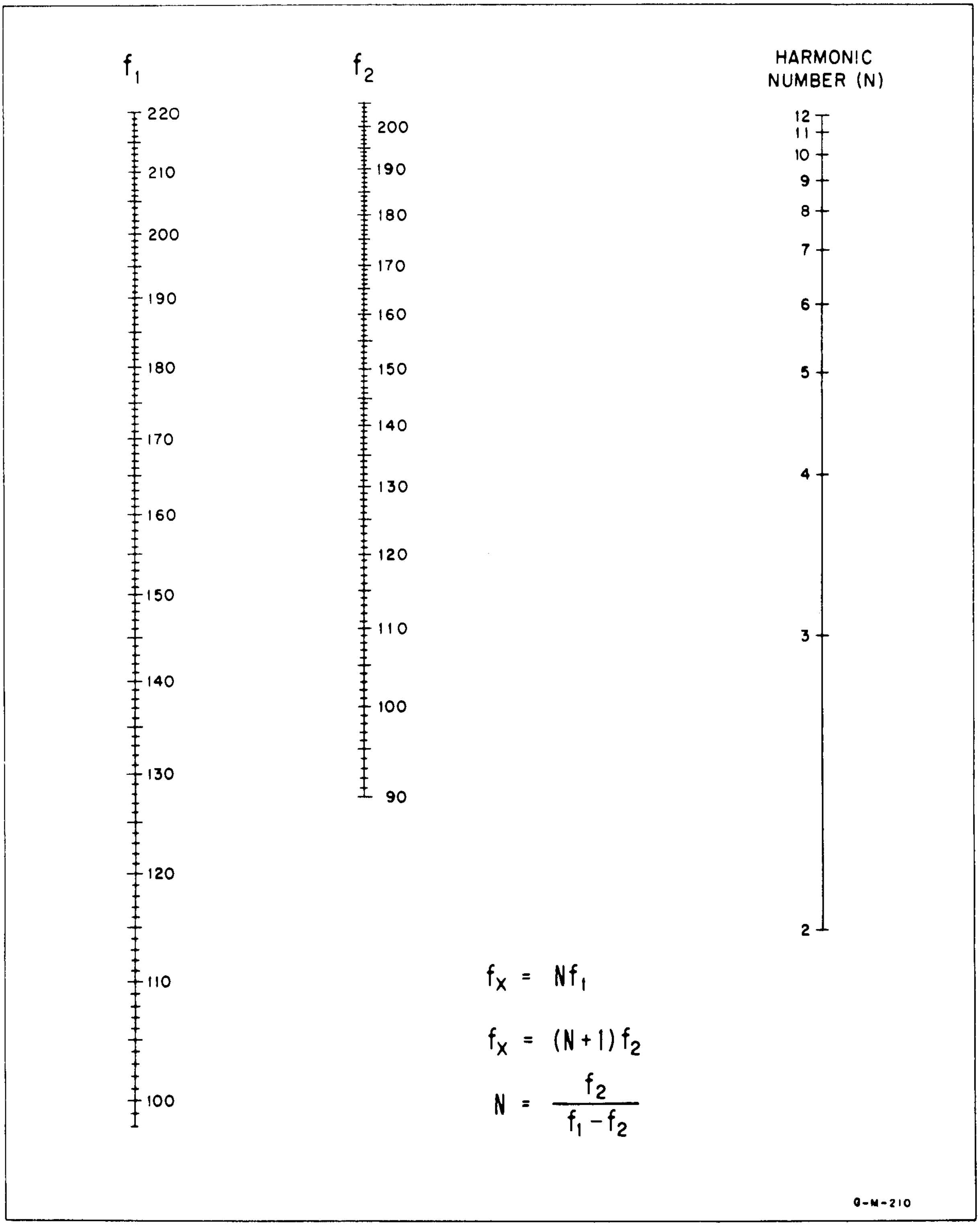


Figure 3-6. Nomograph for Determining a Harmonic Number of an Unknown Frequency Between 400 MC and 2 GC from Two Adjacent Frequencies Obtained with the 540B

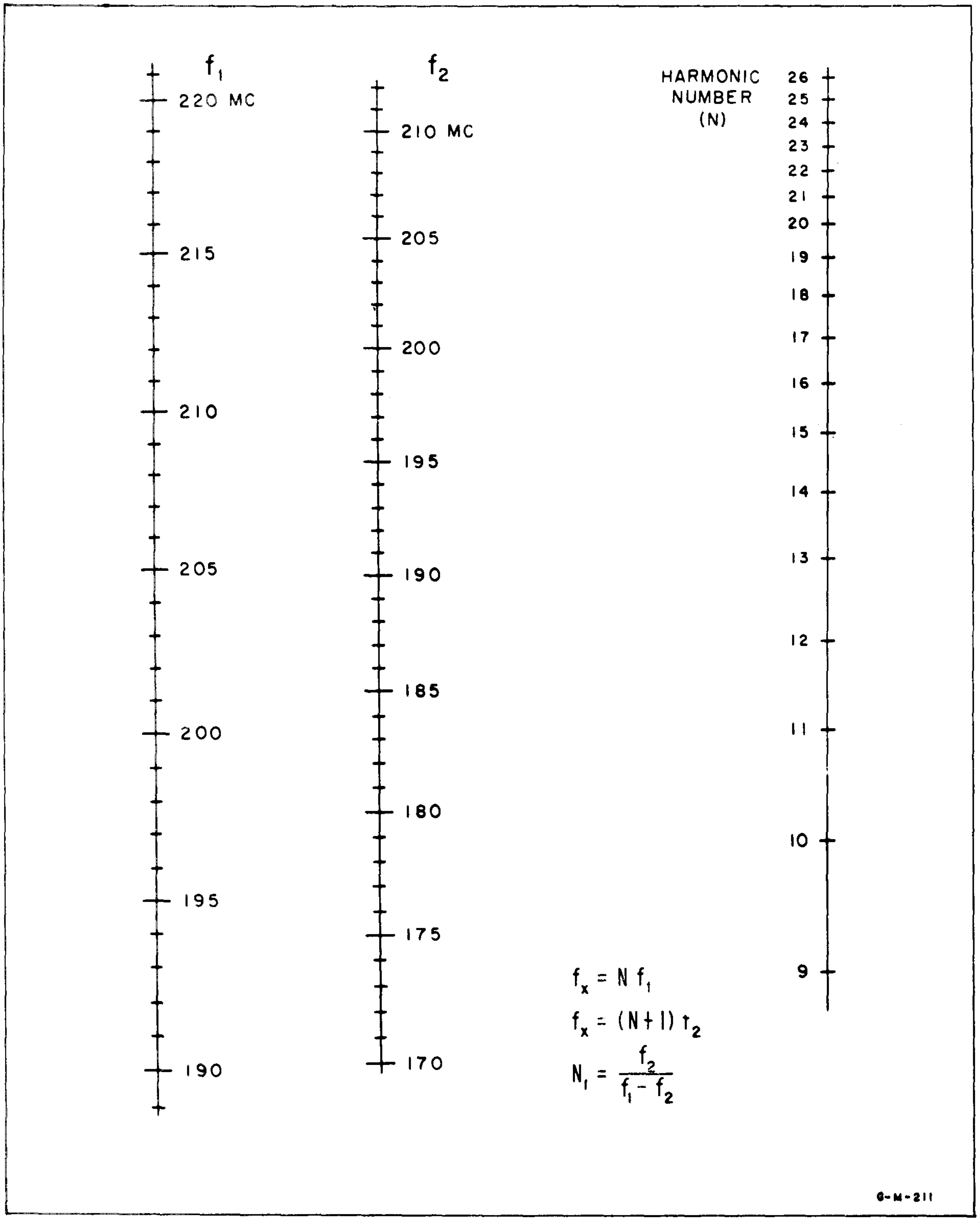


Figure 3-7. Nomograph for Determining a Harmonic Number of Unknown Frequency Between 2 and 5 CC from Two Adjacent Frequencies Obtained with the 540B

3-9. MEASURING FM CARRIER FREQUENCY AND LIMITS OF FREQUENCY DEVIATION.

3-10. To obtain readable zero-beat patterns when measuring the center-frequency and the limits of frequency deviation in frequency-modulation carriers, the oscilloscope in the Model 540B must be swept by a signal of the same frequency that modulates the carrier, The Model 540B oscilloscope is internally swept at the power line frequency. If the carrier being measured must be frequency-modulated at a rate different from the power-line frequency, this frequency signal must also be applied to the HORIZ SWEEP INPUT connector on the rear of the transfer oscillator chassis and the HORIZ SWEEP INPUT switch must be set to the EXT. position. Use sine-wave frequency modulation which results in simple zero-beat presentations; non-sinusoidal modulation gives complex oscilloscope pictures.

3-11. When an external sweep input signal is used, the 60 CYCLE PHASE control on the front panel is inoperative, and it may be necessary to externally adjust the phase of the sweep input signal to produce a stationary pattern such as shown in figure 3-8. The oscilloscope presentation obtained when measuring a frequency-modulated signal indicates much great er deviationtban when a cw signal with residual frequency modulation was measured. The width of the zero-beat point appears much smaller in relation to the full oscilloscope pattern, as shown in figure 3-8. Make measurements as follows:

a. Perform steps a through s of paragraph 3-4 to measure the carrier frequency. Refer to figure 3-8 for typical oscilloscope patterns.

b. Position the zero-beat pattern for the carrier frequency in the center of the oscilloscope screen.

c. With the FINE VERNIER control adjust the zero-beat indication slowly to one side of the oscilloscope screen, as shown in figure 3-8, parts B and C. This is either the lowest or highest frequency present in the carrier.

d. Compute this frequency as directed in paragraph 3-4, steps 1 through s.

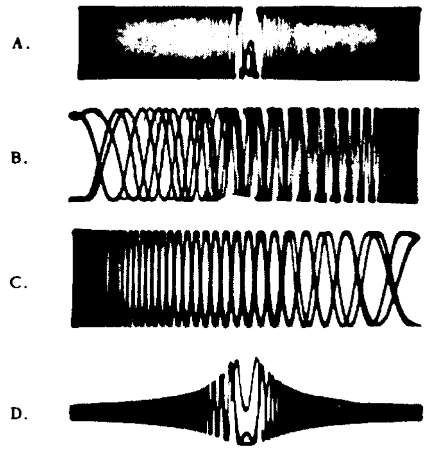
e. Adjust the zero-beat to the opposite side of the oscilloscope, which corresponds to the limit of deviation on the opposite side of the carrier frequency.

f. Compute frequency as in step d.

3-12. MEASURING PULSED RF SIGNALS.

3-13. The carrier frequency of pulsed rf signals is measured by displaying a single pulse from the pulse train as shown in figures 3-10 and 3-11, and adjusting the transfer oscillator until a harmonic produces a zero-beat indication with the carrier during the pulse. To observe a single pulse from the pulse train, an external oscilloscope with triggered sweep must be used instead of the transfer oscillator oscilloscope. Proceed as follows:

a. If the pulse width is greater than one microsecond, connect the VIDEO OUTPUT connector of the



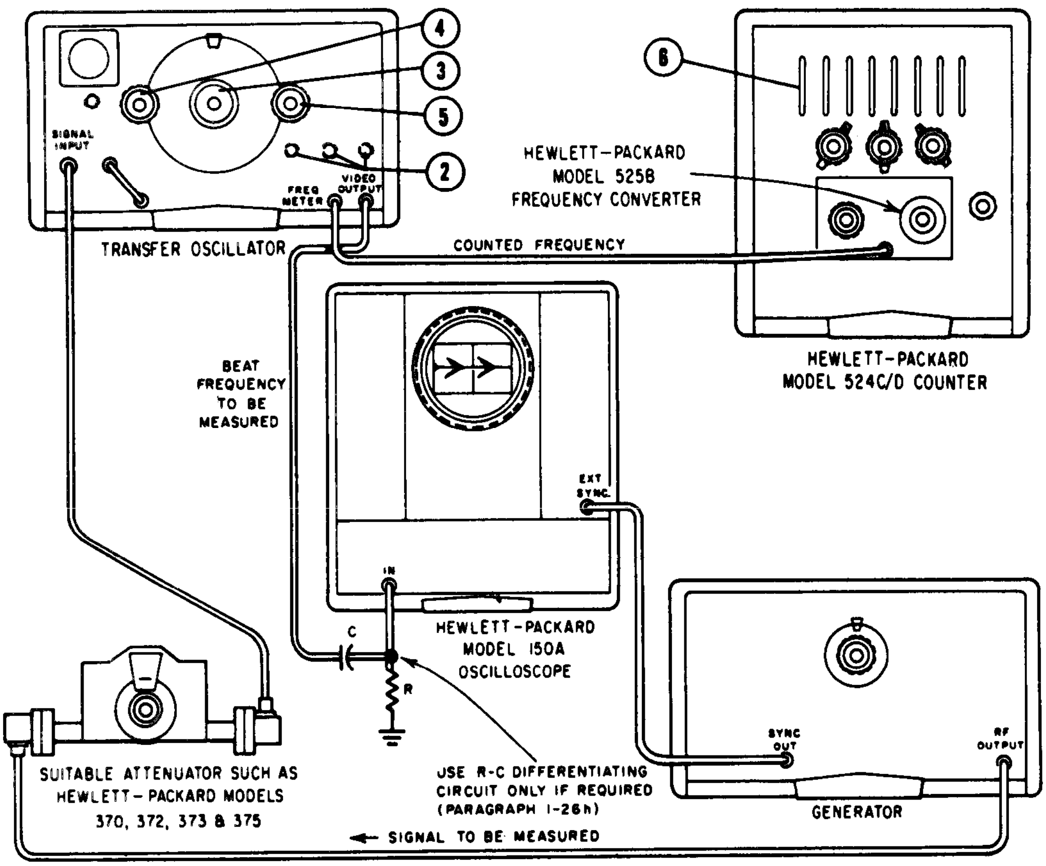
When a frequency modulated signal is being measured, the beat frequency varies at tbe rate of the frequency modulation and it is not possible to reduce the zero-beat indication to a simple horizontal line as in figure 3-11; instead, the zero-beat indication aPPears in the center of a band of difference frequencies similar to those of figure 3-5, but wfth the difference frequencies more tightly packed. The exact zero-beat point is where the lines in the pattern become expanded horizontally. Parts A and D above show the zero-beat indic atione prope rly superimposed while the transfer oscillator is properly tuned to the carrier center frequency. Tbe amplitude of the difference frequencies on either side of center in D is decreased because the frequency deviation of the carrier is so great that display of the difference frequencies is limited by the bandwidth of the oscilloscope vertical amplifier. Parts B and C show the presentation of the same signal as part A, as it appears when the transfer oscillator is properly tuned first to one limit of frequency deviation and then the other, in making a measurement of maximum deviation above and below carrier frequency.

Figure 3-8. Typical Oscilloscope Patterns Obtained when Input Signal is Frequency-Modulated

transfer oscillator to the vertical input jack of an external oscilloscope with triggered horizontal sweep. See figure 3-9 for a connection diagram.

b. If the pulse width is less than one microsecond, connect the MIXER OUTPUT connector to an external wideband amplifier, such as the@ Model 460 AR. Then connect the output of the amplifier to the vertical input jack of the oscilloscope. The external amplifier is required because the mixer output contains frequencies beyond the passband of the transfer oscillator amplifier,

c. Connect the external sync jack of the oscilloscope to the sync output of the pulsed carrier modulator. If no suitable sync output is available a usable output



1. Connect transfer oscillator as shown, using the appropriate mixer.
2. Adjust input signal to below 100 milliwatts.
3. Set FREQUENCY dial to approximate fundamental frequency.
4. Adjust COARSE VERNIER to obtain a pattern on the oscilloscope.
5. Adjust FINE VERNIER to obtain a stable pattern.
6. Read fundamental frequency on electronic counter.
7. Multiply the fundamental frequency by the harmonic number. This is the frequency being measured.

