NAVSHIPS 91572(A)

INSTRUCTION BOOK

for

SIGNAL GENERATOR TS-535A/U

HEWLETT-PACKARD CO.
PALO ALTO, CALIFORNIA

BUREAU OF SHIPS NAVY DEPARTMENT

Contract: NObsr-52305 *Approved by BuShips: 11 December 1951*

List of Effective Pages

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LIST OF ASO SPARES

Symbol Designation	ASO Stock Numbers	Quantity of BuAer Spares	Symbol Designation	ASO Stock Numbers	Quantity of BuAer Spares	Symbol Designation	ASO Stock Numbers	Quantity of BuAer Spares
C-101	R16-C-11897-50	45	E-101	R16-HWP-L1-146	21	O-107	R16-S-2209-225	0
C-102	R16-C-12055	21	E-102	R16-HWP-312-3	0	O-108	R16-C-19575-270	0
C-103	R16-C-11927-500	45	E-102A	R17-HWP-5009-1	1050	O-109	R16-C-19575-275	0
C-104	R16-C-11926	75	E-105	R16-HWP-L1S176	75	O-110	R16-HWP-L1-67	0
C-105	R16-C-8347-950	45	E-106	R17-C-1715-5	150	O-111	R16-HWP-L1F101-3	0
C-106	R16-C-8349-18	45	F-101	R17-F-16305	0	O-112	R16-S-2225-25	0
C-109	R16-C-11354-24	0	H-101	R16-C-19584-500	0	O-113	R16-K-3635-500	90
C-110	R16-C-10493-21	0	H-104	R16-C-19628	0	O-114	R16-HWP-L1F101-13	90
C-111	R16-C-11310-100	0	H-113	R16-C-19582	0	O-115	R16-K-3344-200	90
C-113	R16-C-10312-31-500	0	H-116	R16-C-19578	0	O-116	R16-K-3344-200	0
C-114	R16-C-9679-42-500	60	H-118	G41-W-2446	0	O-117	R16-K-3373-250	0
C-116	R16-C-9656-20-500	60	H-119	G41-W-2444	0	O-119	R16-HWP-L1E188	24
C-117	R16-C-10398-317	0	I-101	G17-L-6297	0	O-120	R16-HWP-L1E120	6
C-118	R16-C-10313-47-941	0	J-102	R16-J-3362-50	45	O-121	R16-HWP-L1F115	6
C-121	R16-C-10004-97-501	0	J-103	R16-J-3362-25	45	P-101	R17-P-4442-460	90
C-125	R16-C-10430-13	0	J-104	R17-R-1968-130	30	P-102	R16-P-3627-375	0
C-129	R16-C-9924-61	0	L-101	R16-C-22051-30	60	P-104	R17-P-5410-100	75
C-130	R16-C-10026-6	0	L-104	R16-R-1941-5	24	R-101	R16-HWP-L1-69	60
C-134	R16-C-11333-103-70	0	M-101	R17-HWP-L1L174	24	R-103	R17-L-2109	0
C-144	R16-C-11599-25-10	0	O-101	R16-HWP-L1-156	45	R-104	R16-JAN-RA20A2SA102AK	0
C-146	R16-C-11676-500-125	30	O-104	R16-HWP-M25B	45	R-105	R16-R-17278-6	0
C-147	R16-C-11612-899	0	O-105	R16-HWP-M25C	45	R-106	R16-JAN-RC30BF333K	0
C-149	R16-C-10480-10	0	O-106	R16-S-2209-250	0	R-107	R16-JAN-RC30BF563K	0

LIST OF ASO SPARES (continued)

Symbol Designation	ASO Stock Numbers	Quantity of BuAer Spares	Symbol Designation	ASO Stock Numbers	Quantity of BuAer Spares	Symbol Designation	ASO Stock Numbers	Quantity of BuAer Spares
R-109	R16-JAN-RC30BF221K	0	R-146	R16-P-5588-7-400	0	T-102	R17-T-7079-15	30
R-111	R16-R-17310-63-500	0	R-147	R16-JAN-RC30BF104K	0	V-101	N16-T-56665	0
R-114	R16-JAN-RC30BF332-K	0	R-148	R16-JAN-RC30BF222K	0	V-102	N16-T-56117	0
R-116	R16-JAN-RC30BF123K	0	R-153	R16-JAN-RC30BF274K	0	V-103	N16-T-56611	0
R-118	R16-P-5583-34-250	0	R-161	R16-JAN-RC30BF683K	0	V-104	N16-T-56684	0
R-119	R16-JAN-RC30BF391K	0	R-166	R16-P-5595-60	0	V-107	N16-T-56758	0
R-120	R16-JAN-RC30BF105K	0	R-168	R16-JAN-RC30BF225K	0	V-109	N16-T-56346	0
R-121	R16-R-17310-178-500	0	R-169	R16-P-5597-865	0	V-110	N16-T-52171	0
R-122	R16-JAN-RC30BF822K	0	R-172	R16-JAN-RC30BF681K	0	V-112	N16-T-56350	0
R-124	R16-JAN-RC30BF621J	0	R-174	R16-JAN-RC30BF474K	0	V-114	N16-T-56458	0
R-125	R16-P-5583-9-250	0	R-175	R16-JAN-RC30BF823K	0	V-115	N16-T-56685	0
R-126	R16-JAN-RC30BF473K	0	R-176	R16-JAN-RC30BF154K	0	V-116	N16-T-53050	0
R-130	R16-P-5581-314-500	0	R-181	R16-P-5590-61	0	V-117	N16-T-55464	0
R-132	R16-R-17347-34	0	R-187	R16-JAN-RW20G112	0	XF-101	R17-P-7275-10	0
R-134	R16-JAN-RC30BF561K	0	R-192	R16-JAN-RC30BF180K	0	XI-101	R17-L-12932-62-10	60
R-135	R16-R-17332-8	0	R-193	R16-JAN-RC30BF100K	0	XI-102	R17-S-10755	0
R-137	R16-JAN-RC30BF564K	0	R-195	R16-JAN-RC30BF330K	0	XR-103	R17-HWP-L1-143	0
R-138	R16-JAN-RC30BF682K	0	R-198	R16-JAN-RW22G501	0	XV-101	R16-S-6185-700	0
R-139	R16-JAN-RC30BF471K	0	R-200	R16-AN-CN77U	30	XV-110	R16-S-6189-75	0
R-140	R16-JAN-RC30BF103K	0	S-101	R17-S-25519-87	21	Y-101	R16-HWP-L1-151	18
R-141	R16-JAN-RC30BF223K	0	S-102	R17-S-25519-86	21	Y-101d	R16-T-2803-560	60
R-142	R16-JAN-RC30BF153K	0	S-103	R17-S-28225-243	0	(UG-201/U)	R16-A-470	0
R-143	R16-JAN-RC30BF224K	0	T-101	R16-T-4848-90	30			

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

IN REPLY REFER TO
Code 993-100
11 December 1951

From: Chief, Bureau of Ships
To: All Activities Concerned with the Installation, Operation and Maintenance of the Subject Equipment

Subj: Instruction Book for Signal Generator TS-535A/U NAVSHIPS 91572(A)

1. This is the instruction book for the subject equipment and is in effect upon receipt, superseding NAVSHIPS 91572.

2. When superseded by a later edition, this publication shall be destroyed.

3. Extracts from this publication may be made to facilitate the preparation of other Department of Defense Publications.

4. All Navy requests for NAVSHIPS Electronics publications should be directed to the nearest District Publications and Printing Office. When changes or revised books are distributed, notice will be included in the BuShips ELECTRON and in the Index of Bureau of Ships General and Electronics Publications, NAVSHIPS 250-020.

H. N. WALLIN
Chief of Bureau

RECORD OF CORRECTIONS MADE

CHANGE NO.	DATE	SIGNATURE OF OFFICER MAKING CORRECTION

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GUARANTEE

The Contractor guarantees that at the time of delivery thereof the supplies provided for under this contract will be free from any defects in material or workmanship and will conform to the requirements of this contract. Notice of any such defect or non-conformance shall be given by the Government to the Contractor within one year of the delivery of the defective or non-conforming item, unless a different period of Guaranty is specified in the Schedule. If required by the Government within a reasonable time after such notice, the Contractor shall with all possible speed correct or replace the defective or non-conforming item or part thereof. When such correction or replacement requires transportation of the item or part thereof, shipping costs, not exceeding usual charges, from the delivery point to the Contractor's plant and return, shall be borne by the Contractor; the Government shall bear all other shipping costs. This Guaranty shall then continue as to corrected or replacing supplies or, if only parts of such supplies are corrected or replaced, to such corrected or replacing parts, until one year after the date of redelivery, unless a different period of Guaranty is specified in the Schedule. If the Government does not require correction or replacement of a defective or non-conforming item, the Contractor, if required by the Contracting Officer within a reasonable time after the notice of defect or non-conformance, shall repay such portion of the contract price of the item as is equitable in the circumstances.

INSTALLATION RECORD

Contract Number: NObsr-52305 *Date of Contract: 30 March, 1951*

Serial Number of Equipment......................................

Date of acceptance by the Navy......................................

Date of delivery to contract destination......................................

Date of completion of installation......................................

Date placed in service......................................

Blank spaces in this table shall be filled in at time of installation.

REPORT OF FAILURE

Report of failure of any part of this equipment, during its service life, shall be made to the Bureau of Ships in accordance with current instructions. The report shall cover all details of the failure and give the date of installation of the equipment. For procedure in reporting failures see Chapter 67 of the "Bureau of Ships Manual," or superseding instructions.

ORDERING PARTS

All requests or requisitions for replacement material should include the following data:

1. Navy stock number, or when ordering from an Army supply depot, the Army stock number.
2. Name of part.

If the Navy stock number has not been assigned, the requisitions should specify the following:

1. Equipment model designation.
2. Name of part and complete description.
3. Manufacturer's designation.
4. Contractor's drawing and part number.
5. AWS, JAN, or Navy type designation.

SAFETY NOTICE

The attention of officers and operating personnel is directed to Chapter 67 of the "Bureau of Ships Manual" or superseding instructions on the subject of radio-safety precautions to be observed.

This equipment employs voltages which are dangerous and may be fatal if contacted by operating personnel. Extreme caution should be exercised when working with the equipment.

RESUSCITATION

AN APPROVED POSTER ILLUSTRATING THE RULES FOR RESUSCITATION BY THE PRONE PRESSURE METHOD SHALL BE PROMINENTLY DISPLAYED IN EACH RADIO, RADAR OR SONAR ENCLOSURE. POSTERS MAY BE OBTAINED UPON REQUEST TO THE BUREAU OF MEDICINE AND SURGERY.

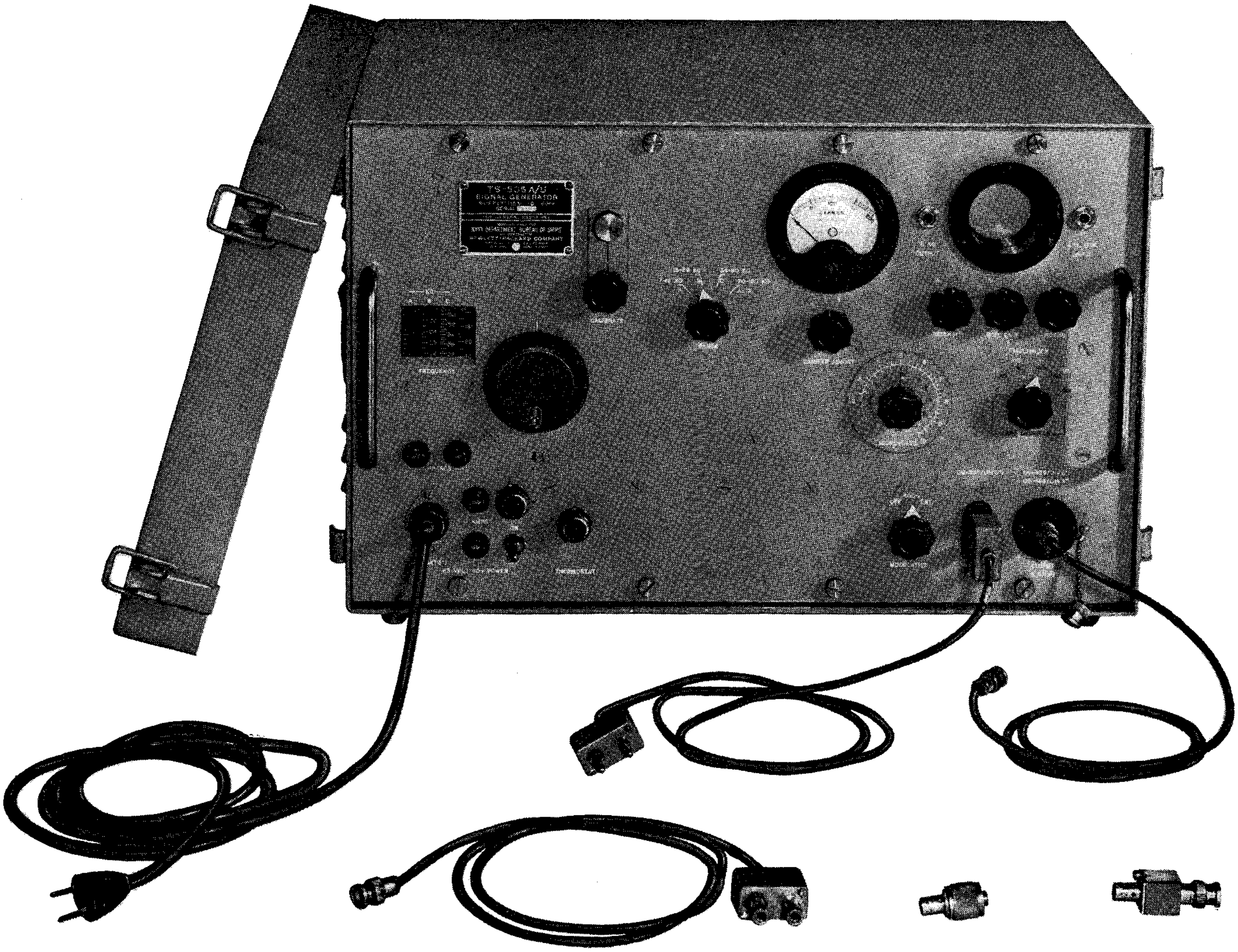


Figure 1—1. Signal Generator TS-535A/U, Panel Cover Removed

SECTION 1
GENERAL DESCRIPTION

1. INTRODUCTORY

Signal Generator TS-535A/U is a general-purpose test equipment designed to generate sine-wave voltages of known frequency at known amplitudes in the upper audio and supersonic spectrum. The frequency calibration of the instrument has been designed to be unusually accurate. Frequencies from 7 kc to 160 kc at amplitudes from 0.5 microvolt to one volt are obtainable from the instrument. These voltages can be 30% internally modulated by a self-contained 400-cps generator or externally modulated by any frequency from 20 to 2000 cps. The instrument is designed to operate from a nominal 115-volt, 50-63 cycle, single phase ac power source and draws approximately 185 watts.

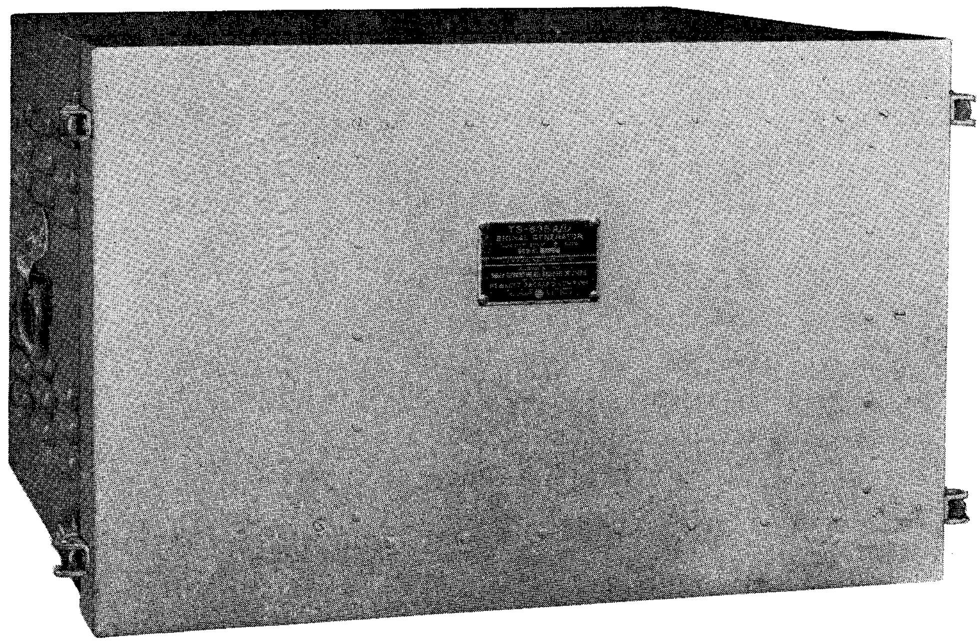


Figure 1—2. Signal Generator TS-535A/U, Panel Cover In Place

This instruction book is intended only for Signal Generator TS-535A/U and pertains to no other equipment.

2. GENERAL.

An unusual feature of this equipment is that its output frequency can be checked against the frequency of a self-contained tuning-fork-controlled oscillator. This check is made by means of Lissajous figures on a cathode-ray tube which is also self-contained. By use of this system output frequencies below 70 kc can be controlled to a specified accuracy within 0.1% of the indicated dial frequency, and frequencies above 70 kc can be controlled within 0.5%. A vernier frequency control is provided for precise adjustments of the main oscillator frequency.

The output attenuator of Signal Generator TS-535A/U is designed to allow selection of output voltages which are accurate within 10% down to the one microvolt level at frequencies below 70 kc and within 10% or 0.5 microvolt (whichever is greater) at frequencies above 70 kc.

Supplied with the instrument is a calibration book which gives dial readings at intervals throughout the frequency range of the instrument. The calibration book makes possible the selection of any frequency within the range of this equipment with the greatest accuracy of which it is capable. In practice normal accuracies of 0.05% or better are usually obtained.

Signal Generator TS-535A/U can also be used as a frequency meter to measure frequencies from less than 3.5 kc to more than 320 kc. These measurements can be made with an accuracy approximately equal to the accuracy of the main carrier oscillator. The measurements are made by means of Lissajous figures resulting when the unknown is connected to the horizontal deflecting system through the EXT HOR INPUT panel jack.

A protective cover for the panel of the instrument is provided for periods when the instrument is not in use. On the inside surface of the panel cover are mounted an instruction book, calibration book, four cables, an external attenuator, and an adaptor. The external attenuator allows the output voltage from the instrument to be reduced to levels lower than are practical with the built-in attenuators. The adaptor is designed to allow connection between the type BNC connectors used on the instrument and the type N series of connectors.

The frequency range from 7 kc to 160 kc is covered in four bands. Three of the bands are direct-reading in frequency, while the highest band utilizes the calibrations of the lowest band but multiplied by a factor of 10. A fourth calibration consisting of a linear scale is provided for exact selection of carrier frequencies.

The main oscillator is of the resistance-tuned type. In order to obtain the highest performance from the circuit, precision components are used in the frequency-determining network of the oscillator. All resistors are a precision wirewound type, and temperature-compensating type capacitors are used to provide a very small temperature coefficient of frequency for the circuit. The main tuning capacitor is driven through a 100:1 gear-reduction drive that provides an extremely long effective scale length.

3. SIMILARITY OF EQUIPMENT.

Signal Generator TS-535A/U is similar in appearance, operation, and circuitry to Signal Generator TS-535/U. This instruction book can be used as a guide in operating Signal Generator TS-535/U as well as Signal Generator TS-535A/U. However, for purposes of repairing Signal Generator TS-535/U, it is desirable to refer to its instruction book, NAVSHIPS 900,839, especially if replacements parts are required.

The output and power transformers T-101 and T-102 in Signal Generator TS-535A/U are physically smaller than in the TS-535/U. However, the TS-535A/U chassis is punched to accommodate either size. The filter choke L-104 is somewhat larger in the TS-535A/U than in the TS-535/U.

Other differences between the two instruments include a standby space heater in the TS-535A/U, modification of some circuit values, and the use of trunk latches instead of thumb screws to secure the panel cover.

TABLE 1—1. EQUIPMENT SUPPLIED

QUANTITY PER EQUIPMENT	NAME OF UNIT	DESIGNATION	OVER-ALL DIMENSIONS			VOLUME	WEIGHT
			HEIGHT	WIDTH	DEPTH		
1	Signal Generator	TS-535A/U	14	22¾	18⅜	3.4	89
1	External Attenuator	CN-77/U	¾	¾	2¼	•	⅛
1	Output Cable	CG-409/U (4′2″)	9/16	9/16	50	•	¼
1	Output Cable	CG-465/U (4′3″)	1½	¾	51	•	½
1	Output Cable	CG-466/U (4′5″)	1½	¾	53	•	½
1	Adaptor	UG-201/U	¾	¾	1 13/32	•	1/16
1	Power Cable	CAQI-62391 (7′3″)	1	1	87	•	⅜
2	Instruction Books	NAVSHIPS 91572(A)	11½	9	¼	•	¾
1	Calibration Book		11½	9	¼	•	¼

No equipment or publications are required which are not supplied. Unless otherwise stated, dimensions are inches, volume cubic feet, weight pounds.

TABLE 1—2. SHIPPING DATA

SHIPPING BOX No.	QUAN-TITY	CONTENTS		BOX OVER-ALL DIMENSIONS			VOLUME	WEIGHT
		NAME	DESIGNATION	HEIGHT	WIDTH	DEPTH		
1	1	Signal Generator	TS-535A/U	27½	20	26	8.3	162
	1	External Attenuator	CN-77/U					
	1	Output Cable	CG-409/U (4′2″)					
	1	Output Cable	CG-465/U (4′3″)					
	1	Output Cable	CG-466/U (4′5″)					
	1	Adaptor	UG-201/U					
	1	Power Cable	CAQI-62391 (7′3″)					
	2	Instruction Books	NAVSHIPS 91572(A)					
	1	Calibration Book						

TABLE 1—3. ELECTRON TUBE COMPLEMENT

QUANTITY	TUBE TYPE	DESCRIPTION
2	6SJ7	Pentode
2	6V6GT/G	Beam tetrode
1	6AG7	Pentode
1	6SA7	Pentagrid converter
3	6SN7W	Twin triode
1	5U4G	Full-wave rectifier
1	0C3/VR105	Voltage regulator
1	6SQ7	Duplex diode triode
2	6L6GA	Beam tetrode
1	2AP1A	Cathode-ray tube
1	6J5	Triode
1	6H6	Duplex diode

REFERENCE DATA

a. NOMENCLATURE:	Signal Generator TS-535A/U
b. CONTRACT:	NObsr-52305, dated 30 March 1951
c. CONTRACTOR:	Hewlett-Packard Company, Palo Alto, California
d. COGNIZANT NAVAL INSPECTOR:	Inspector of Naval Material, San Francisco, California
e. NUMBER OF PACKAGES PER COMPLETE SHIPMENT OF EQUIPMENT:	One
f. TOTAL CUBICAL CONTENTS:	8.3 cu. ft., crated 3.4 cu. ft., uncrated
g. TOTAL WEIGHT:	162 lbs. crated 89 lbs. uncrated
h. FREQUENCY RANGE:	7 kc to 160 kc
i. ACCURACY OF OUTPUT FREQUENCY:	Within 0.1% below 70 kc and within 0.5% above 70 kc when standardized.
j. FREQUENCY BANDS:	Four
k. RANGE OF EACH BAND:	Range "A"— 7 to 16 kc Range "B"—15 to 36 kc Range "C"—34 to 80 kc Range "Ax10"—70 to 160 kc
l. MODULATION CHARACTERISTICS:	INTERNAL: 30% amplitude modulation at fixed frequency of 400 cps. EXTERNAL: 30% amplitude modulation obtainable at frequencies between 20 cps and 2000 cps; approximately one volt external voltage required.
m. POWER FACTOR OF EQUIPMENT:	Approximately 0.9.
n. CHARACTERISTICS OF REQUIRED POWER SUPPLY:	VOLTAGE: 105 to 125 volts, 50-63 cps a-c, single phase. CURRENT DRAWN: Approximately 1.65 amperes.
o. OUTPUT IMPEDANCE:	5 ohms
p. OUTUT VOLTAGE:	1 volt maximum 0.5 microvolt minimum
q. ACCURACY OF OUTPUT VOLTAGE:	Within 10% down to 1 microvolt below 70 kc; within 10% or 0.5 microvolt above 70 kc.

SECTION 2
THEORY OF OPERATION

1. GENERAL.

Signal Generator TS-535A/U is designed to supply sine-wave voltages at frequencies from 7 kc to 160 kc at amplitudes from 0.5 microvolt to one volt. These voltages can be either modulated or unmodulated and can be compared with the frequency of a self-contained, fixed-frequency precision oscillator in order that their frequency can be erated by the Carrier Oscillator and is then applied to the Output Amplifier, either directly or after being modulated in the Modulator section by the output of the Modulating Oscillator. From the Output Amplifier the carrier voltage is passed through the Output System to the output terminals and is also applied to the vertical deflecting-plates of the Oscilloscope from an intermediate stage of the amplifier.

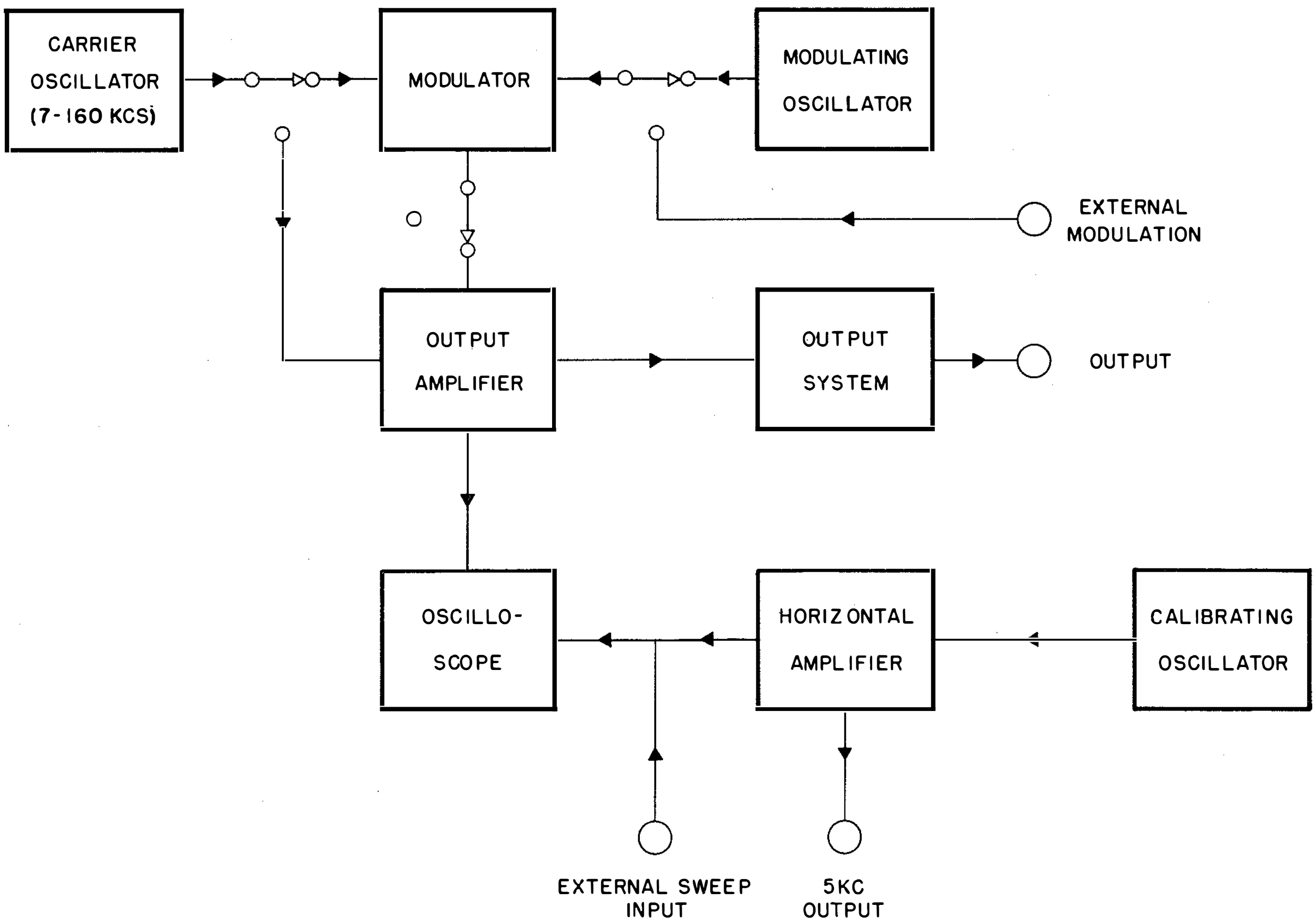


Figure 2—1. Circuit Block Diagram

known with a high order of accuracy. A complete schematic diagram for the equipment is shown on a fold-out page at the back of Section 4 (Fig. 4-16).

Electrically, the instrument consists of eight basic sections as shown in Fig. 2-1. For simplicity, a ninth section, the power supply, is not shown in the diagram. The main carrier frequency is gen-

The horizontal deflecting-plates of the Oscilloscope are driven by the Calibrating Oscillator through the Horizontal Amplifier. Lissajous figures are then produced on the cathode-ray tube, enabling the operator to determine precisely the frequency of the carrier voltage at certain points throughout the carrier frequency range.

2. CARRIER OSCILLATOR.

a. GENERAL.—The Carrier Oscillator used in this instrument is a resistance-tuned sine-wave generator of the Wein Bridge type and is shown in Fig. 2-2 in block form. Basically, the circuit consists of a two-stage resistance-coupled amplifier

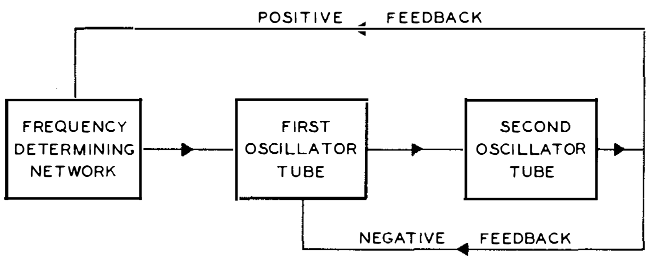


Figure 2—2. Block Diagram of Carrier Oscillator

which is caused to oscillate by the use of a positive feedback circuit. Because two resistance-coupled stages are used, the grid voltage of the first tube is in phase with the output of the second tube. At the "resonant" frequency there is no phase shift in the positive feedback circuit, so that a voltage of proper frequency on the grid of the first tube is reinforced by the output of the second tube and oscillation occurs.

b. POSITIVE FEEDBACK CIRCUIT.—In Fig. 2-3 the oscillator circuit is shown in basic form.

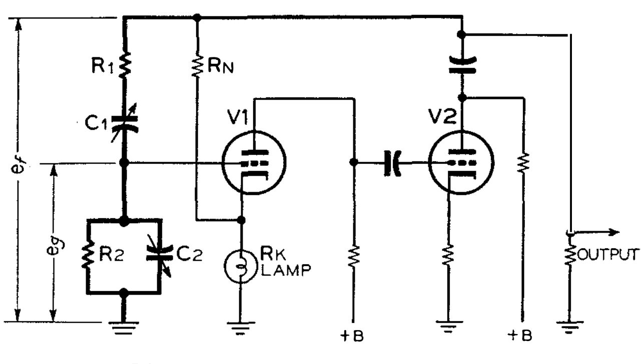


Figure 2—3. Basic Oscillator Circuit

R_1, R_2, C_1, and C_2 in the positive feedback circuit constitute the frequency-selective network shown in block form in Fig. 2-2. The purpose of this network is to control the frequency of oscillation of the system. The characteristics of the frequency-selective network are shown in Fig. 2-4 where it may be seen that at one frequency f_o the ratio of e_g to e_f (curve "a") is greater than at any other frequency. In addition at frequency f_o the phase shift (curve "b") between e_g and e_f is zero; that is, the two voltages are in phase. These two characteristics, combined with negative feedback, limit the

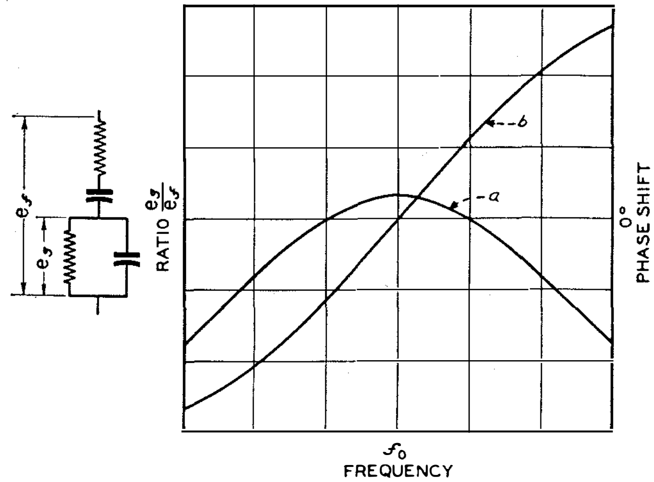


Figure 2—4. Characteristics of Frequency-Determining Network

frequency of oscillation to f_o, for the phase shift through the system does not permit oscillation at any other frequency. Hence, the system oscillates at f_o.

By using a two-section variable capacitor for C_1 and C_2, the oscillator becomes variable. The frequency of oscillation of the system is given by the formula

$$f_o = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}}$$

However, since R_1 and R_2 are equal and since C_1 and C_2 are equal, the above formula may be reduced to

$$f_o = \frac{1}{2\pi\,RC}$$

c. NEGATIVE FEEDBACK AND AUTOMATIC AMPLITUDE LIMITER.—In addition to the positive feedback circuit used in the oscillator, a negative feedback circuit is also used for the purpose of stabilizing the oscillator, minimizing distortion, and keeping amplification constant over a wide range of frequencies. In basic form this circuit consists of R_n and R_k (Fig. 2-3), the latter being a 3-watt incandescent lamp which has a positive temperature coefficient; that is, the lamp's resistance increases when the temperature of the lamp filament increases. This property allows the lamp to operate as an automatic amplitude limiter, for if the amplitude of oscillation tends to increase, the current through the lamp tends to increase, thus increasing the lamp's resistance. Therefore, the negative feedback tends to increase so that the amplitude of oscillation is maintained constant.

