RESTRICTED

INSTRUCTIONS

FOR

ASSEMBLY AND OPERATION

OF

RADIO FREQ. OSCILLATOR EQUIP.

MODEL LN SERIAL

FREQUENCY RANGE: 15 TO 25,000 KCS.

SUPPLY: 110 VOLTS-60-CYCLES

EQUIPMENT CONSISTS OF FOLLOWING UNITS

CAG-60004 RADIO FREQUENCY OSCILLATOR

CAG-20041 POWER UNIT

SEE LICENSE NOTICE INSIDE

NAVY DEPARTMENT

BUREAU OF ENGINEERING

CONTRACTOR

GENERAL RADIO CO.

CAMBRIDGE, MASS.

CONTRACT NOs-41801 CONTRACT DATE 30 APRIL 1935

NOTE

While the rated frequency range of this equipment is 15 to 25,000 kilocycles, the actual working range is 9.5 to 30,000 kilocycles.

GENERAL RADIO COMPANY

CAMBRIDGE, MASS.

FORM 401-A-3507

RESTRICTED

This instruction book is furnished for the information of commissioned, warrant, enlisted and civilian personnel of the Navy whose duties involve design, instruction, operation and installation of radio and sound equipment. The word "RESTRICTED" as applied to this instruction book signifies that this instruction book is to be read only by the above personnel and that the contents of it should not be made known to persons not connected with the Navy.

PATENT NOTICE

This instrument is licensed under patents of the American Telephone and Telegraph Company solely for utilization in research, investigation, measurement, testing, instruction and development work in pure and applied science.

CONTRACTURAL GUARANTEE

All parts included in this equipment, with the exception of vacuum tubes and rectifier tubes, will be replaced at the contractor's expense if found to be defective in design, material, workmanship, or manufacture within a service period of one year, providing the contractor is not obligated to such replacements for a period of more than two years after delivery to the Government of the equipments. This period of two years and the service period of one year are understood not to include any portion of that time that the equipment fails to give satisfactory performance due to defective items requiring replacements. It is also provided that any replacement part shall be guaranteed to give one year of service.

TABLE OF CONTENTS

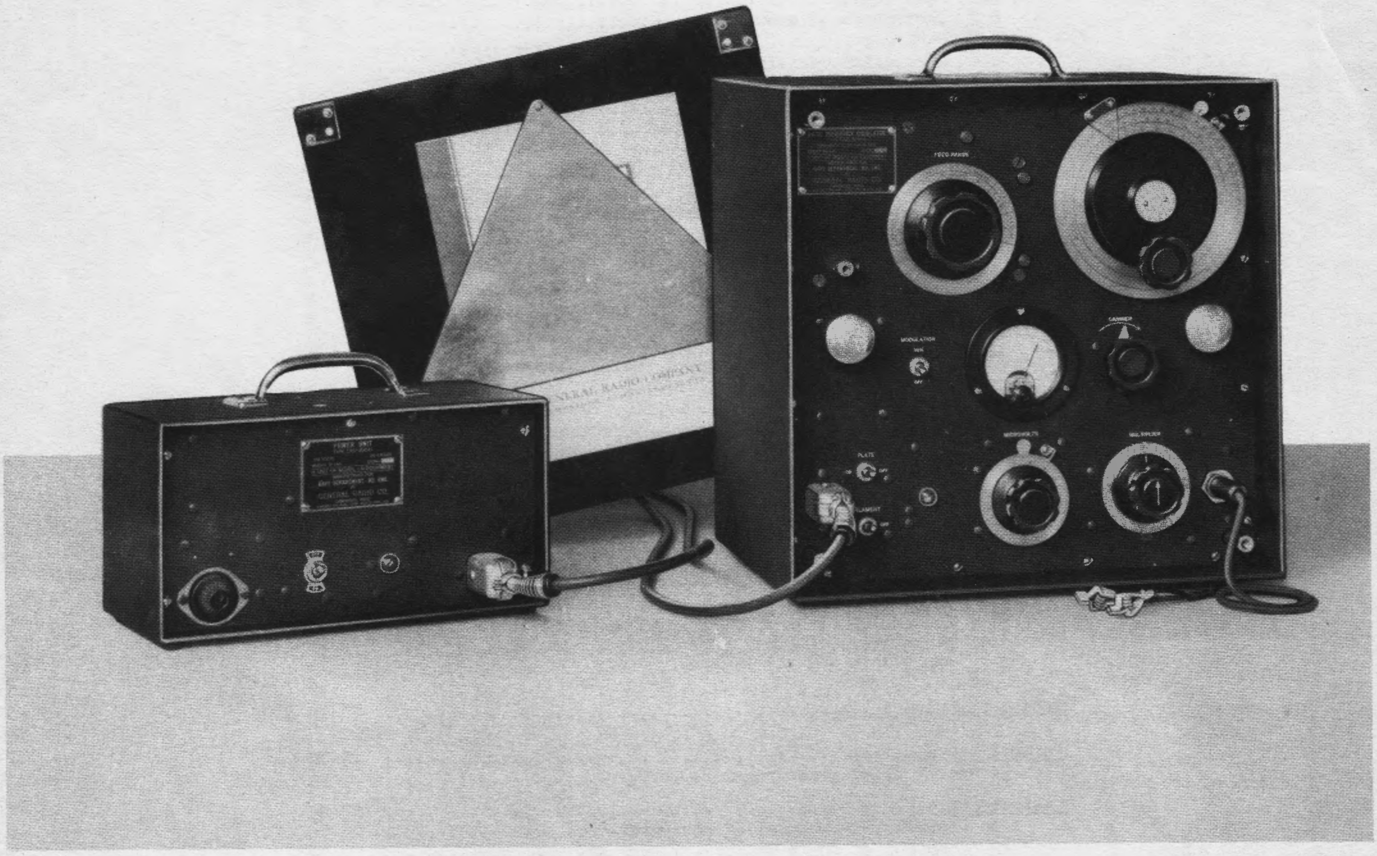


PHOTO 1. Frontispiece. Model LN Equipment.

INSTRUCTIONS
FOR
ASSEMBLY AND OPERATION
OF
RADIO-FREQUENCY OSCILLATOR EQUIPMENT
MODEL LN

WARNING

THIS IS A PRECISION INSTRUMENT. THESE INSTRUCTIONS SHOULD BE READ AND STUDIED IN THEIR ENTIRETY WITH GREAT CARE BEFORE ATTEMPTING TO ASSEMBLE OR OPERATE THIS EQUIPMENT, IN ORDER THAT OPTIMUM PERFORMANCE AND USEFULNESS MAY BE OBTAINED AND DAMAGE TO THE INSTRUMENT AVOIDED.

PART 1
INTRODUCTION

1.1 The Model LN Radio Frequency Oscillator Equipment (instruments similar to which are often classed as Standard-Signal Generators) is a device for producing radio-frequency oscillations, either modulated or unmodulated, covering a wide frequency band and is so arranged and shielded that a continuously variable calibrated output voltage is obtainable across its output leads only. It is designed and intended primarily for use in the testing, servicing, and alignment of all types of radio receiving equipments by dynamic methods (as contradistinct from meter measurements of d-c voltage and currents).

1.2 The frequency range is 9.5 to 30,000 kilocycles, and is covered by seven steps, band switched from the front of the panel. All units are self-contained, no plug-in coils being employed.

1.3 The voltage output range is 0 to 100,000 microvolts.

1.4 The output may be obtained as either pure CW or modulated 30 per cent at 1000 cycles.

1.5 The equipment is designed fundamentally for operation on 110 volts alternating current but may also be operated from batteries.

1.6 The complete equipment consists of two units:

Type CAG-60004 - Radio Frequency Oscillator
Type CAG-20041 - Power Unit

1.7 Each unit is completely self-contained, the oscillator unit being provided with a protective cover and both units with carrying handles. The equipment is accordingly portable.

1.8 Weight--The weight of each unit is as follows:

Type CAG-60004 = 52 pounds
Type CAG-20041 = 13 pounds
Model LN Equipment = 65 pounds

PART 2
TUBE COMPLEMENT

2.1 The following vacuum tubes are required for each equipment, functioning as noted:

No. Required	Navy Type	Function	Location
1	38076	Carrier (R-F) Oscillator	Oscillator Unit (Total) 4
1	38089	Separator	
1	38076	Modulation (A-F) Oscillator	
1	*	Vacuum-Tube Voltmeter	
1	38184	Rectifier	Power Unit
5 (Total)			

*Com. Type 955. See PAR. 7.24.

PART 3
POWER REQUIREMENTS

3.1 The equipment is designed primarily for complete a-c operation, but for applications where alternating current is not available, batteries may be substituted for the Power Unit.

3.2 The power requirements are as follows:

For A-C Operation

110 volts ± 10%
60 cycles ± 10%
25 watts

For Battery Operation

180 volts, 25 ma = "B" Supply
6.3 volts, 1.3 amperes = "A" Supply

PART 4
ASSEMBLY INSTRUCTIONS

4.1 Each complete equipment is packed by the contractor in one shipping case which contains:

1 - Type CAG-60004 Radio Frequency Oscillator
1 - Type CAG-20041 Power Unit

Note: All vacuum tubes are shipped in place, and instruction books and cables, etc. are stowed behind the panel cover of the oscillator unit. There are no loose small parts.

Unpack the equipment as carefully as possible to avoid breakage.

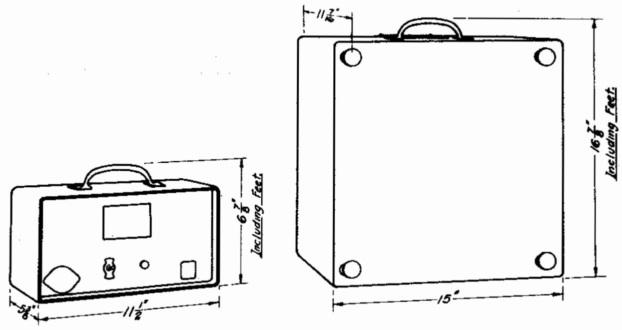
4.2 The equipment is intended to be operated with both of the panels in the vertical position. Both units are fitted with rubber supporting feet for protecting the finish of the surface on which they rest. The rubber feet also serve to insulate the cabinets from a grounded deck; but for all ordinary purposes no precautions need be taken to maintain this isolation, and either or both units can make contact with a grounded metal bulkhead (for instance) without interfering with either the power or radio-frequency circuits. The dimensions of each unit of the equipment are given in the accompanying outline drawings (DWG. 4.2).

4.3 Inasmuch as all tubes have been shipped in place, the equipment is ready for operation (See PART 6) after

a) the power interconnection cable has been plugged into the power unit and oscillator unit (See frontispiece facing Page 1), and

b) connection to the 110-volt, 60-cycle mains has been made to the receptacle in the lower left-hand corner of the power unit.

Directions for battery operation are given in SEC. 6.2.



PART 5
OPERATING PRINCIPLES

5.0 GENERAL

5.01 The Model LN Equipment consists of (1) a Power Unit (see SEC. 5.1 below) and (2) a Radio-Frequency Oscillator Unit which is composed of the following six essential elements:

1. Carrier Oscillator (SEC. 5.2)
2. Separator (SEC. 5.3)
3. Modulation Oscillator (SEC. 5.4)
4. V-T Voltmeter (SEC. 5.5)
5. Attenuator (SEC. 5.6)
6. R-F Filter (SEC. 5.7)

5.02 The circuit of the Oscillator Unit is basically simple and is best understood by considering each of the essential elements separately. Voltage from the Carrier Oscillator is impressed on the Attenuator system through an isolating amplifier (the Separator), a V-T Voltmeter serving to show when the carrier has been adjusted to the amplitude required to make the Attenuator calibration correct. Modulation of the carrier is accomplished in the grid circuit of the Separator.

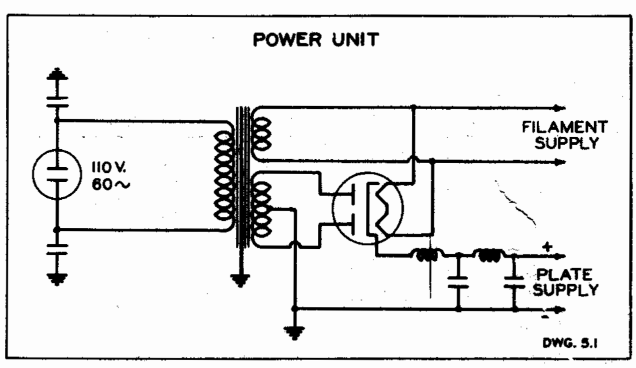
5.1 POWER UNIT

5.11 The Power Unit is of conventional design and furnishes (from the 110-volt, single-phase, 60-cycle mains) all plate, filament, and biasing voltages required by the Oscillator Unit. Its principal features are shown schematically in DWG. 5.1.

5.12 Each side of the 110-volt input circuit is separately fused, and, since neither side is grounded to the cabinet, it can be operated safely on either "floating" or grounded mains without regard to which side of the line is grounded. Input and output circuits are completely isolated by the multi-winding power transformer, the case of which is grounded. The filament-supply circuit is isolated from both the case and the plate-supply circuit, but the negative side of the plate-supply circuit is grounded to the cabinet.

5.13 Each side of the 110-volt circuit is by-passed to ground by a capacitor of 0.002 μf as a protection against circulating currents of radio frequency. Additional radio-frequency filtering is provided in the Oscillator Unit.

5.14 Inspection of DWG. 5.1 will show that when the equipment is operated from a line having one side "grounded", a small leakage current can flow through one of the by-pass capacitors to the Power Unit cabinet and thence to ground through any circuit that happens to be connected between the cabinet and ground. The current is very small (about 80 microamperes at most) because the impedance of the capacitor is so great at 60 cycles, but it is, nevertheless, sufficient to make a small spark when the ground connection is broken. Also, a slight and entirely harmless shock can be experienced by an operator who happens to touch a grounded object and the cabinet simultaneously.



5.15 The remedy for the foregoing situation is, of course, obvious: ground the cabinet of the power unit when the equipment is operated on a grounded line. This is taken care of when the interconnecting cable is in place and the ground (G) terminal on the Oscillator Unit is connected to ground, as it ordinarily would be when testing a receiver.

5.16 Plate voltage is obtained from the high-voltage transformer secondary and a full-wave, heater-type, hot-cathode, high-vacuum rectifier. A two-section hum filter reduces the power-frequency ripple to a satisfactorily low level. This circuit delivers 180 volts at approximately 25 milliamperes.

5.17 The heater-supply circuit supplies 1.3 amperes at 6.3 volts to the Oscillator Unit. An additional 0.65 amperes is used in the Power Unit. (Total: 1.95 amperes.)

5.18 The 110-volt input power for the equipment is approximately 25 watts. The power factor is approximately unity (100%).

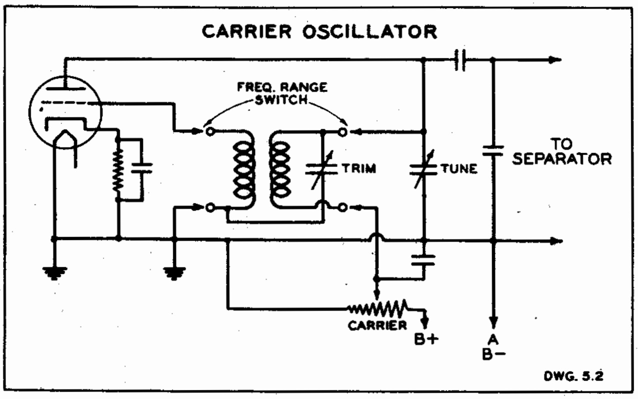
5.2 CARRIER OSCILLATOR

5.21 The Carrier Oscillator is of the conventional tuned-plate type having the coupling between grid and plate circuits essentially electromagnetic. The principal electrical features are shown in the schematic diagram, DWG. 5.2; the details are covered in the Wiring Diagram (Page 16).

5.22 The entire frequency range is covered by seven (7) separate and independent inductance systems, any one of which can be selected by the panel control marked FREQ. RANGE. Connected across the plate coil so selected is the main tuning capacitor (large dial in upper right corner of panel), a variable air capacitor having a maximum value of approximately 1400 µµf. Its plates are so shaped that, at any setting, the logarithm of the resulting frequency is proportional to the number of scale divisions shown on the main tuning dial. In other words, a calibration curve would be practically a straight line if plotted on semi-logarithmic or "ratio-ruling" graphic paper with tuning-dial divisions along the linear horizontal axis and frequency along the logarithmic vertical axis.