LD-S-810

Figure 3-9. Measuring Pulse-Modulated RF Signals

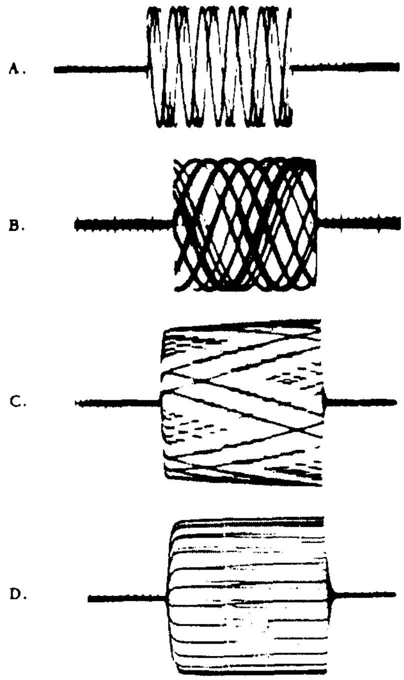
may be obtained by tapping off a portion of the pulsed carrier at a suitable point, and detecting the pulse envelope with a low-pass filter. This envelope is suitable for triggering the oscilloscope sweep.

d. Perform steps a through g of paragraph 3-5. For pulse carriers it is best to be able to adjust the input power to obtain at optimum oscilloscope pattern. If too much input power is applied in pulsed if measurements, the detected video pulse may obliterate ths desired beat frequency in the preeentaUon. Use only enough power to obtain an easily read zero-beat.

e. If using the internal amplifier, turn all three VIDEO RESPONSE controls on the transfer oscillator fully clockwise for maximum gain and bandwidth.

f. Adjust the input attenuator, initially, to provide almost 100 milliwatts of power. It may be necessary to reduce this input power to obtain an optimum zero-beat pattern.

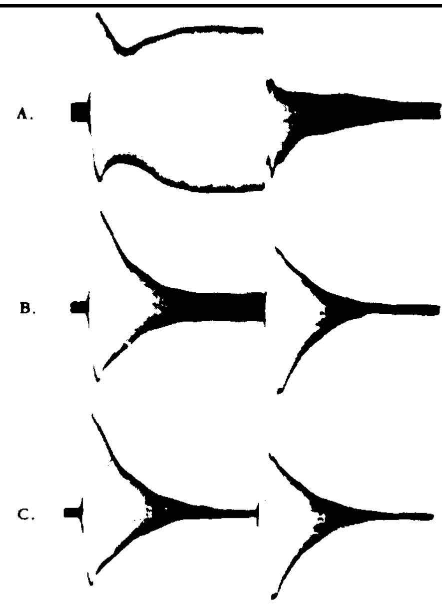
g. Adjust the fundamental frequency of the transfer oscillator to obtain the proper zero-beat pattern described below and illustrated in figure 3-10. The unknown frequency consists of pulses of an rf carrier; the mixer output consists of the difference frequency, lasting for the duration of each pulse. As the transfer oscillator is adjusted to bring a harmonic of the fundamental close to the frequency of the pulsed carrier, the difference frequency first appears as a sine wave within a pulse envelope, indicating that the difference frequency is great enough that several complete cycles



When the transfer oscillator frequency is adjusted to zero-beat wftha pulsed rf signal applied to the system, the first presentation usually recognized on the oscilloscope is similar to that of part A. In this case, about five cycles of the difference frequency occur within each rf pulse envelope. For one-microsecond pulse this corresponds to a difference frequency of about 5 mc. As the transfer oscillator is fine-tuned with the FINE VERNIER control, the number of difference-frequency cycles per pulse decreases as shown in B, and finally becomes less than one cycle, as illustrated in C. When the beat frequency is less than one cycle a pattern like that in D is obtained. The ideal zero-beat indication is when the pattern becomes agroupof horizontal traces.

Figure 3-10. Typical Patterns Obtained On External Synchronized Oscilloscope, when Measuring Pulse -Modulated RF Signals

fall within one pulse duration interval. As the zero-beat point is approached and the difference frequency is reduced to the point where less than one cycle comes within each pulse interval, the waveform within the pulse envelope changes from sinusoidal (or nearly vertical) to horizontal. The lines become nearly horizontal when the beat frequency is essentially zero, where the difference frequency has such along period that it hardly changes within each pulse interval. If the signal under test were perfectly stable, the zero-beat indication would be one horizontal line within the pulse envelope. In practice, many horizontal lines appear. The optimum zero-beat point occurs when these horizontal lines have as little slope as possible.



This presentation of the difference frequency with a pulsed rf signal dees not require resolution of individual traces to identify the zero-beat. Zero-beat is indicated when the first envelope of the differentiated signal decays to a sharp point. Parts A, B, and C illustrate difference frequencies of one, one-tenth, and one -hundredth cycle-per-pulsewidth, respectively, approximately the counterparts of B, C, and D in figure 3-10. Part C of this figure is very close to the ideal zero-beat indications.

Figure 3-11. Typical Patterns Obtained on External Synchronized Oscilloscope when the Pulse Presentations of Figure 3-10 are Differentiated at the Oscilloscope Input

h. If the pulse repetition rate ie above 5 kc, horizontal traces at the optimum zero-beat point may be too crowded for optimum selection of the “best-horizontal” presentation. In this case insert a simple R-C differentiating circuit ahead of the vertical input terminal of the oscilloscope as shown in figure 3-9. The time constant of the R-C differentiating circuit should be on the order of one-tenth of the pulse width of the pulsed carrier. The optimum zero-beat point is then indicated when the first envelope decays to the sharpest obtainable point as illustrated, in figure 3-11. If too short a time constant is used, decay to a sharp point occurs in spite of a relatively high difference frequency, indicated by a lack of sensitivity of the FINE VERNIER control over the narrowness of the decay point. If too long a time constant is used, the decay point does not narrow even at zero-beat.

i. Carry out the frequency calculation and repeat measurements for harmonic number determination, accuracy checks, etc., ase directed in steps 1 through s of paragraph 3-5.

3-14. USE OF FREQUENCY CONTROL CONNECTOR.

3-15. This rear panel connector permits electronically adjusting or frequency modulating the fundamental frequency generated by the transfer oscillator about 0.1% Variation of tbe oscillator frequency is accomplished by applying a steady or varying voltage or resistance, as desired, across the connector. The effect of this applied voltage or resistance is to alter the plate-to-ground capacity in the oscillator circuit to produce a slightly different frequency of oscillation. A constantly varying voltage or resistance will produce frequency modulation, while fixed steps of voltage or resistance will produce incremental changes in the fundamental frequency. Figures 3-12 and 3-13 show typical frequency changes, in percent, produced by various values of resistance and voltage connected across the FREQUENCY CONTROL connector. Theee are typical values which vary from instrument to instrument.

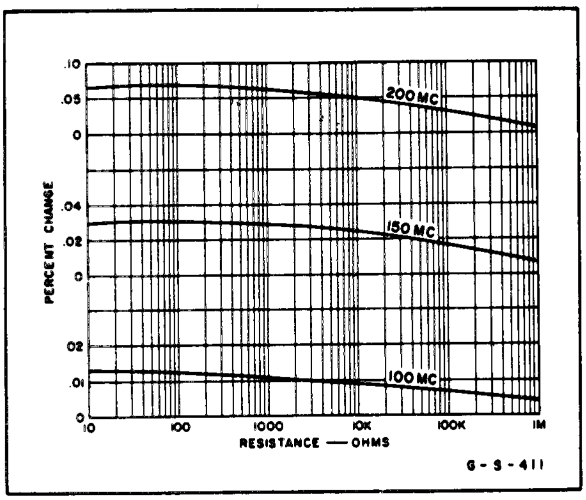


Figure 3-12. Effect of Resistance Connected Across FREQUENCY CONTROL Connector

3-16. EXTENDING THE OPERATING RANGE FROM 12.4 GC TO 18 GC.

3-17. The Model 540B Transfer Oscillator may be used to measure frequencies from 12.4 to 18 gc by the addition of an Model 932A High Frequency Mixer. This external mixer replaces the internal mixer which is net suitable above 12.4 gc. To operate the tranefer oscillator in this range, follow the same operating procedures as given in the previous paragraphs, but connect the transfer oscillator as follows (see figure 3-14):

a. Connect the transfer oscillator OSCILLATOR OUTPUT connector to the OSCILLATOR INPUT connector on Model 932A through low-loss coaxial cable.

b. Connect the VIDEO OUT connector on the Model 932A to the MIXER OUTPUT connector on the transfer oscillator through low -loss coaxial cable.

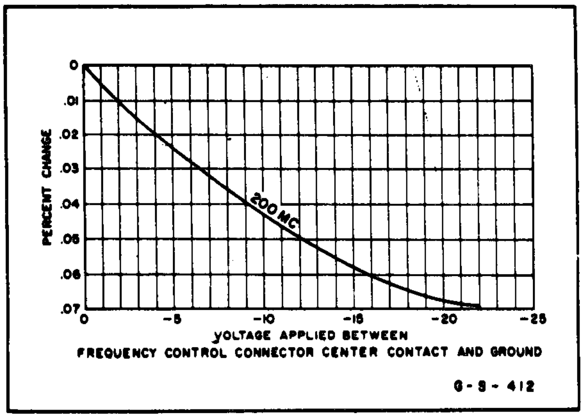


Figure 3-13. Effect of Voltage Connected Across FREQUENCY CONTROL Connector

c. Connect the unknown frequency in the range of 12.4 to 18 gc to the P-band waveguide input of the Model 932A. Use an input power greater than the minimum shown on the graph furnished with the Model 932A, but lese than 100 milliwatts.

NOTE

Greater watchfulness is required when measuring higher frequencies due to closer spacing and decreasing strength of the harmonics. In searching for zero-beat indications produced by adjacent harmonics, be careful not to skip an adjacent harmonic and unintentionally measure a non-adjacent one. As a precaution tune to a third adjacent harmonic producing a zero-beat frequency, ae shown in the example below. Uee the highest possible fundamental frequencies of the oscillator for greatest accuracy.

d. As an example of the fundamental frequencies and adjacent harmonics that should be used to determine the frequency of an approximate 18-gc carrier.

$$f_x = N_1 \text{ (81st harmonic) } \times f_1 \text{ (219.512 mc fundamental)} = 18 \text{ gc}$$

$$f_x = N_2 \text{ (82nd harmonic) } \times f_2 \text{ (216.867 mc fundamental)} = 18 \text{ gc}$$

$$f_x = N_3 \text{ (83rd harmonic) } \times f_3 \text{ (214.286 mc fundamental)} = 18 \text{ gc}$$

using the equations given in paragraph 3-5 r for computing the fundamental frequency and the number of the harmonic causing a zero beat,

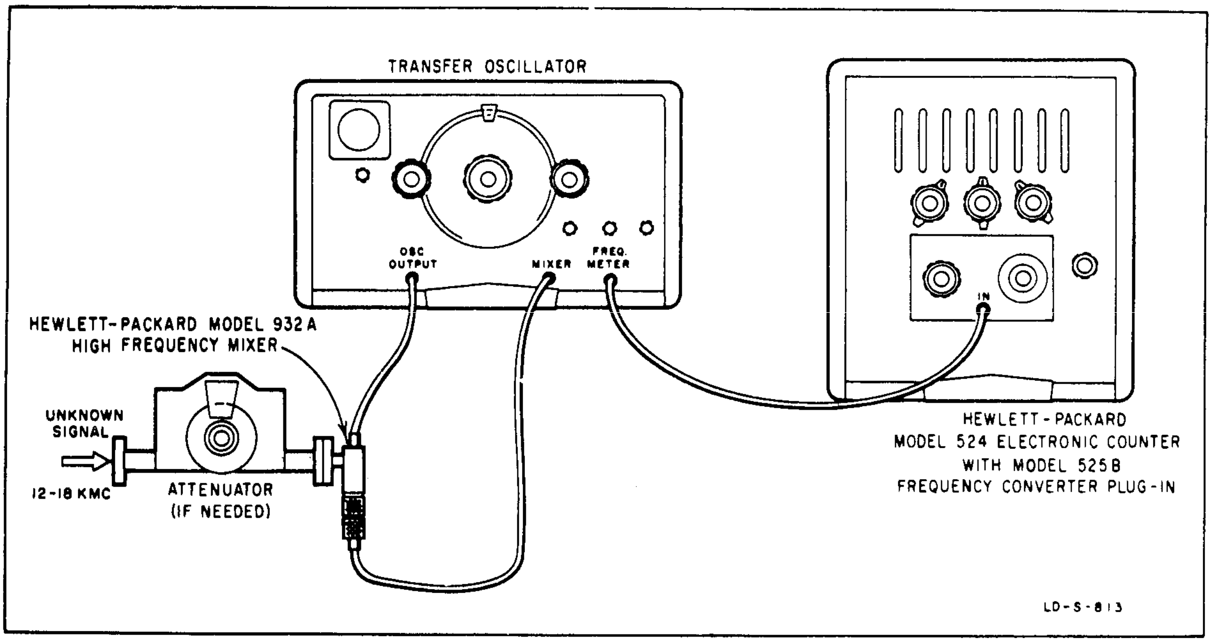


Figure 3-14. Making Measurements at Frequencies between 12.4 and 18 gc

$$f_x = \frac{f_1 \times f_2}{f_1 - f_2}, \quad \frac{47604.910}{2.645} = 17.998 \text{ gc}$$

Equation 1:

$$f_x = \frac{f_2}{f_2 - f_3}, \quad \frac{46471.6}{2.581} = 18.005 \text{ gc}$$

Equation 2:

$$N_1 = \frac{f_2}{f_1 - f_2}, \quad \frac{216.867}{2.645} = 81.991$$

Equation 3:

$$N_2 = \frac{f_1}{f_1 - f_2}, \quad \frac{219.512}{2.645} = 82.991$$

Equation 4:

$$N_3 = \frac{f_2}{f_2 - f_3}, \quad \frac{216.867}{2.581} = 84.024$$

From this example it can be seen that an error in harmonic order will be easily detected, even if computations are made on a ten-inch slide rule.

3-18. MEASURING DETAILED CHARACTERISTICS OF FM SIGNALS.

3-19. The transfer oscillator can be used in conjunction with other equipment for accurate measurement of the detailed characteristics of frequency-modulated rf carriers. The function of the transfer oscillator in this system is to reduce the frequency of the carrier to an intermediate frequency below 100 kilocycles which retains the essential modulation characteristics. These characteristics are detected by the 500B followed by a low-pass filter, and measured by various test instruments - voltmeter, oscilloscope, distortion meter, wave analyzer.

3-20. The Hewlett -Packard 500B Frequency Meter serves as a linear discriminator and converts the intermediate frequency carrier into a train of constant amplitude, constant-width output pulses -- one pulse for each rf input cycle (see figure 3-15). The average current of these pulses is directly proportional to the intermediate frequency and is used to operate the Model 500B's internal milliammeter, which is calibrated in kc. These pulses are supplied at the 500B's PULSE OUTPUT connector and are fed to the low-pass filter.

3-21. The low-pass filter blocks the 500B's output pulse train and passes the average voltage of the pulses. The voltage at the filter output varies at the rate of the original modulating frequency and its a-c amplitude is directly proportional to the degree of frequency deviation. This voltage is then connected to additional test instruments (as shown in figure 3-15) to indicate frequency deviation, carrier drift, waveshape harmonic content and distortion.

