PRELIMINARY INSTRUCTIONS

FOR

FREQUENCY METER SET SCR-211-M

MANUFACTURED BY

BENDIX RADIO

DIVISION OF BENDIX AVIATION CORPORATION

PRO PATRIA VIGILANS

RESTRICTED

PUBLISHED BY AUTHORITY

OF

THE CHIEF SIGNAL OFFICER

Order Numbers
3666-Phila-42
4675-Phila-42
17134-Phila-42

November 13, 1942

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SAFETY NOTICE

THIS EQUIPMENT IS EXTREMELY ACCURATE AND SENSITIVE AND SHOULD BE HANDLED AS A PRECISION INSTRUMENT. UNDER NO CIRCUMSTANCES SHOULD THE ANTENNA TERMINAL OF FREQUENCY METER BC-221-M BE DIRECTLY CONNECTED TO ANY PART OF THE RADIO TRANSMITTER OR RADIO RECEIVER BEING MEASURED. DO NOT TIGHTEN THE DIAL LOCK MORE THAN NECESSARY. EXCESSIVE TIGHTENING WILL CAUSE THE DIAL SETTING TO BE DISTURBED.

TABLE OF CONTENTS

SECTION I

DESCRIPTION

SECTION II

EMPLOYMENT

SECTION III

FUNCTIONING OF PARTS

SECTION IV

MAINTENANCE

TABLE OF CONTENTS *(continued)*

SECTION IV

MAINTENANCE *(continued)*

SECTION V

SUPPLEMENTARY DATA AND LIST OF REPLACEABLE PARTS

LIST OF ILLUSTRATIONS

FIGURE 1 — FREQUENCY METER SET SCR-211-M, COMPONENTS

FREQUENCY METER SET SCR-211-M

SECTION I
DESCRIPTION

1. INTRODUCTORY.—Frequency Meter Set SCR-211-M, is designed to provide a simple, accurate, and reliable crystal calibrated frequency indicating equipment for use in both the laboratory and in the field. Since it is completely portable and self-contained, it is particularly adaptable for adjusting aircraft radio transmitters and radio receivers to any desired frequency in the range from 125 to 20,000 kcs.

2. COMPONENTS.—Each Frequency Meter Set SCR-211-M, as furnished under this order, consists of the following component units:

Quantity	Article	Weight, (Lbs.)
1	Frequency Meter BC-221-M; size over all; height 13.13″, width 10.13″, depth 9.44″; Includes: 1 Frequency Meter BC-221-M Chassis (wired) 1 Crystal Unit DC-9-M (in operating position) 1 Calibration Book MC-177-M (inside front door) 1 Wrench for Bristo #6 Set Screw (spare parts compartment) 1 Wrench for Bristo #8 Set Screw (spare parts compartment) 2 Sets of Vacuum Tubes (one set in service and one set in spare parts compartment)	10.77
1	Instruction Book for Frequency Meter Set SCR-211-M	
1	Bag BG-81-D	2.19
*0 or 1	Additional Spare Set of Vacuum Tubes (Packed in battery compartment)	
1	Strap ST-19-A	

* Order No. 3666-Phila.-42 and 4675-Phila.-42 have no additional sets of vacuum tubes supplied. Order No. 17134-Phila.-42 has one additional set of vacuum tubes supplied with each equipment.

3. ADDITIONAL EQUIPMENT REQUIRED.—The following equipment, not furnished on this order, is required to complete each Frequency Meter Set SCR-211-M:

QUANTITY	ARTICLE
1	Headset P-18 or P-20
12	Batteries BA-2 (6 in use, 6 spare)
8	Batteries BA-23 (4 in use, 4 spare)

4. TOTAL WEIGHT.—Frequency Meter Set SCR-211-M, ready for service with one set of batteries, weights 31¼ pounds.

5. POWER CONSUMPTION.—All power required for the operation of this equipment is supplied by the batteries listed in paragraph 3. The current drains at the specified voltage limits are as follows:

Filaments: 5.4 to 6.0 Volts, 0.8 to 0.9 Amp.

Plates: 121.5 to 135.0 Volts, 0.012 to 0.014 Amp.

These values are typical for operation with the HETerodyne OSCillator-XTAL CHECK-XTAL ONLY switch in the XTAL CHECK position, under which condition maximum plate current is drawn.