5.23 This logarithmic calibration has the decided advantage that the fractional or percentage accuracy of frequency setting is constant over the entire scale, i.e. one (1) degree of movement of the tuning capacitor changes the frequency the same percentage at any point on the scale.

5.24 In addition to the main tuning capacitor which is switched across the plate coil of the inductance system it is desired to use there is, permanently connected across each plate coil, a small adjustable "trimmer" capacitor, (Symbols C-23 to C-29, inclusive, in the Wiring Diagram Page 16). These trimmers are for the purpose of adjusting the <u>total</u> capacity associated with each plate coil, i.e., to compensate for variations in distributed capacity, to the same value. The inductance values of each plate coil are so designed that with this accomplished, two separate and distinct groups of frequency coverage for the same number of degrees of rotation of the tuning capacitor are obtained. These are shown in the following table.



DWG. 5.2

RANGES A C E G

FREQ. RANGE	NOMINAL FREQUENCY	ACTUAL FREQUENCY
A	9.5 kc to 30 kc	9.2 kc to 31 kc
C	95 kc to 300 kc	92 kc to 310 kc
E	0.95 Mc to 3 Mc	0.92 Mc to 3.1 Mc
G	9.5 Mc to 30 Mc	9.2 Mc to 31 Mc

RANGES B D F

FREQ. RANGE	NOMINAL FREQUENCY	ACTUAL FREQUENCY
B	30 kc to 95 kc	29 kc to 98 kc
D	300 kc to 950 kc	290 kc to 980 kc
F	3 Mc to 9.5 Mc	2.9 Mc to 9.8 Mc

It will be noted that within each group, each range differs from its neighbor by a multiple or sub-multiple of 10. As a result of this method of design and adjustment but two calibration curves and two groups of frequency markings on the main tuning dial are necessary.

5.25 All the Model LN equipments supplied under this contract use the calibration charts in this book (Pages 14 and 15). These are accurate to within one per cent and the scales have been so chosen that either the DIVISIONS or the FREQUENCY scales can be read to within at least one part in 1500.

NOTE: THE MODEL LN EQUIPMENT IS NOT INTENDED TO BE USED AS A FREQUENCY STANDARD. WHERE FREQUENCY ACCURACY GREATER THAN 1% IS REQUIRED, IT SHOULD BE USED AS A TRANSFER STANDARD, i.e., THE TUNING CAPACITOR READINGS FOR THE FREQUENCIES DESIRED SHOULD BE NOTED BY COMPARING THE OSCILLATOR WITH A FREQUENCY STANDARD AND THE EQUIPMENT USED AS SOON AS POSSIBLE AFTER SUCH CHECKING.

5.26 The calibration adjustments described in PAR. 5.24 have been made by the contractor and locked. Should recalibration be necessary, consult SEC. 7.3 for instructions.

5.27 A grid condenser and grid-leak combination in addition to cathode self-biasing is used in the oscillator circuits for Range A and Range B (the two lowest-frequency circuits); for all other ranges cathode self-biasing alone is employed.

5.28 The carrier amplitude is adjusted to the required value by means of the CARRIER control, a tapered voltage divider that changes the voltage applied to the plate of the oscillator tube.

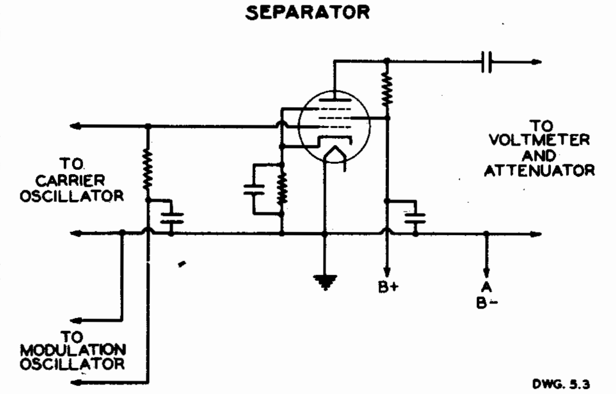
5.29 There is a sufficient amount of capacitance in the tuning circuits to make extremely small the possible shift in frequency with a change in carrier-oscillator tubes. At the highest frequency in any band (the least favorable condition) the possible error is less than 1/4 of one per cent. Should, due to future changes in tube characteristics, greater errors be introduced, such errors can be eliminated by readjustment of the trimming capacitors (Symbols C-23 to C-29, inclusive, in the Wiring Diagram Page 16). See SEC. 7.3 for trimming instructions.

5.3 SEPARATOR

5.31 The Separator circuit is an amplifier inserted between the carrier oscillator and the attenuator. It has two principal functions: first, it operates as a buffer stage to isolate the carrier oscillator from the attenuator or output system, and, second, to provide for modulation of the carrier by the modulation oscillator. DWG. 5.3 shows the schematic circuit.

5.32 As a buffer stage, the Separator makes the frequency of the carrier oscillator independent of the setting of either the MICROVOLTS or MULTIPLIER controls as well as independent of the circuit to which the oscillator output may be connected.

5.33 Modulation is accomplished by introducing audio-frequency voltage into the control-grid circuit of the separator through a high resistance (R-4), therefore the system is free from frequency modulation.



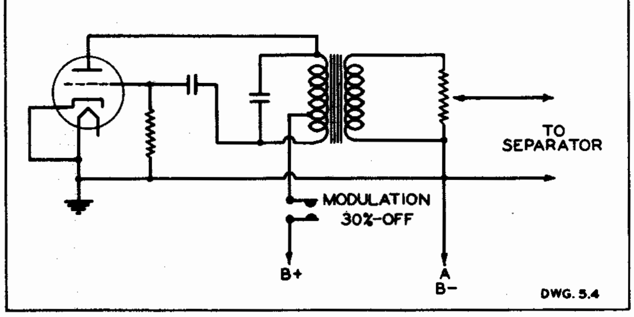
DWG. 5.3

5.4 MODULATION OSCILLATOR

5.41 The Modulation (audio) Oscillator is a conventional Hartley-type circuit in which the iron-cored inductor also serves as the primary winding of the coupling transformer. The circuit is shown schematically in DWG. 5.4.

5.42 The frequency is adjusted to 1000 cycles, and it can be relied on to within ±10%. The harmonic content of the modulated carrier envelope is less than 10% of the fundamental amplitude.

5.43 Across the secondary of the coupling transformer is connected a voltage divider for adjusting the modulation voltage supplied to the separator tube and, therefore, the percentage modulation.



DWG. 5.4

5.44 The modulation voltage is cut in and out of circuit by the MODULATION-30%-OFF switch on the panel. This breaks the plate circuit of the oscillator.

5.5 V-T VOLTMETER

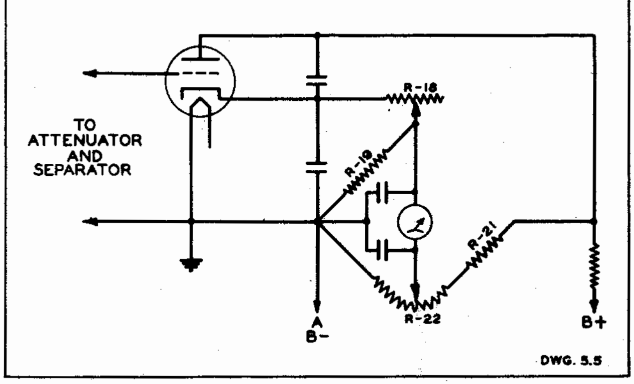
5.51 The settings of the MICROVOLTS and MULTIPLIER dials show the amplitude of the carrier voltage at the output jack when 1.0 volt is maintained across the input terminals of the attenuator. The vacuum-tube voltmeter is connected across the attenuator input, and its indication meter shows when the carrier voltage has been adjusted to the required value. DWG. 5.5 shows the schematic arrangement.

5.52 The tube is a separate-heater triode of the so-called "acorn" type, chosen because its low input reactance assures equally accurate calibration over the entire band of frequencies which this equipment covers. Its grid circuit is connected across the attenuator, and in the plate circuit is connected the indicating meter and a balancing circuit for suppressing the steady component of the plate current. Use of the vacuum-tube voltmeter makes thermocouples unnecessary and removes the ever present danger of burnouts.

5.53 The balancing circuit can be considered as a simple d-c resistance bridge in which R-19, R-22 and R-21, and R-18 plus the internal resistance of the tube are the arms. In conventional vacuum-tube voltmeter circuits the steady component of plate current is balanced out by adjusting R-22 until, with no carrier voltage applied, the indicating meter shows that no current is flowing through it. Any value of carrier voltage thereafter produces a decrease in the internal plate resistance of the vacuum tube and a corresponding deflection of the meter. This method of operation has the disadvantage that the voltmeter calibration is affected by line-voltage changes.

5.54 A different operating method provides stabilizing action that makes the calibration independent of line voltage. An initial adjustment is obtained by adjusting R-22 until the indicating meter deflects to the left-hand index with no applied voltage. Any value of voltage subsequently applied causes the meter to read up scale toward the SET CARRIER position.

5.55 A second adjustment is obtained by applying a known grid voltage of 1.0 volts to the voltmeter circuit and then adjusting R-18 until the meter deflection is at the right-hand index or SET CARRIER position. The initial adjustment at a point in the characteristic curve of the voltmeter tube where the plate current is not zero is what provides the stabilizing action. Accordingly, while variations in line voltage with corresponding variations of "B" supply voltage will affect the carrier output, the vacuum-tube voltmeter calibration always indicates one volt cor-



DWG. 5.5

rectly when the indicating instrument reads at the SET CARRIER position.

5.56 The behavior of the indicating meter needle can best be summarized as follows:

(a) With no plate or filament power the needle points to or near the right-hand index.
(b) With filament power but no plate power, the needle moves up-scale several divisions from the right-hand index, showing that some electrons leave the cathode with sufficient velocity to reach the plate even in the absence of plate voltage.
(c) When plate voltage is applied and the carrier voltage has been brought to zero with the CARRIER control, the needle moves down-scale to the left-hand index.
(d) As the carrier amplitude is increased the needle moves up-scale toward the right-hand index.

5.57 With no carrier voltage applied to the voltmeter, modulation voltage causes a slight up-scale deflection of the meter from the normal position at the left-hand index. This behavior is entirely normal and should be ignored. It is caused by the very small amount of audio-frequency voltage that is impressed on the V-T Voltmeter circuit, and is used in the trouble-shooting procedure as a check on the operation of the Modulation Oscillator.

5.58 The voltmeter circuit was adjusted and calibrated by the manufacturer, and no attention is required from the operator. Should, for any reason, readjustment of the circuit be necessary, refer to SEC. 7.4 for instructions.

5.6 ATTENUATOR

5.61 The attenuator system serves to control the amplitude of the carrier voltage as applied to the output jack so that a definite and continuously variable voltage is obtainable at this point. The entire system is resistive throughout and is so designed that the attenuation introduced is at all times independent of frequency within the limits of the equipment. While the attenuator system is strictly a ratio operating device, the two panel controls are calibrated directly in terms of microvolts at the output jack, with an attenuator input of 1 volt as indicated by the vacuum-tube voltmeter heretofore described. The attenuator system is shown schematically in DWG. 5.6.

5.62 There are three principal elements in the attenuator system. With a carrier voltage of 1 volt introduced from the SEPARATOR, the resistor R-7 reduces this to 0.1 volt (100,000 microvolts) as applied to the MICROVOLTS control (R-8/R-9) when in its MAXIMUM position. The MICROVOLTS control is a two-section, slide-wire continuously variable resistor unit connected as a T-type section in such manner as to provide a smooth control of the voltage supplied to the MULTIPLIER from 100,000 microvolts to zero, at the same time maintaining the impedance between R-7 and ground constant. The MULTIPLIER is a four-section ladder network so designed that its input voltage is attenuated in four steps (five steps including the zero-attenuation point) with a ratio of 10:1 between steps. With these two controls in combination, any desired value of voltage between zero and 100,000 microvolts can be obtained at the output jack, its value being indicated directly by the panel calibration associated with the controls.

5.63 It will be noted that with the attenuator system so designed, the output impedance of the oscillator unit as applied to the receiver or equipment under test is constant at all times and does not vary with adjustment of the MICROVOLTS control. At the highest output step on the MULTIPLIER it is necessary, however, to change the value of impedance in order to obtain the required output with the power available from the oscillator. The following are the output impedances associated with the different ranges of the equipment:

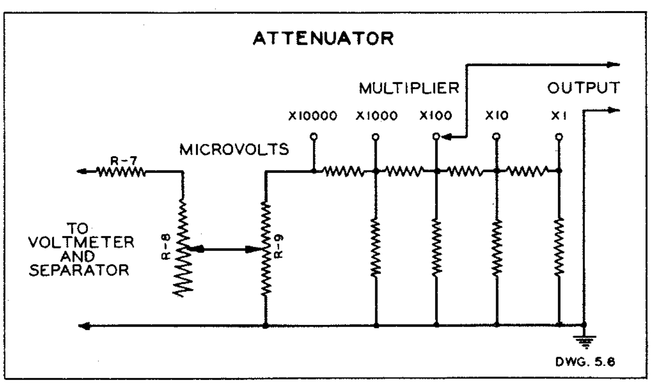
OUTPUT (Microvolts)	MULTIPLIER STEP	INTERNAL OUTPUT IMPEDANCE
0 - 10	1	10 ohms
0 - 100	10	10 ohms
0 - 1,000	100	10 ohms
0 - 10,000	1000	10 ohms
0 - 100,000	10,000	50 ohms

5.64 At any frequency, the actual carrier voltage made available at the output jack is rated as accurate to within 10 per cent above 10,000 µv and to within 25 per cent below 10,000 µv down to a level of less than 1 µv.

5.65 The accuracy figures stated in PAR. 5.64 were with reference to the output jack to the oscillator unit. When a high degree of accuracy is required of a receiver test at very high frequencies, it may be necessary to realize the presence of and allow for a possible error introduced by the output cable. The essential difficulty may be understood when it is appreciated that at 30,000 kc (which corresponds to a wavelength of 10 meters in free space) the wavelength in rubber-insulated conductors is approximately 6 meters. This means that, for greatest accuracy, the length of the lead wires between the output jack and any equipment under test must be kept very short with respect to six meters in order that the familiar difficulties of an open-ended transmission line may be avoided. It has been found, for example, that the 50-centimeter (19.7-inch) concentric-shielded cable supplied with the equipment introduces an error of approximately plus 10% at 7500 kc, which may be more or less depending on the internal input impedance of the receiver to which the cable is connected. It is because of this effect of the impedance of the load and the great variation of loads introduced by different receivers or at different points in the same receiver that it is impossible to provide herein any correction data for the effects of cable length at different frequencies.

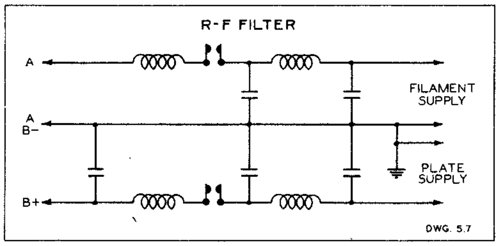
5.66 However, for receiver alignment purposes for which this equipment is primarily intended, extreme accuracy of the input level is unimportant. For other measurements such as those of sensitivity, selectivity, etc., the errors due to the cable are, in general, equally unimportant above 7500 kc from a practical point of view, due to the fact that the artificial antenna used for measurements on such frequencies (usually 300 ohms resistance) is far from representative of actual antennas.

5.67 The change in the average amplitude of the carrier when the 30% modulation is applied is so small that there is no need to distinguish between the "C.W." and "modulated" condition when setting the CARRIER control for one volt.



5.7 R-F FILTER

5.71 The filter is a system of capacitors and inductors inserted between the power jack and the plate, filament, and biasing circuits of the oscillator. Its purpose is to keep carrier-frequency voltage out of the interconnecting cable connecting to the Power Unit (or batteries) from which it might be radiated and picked up by the receiver under test. The filter is shown schematically in DWG. 5.7.



PART 6. OPERATING INSTRUCTIONS

6.0 GENERAL

6.01 The Model LN equipment is simple to operate and most of the essential details will be evident to one who has read the "Operating Principles" section (PART 5) and inspected the instrument. There are, however, certain precautions and maintenance details that require discussion.