3-22. To measure frequency deviation using an ac vacuum tube voltmeter, adjust the dc voltage from the filter to be 1.414 volts when a 100-kc unmodulated signal is applied to the 500B. This system is calibrated by loading the output of the low-pass filter with a 20,000 ohm potentiometer (equal to the 500B's PULSE OUTPUT jack characteristic impedance) and adjusting the dc output of the filter to a predetermined level for a known unmodulated input frequency.

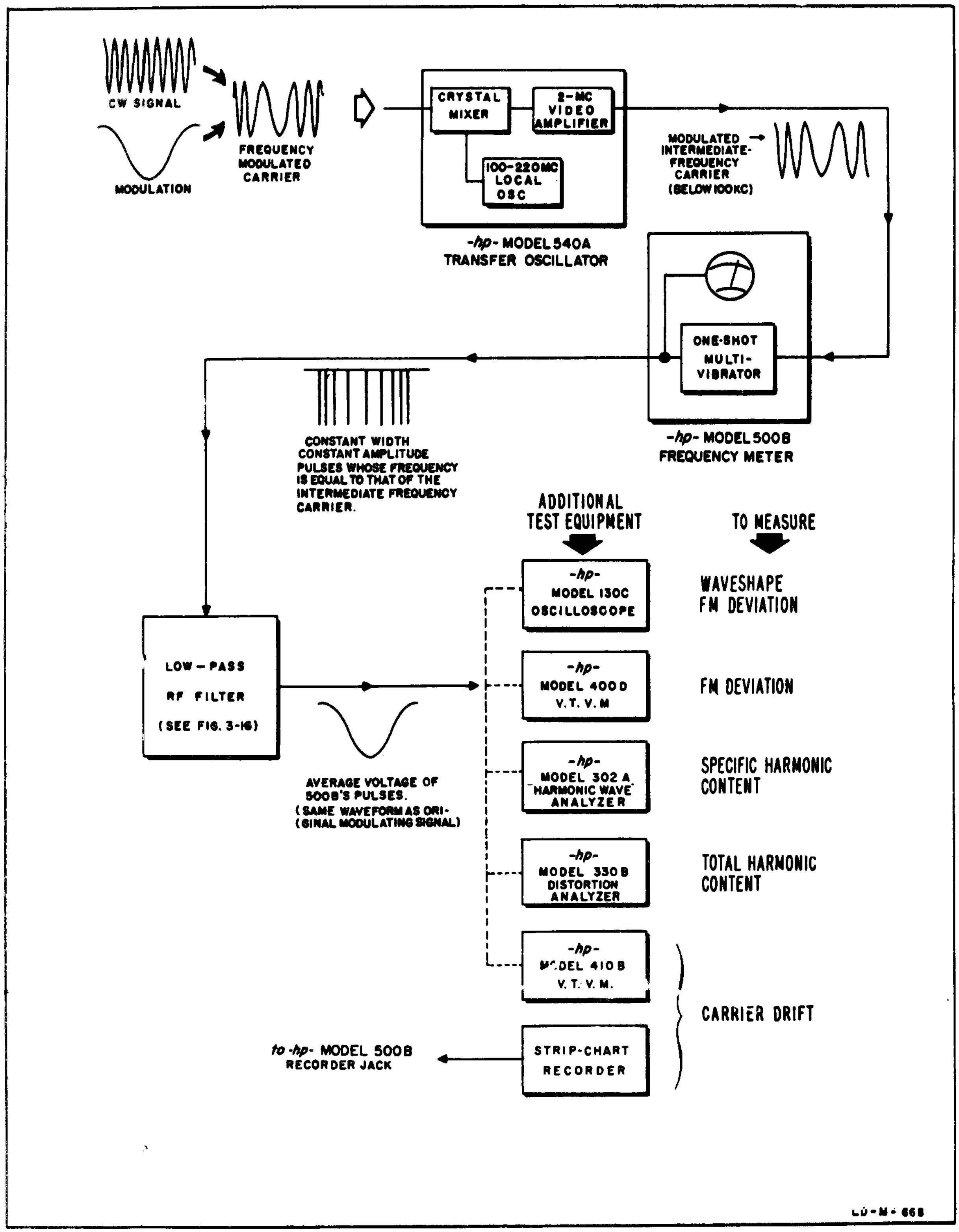


Figure 3-15. System to Measure Frequency Modulation Characteristic

3-23. Abroad indication of carrier drift over nominal periods of time isobtained by observing the range of variation of the Model 500B's meter readings. Drift measurements may be recorded by plugginga l-ma recorder into the Model 500B's RECORDER jack. A low -pass filter is not required for this application. because of the filtering already present at the jack.

3-24. Modulation frequencies and waveforms are observed on an oscilloscope connected to the output of the low-pass filter. Total distortion and harmonic content can be measured directly on the Model 330B Distortion Analyzer and the Model 302A Harmonic Wave Analyzer. Theee measurements are relative and hence special calibrating procedures are not required.

3-25. The cutoff frequency and the sharpness of the filter depend upon the degree of peak-to-peak carrier deviation and the highest modulating frequency since the sum of these two frequencies and the guard band between them (required by the finite alope of the cutoff characteristic) must not exceed the 100 -kc pass band of the Model 500B. The three-section low-pass filter shown in figure 3-16 is sufficiently sharp to enable its use in a wide variety of applications. The guard band of this filter is equal to twice the maximum modulating frequency. Thus the basic fm meas - uring system equipped with this filter can handle modulating frequencies up to 33 kc at very low deviations up to 50 kc at very low modulating frequencies. If greater peak deviation muet be measured, a filter can be used or a system of frequency division employed. The maximum peak deviation this three-section filter will handle is given by the relationship:

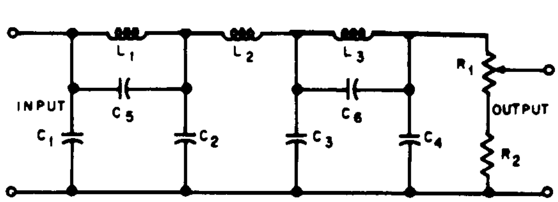
$$D_p = 50 - 1.5\ F_{mod}$$

where D_p is the maximum peak deviation and F_{mod} the maximum modulating frequency. For example, the maximum peak deviation the basic system can handle with a maximum modulating frequency of 15 kc is 27.5 kc:

$$D_p = 50 - 1.5\ (15) = 50 - 22.5 = 27.5\ \text{kc.}$$

3-26. GENERATING HARMONICS FOR OTHER USES.

3-27. The oscillator and harmonic generator sections of the transfer oscillator maybe ueed to produce very accurate harmonics for calibration and other uses. To provide these harmonics, connect the OSCILLATOR



F_{co} Cutoff frequency in kc (slightly higher than the highest modulating frequency)

R_1 20,000 ohm potentiometer

R_2 Small variable resistor adjusted to obtain 10 volts dc across $R_1 + R_2$ with a 100-kc unmodulated signal applied to the ⓗ 500B frequency meter.

$L_1, L_3 = \dfrac{4,700\ \text{mh}}{F_{co}}$ C1, C4 $= \dfrac{5,970\ \text{pf}}{F_{co}}$

$L_2 = \dfrac{6,360\ \text{mh}}{F_{co}}$ C2, C3 $= \dfrac{13,910\ \text{pf}}{F_{co}}$

C5, C6 $= \dfrac{2,320\ \text{pf}}{F_{co}}$

SD-S-206

Figure 3-16. Design Information for a Simple Three-Section Low-Pass Filter

OUTPUT connector to the HARMONIC GENERATOR· OSCILLATOR INPUT connector, Harmonics with the same accuracy as the fundamental frequency (which

3-28. MEASURING FREQUENCIES ABOVE 18 GC.

3-29. Figure 3-17 shows an arrangement for measuring frequencies above 18 gc. Harmonics in the 2-4 gc region are generated in the internal harmonic generator, amplified in the microwave amplifier, and applied to a tunable waveguide crystal mount which generates harmonics in the 18-40 gc region. The cliff erence frequency between one of these harmonics and the frequency being measured is detected in the Model 422 crystal detector and applied to the video amplifier of the 540B for presentation on the internal oscilloscope. As the waveguide harmonic generator and the microwave amplifier both must be tuned, obtaining beat frequency indications is complicated but practical when the frequency of the unknown is known approximately.

SECTION IV

THEORY OF OPERATION

4-1. CIRCUIT DESCRIPTION.

4-2. How the Transfer Oscillator measures frequency is best described by reference to the block diagram in figure 4-1. The 540B oscillator generatee a very stable fundamental frequency that is adjustable from 100 to 220 megacycles per second. Thts frequency is monitored by an electronic counter, and aleo supplied to either one of two crystal-diode mixers, or to a separate harmonic generator, depending upon the input frequency to be measured. The crystal mixers serve both as mixers and harmonic generators. When an input signal is also applied to the same mixer, mixing action occurs with all harmonice generated from the oscillator signal. If the difference between the input signal frequency and some harmonic frequency is less than the bandwidth of the following amplifier, a response will be seen on the oscilloscope. The fundamental frequency is then adjusted so that the harmonic frequency is exactly the same as the input frequency and the zero-beat is easily read on the oscilloscope display. The oscilloscope sweep is provided by a sine wave of the power line frequency obtained from the power transformer. As this sweep allows synchronizing the display only when the frequency modulation of the input signal is also at the power line frequency, provision is made to sweep the oscilloscope from an external signal introduced through a connector on the rear panel, or by use of an external oscilloscope having a triggered sweep. A second amplifier supplies the same difference frequency to an output connector for display on the external oscilloscope. This output is used for obtaining large synchronized displays of rf pulses.

4-3. VARIABLE -FREQUENCY OSCILLATOR (100-220 MC). The fundamental frequency of the transfer oscillator is generated by an extremely stable, push-pull Hartley oscillator and is brought out to the front panel at the OSCILLATOR OUTPUT connector. The signal is then normally coupled through a coaxial jumper to the OSCILLATOR INPUT connector of one of the mixers. The housing for the oscillator, the tuned circuit components and their mountings have all

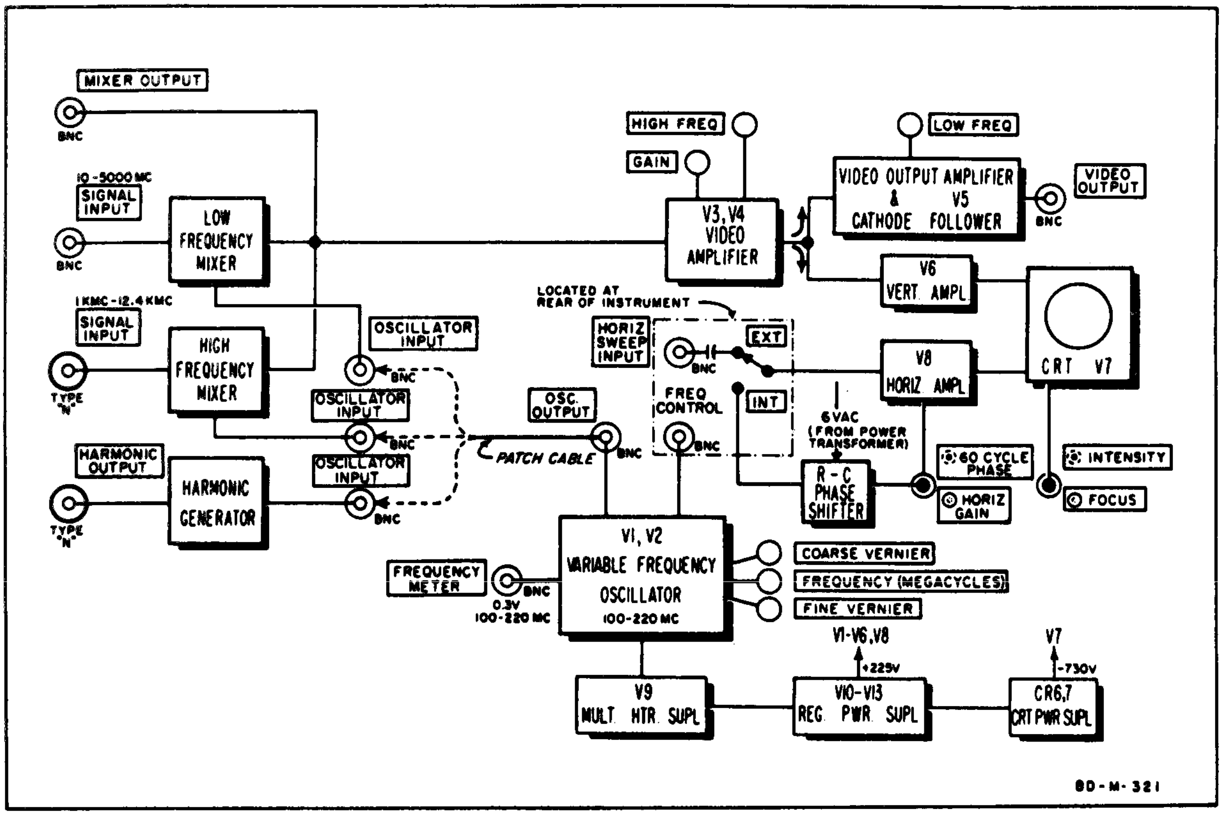


Figure 4-1. Transfer Oscillator Block Diagram

been made very rigid and the operating voltages applied to the circuit are well regulated. Although long-term stability of this oscillator is not an important factor, it is sufficient to afford 1/2% or better accuracy of the main tuning dial calibration.

4-4. Power is extracted from the oscillator by a fixed probe with its tip magnetically coupled to the oscillator plate fnductor. The probe provides a 50-ohm impedance at the front panel OSCILLATOR OUTPUT connector (J7). Pickup for the signal obtained at the FREQUENCY METER connector for monitoring purposes is not mechanically associated with the oscillator plate circuit although it is shown to be so on the schematic diagram. It is simply a resistor loop within the oscillator box. Coupling is adjusted so there is sufficient signal for operating the Model 524 Frequency Counter with Model 525B Plug-In Converter.

4-5. The oscillator circuit is tuned by a split-stator capacitor (C27) and. a two-turn, center-tapped invar ribbon inductor (Ll). Trimmer capacitors C3 and C28 at each plate serve primarily to balance plate-to-ground capacity at the two sides of the plate tank to obtain maximum output power, and are also used to shift the calibration at the high-frequency end of the frequency dial by small amounts. Bias for both oscillator tubes, V1 and V2, is developed across the common cathode resistor. Signal feedback is symmetrical, from each plate to the opposite grid. Heater and plate power are brought in through three separate rf filter circuits to prevent objectional conducted leakage of rf energy from the oscillator housing.

4-6. The FINE FREQUENCY VERNIER control is a mechanical device which rotates a tilted aluminum disk close to the plate tank inductor thereby affecting the plate circuit inductance very slightly. A second provision is made for very fine adjustment of the oscillator frequency by C46 and CR2 connected to the FREQUENCY CONTROL connector on the rear chassis. Fine frequency adjustments can be made by either introducing a small, variable dc voltage or by varying the dc resistance betweenthis jack and ground, thereby changing the effective plate-to-ground capacity of the oscillator circuit.

4-7. The low frequency mixer assembly consists of a transmission-line coupling between the OSCILLATOR INPUT and SIGNAL INPUT connectors. The transmission line is inside a housing which holds the mixer crystal and the difference-frequency output jack on the rear of the housing. The crystal mounting is a phenolic sleeve that receives the crystal, pin-end first. The crystal (a type 1N21B) is pressed into the housing to contact the junction bar which joins the OSCILLATOR INPUT and SIGNAL INPUT connectors. The output connector when threaded onto the housing provides a slight pressure against the crystal to maintain a good contact with the junction bar.