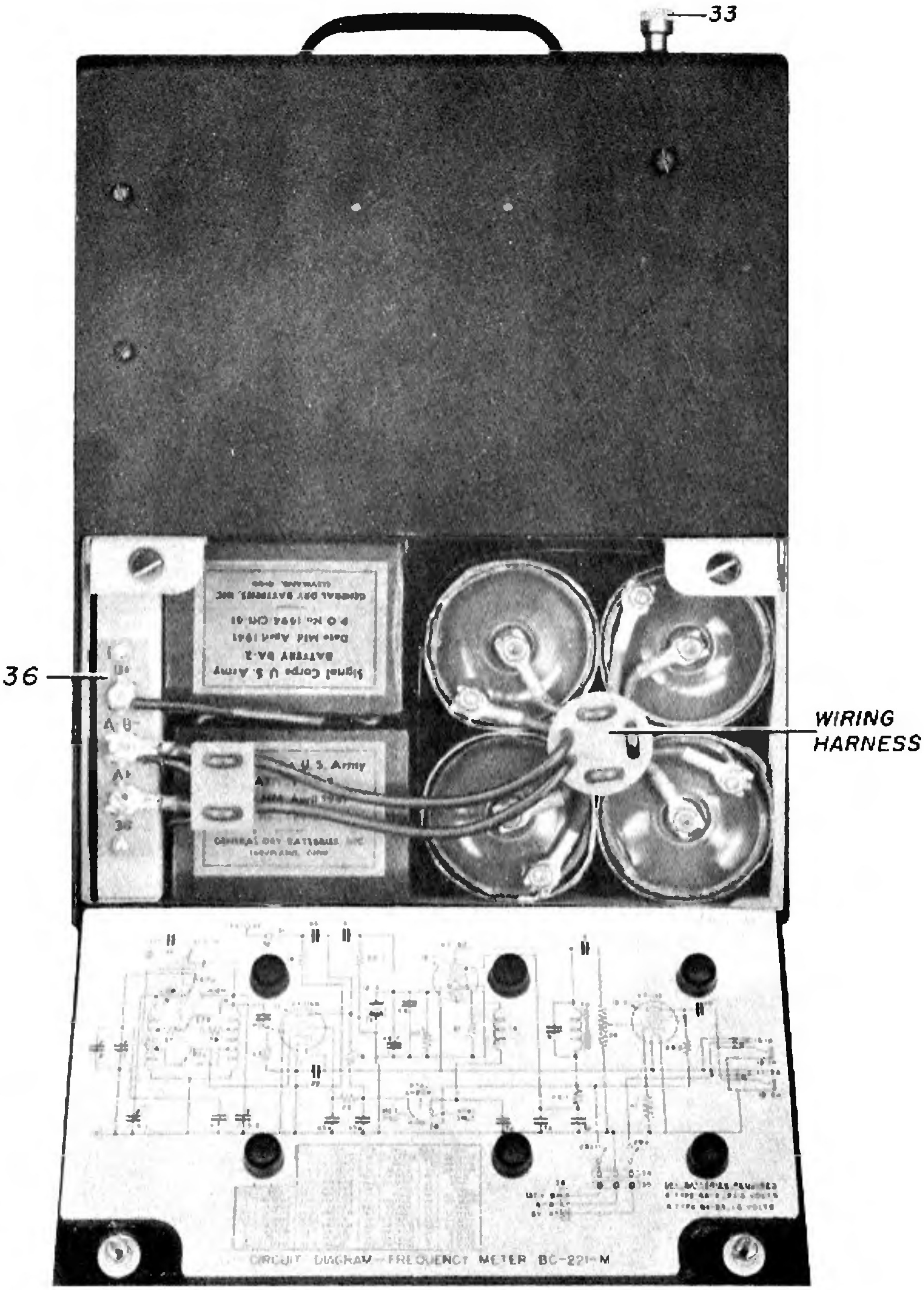


FIGURE 2—FREQUENCY METER BC-221-M, REAR VIEW SHOWING BATTERY COMPARTMENT

SECTION II

EMPLOYMENT

6. INITIAL PROCEDURE.—Frequency Meter BC-221-M is shipped, enclosed within the carrying bag, with all vacuum tubes inserted in their respective sockets and clamped. After unpacking, thoroughly inspect all compartments of the frequency meter cabinet for possible damage which may have occurred during shipment. Remove the second spare set of tubes if any, (contained in a carton in the battery compartment), upon receipt of the equipment and place in stock.