6.02 Detailed instructions for operating the equipment are discussed in the following paragraphs:

6.1 Power Circuits -- A-C Operation
6.2 Power Circuits -- Battery Operation
6.3 Adjusting Output Voltage
6.4 Adjusting Carrier Frequency
6.5 Modulation
6.6 General Instructions for Use

6.1 POWER CIRCUITS -- A-C OPERATION

6.11 Instructions were given in PART 4 for preparing the equipment for operation from the 110-volt, a-c mains using the power unit. Throwing the ON-OFF switch on the Power Unit to ON will apply line voltage to the primary of the power transformer, which will be indicated by the lighting of the pilot lamp. Heater voltage becomes available at the oscillator immediately; plate voltage, as soon as the rectifier tube has reached operating temperature. It will be noted that all tubes, including the rectifier, are of the indirectly heated type; accordingly an appreciable time is required for the equipment to become operative after being turned on.

6.12 Switches are provided on the panel of the Oscillator Unit for controlling the voltages applied to the plate and filament circuits. These are provided for two purposes:

(a) Due in part to the use of vacuum tubes with indirectly heated cathodes, in addition to the time required for initial heating, a gradual drift in the tube characteristics occurs for a period of 15 to 30 minutes after the heaters are energized, even though they are turned OFF for a short period of time only. Accordingly, when using the equipment, best results are obtained by leaving the heaters energized continuously (i.e., FILAMENT switch ON), effecting all ON and OFF control of the equipment by the application and removal of plate potential by use of the PLATE ON-OFF switch.

(b) When operating the Oscillator Unit from batteries, the FILAMENT and PLATE switches are required for controlling the applied voltages. A pilot lamp is provided to indicate when potential is applied to the vacuum-tube heater circuits.

(Note: With no plate potentials applied to the Oscillator Unit, but with the vacuum-tube cathodes heated, the V-T Voltmeter will be deflected a few divisions to the right. This is entirely normal and is explained in PAR. 5.56.)

6.13 The CARRIER control knob should be turned counterclockwise to its extreme limits before closing the PLATE switch, in which position the carrier voltage applied to the vacuum-tube voltmeter is zero as well as the output. Close the PLATE switch (ON). The vacuum-tube voltmeter should then deflect to the left-hand index, its proper reading with the CARRIER control at zero (hard counterclockwise ↶). The Oscillator is now ready to operate as described in SEC. 6.3 and 6.4.

(Note: Should deflection to the left-hand index not be obtained under the above conditions, refer to SEC. 7.4 for description of corrective action.)

6.2 POWER CIRCUITS -- BATTERY OPERATION

6.21 The oscillator can be operated from batteries with very little noticeable difference in performance provided three precautions are observed.

(1) Make all connections to the power-unit end of the interconnecting cable supplied with the equipment.
(2) Keep the batteries as far from the oscillator and receiver under test as the interconnecting cable will permit.
(3) Do not use the batteries supplying the oscillator for operating the receiver under test.

6.22 The oscillator requires 180 volts of plate battery and 6.3 volts of filament battery. The latter is conveniently obtained from a 6-volt lead-acid storage battery. Connections can be made to the plug by means of clips, or a mating jack receptacle of the Howard B. Jones S-4 series can be used.

6.23 When the batteries have been connected, the operation of the equipment is in every way like that for a-c operation.

6.3 ADJUSTING OUTPUT VOLTAGE

6.31 When the oscillator has been made ready for operation as described in the preceding paragraphs, the CARRIER control should be turned clockwise↷until the meter needle moves up scale to the right-hand index. At this setting the Carrier Oscillator is applying 1.0 volt to the input of the Attenuator system, and the output voltage is that indicated by the combined settings of the MICROVOLTS and MULTIPLIER controls. If the meter needle does not move up scale, an indication that the Carrier Oscillator is not oscillating, make sure that the FREQ RANGE switch is definitely set for one of the seven (7) ranges and not halfway between.

6.32 Care should be taken to see that the carrier voltage does not appreciably exceed the standard 1.0-volt value (meter needle at right-hand index) because the Carrier-Oscillator tube (Symbol V-1) is thereby overloaded. Failure to observe this precaution unnecessarily shortens the life of the tube.

6.33 For a given carrier-oscillator plate voltage (fixed setting of CARRIER control) the carrier amplitude must necessarily change considerably over the very wide frequency range covered by this equipment. It is important, therefore, that the vacuum-tube voltmeter indication be verified whenever the carrier frequency is altered. Changes in carrier amplitude with attenuator setting or external output impedance are, however, entirely negligible.

6.34 Connection to the receiver under test is most conveniently made by means of the concentric-shielded output cable supplied, the inner wire being connected to the antenna terminal of the receiver through a suitable standard antenna. One end is fitted with a plug for the output jack; the other end has clips. The inner wire is marked by the red tracer.

6.4 ADJUSTING CARRIER FREQUENCY

6.41 Carrier frequency is adjusted by means of the band-selector switch marked FREQ RANGE and the variable air condenser driven by the large slow-motion dial in the upper right-hand corner of the oscillator panel. The logarithmic relation between frequency and dial settings and its influence on the method of using the calibrations was discussed in PAR. 5.22.

6.42 The tuning control dials carry two direct-reading frequency scales for which the triangular transparent index marker is used. The upper of the two scales, marked "A C E G" is used when the FREQ RANGE switch is set at A, C, E, or G; the lower scale, marked "B D F" is used for ranges B, D, and F.

6.43 This instruction book contains (Pages 14 and 15) a larger-scale, more detailed calibration than the one engraved on the dial. The printed calibration consists of two groups of scales, one for the Ranges A, C, D, and F and the other for Ranges B, D, and E. Each group is in reality one long scale broken up into short sections for convenience. On the upper side of the scale is plotted FREQUENCY and immediately below it the number of scale DIVISIONS as read from the main tuning dial using the circular metal index. The proper location of the decimal point and the "units" for the frequency scale can be obtained by inspection from the setting of the FREQ RANGE switch. The scales chosen are sufficiently open to permit of reading either FREQUENCY or DIVISIONS to within one part in 1500. The calibration is accurate to within 1%.

6.5 MODULATION

6.51 To apply the 30% modulation from the internal 1000-cycle modulation oscillator it is merely necessary to throw the MODULATION-30%-OFF switch to the "30%" position. This applies plate voltage to the Modulation Oscillator tube, the heater of which is always hot when the filament power is ON.

6.6 GENERAL INSTRUCTIONS FOR USE

6.601 For specific details of the proper technique involved in the testing, alignment and servicing of radio receiving equipments by the use of Standard Signal Generators or Radio Frequency Oscillators similar to the Model LN equipment, reference should be made to the instruction books covering the receivers in question, the Standardization Section of the Year Book of the Institute of Radio Engineers or the published literature. However, due to the fact that most commercially published test procedure is concerned with broadcast receivers, where the test values and parameters differ somewhat from those standardized for Naval equipments, certain details of the Navy standard values and methods are included herein. In addition, certain general precautions and procedure which should be observed in the use of the Model LN equipment to permit best results to be obtained and to preclude damage to the instrument are included.

6.602 In coupling the Model LN output to the receiver input, the ground clip of the test lead should always be connected to the grounded binding posts of the receiver. (The ground side of the test lead has no colored tracer.)

6.603 When coupling to the various stages of a receiver, the ground clip of the test lead may be connected to any available point on the chassis, preferably near the tube to which the voltage is applied.

6.604 REGARDLESS OF THE PURPOSE FOR WHICH USED, THE OUTPUT SHOULD ALWAYS BE APPLIED WITH RESPECT TO GROUND, NEVER IN SERIES WITH A LEAD ABOVE R. F. GROUND POTENTIAL.

6.605 In using the Model LN equipment, it is extremely desirable to connect at all times a blocking capacitor between the ungrounded lead from the oscillator and the point to which it is to be connected. This capacitor should not be less than 0.01 µf in value unless it is part of a STANDARD ANTENNA, when the proper antenna value should be used. The purpose of this capacitor is to block any d-c voltage which might be present in the receiver under test or adjustment, with respect to ground, from entering the equipment. Should this occur it would be short circuited by the output attenuator resistance which would immediately be burned out. The use of this blocking capacitor as a permanent part of the output leads is considered extremely valuable and important even when it is known that no d-c voltage is present at the measurement points. Experience has proved that most casualties occur due to the accidental dropping or touching of the output leads across batteries or other potential points.

6.606 One exception to this procedure must be noted, this being the case where the vacuum tube to which the test signal is being applied must receive its bias potential through the output attenuator resistor of the Model LN equipment.

6.607 When making over-all measurements or tests on a receiver, a STANDARD ANTENNA should always be connected between the output lead of the Model LN equipment and the antenna post of the receiver, in order that the input circuit of the receiver function in a normal manner, without detuning, etc. (See PAR. 6.617 for the electrical constants of STANDARD ANTENNAS.)

6.608 It should be remembered that the output impedance of the Model LN equipment is quite low (10 ohms, excepting on the highest range). Accordingly, if the equipment output is connected across an r-f circuit it will be effectively short circuited. Therefore, where it is desired to impress a voltage across a circuit without affecting its performance, such as between an antenna bus and ground, for the purpose of impressing test signals on a number of receivers, a suitably high resistance such as 20,000 ohms should be inserted in series with the ungrounded output lead. Under these conditions the microvolt reading of the Model LN equipment does not indicate the number of microvolts impressed on the receiver due to the voltage drop in the isolating resistor.

6.609 Thirty per cent modulation at 1000 cycles is provided in the Model LN equipment and can be used on all frequency bands without appreciable "frequency modulation" occurring, due to the modulation being introduced into the untuned buffer stage (Separator).

6.610 In using the equipment in a modulated condition it should be realized that three waves are emitted, one at the carrier frequency and two "side bands" one 1000 cycles below and one 1000 cycles above the carrier frequency.

6.611 While either pure or modulated CW signals can be obtained from the Model LN equipment, considerable discretion must be used in employing the modulated method of receiver testing, based on the selectivity of the receiver and the frequency of test, inasmuch as the carrier and both side bands must be received in true proportion in order to obtain accurate measurements.

6.612 DO NOT ATTEMPT TO USE MODULATION IF THE RECEIVER SELECTIVITY IS SUCH THAT APPRECIABLE ATTENUATION IS PRESENTED TO FREQUENCIES 1 KILOCYCLE REMOVED FROM THE DESIRED FREQUENCY.

6.613 The frequency at which this condition applies varies with different models of receivers but care should be exercised at frequencies below 500 kilocycles.

6.614 In aligning or testing a receiver, an output meter should be employed, connected across the output terminals in parallel with a proper output load. Such load should consist of a resistor unit and not a pair of telephone receivers, due to the fact that their impedance is not constant with frequency or conditions.

6.615 Most Naval radio receivers have an excess of sensitivity provided to an extent where at certain frequencies, the inherent noise level of the receiver is sufficient to saturate the detector or audio tubes if the sensitivity control is advanced too far. Accordingly, all Naval receivers are measured and rated for both CW or MCW Sensitivity on the basis of the Sensitivity control being adjusted so that <u>not more than 60 microwatts of noise</u> is present in the output, with no input signal impressed.

6.616 In addition, when testing receivers with regenerative detectors for either CW or MCW Sensitivity, the Regeneration control should be so adjusted (either to produce stronger oscillations for CW tests or to produce less regeneration for MCW tests) that the output signal voltage (for constant input) is 75% of the maximum that can be obtained with critical regeneration or oscillations.

6.617 The STANDARD ANTENNA for Low Frequency receivers (10-1000 kilocycles) consists of 200 µµf of capacity in series with 15 ohms resistance (in addition to the 10 ohms of the Model LN attenuator).

The STANDARD ANTENNA for High Frequency receivers consists of 300 ohms of pure resistance.

The STANDARD OUTPUT LEVEL of reference should be 6 milliwatts.

The STANDARD NOISE LEVEL should be 60 microwatts.

The STANDARD OUTPUT LOAD should be either 600 ohms for low impedance outputs or 20,000 ohms for high impedance outputs, unless special impedances are provided in the receivers and noted in their instruction books.

6.618 To assist in measurements when the output meter is a voltmeter, the following approximate voltages correspond to the desired wattages at the load impedances noted:

6 milliwatts	(1.9 volts at 600 ohms (11.0 volts at 20,000 ohms
60 microwatts	(0.19 volts at 600 ohms (1.1 volts at 20,000 ohms

For receivers provided with output meters having a zero level of 6 milliwatts, -20 dbs equals 60 microwatts.

For receivers provided with output meters having a zero level of 60 microwatts, +20 dbs equals 6 milliwatts.

PART 7. READJUSTMENTS AND MAINTENANCE OF EQUIPMENT

7.1 REMOVING CABINETS

7.11 The Oscillator Unit should be taken out of its cabinet by turning the cabinet on its back (panel horizontal, facing upward). Then remove the 16 (4 on each side) round-head machine screws located around the outer edge of the panel. Lift the unit from the cabinet by means of the two lifting knobs on the panel. Allow the unit to rest on the table top with the panel almost vertical and bearing on the lower edge of the panel and the back edge of the lower shelf compartment. This will be found to be a convenient working position. When replacing the unit proceed with extreme care so as to avoid striking the internal structure against the sides of the cabinet. Be sure that all 16 panel screws have been tightened to insure a good electrical connection between the panel and cabinet on which the effectiveness of the shielding is dependent.

CAUTION: Do not allow the panel to rest on the bench face down without putting blocks under the corners to keep the main tuning dial from striking.

7.12 The Power Unit is most easily taken out of its cabinet by removing the 5 round-head machine screws (at each end of the panel and top center) and then tipping up the lower back edge of the cabinet, thus allowing the unit to slide out. When returning the unit to the cabinet avoid bumping the tube against cabinet.

7.2 REPLACING TUBES

7.21 All tubes except the vacuum-tube voltmeter tube are of types that are standard in the Naval Service and only the ordinary precautions need be observed in handling or replacing them. A means is provided for holding each

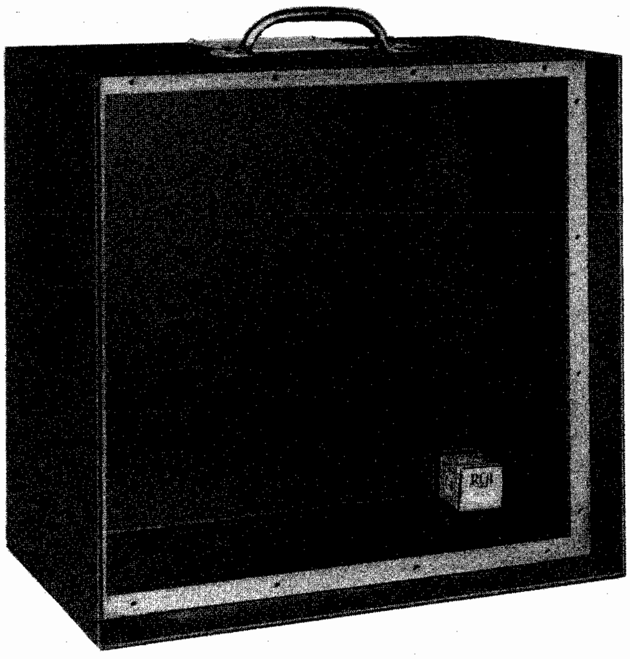


PHOTO 2. The spare commercial-type 955 tube (V-3) is packed in its carton which is cemented to the wall of the Oscillator-Unit Cabinet. Do not remove tube until it is needed.

tube in place to insure its remaining in position during transportation. Its presence has no effect on the operation of the equipment.

7.22 The vacuum-tube voltmeter tube, because it is of a new and unusual type, requires the observance of a few precautions in handling: Do not remove the tube from its socket unless absolutely necessary, because the tube electrodes are supported in glass and may break with excessive handling. Be sure that the power supply is turned off when making replacements. Insert the tube in the five clips with its pointed end into the socket ring. Push the five pins into place in the clips with a small screw driver or test prod rather than exert pressure on the bulb.

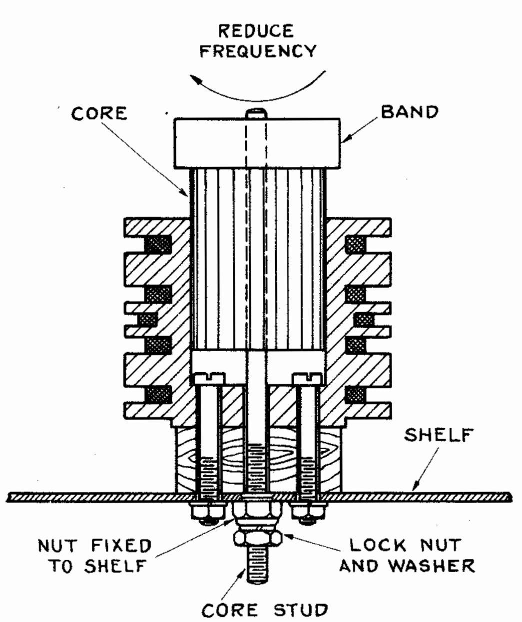
7.23 It is recommended that the shield plate which covers the bottom of the lower shelf be removed when replacing the voltmeter tube. This makes the tube easier to reach and lessens the chance of damaging other parts in this compartment.