4-8. The high frequency mixer operates over the range of 1 to 12.4 gc. This mixer assembly consists of a transmission-line coupling between its corresponding OSCILLATOR INPUT and SIGNAL INPUT connectors. The transmission line is inside a housing which holds two crystals (one 1N21B and one 1N416B) and the video output jack on the rear of the housing. The 1N416B ie a harmonic generator which supplies strong SHF harmonics from the oscillator output, which mix with the incoming signal in the 1N21B.

4-9. VIDEO AMPLIFIER The video amplifier consists of the five resistance-coupled tube stages, V3, V4A and B, and V5A and B, two of which are cathode followers. The bandwidth of the amplifier is approximately 2 megacycles with the VIDEO RESPONSE controls set to maximum, and a gain of approximately 40 db is provided with the VIDEO GAIN control set to maximum. The first two stages, V3 and V4A, provide most of the amplification for both the VIDEO OUTPUT connector and the oscilloscope Vertical Amplifier. Tube V4B with its split load serves two purposes: a cathode follower to drive the low-impedance, low-frequency cutoff network at the input to video output tube V5, and a plate-loaded amplifier to feed the vertical oscilloscope amplifier, V6.

4-10. The high-frequency cutoff of the video amplifier is continuously adjustable by R4 in the grid circuit of V3 from a maximum of 2 megacycles to a minimum of 1 kilocycle. The low-frequency cutoff point may be switched from 100 cps to 10 kc by S1 attached to R18. It is then continuously adjustable from 10 kilocycles to 400 kc by R18 (located in the grid circuit of V5A). Tube V5A makes up for the loss of gain in the low-frequency response network while V5B provides a low impedance termination at the VIDEO OUTPUT connector on the front panel.

4-11. OSCILLOSCOPE VERTICAL AMPLIFIER. The vertical amplifier consists of a single, resistance-coupled pentode, V6, driving the upper vertical plate in the cathode-ray tube. This tube provides approximately 100 volts peak-to-peak and 40 decibels of gain over approximately a 200-kilocycle bandwidth without compensation.

4-12. OSCILLOSCOPE HORIZONTAL AMPLIFIER AND SWEEP CIRCUITS. The oscilloscope sweep circuit consists of a 6.3-volt line frequency voltage source, an adjustable phase-shifing network, R43 and C 24, and a push-pull amplifier-phase inverter, V8. Resistance-coupled amplifiers V8A and V8B are cathode coupled in cascade to act both ss a phase-inverter and push-pull amplifier. To obtain equal gain from both halves of V8 the plate load resistor for the B section is made larger to compensate for the greater degeneration in this stage.

4-13. POWER SUPPLY, A schematic diagram of the power supply is shown in figure 5- . The power supply consists of an electronically regulated + 240 volt supply for operation of a majority of the circuits, an unregulated + 330 volt supply for amplifiers V6 and V8, an unregulated -740 volt supply for the cathode-ray tube V7, and a special, regulated, multivibrator-driven heater supply for the oscillator tube filaments. The multivibrator supplies an oscillator filament voltage independent of line voltage variation. In newer models a slide switch on the rear panel selects the 1-mc voltage to be used. Power Transformer T1 can be wired for operation on either 115 of 230 volts.

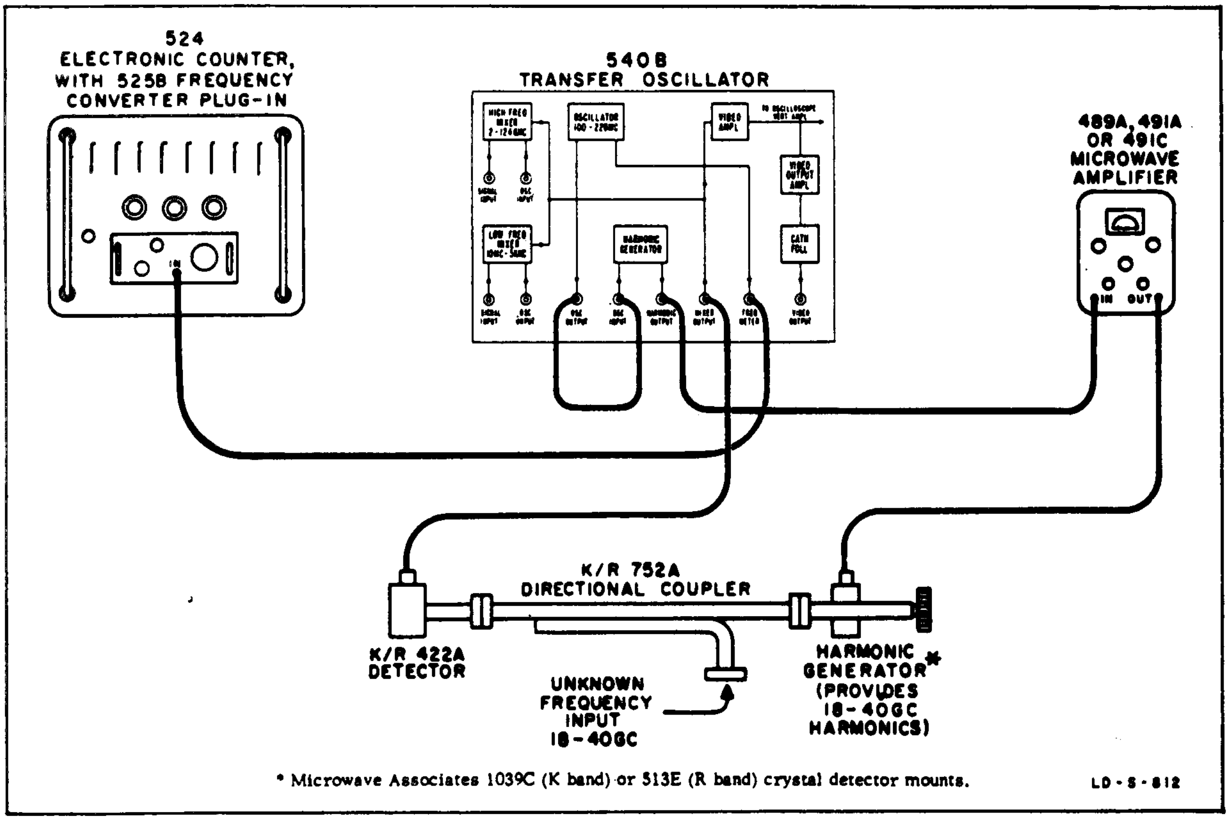


Figure 3-17. Frequency Measurement above 18 gc with the 540B Oscillator

SECTION V

MAINTENANCE

5-1. INTRODUCTION.

5-2. The following paragraphs contain instructions for maintenance of the transfer oscillator. The components of this instrument are conservatively operated to provide maximum reliability with a minimum of repair. When trouble occurs, a systematic approach in localizing the trouble to one section of the instrument will save maintenance time. In most cases, the trouble will be caused by a defective electron tube, and tube replacement will then restore operation. A list of the test equipment required for maintenance is given in table 5-1.

5-3. CABINET REMOVAL.

5-4. To remove the transfer oscillator chassis from the cabinet, rest the instrument on a pad on its back to gain access to the bottom. Loosen the two large slotted setscrews in the bottomed e of the panel bezel. Withdraw these screws about 1/4 inch. The cabinet is now free and can be lifted off the front panel and chassis. The rear cover may have to be removed to gain access to some of the parta on the rear chassis.

WARNING

Be careful when making voltage measurements. Voltages as high as -740 volts dc are present in the chassis when power is applied.

5-5. PERIODIC CLEANING AND LUBRICATION.

5-6. No Lubrication is required. Once a year, remove the cabinet and carefully biow out accumulated duet with a low-pressure air stream. Clean the instrument with a soft cloth.

5-7. TUBE REPLACEMENT.

5-8. In many cases, instrument malfunction can be corrected by replacing a defective tube. Before changing the setting of any internal adjustment, check the tubes. Adjustments made in an attempt to restore operation when the cause is a defective tube will often complicate the repair problem. Check tubes by substitution rather than by using a tube tester, because the results obtained with the tube tester may sometimes be misleading. Before removing a tubs, mark it so that if the substitute tube does not improve operation, the original tubs can be returned to the same socket. Replace only those tubes proved to be weak or defective. A circuit adjustment is provided for those tube positions where variation in tubs characteristics of the replacement tube may affect circuit performance. Table 5-2 lists the tubes and test or adjustments which must be performed after replacement of each particular tube.

5-9. TROUBLESHOOTING.

5-10. Before troubleshooting the transfer oscillator, make sure that a trouble is not caused by poor external connections, line power failure, or malfunctioning of the other equipment used with the transfer oscillator or the source of the signal under test. Carry out troubleshooting by localizing the trouble to one of the main sections of the instrument as directed in table 5-3. When the trouble hae been localized to a particular section, check the tubes in that section before taking any other corrective action. If tube replacement doee not eliminate the trouble, make sure that proper power is being provided by checking all power supply outputs as directed in paragraph 5-13. Then carry out detailed checks of the circuit components other than tubes in the defective section, and continue to other sections if necessary.

5-11. CALIBRATION.

5-12. PRELIMINARY INSTRUCTIONS. Use the procedure given in paragraphs 5-13 through 5-3 to test and adjust each section of the transfer oscillator. Use the entire procedure in the order given to carry out a complete calibration check annually. Always check the power supply section before testing or adjusting and other section. The test equipment required for calibration is listed in table 5-1. Equivalent instruments may be substituted for those listed.

5-13. POWER SUPPLY TEST AND ADJUSTMENT.

5-14. Make voltage adjustments **only if the regulated** +240 volt or Oscillator Filament Supply voltage is outside the limits given. Do not refine either setting if the voltage is within limits. Always check the oscillator filament supply after resetting the + 240 volt dc supply.

5-15. TESTING THE +330 VOLT DC SUPPLY.

a. Connect the ground lead of the dc voltmeter to ground. With the dc probe, measure the + 330 volt dc supply at the point shown in figure 5-1.

b. Thie supply is unregulated and hae a nominal voltage of+ 330 volts dc when the line input voltage is 115 volts ac. If the voltage is low, check V10, C43A, and C43B, or the current being drawn from the supply.

c. Check the total load current at the output from C43B, using the dc clip-on milliammeter. This total load current must be less than 100 ma.

5-16. TESTING THE + 240 VOLT DC SUPPLY. (See paragraph 1-11(4) for earlier model transfer oscillators using +225 volt dc supply.)

a. Connect the transfer oscillator to the Variac and set the Variac to supply 115 volts ac. Turn on and allow three-minute warmup.

b. Connect the ground lead of the dc voltmeter to ground.

Table 5-1. Test Equipment

Nomenclature	Model	Application	Range	Accuracy
AC Vacuum Tube Voltmeter	hp Model 400D ME-30	Measure low-frequency or low-level ac voltage	0. 1 mv to 300 volts	± 2%
Vacuum Tube Voltmeter	hp Model 410B ME -26	Measure dc voltage and high-frequency ac voltage	1 to 1000 ydc	
Variable Auto-Transformer	General Radio Variac Model W2, W5, or V-10	Supply variable power line voltage	100 to 130 volts ac, 1.25 amp	Voltmeter accurate within 1 volt
Probe "T" Connector	hp Model 455A	In-line coaxial connection with 410B voltmeter probe	100 to 200 mc	
50-ohm Coaxial Load	hp Model AC-67A	Matched termination for Model 455A		
Electronic Counter	hp Model 524B/C/D with Model 525B Plug-In Converter AN/USM-26	Precise frequency measurement	100 to 220 mc	$1/10^6$ or better
Square-Wave Generator	hp Model 211A	Signal generator for amplifier response test	Approx 2 kc, 0.5 volt, 0.02 μs rise time	
Oscilloscope	hp Model 160B AN/USM-105A	Observe test waveforms	10 mc, triggered sweep	
Clip-On DC Milliammeter	hp Model 428A	Measure dc current	3 ma to 1 amp	± 3% ± 0.1 ma
SHF Signal Generator	hp Models 614A, 618B, and 620A	Measure mixer sensitivity	0. 8 to 11 gc	

c. With the dc probe, measure the + 240 volt dc supply at the point shown in figure 5-1. This voltage must read + 240 ± 9 volts dc.

d. If the voltage is not + 240 ± 9 volts tic, adjust R73 in figure 5-1 to bring the voltage within these limits.

e. If the voltage cannot be adjusted and is too low, check V10 and Vll, and check the load current from pins 3 and 6 of Vll with the clip-on dc milliammeter. This current must be less than 90 ma.

f. If the voltage is too high, check V12. If voltage fluctuates, check V13.

g. Check voltage regulation by adjusting the Variac to vary the line voltage from 103 to 127 volts ac while measuring the + 240 volt dc supply. The voltage must not vary more than ± 1 volt dc.

h. Measure the ac level across the +240 volt supply (at the same points to which the dc vtvm is connected) as the line voltage is varied from 102 to 127 volts ac rms with the Variac. The ac level must not exceed 5 millivolts. If ripple exceeds this level, test Vll, V12, C43, and C41.

5-17. TESTING OSCILLATOR FILAMENT SUPPLY. The filaments of the tubes in the oscillator circuit are supplied by a multivibrator circuit which is operated from the regulated + 240 volts, thereby making the oscillator filament voltage independent of line voltage variations. However, the multivibrator eutput voltage is proportional to the value of the + 240 volts and must be checked if the setting of the +240 volts dc supply is changed. Since the multivibrator output voltage has a square waveform, care must be taken in the choice of a meter used to measure this voltage. An rms-calibrated meter should be used for this measurement. A peak-responding meter cannot be used for this measurement. Meters which respond to the average but are calibrated for rms, such as the Model 400D/H/L recommended in table 5-1, are suitable when used with the appropriate correction factor. The correction factor is necessary because this type of meter reads 1.11 times the true rms value of a square wave. Hence, if the actual square wave output voltage is 5.2 volts, this type of average - responding rms - calibrated meter would read 5.2 x 1.11 = 5.8 volts. Make the test as follows:

a. Connect a suitable ac vacuum tube voltmeter, as discussed above, between the lead at the top of the oscillator housing (shown in figure 5-1) and ground.

b. The true voltage at this point must be between 5.0 and 5.4 volts ac rms (5.6-6.0 as read ona Model 400D/H/L. If the voltage is within these limits do not change the setting. If this voltage is not within these limits, adjust R55 (figure 5-1) to obtain a true reading of 5.2 .(5. 8 as read on a Model 400D).

c. If the voltage cannot be adjusted and is too low, check V9. Also check the load current drawn from the secondary winding.

d. If step c does not correct the trouble, measure the load current drawn from the secondary winding by temporarily connecting a 0.1-ohm resistor in the circuit between terminal 4 of T2 and ground, and reading the voltage drop across it. Load current must not exceed 0.6 ampere (which would correspond to a drop of 60 millivolts across a 0.1-ohm resistor or a voltage reading of 66.6 millivolts on the Model 400D/H/L). Remove this resistor when measurement is completed.

5-18. TESTING THE -740 VOLT DC SUPPLY. TMe supply furnishes unregulated high voltage for the built-in oscilloscope, and should be checked if trace intensity becomes faint.

a. Connect the ground lead of the dc vtvm to ground. With the dc. probe, measure the -740 volt dc supply at the point shown in figure 5-1 (the non-grounded terminal of C40).

b. This supply has a nominal voltage of -740 volts dc when the line voltage is 115 volts ac. If the voltage is less than 690 volts, check the two semiconductor rectifiers (CR6 and CR7) located on the bottom of the left-hand resistor board as viewed from the back of the instrument.