7. INSTALLATION.—*a. Batteries.*—Since this is a portable equipment, practically no installation is required. However, the batteries necessary for its operation must be installed before the equipment can be made ready for use. Remove the frequency meter chassis from the cabinet while connecting batteries.

Four batteries BA-23 and six Batteries BA-2 are required. Open the battery compartment in the lower rear of the frequency meter cabinet and loosen the binderhead screw on the right hand outer side in order to release the metal strap provided for securing the filament battery. Then insert the four Batteries BA-23 under the strap with their terminal posts facing the rear of the cabinet and push well forward. Before tightening the securing strap, hold the wiring harness in such a position that the two lugs of the main cables align with the A+ and A−/B− terminals on the battery terminal board, and position the four batteries so that their terminal posts match up with the individual battery lugs on the harness (see Figure 2).
Tighten the securing strap with the batteries in this position. Assemble the six Batteries BA-2 in two layers of three each, with the top layer inverted (after interconnecting their respective terminal leads in series). See that the minus and plus 135-volt leads are free for connection to their respective terminals on the terminal board. Insert the batteries in the cabinet, connect them to the terminal board, and install the filament battery wiring harness.

Prior to replacing the frequency meter chassis, check the battery connections for 6-volt and 135-volt meter readings, respectively, at the battery terminal board.

b. Antenna.—A short antenna must be provided for coupling to the receivers and transmitters which are to be adjusted. This should preferably be a rigid wire, such as No. 12 B. & S. hard drawn bus, not over 2 to 3 feet long. This wire should be secured to the antenna terminal on the top of of the frequency meter cabinet and so bent that its remote end will run parallel, and close, to the transmitter or receiver antenna lead. Where conditions will not permit this arrangement, such as in an airplane, a flexible insulated pick-up wire may be employed, with means provided to prevent its becoming a hazard during flight. One end should be skinned and secured to the antenna terminal on the frequency meter. Then, if the remote end is fitted with a completely taped test clip (jaws dulled), it will be possible to secure the lead at various coupling points, as desired, without grounding or contacting thereto. Under no circumstances should the antenna terminal of Frequency Meter BC-221-M be directly connected to any part of the transmitter or receiver being measured.

c. Headset.—Plug a Headset P-18 or P-20 in either PHONES jack; then turn the POWER switch ON and the HET. OSC.-XTAL CHECK-XTAL ONLY switch to XTAL CHECK. Allow the vacuum tube filaments to heat for at least 20 minutes. The equipment will then be ready for use.

8. OPERATION.—*a. Correcting to Calibration.*—(1) Before attempting to make any frequency adjustments, always correct the heterodyne oscillator to agree with the calibration through comparison with the crystal oscillator at the crystal check point nearest to the frequency desired. Comparison between the crystal and heterodyne oscillator may be made at many points over the calibrated range through the employment of the fundamental or harmonic frequencies of either or both oscillators. Comparison between the two oscillators is effected by rotating the heterodyne tuning control through a portion of the scale range corresponding to the crystal check point desired, and noting the beat tones as heard in the headset when plugged into either PHONES jack.

(2) To correct the heterodyne oscillator preparatory to setting on any desired frequency within the calibrated range, proceed as follows:

(a) From the HIGH or LOW frequency indices (pages 29 and 30) determine in which band the desired frequency is located, and set the FREQuency BAND switch to correspond.

(b) Also, from the frequency indices, ascertain on which page the desired frequency is listed, and turn thereto. The crystal check point nearest the desired frequency will be found noted in red at the bottom of this page, together with its dial setting.

(c) Set the heterodyne oscillator dials to agree with this crystal check point dial setting (POWER switch ON and HET. OSC.-XTAL CHECK-XTAL ONLY switch at XTAL CHECK). A beat-note should be heard in the headset, as a complete absence of beat-note can result only from three possible conditions, i.e., when the heterodyne oscillator is exactly on calibration; when it is so far off calibration that the beat-frequency is above audibility; and when the equipment is defective. However, if no beat-notes are heard, either of the first two of these conditions may be determined by rotating the CORRECTOR dial to where the beat-notes become audible, and noting the direction of change. If the third condition is the cause, no beat-notes should be heard at any point in the complete hererodyne oscillator range.