7.24 Due to the fact that the commercial-type 955 tubes used in the vacuum-tube voltmeter are non-standard in the Naval Service and not stocked for issue, a spare tube is included with each Oscillator Unit. To preclude possible damage or loss, it is recommended that this tube be permitted to remain as shipped until such time as its use is required.

7.25 The spare tube is packed in its commercial carton and the carton is firmly cemented to the bottom, back, and right side walls of the Oscillator Unit cabinet, as shown in PHOTO 2.

7.3 READJUSTMENT OF FREQUENCY CALIBRATION

7.31 General - Readjustment of the frequency calibration for any range is readily accomplished, if it should ever become necessary, by the method described in the following paragraphs. In PAR. 5.24 it was pointed out that each plate coil has connected across it a trimmer capacitor for adjusting the total capacitance associated with that coil. Each coil also has a movable iron core by means of which the inductance of that coil can be adjusted to the required value. The recalibration process is, therefore, simply a matter of (1) adjusting the inductance of the plate coil for a calibration frequency at the low-frequency end of the range and (2) of adjusting the corresponding trimmer capacitor for a calibration point at the high-frequency end of the range.



DWG 7.34

7.32 Any sufficiently accurate method of measuring the frequency at each end of the range in question may be used, but the simplest and most satisfactory is with a heterodyne-frequency meter such as that of the Model LB, LD, LD-1, LD-2, or LD-3 equipment. Connect the test lead of the Model LN equipment to the heterodyne-frequency meter and measure the frequency in the usual way.

7.33 The calibration was originally adjusted by the contractor at the frequencies given in the following table which also shows the corresponding number of dial divisions as taken from the calibration charts, Page 14. Use these same frequencies when readjusting the calibration. First, measure the frequency at the low-frequency test point; then measure the frequency at the high-frequency test point to determine whether the inductance, the capacitance, or both will require readjustment. Note that if readjustment of the inductance is required, the calibration will be out at both ends of the band.

FREQ.	LOW END ADJUST L			HIGH END ADJUST C		
RANGE	FREQ.	DIV.	COIL	FREQ.	DIV.	CAPACITOR
A	10 kc	23.2	L-1	30 kc	286.4	C-29
B	30 kc	10.9	L-2	95 kc	287.0	C-28
C	95 kc	10.1	L-3	300 kc	286.4	C-27
D	300 kc	10.9	L-4	950 kc	287.0	C-26
E	0.95 Mc	10.1	L-5	3 Mc	286.4	C-25
F	3 Mc	10.9	L-6	9.6 Mc	290.0	C-24
G	9.6 Mc	13.0	L-7	25 Mc	241.3	C-23

7.34 To Readjust Inductance: Remove the Oscillator Unit from its cabinet (See SEC. 7.1) and remove the shield from the oscillator compartment. With the help of the photograph on Page 20, identify the coils that must be readjusted and note the method used for locking the cores in position. All cores, except that for Range A (L-1), are held by two setscrews through the coil form. Coil L-1 has a threaded brass shaft imbedded in its core which is screwed into a nut attached to the base of the oscillator compartment (See DWG. 7.34). A lock nut and lock washer make the adjustment permanent.

7.35 Next, mark the original position of the core in the coil form with a pencil mark on the core for use as a reference point. Then loosen the two setscrews and move the core slightly in the required direction:

a) out of the coil to reduce inductance and increase frequency, and
b) into the coil to increase inductance and reduce frequency.

Tighten the setscrews, replace the shield, and measure the frequency with the main tuning dial set at the required point. Repeat until the calibration is correct at this point. For the preliminary adjustments it may not be necessary to replace and tighten all of the screws holding the shield, but this should always be done for the final check because the position of the shield affects the frequency. The Oscillator Unit need not be returned to its cabinet for these tests. Readjustment can be facilitated by holding the shield or other flat metal plate near the coil in the same position normally occupied by the shield.

7.36 If Coil L-1 must be readjusted, loosen the lock nut and rotate the bakelite binding band at the top of the core:

a) counterclockwise (core out of coil) to reduce inductance and increase frequency, and

b) clockwise (core into coil) to increase inductance and reduce frequency,

as viewed from above.

7.37 To Readjust Capacitance: Access to all trimming capacitors is obtained from the front of the oscillator-unit panel by removing the nameplate and three hex-head machine screws as shown in PHOTO 3. Set the main tuning dial at the required calibration point for the range in question and adjust the corresponding capacitor with a non-metallic screwdriver, until the resulting frequency is correct:

a) clockwise rotation decreases capacitance and increases frequency, and

b) counterclockwise rotation increases capacitance and decreases frequency.

7.38 After the foregoing instructions have been properly carried out, the frequency of the oscillator will be in very close agreement with the printed calibration at two points in each range. The frequency should agree to within ±1% at all other points in each range. If they do not, it is evident that the main tuning condenser has become damaged and requires readjustment, a difficult operation that should not be attempted by the operator.

7.4 RECALIBRATION OF V-T VOLTMETER

7.41 GENERAL

7.411 By the method outlined briefly in SEC. 5.5, the V-T Voltmeter calibration has been made substantially independent of line voltage. Perfect compensation is not to be expected, but deviations are well within the limits of accuracy imposed on the equipment.

7.412 Recalibration and readjustment of the V-T Voltmeter circuit may become necessary because of changes in the characteristic of the indicating meter or of the tube. Barring accidents such as severe mechanical shock or burning out of the meter, no trouble with the indicating meter should be experienced. Changes in the tube characteristics either because of aging or the necessity for replacing the tube, can be taken care of by recalibrating the circuit using the method described in the following paragraphs.

7.413 It should be noted that the most important requirement to be put upon the behavior of the circuit is that the meter needle point to the left-hand index when the Carrier Oscillator has been turned off by turning the CARRIER control as far counterclockwise ↶ as possible. (The Modulation Oscillator must, of course, be turned OFF and the power switches turned ON.) The meter should be brought to this setting by adjusting the zero-adjust screw on the face of the meter, even if this readjustment causes the needle to deviate slightly from the right-hand index when all power is turned OFF.

7.414 The procedure described in the preceding paragraph is necessary because slight shifts in the characteristics of the vacuum tube occur for which it is not necessary to recalibrate the V-T Voltmeter circuit. By bringing the needle to the left-hand index for the condition of "zero carrier" by means of the zero adjusting screw, the change in meter current as the carrier voltage is increased from zero to 1.0 volt remains the same. In other words, the balance condition in the circuit can shift considerably without affecting the calibration, if care is always taken to make the change in meter current the same as for the original calibration.

7.415 The indicating meter is a conventional 0-200 µa meter with a so-called offset zero. When the current is zero, the needle stands at the right-hand index; when the current is 100 µa, the needle stands at the left-hand index.

7.42 RECALIBRATION

7.421 The recalibration procedure is essentially one of connecting a calibrated voltmeter in parallel with the V-T Voltmeter and making the necessary adjustments in R-22 and R-18 so that 1.0 volt on the two voltmeters correspond. The resulting calibration, if carefully done, will be as accurate as the calibration of the calibrated voltmeter. The procedure is suggested in PAR. 5.54 and PAR. 5.55.

7.422 Begin by setting the meter needle to the right-hand index by means of the zero-adjust screw on the meter face. All power should be turned OFF.

7.423 Then remove the Oscillator Unit from its cabinet and connect the Power Unit. Connect the calibrated voltmeter by attaching one clip to the tube-end of R-7 and the other clip to the shield. The connecting wires should be bare and as short as possible. Choose the best available voltmeter for the purpose. A vacuum-tube voltmeter capable of indicating 1.0 volt would be desirable but in its absence a copper-oxide rectifier voltmeter can be used, inasmuch as the calibration frequency will be 9.2 kc.

7.424 Set the FREQ RANGE switch and the main tuning dial for the lowest possible frequency (i.e., 9.2 kc) and adjust the CARRIER control until the calibrated voltmeter indicates 1.0 volt. The actual adjustments in R-18 and R-22 can now be made.

7.425 Turn the CARRIER control as far counterclockwise ↶ as it will go and adjust R-22 until the indicating meter points to the left-hand index. Next set the CARRIER control so that the calibrated voltmeter reads 1.0 volt and adjust R-18 until the needle points to the right-hand index. Since the adjustment of R-18 and R-22 are not completely independent, the setting of each should be checked a second time and readjusted if necessary.

7.5 ADJUSTING PERCENTAGE MODULATION

7.51 The design of the Separator circuit is such that the percentage of modulation is 30% when the V-T Voltmeter indicates that 1 volt of carrier voltage is being applied to the Attenuator and when the Modulation (audio) Oscillator is delivering 3.9 volts across the output terminals of R-24. When so adjusted the actual value of percentage modulation will fall well within the specified limits of 25% to 35%.

7.52 To adjust the modulation percentage, therefore, it is merely necessary to connect a high-resistance copper-oxide rectifier voltmeter between the blade of R-24 and the shield and to then adjust R-24 until 3.9 volts are obtained.

7.53 While the method for determining the percentage of modulation is by no means the most precise method known, the accuracy obtainable is more than adequate. The same method has been used in commercial standard-signal generators for many years. The same statement about absolute accuracy of the percentage modulation as was made for the accuracy of the carrier-frequency input voltage, PAR. 5.66 applies here.

7.54 The accuracy of the percentage modulation enters directly into the accuracy of the carrier voltage in measurements on receivers designed for modulated-wave reception. For this reason it is always well to verify the Modulation Oscillator voltage (PAR. 7.52) whenever particularly accurate measurements are being made.

7.6 MAINTENANCE OF EQUIPMENT

7.61 GENERAL

7.611 The Model LN equipment is, functionally, an assembly of the seven (7) basic elements mentioned in Section 5.00. Each element is itself an assembly of coils, capacitors, resistors, tubes and switches just as a radio receiver is made up from the same kind of parts. The first step should, therefore, be to localize the trouble, i.e., decide which element of the complete system has failed to function as it should. Once the search has been narrowed down to the power unit or vacuum-tube voltmeter or other element, the remainder of the process is simply one of locating the defective part or parts by means of voltage, resistance, and capacitance tests in the conventional way. Exactly the same technique should then be used as would be used in locating trouble in a receiver.

7.612 The trouble-shooting suggestions presented here will, therefore, consist of two parts: a "Test Procedure for Localizing Trouble" and a group of miscellaneous notes suggesting tests that can be applied in checking over any one element. No attempt can be made to list every conceivable defect that will cause trouble, but the logical procedure that has been suggested will enable the operator to run down even the most stubborn faults. It is essential that the operator be thoroughly familiar with the contents of this instruction book: PART 5 (Operating Principles), PART 6 (Operating Instructions), and the Wiring Diagram, in particular, and have a good basic knowledge of the conventional methods used in servicing radio equipment.

7.62 TEST PROCEDURE FOR LOCATING TROUBLE

7.621 The procedure suggested below is principally the information concerning the behavior of the vacuum-tube voltmeter, summarized in PAR. 5.56, and arranged in logical order for easy reference. It is assumed that the operator has before him the Model LN equipment and that, for some unknown reason, he is unable to secure a signal in a receiver connected in the prescribed manner (SEC. 6.6) to the clips at the end of the test lead. The receiver is known to be in working order; what is wrong with the Model LN equipment?

Note that the mere fact that the equipment appears to meet a given test successfully is not conclusive evidence that the operation is entirely normal, and, for that reason, the word "probably" is emphasized many times. This procedure will, however, localize any ordinary case of "dead instrument" and give the operator a basis for further tests.

7.622 Proceed no farther until both pilot lamps have been made to light, as evidence that the 110-volt supply mains, fuses, and at least a part of the power-supply system are in working order. See SEC. 7.68.

7.623 With FILAMENT OFF, PLATE OFF, MODULATION OFF, CARRIER in extreme counterclockwise position ↶, FREQUENCY RANGE properly set (Be Sure!) for any one of the seven (7) ranges: needle should be at or very close to right-hand index. If it is not, meter may be damaged, see SEC. 7.63.

7.624 Turn FILAMENT to ON, and as heaters warm up, the needle should move 1/8-inch or so to right. If it does, vacuum-tube voltmeter tube (V-3) has heater power and its cathode is emitting electrons; if not, see SEC. 7.63.

7.625 Turn PLATE to ON and needle should move to or very close to left-hand index. If it does, V-T Voltmeter circuit is probably OK and since it has plate power the plate-supply system in the Power Unit is probably OK; if not, see SEC. 7.63 and SEC. 7.68.

7.626 Apply carrier voltage (i. e. turn CARRIER clockwise ↷) and needle should move up-scale toward right-hand index. If it does, Carrier Oscillator (at least one range), Separator, and V-T Voltmeter circuits are probably OK; if not, continue with the next suggestion, PAR. 7.627.

7.627 Set FREQ RANGE switch successively for each range to see if operation (as in PAR. 7.626) is secured for all. If it is, the Carrier Oscillator and Separator are probably OK. Operation on some bands and not on others probably indicates a defect in Carrier Oscillator, inasmuch as the Separator and V-T Voltmeter are untuned and should respond at all frequencies if they respond at one. If there is complete failure, continue to PAR. 7.628.

7.628 Remove carrier voltage (CARRIER to extreme counterclockwise position) and turn MODULATION to ON. Meter needle should deflect to right by about 1/8 inch or so. If it does, Modulation Oscillator, Separator, and V-T Voltmeter are probably OK; if not, trouble is probably in Modulation Oscillator, especially if preceding tests have indicated that V-T Voltmeter and Separator operate satisfactorily when carrier voltage is applied.

7.629 If the instrument has met all of the foregoing tests in a satisfactory manner and there is still no output voltage at the end of the test lead, the trouble is in the Attenuator or the test lead. See SEC. 7.67.

7.63 V-T VOLTMETER

7.631 If preliminary tests have indicated that the V-T Voltmeter is inoperative, remove the Oscillator Unit from its cabinet and proceed with the following tests. No socket adaptor is available for the tube so that it will be necessary to identify the socket terminals from the sketch accompanying the Wiring Diagram. Note that the tube should be in its socket with the sharp end into socket pointing toward the shelf on which the socket is mounted. Remove the shield plate, if necessary, to get at the terminals of the socket or other components.

7.632 Test d-c voltages, with tube in its socket, PLATE and FILAMENT ON, and CARRIER turned as far counterclockwise ↶ as it will go. (Numbers refer to tube-socket terminals in the Wiring Diagram.)

a) Heater Voltage (1 to 5): 6.3 volts. (a-c)
b) Plate Voltage (2 to shield): 28.5 to 31.5 volts.
c) Plate Supply Voltage (3 on V-2 to shield): 152 to 168 volts.
d) Drop across R-22 (Junction of R-21 and R-22 to shield): 3.1 to 3.5 volts.

7.633 If voltages are OK, install new tube, replace shield and repeat the original test procedure (SEC. 7.62).

7.634 If vacuum-tube voltmeter is still inoperative, make a circuit continuity test with ohmmeter until defect is located. Turn OFF all power for this test.

7.635 <u>Meter:</u> Notes on the recalibration of the V-T Voltmeter (SEC. 7.4) tell how any possible drifts in the indicating meter or auxiliary circuit can be allowed for. The normal zero or no-current position of the needle is at the right-hand index when there are no plate or heater voltages applied. If, under this condition, the needle does not point to the right-hand index and it cannot be returned there by means of the "zero-adjust" screw (SEC. 7.4), the meter is probably damaged beyond any repair that the operator would be equipped to make.

7.64 SEPARATOR

7.641 If preliminary tests have indicated that the Separator is inoperative, remove the Oscillator Unit from its cabinet and proceed with the following tests. Use the 6-pin socket adaptor of the Model OE equipment.

7.642 Test d-c voltages with tube in position in analyzer PLATE and FILAMENT ON, CARRIER turned as far counterclockwise as it will go, and MODULATION OFF. (Numbers and letters refer to points noted on Wiring Diagram).

a) Heater Voltage (1 to 6): 6.3 volts (a-c)
b) Plate Voltage (2 to shield): 133 to 147 volts
c) Screen Voltage (3 to shield): 152 to 168 volts
d) Suppressor Grid Voltage (4 to shelf): 19 to 21 volts
e) Cathode Voltage (5 to shield): 19 to 21 volts
f) Control Grid (cap to shield): Zero

7.643 If voltages are OK, install new tube and repeat the original test procedure (SEC. 7.62).

7.644 If Separator is still inoperative, make a circuit continuity test with ohmmeter until defect is located. Turn OFF all power for this test.