5-19. TESTING OSCILLATOR OUTPUT AND DIAL CALIBRATION.

5-20. Following the replacement of tubes V1 or V2 in the oscillator circuit, the nigh frequency end of the main tuning dial may be slightly out of calibration and the output voltage may be too low. Proceed as follows:

a. Turn on tbe transfer oscillator power and allow 20 minutes warmup time.

b. Using& coaxial “T” connector with a type N-to-BNC adapter on each end, such as the **Model 455A,**

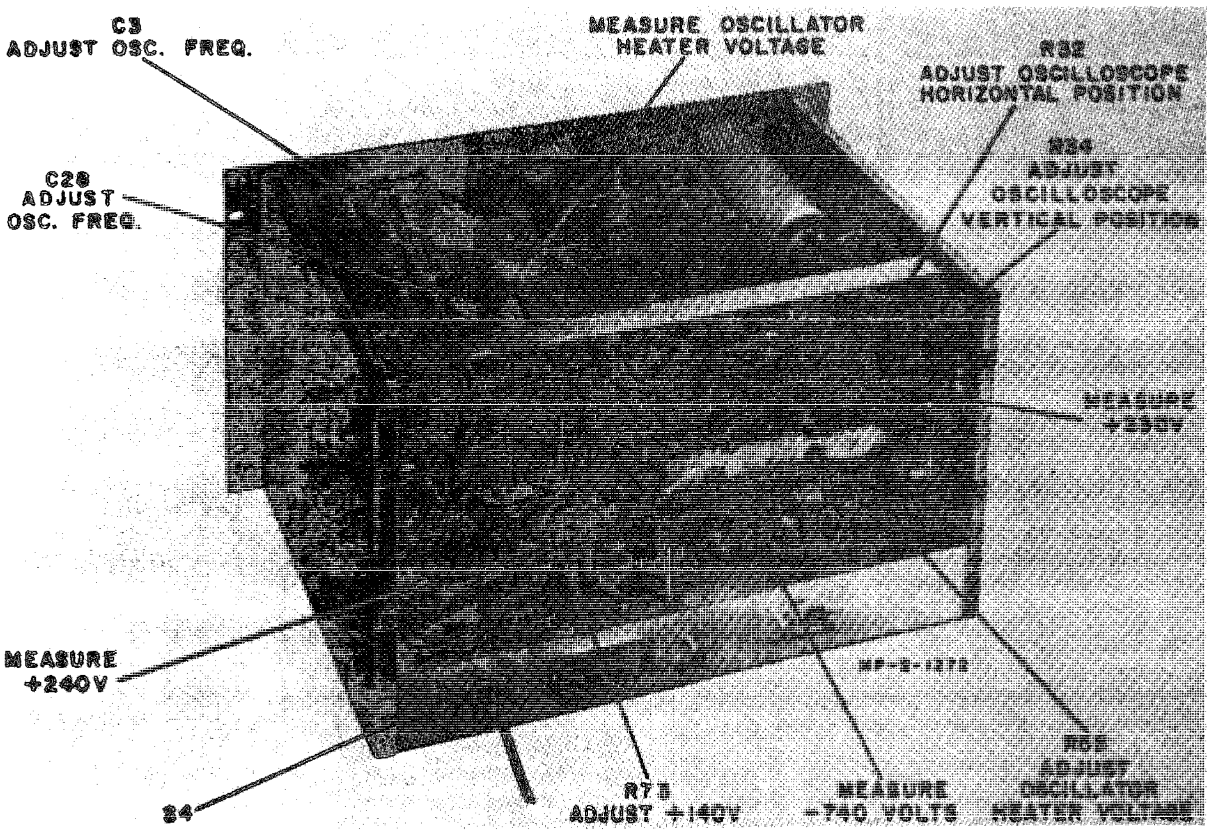


Figure 5-1. Location of Measurement and Adjustment Points

Table 5-2. Adjustments Required when Tubes are Replaced

Circuit Reference	Tube Type	Function	Test and/or Adjustment Required after Replacement of Tube
V1	6C4/6135	1/2 RF Oscillator	Adjust FREQUENCY dial calibration para 5-19
V2	6C4/6135	1/2 RF Oscillator	Adjust FREQUENCY dial calibration para 5-19
V3	6C4/6135	lst Video Amplifier	Check video response, para 5-21
V4	6U8	2nd & 3rd Video Amplifier and Cathode Follower	Check video response, para 5-21
V5	12AT7	4th Video Amplifier and Cathode Follower	Check video response, para 5-21
V6	6CB6	Oscilloscope Vertical Amplifier	Check vertical trace centering, para 5-23
V7	2BP1	Cathode -Ray Tube	Adjust horizontal and vertical position of pattern, para 5-23
V8	12AX7	Horizontal Amplifier	Check horizontal trace centering, para 5-23
V9	6350	Heater Supply Multivibrator	Adjust oscillator filament voltage, para 5-17
V10	5U4	High Voltage Rectifier	none
V11	6AS7	Series Voltage Regulator	Adjust + 240 volt dc supply, paras 5-16, 5-17
V12	6CB6	Voltage Control	Adjust + 240 volt dc supply, paras 5-16, 5-17
V13	5651	Reference Tube	Adjust + 240 volt dc supply, paras 5-16, 5-17

plug one of the top ends of the "T" into the OSCILLATOR OUTPUT connector. Terminate the other end of the top of the "T" with a proper 50-ohm termination, such as the ℏ Model AC-67A.

c. Unscrew the cap on the end of the ac probe of a high-frequency vtvm (ℏ Model 410B) and plug it into the leg of the "T" connector. Measure the output voltage while turning the FREQUENCY dial through its full frequency range. The voltage must remain between 1.75 and 2.2 volts. If the voltage is below 2.0 volts at its highest point, replace V1 and/or V2.

d. Connect the front panel FREQUENCY METER connector to an electronic counter to measure the oscilloscope output frequency.

e. Set the FINE VERNIER dial to the mid-position of its travel so that its white dot is up.

f. Compare the FREQUENCY dial indication to the counter reading at each major dial calibration.

g. If the FREQUENCY dial reading is incorrect at 200 megacycles, readjust C3 and C28 (figure 5-1) to bring the frequency to 200 megacycles. Divide this adjustment equally between C3 and C28 to prevent dial error at low frequencies.

h. The oscillator output signal available at the FREQUENCY METER comector must have an amplitude of at least 0.2 volts when connected to a 50-ohm resistive termination through 50-ohm coaxial line. Use an oscilloscope or the Model 410B Vacuum Tube Voltmeter for this measurement. If insufficient output is present, check R51.

5-21. MEASURING VIDEO AM AMPLIFIER GAIN AND RESPONSE.

5-22. To measure video amplifier response feed a fast pulse into the transfer oscillator and view the degradation of the waveshape on the oscilloscope. Proceed as follows:

a. Turn on the transfer oscillator and allow 5 minutes warmup; set VIDEO RESPONSE controls fully clockwise.

b. Connect a square-wave generator to a teat oscilloscope and adjust the square-wave generator to provide 0,5 volts (peak) output at 2 kc as measured on the test oscilloscope.

c. Connect the test oscilloscope to the transfer oscillator VIDEO OUTPUT connector.

d. Reduce the equare-wave generator output 40 db, and connect it to the MIXER OUTPUT connector of the transfer oscillator.

e. The pattern viewed on the test oscilloscope should have an equal or greater amplitude compared with step b, indicating that the transfer oscillator provides at least 40 db gain. If the amplifier does not provide efficient gain check V3, V4, V5, and V6.

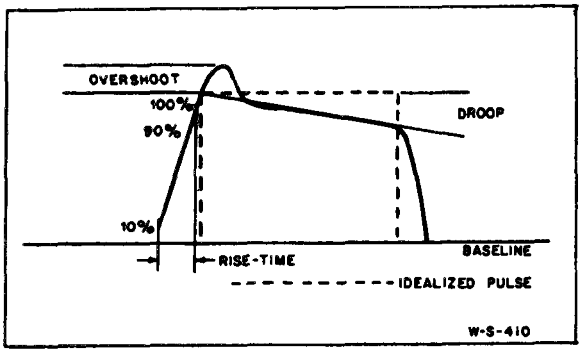


Figure 5-2. Waveform Definitions

f. The overshoot on the waveform displayed on the test oscilloscope must be less than 25% (see figure 5-2). If greater overshoot is present, bend the leads of capacitor C9 (between tube pins 1 and 2 of V4) slightly to change that capacitor's position until the overshoot has been reduced to less than 25%.

g. The droop of the waveform top displayed on the test oscilloscope must be less than 10% (see figure 5-2). If it is not, check V3, V4, and C6 and adjust the value of C6 by padding if necessary.

h. The rise time (10%-90%) of the pattern displayed on the test oscilloscope must be 0.22 μsec or less. If not, check V3 and V4.

5-23. CENTERING OSCILLOSCOPE TRACE.

5-24. To center the transfer oscillator oscilloscope trace, proceed as follows:

a. Turn on the transfer oscillator and allow 5 minute warmup.

b. Adjust oscilloscope controls to obtain a full-width line on the screen.

c. Adust R32 (see figure 5-1) to center the horizontal position of the line.

d. Adjust R34 (see figure 5-1) to center the vertical position of the line.

5-25. MEASURING MIXER SENSITIVITY AND FREQUENCY RESPONSE.

5-26. Mixer sensitivity is defined as the minimum input signal power which will give an output amplitude from the mixer 6 db above the noise level. To measure sensitivity and frequency response, proceed as follows:

a. Turn all VIDEO RESPONSE controls fully clockwise.

b. Connect the jumper cable between the OSCILLATOR OUTPUT connector and the OSCILLATOR INPUT connector of the mixer to be checked.

c. Connect the ac vtvm to the VIDEO OUTPUT connector, This measurement reads noise.

d. Connect a signal generator of the appropriate frequency to the SIGNAL INPUT connector of the mixer being checked. Check the Low Frequency Mixer at 1 and 4 gc, the High Frequency Mixer at 4, 8, and 11 gc.

e. Adjust the signal generator output until the voltage reading on the ac vtvm is exactly twice the value noted in step c. The input power being supplied by

Table 5-3. Trouble Localization

Indication of Trouble	Items to Check
Instrument inoperative; POWER light does not glow	Check power connections and fuse F1 Check continuity of T1 primary windings
Instrument inoperative; POWER light glows	Check power supply output voltages and VI
No horizontal trace appears on oscilloscope	Check that HORIZ SWEEP INPUT switch is in INT position Check V8
Horizontal line appears on oscilloscope but no vertical trace	Check tubes V3, V4, and V6
Cannot obtain beat frequency	Check oscillator output Check mixer by using other mixer or replacing crystal

the signal generator at this point is the sensitivity of the mixer at that frequency.

f. To measure the frequency response of a mixer, measure sensitivity while adjusting the input signal frequency to cover the entire range of the mixer. Typical sensitivity of the mixers is shown in figure 3-2. The sensitivity of individual mixers may vary at certain frequencies; variations up to ± 10 db are acceptable. Mixers with poorer response than this may be replaced. However, the crystals furnished with the instrument have been selected for best overall performance (an absence of points of poor response throughout the band). If a crystal is replaced to secure higher gain at a particular frequency, keep the original crystal for general use.

5-27. REPLACING PARTS IN THE LOW FREQUENCY MIXER.

5-28. REPLACING THE 1N21B CRYSTAL. The low frequency mixer contains one 1N21B crystal diode which has been selected to give most uniform harmonic generation and frequency mixing, and freedom from dead spots, from 200 mc to 4 gc. The crystal is easily changed as follows (see figure 5-3):

a. Unscrew the cylindrical portion of the mixer from the rectangular body to gain access to the crystal.

b. Pull the crystal from the body.

c. Insert replacement crystal 2N21B into the body.

d. Replace the cylindrical cover.

5-29. A replacement crystal may not give exactly the same sensitivity or noise level. If, after the crystal is replaced, the noise level is too high or the sensitivity is too low, try another replacement crystal. In a given crystal sensitivity will vary with the input frequencies; in addition, the sensitivity curve of one crystal will differ from that of another. The selection of a crystal can thus be for best overall sensitivity across the full frequency band or for maximum sensitivity in a chosen narrow band of frequencies. In the latter case, there may be frequencies outside the chosen bands where sensitivity drops below normal which are considered unimportant. Once this crystal is replaced, the original specified sensitivity across the frequency band can no longer be guaranteed unless the transfer oscillator is returned to the factory for recalibration.

5-30. REPLACING PARTS IN THE HIGH FREQUENCY MIXER.

5-31. REPLACING THE 1N21B CRYSTAL. The high frequency mixer contains two crystal diodes, one 1N21B and one 1N416B. The two diodes have different effects on operation and only the 1N21B is field replaceable. The description of performance given for the 1N21B in the low-frequency mixer applies also to the 1N21B in the high - frequency mixer. Once the crystal is replaced, the original specified sensitivity across the frequency band can no longer be guaranteed unless the transfer oscillator is returned to the factory for recalibration. To replace the 1N21B crystal in the high-frequency mixer, proceed as follows:

a. Refer to figure 5-4; remove the connector cap from tine filter assembly to gain access to crystal.

b. Being careful to prevent discharge of static electricity through the crystal diode, remove the crystal from the filter assembly. Such a discharge is only remotely possible and is easily prevented by having one's body grounded at the moment the crystal is touched.

c. Insert replacement crystal 1N21B into the filter assembly and install connector cap on filter assembly.

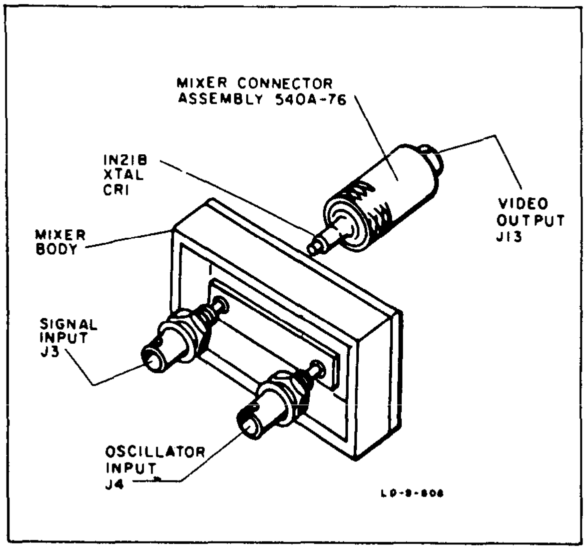


Figure 5-3. LOW Frequency Harmonic Mixer

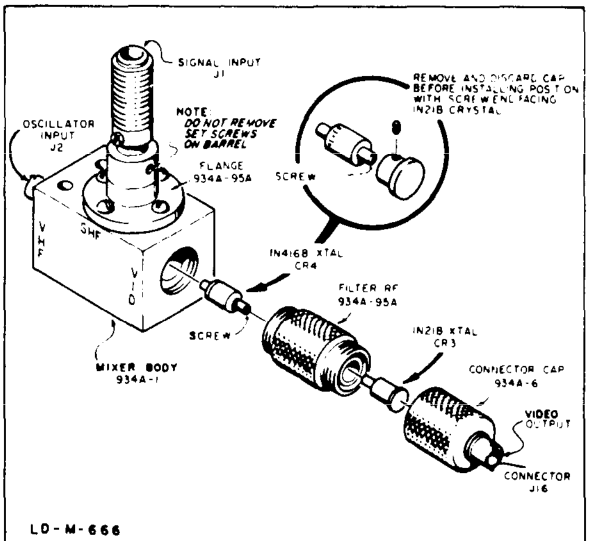


Figure 5-4. High Frequency Harmonic Mixer

5-32. REPLACING THE 1N416B CRYSTAL. The 1N416B crystal may be replaced in the field for emergency operation, but in most cases will later require a fine adjustment in penetratio the probe assembly to regain original sensitivity across the full frequency band. The effect of replacing the 1N416B differs from the effect of the 1N21B in that it has greater effect upon the overall sensitivity and on noise level, and there is less effect upon sensitivity over narrow frequency bands (holes). To replace the 1N416B crystal, proceed as follows:

a. Refer to figure 5-4; remove the filter assembly (with connector cap remaining installed) from the mixer body to gain access to the crystal.

b. Being careful to prevent discharge of static electricity through the crystal diode, remove the crystal from the mixer body by a straight pull with a long-nose pliers. Such static discharge is only remotely possible and is easily prevented by having one's body grounded at the moment the crystal is touched.

c. A replacement 1N416B crystal has a cap on one end of its body. Remove this cap, noting the capped end.

d. With a pair of long-nosed pliers, insert replacement crystal into the mixer body, capped end last.

e. Install filter assembly on mixer body.