If the amplitude of oscillation tends to decrease, the reverse of the above action occurs, and the amplitude is also maintained constant. Hence, the lamp acts as an automatic amplitude limiter. Negative feedback also gives a constant phase characteristic to the two-stage amplifier, thus stabilizing the frequency of oscillation of the system and reducing its sensitivity to supply voltage variations.

d. COMPLETE OSCILLATOR CIRCUIT.—Fig. 2-5 shows the complete oscillator circuit used in this instrument. R-101 and R-102 are the frequency-determining resistors, each having four sections to accommodate the four ranges of the instrument. These resistors are wound with low temperature coefficient wire to very close tolerances in order to make the oscillator calibration as accurate as possible. C-102 is the main frequency-determining condenser and is a two-section variable condenser, one section being in series with R-102 and one section being in parallel with R-101. C-101 is a trimmer condenser which functions as a frequency vernier, being labeled CALIBRATE on the front panel, C-103 and C-104 are trimmers which adjust the tracking of the circuit. C-105 and C-106 are temperature-compensating type capacitors which compensate for the frequency drifts caused by temperature changes. C-108 is a capacitor which compensates for the effect of stray capacities that tend to make the phase shift through the two tubes less than 360° at the higher frequencies.

R-103, R-104, and R-105 constitute the negative feedback circuit. R-104 is a variable resistor which adjusts the magnitude of negative feedback voltage and hence the voltage output of the oscillator.

C-103, C-104, R-104, and C-108 are calibration adjustments which should not be adjusted except by laboratory personnel who have *sufficient equipment* on hand to aid in making such adjustments properly.

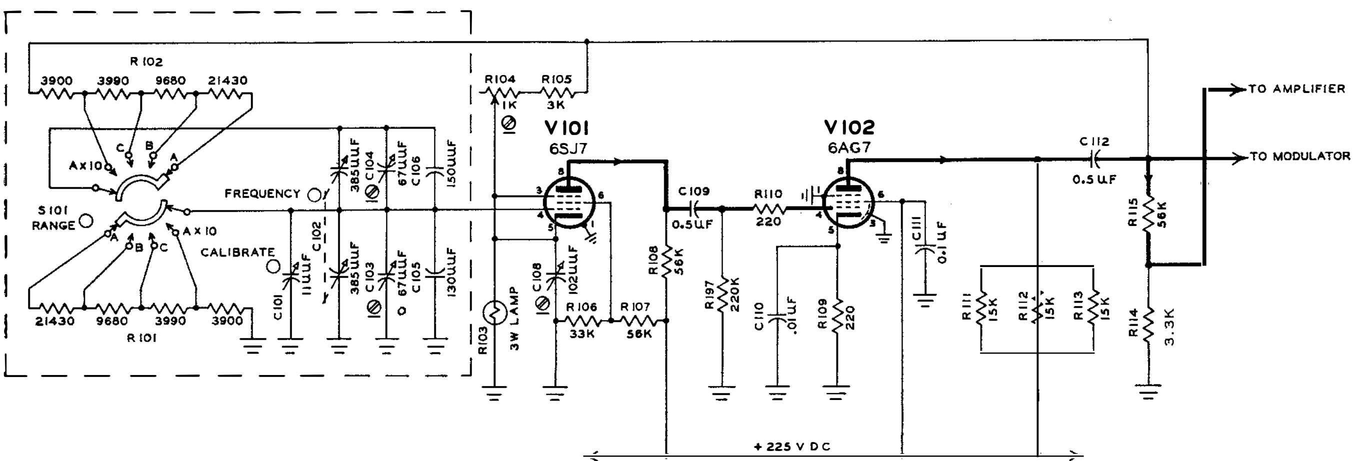


Figure 2—5. Complete Carrier Oscillator Circuit

A high-gain tube (type 6SJ7) is used for V-101, while a high g_m tube (type 6AG7) is used for V-102 because of its low plate load on the higher frequency ranges when low-value resistors are used in the frequency-determining network.

3. MODULATING OSCILLATOR.

The Modulating Oscillator is an oscillator of the same general type as the Carrier Oscillator. The two circuits are quite similar, the major differences being that the Modulating Oscillator is a fixed frequency oscillator, that the frequency-determining network in the Modulating Oscillator is less elaborate than in the Carrier Oscillator, and that different tubes are used.

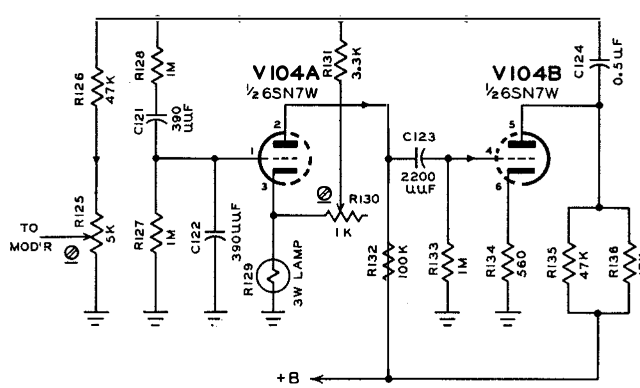


Figure 2—6. Complete Modulating Oscillator Circuit

Fig. 2-6 is a schematic of the complete circuit of the Modulating Oscillator. R-127, R-128, C-121, and C-122 comprise the frequency-determining network. R-125 is a potentiometer in the output circuit of the oscillator, so located in order to apply the proper amount of voltage to the Modulator section. R-130 adjusts the magnitude of the negative

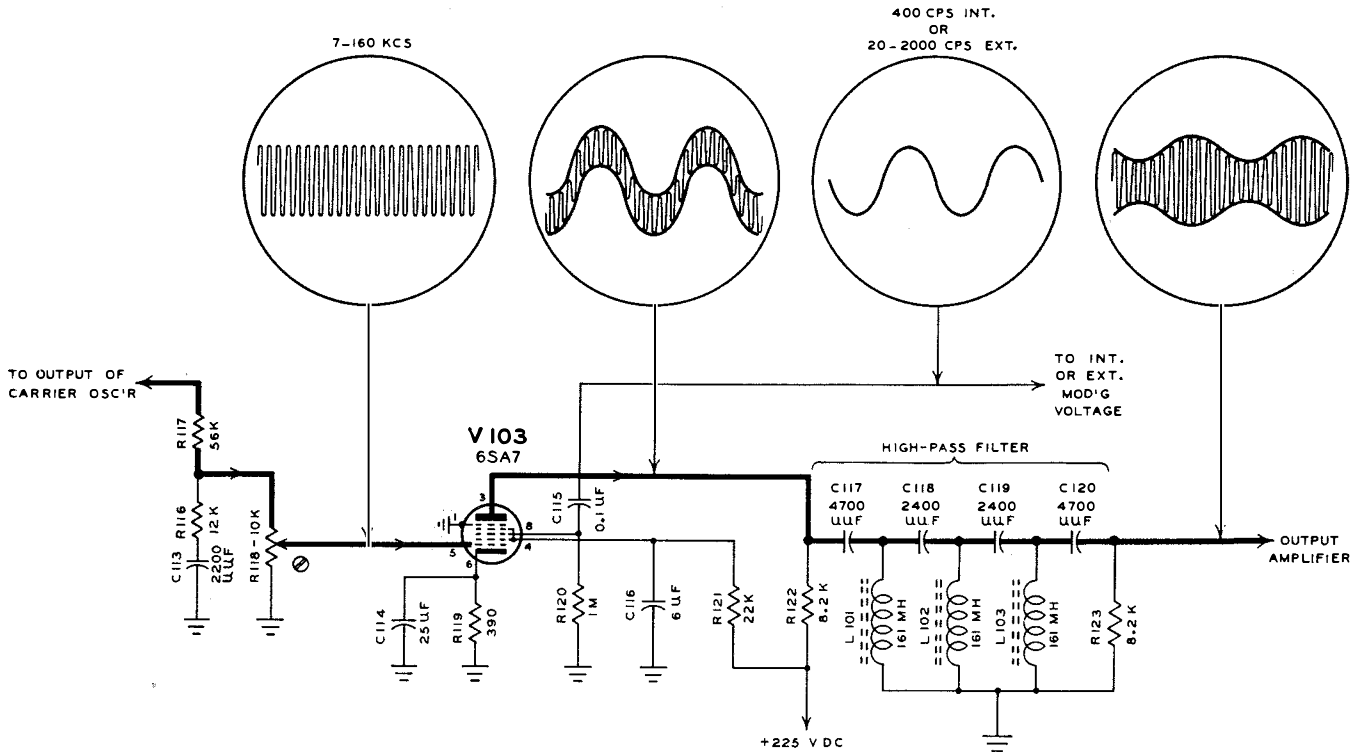


Figure 2—7. Complete Modulator Circuit

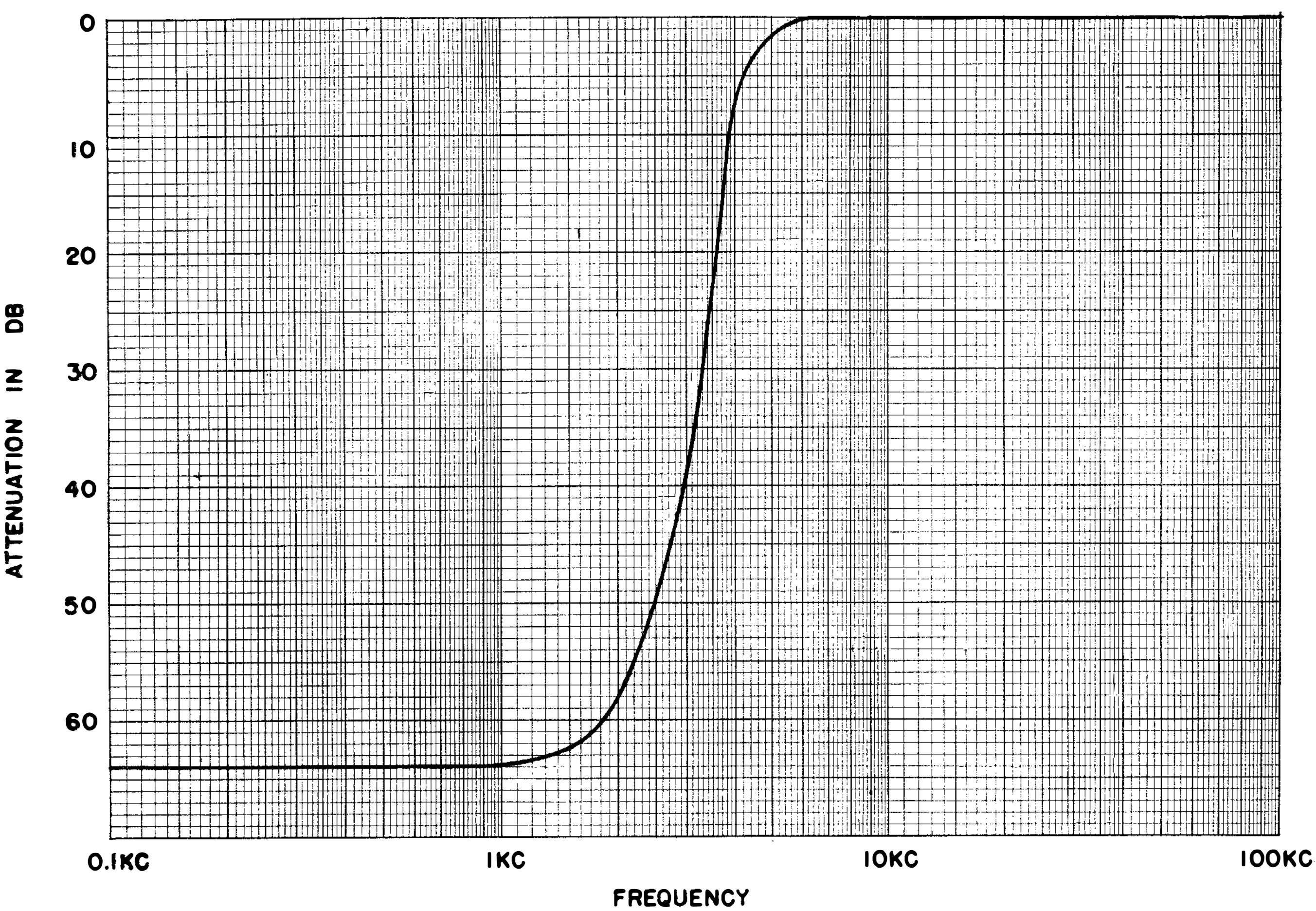


Figure 2—8. Characteristics of High-Pass Filter

feedback voltage within the oscillator circuit. A type 6SN7W twin triode is used as the oscillator.

4. MODULATOR SECTION.

Fig. 2-7 shows the complete Modulator section used in this instrument. A type JAN-6SA7 pentagrid converter tube is used as the modulator tube. The output of the Carrier Oscillator is introduced into the first grid of the Modulator tube, while the output of the 400-cps Modulating Oscillator is introduced into the third grid. The two voltages thus both affect the plate current of the tube in such a manner as to produce an amplitude-modulated wave in the plate circuit. Typical wave-forms which are present in the various parts of the circuit are shown in Fig. 2-7.

The output of the tube is passed through a high-pass filter which has a cut-off frequency of approximately 4000 cps. This arrangement removes the modulating frequency component of the plate voltage (which component can be as high as 2000 cps in the case of a 2000-cps external modulating voltage) from the output of the Modulator section. Characteristics of the filter are shown in Fig. 2-8.

S-102 is a three-position, two-circuit rotary switch, which in the EXT position allows any voltage applied to the EXT MOD terminals to modulate the output of the Carrier Oscillator. A voltage of approximately one volt is required at the EXT MOD terminals for 30% modulation. When S-102 is in the INT position, the output of the Modulating Oscillator is applied to the Modulator tube. When S-102 is in the OFF position, the output of the Carrier Oscillator is passed directly to the Output Amplifier, so that no modulation whatsoever occurs.

R-118 is a potentiometer which sets the level of the carrier voltage applied to the Modulator tube so that the voltage output from the oscillator is the same as from the Modulator when the Modulation switch S-102 is in the EXT position.

5. OUTPUT AMPLIFIER.

The output amplifier, shown in Fig. 2-9, consists of two sections: a buffer amplifier that includes V-105A and V-105B and a power amplifier that includes V-106 to V-108.

The buffer amplifier is provided to prevent adjustments in the CARRIER ADJUST control R-146 from reflecting a change in load back into the Carrier Oscillator or Modulator sections. The buffer uses a type 6SN7W tube with negative feedback from the plate of V-105B to the cathode of V-105A.

The power amplifier is a conventional audio power amplifier using negative feedback. A tertiary winding on the output transformer provides the feedback which is applied to the cathode of V-106A. V-106A is a straight voltage amplifier, while V-106B is a plate- and cathode-loaded type phase inverter or paraphase amplifier in which two out-of-phase voltages are derived from the one tube. In this inverter a load is placed in the cathode of the tube equal to the load in the plate circuit. Thus, essentially equal but out-of-phase voltages are obtained from the cathode and plate circuits. These voltages are then applied to the grids of the

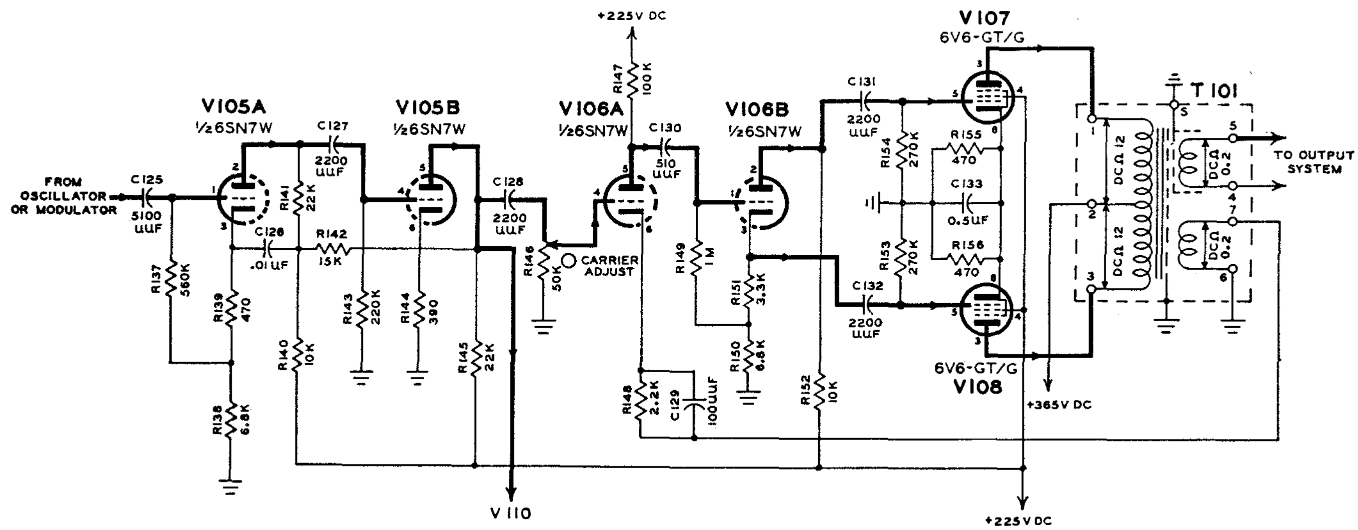


Figure 2—9. Complete Output Amplifier Circuit

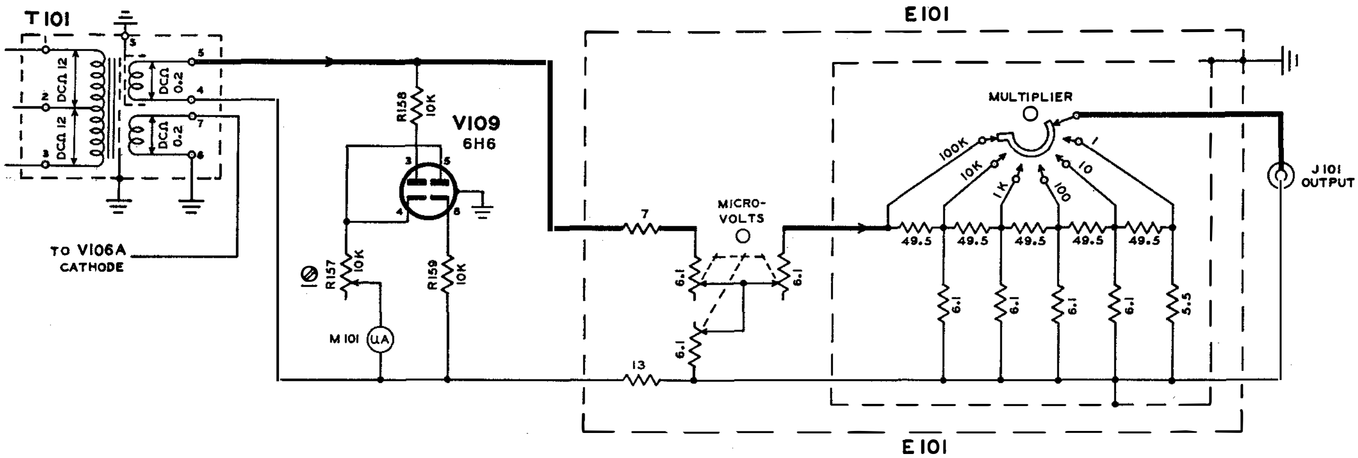


Figure 2—10. Complete Circuit of Output System

push-pull output amplifier tubes. A type 6SN7W twin triode is used for V-106.

The output stage is a conventional push-pull power stage using type 6V6GT/G beam tetrodes.

6. OUTPUT SYSTEM.

Included in the output system are a vacuum tube voltmeter and two output attenuators. These circuits are shown in Fig. 2-10.

The voltmeter (V-109) is a half-wave rectifier type voltmeter using a 6H6 duplex diode. The function of this voltmeter is to monitor voltage applied to the input of the attenuator. One diode is the voltmeter rectifier while the second diode is connected so that part of its "emission velocity" current flows through the meter in a direction opposite to the "emission velocity" current of the first diode. The two diodes thus "buck" each other and prevent relatively large "no signal" meter deflections which would be caused by the use of one diode alone. Potentiometer R-157 is a calibration adjustment which adjusts the calibration of the voltmeter by adjusting the resistance in the voltmeter circuit to give proper meter deflection.

The output attenuator consists of two sections—the first a continuously-variable section consisting of three ganged slidewires which has a practical range of approximately 26 db. The second unit is a five-section ladder structure having a range of 100 db. These two attenuators are designed to be used conjunctively to provide an output from approximately one-half microvolt or −6 db (0 db is arbitrarily assumed as one microvolt) to one volt or +120 db. The continuously-variable unit is calibrated in decibels and microvolts on the front panel, while the ladder unit is calibrated in decibels and voltage multiplying factors. The design of the attenuator is such that the impedance looking back into the output terminal is 5 ohms.

7. CALIBRATING OSCILLATOR.

The Calibrating Oscillator (Fig. 2-11) includes V-112 and its associated circuit. V-112 is a class A amplifier tube which supplies energy to a tuning fork in order to maintain the vibration of the fork. The plate circuit of V-112 is connected to one of the

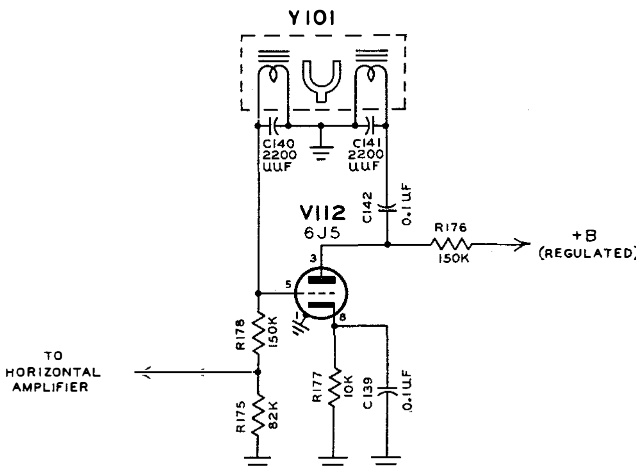


Figure 2—11. Complete Circuit of Calibrating Oscillator

tuning fork driving coils, while the grid circuit of V-112 is connected to the other driving coil. The core of the coil is a permanent horseshoe magnet, the ends of which are set close to the tines of the tuning fork.

A tuning fork functions somewhat like a quartz crystal in that it vibrates at a single frequency (in this case 5 kc) and maintains that frequency within very close limits (±0.01%). The tuning fork used in this instrument is of bimetallic construction, so designed that the fork has a very low temperature coefficient of frequency, comparable to that of good quality quartz plates.

Assuming that the circuit is oscillating, the operation may be analyzed as follows: A sine-wave voltage on the grid of V-112 is amplified and appears 180 degrees out of phase in the plate circuit from where it is passed to the plate driving coil, changing the current through the coil. The changing current through the coil changes the magnetic field of the plate electromagnet so that the nearest tine of the fork is either attracted more strongly or repelled, depending on whether the magnetic field is increasing or decreasing. The change in the attraction for the fork tine nearest the plate coil causes that tine to move, and the other tine which is next to the grid coil also moves because of the stress of the fork metal. The movement of the fork tine nearest the grid driving coil changes the reluctance of the grid coil magnetic circuit, changing the amount of flux in the magnetic circuit. This change in flux induces a current in the grid coil. The grid coil is connected between grid and ground in such a manner that the voltage associated with the current change in the grid coil is applied in phase with the original voltage on the grid. Thus, the original grid voltage reinforces itself so that the system oscillates at 5 kc, the frequency being controlled by the natural frequency of the tuning fork.

In order to obtain maximum stability from the oscillator, the tuning fork and its driving coils are operated in a temperature-controlled chamber which is maintained at approximately 70° C by a bimetallic thermostatic switch.

8. HORIZONTAL AMPLIFIER.

V-111 and its associated circuit, shown in Fig. 2-12, constitute a resistance-coupled amplifier whose purpose is to amplify the output of the 5 kc Oscillator to a level sufficient to drive the horizontal deflecting-plates of the cathode-ray tube. V-111 obtains its 5 kc driving voltage from the grid circuit of V-112.

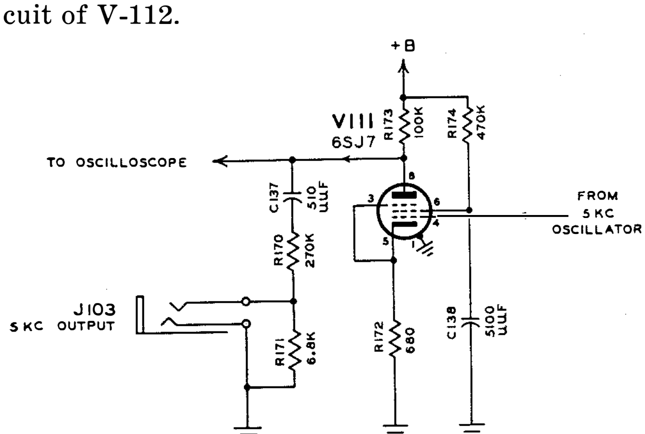


Figure 2—12. Complete Circuit of Horizontal Amplifier

9. OSCILLOSCOPE.

A type 2AP1A cathode-ray tube is used as the Oscilloscope, the circuit of which is shown in Fig. 2-13. The function of the Oscilloscope is to enable the operator to compare the main carrier frequency with the frequency of the precision tuning fork oscillator, the comparison being made by means of Lissajous figures.

The circuit of the Oscilloscope is conventional. D-c voltages are supplied to the tube elements by

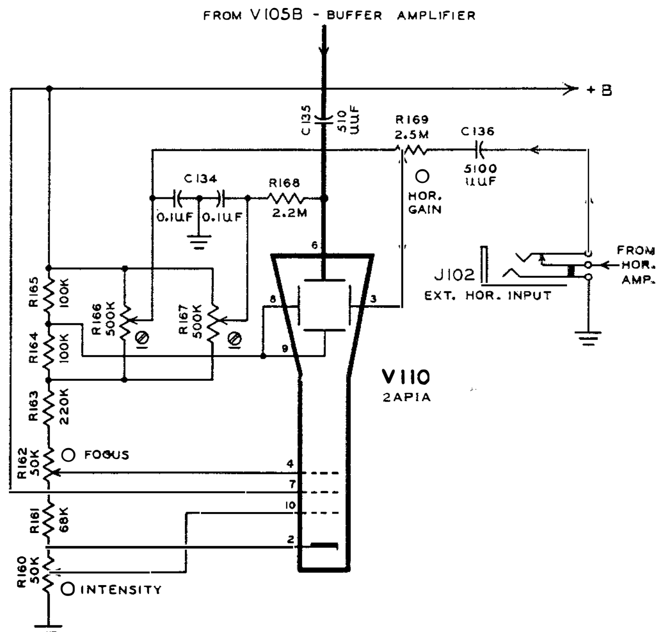


Figure 2—13. Complete Circuit of Oscilloscope

the voltage divider consisting of R-160 to R-165. Potentiometer R-160 is the INTENSITY panel control, while potentiometer R-162 is the FOCUS control. Potentiometer R-169, labeled HOR GAIN, varies the 5 kc voltage applied to the horizontal deflecting-plates of the cathode-ray tube. Potentiometers R-166 and R-167 are internal adjustments which center the Lissajous patterns on the cathode-ray tube.

10. POWER SUPPLY.

The power supply for this instrument (shown in Fig. 2-14) is designed to operate from a 105-125 volt, 50-63 cps, single phase ac source and consists of a conventional full-wave rectifier, a two-section pi filter, and a dc voltage-regulator circuit. Regulated voltage is applied to the Carrier Oscillator, Modulator, Output Amplifier, and Calibrating Oscillator sections. Unregulated voltage is supplied to the Modulating Oscillator, Horizontal Amplifier, and Oscilloscope sections and the plates of the power output tubes.

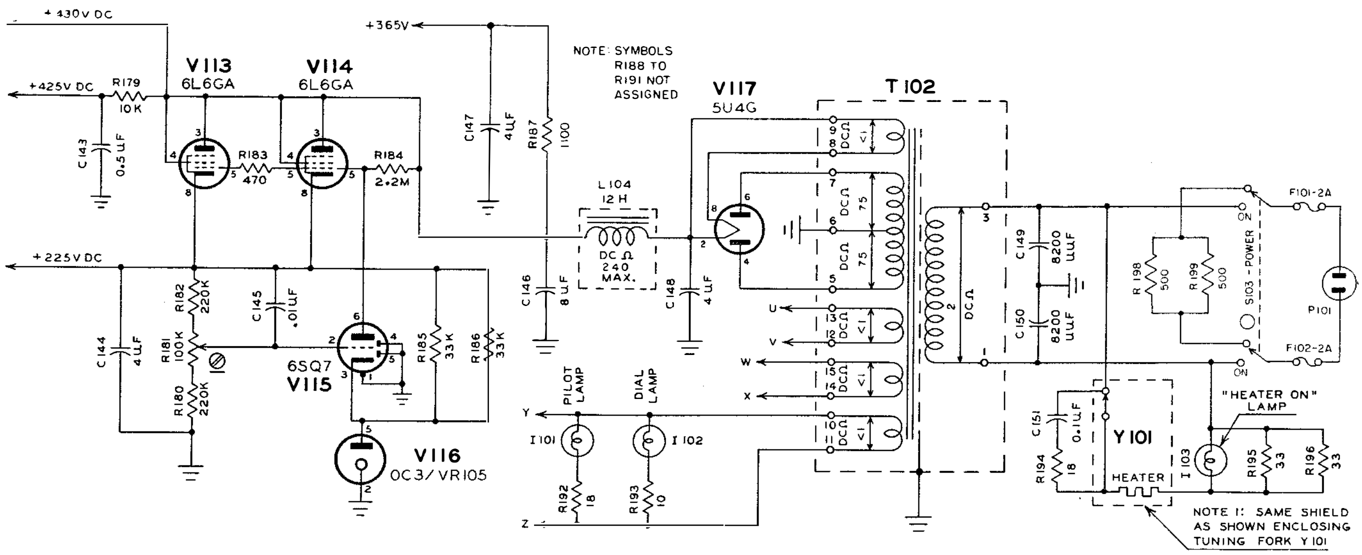


Figure 2—14. Complete Circuit of Power Supply

A dc voltage-regulator circuit is designed to maintain its output voltage essentially constant regardless of whether the rectifier voltage output increases or decreases or whether the load current increases or decreases. Voltage-regulators also reduce ripple, etc., which appear in the rectifier output. The operation of the voltage-regulator can be analyzed by referring to the basic circuit shown in Fig. 2-15. V1 in Fig. 2-15 is a constant-voltage tube

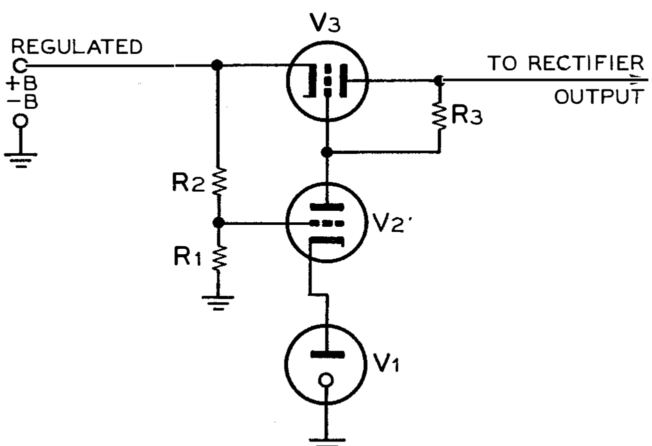


Figure 2—15. Basic Voltage Regulator Circuit

which maintains the cathode of V2 at a uniform potential. V3 operates as a variable resistor, and V2 controls the grid voltage of V3.

If the regulated B+ voltage at the cathode of V3 tends to increase, the grid voltage of V2 tends to increase, causing V2 to draw more current. This lowers the plate voltage of V2 and therefore the grid voltage of V3, resulting in a greater plate resistance for V3. The greater plate resistance causes a greater voltage drop across V3, compensating for the increased voltage at its cathode and resulting in a substantially constant voltage.

If the regulated B+ voltage tends to decrease, the reverse of the above action occurs, also tending to maintain the cathode voltage substantially constant.

Potentiometer R-181 (Fig. 2-14) adjusts the magnitude of the regulated dc voltage.

It should be noted that all of the current supplied by the regulator passes through the plate circuit of the compensating tube. Therefore, two power tubes in parallel are used in the developed circuit for this application.

A heater circuit for the tuning fork is also operated directly from the line power source. This circuit consists of a heater (Y-101e) and its controlling thermostat (Y-101d). The thermostat is shunted by a capacitor and resistor which prevent arcing of the thermostat contacts. A pilot lamp in series with the heater indicates to the operator when the heater is in operation. The thermostat is nonadjustable and is set to open at 70° C. ± 2 degrees.

In addition to the heater for the tuning fork, a space heater for the instrument is also operated directly from the power line. This heater consists of two 37-watt wirewound resistors connected so that they are energized when the power switch for the instrument is in the OFF position. These space heaters are designed to maintain the temperature within the combination case a few degrees higher than the ambient temperature so as to minimize condensation of moisture within the case during periods of non-use.

11. SUMMARY.

Voltages are generated by the Carrier Oscillator and, if modulation is desired, are applied to the Modulator tube where modulation by the Modulating Oscillator occurs. The Modulator output is passed through a high-pass filter to remove undesired modulation products and the resultant voltage applied to the Output Amplifier. If no modulation is desired, the output of the Carrier Oscillator is applied directly to the Output Amplifier.

The Output Amplifier feeds the Output System and also the vertical deflecting plates of the Oscilloscope. The output carrier voltage can be controlled very accurately by means of the Output System.

The horizontal deflecting-plates of the Oscilloscope are driven by the 5 kc Calibrating Oscillator through the Horizontal Amplifier. Lissajous figures are produced on the Oscilloscope allowing extremely close control of the output carrier frequency.

12. PLUG-IN ATTENUATOR.

Supplied with the instrument is a plug-in attenuator which is designed to allow the output voltage to be reduced to values lower than are practical with the self-contained attenuator. This plug-in attenuator consists merely of a 0.55-ohm wire-wound resistor which is connected across the output of the instrument when the attenuator is inserted into the output jack. The circuit configuration with the plug-in attenuator in use is shown in Fig. 2-16. Because the 0.55-ohm attenuator is in parallel with the 5-ohm internal impedance of the generator, the apparent internal impedance of the generator is modified to 0.5 ohm, and the output voltage is reduced by a factor of 10. Thus, the external plug-in attenuator can be used to reduce the apparent internal impedance of the generator or to reduce the minimum voltage obtainable from the generator. Voltages as low as 0.1 microvolt can be practically obtained by this system.

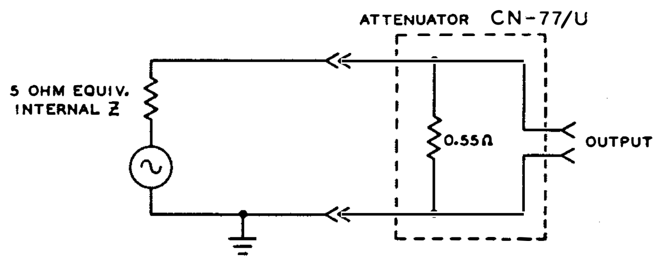


Figure 2—16. Circuit When Plug-in Attenuator is Used

SECTION 3
INSTALLATION AND OPERATION

1. UNPACKING.

Signal Generator TS-535A/U is packed in a wooden box secured by nails and by steel straps. Inside the box are a waterproof liner, cardboard fillers, waterproof paper, and an inner cardboard box which contains the instrument itself and two instruction books, one of which is in the rack inside the panel cover on the instrument. The calibration book is also located in the rack in the panel cover.