7.65 CARRIER OSCILLATOR

7.651 If preliminary tests have indicated that the Carrier Oscillator is inoperative in all ranges, remove the Oscillator Unit from its cabinet and proceed with the following tests. Use the 5-pin socket adaptor of the Model OE equipment.

7.652 Test d-c voltages with tube in its position in analyzer and PLATE and FILAMENT ON. (Numbers refer to tube-socket terminals noted on Wiring Diagram.)

a) Heater Voltage (1 to 5): 6.3 volts (a-c)
b) Plate Voltage (2 to shelf): Varies between 0 and 160 volts, depending on setting of CARRIER control. Inserting socket adaptor may or may not cause circuit to stop oscillating. Repeat for all settings of FREQ RANGE switch, since this checks continuity of all plate coils.
c) Grid Voltage (3 to shield): Zero

7.653 With PLATE and FILAMENT OFF, measure between cathode terminal (4) and shield with ohmmeter. Should be between 475 and 525 ohms. This checks continuity of cathode-to-ground bias circuit.

7.654 If all voltages are OK, install new tube and repeat the original test procedure (SEC. 7.62).

7.655 If Carrier Oscillator is still inoperative, test all capacitors, all grid coils, and all settings of FREQ RANGE switch for continuity.

7.656 Erratic performance of the Carrier Oscillator (such as failure of the circuit to oscillate at some settings of the main tuning capacitor, C-5) in a given band is often difficult to trace. About all that can be done is to

a) Substitute a new tube.
b) Check operation of FREQ RANGE switch.
c) Make visual inspection of main tuning capacitor (C-5) for a defect.
d) Make visual inspection of the oscillator coil for the range in question.

7.657 Often, defects in the coil system can be suspected if a greater than normal amount of plate voltage (CARRIER control) is necessary in order to make a full 1 volt of carrier voltage appear across the V-T Voltmeter. Normal voltages can be checked in the following manner. With PLATE and FILAMENT ON, MODULATION OFF, and main tuning capacitor set at 0 divisions, adjust CARRIER CONTROL until V-T Voltmeter shows that 1 volt of carrier is being applied. The following table shows the normal d-c voltage that is obtained between the blade of the CARRIER control (R-3) and ground:

Ranges A, B, C, D, and E: Less than 30 volts.
Range F: Less than 50 volts.
Range G: 120 to 160 volts.

7.66 MODULATION OSCILLATOR

7.661 If preliminary tests have indicated that the Modulation (or Audio) Oscillator is inoperative, remove the Oscillator Unit from its cabinet and proceed with the following tests. Use the 5-pin socket adaptor of the Model OE equipment.

7.662 Connect an oxide-rectifier voltmeter between blade of R-24 and ground. This should read 3.9 volts with power on and MODULATION ON. If there is any voltage at all, it shows that the oscillator is in operating condition. See SEC. 7.5 for method of adjusting modulation percentage to the nominal value of 30%.

7.663 Test d-c voltages with tube in its position in analyzer, PLATE, FILAMENT and MODULATION ON, and CARRIER as far counterclockwise as it will go. (Numbers refer to tube socket terminals noted on Wiring Diagram.)

a) Heater Voltage (1 to 5): 6.3 volts (a-c)
b) Plate Voltage (2 to shield): 152 to 168 volts
c) "G" Terminal of T-1 to shield: 152 to 168 volts. This with test (b) checks continuity of both halves of primary winding.

7.664 If all voltages are OK, install new tube and repeat the original test procedure (SEC. 7.62).

7.665 If oscillator is still inoperative, make a continuity test of all wiring and circuit elements until the defect is located.

7.67 ATTENUATOR

7.671 If a carrier voltage of one volt can be applied to the input of the attenuator system (as indicated by the vacuum-tube voltmeter) and no signal voltage is available at the clips on the test lead, begin at the clips and work back toward the vacuum-tube voltmeter with an ohmmeter (PLATE and FILAMENT OFF).

7.672 Check test lead for continuity.

7.673 Inspect plug and output jack for visible defects.

7.674 Connect ohmmeter to test lead and measure internal output resistance of attenuator. Resistance should be 10 ohms for all settings of MULTIPLIER except "10,000" where it should be 50 ohms. If values do not check, either R-9 or MULTIPLIER system are faulty. Remove cabinet and check R-9. See note below about defective MULTIPLIER networks. If resistance shows open circuit on any or all MULTIPLIER points, look for defective switch (dirty contacts), defective output jack, or failure of MULTIPLIER unit or output jack to make contact with panel.

7.675 Remove cabinet and measure resistance of R-7 (450 ohms). Resistance of tube end of R-7 to shield should be 500 ohms for all settings of MICROVOLTS control. Measure resistance for all settings of MICROVOLTS control as check on operation of contact arms, dirty contacts, etc.

7.676 If tests thus far indicate some defect in the MULTIPLIER network (probably an open-circuited resistor), remove the shield surrounding the unit and carefully test each resistor individually without dismounting it. Faulty resistors in this unit cannot be repaired or replaced without special tools, and it is essential that the operator locate the fault so that he knows it to be one that he cannot repair himself.

7.68 POWER UNIT AND R-F FILTER

7.681 Defects in the Power Unit, interconnecting cable, or power wiring (including R-F Filter) in the Oscillator Unit are readily traced by progressive voltage tests supplemented by ohmmeter tests in the conventional manner. The method of procedure will be obvious after a study of the wiring diagram. The following miscellaneous suggestions may be helpful:

7.682 The open-circuit or no-load voltages measured at the output jack (J-3) on the Power Unit or at the oscillator end of the interconnecting cable should be approximately as follows: Numbers refer to numbers on wiring diagram.

a) Heater (13 to 14): 7.0 volts, approx. (a-c)
b) Plate (15 to 16): 320 volts, approx.
c) Plate (15 to cabinet): 320 volts, approx.
d) Plate (16 to cabinet): Zero

7.683 More reliable voltage tests of the power unit are made under load. Normal no-load plate voltages can, for example, be obtained when the cathode emission of the rectifier tube has fallen too low to deliver power under load. Full-load voltage measurements can be made without removing either unit from its cabinet by withdrawing the interconnecting cable plug one-eighth of an inch or so from the panel jack. If not withdrawn too far, neither circuit is broken and carefully insulated test prods can be inserted between the plug and the panel. TEST PRODS MUST NOT BE ALLOWED TO TOUCH EITHER THE PANEL OR THE METAL SHELL OF THE PLUG. Normal full load voltages are as follows:

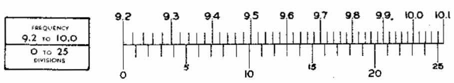
a) Heater (13 to 14): 6.3 volts (a-c)
b) Heater (13 to cabinet): 6.3 volts (a-c)
c) Plate (15 to 16): 160 volts
d) Plate (15 to cabinet): 160 volts

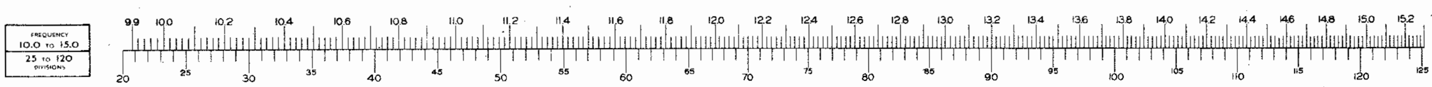
7.684 If it is suspected that the Oscillator Unit is not taking plate-supply current, a full-load voltage test can be made by connecting a 6000-ohm dummy-load-resistor across the testing voltmeter.

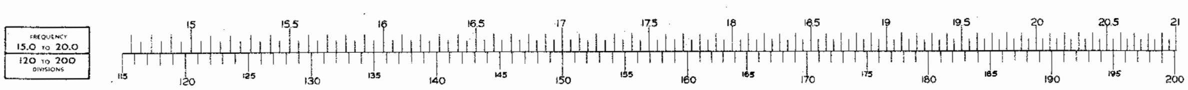
FREQUENCY

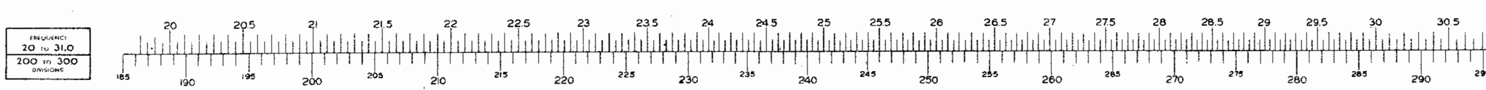
RANGES
ACEG

Accurate to within I
and units (kc or Mc)
ting of FREQ RANGE
on metal index.





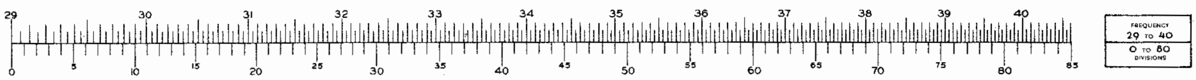


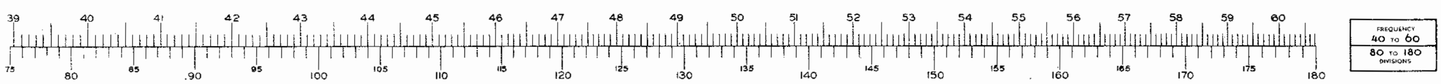


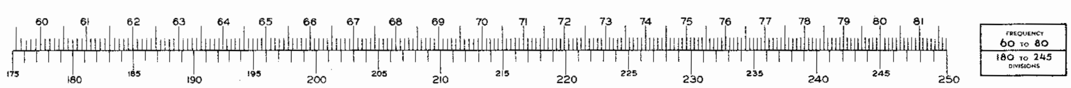
:ALIBRATION

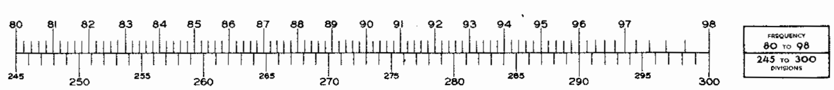
Locate decimal point
inspection from set-
;ch.   Read DIVISIONS

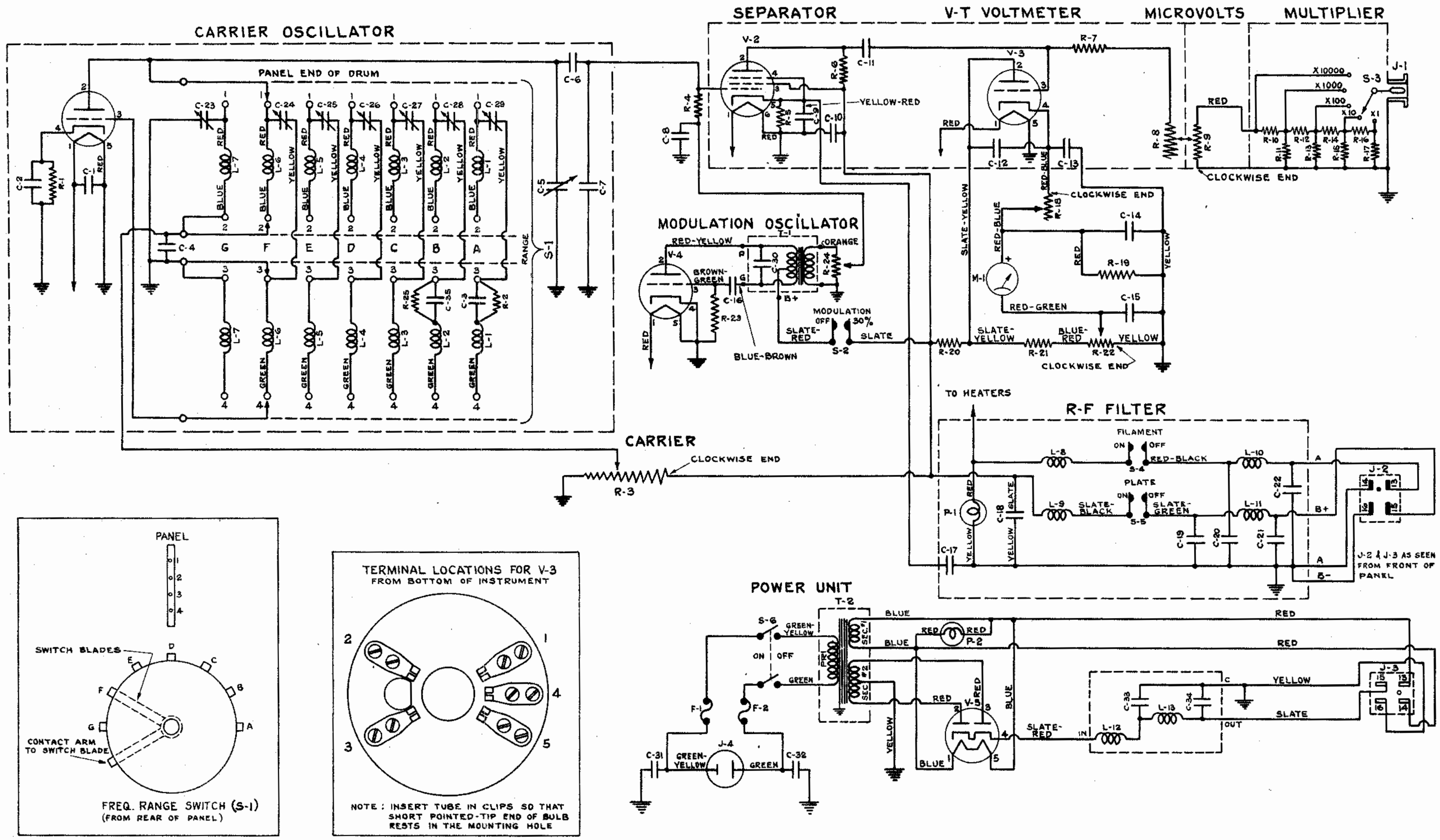
RANGES
BDF











WIRING DIAGRAM

PHOTOGRAPHS

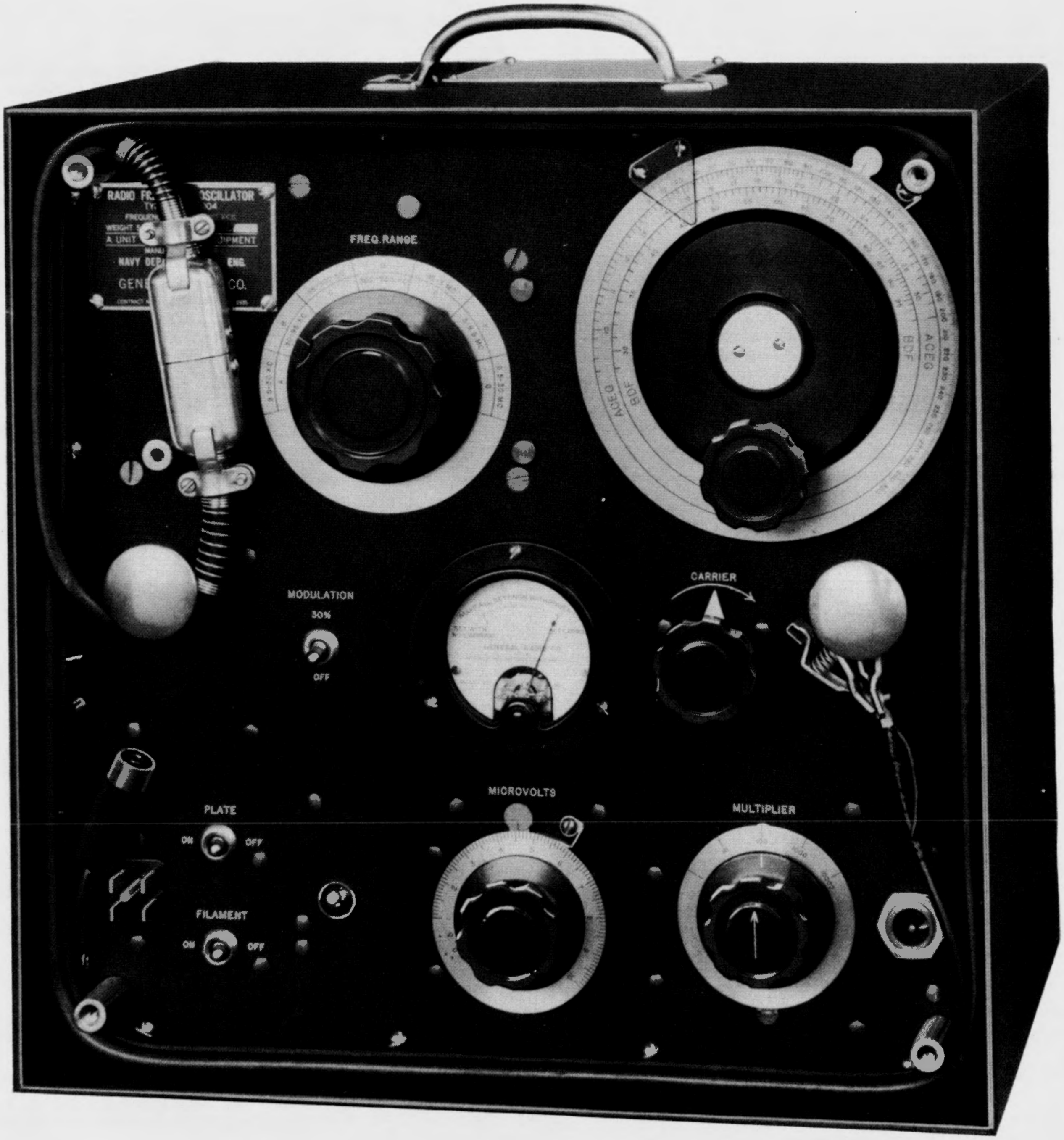


PHOTO 3. Oscillator Unit with cover removed to show method of stowing the cables.