5-33. REPLACING THE FILTER ASSEMBLY. The filter assembly on the high-frequency mixer can be replaced as a unit without need for subsequent adjustment. Do not attempt to repair any internal part of the filter assembly. The filter assembly contains an inductor which consists of a short piece of 0.001 inch diameter copper wire. To check for continuity, use a 20,000-ohm/volt multimeter on a high range. Excessive current will quickly burn out this wire. To replace the filter assembly, proceed as follows:

a. Refer to figure 5-4; remove the connector cap from the filter assembly.

b. Remove the crystal from the filter assembly.

c. Remove the filter assembly from the mixer body.

d. Install the replacement filter assembly on the mixer body.

e. Install the crystal in the filter assembly.

f. Install the connector cap on the filter assembly and connect cable.

5-34, REPLACING AND ADJUSTING THE PROBE ASSEMBLY. The probe assembly may be replaced in the field for emergency operation, but requires fine adjustment of the probe penetration to regain original sensitivity across the full frequency band. Do not attempt to replace any of the internal parts of the probe assembly. To replace the probe assembly, proceed as follows:

a. Loosen both the knurled nuts that secure the probe assembly to the front panel. Remove outer nut.

b. Remove both BNC cables from rear of mixer assembly.

c. Remove mounting screws that secure assembly to the front panel, and remove assembly from transfer oscillator.

d. Loosen the two #8 allen setscrews on the collar and remove the probe assembly from the mixer body, unscrewing inner knurled nut to allow probe assembly to be removed through panel hole.

e. Install the replacement probe assembly with care. Do not force it down into the mixer body. After the probe has touched bottom, lift is slightly less than 1/128 inch (approximately .005 inch), and tighten the allen setscrews on the collar.

f. Thread inner knurled nut well down on probe assembly so it will not strike panel when being installed in transfer oscillator.

5-35. HARMONIC GENERATOR ASSEMBLY.

5-36. The 1N21B crystal diode used in the harmonic generator is selected at the factory to give good harmonic generation above 1 gc from a 200-mc fundamental. The crystal can be replaced in the field; proceed as follows:

a. Refer to figure 5-5; remove generator body from the connector.

b. Remove crystal 1N21B from the connector.

c. Insert replacement crystal 2/21B into the connector.

d. Restore generator body to connector.