Special precautions are necessary only to make certain that the box is opened from the top and that excessive jars and shocks are not given the instrument during unpacking.

2. INSTALLATION.

Inasmuch as Signal Generator TS-535A/U is a portable test equipment it is not anticipated that it will be secured in a permanent position. However, overall dimensions are shown for convenience in Fig. 3-1.

If Signal Generator TS-535A/U is to be operated from line voltages that are significantly lower or higher than 115 volts, the power transformer connections should be changed as described in Section 4, paragraph 11.

3. OPERATION.

a. GENERAL.—Signal Generator TS-535A/U is very useful for the testing of sonar receivers. To this end the instrument generates voltages in the frequency range from 7 kc to 160 kc with provision for determining the carrier frequency to a high order of accuracy. The instrument has a low-impedance output system so that its output voltage is not critical with load. The voltages which are generated by the instrument can be either modulated or unmodulated, as desired. Signal Generator TS-535A/U can also be used as a frequency meter.

When operating a precision signal generator such as Signal Generator TS-535A/U, it is desirable to know the accuracy limits with which the measurements can be made. For this reason, an abstract of the specifications of Signal Generator TS-535A/U is given in Table 3-1.

TABLE 3—1. ELECTRICAL SPECIFICATIONS

ACCURACY OF INDICATED OUTUT FREQUENCY	Within ±0.1% below 70 kc and within ±0.5% above 70 kc provided calibration book used and calibrator adjusted as per paragraph 3e(3).
STABILITY OF MAIN OSCILLATOR	Within 0.05% for 30 minutes below 70 kc and within 0.25% for 30 minutes above 70 kc provided instrument has had 30-minute warm-up.
DISTORTION OF OUTPUT CARRIER	Less than 1% below 70 kc and less than 3% above 70 kc.
LINE VOLTAGE CHANGES	±5% line voltage change causes output frequency change of not more than 0.05% below 70 kc and not more than 0.25% above 70 kc during 5-minute interval.
INTERNAL IMPEDANCE	5 ohms ±1 ohm.
HUM	At least 65 db below maximum output level.
ACCURACY OF INDICATED OUTPUT VOLTAGE	Within 10% down to one microvolt level at frequencies below 70 kc and within 10% or 0.5 microvolt (whichever is greater) at frequencies above 70 kc.
MINIMUM OUTPUT VOLTAGE	Not more than 0.5 microvolt.
MODULATION	No appreciable envelope distortion discernible at 30% modulation when modulating frequency within 20 cps to 2000 cps.
ACCURACY OF 5 KC OSCILLATOR	Within 0.01% after 30-minute warm-up.

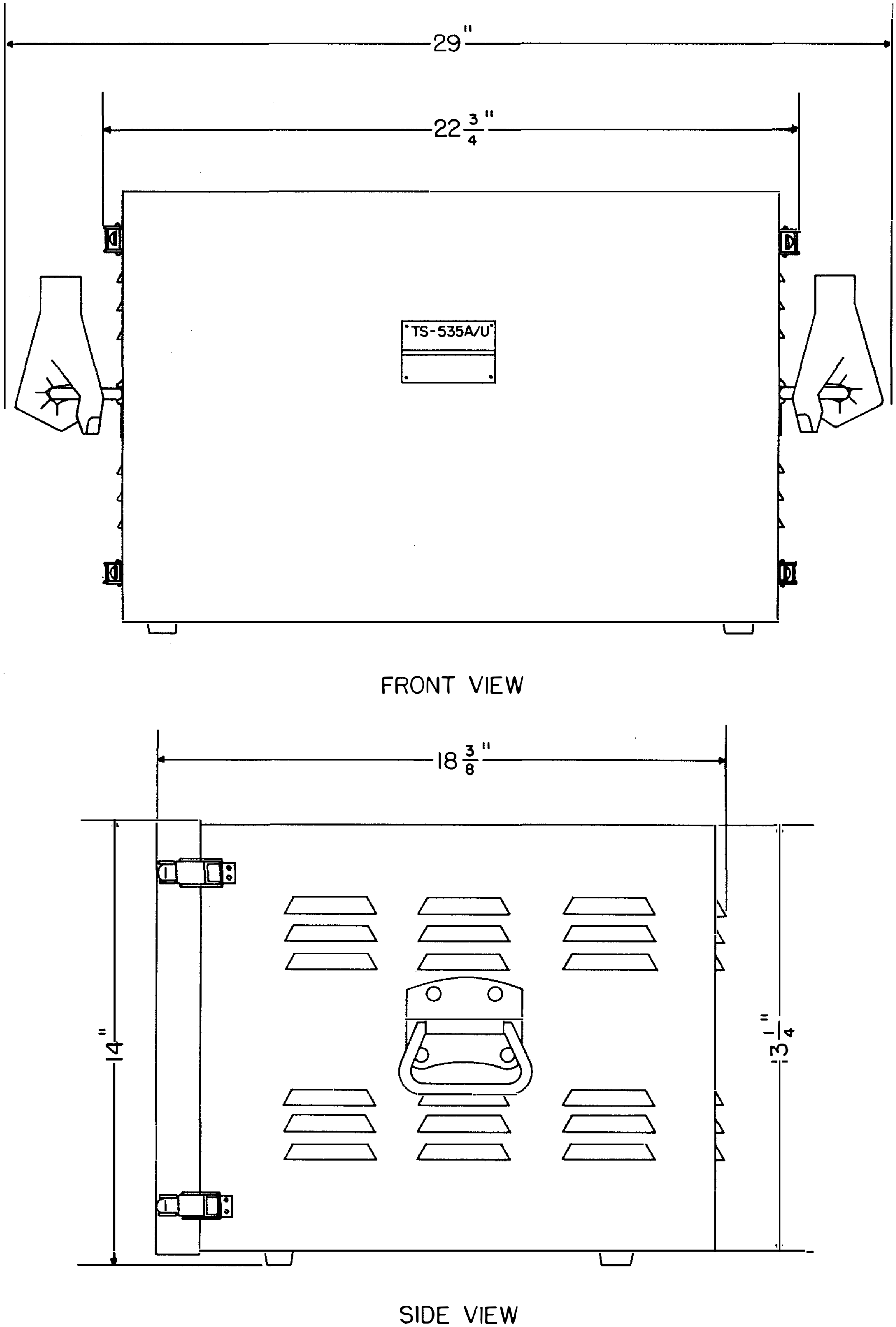


Figure 3—1. Signal Generator TS-535A/U, Overall Dimensions

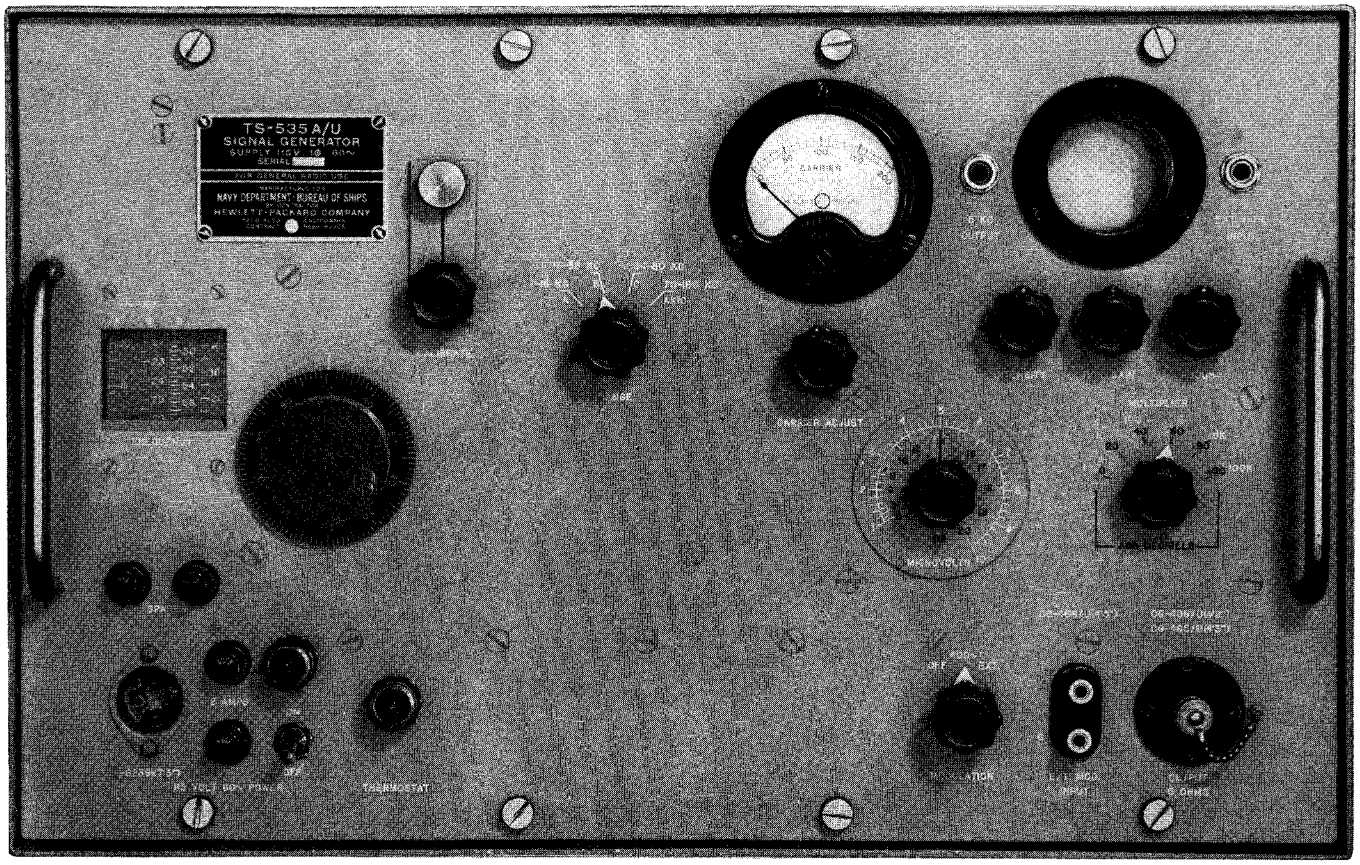


Figure 3—2. Panel View of Signal Generator TS-535A/U

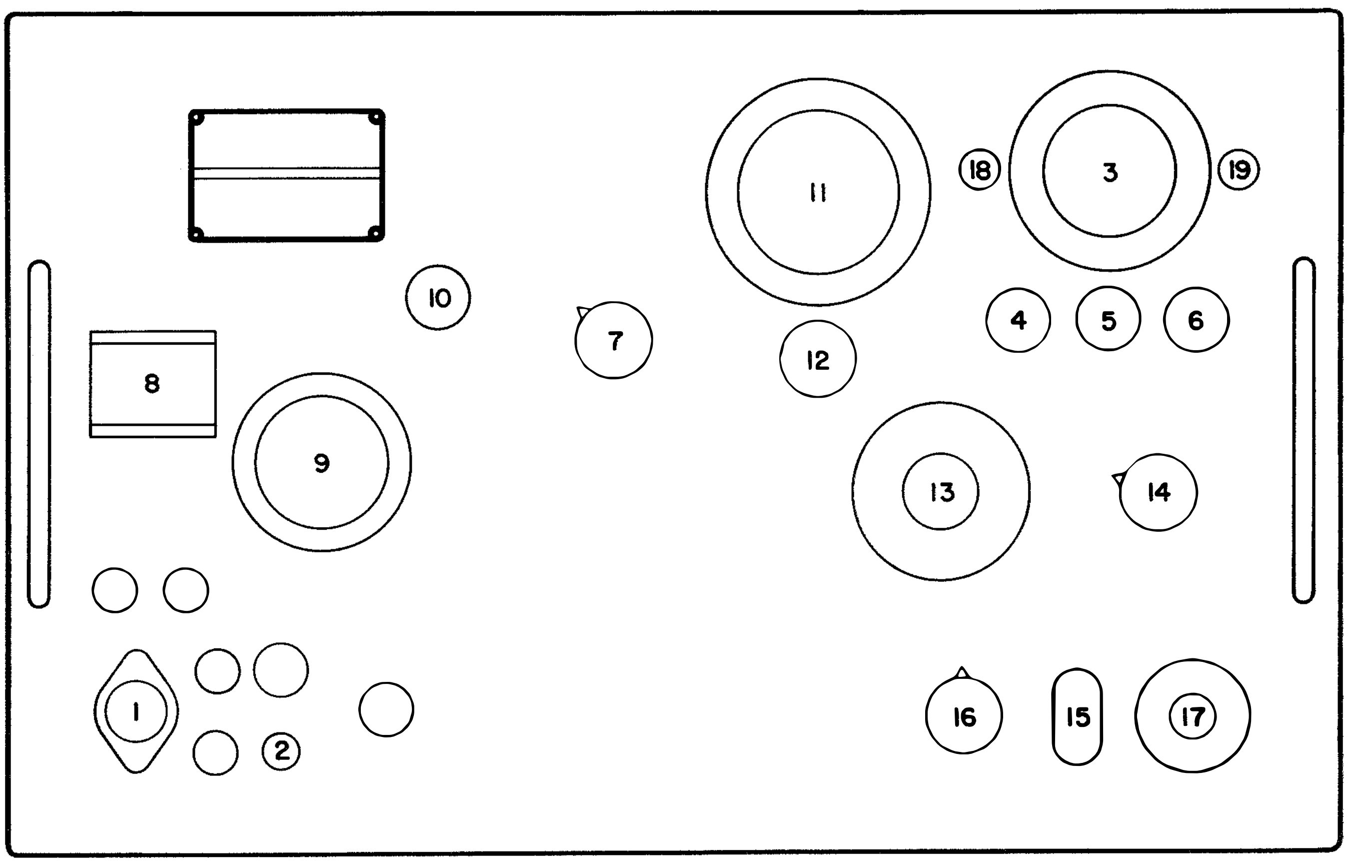


Figure 3—3. Panel of Signal Generator TS-535A/U With Panel Controls Numbered

b. CONTROLS.—Controls, dials, and terminals of Signal Generator TS-535A/U together with the function of each are given in Table 3-2.

c. POWER SOURCE.—Signal Generator TS-535A/U operates from a 105- to 125-volt, 50-63 cycle, single phase ac source and requires about 185 watts of power. Before using the instrument, it should be turned on and allowed a warm-up period of three or four minutes. A warm-up period of thirty minutes or more is desirable when maximum accuracy of frequency calibration is desired.

When the power switch, marked ON - OFF, is in the OFF position, two internal space heaters are connected to the power source so that the temperature within the instrument's combination case will be maintained a few degrees above the ambient temperature.

d. GENERAL CALIBRATING INFORMATION.

(1) LISSAJOUS FIGURES.—A unique operating feature of this signal generator is that the carrier frequency can be compared with the frequency of a precision, self-contained 5 kc oscillator in order that the carrier frequency can be known very accurately. This comparison is made by means of Lissajous figures produced on the cathode-ray tube. If necessary, corrections can be made in the calibration of the main oscillator so that the main frequency calibration agrees with the 5 kc precision oscillator. As a result of this operating feature it is necessary that the operator be familiar with Lissajous figures and the procedure required to check the main oscillator calibration. The operator also must be familiar with the procedure for making corrections in the main oscillator calibration if such corrections are found necessary.

TABLE 3—2. OPERATING CONTROLS

REFERENCE NUMBER	DESIGNATION	FUNCTION
1	. . . .	Power plug
2	ON - OFF	Power switch; in OFF position, standby heater is connected to power source
3	. . . .	Cathode-ray tube
4	INTENSITY	Adjusts intensity of crt trace
5	HOR GAIN	Adjusts horizontal length of crt trace
6	FOCUS	Adjusts focus of calibration tube trace
7	RANGE	Frequency range selector switch
8	FREQUENCY	Main frequency dial
9	. . . .	Main frequency control knob
10	CALIBRATE	Corrects or zeroes calibration of main frequency dial
11	CARRIER	Output level reference meter
12	CARRIER ADJUST	Adjusts level of carrier
13	MICROVOLTS - DB	Carrier voltage selector
14	MULTIPLIER	Carrier voltage multiplier (multiplies reading of control number 13)
15	EXT MOD INPUT	Terminals to which external modulating voltage should be applied
16	MODULATION	Selects type of modulation to be used
17	OUTPUT 5 OHMS	Terminal at which carrier voltage is obtained
18	5 KC OUTPUT	Jack at which 5 kc output voltage is obtained when desired for external use
19	EXT HOR INPUT	Jack at which external sweep voltage for calibrator tube is inserted

The Lissajous figures which are produced on the cathode-ray tube or oscilloscope give a direct comparison between the frequencies of the two oscillators. For example, assume that a figure such as that shown in Fig. 3-4 is obtained on the oscilloscope. If this figure is stationary or almost sta-

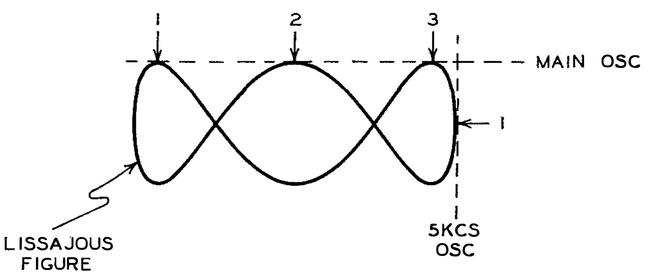


Figure 3—4. Typical Lissajous Figure Showing Points of Tangency

tionary, the operator can determine the ratio of the Carrier Oscillator frequency to the Calibrating Oscillator frequency, which in this case is 3-to-1. This ratio can be determined by imagining that two straight lines adjoin the Lissajous figure in the manner shown by the dotted lines in Fig. 3-4. The horizontal dotted line in Fig. 3-4 is labeled "Main Osc" and is seen to touch or be tangent to the Lissajous figure at three points. The vertical dotted line is labeled "5 kc Osc" and is seen to touch the Lissajous figure at only one point. The number of these points of tangency can be used to determine the frequency of the main oscillator by use of the equation.

$$\frac{\text{No. of horiz. tangencies}}{\text{No. of vert. tangencies}} \times 5 \text{ kc} = \text{Main Osc Freq}$$

In this example, if we substitute "3" as the number of horizontal tangencies and "1" as the number of vertical tangencies, the main carrier frequency is seen to be 15 kc.

$$\frac{3}{1} \times 5 \text{ kc} = 15 \text{ kc}$$

Various Lissajous figures which are obtained in the operation of the instrument are shown in Figs. 3-6 and 3-7. Reference should be made to these when calibrating the instrument.

(2) CALIBRATION BOOK.—Supplied with each instrument is a calibration book which has been prepared in order to allow the operator to select carrier frequencies with the greatest accuracy of which this generator is capable. Fig. 3-5 shows part of a typical page from this calibration book. The first column lists various frequencies at regular intervals throughout the range of the instrument, while the second column lists a dial reading for each frequency. This dial reading is a combination of the linear scale on the main tuning dial (right-hand scale on main tuning dial) and the reading of the scale on the periphery of the main frequency control knob. The manner in which this reading should be determined can be seen by assuming that one of the readings in the book is, say 3119 on the "A" range. The RANGE switch should be set to the "A" range and then, to set the main tuning dial to the point 3119, turn the main tuning control until the point "31" on the right-hand scale of the main tuning dial is at the horizontal hairline. Next, slowly turn the main tuning control knob in a clockwise direction until the point "19" is at the mark at the top of the main tuning knob dial. The combination of these readings is then "3119". It is desirable that any dial reading be approached in such a way that the main frequency control knob is turned in a clockwise direction to avoid backlash error. When tuning from a higher frequency to a lower frequency this precaution requires that the dial be first set to a reading lower than the desired reading so that the desired reading can then be approached by rotating the main frequency control knob in a clockwise direction.

Two other columns "Divisions per Cycle" and "Cycles per Division," are given in the calibration book. These are included so that frequencies which are not shown in the book can be selected accurately. For example, if it is desired to obtain an output frequency of 14.35 kc, the operator should refer to the calibration book where it would be seen that no dial reading is given for 14.35 kc.* Therefore, it is necessary to calculate the dial reading for the desired frequency and this can be done from the information given in the "Divisions per Cycle" column (column 3). It should be noted that the entries in this column are not in horizontal alignment with the first two columns for the reason that column 3 gives divisions per cycle data *between* any two of the entries in columns 1 and 2.

Assuming that it is desired to obtain the dial reading for a carrier frequency of 14.35 kc and noting that no reading is given in the calibration book (see Fig. 3-5) for this frequency, it is necessary to note the reading in column 3 for the frequency interval which includes 14.35 kc. In this case, therefore, the operator should note the reading between 14.3 kc and 14.4 kc. The reading in column 3 of Fig. 3-5 between these two frequencies is 0.40

*To follow this example, refer to Fig. 3-5. All examples involving reference to the Calibration Book are drawn from the values set out in Fig. 3-5.

A RANGE
(Continued)

Frequency in Kilocycles	Dial Reading	Divisions per Cycle	Cycles per Division	Frequency in Kilocycles	Dial Reading	Divisions per Cycle	Cycles per Division
11.7	2172.0			14.0	2961.0		
		0.310	3.23			0.370	2.70
11.8	2203.0			14.1	2998.0		
		0.320	3.13			0.410	2.44
11.9	2235.0			14.2	3039.0		
		0.325	3.08			0.400	2.50
12.0	2267.5			14.3	3079.0		
		0.315	3.17			0.400	2.50
12.1	2299.0			14.4	3119.0		
		0.330	3.03			0.415	2.41
12.2	2332.0			14.5	3160.5		
		0.330	3.03			0.410	2.44
12.3	2365.0			14.6	3201.5		
		0.325	3.08			0.425	2.35
12.4	2397.5			14.7	3244.0		
		0.335	2.99			0.425	2.35
*12.5	2431.0			14.8	3286.5		
		0.335	2.99			0.425	2.35
12.6	2464.5			14.9	3329.0		
		0.325	3.08			0.450	2.22
12.7	2497.0			*15.0	3374.0		
		0.335	2.99			0.430	2.32
12.8	2530.5			15.1	3417.0		
		0.345	2.90			0.465	2.15
12.9	2565.0			15.2	3463.5		
		0.335	2.99			0.445	2.25
13.0	2598.5			15.3	2508.0		

Figure 3—5. Part of Typical Page From Calibration Book

meaning 0.40 divisions change on the frequency control knob changes the carrier frequency by one cycle. Now, since the operator desires a carrier frequency of 14.35 kc or 14,350 cps, it is necessary to determine the number of divisions on the frequency control knob that corresponds to a frequency change of 50 cycles (the difference between 14.3 kc and 14.35 kc). Therefore, the "Divisions per Cycle" figure should be multiplied, in this case, by "50", giving 20 divisions (0.4 x 50 = 20).

Now it is necessary to add 20 divisions to the reading given for 14.3 kc, giving a result of 3099 (3079 + 20 = 3099). Therefore, set the main tuning dial so that "30" on the linear (right-hand) scale is under the horizontal hairline and then advance the frequency control knob in a clockwise direction so that its scale reads "99". The desired carrier frequency will then be 14.35 kc plus or minus 0.1% or better.

The fourth column in the Calibration Book gives "Cycles per Division" data between every two entries in the book. This column is included in order that the operator may perform the reverse function for which the third column is intended—that is, so

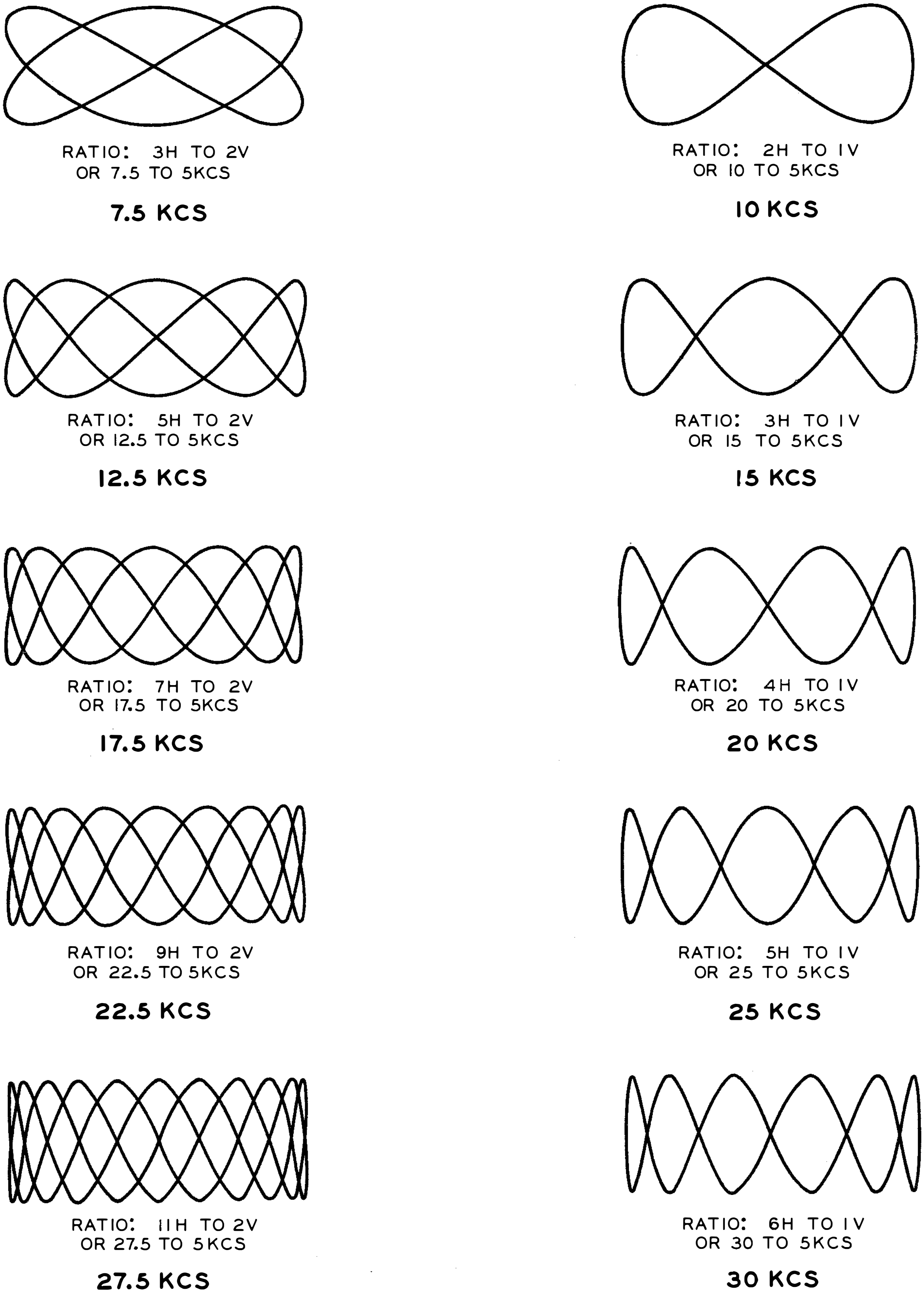
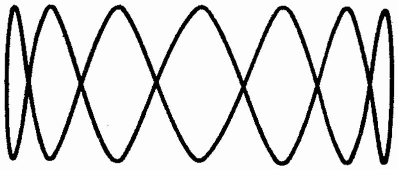
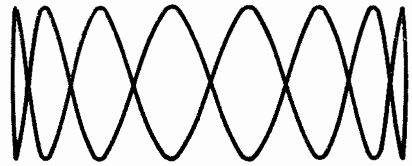


Figure 3—6. Lissajous Figures Obtained at Check Points



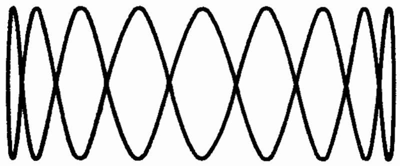
RATIO: 7H TO 1V
OR 35 TO 5KCS

35 KCS



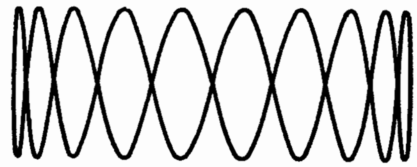
RATIO: 8H TO 1V
OR 40 TO 5KCS

40 KCS



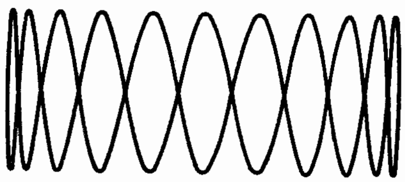
RATIO: 9H TO 1V
OR 45 TO 5KCS

45 KCS



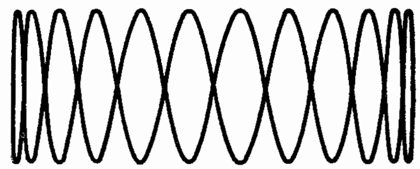
RATIO: 10H TO 1V
OR 50 TO 5KCS

50 KCS



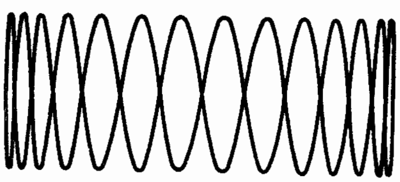
RATIO: 11H TO 1V
OR 55 TO 5KCS

55 KCS



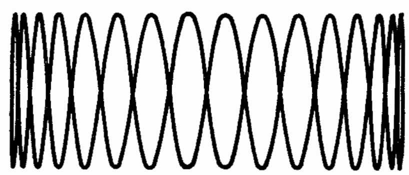
RATIO: 12H TO 1V
OR 60 TO 5KCS

60 KCS



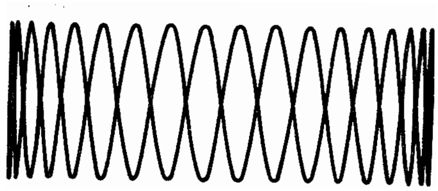
RATIO: 14H TO 1V
OR 70 TO 5KCS

70 KCS



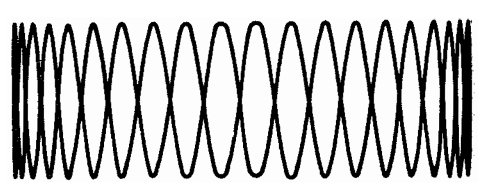
RATIO: 16H TO 1V
OR 80 TO 5KCS

80 KCS



RATIO: 18H TO 1V
OR 90 TO 5KCS

90 KCS



RATIO: 20H TO 1V
OR 100 TO 5KCS

100 KCS

Figure 3—7. Lissajous Figures Obtained at Check Points that the operator may determine the exact frequency for which he knows the dial reading. This sort of procedure is most often required when measuring unknown frequencies, etc.

To determine the manner in which the fourth column in the Calibration Book is intended to be used, assume that the operator has a dial reading of, say, 3099 on the "A" range and that he desires to determine the carrier frequency of the instrument. The procedure is to look in the Calibration Book under the "A" range and determine the two frequencies between which the reading of 3099 lies (refer to Fig. 3-5). In Fig. 3-5, 3099 lies between "3079" corresponding to a carrier of "14.3" kc and "3119" corresponding to a carrier of "14.4" kc. Now, column 4 shows that between these two points, the "Cycles per Division" is "2.50", meaning that a change of one division on the periphery of the main frequency control knob changes the carrier frequency by 2.50 cycles. In this example the unknown frequency is 20 divisions from a reading for which the carrier frequency is known (14.3 kc is "3070"). Therefore, multiply 20 by 2.50, giving a result of 50 cps. Add this to 14.3 kc, giving a final result of 14.350 kc—the unknown frequency.

(3) THE *CALIBRATE* CONTROL AND CHECK POINTS.—The CALIBRATE control is a frequency vernier which is provided for zeroing or correcting the frequency calibration of the carrier oscillator at special points throughout the frequency range of Signal Generator TS-535A/U. These special points are called check points and are printed in red in the Calibration Book. The Lissajous figures which should be obtained at various check points are shown in Figs. 3-6 and 3-7.

Before the carrier oscillator is set to a desired frequency, the linear scale reading of the check point nearest the desired frequency should be looked up in the Calibration Book and the main tuning dial set to that dial reading. Then, if necessary, the CALIBRATE control should be unlocked and adjusted so that the proper Lissajous figure is obtained on the Calibrator tube.

For example, assume that it is desired to select a carrier frequency of 14 kc. By looking in the Calibration Book it will be seen that the nearest check point to 14 kc is 15 kc. Assuming that the linear dial reading given for 15 kc in the Calibration Book is 3374, the linear scale on the main tuning dial should be set to 3374 (using clockwise approach) and the RANGE switch set to the "A" range. If a 3-to-1 Lissajous figure (see Fig. 3-6) does not now appear on the Calibrator tube, the CALIBRATE control should be adjusted until the proper figure does appear and is stationary or practically so. The control should then be relocked. This procedure is called calibrating.

After the oscillator has been calibrated at the nearest check point to 14 kc, the main tuning dial should be set to the reading given for 14 kc in the Calibration Book, taking care to approach the reading with a clockwise rotation of the main frequency control knob.

e. SELECTING CARRIER FREQUENCY.

(1) GENERAL.—The frequency range of Signal Generator TS-535A/U is covered in four ranges and therefore the first step in selecting a desired carrier frequency is the determination of the range which should be used. The coverage of each of the four ranges is as follows:

RANGE "A" extends from 7 kc to 16 kc.
RANGE "B" extends from 15 kc to 36 kc.
RANGE "C" extends from 34 kc to 80 kc.
Range "Ax10" extends from 70 kc to 160 kc. (ten times the "A" range)

The window of the main tuning dial is marked to indicate those calibrations which correspond to the "A", "B", and "C" ranges, but the "Ax10" range has no special, separate calibration on the main frequency dial. The "Ax10" range is the same as the "A" range except that the frequency coverage of the "A" range is multiplied by a factor of 10. Thus, the "A" range extends from 7 to 16 kc and is calibrated as such on the main tuning dial, while the "Ax10" range extends from 70 to 160 kc and utilizes the "A" range calibration but multiplied by 10.

The calibrations of the "A", "B", and "C" ranges are direct-reading in kilocycles per second. The fourth set of calibrations (extreme right-hand calibrations) on the main tuning dial is simply a linear calibration whose purpose is to allow the operator to select a desired carrier frequency with a high order of accuracy as explained in paragraph 3e(3) below. Now the fact that there are in effect two sets of calibrations for the instrument means that there are two methods of selecting a desired carrier frequency. These two methods are described in the following paragraphs.

(2) METHOD I.—Method I is the easier and quicker method to use when selecting a desired carrier frequency and will probably be used in the majority of measurements.

When the proper range has been selected in accordance with paragraph 3e(1) above, set the

RANGE switch to that range. Then tune the main tuning dial to some multiple of 5 kc and, if necessary, adjust the CALIBRATE control to obtain the proper Lissajous pattern as shown in Fig. 3-6.

The final step is to set the main tuning dial to the desired carrier frequency as indicated by the direct-reading calibrations on the main tuning dial. The carrier frequency will then be accurate within approximately one or two per cent.