(d) With the heterodyne oscillator dial on the desired crystal check point setting, adjust the heterodyne oscillator frequency as close to the crystal oscillator frequency as possible, by rotation of the CORRECTOR dial only. After the operator has become familiar with the equipment, it will be found that this adjustment can be precisely made to practically zero beat. This is possible because the design is such that all "locking in" tendencies have been minimized, and characteristic "rushes" due to the rise and fall of the beat-frequency peaks are aurally recognizable well below the lower limit of audible tone.

b. Accuracy of Calibration.—When corrected as described in paragraph 8*a*, the heterodyne oscillator frequency will agree with the calibration throughout the range of frequencies to which this particular crystal check point applies, provided that; the ambient temperature does not vary by more than ±5°C; the filament voltage and plate voltage do not vary individually or collectively by more than ±10%; and the frequency measurements under any or all of the conditions stated above are made not later than 15 minutes after correction.

9. READJUSTMENT OF TRIMMER CAPACITORS.—It may be found that the heterodyne oscillator cannot be corrected to agree with the calibration as explained in paragraph 8*a*, particularly if the frequency meter is being used in a locality where either extreme condition of humidity prevails. Under such conditions, and then only, it becomes necessary to reset the heterodyne trimmer capacitors 3-1 and 3-2. Access to the trimmer adjusting screws may be obtained through the holes marked LOW and HIGH on the right hand wall of the frequency meter chassis after it has been removed from the cabinet. The chassis should be conveniently placed on a firm foundation to the right and in front of the cabinet, and the respective power input plugs and jacks should be interconnected with laboratory test leads. A small screwdriver will be required to make these adjustments, the necessary procedure being as follows:

a. Place the unit in operation, with the FREQuency BAND switch set to LOW. Allow at least ten minutes for warm-up before proceeding.

b. Set the DIAL UNITS and DIAL HUNDREDS scales to agree with the reading given for 250 kcs on Page 27 of the calibration book. Set the CORRECTOR dial at midscale (5.5 divisions).

c. After making sure that the dials are set correctly as in *b*, rotate the trimmer capacitor 3-1 toward the right with a small screwdriver, while listening in the headset, until the heterodyne oscillator is set to zero beat of a strong beat with the crystal calibrator.

d. Check the ability of the CORRECTOR capacitor to reset to zero beat at all crystal check points listed on pages 28 and 31 of the calibration book, proceeding as outlined in paragraph 8*a*.

e. If the unit cannot be corrected at all crystal check points in the low band with the trimmer adjustment that was made with the CORRECTOR dial set at 5.5 for 250 kcs, repeat the processes outlined in *c* and *d* with the CORRECTOR dial set to 6 divisions for 250 kcs.

f. By thus progressing, a setting of the low frequency trimmer will be found where it will be possible with the CORRECTOR capacitor to reset the unit to zero beat at all crystal check point readings given for the low band in the calibration book.

g. Repeat the above described processes with the FREQuency BAND switch set to the high frequency band and the DIAL UNITS and DIAL HUNDREDS scales set to agree with the reading given for 4000 kcs on Page 71 of the calibration book. Set the trimmer capacitor 3-2 to the position where it is possible with the CORRECTOR capacitor to reset to zero beat at all crystal check points listed for the high frequency band.

10. RADIO TRANSMITTER ADJUSTMENTS.—*a.* Briefly, the method of adjusting a radio transmitter to a desired frequency consists of zero beating the transmitter frequency with the proper heterodyne oscillator frequency, effecting the comparison by means of a headset plugged into one of the PHONES jacks located on the front panel of the frequency meter.

b. Specifically, the procedure is as follows:

(1) Correct the heterodyne oscillator to calibration

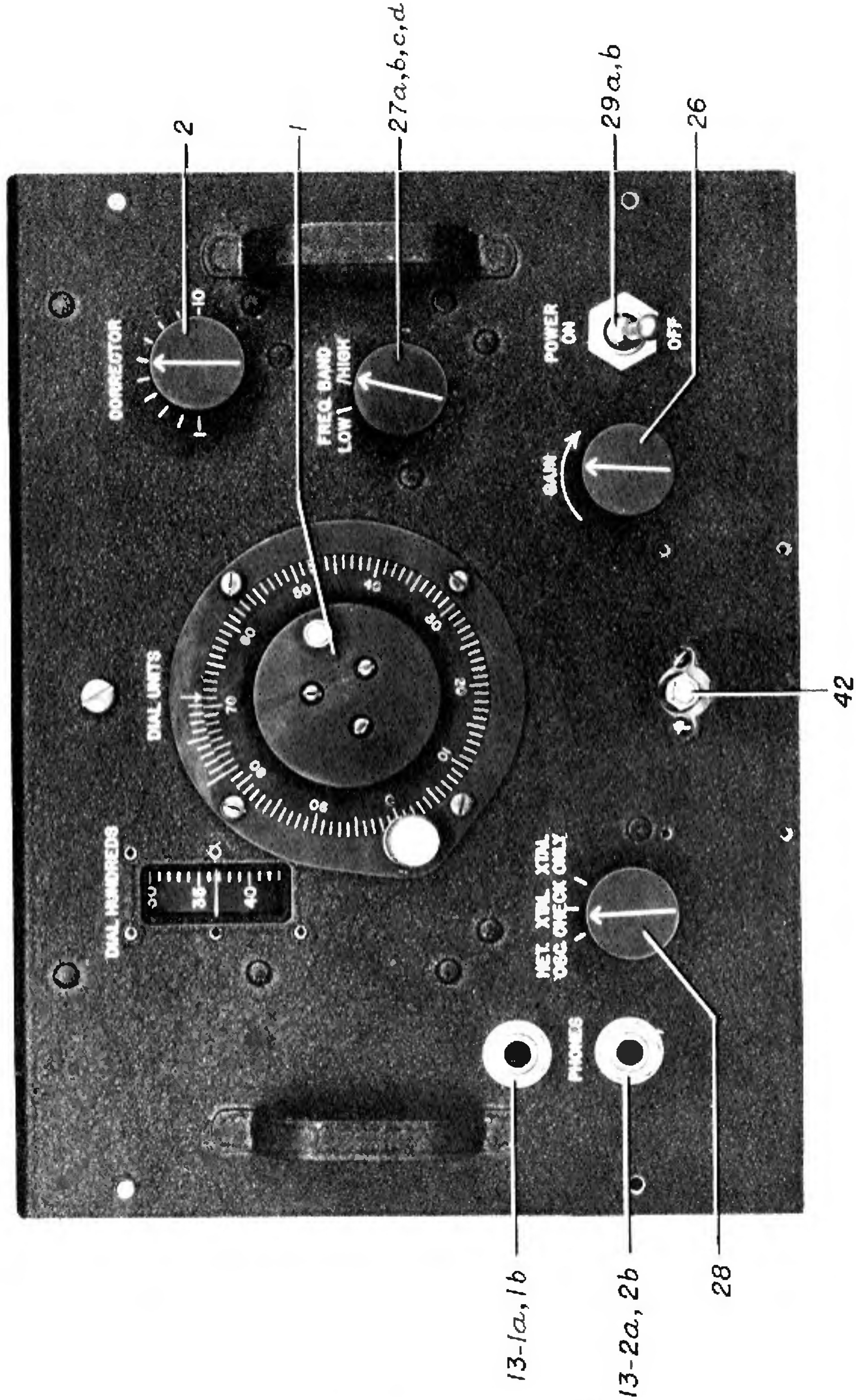


FIGURE 3 — FREQUENCY METER BC-221-M, CHASSIS, FRONT VIEW

at the crystal check point nearest to the desired frequency, as explained in paragraph 8*a*.

(2) Turn the HET. OSC.-XTAL CHECK-XTAL ONLY switch to HET. OSC.

(3) Turn the frequency meter tuning control to the dial setting of the desired frequency, as given in the calibration book. Do not disturb the CORRECTOR capacitor adjustment as made in (1).

(4) With the frequency meter antenna loosely coupled to the transmitter output, tune the radio transmitter to give an audible beat in the headset. The approximate frequency of the transmitter must be known or must be determined.

(5) Adjust the GAIN control to obtain a comfortable signal level in the headset.

(6) Tune the radio transmitter to zero beat with the frequency meter.

(7) Note: For greater accuracy, operations (2) to (6) should be accomplished in the shortest possible interval following operation (1), otherwise changes in voltage or temperature or both, may cause the frequency meter to drift.