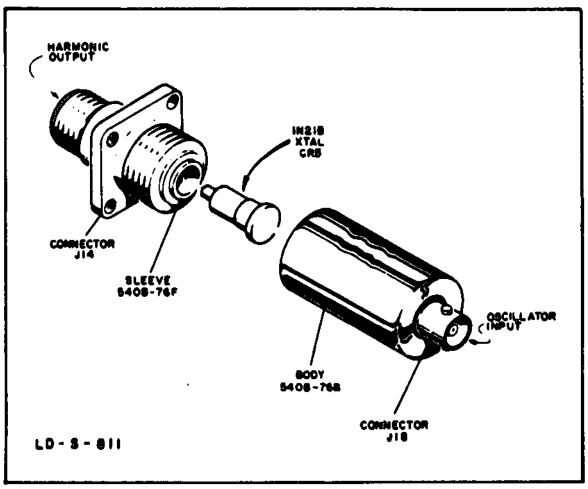


Figure 5-5. Harmonic Generator

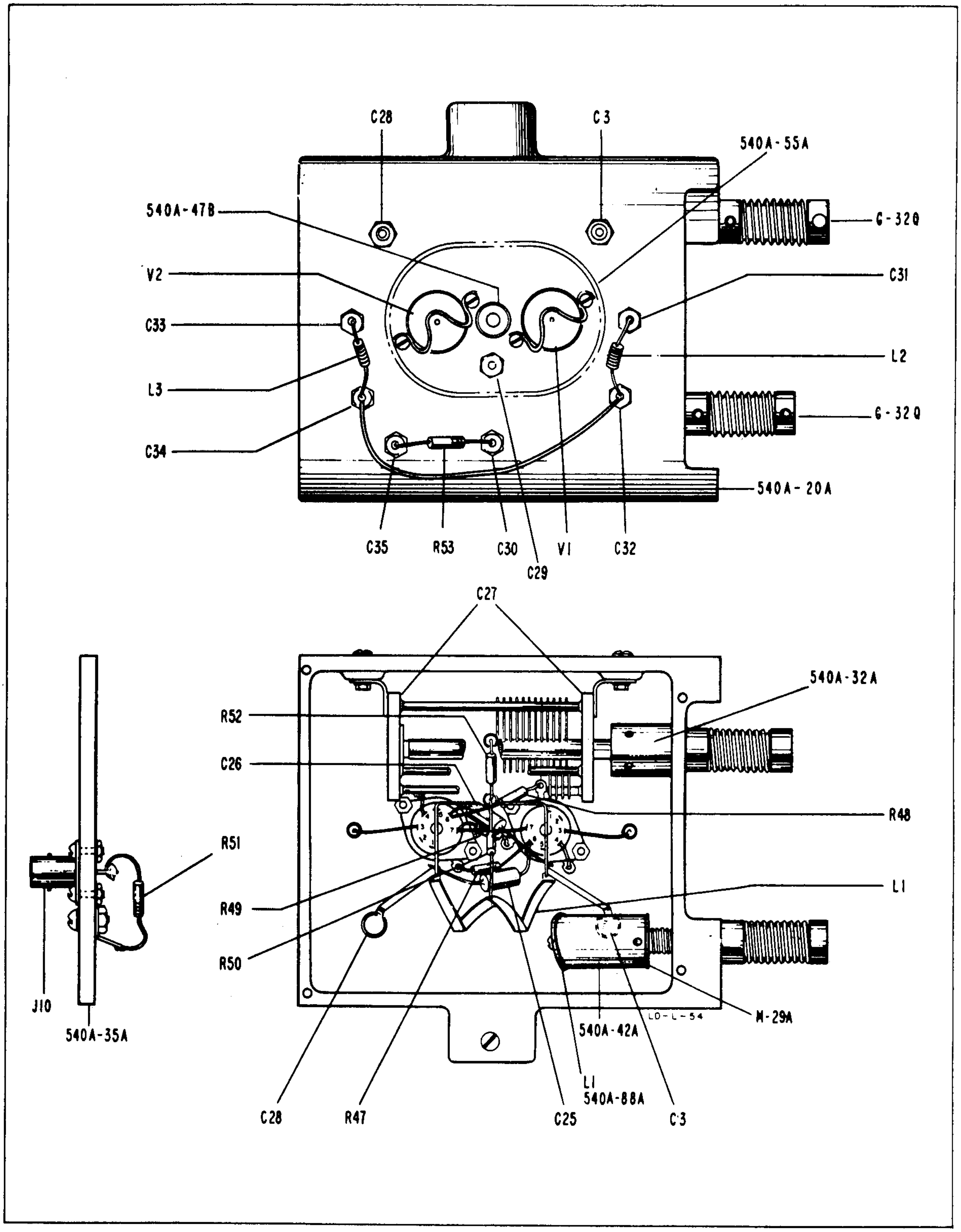


Figure 5-6. Oscillator Assembly

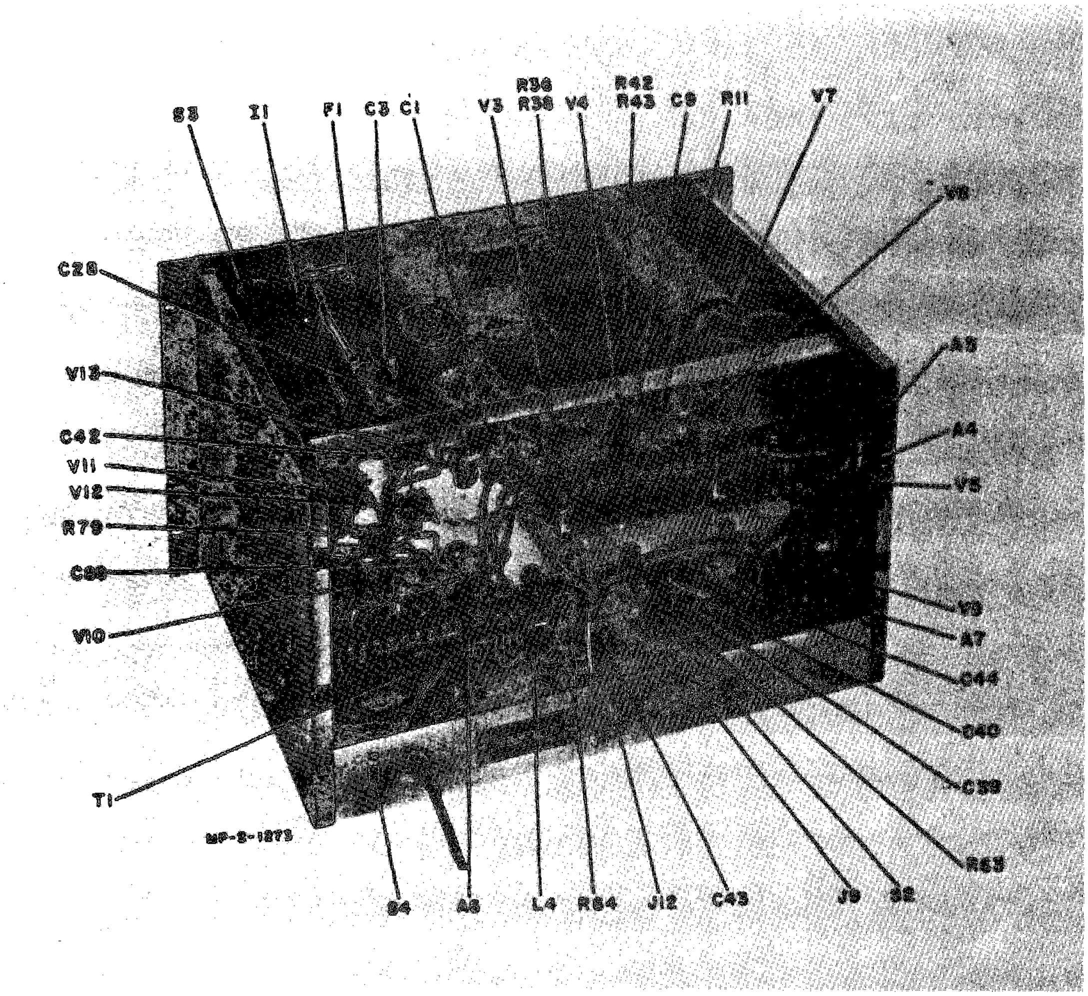


Figure 5-7. Chassis Board, Parts Location

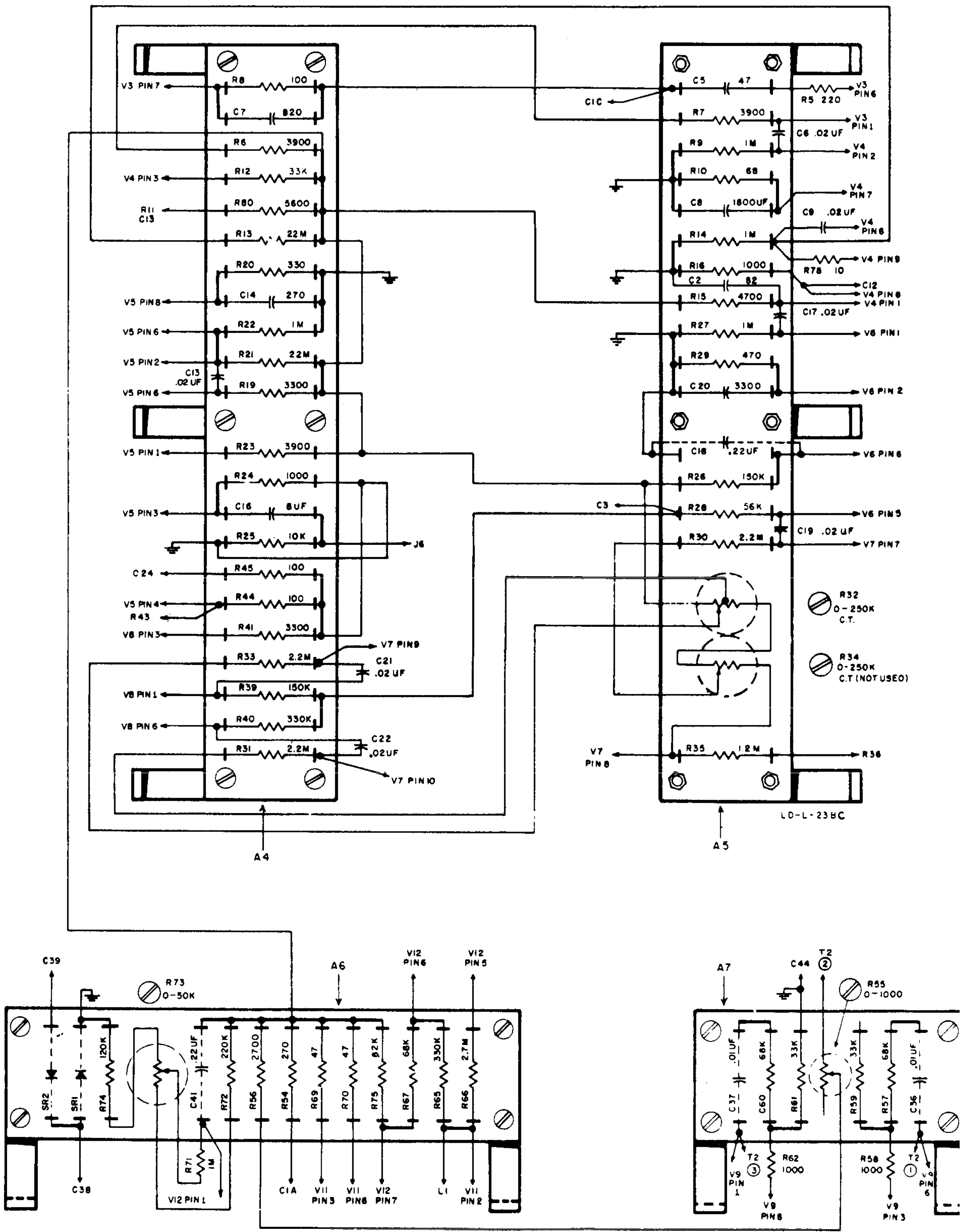


Figure 5-8. Resistor Board, Parts Location

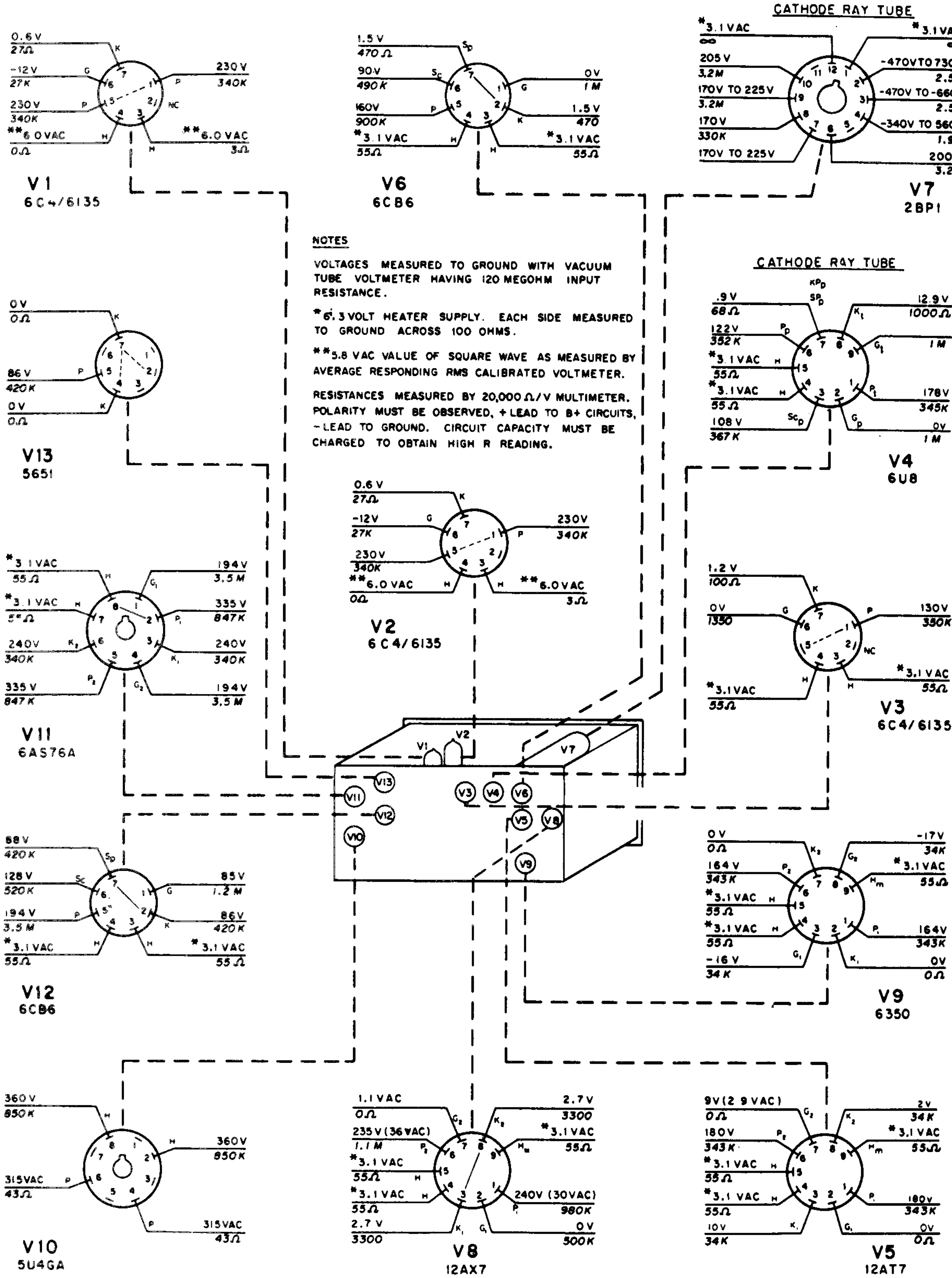


Figure 5-9. Voltage and Resistance Diagram

LD-E-1142

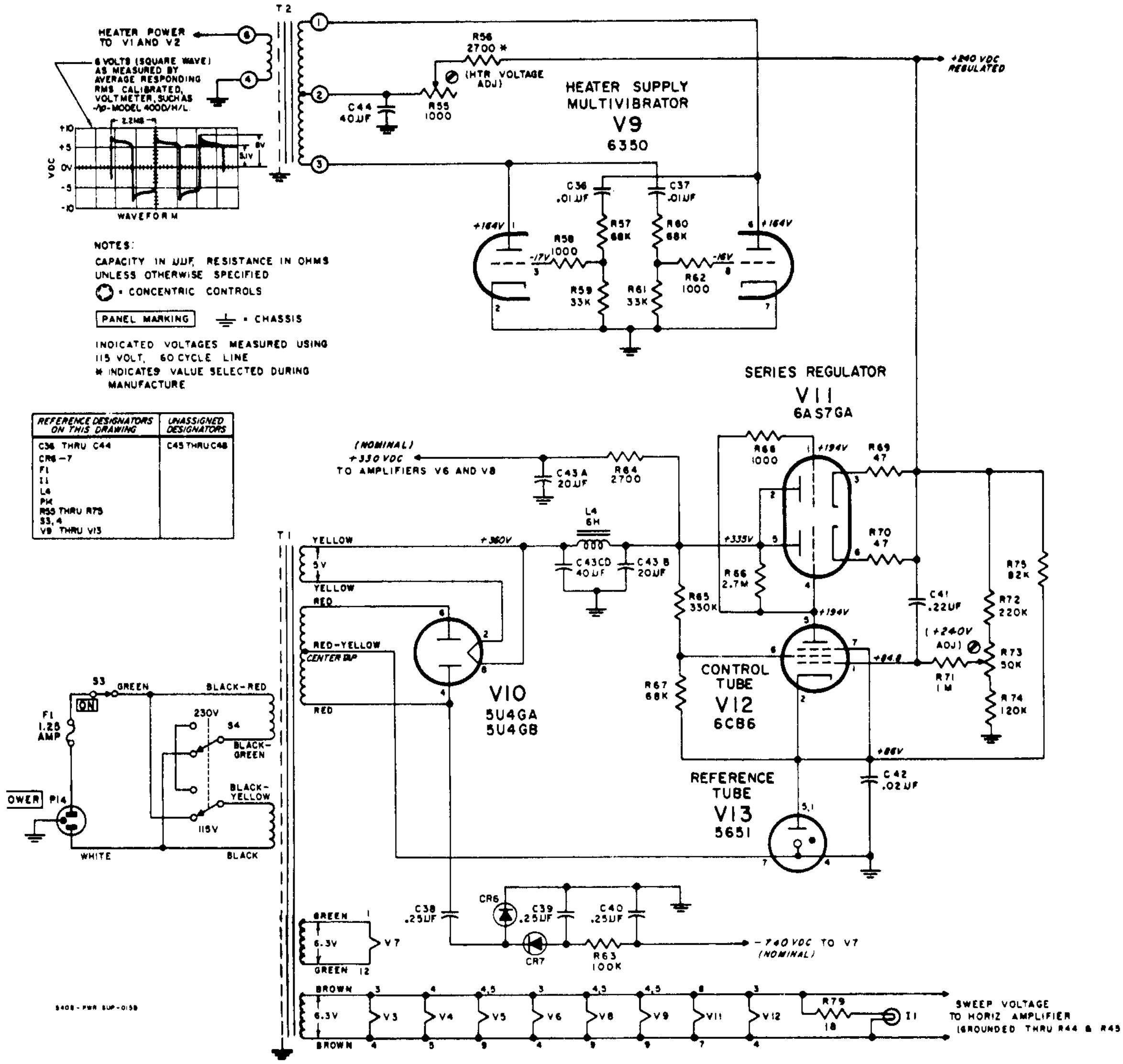


Figure 5-10. Power Supply

Figure 5-11. Oscillator Schematic

(Located in back of Manual)

SECTION V.1

PREVENTIVE MAINTENANCE INSTRUCTIONS

5.1-1. 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 5.1-4).

b. Weekly preventive maintenance checks and services (para 5.1-5).

c. Monthly preventive maintenance checks and services (para 5.1-6).

d. Quarterly preventive maintenance checks and services (para 5.1-7).

e. Cleaning (para 5.1-8).

f. Touchup painting (para 5.1-9).

5.1-2. 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 severiceable.

a. Systematic Care. The procedures given in paragraphs 5.1-4 through 5.1-8 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 (para 5.1-4 through 5.1-7) 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.

5.1 • PREVENTIVE MAINTENANCE CHECKS AND SERVICES PERIODS

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

5.1-4. DAILY PREVENTIVE MAINTENANCE CHECKS AND SERVICES CHART

Sequence No.	Item	Procedure	References
1	Completeness..................	See that the equipment is complete.................	None.
2	Exterior surfaces.............	Clean the exterior surfaces........................	Para 5.1-8.
3	Connectors....................	Check the tightness of all connectors..............	None.
4	Controls......................	While making the operating checks (item 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.	None.
5	Operation.....................	During operation, be alert for any unusual performance or condition.	None.

5.1-5. WEEKLY PREVENTIVE MAINTENANCE CHECKS AND SERVICES CHART

Sequence No.	Item	Procedure	References
1	Cables........................	Inspect 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. Clean and touchup paint as required.	Para 5.1-9.

5.1-6. MONTHLY PREVENTIVE MAINTENANCE CHECKS AND SERVICES CHART

Sequence No.	Item	Procedure	References
1	Pluckout items.................	Inspect seating of pluckout items. Make certain that tube clamps grip tubes bases tightly.	None.
2	Jacks.........................	Inspect jacks for snug fit and good contact........	None.
3	Transformer terminals..........	Inspect terminals on power transformer. All nuts must be tight. There should be no evidence of dirt or corrosion.	None.
4	Terminal blocks................	Inspect terminal blocks for loose connections and cracked or broken insulation.	None.
5	Resistors and capacitors.......	Inspect resistors and capacitors for cracks, blistering, or other detrimental defects.	None.
6	Gaskets and insulators.........	Inspect gaskets, insulators, bushings, and sleeves for cracks, chipping, and excessive wear.	None.

5.1-7. 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 if 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.
3	Spare parts....................	Check all spare parts (operator and organizational) for general condition and method of storage. No overstock should be evident and all shortages must be on valid requisitions.	

5.1-8. 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 case; use a cloth dampened (not wet) with Cleaning Compound (Federal stock No. 7930-395-9542).

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

Caution: Do not press on the face (glass) of the cathode ray tube when cleaning; the cathode ray tube may be damaged.

d. Clean the front panel and control knobs; use a soft clean cloth. If dirt is difficult to remove, dampen the cloth with water; use mild soap if necessary.

5.1-9. 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.

CODE LIST OF MANUFACTURERS (Sheets 1 of 2)

The following code numbers are from the Federal Suppy Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00136	McCoy Electronics	Mount Holly Springs, Pa.
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire & Cable Company	Redwood City, Calif.
04870	P. M. Motor Co.	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06136	Ward Leonard Electric	Los Angeles, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
[illegible]6[illegible]5	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
[illegible]751	U.S. Semcor Div. of Nuclear Corp. of Am.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
14298	American Components, Inc.	Conshocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.

From: F.S.C. Handbook Supplements
H4-1 Dated: December 1962
H4-2 Dated: April 1962

CODE LIST OF MANUFACTURERS (Sheet 2 of 2

CODE NO.	MANUFACTURER	ADDRESS
73734	Federal Screw Products Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y
75818	Lenz Electric Mfg. Co.	Chicago, Ill
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
81415	Wilker Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J
85471	A. B. Boyd Co.	San Francisco, Calif.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94928	Telefunken	Berlin, W. Germany
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
~~98220~~	~~Francis L. Mosley~~	~~Pasadena, Calif.~~
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING H P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK

CODE NO.	MANUFACTURER	ADDRESS
0000F	Malco Tool and Die	Los Angeles, Calif
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
000II	Bircher Corporation, Industrial Division	Monterey Park, Calif.
000KK	Ametem	New Rochelle, N.Y.
000LL	Avery Label	Monrovia, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000PP	Atohm Electronics,	Sun Valley, Calif.
000QQ	Cooltron	Oakland, Calif.
000RR	Radio Industries	Des Plaines, Ill.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000TT	Thomas & Betts Co., The	Elizabeth 1, N.J.
000WW	California Eastern Lab.	Burlingame, Calif.
000XX	Methode Electronics, Inc.	Chicago 31, Ill.
000YY	S. K. Smith Co.	Los Angeles 45, Calif.

From: F.S.C. Handbook Supplements
H4-1 Dated: December 1962
H4-2 Dated: April 1962

00015-29
Revised: 20 December 1962

APPENDIX I

REFERENCES

DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (types 7, 8, and 9), Supply Bulletins, Lubrication Orders, and Modification Orders.
SB 11-573	Painting and Preservation Supplies Available for Field Use for Electronics Command Equipment.
TB SIG 364	Field Instructions for Painting and Preserving Electronics Command Equipment.
TM 9-213	Painting Instructions for Field Use.
TM 11-5134-15	Organizational, DS, GS and Depot Maintenance Manual: Signal Generators SG-299/U, SG-299A/U, SG-299B/U, and SG-299C/U.
TM 11-5527	Multimeters TS-352 U, TS-352A/U, and TS-352B/U.
TM 11-6625-274-12	Operator's and Organizational Maintenance Manual: Test Sets, Electron Tube TV-7 U, TV-7A/U, TV-7B/U, and TV-7D/U
TM 11-6625-316-12	Operator and Organizational Maintenance Manual; Test Sets, Electron Tube TV-2/U, TV-2A/U, TV-2B/U, and TV-2C/U.
TM 11-6625-320-12	Organizational Maintenance Manual: Voltmeter, Meter ME-30A/U and Voltmeters, Electronic ME-30B/U, ME-30C/U, and ME-30E/U.
TM 33-750	Army Equipment Record Procedures.

APPENDIX II

BASIC ISSUE ITEMS LIST

Section I. INTRODUCTION

1. General

This appendix lists items supplied for initial operation and for running spares. The list includes tools, parts, and material issued as part of the major end item. The list includes all items authorized for basic operator maintenance of the equipment. End items of equipment are issued on the basis of allowances prescribed in equipment authorization tables and other documents that are a basis for requisitioning.

2. Columns

Columns are as follows:

a. Federal Stock Number. This column lists the 11-digit Federal stock number.

b. Designation by Model. Not used.

c. Description. Nomenclature or the standard item name and brief identifying data for each item are listed in this column. When requisitioning, enter the nomenclature and description.

d. Unit of issue. The unit of issue is each unless otherwise indicated and is the supply term by which the individual item is counted for procurement, storage, requisitioning, allowances and issue purposes.

e. Expendability. Nonexpendable items are indicated by NX. Expendable items are not annotated.

f. Quantity Authorized. Under "Items Comprising an Operable Equipment," the column lists the quantity of items supplied for the initial operation of the equipment. Under "Running Spare Items" the quantities listed are those issued initially with the equipment as spare parts. The quantities are authorized to be kept on hand by the operator for maintenance of the equipment.

g. Illustration. The "Item No." column lists the reference symbols used for identification of the items in the illustration or text of the manual.