When using Method I to select the output frequency, it is not necessary to set the CALIBRATE control each time the carrier frequency is changed, although it is desirable to do so the first time a carrier is selected after the instrument has been out of use for a time.

(3) METHOD II.—Method II is the more accurate method for selecting a carrier frequency, and if this method is used, the full capabilities of the instrument are utilized.

When the proper range has been determined in accordance with paragraph 3e(1) above, set the RANGE switch to that range. Then look under the proper range in the Calibration Book and select the linear dial reading of the check point which is nearest the desired carrier frequency. Set the main tuning dial and the main frequency control knob so that the combination of their readings is equal to the reading of the check point as given in the Calibration Book. If necessary, adjust the CALIBRATE control so that the proper Lissajous figure is obtained on the Calibrator tube.

Next, if necessary, interpolate between the readings given in the Calibration Book which are immediately above and immediately below the desired carrier frequency, as explained in paragraph 3d(2), in order to obtain the dial reading for the desired carrier frequency. Then set the dial to the reading which was obtained by the interpolation process. If this is done carefully and accurately, the full accuracy of Signal Generator TS-535A/U will be obtained.

f. SELECTING OUTPUT VOLTAGE.—Signal Generator TS-535A/U generates voltages from one volt to 0.5 microvolt and these voltages are selected by the combined use of the MICROVOLTS and the MULTIPLIER controls. These controls are labeled "13" and "14" respectively in Fig. 3-3.

The primary output voltage control is the MICROVOLTS control which is calibrated from approximately 0.5 to 10 microvolts; however, the reading of this control is multiplied by the reading of the MULTIPLIER control which is calibrated from "1" to "100K" in six decade steps. To obtain a desired output voltage, these controls should be set so that their readings, when multiplied together, equal the desired voltage. For example, if a carrier voltage of 5 millivolts (0.005 volt) were desired, the MICROVOLTS control should be set to "5" (microvolts) and the MULTIPLIER control set to "1K" (.000005 volt x 1000 = .005 volt).

The MICROVOLTS and the MULTIPLIER controls are also calibrated in red in decibels above a zero level of one microvolt. To determine the output level of the carrier using the decibel notation, the db readings of the two controls should be added together rather than multiplied as in voltage readings. For example, if the MICROVOLTS control is set at "6" db and the MULTIPLIER control at "40" db, the true output level is 46 db above a reference level of one microvolt. Using this notation, 46 db corresponds to an output level of 200 microvolts.

The MICROVOLTS control has two dots at the counter-clockwise end of its arc of rotation. The extreme end dot signifies the limit of rotation of the control. The upper dot is provided to indicate the point at which approximately one-half microvolt output can be obtained from the instrument (when the MULTIPLIER control is at the "1" position). The accuracy of the one-half microvolt dot is not specified and this point should be considered merely as an approximation. One-half microvolt corresponds to −6 db with this instrument where 0 db is taken as one microvolt. The one-half microvolt point should not be used except when the MULTIPLIER control is in the "1" position.

The MICROVOLTS control is an attenuator of slidewire construction and conventional usage of slidewires should be followed when setting this control. That is, when setting the control to a desired point, "rock" or rotate the control back and forth, decreasing the arc of rotation gradually before finally setting the control.

g. OUTPUT METER.—The output meter (number "11" in Fig. 3-3) monitors the voltage which is applied to the input of the output attenuator controls. The only operation required for this meter is that the pointer be set to the red mark on the meter face at all times. This adjustment is made with the CARRIER ADJUST control which is located directly below the meter. Setting this meter to the red mark places the proper reference level of one volt at the attenuator system input.

h. EXTERNAL PLUG-IN ATTENUATOR.—The external plug-in attenuator which is supplied with the instrument is designed to allow the output voltage to be reduced to less than 0.5 microvolt. This attenuator can be used practically to reduce the output voltage down to about 0.1 microvolt. The insertion loss of the plug-in attenuator is 20 db; thus, when this unit is used, the output voltage will be 20 db less than is indicated by the output voltage controls. On a voltage basis a loss of 20 db corresponds to a voltage reduction of 10 times, so that the voltage output indicated by the output voltage controls must be divided by 10 when the plug-in attenuator is used. For example, if the settings of the MICROVOLTS and the MULTIPLIER controls indicate an output of 200 microvolts (+46 db), this voltage will be reduced to 20 microvolts or +26 db when the plug-in attenuator is used.

Another feature of the use of the plug-in attenuator is that the internal impedance of the generator is reduced from a nominal value of 5 ohms to 0.5 ohm. For this reason it may be sometimes desirable to use the plug-in attenuator even though a relatively high output level is being used, as, for example, when making sensitivity measurements on a receiver having a loop antenna which is inductively coupled to the signal generator, the combination presenting a low-impedance load for the signal generator.

i. RATED LOAD.—If loads of 100 or more ohms are used with this instrument, no particular precautions need be observed as far as loading the instrument is concerned. However, if loads of less than about 100 ohms are used, it may be desirable to apply a correction factor to the output voltage calibration of the instrument. The nominal internal impedance of the instrument is 5 ohms so that, if loads which are not large compared with 5 ohms are used, the carrier voltage will not be as great as the voltage calibration of the instrument indicates.

There are two ways in which an error in voltage calibration can be avoided when using low-impedance loads. One method is to calculate the error involved, knowing that the internal impedance of the generator is 5 ohms. The second method is to use the external attenuator. When this attenuator is used, the internal impedance of the generator is reduced to 0.5 ohm while the output voltage is reduced by a factor of 10.

If at any time it is desired to calculate the carrier voltage impressed across the load, the following procedure can be used.

Fig. 3-8 shows an equivalent circuit of Signal Generator TS-535A/U when a load is connected across the output jack of the instrument. The internal impedance of the generator is nominally 5 ohms

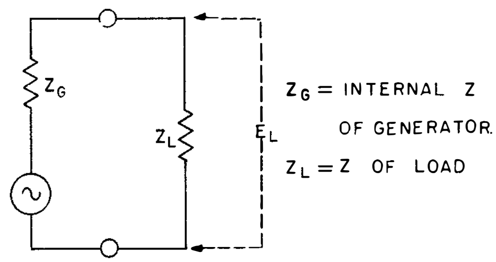


Figure 3—8. Equivalent Circuit of Signal Generator TS-535A/U When a Load is Connected to Output

and indicated by Z_G. The external load placed on the generator is represented by Z_L. The voltage indicated by the generator is impressed across Z_G and Z_L in series and therefore the voltage which is impressed across Z_L alone is

$$E_L = \frac{Z_L \times E_G}{Z_L + Z_G}$$

For example: Assume it is desired to know the voltage that appears across a 20-ohm load connected to the output jack when the MICROVOLTS and MULTIPLIER controls are set for an output of 1000 microvolts. The voltage across the load is calculated using the above equation as follows:

$$E_L = \frac{20 \times 1000}{20+5} = 800 \text{ MICROVOLTS}$$

In some applications, it may be necessary to determine the settings of the MICROVOLTS and MULTIPLIER controls to obtain a desired voltage across a known load. For this type of application, the following expression should be used:

$$E_G = \frac{E_L(Z_L + Z_G)}{Z_L}$$

where E_L is the voltage desired across the load. In a typical application, it might be desired to obtain a voltage of 10 microvolts across a load of 25 ohms. The necessary generator voltage is calculated as follows:

$$E_G \doteq \frac{10(25+5)}{25} = 12 \text{ MICROVOLTS}$$

Therefore, the MICROVOLTS control should be set to "1.2" and the MULTIPLIER control to "10". The instrument will then generate 12 microvolts, 10 of which appear across the 25-ohm load.

These are examples where the load is sufficient to cause a significant voltage drop across the internal impedance of the generator. When the load resistance is greater than approximately 100 ohms, no corrections are normally required.

j. INTERNAL MODULATION.—If it is desired to modulate the output voltage with the internal 400-cps oscillator, all that is necessary is that the MODULATION switch be set to the "400" position as the final step of operation.

k. EXTERNAL MODULATION.—If it is desired to modulate the carrier externally, the MODULATION switch should be set to the EXT position and the external voltage should be connected into the binding posts marked EXT MOD INPUT.

CAUTION

The lower of these binding posts is grounded and should not be connected to any point at an ac or dc potential.

The amplitude of the external modulating voltage should be adjusted to give the desired percentage of modulation, approximately 1.05 volts being required for 30% modulation.

l. OUTPUT CABLES.—Three different output cables are supplied with this instrument. One cable has UG-88/U plugs on both ends and can be used between the output connector of this signal generator and a UG-185/U or similar connector. A UG-201/U adaptor is supplied with the equipment so that this same cable can be used with a type N coaxial jack. A second output cable has a UG-88/U plug on one end so that it can be connected to the UG-291/U connector on the panel of the instrument and on the other end is a binding post set so that a twisted pair set of leads can be connected. The third cable has banana plug sets on both ends. This cable is intended to be used to connect external modulating voltages in the EXT MOD INPUT binding posts.

m. STEP-BY-STEP OPERATING PROCEDURE.—Following is a step-by-step operating procedure which is included here for the convenience of the operator. This procedure is based on Method II—the more accurate method for selecting carrier frequency.

(1) Plug unit into nominal 115-volt, 50-63 cycle single phase AC source and turn on POWER switch. Allow unit to heat at least thirty minutes, preferably longer. For voltages less than 110 volts or more than 120 volts, see Sec. 4, Paragraph 11.

(2) Set RANGE switch to the range which includes desired carrier frequency.

(3) Adjust the INTENSITY, HORIZONTAL GAIN, and FOCUS controls to give clearly defined pattern on cathode-ray tube.

(4) Set main tuning dial to check point nearest desired frequency (obtain from Calibra-

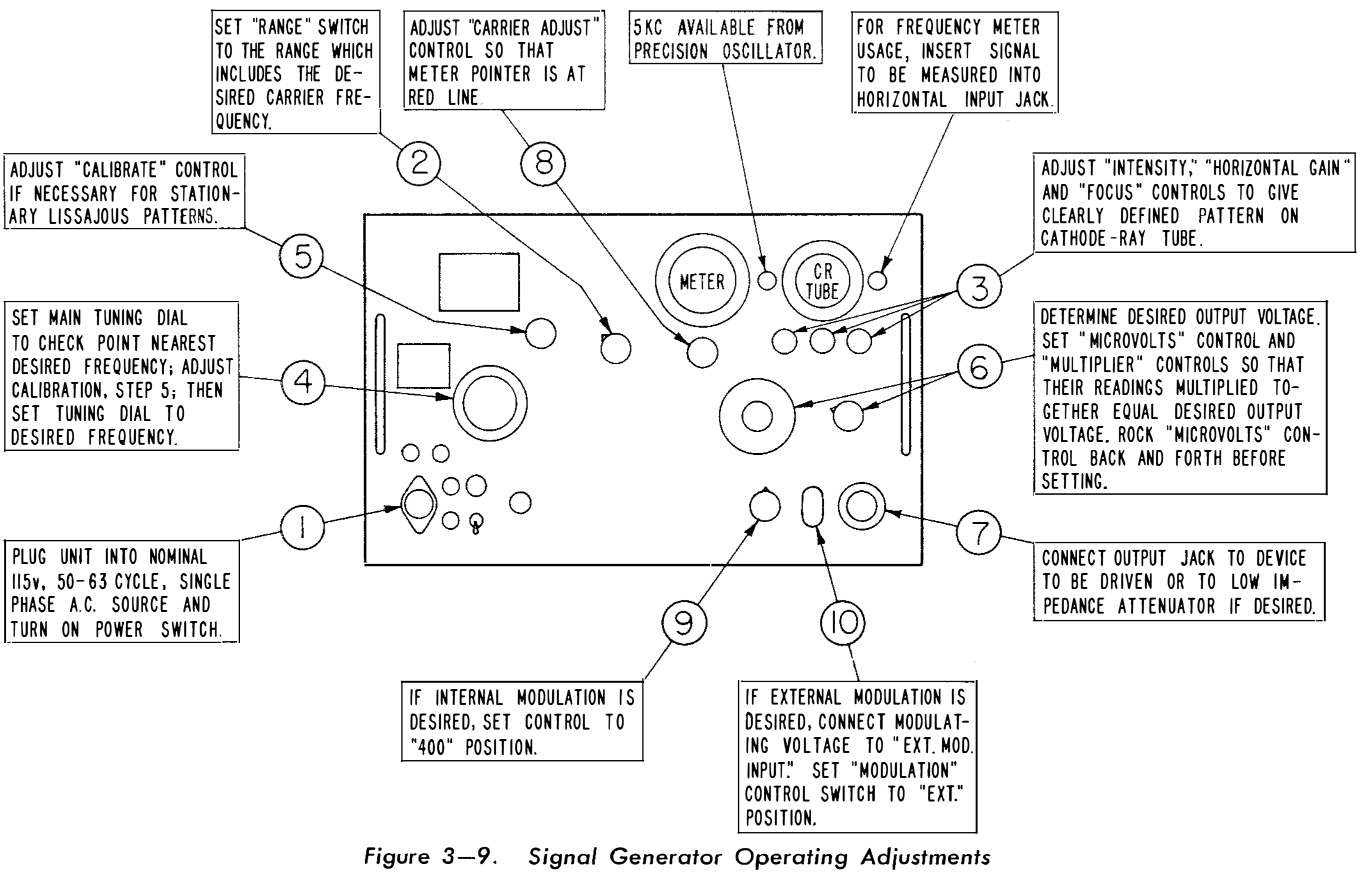


Figure 3—9. Signal Generator Operating Adjustments

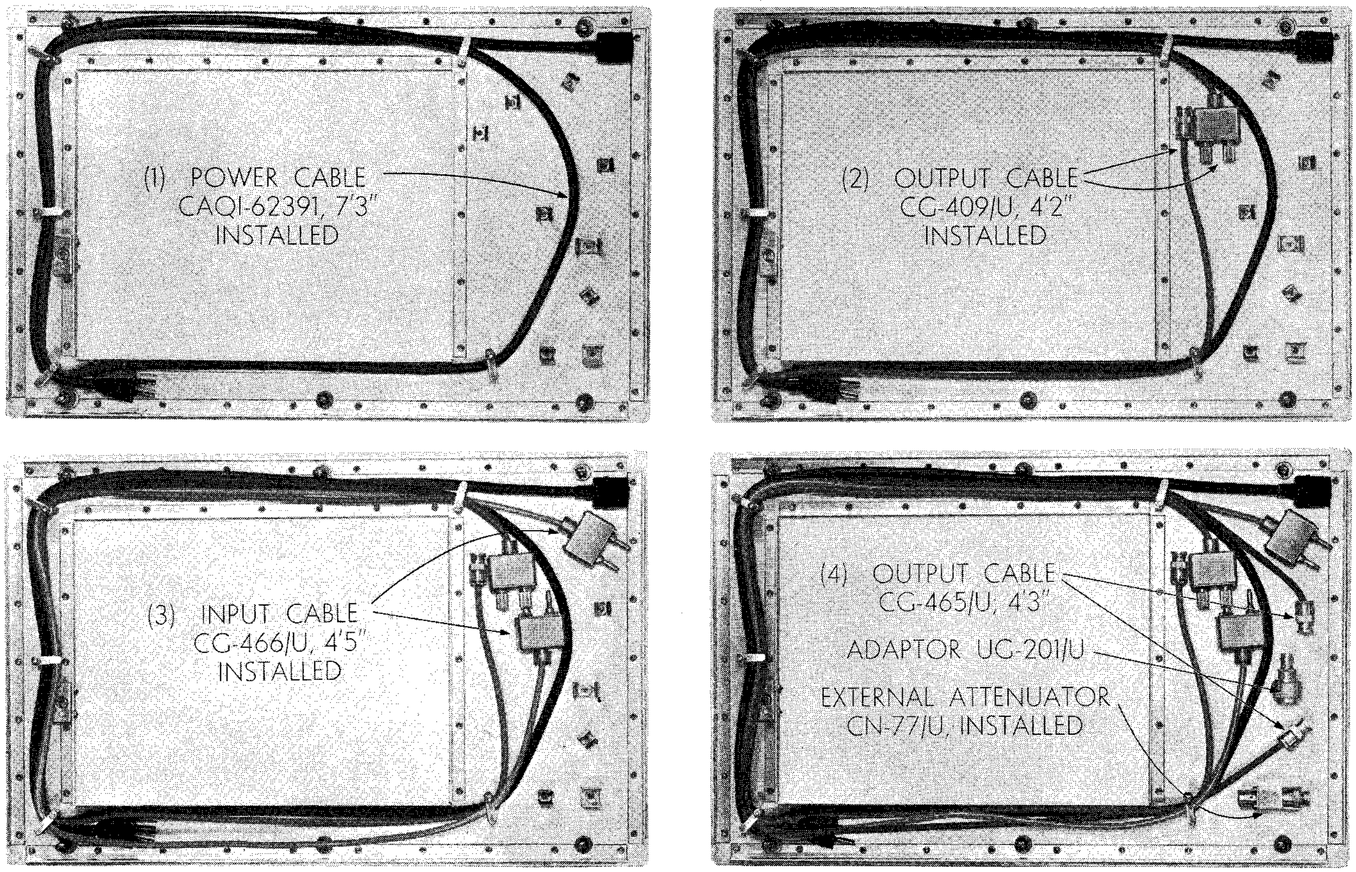


Figure 3—10. Procedure for Replacing Cables in Panel Cover

tion Book) and adjust CALIBRATE control if necessary for stationary Lissajous pattern on cathode-ray tube.

(5) Set main tuning dials to desired frequency. If greatest accuracy is desired, refer to Calibration Book and set linear scale on dial to reading given in book. If desired frequency is not listed in Calibration Book, it is necessary to calculate dial reading from data given in Calibration Book.

(6) Determine desired output voltage. Set MICROVOLTS and MULTIPLIER controls so that their readings multiplied together equal desired output voltage. Rotate or rock MICROVOLTS control back and forth before setting.

(7) Connect output jack to device to be driven. If external load is a low impedance, it may be necessary to calculate carrier voltage or to insert plug-in attenuator between generator output and load. If plug-in attenuator is used, output voltage is reduced to one-tenth indicated value.

(8) Adjust CARRIER ADJUST control so that meter pointer is at red line.

(9) If internal modulation is desired, set MODULATION control to "400" position.

(10) If external modulation is desired, connect external modulating voltage to EXT MOD INPUT. Set MODULATION control to EXT position. Adjust external voltage to give desired percentage modulation. (Approximately one volt ac required for 30% modulation.)

n. 5 KC OUTPUT.—Provision has been made so that the 5 kc output of the 5 kc precision oscillator can be obtained for external use. This voltage can be obtained by plugging an ordinary telephone-type tip-and-sleeve plug (such as JAN PJ-055B, standard Navy stock number N17-P-61264-5423) into the jack marked 5 KC OUTPUT. When the plug is inserted into this jack, the amplitude of the voltage available is usually about 1.4 volts when a 100,000-ohm load is used.

o. FREQUENCY METER USAGE.—The Signal Generator TS-535A/U can be used as a frequency meter to measure voltages up to several hundred kilocycles. All that is necessary for this usage is that the unknown voltage be connected into the jack marked "EXT HOR INPUT." Then the main oscillator should be tuned until some simple Lissajous pattern is obtained. Since the unknown voltage is on the horizontal deflecting plates, the main oscillator frequency should be multiplied by the vertical/horizontal ratio obtained. This ratio is the reciprocal of the ratio set out in Paragraph 3d(1) of this section.

It is necessary that the unknown voltage have an amplitude of about 10 volts in order to provide sufficient deflection of the cathode-ray tube trace. Frequencies above 150 or 200 kc may require a voltage of fifteen or twenty volts for adequate deflection.

p. CABLE REPLACEMENT.—Fig. 3-10 shows how the output cables should be replaced in the cover which shields the control panel of the instrument.

q. STANDBY HEATER.—When the ON-OFF switch is in the OFF position, an internal space heater is connected to the power source. This heater aids in preventing moisture condensation within the combination case during standby periods.

To completely disconnect Signal Generator TS-535A/U from the power source, it is necessary to disconnect the power cable either from the instrument or from the power outlet.

4. SIGNAL GENERATOR USAGE.

Probably the most common error made in measurements involving a signal generator is that an incorrect carrier voltage is impressed across the input to the device under test. This error usually occurs because no consideration is given to the relation between the impedance of the device under test and the internal impedance of the signal generator.

The voltage controls of Signal Generator TS-535A/U are calibrated on the assumption that the external load—the load into which the instrument is working—is large compared to the 5-ohm internal impedance of Signal Generator TS-535A/U. If the external load is not large compared to the internal impedance of the signal generator and if the voltage across the rated load is at all important, the voltage actually impressed across the load must be calculated as explained in Paragraph 3*i* of this section.

Before making sensitivity or selectivity tests on a receiver, it is essential that the receiver AVC circuit (if any) be switched off or shorted out in order to prevent the erroneous readings introduced by the AVC action. This precaution is also essential when making such measurements as stage gains in the rf section of the receiver.

The sensitivity of communications receivers is almost invariably measured by inserting a dummy antenna between the signal generator and the receiver input terminals. Several different types of dummy antennas are in use so that the instruction book for the receiver should be consulted for the manufacturer's recommendations in regard to the type of dummy antenna to be used in such measurements.

FAILURE REPORTS

A FAILURE REPORT must be filled out for the failure of any part of the equipment whether caused by defective or worn parts, improper operation, or external influences. It should be made on Failure Report, form NBS-383, which has been designed to simplify this requirement. The card must be filled out and forwarded to BUSHIPS in the franked envelope which is provided. Full instructions are to be found on each card.

Use great care in filling the card out to make certain it carries adequate information. For example, under "Circuit Symbol" use the proper circuit identification taken from the schematic drawings, such as T-803, in the case of a transformer, or R-207, for a resistor. Do not substitute brevity for clarity. Use the back of the card to completely describe the cause of failure and attach an extra piece of paper if necessary.

The purpose of this report is to inform BUSHIPS of the cause and rate of failures. The information is used by the Bureau in the design of future equipment and in the maintenance of adequate supplies to keep the present equipment going. The cards you send in, together with those from hundreds of other ships, furnish a store of information permitting the Bureau to keep in touch with the performance of the equipment of your ship and all other ships of the Navy.

This report is not a requisition. You must request the replacement of parts through your Officer-in-Charge in the usual manner.

Make certain you have a supply of Failure Report cards. and envelopes on board. They may be obtained from any Electronics Officer.

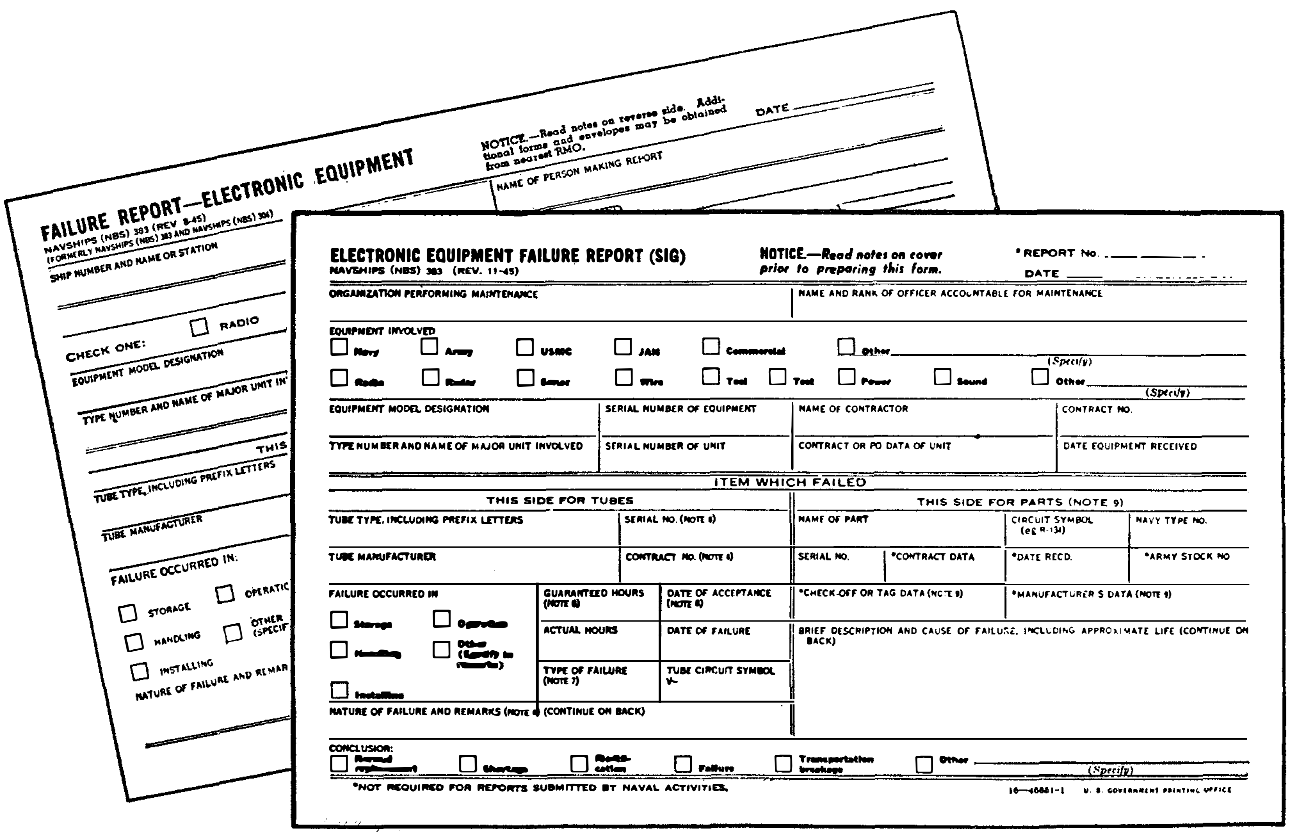


Figure 4—1. Sample Failure Report

SECTION 4
MAINTENANCE

1. GENERAL.

Signal Generator TS-535A/U is a precision test equipment and consequently, in general, all major repairs should be attempted only by experienced technicians who have accurate laboratory test equipment at hand. Some of the equipment such as secondary frequency standards necessary for thorough testing of this signal generator is not ordinarily found aboard ship.

Unnecessary repairs or attempts to make the instrument more accurate should not be undertaken, because almost invariably such attempts result in a loss of accuracy and general performance for the instrument. Remember that precision test equipment can only be tested satisfactorily with more precise test equipment.

In order to assist in possible trouble-shooting of Signal Generator TS-535A/U, this section of the instruction book includes a schematic diagram, voltage and resistance diagrams, trouble and servicing charts, photographs showing the physical location of components, and other pertinent maintenance data.

In performing maintenance or repair work on Signal Generator TS-535A/U, it is suggested that a high-impedance voltmeter such as Multimeter TS-352/U Series, Navy Model OE Series, an electronic voltmeter such as Multimeter ME-25/U Series, Navy Model OBQ or equivalent be used.

2. PERIODIC TESTS.

NOTE

The attention of maintenance personnel is invited to the requirements of Chapter 67 of the *Bureau of Ships Manual* of the latest issue.

No periodic tests are required for this instrument. The only periodic operations necessary are the lubrication of the moving parts in the main tuning capacitor drive system at intervals of six months and the lubrication of the slidewire attenuator at yearly intervals. The procedures to follow are given in paragraph 9 of this section.

3. TUBE REPLACEMENT.

NOTE

All tubes of a given type supplied with the equipment shall be consumed prior to employment of tubes from general stock.

If a tube is suspected of causing faulty operation of this signal generator, that tube's operation should first be checked with a tube tester such as Tube Tester TV-3/U Series, Navy Model OZ or equivalent. If the tube tests "good," it should be further checked by replacing with a new tube of the same type and determining whether the trouble is corrected.

In general tubes in this instrument do not require replacing until they cause trouble of some sort. The troubles which can be caused by defective tubes but which will nevertheless allow the instrument to operate are excessive distortion, instability, lack of gain, excessive hum, microphonics, etc.

a. REPLACEMENT OF V-103.—When replacing Modulator tube V-103, it is strongly recommended that the output level of the Modulator tube and the percentage of internal modulation be checked. See Paragraph 5*c* below for these procedures. It should be noted that the operating conditions for the Modulator tube are probably the most critical of any tube in this instrument and that the recommended tests should be made very carefully.

b. REPLACEMENT OF V-109.—When replacing output meter rectifier tube V-109, it is desirable to check the calibration of the output meter, because tube replacement may change the calibration of the voltmeter by as much as 12% or more. The procedure for this test is given in Paragraph 5*e* below.

c. REPLACEMENT OF LAMPS R-103 AND R-129.—When replacing lamps R-103 and/or R-129, it is desirable to measure the ac voltage generated by the Carrier and Modulating oscillators in which these lamps are situated. It may be necessary to readjust the voltage output of the oscillators because these lamps have a wide tolerance in their characteristic. For the procedure to use, see Paragraphs 5*b* and 5*d* in this section.

d. REPLACEMENT OF V-113 TO V-116.—When replacing any of the dc regulator circuit tubes V-113 to V-116, it is desirable to measure the value of the regulated dc voltage and to make certain the regulated voltage remains constant with line voltage changes. The procedures to use are given in Paragraph 5*g* of this section.

4. LOCALIZING TROUBLE.

The first step in correcting any trouble or failure which may occur in the instrument is to isolate the section of the circuit which is causing the trouble. Such isolation can best be accomplished by considering the circuit as composed of the eight basic sections shown in Fig. 4-2. Ordinarily, trouble occurs in only one section at a time, so all that is usually necessary is to correct the one trouble. A chart has been prepared to facilitate isolation of trouble and if the requirements of the chart are fulfilled as regards any one section, that section can be assumed to be operating properly. Table 4-2 has been prepared to indicate the causes of certain specific troubles in order to assist in possible trouble-shooting of the equipment.

Standard signal-tracing procedures should be used if trouble occurs. Trace the signal through the circuit from the main carrier oscillator to the output jack. The schematic diagram at the back of this section (Fig. 4-16) has been marked with heavy lines and arrowheads to indicate the flow of the signal through the circuit. In addition certain secondary circuits are marked with arrowheads only (no heavy lines) to indicate the signal flow in those circuits. When signal-tracing, the signal flow shown in this diagram and on the Servicing Block Diagram (Fig. 4-13) should be followed.

When signal-tracing, it is important to bear in mind that feedback amplifiers are used in Signal Generator TS-535A/U and therefore the usual consistent gain in signal voltage is sometimes not obtained. For example, in some cases less voltage will be measured in a tube's plate circuit than in the grid circuit and occasionally less voltage may be measured in the grid circuit than in the cathode

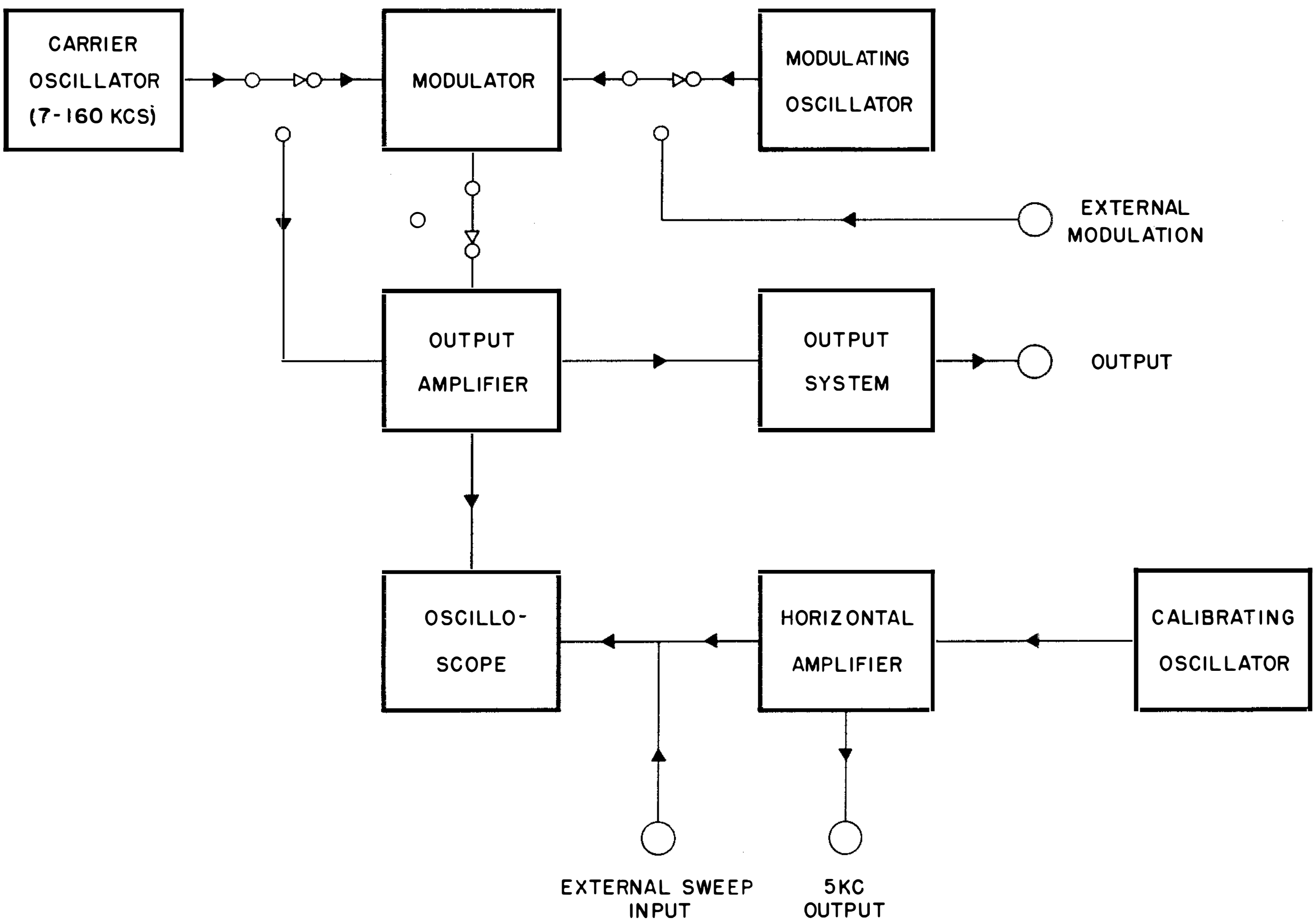


Figure 4—2. Circuit Block Diagram

circuit. These effects are caused by a combination of the use of negative feedback amplifiers and the change in circuit conditions caused by adding the voltmeter impedance into the circuit.

5. ELECTRICAL ADJUSTMENTS.

a. GENERAL.—The various maintenance and calibrating electrical adjustments for Signal Generator TS-535A/U are indicated on the schematic diagram by small circles with two parallel diagonal lines through each of them—signifying a screwdriver slotted shaft. Components which are marked with this symbol are intended to be adjusted only by maintenance personnel.