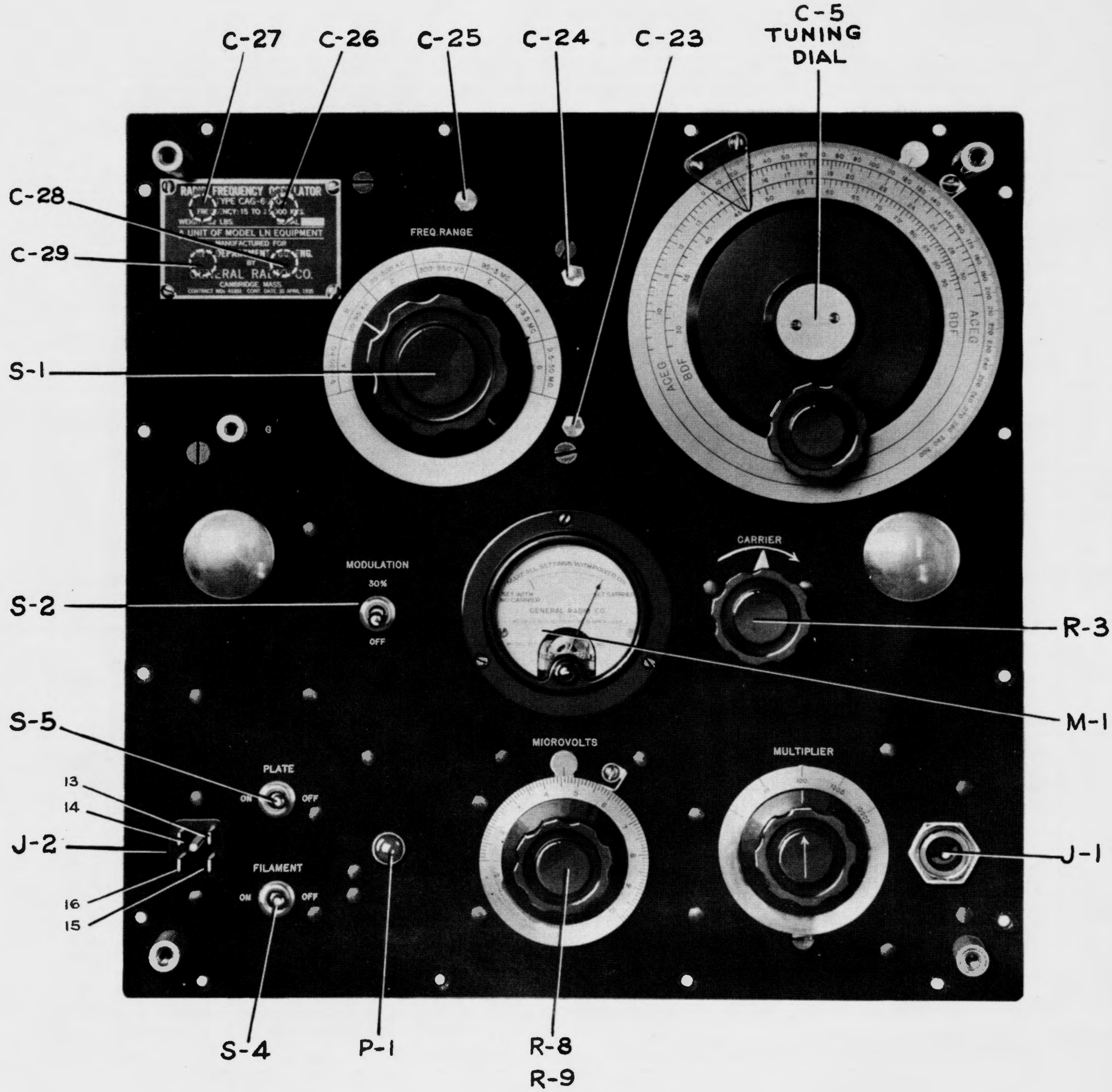


PHOTO 4. Panel view of Oscillator Unit with cabinet removed.

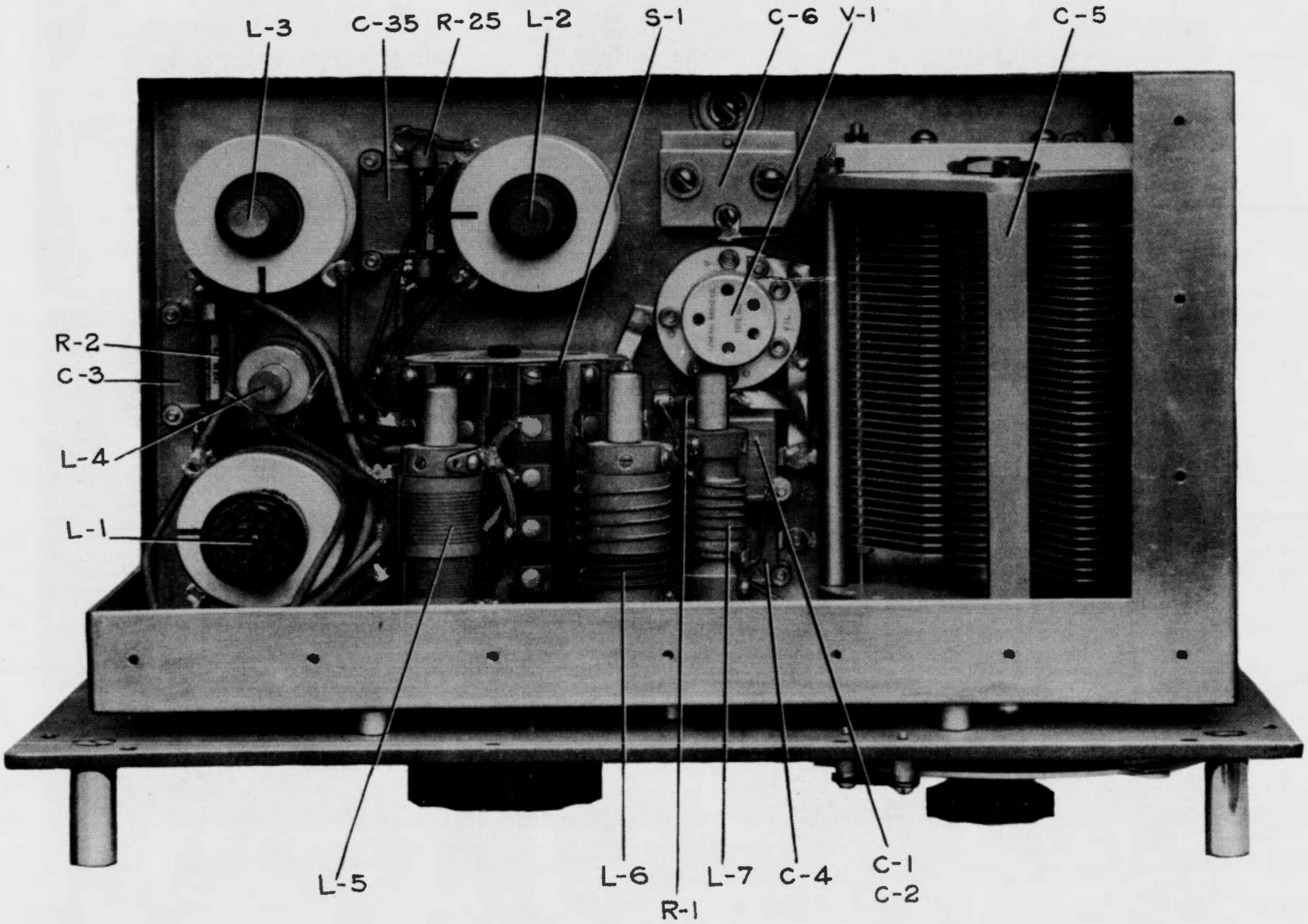


PHOTO 5. Interior of Oscillator Unit viewed from above.

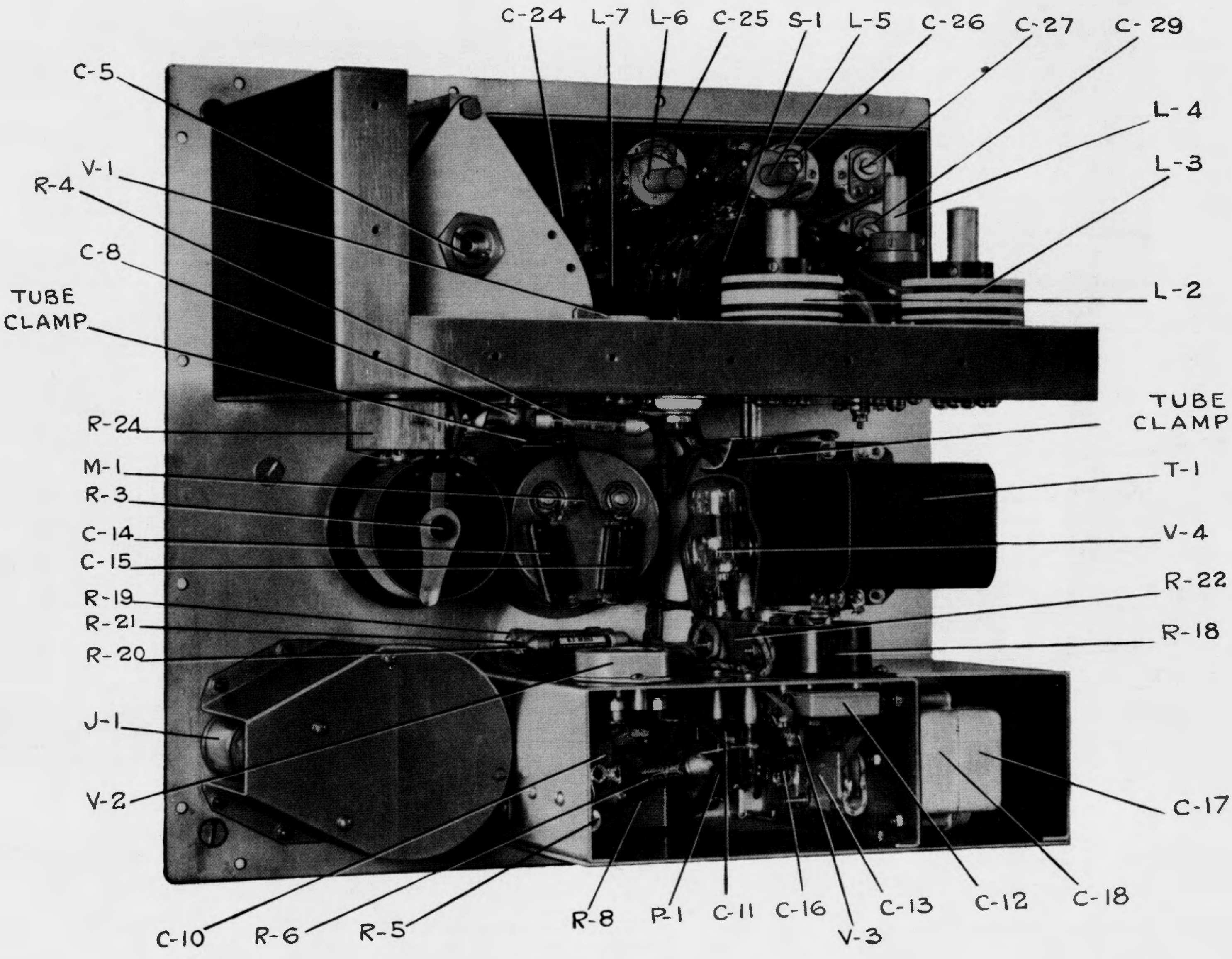


PHOTO 6. Rear view of Oscillator Unit from the left.

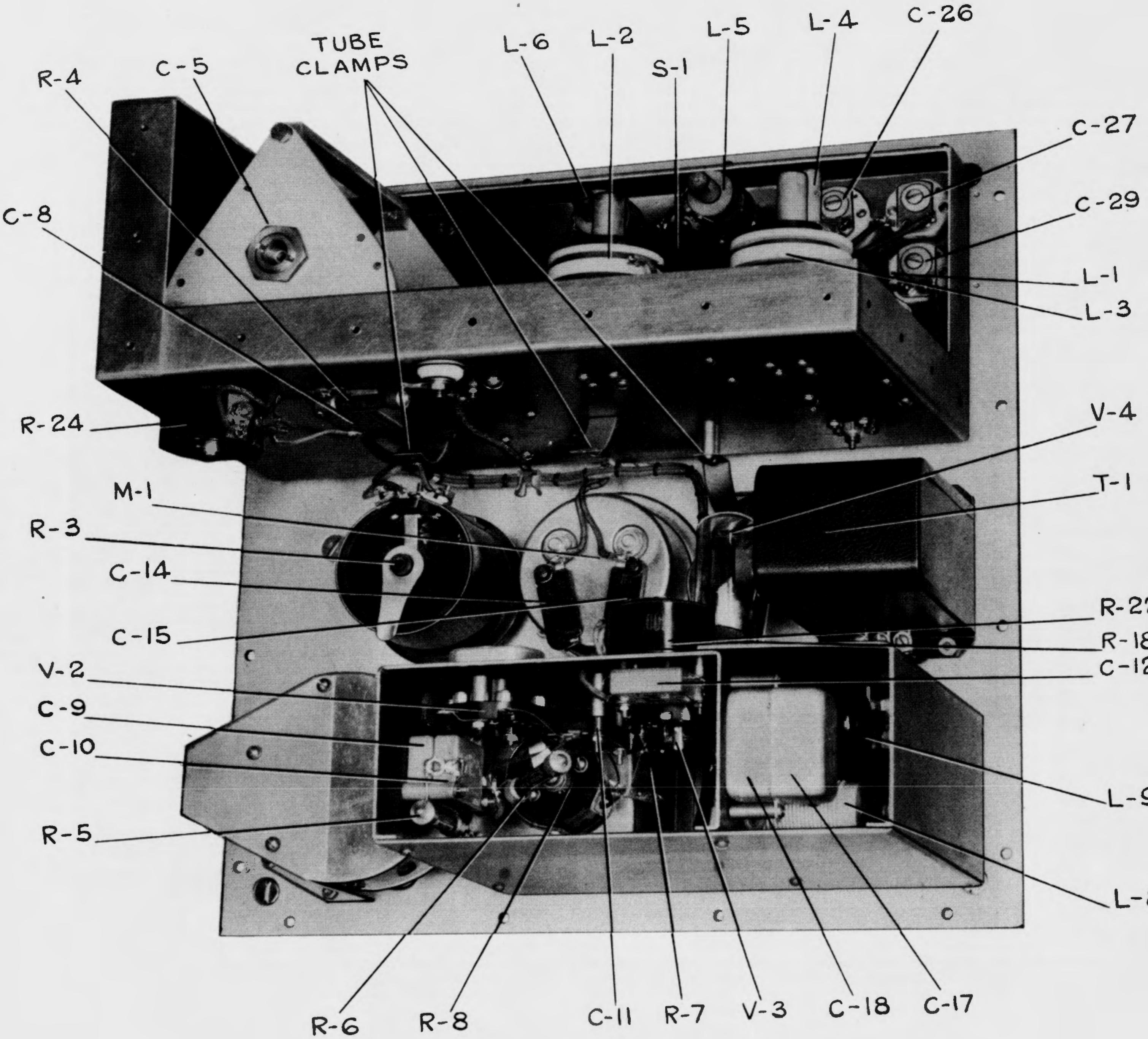


PHOTO 7. Rear view of Oscillator Unit from the right.