6625-788-3780							COMPARATOR, FREQUENCY CM-77A/USM: Used for fast, accurate determination of CW and AM signals frequencies. Measuring center frequency or deviation range of FM signals. Measuring frequency in presence of high noise levels and high accuracy measurements of pulsed signals.					
							10 MC to 12000 MC range; oper. power rqmts 115 or 230V, 50 to 1000 cyc single ph.; dimen 20-1/2 lg x 12-1/2 h x 15-1/4 d; 1 cable assy spec purp furnished; Hewlett-Packard Model 540B					
							ITEMS COMPRISING AN OPERABLE EQUIPMENT					
							COMPARATOR, FREQUENCY CM-77A/USM: (Basic Component)		NX	1		
ORD THRU AGC							TECHNICAL MANUAL TM 11-6625-493-15			2		
6150-617-1470							CABLE ASSEMBLY, SPECIAL PURPOSE, ELECTRICAL: 4 ft lg; UG-88/U connector ea end; H-P p/n AC-16K (Not installed) (Not mounted)			1		
5995-829-3428							CABLE ASSEMBLY, SPECIAL PURPOSE, ELECTRICAL: RG-55/U cable; UG-88/U connector ea end, 6 in lg; Hewlett-Packard p/n 540A-16M			2		W1, W2
							RUNNING SPARE ITEMS					
5960-642-8341							ELECTRON TUBE: JAN type 5U4GB			1		V10
5960-[illegible]-8929							ELECTRON TUBE: JAN type 6AS7GA			1		V11
5960-812-7740							ELECTRON TUBE: JAN type 6CB6A			1		V6, V12
5960-729-6963							ELECTRON TUBE: JAN type 6U8A			1		V4
5960-262-0167							ELECTRON TUBE: JAN type 12AT7WA			1		V5
5960-166-7664							ELECTRON TUBE: JAN type 12AX7			1	v	V8
5960-262-0886							ELECTRON TUBE: JAN type 5651WA			1		V13
5960-262-0134							ELECTRON TUBE: JAN type 6135			1		V1, V3
5960-620-3055							ELECTRON TUBE: JAN type 6350			1		V9
5920-131-9817							FUSE, CARTRIDGE: 1-1/4 amp 125V slo-blo type; Buss Fusetron type MDL-1-1/4			5		F1
5920-280-3173							FUSE, CARTRIDGE: 0.6 amp Littelfuse p/n 313.600 (NOTE: For use W/230 V operation only)			5		F1
6240-155-8706							LAMP, INCANDESCENT: 6-8V, 0.15 amp; GE p/n 47			1		I1

FEDERAL STOCK NUMBER	DESIGNATION BY MODEL	DESCRIPTION	UNIT OF ISSUE	EXP	QTY AUTH	ILLUSTRATION FIGURE NO.	ILLUSTRATION ITEM NO.
		CN-77A/USM (continued)					
5960-262-0315		SEMICONDUCTOR DEVICE, DIODE: MIL type 1N21B			1		CR1, CR3, CR5
5960-729-5406		SEMICONDUCTOR DEVICE, DIODE: JAN type 1N416B			1		CR4

APPENDIX III

MAINTENANCE ALLOCATION

Section I. INTRODUCTION

1. General

a. This appendix assigns maintenance functions to be performed on components, assemblies, and subassemblies by the lowest appropriate maintenance category.

b. Columns in the maintenance allocation chart are as follows:

(1) *Part or component.* This column shows only the nomenclature or standard item name. Additional descriptive data are included only where clarification is necessary to identify the component. Components, assemblies, and subassemblies are listed in top-down order. That is, the assemblies which are part of a component are listed immediately below that component, and subassemblies which are part of an assembly are listed immediately below that assembly. Each generation breakdown (components, assemblies, or subassemblies) are listed in disassembly order or alphabetical order.

(2) *Maintenance function.* This column indicates the various maintenance functions allocated to the categories.

(*a*) *Service.* To clean, to preserve, and to replenish lubricants.

(*b*) *Adjust.* To regulate periodically to prevent malfunction.

(*c*) *Inspect.* To verify serviceability and detect incipient electrical or mechanical failure by scrutiny.

(*d*) *Test.* To verify serviceability and to detect incipient electrical or mechanical failure by use of special equipment such as gages, meters, etc.

(*e*) *Replace.* To substitute serviceable components, assemblies, or subassemblies, for unserviceable components, assemblies, or subassemblies.

(*f*) *Repair.* To restore an item to serviceable condition through correction of a specific failure of unserviceable condition. This function includes but is not limited to welding, grinding, riveting, straightening, and replacement of parts other than the trial and error replacement of running spare type items such as fuses, lamps, or electron tubes.

(*g*) *Align.* To adjust two or more components of an electrical system so that their functions are properly synchronized.

(*h*) *Calibrate.* To determine, check, or rectify the graduation of an instrument, weapon, or weapons system, or components of a weapons system.

(*i*) *Overhaul.* To restore an item to *completely serviceable* condition an prescribed by serviceability standards. This is accomplished through employment of the technique of “Inspect and Repair Omy as Necessary” (IROAN). Maximum utilization of diagnostic and test equipment is combined with minimum disassembly of the item during the overhaul process.

(*j*) *Rebuild.* To restore an item to a standard as near as possible to original or new condition in appearance, performance, and life expectancy. This is accomplished through the maintenance technique of complete disassembly of the item, inspection of all parts or components, repair or replacement of worn or unserviceable elements using original manufacturing tolerances and/or specifications and subsequent reassembly of the item.

(3) *Operator, organizational, direct support, general support, and depot.* The symbol X indicates the categories responsible for performing that particular maintenance operation, but does not necessarily indicate that repair parts will be stocked at that level. Categories higher than those marked by X are authorized to perform the indicated operation.

(4) *Tools required.* This column indicates codes assigned to each individual tool equipment, test equipment, and maintenance equipment referenced. The grouping of codes in this column of the maintenance allocation chart indicates the tool, test, and maintenance equipment required to perform the maintenance function.

(5) *Remarks.* Entries in this column will be utilized when necessary to clarify any of the data cited in the preceding column.

c. Columns in the allocation of tools *for* maintenance functions are as follows:

(1) *Tools required for maintenance functions.* This column lists tools, test, and maintenance equipment required to perform the maintenance functions.

(2) *Operator, organizational, direct support, general support, and depot.* The dagger (†) symbol indicates the categories normally allocated the facility.

(9) *Tool code.* This column lists the tool code assigned.

2. Maintenance by Using Organizations

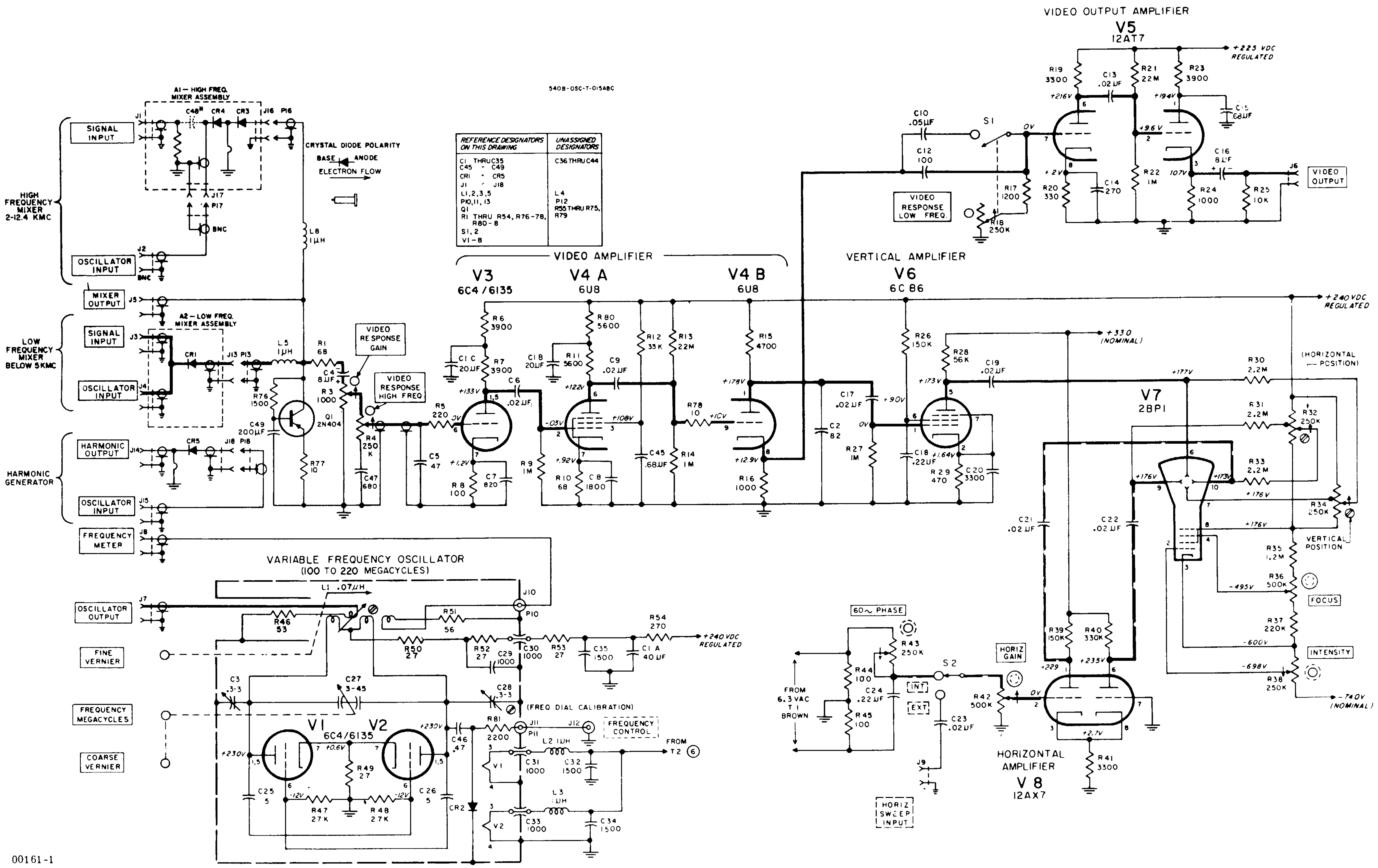
When this equipment is used by signal services organizations organic to theater headquarters or communication zones to provide theater communications, those maintenance functions allocated up to and including general support are authorized to the organization operating this equipment.

SECTION II. MAINTENANCE ALLOCATION CHART

PART OR COMPONENT	MAINTENANCE FUNCTION	ECHELON O/C	O	DS	GS	D	TOOLS REQUIRED	REMARKS
FREQUENCY COMPARATOR CM-77A/USM	service	X						
	adjust				X		1,3,6,12	
	inspect	X						
	test		X				11	Circuit continuity,etc.
					X		1,2,3,4,5,6,7,8,9,12, 13,15	
	repair		X				11	Easily replaced parts
					X		10	
	calibrate				X		3,4,12	
	overhaul					X	1,2,3,4,5,6,7,8,9,10, 12,13,14	

SECTION III. ALLOCATION OF TOOLS FOR MAINTENANCE FUNCTIONS

TOOLS REQUIRED FOR MAINTENANCE FUNCTIONS	ECHELON O/C	O	DS	GS	D	TOOL CODE	REMARKS
CM-77A/USM (continued)							
VARIABLE TRANSFORMER CH-16A/U				†	†	1	
VACUUM TUBE VOLTMETER ME-26/U				†	†	2	
VACUUM TUBE VOLTMETER ME-30				†	†	3	
FREQUENCY METER AN/USM-26				†	†	4	
OSCILLOSCOPE AN/USM-105				†	†	5	
MILLIAMMETER				†	†	6	FSN 6625-795-7493
SIGNAL GENERATOR				†	†	7	FSN 6625-553-1465
SIGNAL GENERATOR SG 299/U				†	†	8	
MULTIMETER TS-352/U				†	†	9	
TOOL EQUIPMENT TK-21/G				†	†	10	
TOOLS & TEST EQUIPMENT AUTHORIZED TO ORGANIZATIONAL REPAIRMAN BY VIRTUE OF HIS ASSIGNED MISSION		†				11	
PROBE "T" CONNECTOR ON ME-26				†	†	12	
50-OLIM COAXIAL LOAD FOR PROBE "T" CONNECTOR				†	†	13	
TEST SET ELECTRON TUBE TV-2					†	14	
TEST SET ELECTRON TUBE TV-7				†	†	15	


VIDEO OUTPUT AMPLIFIER
V5
12AT7
VIDEO AMPLIFIER
V3
6C4/6135
V4 A
6U8
V4 B
6U8
VERTICAL AMPLIFIER
V6
6CB6
V7
28P1
VARIABLE FREQUENCY OSCILLATOR
(100 TO 220 MEGACYCLES)
V1
V2
6C4/6135
HORIZONTAL
AMPLIFIER
V8
12AX7
HIGH FREQUENCY MIXER 2-12.4 KMC
LOW FREQUENCY MIXER BELOW 5KMC
HARMONIC GENERATOR
SIGNAL INPUT
OSCILLATOR INPUT
MIXER OUTPUT
HARMONIC OUTPUT
FREQUENCY METER
OSCILLATOR OUTPUT
FINE VERNIER
FREQUENCY MEGACYCLES
COARSE VERNIER
CRYSTAL DIODE POLARITY
VIDEO RESPONSE GAIN
VIDEO RESPONSE HIGH FREQ
VIDEO RESPONSE LOW FREQ
VIDEO OUTPUT
FREQUENCY CONTROL
HORIZ GAIN
HORIZ SWEEP INPUT
60~ PHASE
FOCUS
INTENSITY
+240 VDC REGULATED
+225 VDC REGULATED

00161-1

By Order of the Secretary of the Army:

HAROLD K. JOHNSON,
General,
United States Army,
Chief of Staff.

Official:

J. C. LAMBERT,
Major General, United States Army,
The Adjutant General.

Distribution:

Active Amy:

USASA (2)
CNGB (1)
CofT (1)
CofEngrs (1)
TSG (1)
Cofspts (1)
CC-E (2)
USAARMBD (2)
USAARTYBD (2)
USCONARC (2)
USAMC (2)
USAMICOM (2)
USAECOM (2)
USASCC (2)
ARADCOM (2)
ARADCOM Rgn (2)
OS Maj Cored (2)
OS Base Cored (2)
USASMC (3)
USASA 1st Fld Sta (1)
USACDCDA :
  Ft Huachuca (1)
  Ft Monmounth (1)
USAEMSA (15)
Lexington A Dep (6)
Sacramento A Dep (6)
Tobyhanna A Dep (6)
Letterkenny A Dep (5)
Ft Worth A Dep (5)
Sharpe A Dep (3)
Navajo A Dep (6)
Charleston A Dep (1)
Savanna A Dep (5)
Svc Colleges (1)
11th Air Assault Div (3)
GENDEP (OS) (1)
Sig Sec GENDEP (OS) (4)
Sig Dep (OS) (6)
Chicago Proc Dist (1)
Ft Huachuca (1)
WSMR (1)
USAELRDL (6)
USAERDL (2)
CRREL (2)
Oakland A Tml (5)
Units org under fol TOE:
  (2 copies each)
  11-15E
  11-587
  11-692
  11-697

NG: None.

USAR: None.

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

☆U.S. GOVERNMENT PRINTING OFFICE: 1994 - 300-421/82726

PIN: 020795-000

This fine document...

Was brought to you by me:

Liberated Manuals -- free army and government manuals

Why do I do it? I am tired of sleazy CD-ROM sellers, who take publicly available information, slap “watermarks” and other junk on it, and sell it. Those masters of search engine manipulation make sure that their sites that sell free information, come up first in search engines. They did not create it... They did not even scan it... Why should they get your money? Why are not letting you give those free manuals to your friends?

I am setting this document FREE. This document was made by the US Government and is NOT protected by Copyright. Feel free to share, republish, sell and so on.

I am not asking you for donations, fees or handouts. If you can, please provide a link to liberatedmanuals.com, so that free manuals come up first in search engines:

<A HREF=http://www.liberatedmanuals.com/>Free Military and Government Manuals</A>

– Sincerely
  Igor Chudov
  http://igor.chudov.com/
– Chicago Machinery Movers