The electrical adjustments for Signal Generator TS-535A/U are of two types—potentiometers and trimmer capacitors. The trimmer capacitors have high-torque type shafts and require no particular precautions before adjustment. However, all of the potentiometers which are internal adjustments have locking type shafts and it is necessary to loosen the lock-nut before attempting to adjust these potentiometers. After the adjustment has been made, it is necessary to retighten the lock-nut.

b. OSCILLATOR SECTION.—In the carrier oscillator section (tubes V-101 and V-102), several internal electrical adjustments are provided but only one of these, R-104, is normally used throughout the life of the instrument. R-104 is a potentiometer connected as a variable resistor and is provided so that the magnitude of the negative feedback voltage can be adjusted as required by tolerances in the lamp (R-103) characteristic.

When oscillator tubes V-101 (JAN-6SJ7) or V-102 (JAN-6AG7) or the lamp (R-103) are changed, R-104 should be adjusted if necessary so

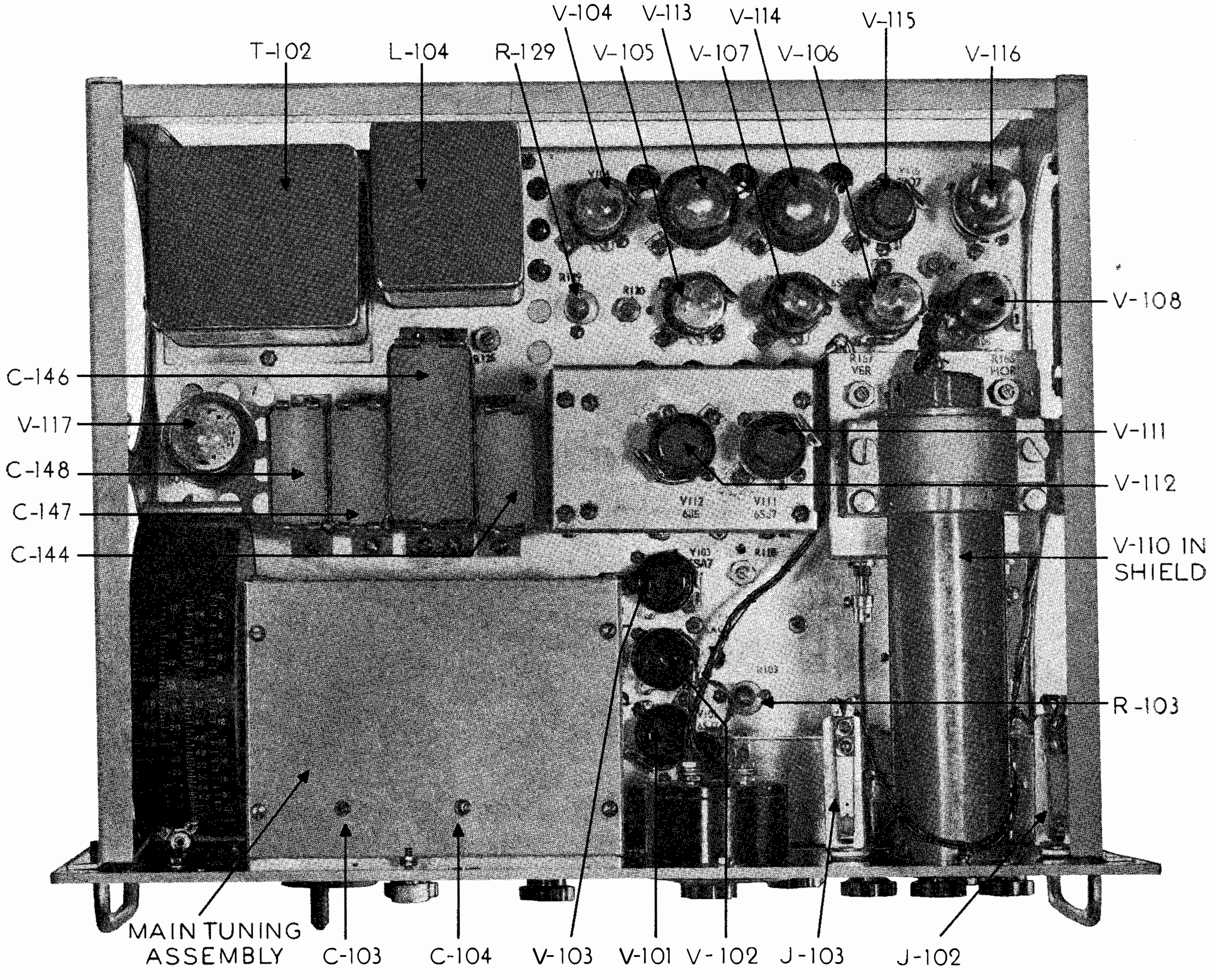


Figure 4—4. Upper Side of Deckplate

that the ac voltage from the high side of R-114 to ground is 1.5 volts ac. It is desirable to make this measurement with Signal Generator TS-535A/U range switch set to the "A" range in order to minimize frequency errors in the voltmeter.

The other adjustments provided in the carrier oscillator section are C-103, C-104, and C-108. These are all adjustments for setting the frequency calibration of the oscillator section. Ordinarily, these components will require no adjustment throughout the life of the instrument and should therefore never be reset, because it will be very difficult to restore the frequency calibration of the oscillator. However, if for some unforeseeable reason it becomes necessary to recalibrate the oscillator, refer to the procedure in Paragraph 7 of this section.

c. MODULATOR SECTION.—R-118 at the output of the carrier oscillator and R-125 at the output of the modulating oscillator are internal adjustments whose settings determine the amplitude of the modulation and carrier voltages applied to the Modulator tube V-103.

To adjust R-118, set the MODULATION switch to the OFF position and the RANGE switch to the "A" range. Using the CARRIER ADJUST control, set the output meter pointer to the red line. Next, set the MODULATION switch to the "EXT" position and adjust R-118 so that the output meter pointer is again at the red line.

R-125 is provided for setting the internal 400 cps modulation to 30%. To adjust R-125, set the MODULATION switch to "400 cps" and the RANGE switch to the "A" range. Connect the output of Signal Generator TS-535A/U to an oscilloscope such as Oscilloscope OS-8/U, Navy Model OBL or equivalent. Use the oscilloscope's linear sweep, adjusted so that a stationary envelope pattern is obtained. Then adjust R-125 so that the carrier is modulated 30%. The pattern which corresponds to 30% modulation is that in which the ratio of height of trough to crest of the envelope is 7-to-

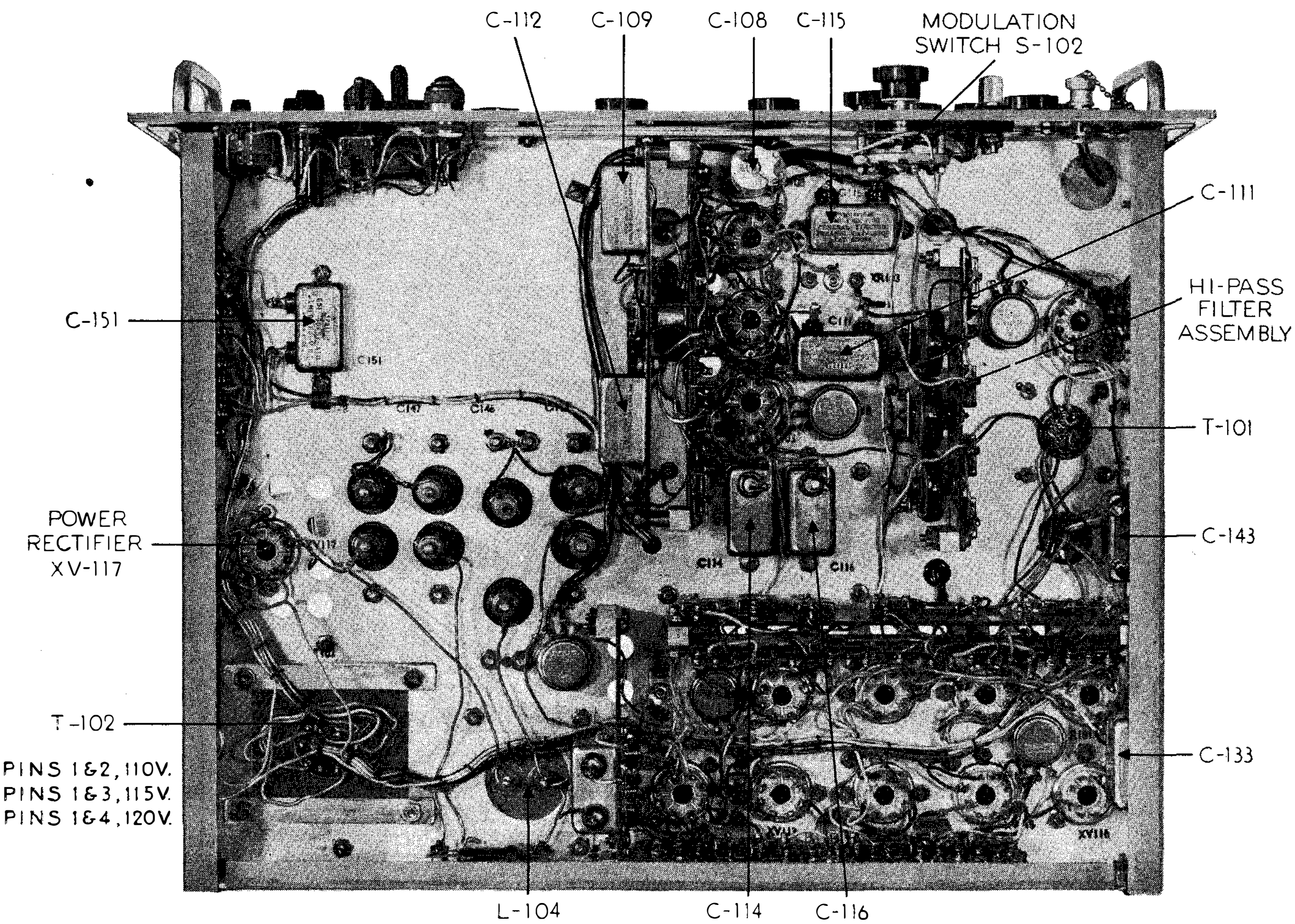
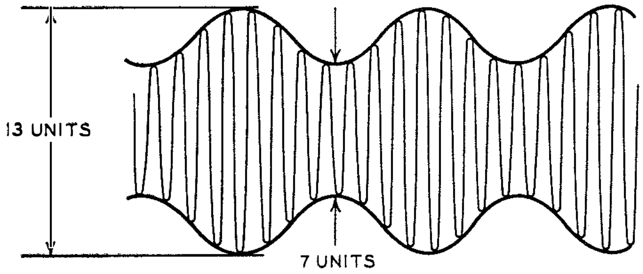


Figure 4—5. Lower Side of Deckplate



$$\% \text{ MODULATION} = 100 \times \frac{MAX - MIN}{MAX + MIN} = 100 \times \frac{13-7}{13+7} = 100 \times \frac{6}{20} = 30\%$$

Figure 4—3. Oscilloscope Pattern Showing 30% Modulation

13, as measured with a ruler or by means of an ordinary oscilloscope graph card. (See Fig. 4-3.)

After this adjustment has been made, it is desirable to tune Signal Generator TS-535A/U through its entire frequency range at the same time continuously checking the percentage modulation in order to make certain that the modulation is approximately 30% throughout the frequency range. If the percentage modulation is not reasonably constant, it is best to select another JAN-6SA7 Modulator tube and repeat the entire process.

d. MODULATING OSCILLATOR.—R-130 in the modulating oscillator is provided so that the amplitude of the negative feedback voltage in this circuit can be adjusted if necessary when a new tube V-104 (JAN-6SN7W) or lamp (R-129) is installed. R-130 should be adjusted so that the ac voltage across R-125 is 1.9 volts ac, as measured with a high-impedance voltmeter.

After making this adjustment it is desirable to measure the percentage modulation of the carrier as outlined in Paragraph 5*c* and to readjust the percentage modulation if necessary.

e. OUTPUT MONITOR.—R-157 in the output voltmeter circuit is provided for correcting the calibration of the voltmeter when tube V-109 (JAN-6H6) is replaced or when otherwise found necessary. It is desirable to allow the new tube to heat for as long a time as possible (even up to 48 hours) before adjusting the calibration.

Before adjusting R-157, set the MULTIPLIER control to the "100K" position and the MICROVOLTS control to "10." Set the RANGE switch to the "A" range and connect an ac vacuum tube voltmeter such as Navy Model OBQ series or equivalent across the output jack of the TS-535A/U.

Next, adjust the CARRIER ADJUST control so that the external voltmeter reads exactly one volt.

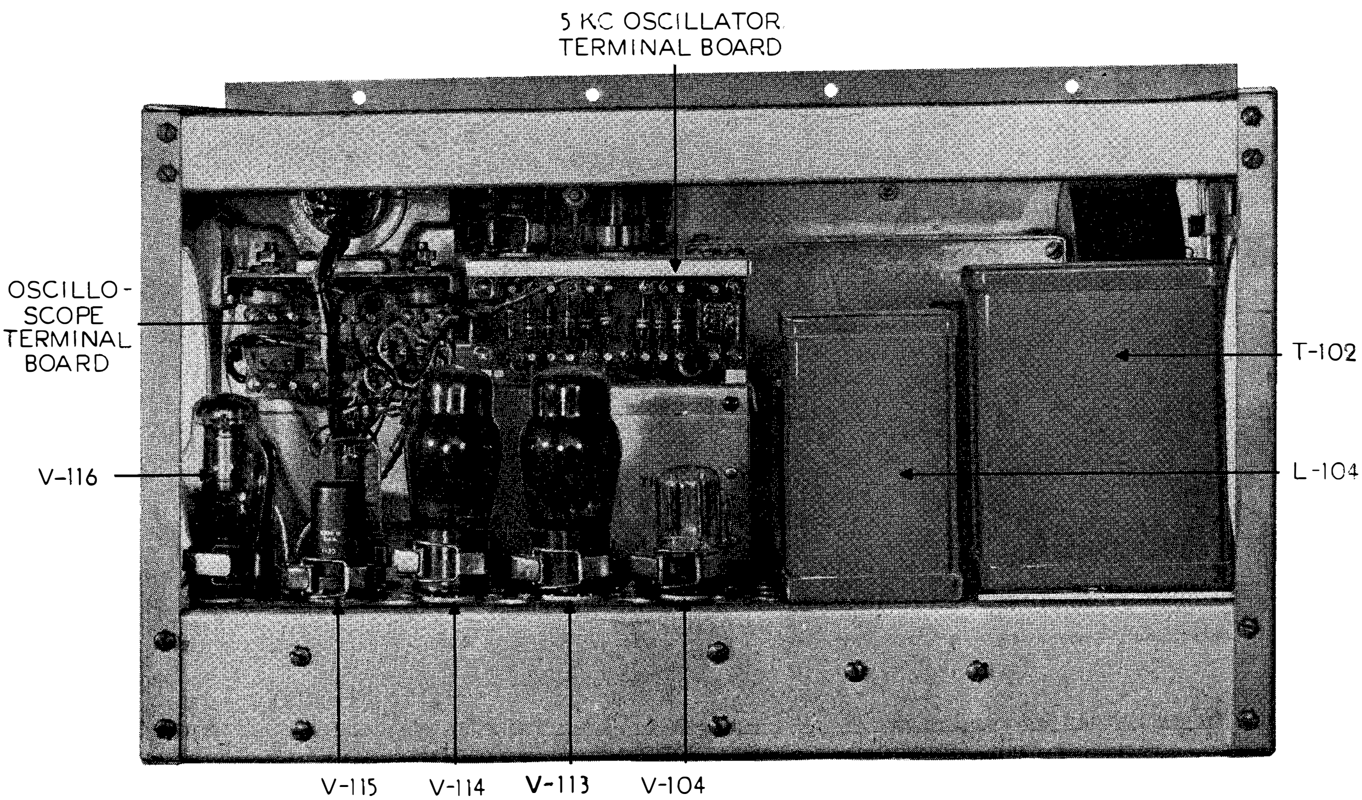


Figure 4—6. Rear View of Chassis

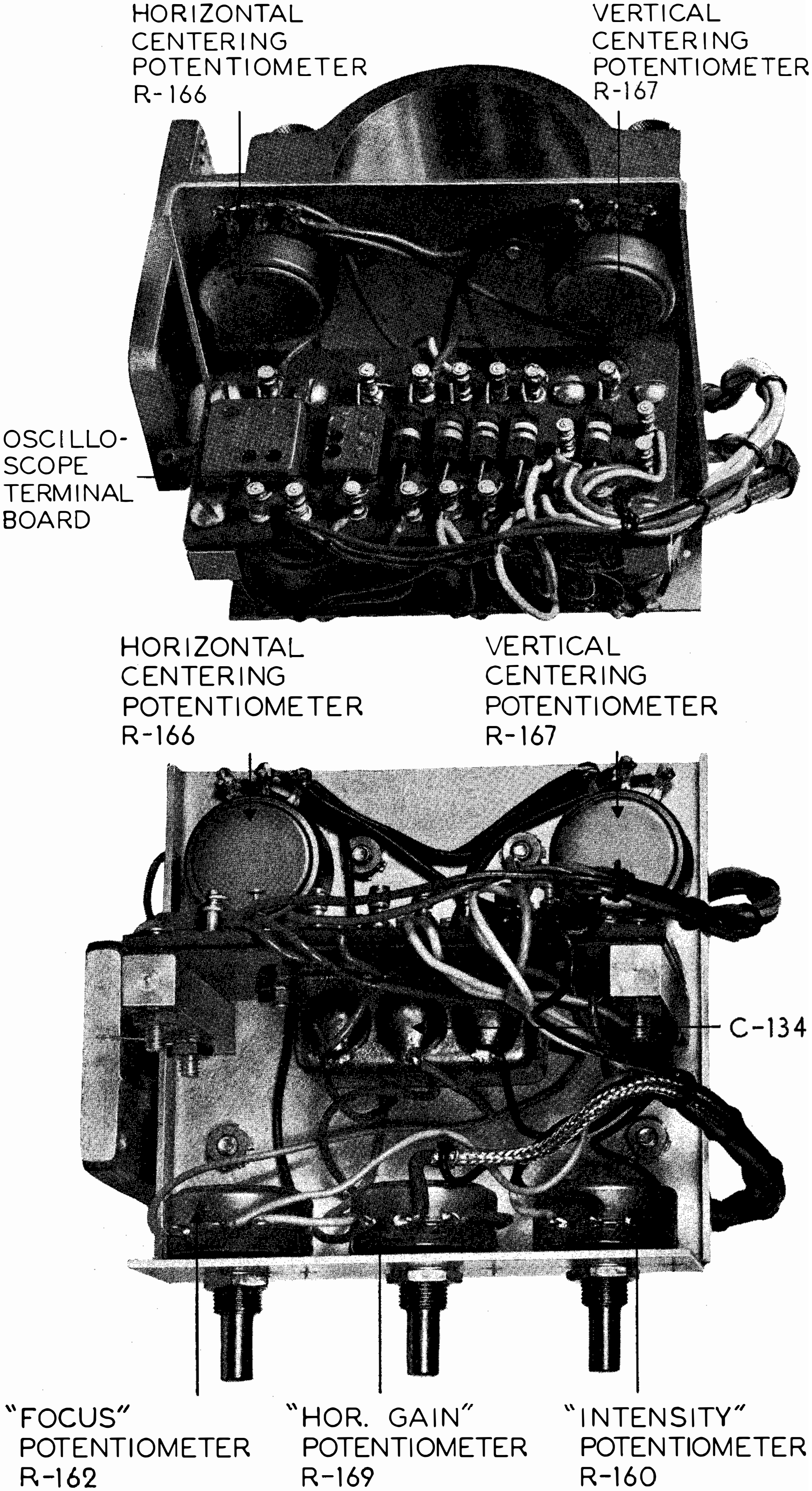


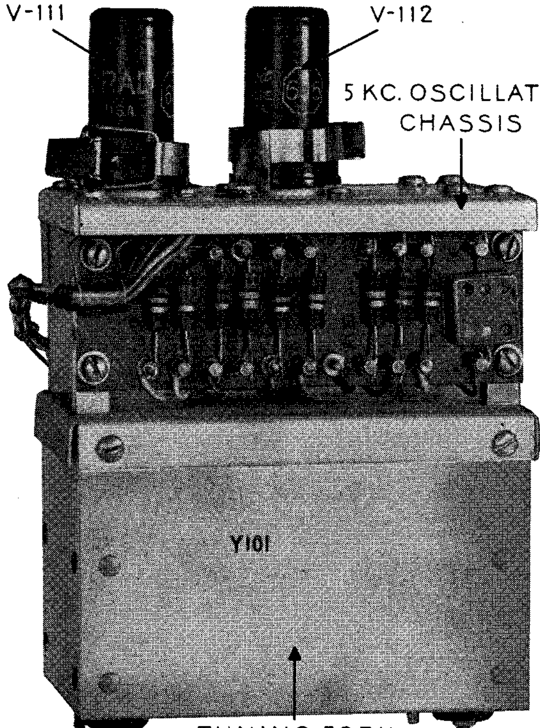
Figure 4—7. Two Views of Oscilloscope Assembly

Then adjust R-157 so that the output meter pointer is at the red mark. Relock the shaft lock on R-157.

f. OSCILLOSCOPE ADJUSTMENT.—Potentiometers R-166 and R-167 are provided for centering the patterns obtained on the Oscilloscope. Before adjusting either of these controls, adjust the HOR GAIN control so that the pattern on the Oscilloscope has the desired horizontal width. Then adjust R-166 to center the pattern horizontally and R-167 to center the pattern vertically.

g. REGULATED VOLTAGE.—Potentiometer R-181 is provided for adjusting the value of the dc regulated voltage supply when tubes V-113 to V-116 are changed or when otherwise found necessary. The value of the regulated voltage should be 225 volts dc ±2 volts. If the regulated voltage is not within these limits when a new tube V-113 to V-116 is inserted in the regulator circuit, adjust R-181 so that the desired value is obtained.

After making this adjustment, it is desirable to vary the ac line voltage slowly from 105 volts to 125 volts, at the same time noting the value of the dc voltage as read on the dc voltmeter. The value of the dc voltage should remain essentially constant. Normally, the regulator circuit will hold the dc voltage constant over a range from less than 100 volts to more than 130 volts. An excessive change in the regulated dc voltage is usually caused by an over-age tube, and it is therefore necessary to replace that tube if this condition is encountered.



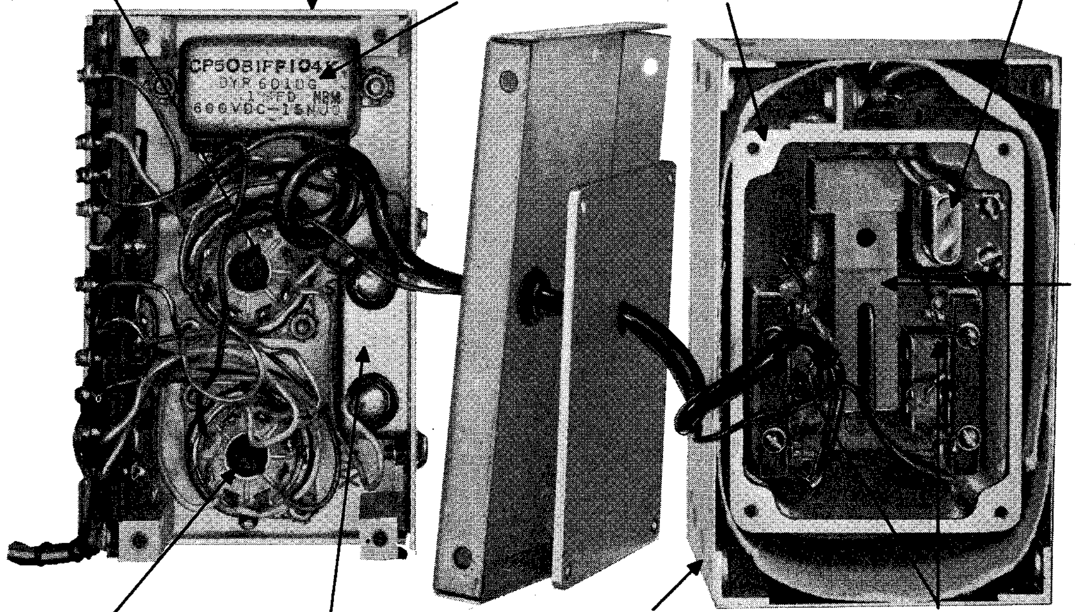


Figure 4—8. Two Views of Tuning Fork Assembly

h. ZERO-SETTING OF METER M-101.—Because the output meter, M-101, is hermetically sealed, the arrangement of its zero corrector is somewhat different from that of conventional meters. The zero corrector in M-101 is sealed with solder so that it can not be rotated while the solder is hard.

The meters are zero-set at the factory. However, should further zero-setting become necessary, the following procedure is recommended by the meter manufacturer: Insert a heated soldering iron having a chisel-shaped tip into the zero corrector. When the solder softens, rotate the iron as necessary for zeroing. A pencil type such as test tool set AN/USM-3 iron of about 20 watts is recommended. The solder will freeze the corrector in position when the iron is removed.

6. CARRIER DISTORTION.

The design of the circuits in the Signal Generator TS-535A/U is such that tubes can be replaced at random without increasing the distortion beyond the limits of 1% below 70 kc and 3% below 160 kc unless an inferior tube is obtained.

Equipment is not ordinarily found aboard ship for measuring distortion. However, a procedure for distortion measurement is set out below so that distortion can be measured should the opportunity occur.

In order to measure the harmonic distortion in the carrier voltage of this instrument, it is necessary to have an electronic tube voltmeter such as voltmeter ME-6/U Series and at least one elimination filter. A set of filters which covers the frequency range of this instrument at regular intervals is desirable. Any filter used should be capable of attenuating the fundamental by at least 50 db and should not attenuate the second harmonic more than one db. The vacuum tube voltmeter should have a range from at least 10 millovolts to one volt.

After the signal generator has heated for at least fifteen minutes, the carrier frequency should be adjusted to that of the filter. Set the MODULATION switch to the OFF position. Connect the vacuum tube voltmeter to the signal generator and adjust the carrier voltage so that the voltmeter reads exactly one volt. Then connect the filter between the output terminal of the generator and the voltmeter and tune the filter or carrier fre-

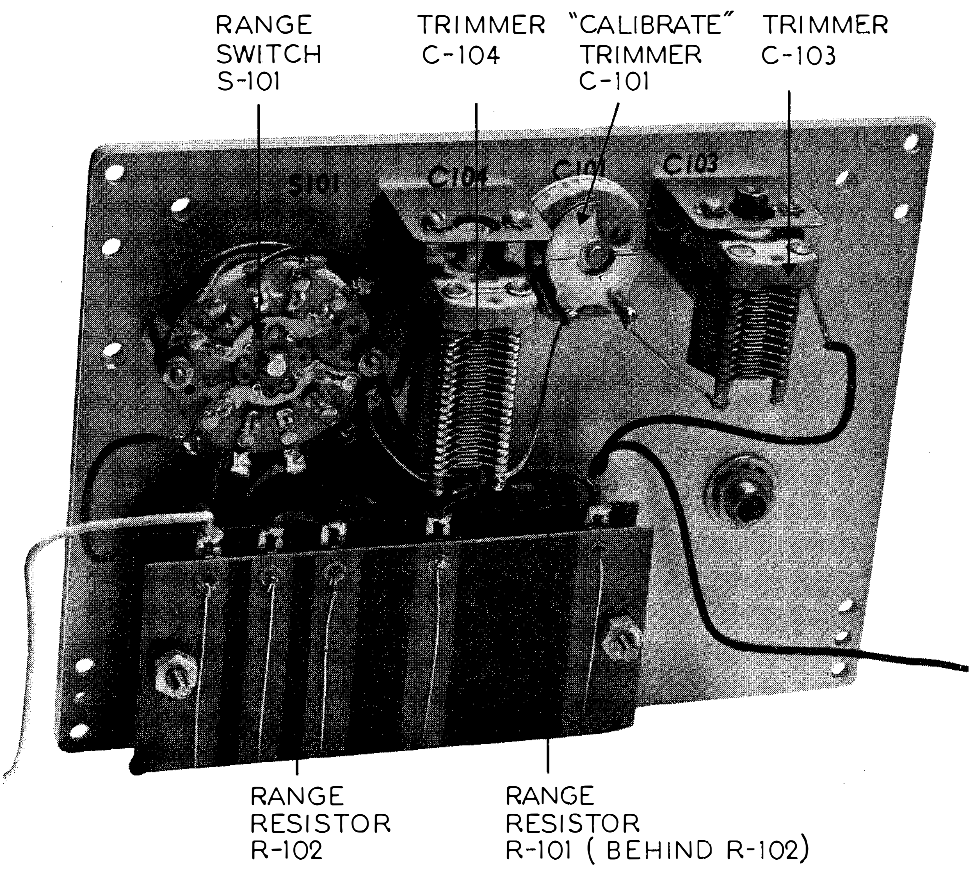


Figure 4—9. Partial View of Main Tuning Assembly

quency of the signal generator so that a minimum reading is obtained on the voltmeter. Readjust the range switch on the voltmeter as necessary to obtain an easily-read deflection of the meter pointer. Note the new reading of the voltmeter when the filter has been tuned to maximum attenuation. The new reading on the voltmeter should be less than one per cent of the original voltmeter reading—that is, less than 0.01 volt if the carrier frequency is below 70 kc. If the carrier is higher than 70 kc, the reading on the voltmeter should be less than 0.03 volt (3% distortion). If necessary, tubes V-101, V-102, V-105, V-106, V-107, and/or V-108 should be changed in the signal generator as required to reduce the harmonic distortion.

7. RECALIBRATION OF OSCILLATOR.

Recalibration of the carrier oscillator of this signal generator will probably never be necessary throughout the life of the instrument. However, the necessary information is included here in the event that an unforeseen condition may require such recalibration. It should be noted that this procedure is very difficult and will probably result in some loss of accuracy over the original calibration; consequently the accuracy obtainable when using the Calibration Book will be lessened.

The minimum equipment required for recalibrating the oscillator is an accurate ac electronic voltmeter such as electronic voltmeter ME-6/U series, multimeter ME-25/U series, Navy Model OBQ series or equivalent and two aligning tools. However, use of this minimum equipment will require that the cathode-ray tube contained in the signal generator be used and that the 5 kc oscillator in the signal generator be used. It is recommended that an external oscilloscope and an external secondary frequency standard (which has sinusoidal rather than square wave output) be used if possible. The following procedure assumes the use of an external oscilloscope and an external standard having an accuracy of 0.01% or better and output frequencies of 1, 10, and 100 kc.

Signal Generator TS-535A/U should be allowed a warmup of at least one hour, preferably longer. It is desirable that a regulated 115-volt ac line be used rather than an unregulated line. The generator should be removed from its case.

Connect the voltmeter from the high side of resistor R-114 to ground and set the signal generator on a large metal plate to simulate the ground plane normally supplied by the case of the instrument. Set the RANGE switch to the "A" range. Connect the output of Signal Generator TS-535-A/U to the vertical deflecting-plate input of the

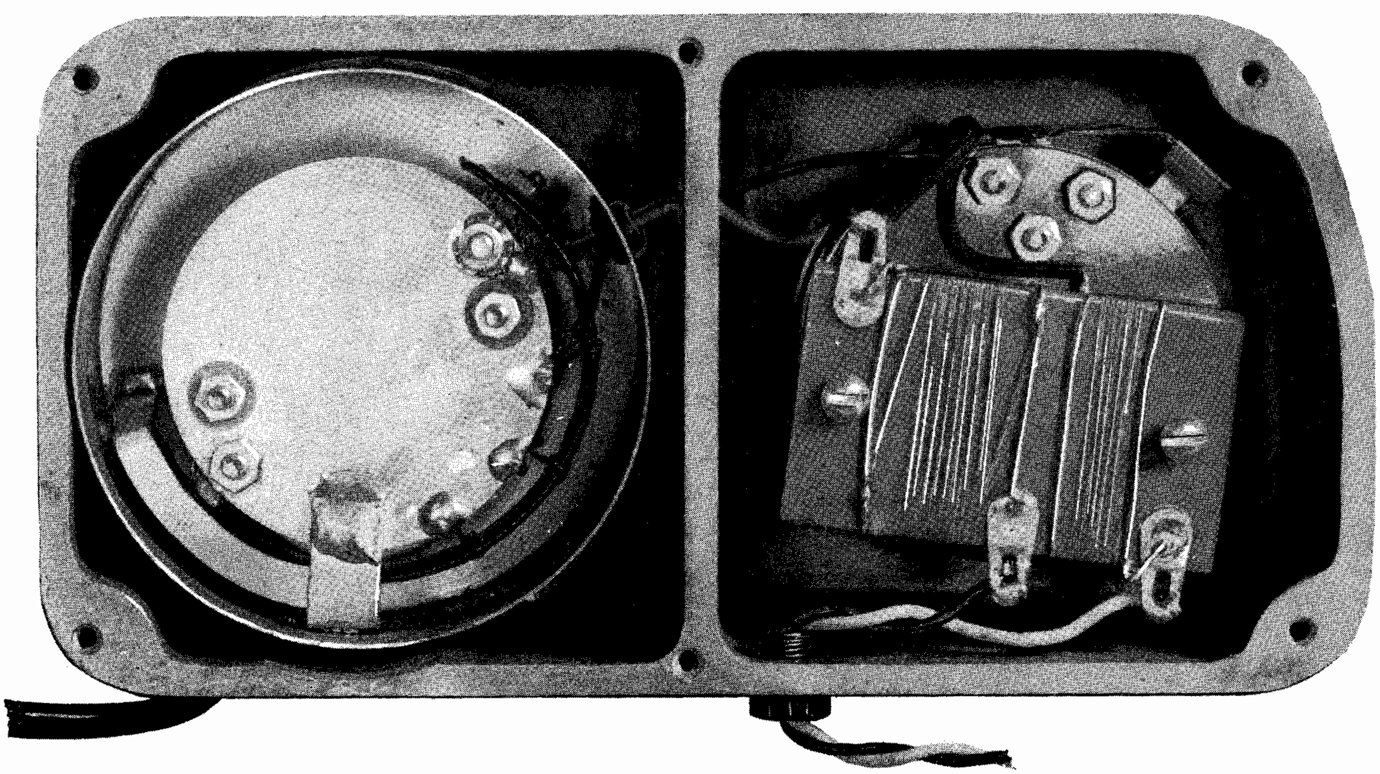


Figure 4—10. Internal View of Output Attenuator Assembly

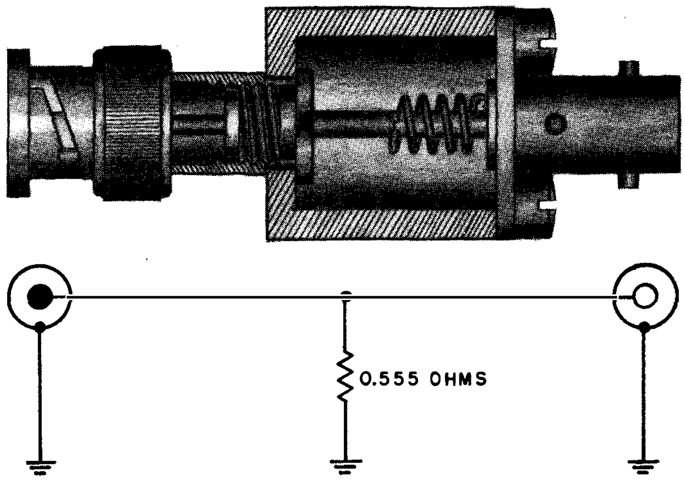


Figure 4—11. Cut-away and Schematic Drawing of Plug-in Attenuator CN-77/U

oscilloscope and connect the secondary frequency standard to the horizontal deflecting-plate input. Adjust the oscilloscope so that the patterns are clear. The secondary frequency standard should be set to its 1 kc output.