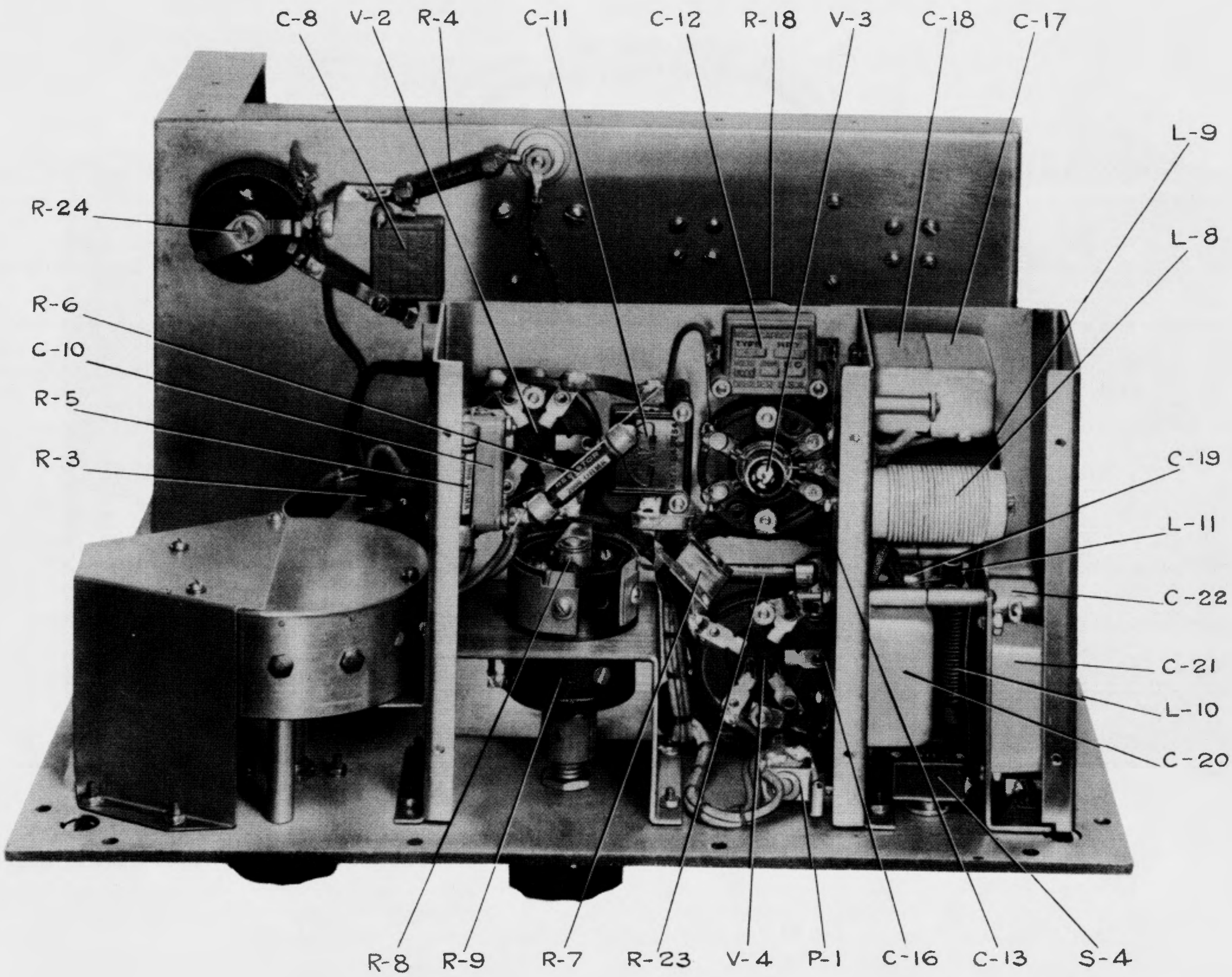


PHOTO 8. Oscillator Unit viewed from underneath. The shield plate has been removed.

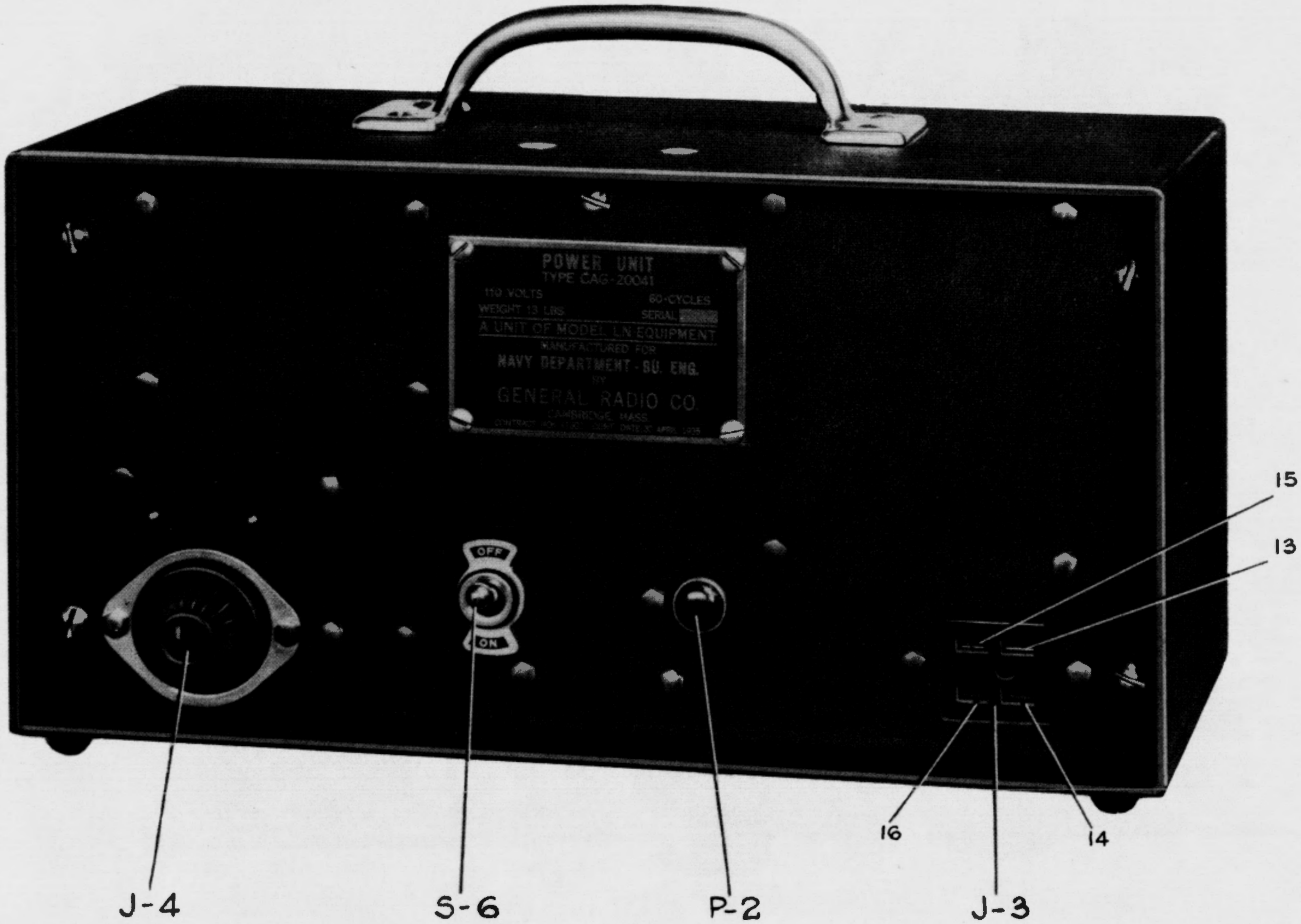


PHOTO 9. Power Unit showing front of panel and cabinet.

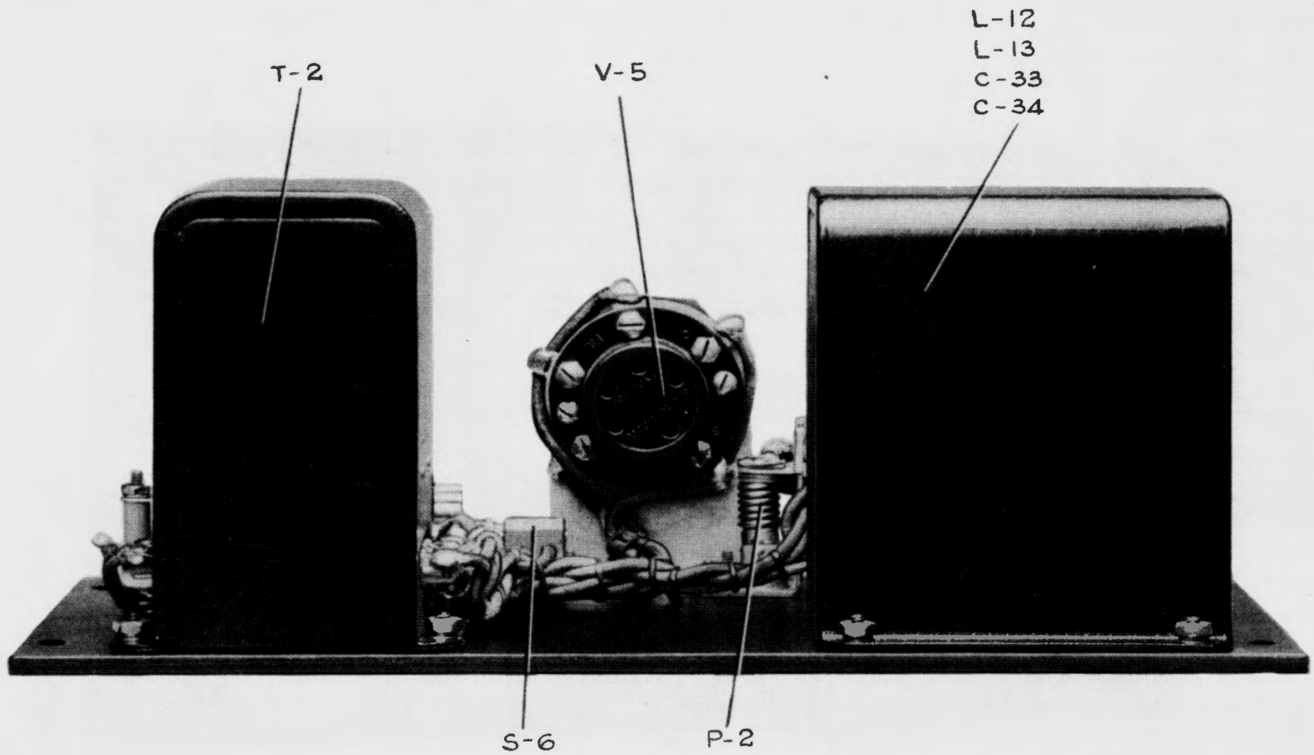


PHOTO 10. Interior of Power Unit viewed from above.

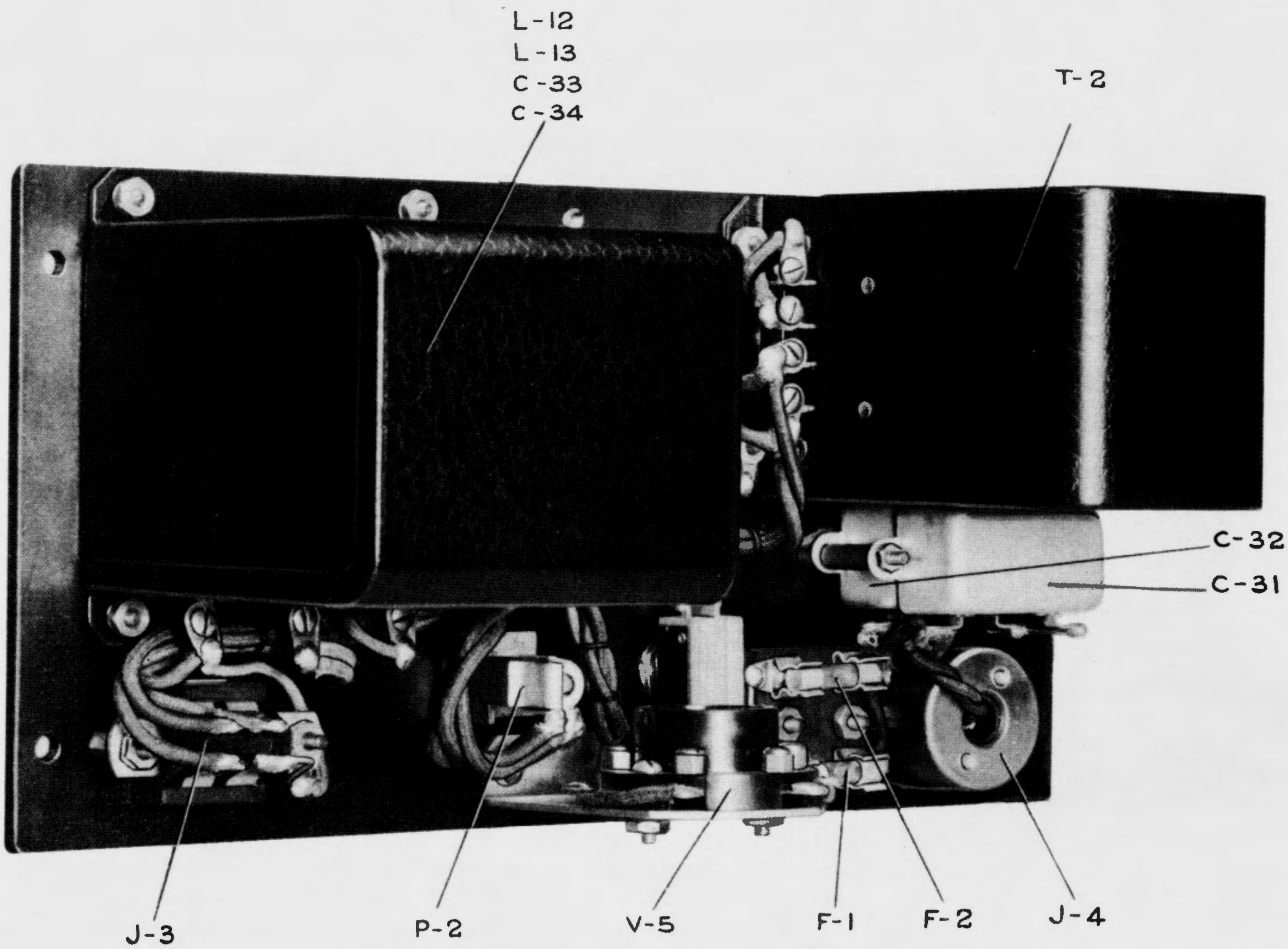


PHOTO 11. Rear view of Power Unit viewed from left.