Refer to the Calibration Book and set the main tuning dial to the reading given for 16 kc on the "A" range. Now, adjust trimmers C-103 and C-104 simultaneously with the insulated aligning tools so that a stationary 16-to-1 figure is obtained on the oscilloscope at the same time that the voltmeter shows a reading of 1.5 volts ac. This adjustment requires care and usually requires some maneuvering, because the settings of the two trimmers are interdependent. When the proper conditions have been fulfilled, turn the main tuning dial back to the reading given in the Calibration Book for 7 kc. A stationary or almost stationary 7-to-1 Lissajous figure should be obtained on the oscilloscope and the voltmeter should read 1.5 volts ac. If a 7-to-1 pattern is not obtained at this point, the only alternative is to correct the readings given in the Calibration Book, because the calibration at the low-frequency end of the band is dependent to a great extent upon the resistance of the range resistors R-101 and R-102, and it is not practical to change the values of these resistors. If the voltmeter reading is not approximately 1.5 volts ac at the low-frequency end of the dial, the voltage should be reset at 16 kc so that the voltages at both ends of the range are equal.

Assuming that the pattern at the low end of the "A" range has negligible error, the next step is to check the calibration at intervals throughout the "A", "B", and "C" ranges. After this has been done, the main tuning dial should be set to the reading given in the Calibration Book for 100 kc and the external frequency standard set to its 100 kc output. Then trimmer C-108 should be adjusted until a 1-to-1 pattern (circle or ellipse) is obtained on the external oscilloscope. Readings at intervals throughout the "Ax10" range should then be checked to make certain that the calibration is correct. However, it should be noted that the accuracy of the "Ax10" range is inherently less than that of the other three ranges.

8. CALIBRATING OSCILLATOR.

No means have been incorporated into the circuit of Signal Generator TS-535A/U for adjusting the frequency of the 5 kc Calibrating Oscillator, because the only way this can be accomplished satisfactorily is by modifying the natural frequency of the tuning fork. The adjustment of the tuning fork will last far beyond the life of the instrument and therefore it is not recommended that any attempt ever be made to recalibrate the system.

9. LUBRICATION.

At approximately six month intervals it is desirable to place a drop of oil on moving parts in the main tuning condenser drive. This lubrication is not at all critical. Navy Symbol N.S.2190T (Federal Standard Stock Catalog Number 14-0-2879-25 for 5 gallon can) is suggested for this application.

At yearly intervals the slidewire (MICROVOLTS control) in the output attenuator E-101 should be lightly filmed with Petrolatum, Navy Specification 14-P-1, Standard Navy Type No. G36-G-5-12-500 for 2 oz. jar, W14-P-98 for 1 lb. can, W14-P-100 for 5 lb. can. The Petrolatum should be smeared all along the length of the six wires which make up the slidewire. After applying the Petrolatum, remove any excess with a soft lintless cloth.

10. TROPICALIZATION.

This instrument has been tropicalized at the time of its manufacture in that a fungus- and moisture-proof varnish has been applied to all soldered joints and phenolic pieces. Before attempting to unsolder or resolder any joints, it is desirable that this varnish be removed from the joint. Then after the joint has been resoldered, an approved varnish should be again applied to the joint.

11. POWER TRANSFORMER.

The primary winding of the power transformer T-102 is tapped for 110-, 115-, or 120-volt operation. The 115-volt tap is connected at the factory. If line voltages are encountered which are less than 110 or more than 120 volts, the transformer connection may be changed to the 110- or 120-volt tap (pins 2 and 4 respectively on T-102).

12. REPLACEMENT OF TRANSFORMERS AND CHOKE.

The transformers (T-101, T-102) and the filter choke (L-104) used in Signal Generator TS-535-A/U are electrically the same as those used in Signal Generator TS-535/U, although physically the units in the TS-535A/U are somewhat larger and the mounting dimensions are different.

However, the deck-plate of the TS-535A/U is punched to accept either size of transformer or choke. Thus, in the TS-535A/U transformer —304369 can be used as a replacement for T-101; transformer —304370 can be used for T-102; and filter choke —304419 can be used for L-104.

13. MAINTENANCE DATA.

The following pages contain voltage diagrams, resistance diagrams, a Servicing Block Diagram, and other data which may be found useful in trouble-shooting and repair of this instrument.

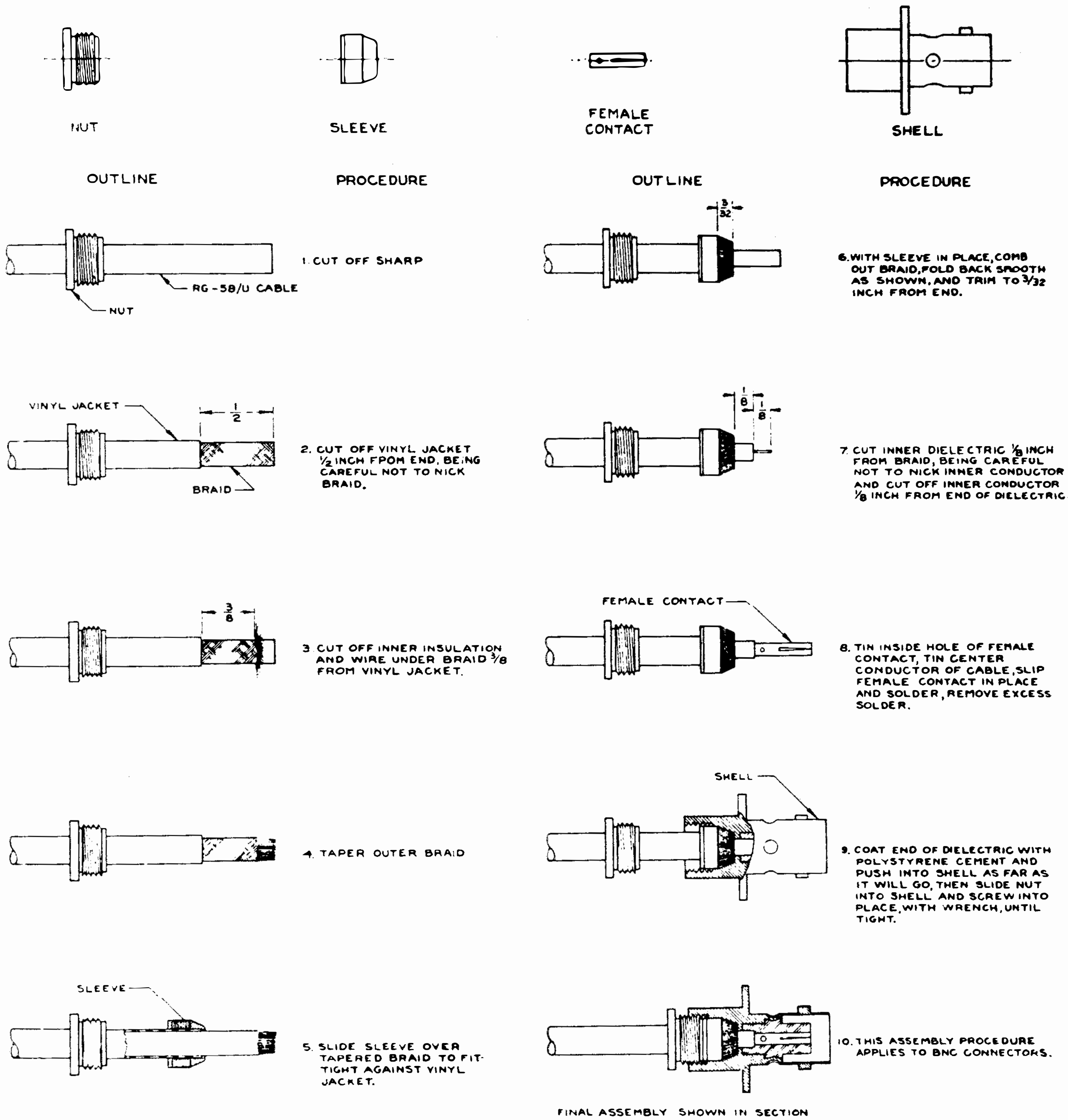


Figure 4—12. Assembly of BNC Connectors to RG-58/U Cable

TABLE 4—1. WINDING DATA

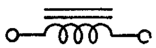
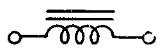
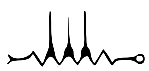
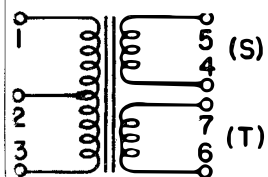
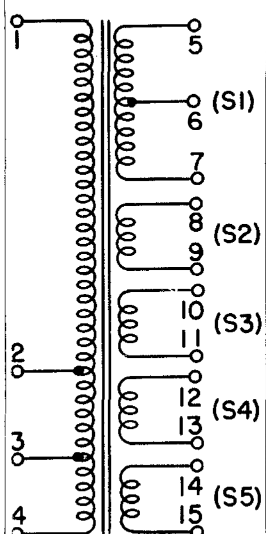
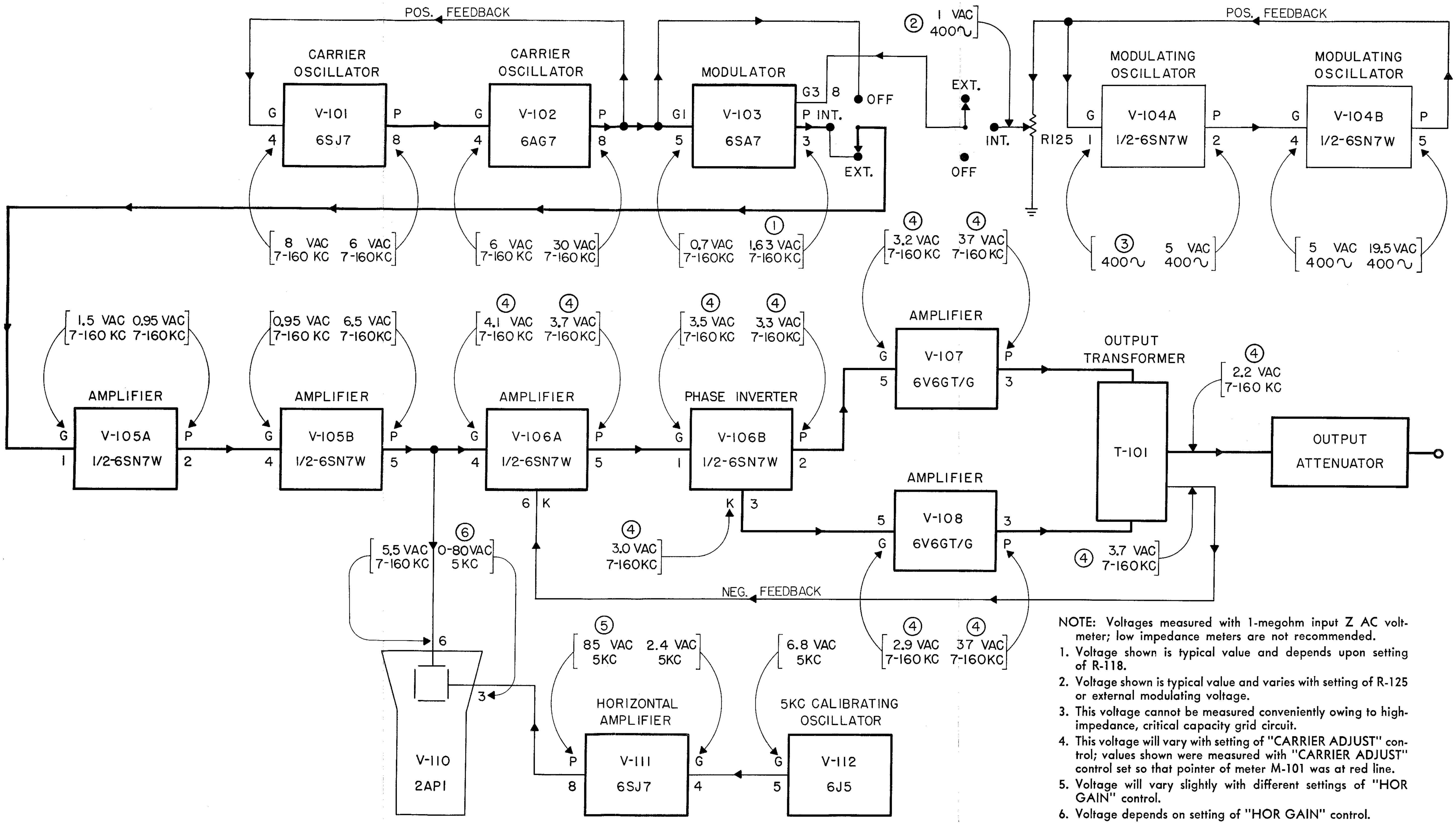
Symbol Desig.	Navy Type Designation	Diagram	Winding	Wire Size	Turns	DC Resistance Ohms	Impedance Ratio	Remarks
L-101	-472153		Single	No. 38 SSE	2650	400		Winding impregnated by Fosterite method
L-104	·		Single	No. 30 PE	3250	235 240		Hermetically sealed
R-101	-636235		21430 ohms 9680 ohms 3990 ohms 3900 ohms	See "Remarks" See "Remarks" See "Remarks" See "Remarks"		21430 9680 3990 3900		Consists of one winding tapped to form a four-section resistor; all resistance ±0.25% tol; wire is 174 ohms per ft. cupron
T-101	·	 	Primary	No. 30	440	18	400 to 1	Hermetically sealed case. Response 7 kc to 160 kc ±1 db; 3 watt operating level
			Secondary	No. 21 Dbl.	25	.065	1.2 to 1	
			Tertiary	No. 21 Dbl.	22	.060	1 to 1	
T-102	·	 	Primary	No. 19	205 tapped at 196 and 187	Approx. 1.4		Tapped winding
			Secondary No. 1	No. 30	1530	115		
			Secondary No. 2	No. 16	9	Less than .1		
			Secondary No. 3	No. 16 Dbl.	11½	.1		
			Secondary No. 4	No. 18	11½	.1		
			Secondary No. 5	No. 24	11½	.1		
Y-101e	·		Single	See "Remarks"	Approx. 29 turns	Approx. 330		Wound with 10.5 ohms per ft. resistance wire

TABLE 4—2. TROUBLE CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
Instrument dead: pilot light does not light; no output.	Fuse blown	Check for short. Replace fuse F-101 and/or F-102
	Poor connection to ac supply	Check power plug at both ends to make certain of its connections
Pilot lamp glows but no output; No dc voltages in instrument.	Rectifier tube failure	Replace V-117 (5U4G)
	Open winding in power tansformer T-102	Replace T-102
Jumpy output, similar to motorboating and flashing of lamp R-103.	Shorted capacitor C-104, C-106, or high side of C-102	Clear short with weak air stream or other means; do not bend capacitor plates
Distortion of carrier wave shape.	Poor or aged tube(s)	Replace tube(s)
	Improper DC voltages on tube elements	Check voltages with chart on page 4-19. This will give indication of open resistor, shorted condensor, etc.
Unstable output voltage; excessive frequency or voltage variation.	Poor or aged tube(s)	Replace tube(s)
	Poor lamp R-103	Replace lamp (See section 4, paragraph 3c.)
Excessive hum in output.	Poor tube(s)	Replace tube(s)
	Leaky filter capacitor(s)	Replace filter capacitor(s)
Failure of oscillator section; no AC voltage at output of V-102.	Poor tube	Replace V-101 and/or V-102
	Lamp (R-103) failure	Replace lamp (See section 4, paragraph 3c.)
	Incorrect DC voltages on oscillator tubes	Check DC voltages with chart on page 4-19.
	Shorted air capacitor(s)	Clear short in trimmers C-101, C-103, C-104, or main tuning capacitor C-102
	Open range resistor R-101 or R-102	Replace resistor R-101 or R-102
Too high AC voltage at output of oscillator section (100 volts or more).	Open negative feedback circuit in oscillator section	Replace R-104 or R-105 or search out other open point in circuit
Failure of amplifier section; AC voltage at grid of V-105A but no indication on output meter; no voltage at output terminal.	Poor tube	Replace tube(s)
	No DC voltage on tube element	Check DC voltages with chart on page 4-19. This will indicate open resistor, shorted condensor, etc.
	Open winding in output transformer T-101	Measure dc resistance of windings and compare with values on schematic diagram. Replace transformer if necessary.
Instability of carrier oscillator; figures on calibrator tube do not remain reasonably stationary.	Over-age tube V-101 and/or V-102	Replace tube. (See Section 4, Paragraph 5B.)
	Loss of regulation in dc regulated voltage	Replace V-113 to V-116. (See Section 4, Paragraph 5g.)
	Occasionally poor tube V-112	Replace V-112
	Widely variant AC line voltage—less than 100 volts	Use regulated AC line if possible
Too high voltage output terminal J-101—5 volts or more.	Open negative feedback circuit in amplifier	Check negative feedback circuits in amplifier for open circuit. Check tertiary winding on output transformer T-101 for open circuit. If unit has been repaired since manufacture, make certain that output transformer is properly connected.



NOTE: Voltages measured with 1-megohm input Z AC voltmeter; low impedance meters are not recommended.

1. Voltage shown is typical value and depends upon setting of R-118.
2. Voltage shown is typical value and varies with setting of R-125 or external modulating voltage.
3. This voltage cannot be measured conveniently owing to high-impedance, critical capacity grid circuit.
4. This voltage will vary with setting of "CARRIER ADJUST" control; values shown were measured with "CARRIER ADJUST" control set so that pointer of meter M-101 was at red line.
5. Voltage will vary slightly with different settings of "HOR GAIN" control.
6. Voltage depends on setting of "HOR GAIN" control.
7. Voltages were measured at 10 kc with MODULATION switch in EXT position.

Figure 4—13. Servicing Block Diagram

NOTES: DC Voltages shown were measured with 20,000-ohm per voltmeter. Voltmeters having lower resistance than 20,000 ohms per volt are not recommended for servicing of this instrument.

1. Measured on 50-volt range.
2. 310 to 350 volts depending upon setting of "HOR GAIN" control.
3. 105 to 145 volts depending upon setting of "FOCUS" control.
4. 0 to 55 volts depending upon setting of "INTENSITY" control.
5. Resistance depends upon setting of "RANGE SWITCH."
6. Resistance depends upon setting of R-118.
7. Resistance depends upon setting of "CARRIER ADJUST" control.
8. Resistance depends upon setting of R-157.
9. Resistance depends upon setting of R-166 and R-169.
10. Resistance depends upon setting of R-162.
11. Resistance is approximately 2.6 M.
12. Resistance depends upon setting of R-160.
13. Resistance depends upon setting of R-181.

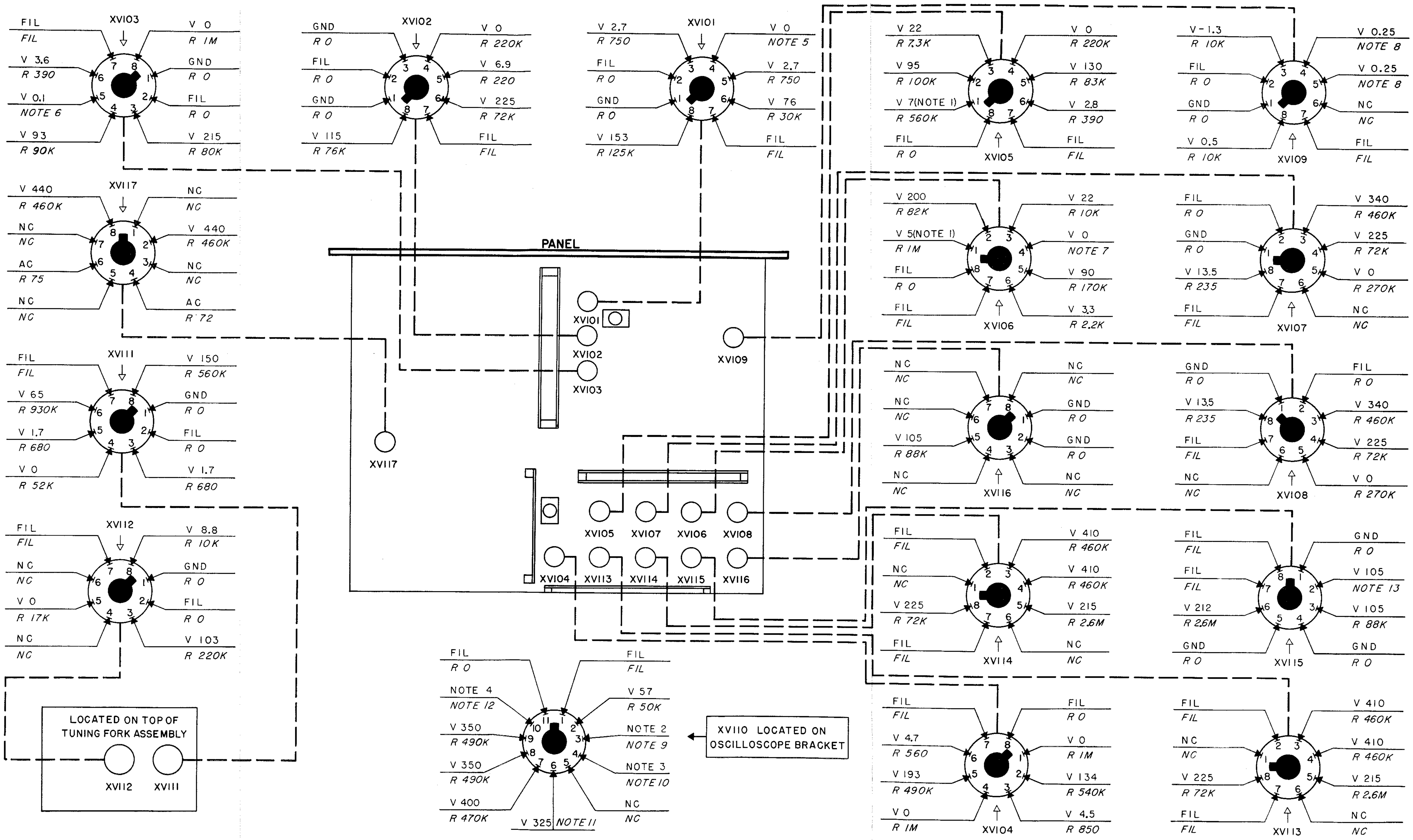


Figure 4—14. Voltage and Resistance Diagram

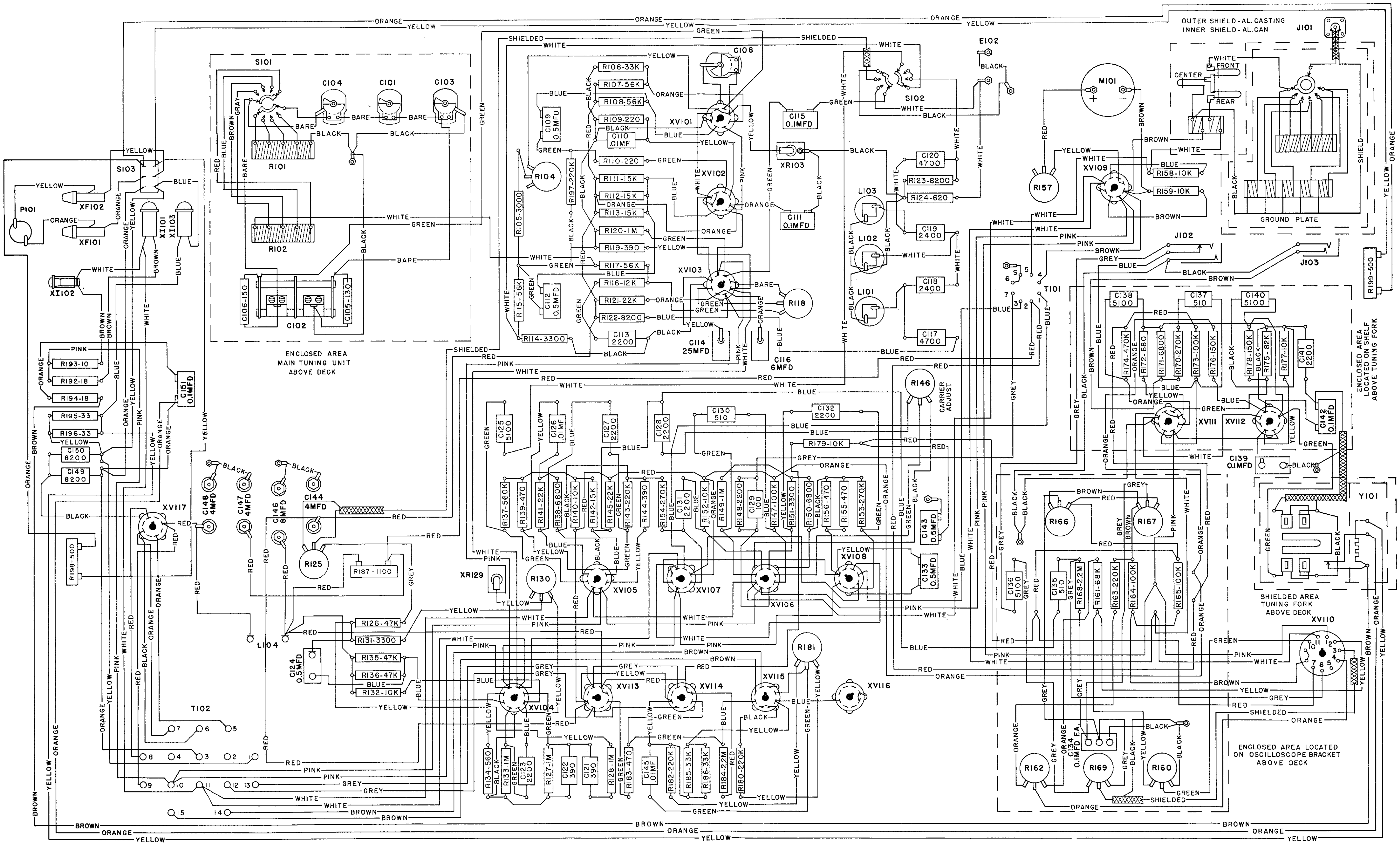


Figure 4—15. Practical Wiring Diagram

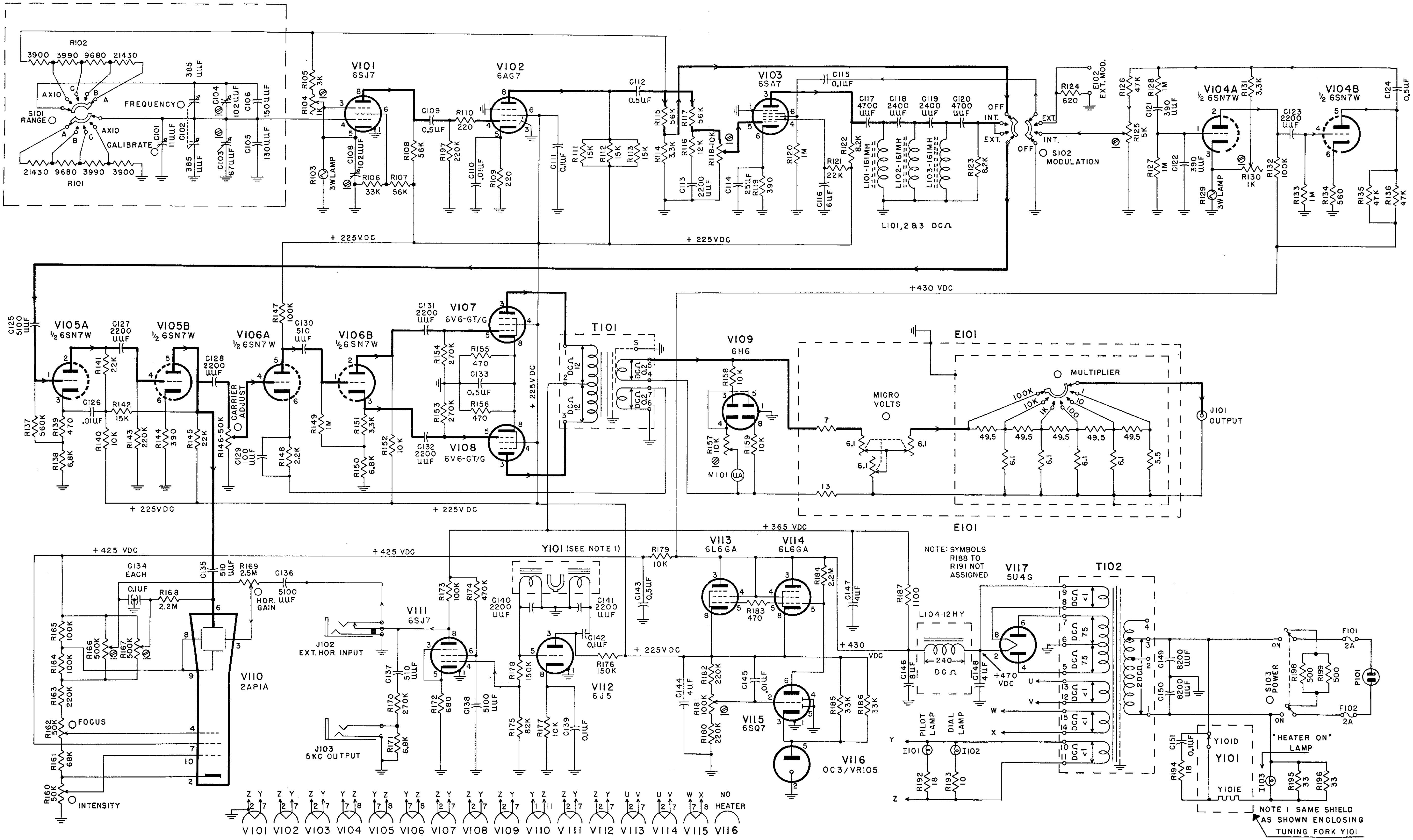


Figure 4–16. Schematic Diagram

TABLE 5-1. TABLE OF REPLACEABLE PARTS

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
	Capacitors						
C-101	**CAPACITOR,** variable: trimmer type; air dielectric; plate meshing type; single section; 2.8 to 11.2 mmf; 0.020" air gap; 0.767" lg x 15/16" w x 1 7/32" d excluding shaft, shaft 1/4" dia by 27/32" lg, bushing 5/16"-32 x 11/32" lg; shaft adjustment; 4 aluminum plates; 360° continuous rotation; ceramic insulation; post terminals; single hole mtg by above bushing.	Vernier tuning capacitor for C-102	(–484708)	. . . . N16-C-58354-7290	CBGB:O-11L	L1-148	C-101
C-102	**CAPACITOR,** variable: air dielectric-plate meshing type; two sections each 11.8 to 385 mmf; 0.018" air gap; 3 7/16" lg x 3 3/16" w x 1 27/32" h excluding shaft, shaft 3/8" lg x 1/4" diam; extension shaft adj; 23 aluminum plates; 182° clockwise rotation; ceramic insulation; lug terminals; four 0.130" mtg holes in each end plate on 7/8" x 2 13/16" mtg/c.	Main tuning capacitor	(–484705)	. . . . N16-C-63017-4508	CRK: 886540	L1-126	C-102
C-103	**CAPACITOR,** variable: trimmer type; air dielectric; plate meshing type; single section; 5.7 to 67.3 mmf; 0.020" air gap; 1 7/32" lg x 15/16" w x 1 3/8" h excluding shaft, shaft 5/16" lg x 1/4" hex; screwdriver adj; 23 aluminum plates; 360° continuous rotation; ceramic insulation; post and lug terminals; mts by two 3/16" sq x 3/32" lg mtg posts tapped for #4-40 screws on 11/16" mtg/c.	Padder for main tuning capacitor C-102	(–484709)	. . . . N16-C-60152-5882	CBGB: A-67L	L1-147	C-103
C-104	**CAPACITOR,** variable: trimmer type; air dielectric; plate meshing type; single section; 7.5 to 102.7 mmf; 0.020" air gap; 1 13/16" lg x 15/16" w x 1 1/4" h shaft 5/16" lg x 1/4" hex; screwdriver adj; 35 aluminum plates; 360° continuous rotation; ceramic insulation; two 5/16" lg x 3/16" sq mtg posts with #4-40 tap, holes 21/32" c to c.	Padder for main tuning capacitor C-102	(–483024)	. . . . N16-C-60564-9471	CBGB: A-103L	352	C-104, C-108

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
	Capacitors (continued)						
C-105	**CAPACITOR,** fixed: ceramic temperature compensating type; 130 mmf ± 2%; negative temperature coefficient —470 parts/million/°C; 500 vdcw. 1.328 in. lg by 0.340 in. dia; ceramic insulation, two axial wire lead terminals; spec JAN-C-20A.	Temperature compensating capacitor for frequency-determining network	CC36TH131G	. . . . N16-C-17260-9997	CER:	. . . .	C-105
C-106	**CAPACITOR,** fixed: ceramic temperature compensating type; 150 mmf ± 2%; negative temperature coefficient —470 parts/million/°C; 500 vdcw. 1.328 in. lg. by 0.340 in. dia; two axial wire lead terminals; ceramic insulation; spec JAN-C-20A.	Temperature compensating capacitor for frequency-determining network	CC36TH151G	. . . . N16-C-17388-9997	CER:	. . . .	C-106
C-107	This symbol not assigned.						
C-108	Same as C-104.	Phase-shifting capacitor for V-101 and V-102					
C-109	**CAPACITOR,** fixed: paper; 0.5 mf ± 10%; 600 vdcw. hermetically sealed metal case; 1 13/16 in. lg. by 1 in. wide by 7/8 in. high; pyranol impregnated and filled; two solder lug terminals; two mtg feet w/3/16 in. dia holes in ea on 2 1/8 in. centers spec JAN-C-25.	Interstage coupling capacitor between V-101 and V-102	CP53B1FF504K	. . . . N16-C-47297-3100	CD:	. . . .	C-109, C-112, C-124, C-133, C-143
C-110	**CAPACITOR,** fixed: mica; 0.01 mf ± 10%; 300 vdcw. 53/64 in. lg by 53/64 in. wide by 11/32 in. high; temp coef. B; molded low loss Bakelite case two axial wire leads, spec JAN-C-5.	Cathode by-pass capacitor for V-102	CM35B103K	. . . . N16-C-33622-5222	CAN:	. . . .	C-110, C-126, C-145
C-111	**CAPACITOR,** fixed: paper; 0.1 mf ± 10%; 600 vdcw. hermetically sealed metal case; 1 13/16 in. lg. by 3/4 in. wide by 1 in. high; pyranol impregnated and filled; two solder lug terminals; two mtg feet w/3/16 in. dia holes in each on 2 1/8 in. centers; spec JAN-C-25.	Screen by-pass capacitor for V-102	CP53B1FF104K	. . . . N16-C-45777-3175	CD:	. . . .	C-111, C-115, C-139, C-142, C-151