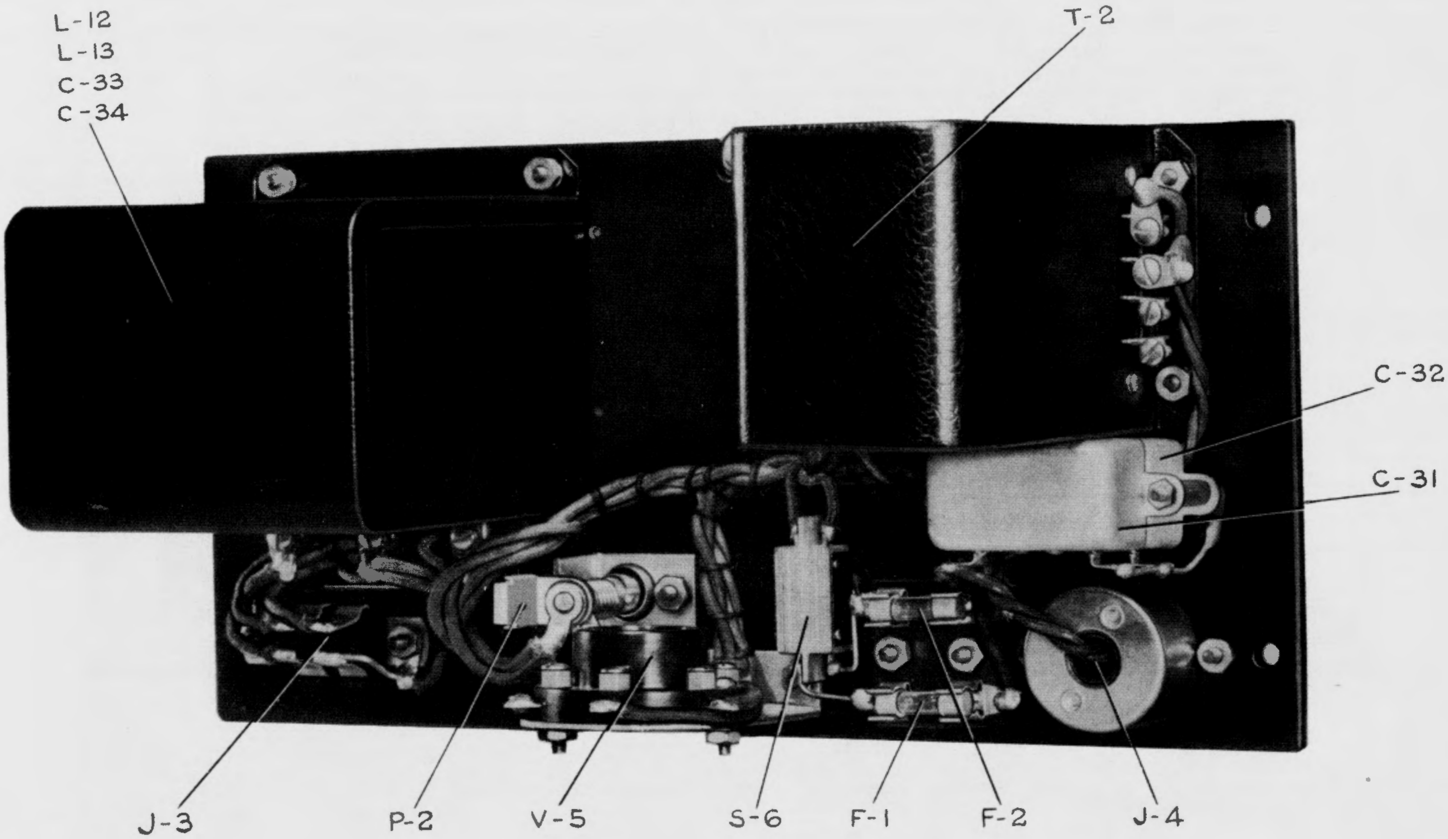


PHOTO 12. Rear view of Power Unit viewed from right.

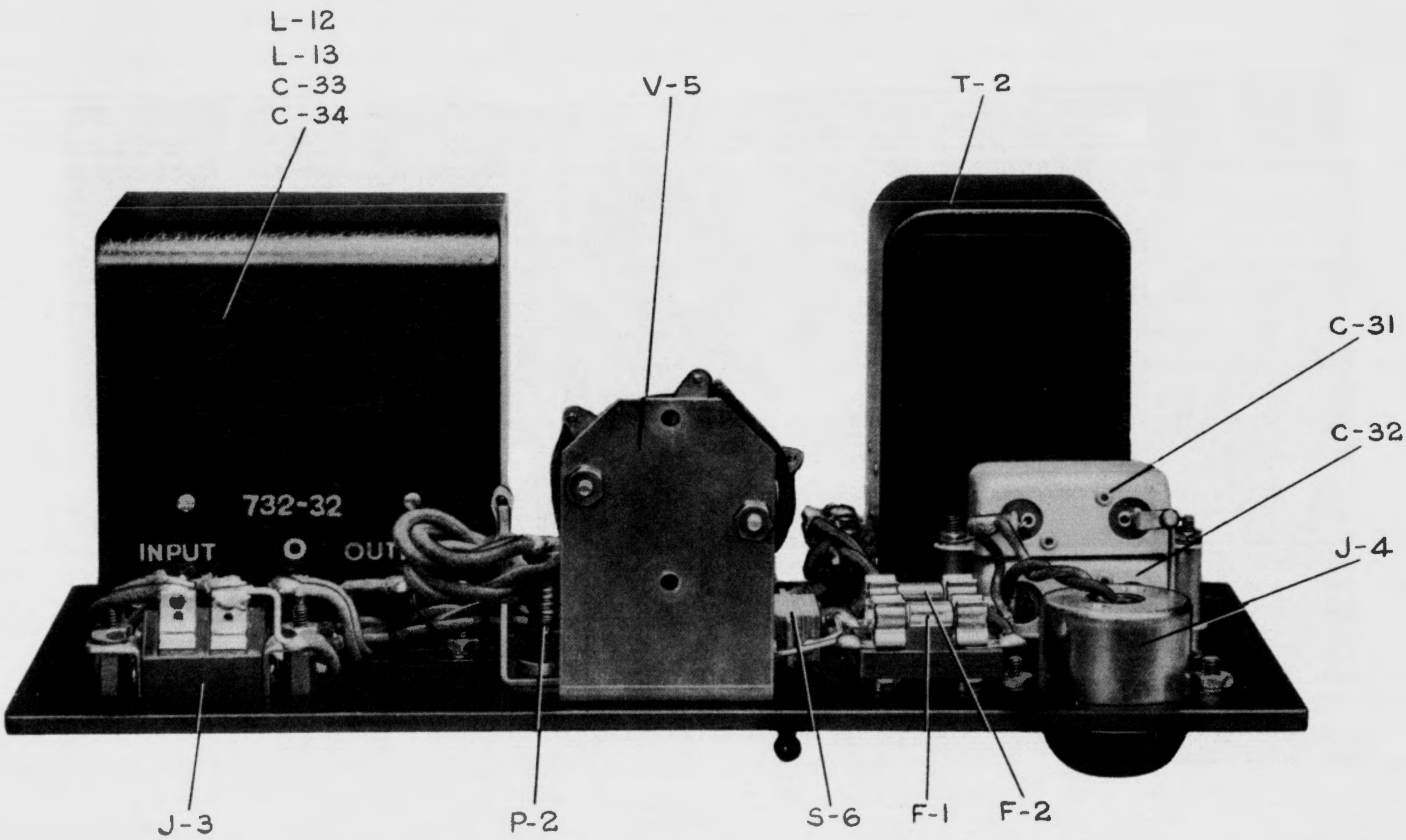


PHOTO 13. Power Unit viewed from below.

PARTS LIST

In the following list every part is given a separate symbol to correspond with the symbols used in the Wiring Diagram and in the Photographs. A quantity of one only of each item is called for unless otherwise noted.

CONDENSERS

Part No.	Cap.	Manufacturer's Name	Manufacturer's Part No.	Manufacturer's Drawing No.	Tolerance	Remarks
C-1	0.02 µf	DUB	4	—	±10%	
C-2	0.02 µf	DUB	4	—	±10%	
C-3	0.02 µf	DUB	4	—	±10%	
C-4	0.02 µf	DUB	4	—	±10%	
C-5	1400 µµf	GRCo	539-N1	539-7L	—	Main Tuning Condenser
C-6	25 µµf	GRCo	P-432-335	P-432-2D	±10%	
C-7	25 µµf	MICA	S	—	±10%	
C-8	0.02 µf	DUB	4	—	±10%	
C-9	0.02 µf	DUB	4	—	±10%	
C-10	0.02 µf	DUB	4	—	±10%	
C-11	0.005 µf	DUB	4	—	±10%	
C-12	0.02 µf	DUB	4	—	±10%	
C-13	0.02 µf	DUB	4	—	±10%	
C-14	0.002 µf	AERVX	1462	—	±10%	
C-15	0.002 µf	AERVX	1462	—	±10%	
C-16	0.02 µf	DUB	4	—	±10%	
C-17, C-18, C-19, C-20	0.5 µf	DUB	DA-4050	—	±10%	
C-21, C-22	0.5 µf	GRCo	P-432-309	P-432-3D	±10%	
C-23	10 µµf	GRCo	P-432-321	P-432-41	—	Trimmers
C-24, C-25, C-26	70 µµf	HAMD	IBT-70	—	—	Trimmers
C-27, C-28, C-29	10 µµf	GRCo	P-432-321	P-432-41	—	Trimmers
C-30	0.1 µf	GRCo	139-234	—	± 5%	In P-432-36 (T-1)
C-31, C-32	0.002 µf	DUB	4	—	—	
C-33	2 µf	GRCo	139-239	—	—	In 732-32
C-34	4 µf	GRCo	139-239	—	—	In 732-32. Two 2-µf units in parallel
C-35	0.02 µf	DUB	4	—	—	

RESISTORS

Part No.	Resistance	Manufacturer's Name	Manufacturer's Part No.	Manufacturer's Drawing No.	Tolerance	Remarks
R-1	500 Ω	IRC	F-1/2	—	±10%	
R-2	0.1 MΩ	IRC	F-1	—	±10%	
R-3	10 kΩ	GRCo	371-403-T	371-3L	±10%	
R-4	0.5 MΩ	IRC	F-1	—	±10%	
R-5	2 kΩ	IRC	F-2	—	±10%	
R-6	2 kΩ	IRC	F-2	—	±10%	
R-7	450 Ω	GRCo	P-432-34	P-432-30	± 1%	
R-8	50 Ω	GRCo	P-432-307	P-432-24	± 1%	Part of P-432-303
R-9	95 Ω	GRCo	P-432-306	P-432-24	± 1%	Part of P-432-303
R-10, R-11	95 Ω, 11.4 Ω	GRCo	P-432-320	P-432-22	1%	In P-432-38
R-12, R-13	99 Ω, 12.2 Ω	GRCo	603-321	603-36	± 1%	In P-432-38
R-14, R-15	99 Ω, 12.2 Ω	GRCo	603-321	603-36	± 1%	In P-432-38
R-16, R-17	99 Ω, 11 Ω	GRCo	603-322	603-36	± 1%	In P-432-38
R-18	10 kΩ	GRCo	301-417	301-5L	—	
R-19	10 kΩ	IRC	F-2	—	±10%	
R-20	0.1 MΩ	IRC	F-1	—	±10%	
R-21	20 kΩ	IRC	F-2	—	±10%	
R-22	2500 Ω	GRCo	301-416	301-5L	±10%	
R-23	0.5 MΩ	IRC	F-1	—	±10%	
R-24	2500 Ω	GRCo	301-416	301-5L	±10%	
R-25	100 kΩ	IRC	F-1	—	±10%	

INDUCTORS

Part No.	Service	Manufacturer's Name	Part No.	Drawing No.	Remarks
L-1	R-F Tune	GRCo	P-432-341	P-432-31	
L-2			P-432-342	P-432-31	
L-3			P-432-343	P-432-31	
L-4			P-432-344	P-432-32	
L-5			P-432-345	P-432-32	
L-6			P-432-346	P-432-32	
L-7			P-432-347	P-432-32	
L-8	R-F Filter	GRCo	P-342-315	P-432-29	
L-9	R-F Filter	GRCo	379-400	379-3L	
L-10, L-11	R-F Filter	GRCo	P-342-316	P-432-29	
L-12, L-13	Hum Filter	GRCo	732-32	732-8	Includes C-33 and C-34

JACKS, RECEPTACLES, BINDING POSTS, ETC.

Part No.	Service	Manufacturer's Name	Part No.	Drawing No.	Remarks
J-1	Output	GRCo	P-432-313	—	Part of P-432-38
J-2	Osc. Inter.	GRCo	P-432-301	P-432-22	Oscillator Intercon- nection
J-3	Pow. Inter.	GRCo	P-432-78	P-432-27	Power Unit Intercon- nection
J-4	110 v.	HUB	9808	—	Base
Ground Post		GRCo	138-XB	138-8	Chromium Plate

TRANSFORMERS

Part No.	Service	Manufacturer's Name	Part No.	Drawing No.	Remarks
T-1	Modulation	GRCo	P-432-36	P-432-11	Includes C-30
T-2	Power	GRCo	P-432-31	P-432-12	

CABLES

Part No.	Service	Manufacturer's Name	Part No.	Drawing No.	Remarks
K-1	Power Inter.	GRCo	P-432-35	P-432-10	
K-2	Output	GRCo	P-432-324	P-432-44	

TUBES

Part No.	Navy Type	Manufacturer's Name	Type No.	Drawing No.	Remarks
V-1	38076	RCA	76	—	Carrier Osc.
V-2	38089	RCA	89	—	Separator
*V-3	-	RCA	955	—	Voltmeter
V-4	38076	RCA	76	—	Modulation Osc.
V-5	38184	RCA	84	—	Rectifier

*One spare supplied.

METERS

Part No.	Range	Manufacturer's Name	Part No.	Drawing No.	Remarks
M-1	150-0-50 μa	WEST	—	—	See note below
Meter Shield		GRCo	P-432-39	P-432-21	

NOTE: Weston Electrical Instrument Corporation Model 301, 150-0-50 microamperes, S-29006, SO-51450.

VACUUM TUBE SOCKETS

Part No.		Manufacturer's Name	Part No.	Drawing No.	Remarks
(V-1)	5-Pin	GRCo	658	—	
(V-2)	6-Pin	GRCo	444	—	
(V-3)	5-Acorn	HAMD	3-900	—	
(V-4)	5-Pin	GRCo	438	438-3	
(V-5)	5-Pin	GRCo	438	438-3	

FUSES

Part No.	Rating	Manufacturer's Name	Part No.	Drawing No.	Remarks
F-1	1 a	BUSS	7-AG	—	
F-2	1 a	BUSS	7-AG		
Fuse Block		GRCo	139-22	139-13L	

SWITCHES

Part No.	Service	Manufacturer's Name	Part No.	Drawing No.	Remarks
S-1	Freq.	GRCo	659-B1		
S-2	Mod.Osc.	HUB	8480-G	—	With D-15722 Dress Nut
S-3	Mult.	GRCo	P-432-314	—	Part of P-432-38
S-4	Fil.	HUB	8480-G	—	With D-15722 Dress Nut
S-5	Plate	HUB	8480-G	—	With D-15722 Dress Nut
S-6	Line	ARROW	20902-D	—	With #20983 Dress Nut
Switch Plate		GRCo	139-155	139-18	For use with S6

PILOT LAMPS

Part No.	Voltage	Manufacturer's Name	Manufacturer's Part No.	Manufacturer's Drawing No.	Remarks
P-1	6 v	GElec	Mazda 40	—	GR Part 139-330
P-2	6 v	GElec	Mazda 40	—	GR Part 139-330
Light Socket		YAX	A-14	—	2 Required GR Part 139-328
Light Cap		WElec	4-D	—	2 Required GR Part 139-329
Light Bracket Osc.		GRCo	139-513	139-45	
" " Power Unit		GRCo	139-120A	139-22	

CABINETS, PANELS, NAME PLATES

Part	Manufacturer's Name	Manufacturer's Part No.	Manufacturer's Drawing No.	Remarks
Oscillator Cabinet	GRCo	P-432-311	P-432-1	
Osc. Cabinet Cover	GRCo	P-432-312	P-432-25 P-432-14	
Power Unit Cabinet	GRCo	P-432-30	P-432-2	
Oscillator Panel	GRCo	P-432-80	P-432-4	
Power Unit Panel	GRCo	P-432-84	P-432-3	
Equip. Name Plate	GRCo	P-432-802	P-432-16	
Osc. Name Plate	GRCo	P-432-801	P-432-15	
Power Unit Name Plate	GRCo	P-432-88	P-432-15	

DIRECTORY OF MANUFACTURERS

KEY	MANUFACTURER	ADDRESS
AERVX	Aerovox Corporation - - - - - - - -	70 Washington Street, Brooklyn, New York.
ARROW	Arrow, Hart & Hegeman Electric Co.	103 Hawthorne Street, Hartford, Connecticut.
BUSS	Bussman Manufacturing Company - - -	St. Louis, Missouri.
DUB	Cornell-Dubilier Corporation - - -	4377 Bronx Boulevard, New York City.
GElec	General Electric Company - - - - -	1 River Road, Schenectady, New York.
GRCo	General Radio Company - - - - - - -	30 State Street, Cambridge, Massachusetts.
HAMD	Hammarlund Manufacturing Co. Inc. -	424-438 West 33rd Street, New York City.
HUB	Harvey Hubbell, Inc. - - - - - - -	Bridgeport, Connecticut.
IRC	International Resistance Company -	401 North Broad Street, Philadelphia, Penna.
MICA	Micamold Radio Corporation - - - -	1087 Flushing Avenue, Brooklyn, New York.
RCA	RCA Radiotron Company, Inc. - - - -	415 So. 5th Street, Harrison, New Jersey.
WElec	Western Electric Company - - - - -	Hawthorne Station, Chicago, Illinois.
WEST	Weston Elec. Instrument Corporation	Newark, New Jersey.
YAX	Yaxley Manufacturing Company - - -	Indianapolis, Indiana.