Capacitors (continued)

C-112	Same as C-109.	Interstage coupling capacitor between V-102 and V-103						
C-113	**CAPACITOR,** fixed: mica; 2200 mmf ± 10%; 500 vdcw. 53/64 in. lg by 53/64 in. wide by 11/32 in. high; temp coef B; molded low loss bakelite case; two axial wire leads; spec JAN-C-5.	Oscillator output voltage compensating capacitor	CM35B222K	. . . . N16-C-31908-1608	CAN:		. . . .	C-113, C-123, C-127, C-128, C-131, C-132, C-140, C-141
C-114	**CAPACITOR,** fixed: electrolytic; 25 mf —10% + 250%; 25 vdcw; operating temp range —20 to + 85°C; hermetically sealed metal case; 1 13/16 in. lg by 1 in. wide by 13/16 in. high; negative terminal internally grounded; one solder lug terminal; two mtg feet with 3/16 in. dia holes in ea on 2⅛ in. centers; spec JAN-C-62.	Cathode by-pass capacitor for V-103	CE62B250F	. . . . N16-C-19781-5641	CSF:		. . . .	C-114
C-115	Same as C-111.	DC blocking capacitor for V-103						
C-116	**CAPACITOR,** fixed: electrolytic; 6 mf —10% + 250%; 400 vdcw; operating temp range —20 to + 85° C; hermetically sealed metal case; 1 13/16 in. lg by 1 in. wide by 13/16 in. high; negative terminal internally grounded; one solder lug terminal; two mtg feet with 3/16 in. dia holes in ea on 2⅛ in. centers; spec JAN-C-62.	Screen grid bypass capacitor for V-103	CE32B060Q	. . . . N16-C-19492-7401	CD:		. . . .	C-116
C-117	**CAPACITOR,** fixed: mica; 4700 mmf ± 5%; 500 vdcw; 53/64 in. lg by 53/64 in. wide by 11/32 in. high; temp coef B; molded low loss bakelite case; two axial wire leads; spec JAN-C-5.	High-pass filter capacitor at output of V-103	CM35B472J	. . . . N16-C-32641-6328	CAN:		. . . .	C-117, C-120
C-118	**CAPACITOR,** fixed: mica; 2400 mmf ± 5%; 500 vdcw; 53/64 in. lg by 53/64 in. wide by 11/32 in. high; temp coef B; molded low loss bakelite case; two axial wire leads; spec JAN-C-5.	High-pass filter capacitor at output of V-103	CM35B242J	. . . . N16-C-31982-2328	CAN:		. . . .	C-118, C-119

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
			Capacitors (continued)				
C-119	Same as C-118.	High-pass filter capacitor at output of V-103					
C-120	Same as C-117.	High-pass filter capacitor at output of V-103					
C-121	**CAPACITOR**, fixed: mica; 390 mmf ± 5%; 500 vdcw. 51/64 in. lg by 15/32 in. wide by 7/32 in thick; temp coef D; molded low loss bakelite case; two axial wire leads; spec JAN-C-5.	Frequency-determining capacitor for oscillator V-104	CM20D391J	. . . . N16-C-29898-3606	CAN:	. . . .	C-121, C-122
C-122	Same as C-121.	Frequency-determining capacitor for oscillator V-104					
C-123	Same as C-113.	Interstage coupling capacitor between V-104A and V-104B					
C-124	Same as C-109.	DC blocking capacitor for V-104					
C-125	**CAPACITOR**, fixed: mica; 5100 mmf ± 5%; 500 vdcw; 53/64 in. lg by 53/64 in. wide by 11/32 in. high; temp coef B; molded low loss bakelite case; two axial wire leads; spec JAN-C-5.	Coupling capacitor between V-103 and V-105A	CM35B512J	. . . . N16-C-32720-7528	CAN:	. . . .	C-125, C-136, C-138
C-126	Same as C-110.	DC blocking capacitor for V-105A					
C-127	Same as C-113.	Interstage coupling capacitor between V-105A and V-105B					
C-128	Same as C-113.	Interstage coupling capacitor between V-105B and V-106A					

Capacitors (continued)

C-129	**CAPACITOR,** fixed: mica; 100 mmf ± 10%; 500 vdcw; $\frac{51}{64}$ in. lg by $\frac{15}{32}$ in. wide by $\frac{7}{32}$ in. thick; temp coef B; molded low loss bakelite case; two axial wire leads; spec JAN-C-5.	Gain compensating capacitor for V-106A	CM20B101K	. . . . N16-C-28558-1676	CAN:	. . . .	C-129
C-130	**CAPACITOR,** fixed: mica; 510 mmf ± 5%; 500 vdcw; $\frac{51}{64}$ in. lg by $\frac{15}{32}$ in. wide by $\frac{7}{32}$ in. thick; temp coef B; molded low loss bakelite case; two axial wire leads; spec JAN-C-5.	Interstage coupling capacitor between V-106A and V-106B	CM20B511J	. . . . N16-C-30188-4996	CAN:	. . . .	C-130, C-135, C-137
C-131	Same as C-113.	Interstage coupling capacitor between V-106B and V-107					
C-132	Same as C-113.	Interstage coupling capacitor between V-106B and V-108					
C-133	Same as C-109.	Cathode by-pass capacitor for V-107 and V-108					
C-134	**CAPACITOR,** fixed: paper; 2 sections each 0.1 mf —10% + 20%; 600 vdcw; hermetically sealed metal can; 1$\frac{13}{16}$ in. lg by ¾ in. wide by 1 in. high; pyranol filled and impregnated; three solder lug terminals; two mtg feet with a $\frac{3}{16}$ in. dia hole in each located 2⅛ in c to c; spec JAN-C-25.	By-pass capacitor for V-110 supply circuit	CP53B4FF104V	. . . . N16-C-53204-4100	CD:	. . . .	C-134
C-135	Same as C-130.	DC blocking capacitor for V-110					
C-136	Same as C-125.	DC blocking capacitor for V-110					
C-137	Same as C-130.	DC blocking capacitor for 5KC output jack J-103					
C-138	Same as C-125.	Screen grid by-pass capacitor for V-111					

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
Capacitors (continued)							
C-139	Same as C-111.	Cathode by-pass capacitor for V-112					
C-140	Same as C-113.	Phase-shifting capacitor for electro-magnet Y-101b					
C-141	Same as C-113.	Phase-shifting capacitor for electro-magnet Y-101c					
C-142	Same as C-111.	Plate coupling capacitor between electro-magnet Y-101c and V-112					
C-143	Same as C-109.	Filter capacitor in 425 V DC supply					
C-144	**CAPACITOR,** fixed: paper; 4 mf ± 10%; 600 vdcw; hermetically sealed metal case; 2½ in. lg by 1$\frac{3}{16}$ in wide by 3½ in. high; pyranol filled and impregnated; two porcelain pillar terminals with screw and nut; two footed mtg brackets with 0.187 in. dia hole in ea foot located 3 in. c to c; spec JAN-C-25.	By-pass capacitor in 225 V DC supply	CP70E1FF405K	. . . . N16-C-49957-5958	CAN:	. . . .	C-144
C-145	Same as C-110.	Coupling capacitor in grid of V-115					
C-146	**CAPACITOR,** fixed: paper; 8 mf ± 10%; 1000 vdcw; hermetically sealed metal case; 3¾ in. lg by 1¾ in. wide by 3⅞ in. high, pyranol filled and impregnated; two porcelain pillar terminals with screw and nut; two footed mtg brackets with two 0.213 in. dia holes on ⅝ in. centers in ea foot located 4⅜ in. c to c; spec JAN-C-25.	Filter capacitor in LC filter for V-117	CP70E1FG805K	. . . . N16-C-51481-2592	CAN:	. . . .	C-146

Capacitors (continued)

C-147	**CAPACITOR,** fixed: paper; 4 mf ± 10%; 1000 vdcw; hermetically sealed metal case; 2½ in. lg by 1$\frac{3}{16}$ in. wide by 4¾ in. high, pyranol filled and impregnated; two porcelain pillar terminals with screw and nut; two footed mtg brackets with 0.187 in. dia hole in ea foot located 3 in. c to c; spec JAN-C-25.	Filter capacitor in 365 V DC supply	CP70E1FG405K	. . . . N16-C-49960-8655	CAN:	. . . .	C-147, C-148
C-148	Same as C-147.	Filter capacitor in LC filter for V-117					
C-149	**CAPACITOR,** fixed: mica; 8200 mmf ± 10%; 500 vdcw. 1$\frac{1}{32}$ in. lg by $\frac{41}{64}$ in. wide by $\frac{11}{32}$ in. high; temp coef B; molded low loss bakelite case; two axial wire leads; spec JAN-C-5.	Filter capacitor across power line	CM40B822K	. . . . N16-C-33279-7540	CAN:	. . . .	C-149, C-150
C-150	Same as C-149.	Filter capacitor across power line					
C-151	Same as C-111.	Arc suppressor across Y-101d					

Miscellaneous

E-101	**ATTENUATOR,** variable: consists of two attenuators and impedance-matching resistors, all within one common shield; T and ladder circuit; wirewound; input 25 ohms ± 0.5%; Output 5 ohms ± 0.5%; aluminum case 7″ lg x 2¼″ d x 3$\frac{9}{16}$″ h, two shafts, one is ¼″ diam x $\frac{27}{32}$″ lg and other shaft is ¼″ diam x $\frac{11}{16}$″ lg; linear db attenuation; one attenuator has range of 100 db in 20 db steps and other has continuously-adjustable range of 26 db so that unit as a whole has conjunctive range of 126 db; two #22 ga stranded wire input leads and one UG-58/U output cable; panel mtg by means of four 10-24 tapped holes irregularly spaced.	Output attenuator	(-636246)		CAQI: L1-E101	L1-146	E-101

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
	Miscellaneous (continued)						
E-102	**POST SET,** binding: nickel-plated brass; set consists of two binding posts each including body and ferrule type thumb screw; each 1⅛" lg x ⅜" in diam overall.	"Ext Mod" binding posts			CAQI: 312-3	5179	E-102
E-102A	**SCREW,** thumb: knurled body; brass, nickel plated; ½" lg x ⅜" O.D.; $\frac{5}{16}$-24 thread, $\frac{13}{32}$" deep.	Nut for binding post set E-102			CAQI: L1-E102A	5009-1	E-102A, E-105
E-102B	**POST,** binding: screw type; $\frac{19}{32}$" lg x ⅜" dia overall; $\frac{10}{32}$" x ⅞" mtg stem.	Post for binding post set E-102			CAQI: L1-E102B	5009-2	E-102B, E-105
E-103A	**BOARD,** terminal: black moulded polystyrene; 1½" lg x ¾" wide x $\frac{7}{32}$" thk overall; two $\frac{3}{16}$" holes on ¾" mtg centers.	Panel Insulator for binding post set E-102			CAQI: L1-E103A	L1-S-182	E-103A
E-103B	**BOARD,** terminal: natural paper base bakelite; 1⅜" lg x ¾" wide x ⅛" thk overall; two #10 drill holes on ¾" mtg centers.	Rear insulator for binding post set E-102			CAQI: L1-E103B	L1-S-181	E-103B
E-104	**INSULATOR,** disk: black paper base bakelite; 1$\frac{11}{16}$" O.D.; ⅛" thick; four mounting holes on 1$\frac{5}{16}$" dia; one $\frac{7}{16}$" dia clearance hole and four mounting holes for UG-88/U connector.	Insulator for mounting J-101 on panel			CAQI: L1-E104	L1-F-101 Sheet 1, Item 4	E-104
E-105	**POST SET,** binding: includes 2 binding posts same as E-102 with addition of mounting plate and connector body; 2⅛" lg x 1½" wide x $\frac{11}{16}$" thick overall dimensions.	Terminates one end of output cable—W-103			CAQI: L1-E105	L1-S-176	E-105
E-106	**LENS,** indicator light: red; threaded type; ½" dia smooth glass frosted back lens; convex; bezel $\frac{13}{16}$ in. OD, ⅝ in.-27 threads per in. $\frac{3}{16}$ in. deep; brass, black nickel; polaroid shutter.	Lens for indicator light X1-101			CAYZ: Lens 93-11-1	L1-S-179	E-106, E-107
E-107	**LENS,** indicator light: Same as E-106.	Lens for Indicator light X1-103					

Fuses

F-101	**FUSE,** cartridge: rated 2 amp; 250 volts; opens in 1 hr on 135% overload and in 2 min on 200% overload, carries 110% overload indefinitely; one time; glass body; ferrule terminals; ¼″ diam x 1¼″ lg overall.	Power line fuse	(–28032-2)	. . . . N17-F-16302-100	CLF: #1042	L1-S-170	F-101, F-102
F-102	Same as F-101.	Power line fuse					

Hardware

H-101	**CLAMP:** tube; stainless steel; 1¼″ diam x 7/32″ h; tension lock type.	Clamp for V-101	(–491788)	. . . . N16-C-300442-625	CAIS: Type 926-B2	L1-134	H-101 to H-103, H-109, H-111, H-112, H-115
H-102	Same as H-101.	Clamp for V-102					
H-103	Same as H-101.	Clamp for V-103					
H-104	**CLAMP:** tube; stainless steel; 1¼″ diam x ¾″ h; tension lock type.	Clamp for V-104	(–49679)	. . . . N16-C-300798-621	CAIS: Type 926-B	19M-S-753	H-104 to H-108
H-105	Same as H-104.	Clamp for V-105					
H-106	Same as H-104.	Clamp for V-106					
H-107	Same as H-104.	Clamp for V-107					
H-108	Same as H-104.	Clamp for V-108					
H-109	Same as H-101.	Clamp for V-109					
H-110	This symbol not assigned.						
H-111	Same as H-101.	Clamp for V-111					
H-112	Same as H-101.	Clamp for V-112					
H-113	**CLAMP:** tube; stainless steel; 1⅜″ diam x ¾″ h; tension lock type.	Clamp for V-113	(–49680)	. . . . N16-C-300526-211	CAIS: Type 926-C	19M-S-754	H-113, H-114, H-117
H-114	Same as H-113.	Clamp for V-114					
H-115	Same as H-101.	Clamp for V-115					
H-116	**CLAMP:** tube; stainless steel; 1 5/32″ diam x ¾″ h; tension lock type.	Clamp for V-116	(–49496)	. . . . N16-C-300379-452	CAIS: Type 926-A	L1-132	H-116

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
	Hardware (continued)						
H-117	Same as H-113.	Clamp for V-117					
H-118	**WRENCH:** Allen key set-screw type; 5/64″ max distance across flats; 45/64″ max lg on short arm, 1 31/32″ max length of long arm; alloy steel; cad pl; 90° bend between long and short arms.	Wrench for #8 Allen-head set screw				19M-S-770	H-118
H-119	**WRENCH:** Allen key set-screw type; 0.050″ max distance across flats; 21/32″ max lg of short arm, 1 27/32″ max lg of long arm; alloy steel cad pl; 90° bend between long and short arms.	Wrench for #3, #4 Allen-head set screw				19M-S-771	H-119
	Indicating Devices						
I-101	**LAMP**, incandescent: 6-8v, 0.15 amp; bulb T-3-1/4 clear; 1 3/16″ lg overall; miniature bayonet base.	Dial lamp for frequency control dial			CG: #47	19M-S-720	I-101 to I-103
I-102	Same as I-101.	Pilot lamp					
I-103	Same as I-101.	"Heater on" lamp for tuning fork heater Y-101e					
	Jacks						
J-101	**CONNECTOR**, female contact; round female contact one end; also includes cap and chain.	"Output" jack	UG-291/U and CW-123/U		CARO: No's 5000 & 1500		J-101
J-102	**JACK**, telephone: 3 conductor 1/4 in. dia plug w/shank 1.218 in. max lg; 2 23/32 in. lg by 3/4 in. wide by 27/32 in. high, not including terminals and bushing; J10 contact arrangement; mounted by 3/8 in.-32 thread by 3/8 in. lg. bushing; includes locknut and washer; 7/16 in. dia mounting hole required; solder lug terminals; black nickel finish.	"Ext. Hor. Input" jack	(–491839)	. . . . N17-J-39530-3446	CBIN: LJ-35	L1-167	J-102

Jacks (continued)

J-103	**JACK,** telephone: 3 conductor ¼ in. dia plug w/shank 1.218 in. max lg; 2 23/32 in. lg by ¾ in. wide by 27/32 in. high, not including terminals and bushing; J2 contact arrangement; mounted by ⅜ in.-32 thread by ⅜ in. lg bushing; 7/16 in. dia mounting hole required; black nickel finish.	"5 kc Output" jack	(–491840)	. . . . N17-J-39524-7501	CBIN: LJ-31	L1-166	J-103
J-104	**CONNECTOR,** male contact; 2 flat parallel blades; 1⅞" lg. x 1¼" h x 15/16" d; rated 10 amp, 250v; nickel plated steel body with black phenolic base; two 5/32" mtg holes on 1½" mtg/c; flush mtg type.	Input power connector	(–49844)	. . . . N17-C-73443-8438	CG: #2711	L1-139	J-104

Reactors

L-101	**COIL,** RF: filter choke; single multilayer winding universal wound; unshielded; 161 millihenries ± 5% at 1 kc, self-resonant at 170 kc ± 10%; 1 11/16" lg x 1⅜" diam o/a; powdered iron core, phenolic mtg base; one No. 4-40 thd x 5/16" lg mtg stud; two solder lug term on phenolic mtg base; winding impr by Fosterite method.	High pass filter coil in output of V-103	(–472153)		CAQI: L1-L101	L1-159	L-101 to L-103
L-102	Same as L-101.	High Pass filter coil in output of V-103					
L-103	Same as L-101.	High pass filter coil in output of V-103					
L-104	**REACTOR,** filter choke: 20 hy min, 80 ma; 240 ohms max dc resistance; 1750 volts to core; hermetically sealed metal case, 3⅞" h x 3 1/16" w x 3 9/16" lg; four 8-32 mtg studs on 2⅛" x 2⅝" mtg/c; two ceramic-insulated solder lug terminals ½" c to c.	Filter choke in LC filter for V-117			CBNC: #14081	50M-M-194	L-104

Meters

M-101	**METER,** ammeter: DC; 0 to 200 microamperes; hermetically sealed case; 3½" round flush mtg style; red line inserted on face at half-scale; three 0.150 in. mounting holes 120° apart on a 1.58 in. radius; spec MIL-M-6A.	Output monitor meter	MR36W200DCUA (Modified)		CV: Tpe 1301	L1-L-174	M-101

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
	Mechanical Parts						
O-101	**SHAFT ASSEMBLY:** flexible type; end fittings are nickel plated steel; shaft unplated; for coupling two 1/4" diam shafts at angles up to 90°; 4 1/8" lg x 7/16" diam overall.	Shaft coupler			CMA: TX-11-4-1/8	L1-156	O-101 to O-103
O-102	Same as O-101.	Shaft coupler					
O-103	Same as O-101.	Shaft coupler					
O-104	**COUPLING,** rigid: flanged type; 1/4" shaft size each end; two set-screw mtg; 7/8" lg x 1 5/8" diam overall; cad plated steel, ceramic separator ring.	Couples C-102 to drive mechanism			CAQI: M-25B	L1-155-1	O-104
O-105	**COUPLING,** rigid: flanged type; 1/4" shaft size each end; two set-screw mtg; 7/8" lg x 1 5/8" diam overall; cad plated steel.	Couples drive mechanism to "Frequency" dial			CAQI: M-25C	L1-155-2	O-105
O-106	**SCREW,** captive: knurled thumb head, slot drive; stainless steel; #10-24; 1 1/2" lg; threaded portion 15/32" lg.	Screws for securing instrument in cabinet case			CAQI: L1-0106	L1-S-175	O-106
O-107	**SCREW,** captive; knurled thumb head, slot drive; stainless steel; #10-24; 1 23/32" lg; threaded portion 9/32" lg.	Screws for securing O-108			CAQI: L1-0107	616A-S-346	O-107
O-108	**CLAMP,** aluminum; painted; two bolts employed; 3 7/8" lg x 1 1/4" wide x 1 3/8" thk overall.	Clamps cathode ray tube in place			CAQI: L1-0108	L1-S-183	O-108
O-109	**CLAMP,** aluminum; painted; two bolts employed; 3 7/8" lg x 17/32" wide x 1 3/8" thk overall.	Clamps cathode ray tube shield			CAQI: L1-0109	L1-S-184	O-109
O-110	**COLLAR,** spacing: aluminum, 2 1/4" O.D. x 1" wide; 1 5/8 dia hole; clamp is parted in center to make two sections; sponge rubber cemented in inner diameter.	Collar for mounting cathode ray tube			CAQI: L1-0110	L1-67	O-110
O-111	**PLATE,** lock: aluminum painted; 2 9/16" lg x 1" wide, 1/8" thk; .4687" hole for locking knob hub.	Lock plate for locking "Calibrate" knob		. . . . N16-P-403981-113	CAQI: L1-0111	L1-F-101 Sheet 1 Item 3	O-111

Mechanical Parts (continued)

O-112	**SCREW**, adjusting: stainless steel: 1″ lg; ¾″ diam knurled head; #10-24; ½″ thread; special cone on head.	Adjusting screw for locking "Calibrate" knob			CAQI: L1-0112	L1-F-101 Sheet 1 Item 2	O-112
O-113	**KNOB**, round, fluted molded black phenolic; for ¼″ diam shaft; mts by two #8-32 set screws spaced 90° apart on hub; 1⅛″ O.D. x ⅝″ thk; brass insert; shaft hole ½″ deep.	"Calibrate" knob		. . . . N16-K-700314-539	CAQI: L1-0113	L1-F-101 Sheet 1 Item 11	O-113
O-114	**KNOB**, round, aluminum; black anodized, for ¼″ dia shaft; two 8/32″ set screws; 2¾″ dia; 100 engraved divisions.	Vernier tuning knob		. . . . N16-D-46357-1945	CAQI: L1-0114	L1-F-101 Sheet 2 Item 13	O-114
O-115	**KNOB**, round; fluted; molded black phenolic; for ¼″ diam shaft; mts by two #8-32 set screws spaced 90° apart on hub 1⅛″ O.D. x ⅝″ thk; brass insert; shaft hole ½″ deep. Clear plastic pointer with red indicator line.	"Microvolts" adjustment knob		. . . . N16-K-700314-473	CAQI: L1-0115	L1-S-187	O-115
O-116	**KNOB**, round, fluted; molded black phenolic for ¼″ diam shaft; mts by two #8-32 set screws spaced 90° apart on hub; white index dot on knob face near edge; 1⅛″ O.D. x ⅝″ thk; brass insert; shaft hole ½″ deep.	"Intensity", "Horizontal Gain", "Focus" and "Carrier Adjust" knobs		. . . . N16-K-700314-446	CAQI: L1-0116	L1-S-185	O-116
O-117	**KNOB**, round, fluted; molded black phenolic; for ¼″ diam shaft; mts by two #8-32 set screws spaced 90° apart on hub; white plastic pointer; 1⅛″ O.D. x 11/16″ thk; brass insert; shaft hole ½″ deep.	"Modulation", "Range" and "Attenuator" knobs		. . . . N16-K-700324-791	CAQI: L1-0117	L1-S-186	O-117
O-118	**WINDOW**: transparent lucite; 3¾″ lg x 2 1/16″ w x ⅛″ thk overall; 4 mtg holes on 2¾″ x 1 11/16″ mtg centers; 1 horizontal and 3 vertical hairline.	Pointer "Frequency" dial		. . . . N16-P-403561-141	CAQI: L1-0118	L1-F-101 Sheet 1 Item 10	O-118
O-119	**GASKET**, cabinet cover; moulded neoprene; 21 1/16″ lg x 13 7/16″ wide x ¼″ thk overall cross-section 5/16″ wide.	Gasket for sealing cover to cabinet		. . . . N17-G-159404-601	CAQI: L1-0119	L1-E-188	O-119
O-120	**COVER**, combination case: aluminum painted; 10 ga; 21⅛″ lg x 13½″ wide, 2¼″ lip; includes brackets for accessories and handbook.	Cover for combination case		. . . . N16-C-650001-537	CAQI: L1-0120	L1-E-120	●-120

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	Mechanical Parts (continued)						
O-121	**CASE**, combination: aluminum painted; 10 ga; 20$\frac{15}{16}$″ wide x 13$\frac{5}{16}$″ high overall; folding handle each end; includes mounting supports for instruments.	Instrument Case		. . . . N16-C-10634-9535	CAQI: L1-0121	L1-F-115 Sheet 1	O-121
	Plugs						
P-101	**PLUG,** female contact; 2 rectangular parallel contacts; $\frac{15}{32}$″ dia x 1⅛″ lg overall dimensions; brown moulded bakelite body; $\frac{5}{16}$″ dia cable opening.	Terminates one end of power cord W-101		. . . . N17-C-71129-5700	CG: #2716	L1-S-177	P-101
P-102	**PLUG:** JAN Type UG-88/U; single round axial hole contact.	Terminates one end of output cables W-102, W-103			JAN UG-88/U	. . . .	P-102, P-103
P-103	**PLUG:** Same as P-102.	Terminates one end of output cable W-102			JAN UG-88/U	. . . .	
P-104	**PLUG:** male contact; 2 banana type plugs; includes mounting plate and connector body; 2⅜″ lg x 1⅞″ wide by ⅞″ thk overall dimensions.	Terminates one end of output cable W-104			CAQI: L1-P104	L1-S-178	P-104, P-105
P-105	**PLUG:** Same as P-104.	Terminates one end of output cable W-104					
	Resistors						
R-101	**RESISTOR,** fixed: wirewound; 39000 ohm ± ¼%; 1 w; tapped at 3900 ohm, 3990 ohm, 9680 ohm and 21430 ohm; 4$\frac{5}{16}$ in. lg by 1⅞ in. wide by $\frac{1}{16}$ in. high; fungicidal varnish; 5 solder lug terminals; two 0.169 in. dia mounting holes, 4$\frac{1}{16}$ in. c to c.	Carrier frequency determining resistor	(-636235)		CAQI: L1-R101	L1-69	R-101, R-102
R-102	Same as R-101.	Carrier frequency determining resistor					

Resistors (continued)

R-103	**LAMP** (non-linear resistor): 120 v, 3 w, 0.025 amp; clear S-6 bulb; $1\frac{3}{4}$ in. overall height; candelabra screw base; 5 C carbon filament; any burning position.	Automatic feedback limiter for V-101			CAQI: 211-4	5M-S-432	R-103, R-129
R-104	**RESISTOR,** variable: wirewound; 1000 ohms; 2 watts three terminals; 1.28 in. dia by 0.62 in. deep; $\frac{3}{8}$ in-32 by $\frac{3}{8}$ in. lg bushing; $\frac{1}{4}$ in. dia by $\frac{1}{2}$ in. lg shaft, spec JAN-R-19.	Negative feedback adjustment for V-101	RA20A2SA102AK		CTC: #HT-252	. . . .	R-104
R-105	**RESISTOR,** fixed; wirewound; 3000 ohms ± 5%; 2 watts axial leads; $1\frac{3}{4}$ in. lg by $\frac{21}{64}$ in. dia; spec JAN-R-184.	Voltage dropping resistor in feedback of V-101	RU6A302J	. . . . N16-R-68414-2146	CIR: BW-2	. . . .	R-105
R-106	**RESISTOR,** fixed: composition; 33,000 ohms ± 10%; 1 watt; axial leads; $\frac{23}{32}$ in. lg by $\frac{1}{4}$ in. dia; spec JAN-R-11.	Screen voltage divider of V-101	RC30BF333K	. . . . N16-R-50418-0231	CIR: BTA	. . . .	R-106, R-185, R-186
R-107	**RESISTOR,** fixed: composition; 56,000 ohms ± 10%; 1 watt; axial leads; $\frac{23}{32}$ in. lg by $\frac{1}{4}$ in. dia; spec JAN-R-11.	Screen voltage divider of V-101	RC30BF563K	. . . . N16-R-50517-0231	CIR: BTA	. . . .	R-107, R-108, R-115, R-117
R-108	Same as R-107.	Plate load resistor of V-101					
R-109	**RESISTOR,** fixed: composition; 220 ohms ± 10%; 1 watt; axial leads; 0.562 in. lg by 0.225 in. dia; spec JAN-R-11.	Cathode resistor of V-102	RC30BF221K	. . . . N16-R-49662-0231	CBZ: GB-2211	. . . .	R-109, R-110
R-110	Same as R-109.	Supressor resistor of V-102					
R-111	**RESISTOR,** fixed: composition; 15,000 ohms ± 10%; 2 watts; axial leads; 0.688 in. lg by 0.312 in. dia; spec JAN-R-11.	Plate load resistor of V-102	RC40BF153K	. . . . N16-R-50337-0551	CBZ: HB-1531	. . . .	R-111, to R-113
R-112	Same as R-111.	Plate load resistor of V-102					
R-113	Same as R-111.	Plate load resistor of V-102					
R-114	**RESISTOR,** fixed: composition; 3300 ohms ± 10%; 1 watt axial leads; $\frac{23}{32}$ in. lg by $\frac{1}{4}$ in. dia; spec JAN-R-11.	V-102 output voltage divider	RC30BF332K	. . . . N16-R-50067-0231	CIR: BTA	. . . .	R-114

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			Resistors (continued)				
R-115	Same as R-107.	V-102 output voltage divider					
R-116	**RESISTOR,** fixed: composition; 12,000 ohms ± 10%; 1 watt; axial leads; $\frac{33}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Voltage divider for grid of V-103	RC30BF123K	. . . . N16-R-50310-0231	CIR: BTA	. . . .	R-116
R-117	Same as R-107.	Voltage divider for grid of V-103					
R-118	**RESISTOR,** variable: composition; 10,000 ohms; 2 watts; 3 solder lug term; enclosed case $1\frac{1}{16}$" dia x $\frac{9}{16}$" d; type 2 screwdriver shaft; shaft lock; linear taper; ⅜"-32 thd bushing ½" lg; (± 20% tol, ⅝" shaft).	Internal gain adjustment for V-103	(–635897-L20)	. . . . N16-R-87682-5370	CBZ: JLU1032 bushing-SD4040L	L1-154-1	R-118, R-157
R-119	**RESISTOR,** fixed: composition; 390 ohms ± 10%; 1 watt; axial leads; $\frac{33}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Cathode resistor of V-103	RC30BF391K	. . . . N16-R-49734-0231	CIR: BTA	. . . .	R-119, R-144
R-120	**RESISTOR,** fixed: composition; 1 megohm ± 10%; 1 watt; axial leads; $\frac{33}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Grid resistor of V-103	RC30BF105K	. . . . N16-R-50976-0231	CIR: BTA	. . . .	R-120, R-127, R-128, R-133, R-149
R-121	**RESISTOR,** fixed: composition; 22,000 ohms ± 10%; 2 watts; axial leads; 0.688 in. lg by 0.312 in. dia; spec JAN-R-11.	Screen dropping resistor of V-103	RC40BF223K	. . . . N16-R-50373-0551	CBZ: HB-2231	. . . .	R-121
R-122	**RESISTOR,** fixed: composition; 8200 ohms ± 10%; 1 watt; axial leads; $\frac{33}{32}$ in. lg by ¼ in dia; spec JAN-R-11.	Plate load resistor of V-103	RC30BF822K	. . . . N16-R-50238-0231	CIR: BTA	. . . .	R-122, R-123
R-123	Same as R-122.	High pass filter terminating resistor at output of V-103					
R-124	**RESISTOR,** fixed; composition; 620 ohms ± 5%; 1 watt; axial leads; $\frac{33}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Impedance matching resistor for "Ext. Mod" terminals	RC30BF621J	. . . . N16-R-49822-0751	CIR: BTA	. . . .	R-124

Resistors (continued)

R-125	**RESISTOR,** variable: composition; 5000 ohms; 2 watts; 3 solder lug term; enclosed case 1-1/16" dia x 9/16" d; type 2 screwdriver shaft; shaft lock; linear taper; 3/8"-32 thd bushing 1/2" lg (± 20% tol, 5/8" shaft).	V-104 output voltage selector	(–635894-L20)	. . . . N16-R-87522-5480	CBZ: JLU5022 bushing-SD4040L	L1-154-2	R-125
R-126	**RESISTOR,** fixed: composition; 47,000 ohms ± 10%; 1 watt; axial leads; 21/32 in. lg by 1/4 in. dia; spec JAN-R-11.	V-104 output voltage divider	RC30BF473K	. . . . N16-R-50481-0231	CIR: BTA	. . . .	R-126
R-127	Same as R-120.	Frequency determining resistor for oscillator V-104					
R-128	Same as R-120.	Frequency determining resistor for oscillator V-104					
R-129	Same as R-103.	Automatic feedback limiter for oscillator V-104					
R-130	**RESISTOR,** variable: composition; 1000 ohms; 2 watt, 70°C max operating; 3 solder lug term; enclosed metal case 1-1/16" dia x 9/16" d; type 2 metal screwdriver shaft 0.25" dia; linear taper; shaft locking device; 3/8"-32 x 1/2" lg mtg bushing; resistant to salt spray.	Feedback adjusting resistor for oscillator V-104	(–636059-L10)	. . . . N16-R-87349-4560	CBZ: JLU1021 bushing-SD4040L	L1-154-3	R-130
R-131	Same as R-114.	Feedback voltage divider for oscillator V-104					
R-132	**RESISTOR,** fixed: composition; 100,000 ohms ± 10%; 2 watts; axial leads; 0.688 in. lg by 0.312 in. dia; spec JAN-R-11.	Plate load resistor for V-104A	RC40BF104K	. . . . N16-R-50634-0551	CBZ: HB-1041	. . . .	R-132
R-133	Same as R-120.	Grid resistor for V-104B					
R-134	**RESISTOR,** fixed: composition; 560 ohms ± 10%; 1 watt; axial leads; 21/32 in. lg by 1/4 in. dia; spec JAN-R-11.	Cathode resistor for V-104B	RC30BF561K	. . . . N16-R-49806-0231	CIR: BTA	. . . .	R-134

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Resistors (continued)							
R-135	**RESISTOR,** fixed: composition; 47,000 ohms ± 10%; 2 watts; axial leads; 0.688 in. lg by 0.312 in. dia; spec JAN-R-11.	Plate load resistor for V-104B	RC40BF473K	. . . . N16-R-50481-0551	CBZ: HB-4731	. . . .	R-135, R-136
R-136	Same as R-135.	Plate load resistor for V-104B					
R-137	**RESISTOR,** fixed: composition; 560,000 ohms ± 10%; 1 watt; axial leads; 23/32 in. lg by ¼ in. dia; spec. JAN-R-11.	Grid resistor for V-105A	RC30BF564K	. . . . N16-R-50859-0231	CIR: BTA	. . . .	R-137
R-138	**RESISTOR,** fixed: composition; 6800 ohms ± 10%; 1 watt; axial leads; 23/32 in. lg by ¼ in. dia; spec JAN-R-11.	Impedance increasing resistor for V-105A	RC30BF682K	. . . . N16-R-50202-0231	CIR: BTA	. . . .	R-138, R-150, R-171
R-139	**RESISTOR,** fixed: composition; 470 ohms ± 10%; 1 watt; axial leads; 23/32 in. lg by ¼ in. dia; spec JAN-R-11.	Cathode resistor for V-105A	RC30BF471K	. . . . N16-R-49770-0231	CIR: BTA	. . . .	R-139, R-155, R-156, R-183
R-140	**RESISTOR,** fixed: composition; 10,000 ohms ± 10%; 1 watt; axial leads; 23/32 in. lg by ¼ in. dia; spec JAN-R-11.	Decoupling resistor in 225 V DC supply	RC30BF103K	. . . . N16-R-50283-0231	CIR: BTA	. . . .	R-140, R-152, R-158, R-159, R-177, R-179
R-141	**RESISTOR,** fixed: composition; 22,000 ohms ± 10%; 1 watt; axial leads; 23/32 in. lg by ¼ in. dia; spec JAN-R-11.	Plate load resistor for V-105A	RC30BF223K	. . . . N16-R-50373-0231	CIR: BTA	. . . .	R-141, R-145
R-142	**RESISTOR,** fixed: composition; 15,000 ohms ± 10%; 1 watt; axial leads; 23/32 in. lg. by ¼ in. dia; spec JAN-R-11.	Feedback resistor for V-105A	RC30BF153K	. . . . N16-R-50337-0231	CIR: BTA	. . . .	R-142
R-143	**RESISTOR,** fixed: composition; 220,000 ohms ± 10%; 1 watt; axial leads; 23/32 in. lg by ¼ in. dia; spec JAN-R-11.	Grid resistor of V-105B	RC30BF224K	. . . . N16-R-50715-0231	CIR: BTA	. . . .	R-143, R-163, R-180, R-182, R-197
R-144	Same as R-119.	Cathode resistor of V-105B					
R-145	Same as R-141.	Plate load resistor for V-105B					

Resistors (continued)

R-146	**RESISTOR,** variable: composition; 50,000 ohms; ± 20%; linear taper; 2 watts ⅞″ lg x ¼″ dia shaft; ⅜″-32 x ⅜″ bushing; 70° C max operating temp; 3 solder lug terminals.	"Carrier Adjust" control for output amplifier	(–631234-N20)		CBZ: JU-5032 bushing P-3056	L1-153-1	R-146, R-160, R-162
R-147	**RESISTOR,** fixed: composition; 100,000 ohms ± 10%; 1 watt; axial leads; $\frac{21}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Plate load of V-106A	RC30BF104K	. . . . N16-R-50634-0231	CIR: BTA	. . . .	R-147, R-164, R-165, R-173
R-148	**RESISTOR,** fixed: composition; 2200 ohms ± 10%; 1 watt; axial leads; $\frac{21}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Cathode resistor of V-106A	RC30BF222K	. . . . N16-R-50013-0231	CIR: BTA	. . . .	R-148
R-149	Same as R-120.	Grid resistor of V-106B					
R-150	Same as R-138.	Cathode resistor for V-106B					
R-151	Same as R-115.	Cathode bias resistor of V-106B					
R-152	Same as R-140.	Plate load resistor of V-106B					
R-153	**RESISTOR,** fixed: composition; 270,000 ohms ± 10%; 1 watt; axial leads; $\frac{21}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Grid resistor for V-108	RC30BF274K	. . . . N16-R-50742-0231	CIR: BTA	. . . .	R-153, R-154, R-170
R-154	Same as R-153.	Grid resistor for V-107					
R-155	Same as R-139.	Cathode resistor for V-107, V-108					
R-156	Same as R-139.	Cathode resistor for V-107, V-108					
R-157	Same as R-118.	Meter multiplier for M-101					
R-158	Same as R-140.	Meter multiplier for M-101					
R-159	Same as R-140.	Cathode resistor for V-109					

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Resistors (continued)							
R-160	Same as R-146.	"Intensity" control for V-110					
R-161	**RESISTOR,** fixed: composition; 68,000 ohms ± 10%; 1 watt; axial leads; 23/32 in. lg by 1/4 in. dia; spec JAN-R-11.	Voltage divider in supply for V-110	RC30BF683K	. . . . N16-R-50553-0231	CIR: BTA	. . . .	R-161
R-162	Same as R-146.	"Focus" control of V-110					
R-163	Same as R-143.	Voltage divider in supply for V-110					
R-164	Same as R-147.	Voltage divider in supply for V-110					
R-165	Same as R-147.	Voltage divider in supply for V-110					
R-166	**RESISTOR,** variable: composition; 0.5 megohm; 2 watts; 3 solder lug term; enclosed case; 1 1/16" dia x 9/16" d; type 2 screwdriver shaft; shaft lock; linear taper; 3/8"-32 thd bushing 1/2" lg (± 20% tol. 5/8" shaft).	Horizontal centering control of V-110	(–635891-L20)	. . . . N16-R-88182-5495	CBZ: JLU-5042 bushing SD4040L	L1-154-4	R-166, R-167
R-167	Same as R-166.	Vertical centering control of V-110					
R-168	**RESISTOR,** fixed: composition; 2.2 megohms ± 10%; 1 watt; axial leads; 23/32 in. lg by 1/4 in. dia; spec JAN-R-11.	Decoupling resistor for V-110 supply circuit	RC30BF225K	. . . . N16-R-51066-0231	CIR: BTA	. . . .	R-168, R-184
R-169	**RESISTOR,** variable: composition; 2.5 megohms; linear taper; 2 watts; 7/8" lg x 1/4" dia shaft; 3/8"-32 x 3/8" bushing (± 20% tol).	"Horizontal Gain" control for V-110	(–632245-N20)	. . . . N16-R-88412-5274	CBZ: JU2552 bushing P3056	L1-153-2	R-169
R-170	Same as R-153.	Voltage divider for "5KC Output" jack J-103					

Resistors (continued)

R-171	Same as R-138.	Voltage divider for "5KC Output" jack J-103					
R-172	**RESISTOR,** fixed: composition; 680 ohms ± 10%; 1 watt; axial leads; $\frac{33}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Cathode resistor for V-111	RC30BF681K	. . . . N16-R-49842-0231	CIR: BTA	. . . .	R-172
R-173	Same as R-147.	Plate load resistor for V-111					
R-174	**RESISTOR,** fixed: composition; 470,000 ohms ± 10%; 1 watt; axial leads; $\frac{33}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Screen dropping resistor for V-111	RC30BF474K	. . . . N16-R-50823-0231	CIR: BTA	. . . .	R-174
R-175	**RESISTOR,** fixed: composition; 82,000 ohms ± 10%; 1 watt; axial leads; $\frac{33}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Grid resistor for V-112	RC30BF823K	. . . . N16-R-50589-0231	CIR: BTA	. . . .	R-175
R-176	**RESISTOR,** fixed: composition; 150,000 ohms ± 10%; 1 watt; axial leads; $\frac{33}{32}$ in. lg by ¼ in. dia; spec JAN-R-11.	Plate load resistor for V-112	RC30BF154K	. . . . N16-R-50679-0231	CIR: BTA	. . . .	R-176, R-178
R-177	Same as R-140.	Cathode resistor for V-112					
R-178	Same as R-176.	Grid resistor for V-112					
R-179	Same as R-140.	Filter resistor in 425V DC supply					
R-180	Same as R-143.	Voltage divider for V-115					
R-181	**RESISTOR,** variable: composition; 0.10 megohm; 2 watts; 3 solder lug term; $1\frac{1}{16}$″ dia x $\frac{9}{16}$″ d enclosed metal case; type 2 slotted shaft ¼″ dia; linear taper; shaft locking device; ½″ lg x ⅜″-32 mtg bushing (± 20% tol).	Voltage regulator adjustment for V-115	(-635939-L20)	. . . . N16-R-88012-5530	CBZ: JLU-1042 bushing SD4040L	L1-154-5	R-181
R-182	Same as R-143.	Voltage divider for V-115					
R-183	Same as R-139.	Parasitic suppressor between V-113 and V-114					

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
			Resistors (continued)				
R-184	Same as R-168.	Voltage dropping resistor for V-114					
R-185	Same as R-106.	Voltage dropping resistor in 225V DC supply					
R-186	Same as R-106.	Voltage dropping resistor in 225V DC supply					
R-187	**RESISTOR,** fixed: wirewound; 1100 ohms ± 5%; 15.0 watts; inorganic cement coated; flat type, 2½″ lg x 1⅝″ wd overall; 2″ mtg centers; radial strap terminals; spec JAN-R-26A.	Voltage dropping resistor in 365V DC supply	RW20G112		(A):	. . . .	R-187
R-188	This symbol not assigned.						
R-189	This symbol not assigned.						
R-190	This symbol not assigned.						
R-191	This symbol not assigned.						
R-192	**RESISTOR,** fixed: composition; 18 ohms ± 10%; 1 watt; axial leads; 0.562 in. lg by 0.225 in. dia; spec JAN-R-11.	Voltage dropping resistor for I-101	RC30BF180K	. . . . N16-R-49302-0231	CBZ: GB-1801		R-192, R-194
R-193	**RESISTOR,** fixed: composition; 10 ohms ± 10%; 1 watt; axial leads; 0.562 in. lg by 0.225 in. dia; spec JAN-R-11.	Voltage dropping resistor for I-102	RC30BF100K	. . . . N16-R-49239-0231	CBZ: GB-1001		R-193
R-194	Same as R-192.	Arc suppressor for Y-101d					
R-195	**RESISTOR,** fixed: composition; 33 ohms ± 10%; 1 watt; axial leads; 0.562 in. lg by 0.225 in. dia; spec Jan-R-11.	Voltage dropping resistor for Y-101e	RC30BF330K	. . . . N16-R-49365-0231	CBZ: GB-3301		R-195, R-196
R-196	Same as R-195.	Voltage dropping resistor for Y-101e					

Resistors (continued)

R-197	Same as R-143.	Grid resistor for V-102					
R-198	**RESISTOR**, fixed: wirewound; 500 ohms ± 5%; 37 watts; inorganic cement coated; flat type, 4¾″ lg x 1⅝″ wd overall; 4¼″ mtg centers, radial strap terminals; spec JAN-R-26A.	Standby heater resistor	RW22G501		(A):	. . . .	R-198, R-199
R-199	Same as R-198.	Standby heater resistor					

Switches

S-101	**SWITCH**, rotary: 2 pole 4 positions; coin silver alloy rotor and spring silver alloy clips; ceramic wafer; 1⅞″ O.D. x ¾″ lg body overall; shorting contacts; solder lug terminals; single hole mtg 1″ shaft with ⅜″-32 x ⅜″ bushing; wax impregnated body; has locating lug and shaft flat ⅜″ lg; terminals and rotor on back side of wafer.	Frequency range switch	(–241284)	. . . . N17-S-61361-5401	COC: 33740-HIC	L1-145	S-101
S-102	**SWITCH**, rotary: 2 pole 3 positions; coin silver alloy rotor and spring silver alloy clips; ceramic wafer; 1⅞″ O.D. x 11/16″ lg body overall; shorting contacts; solder lug terminals; single hole mtg, 1″ shaft with ⅜″-32 x ⅜″ bushing; wax impregnated body; has locating lug and shaft flat ⅜″ lg; terminals and rotor on back side of wafer.	Modulation selector switch	(–241283)	. . . . N17-S-61164-9221	COC: 31854-HIC	L1-144	S-102
S-103	**SWITCH**, toggle: DPDT; JAN ST22N modified in that lever and bushing are black nickel.	Power switch	ST22N (with black nickel finish)	. . . . N17-S-74139-4844	CHH:	19M-S-765	S-103

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
	Transformers						
T-101	**TRANSFORMER,** AF: plate coupling type; prim 8000 ohms impedance secondary 25 ohms impedance tertiary 20 ohms impedance; hermetically sealed case; case $2\frac{1}{16}$" wd x $2\frac{5}{16}$" lg x $3\frac{1}{8}$" h excluding term; 3 w operating level; turns ratio of primary to secondary to tertiary is 20 to 1.125 to 1; 3 watts power capacity; freq response 7 kc to 160 kc ± 1 db; electrostatic shield between primary and secondary and between secondary and tertiary; eight solder lug terminals; mts by four #6-32 x $\frac{3}{8}$" mtg studs on $1\frac{7}{16}$" x $1\frac{11}{16}$" mtg/c.	Output transformer			CBNC: #2220	50M-M-193	T-101
T-102	**TRANSFORMER,** power: filament and plate type; input 120v tapped for 110v and 115v operation; 50-1000 cycles, single phase; 5 output windings; secd #1—860v at 0.14 ma CT; secd #2—6.3v at 2 amp; secd #3—6.3v at 5.75 amp; secd #4—6.3v at 0.5 amp; secd #5—5v at 3 amp; HS metal case $4\frac{5}{16}$" lg x $3\frac{11}{16}$" wd x $5\frac{9}{16}$" h excluding term; fifteen $\frac{7}{8}$" lg solder lug term mtd on ceramic feed thru insulators on mtg surface of case; mts by four 10-32 x $\frac{1}{2}$" lg studs on $2\frac{11}{16}$" x $3\frac{5}{16}$" mtg/c.	Power Transformer			CBNC: #7086	50M-L-192	T-102
	Electron Tubes						
V-101	**TUBE,** electron:—6SJ7; pentode.	Oscillator	-6SJ7		. . . .	. . . .	V-101, V-111
V-102	**TUBE,** electron:—6AG7; pentode.	Oscillator	-6AG7		. . . .	. . . .	V-102
V-103	**TUBE,** electron:—6SA7; pentagrid converter.	Modulator	-6SA7		. . . .	. . . .	V-103
V-104	**TUBE,** electron:—6SN7W; twin triode.	Oscillator	-6SN7W		. . . .	. . . .	V-104, V-105, V-106
V-105	Same as V-104.	Amplifier					
V-106	Same as V-104.	Amplifier					

Electron Tubes (continued)

V-107	**TUBE**, electron: —6V6GT/G; beam power amplifier.	Amplifier	–6V6GT/G		. . . .	. . . .	V-107, V-108
V-108	Same as V-107.	Amplifier					
V-109	**TUBE**, electron:—6H6; duplex diode.	Rectifier	–6H6		. . . .	. . . .	V-109
V-110	**TUBE**, electron: —2APIA; cathode-ray.	Oscilloscope	–2AP1A		. . . .	. . . .	V-110
V-111	Same as V-101.	Amplifier					
V-112	**TUBE**, electron:—6J5; triode.	Oscillator	–6J5		. . . .	. . . .	V-112
V-113	**TUBE**, electron: —6L6GA; beam power amplifier.	Voltage regulator	–6L6GA		. . . .	. . . .	V-113, V-114
V-114	Same as V-113.	Voltage regulator					
V-115	**TUBE**, electron: —6SQ7; duplex diode triode.	DC amplifier	–6SQ7		. . . .	. . . .	V-115
V-116	**TUBE**, electron: —OC3/VR-105; voltage regulator.	Voltage regulator	–OC3/VR-105		. . . .	. . . .	V-116
V-117	**TUBE**, electron: —5U4G; rectifier.	Power rectifier	5U4G		. . . .	. . . .	V-117

Cables

W-101	**CABLE ASSEMBLY**, power: type 18-SJ 41/34 wire; 7 ft lg excluding terminations.	Power cord	(–62391 (7′ 3″))	. . . . N17-C-48236-2026	CAQI: L1-W101	L1-S-130	W-101
W-102	**CABLE ASSEMBLY**, special purpose: consists of 4 ft of RG-58/U transmission line with UG-88/U plug on each end.	Output cord	CG-409/U(4′ 2″)		CAQI: L1-W102	L1-S-126	W-102
W-103	**CABLE ASSEMBLY**, special purpose: consists of 4 ft of RG-58/U transmission line with UG-88/U plug on one end and binding posts and binding post holder on opposite end.	Output cord	CG-465/U (4′ 3″)		CAQI: L1-W103	L1-S-127	W-103
W-104	**CABLE ASSEMBLY**, special purpose: consists of 4 ft of RG-58/U transmission line with banana plug set on each end.	Output cord	CG-466/U (4′ 5″)		CAQI: L1-W104	L1-S-128	W-104
. . . . .	**ADAPTOR:** adapts type BNC plug to type N receptacle.	Adaptor	UG-201/U		CARO: #1400	. . . .	. . . .

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	JAN. or NAVY TYPE DESIG.	STOCK NUMBERS Signal Corps Standard Navy Air Force	MFR. & MFRS. DESIG.	CON'TRS DRWG. & PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED
	Sockets						
XF-101	**HOLDER,** fuse: extractor post type; for single 3AG cartridge fuse; molded phenolic housing; rated 15 amp, 125v max; 2⅝″ lg x 11/16″ dia overall; ½″ dia threaded body for panel hole mtg; 2 solder lug terminals; knurled thumbscrew type removable grip.	Holder for F-101			CLF: Cat: #342001	19M-S-757	XF-101, XF-102
XF-102	Same as XF-101.	Holder for F-102					
XI-101	**LIGHT,** indicator: with lens; ½″ dia red etched lens; for min bay base, T-3-¼ bulb; enclosed shell; black nickel plated face; 2⅜″ lg x 13/16″ dia overall; 11/16″ dia mtg hole reqd, 5/32″ max panel thk; horizontally mtd socket, lamp replaceable from front of panel; threaded jewel holder; two solder lug terms projecting from bottom of base; polaroid disc.	Socket for I-101			CAYZ: series DP90	L1-140	XI-101, XI-103
XI-102	**LAMPHOLDER,** miniature bayonet; steel shell body; 2 1/16″ lg x ¾″ w x ⅝″ h including terminals; mts by ⅞″ x 3/16″ w slot; mtg clip located parallel to but inverted from body; two solder lug term located together at base of body.	Socket for I-102			CASX: Cat. #610	L1-141	XI-102
XI-103	Same as XI-101.	Socket for I-103					
XR-103	**LAMPHOLDER,** candelabra screw; nickel plated brass; 1 13/32″ lg x 1⅝″ h x ¾″ w overall; no switch; mts by two ⅛″ holes on 13/16″ mtg/c.	Holder for R-103			CAQI: M-1	L1-143	XR-103, XR-131
XR-131	Same as XR-103.	Holder for R-131					
XV-101 to XV-109 and XV-111 to XV-117	**SOCKET,** tube: octal; one piece saddle mtg; two ⅛″ dia mtg holes on 1½″ mtg/c; round ceramic body 1⅛″ dia x 53/64″ h excluding terminals; silver plated phosphor bronze contacts.	Tube sockets	(–49520)	. . . . N16-S-63509-2071	CFK: 65A5	L1-142	XV-101 to XV-109 and XV-111 to XV-117

Sockets (continued)							
XV-110	**SOCKET,** tube: 11 contact magnal; normally retainer ring mtg but mounted here by special casting; round molded mica filled phenolic body 1 23/32" dia x 1 9/64" h.	Crt socket	(-49707)	. . . . N16-S-64202-5225	CMG: #9452	L1-136	XV-110
Tuning Fork Assembly							
Y-101	**TUNING FORK,** sub-assembly: includes 5 kc tuning fork (Y-101a), two sets of electromagnets (Y-101b and Y-101C), controlling thermostatic switch (Y-101d), heater (Y-101e).	Frequency control			CAQI: L1-Y101	L1-151	Y-101
Y-101d	**SWITCH,** thermostatic: SPST; max operating temperature 600° F; hermetically sealed pre-set type; 70° C ± 2°, maximum rating 50 w 250v ac; metal case 13/32" x 11/32", mts by two holes .460" centers.	Heater control			CBNU:	L1-S-171	Y-101d
Accessories							
R-200	**ATTENUATOR,** fixed: single resistor; wirewound; input and output impedance 0.55 ohm ± 0.5%; silver plated brass case 2¼" lg x ¾" w x ¾" h including terminals; designed as a fixed 20 db attenuator; two coaxial connector type terminals (UG-88/U and UG-185/U); designed to be used as external plug-in attenuator.	External attenuator	CN-77/U		CAQI: L1-E102	L1-S-129	. . . .

TABLE 5-2. CROSS REFERENCE PARTS LIST

JAN (or AWS) DESIGNATION	KEY SYMBOL
CC36TH131G	C-105
CC36TH151G	C-106
CE62B060Q	C-116
CE62B250F	C-114
CG-409/U(4′2″)	W-102
CG-465/U(4′3″)	W-103
CG-466/U(4′5″)	W-104
CN-77/U	R-200
CM20B101K	C-129
CM20B511J	C-130
CM20D391J	C-121
CM35B103K	C-110
CM35B222K	C-113
CM35B242J	C-118
CM35B472J	C-117
CM35B512J	C-125
CM40B822K	C-149
CP53B1FF104K	C-111
CP53B4FF104V	C-134
CP53B1FF504K	C-109
CP70E1FF405K	C-144
CP70E1FG405K	C-147
CP70E1FG805K	C-146
MR36W200DCUA (Modified)	M-101
RA20A2SA102AK	R-104
RC30BF100K	R-193
RC30BF103K	R-140
RC30BF104K	R-147
RC30BF105K	R-120
RC30BF123K	R-116
RC30BF153K	R-142
RC30BF154K	R-176
RC30BF180K	R-192
RC30BF221K	R-109
RC30BF222K	R-148
RC30BF223K	R-141
RC30BF224K	R-143
RC30BF225K	R-168
RC30BF274K	R-153
RC30BF330K	R-195
RC30BF332K	R-114
RC30BF333K	R-106
RC30BF391K	R-119
RC30BF471K	R-139
RC30BF473K	R-126
RC30BF474K	R-174
RC30BF561K	R-134
RC30BF563K	R-107
RC30BF564K	R-137
RC30BF621J	R-124
RC30BF681K	R-172
RC30BF682K	R-138
RC30BF683K	R-161
RC30BF822K	R-122
RC30BF823K	R-175
RC40BF104K	R-132
RC40BF153K	R-111
RC40BF223K	R-121
RC40BF473K	R-135
RU6A302J	R-105
RW20G112	R-187
RW22G501	R-198
ST22N (with black nickel finish)	S-103
UG-201/U	. . . .
UG-291/U (and CW-123/U)	J-101
–OC3/VR-105	V-116
–2AP1A	V-110
–5U4G	V-117
–6AG7	V-102
–6H6	V-109
–6J5	V-112
–6L6GA	V-113
–6SJ7	V-101
–6SA7	V-103
–6SN7W	V-104
–6SQ7	V-115
–6V6GT/G	V-107

NAVY TYPE	KEY SYMBOL
–241283	S-102
–241284	S-101
–28032-2	F-101
–472153	L-101
–483024	C-104
–484705	C-102
–484708	C-101
–484709	C-103
–491788	H-101
–491839	J-102
–491840	J-103
–49496	H-116
–49520	XV-101
–49679	H-104
–49680	H-113
–49707	XV-110
–49844	J-104
–62391 (7′3″)	W-101

TABLE 5-2. CROSS REFERENCE PARTS LIST (Continued)

NAVY TYPE	KEY SYMBOL
-631234-N20	R-146
-632245-N20	R-169
-635891-L20	R-166
-635894-L20	R-125
-635897-L20	R-118
-635939-L20	R-181
-636059-L10	R-130
-636235	R-101
-636246	E-101

STANDARD NAVY	KEY SYMBOL
N16-C-10634-9535	O-121
N16-C-17260-9997	C-105
N16-C-17388-9997	C-106
N16-C-19492-7401	C-116
N16-C-19781-5641	C-114
N16-C-28558-1676	C-129
N16-C-29898-3606	C-121
N16-C-300379-452	H-116
N16-C-300442-625	H-101
N16-C-300526-211	H-113
N16-C-300798-621	H-104
N16-C-30188-4996	C-130
N16-C-31908-1608	C-113
N16-C-31982-2328	C-118

STANDARD NAVY	KEY SYMBOL
N16-C-32641-6328	C-117
N16-C-32720-7528	C-125
N16-C-33279-7540	C-149
N16-C-33622-5222	C-110
N16-C-45777-3175	C-111
N16-C-47297-3100	C-109
N16-C-49957-5958	C-144
N16-C-49960-8655	C-147
N16-C-51481-2592	C-146
N16-C-53204-4100	C-134
N16-C-58354-7290	C-101
N16-C-60152-5882	C-103
N16-C-60564-9471	C-104
N16-C-63017-4508	C-102
N16-C-650001-537	O-120
N16-D-46357-1945	O-114
N16-K-700314-446	O-116
N16-K-700314-473	O-115
N16-K-700314-539	O-113
N16-K-700324-791	O-117
N16-P-403561-141	O-118
N16-P-403981-113	O-111
N16-R-19822-0751	R-124
N16-R-49239-0231	R-193
N16-R-49302-0231	R-192

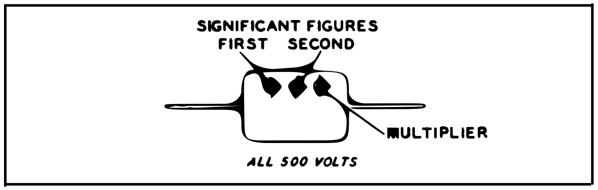
STANDARD NAVY	KEY SYMBOL
N16-R-49365-0231	R-195
N16-R-49662-0231	R-109
N16-R-49734-0231	R-119
N16-R-49770-0231	R-139
N16-R-49806-0231	R-134
N16-R-49842-0231	R-172
N16-R-50013-0231	R-148
N16-R-50067-0231	R-114
N16-R-50202-0231	R-138
N16-R-50238-0231	R-122
N16-R-50283-0231	R-140
N16-R-50310-0231	R-116
N16-R-50337-0231	R-142
N16-R-50337-0551	R-111
N16-R-50373-0231	R-141
N16-R-50373-0551	R-121
N16-R-50418-0231	R-106
N16-R-50481-0231	R-126
N16-R-50481-0551	R-135
N16-R-50517-0231	R-107
N16-R-50553-0231	R-161
N16-R-50589-0231	R-175
N16-R-50634-0231	R-147
N16-R-50634-0551	R-132
N16-R-50679-0231	R-176

STANDARD NAVY	KEY SYMBOL
N16-R-50715-0231	R-143
N16-R-50742-0231	R-153
N16-R-50823-0231	R-174
N16-R-50859-0231	R-137
N16-R-50976-0231	R-120
N16-R-51066-0231	R-168
N16-R-68414-2146	R-105
N16-R-87349-4560	R-130
N16-R-87522-5480	R-125
N16-R-87682-5370	R-118
N16-R-88012-5530	R-181
N16-R-88182-5492	R-166
N16-R-88412-5274	R-169
N16-S-63509-2071	XV-101
N16-S-64202-5225	XV-110
N17-C-48236-2026	W-101
N17-C-71129-5700	P-101
N17-C-73443-8438	J-104
N17-F-16302-100	F-101
N17-G-159404-601	O-119
N17-J-39524-7501	J-103
N17-J-39530-3446	J-102
N17-S-61164-9221	S-102
N17-S-61361-5401	S-101
N17-S-74139-4844	S-103

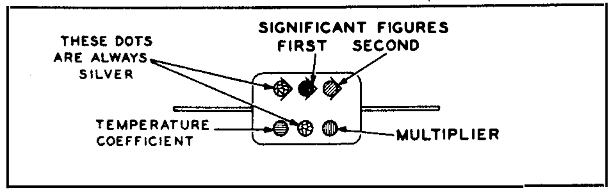
TABLE 5-3. APPLICABLE COLOR CODES

CAPACITOR COLOR CODES

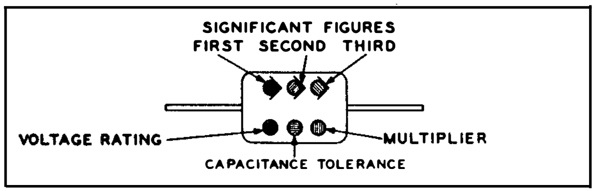
RMA 3-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



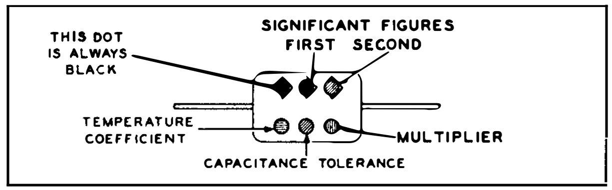
JAN 6-DOT COLOR CODE FOR PAPER-DIELECTRIC CAPACITORS



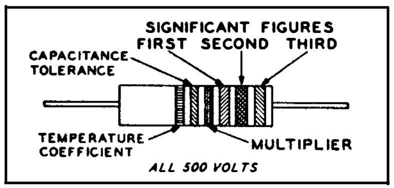
RMA 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



JAN 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS

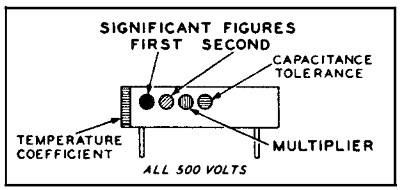


RMA COLOR CODE FOR TUBULAR CERAMIC-DIELECTRIC CAPACITORS

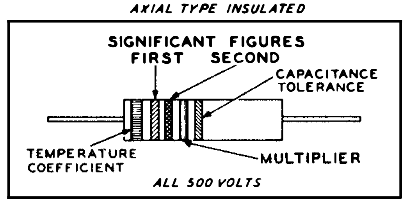


JAN COLOR CODE FOR FIXED CERAMIC-DIELECTRIC CAPACITORS

RADIAL TYPE NON-INSULATED



AXIAL TYPE INSULATED



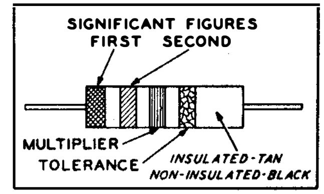
RMA: RADIO MANUFACTURERS ASSOCIATION
JAN: JOINT ARMY-NAVY

RESISTORS		CAPACITORS						
				MULTIPLIER				
TOLERANCE	MULTIPLIER	SIGNIFICANT FIGURE	COLOR	RMA MICA AND CERAMIC-DIELECTRIC	JAN MICA AND PAPER-DIELECTRIC	JAN CERAMIC DIELECTRIC	VOLTAGE RATING	TEMPERATURE COEFFICIENT
	1	0	BLACK	1	1	1		A
	10	1	BROWN	10	10	10	100	B
	100	2	RED	100	100	100	200	C
	1,000	3	ORANGE	1,000	1000	1000	300	D
	10,000	4	YELLOW	10,000			400	E
	100,000	5	GREEN	100,000			500	F
	1,000,000	6	BLUE	1,000,000			600	G
	10,000,000	7	VIOLET	10,000,000			700	
	100,000,000	8	GRAY	100,000,000		0.01	800	
	1,000,000,000	9	WHITE	1,000,000,000		0.1	900	
5	0.1		GOLD	0.1	0.1		1000	
10	0.01		SILVER	0.01	0.01		2000	
20			NO COLOR				500	

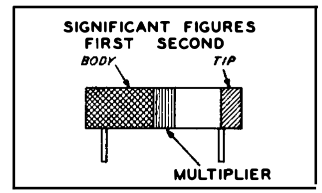
RESISTOR COLOR CODES

RMA COLOR CODE FOR FIXED COMPOSITION RESISTORS

AXIAL TYPE

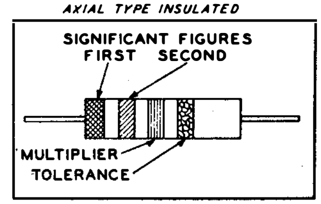


RADIAL TYPE



JAN COLOR CODE FOR FIXED COMPOSITION RESISTORS

AXIAL TYPE INSULATED



RADIAL TYPE NON-INSULATED

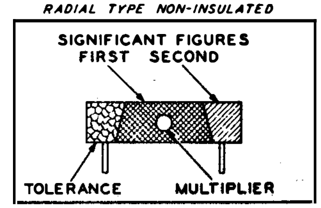


TABLE 5-4. LIST OF MANUFACTURERS

CODE NO.	MFR'S DESIG.	NAME	ADDRESS
CADH	CADH	Standard Coil Products Company	Chicago, Illinois
CAIS	CAIS	Birtcher Corporation	Los Angeles, California
CAQI	CAQI	Hewlett-Packard Company	Palo Alto, California
CARO	CARO	Industrial Products Company	Danbury, Connecticut
CASX	CASX	Gothard Manufacturing Company	Springfield, Illinois
CAW	CAW	Aerovox Corporation	New Bedford, Massachusetts
CAY	CAY	Westinghouse Electric Corporation	Baltimore, Maryland
CAYZ	CAYZ	Dial Light Corporation	New York, New York
CBCA	CBCA	George Ulanet Company	Newark, New Jersey
CBGB	CBGB	Sarkes Tarzian	Bloomington, Indiana
CBGM	CBGM	Transformer Engineers	Pasadena, California
CBIN	CBIN	Carter Radio Division, Precision Parts Co.	Chicago, Illinois
CBN	CBN	Central Radio Laboratory	Milwaukee, Wisconsin
CBNC	CBNC	Triad Transformer Mfg. Company	Los Angeles, California
CBNU	CBNU	Stevens Manufacturing Company	Mansfield, Ohio
CBZ	CBZ	Allen-Bradley Company	Milwaukee, Wisconsin
CD	CD	Cornell-Dubilier Corporation	South Plainfield, New Jersey
CER	CER	Erie Resistor Corporation	Erie, Pennsylvania
CFK	CFK	A. W. Franklin Manufacturing Company	New York, New York
CG	CG	General Electric Company	Schenectady, New York
CHH	CHH	Arrow-Hart & Hegeman Electric Company	Hartford, Connecticut
CIR	CIR	International Resistance Corporation	Philadelphia, Pennsylvania
CLF	CLF	Littelfuse Laboratories, Incorporated	Chicago, Illinois
CMA	CMA	National Company, Incorporated	Malden, Massachusetts
CMG	CMG	Cinch Manufacturing Company	Chicago, Illinois
CMR	CMR	Micamold Radio Corporation	Brooklyn, New York
COC	COC	Oak Manufacturing Company	Chicago, Illinois
CRA	CRA	Utah Radio Products Company	Chicago, Illinois
CRK	CRK	Radio Condensor Company	Camden, New Jersey
CSF	CSF	Sprague Electrical Specialties Company	North Adams, Massachusetts
CTC	CTC	Chicago Telephone Supply Company	Elkhart, Indiana
CTR	CTR	Chicago Transformer Division, Essex Wire Corp.	Chicago, Illinois
CV	CV	Weston Electrical Instrument Corporation	Newark, New Jersey
(A)	(A)	Model Engineering & Mfg., Inc.	Huntington, Indiana

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