11. RADIO RECEIVER ADJUSTMENTS.—*a.* The method of adjusting a radio receiver to a desired frequency consists of tuning it to the proper heterodyne oscillator output frequency, and effecting the comparison by means of a headset connected to the receiver output circuit. The method varies with the character of signal reception involved, as detailed in the following subsections (1) and (2):

(1) To tune a CW radio receiver to a desired frequency, proceed as follows:

(a) Correct the heterodyne oscillator to calibration at the crystal check point nearest the desired frequency as explained in paragraph 8*a*.

(b) Turn the HET. OSC-XTAL CHECK-XTAL ONLY Switch to HET. OSC., and change over to a separate headset connected to the receiver output jack. Be sure to leave the headset for the frequency meter unit inserted in one of the jacks provided, otherwise the filament circuit will be opened and the frequency meter rendered inoperative.

(c) Turn the frequency meter tuning control to the dial setting of the desired frequency, as given in the calibration book and lock the dial. Do not disturb the CORRECTOR capacitor adjustment as made in paragraph 11*a*(1)(a).

(d) With the frequency meter antenna loosely coupled to the radio receiver antenna lead, tune the radio receiver to give an audible signal.

(e) Adjust the radio receiver tuning to that side of zero beat which results in best reception conditions for the particular operator concerned.

(f) Note: The notation, paragraph 10*b*(7) applies to this and all other operations for which the frequency meter may be employed.

(2) To tune an MCW receiver to a desired frequency, the following procedure applies:

(a) Correct the heterodyne oscillator to calibration at the crystal check point nearest to the desired frequency, as explained in paragraph 8*a*.

(b) Turn the frequency meter tuning control to the dial setting of the desired frequency, as given in the calibration book. Do not disturb the CORRECTOR capacitor adjustment as made in paragraph 11*a*(2)(a).

(c) Turn the HET. OSC.-XTAL CHECK-XTAL ONLY switch to HET. OSC.

(d) Adjust a local unmodulated radio transmitter (capable of being modulated) to zero beat with the frequency meter, proceeding as outlined in paragraphs 10*b*(4), 10*b*(5), and 10*b*(6).

(e) Change over to a separate headset connected to the receiver output jack, modulate the radio transmitter output, and tune the receiver for maximum undistorted response. Be sure to leave the headset for the frequency meter unit inserted in one of the jacks provided, otherwise the filament circuit will be opened and the frequency meter rendered inoperative.

12. FREQUENCY MEASUREMENTS.—*a.* Frequency Meter Set SCR-211-M may also be employed for accurately measuring a frequency emitted from an external source, whether it be of local or remote origin, provided that such frequency lies within the calibrated range.

b. If it is desired to measure accurately the emitted frequency of an adjacent radio transmitter or oscillator, the frequency of which is approximately known, correct the heterodyne oscillator to the crystal check point nearest to the approximately known frequency, as explained in paragraph 8*a*. Determine the actual frequency (after loosely coupling the frequency meter antenna to the source and turning the HET. OSC.-XTAL CHECK-XTAL ONLY switch to HET. OSC.) by turning the frequency meter tuning control to the zero beat point found nearest the setting given for the approximate frequency, and read the actual frequency from the frequency column opposite the resultant dial setting in the calibration book.

c. If it is desired to measure accurately the emitted frequency of an adjacent radio transmitter or oscillator, the frequency of which is unknown, determine the approximate frequency with the aid of an absorption type wave-meter, following which, determine the actual frequency as explained in paragraph 12*b*.

d. When it is desired to measure accurately a frequency of remote origin, first tune the signal on a radio receiver, and note the approximate frequency from the radio receiver calibration. Correct the heterodyne oscillator to calibration at the crystal check point nearest thereto. Turn the HET. OSC.-XTAL CHECK-XTAL ONLY switch to HET. OSC. Loosely couple the frequency meter antenna to the radio receiver antenna lead, and turn the frequency meter tuning control until its signal is heard in the radio receiver headset. If the signal in question is CW in character, tune the receiver to zero beat, and tune the frequency meter to zero beat with the radio receiver. If the signal is modulated, first adjust the receiver for maximum response in the MCW condition, after which switch over for CW reception and tune the frequency meter to zero beat therewith. In both cases, the frequency read from the appropriate column in the calibration book (for the resultant frequency meter dial setting) is the frequency of the signal in question.

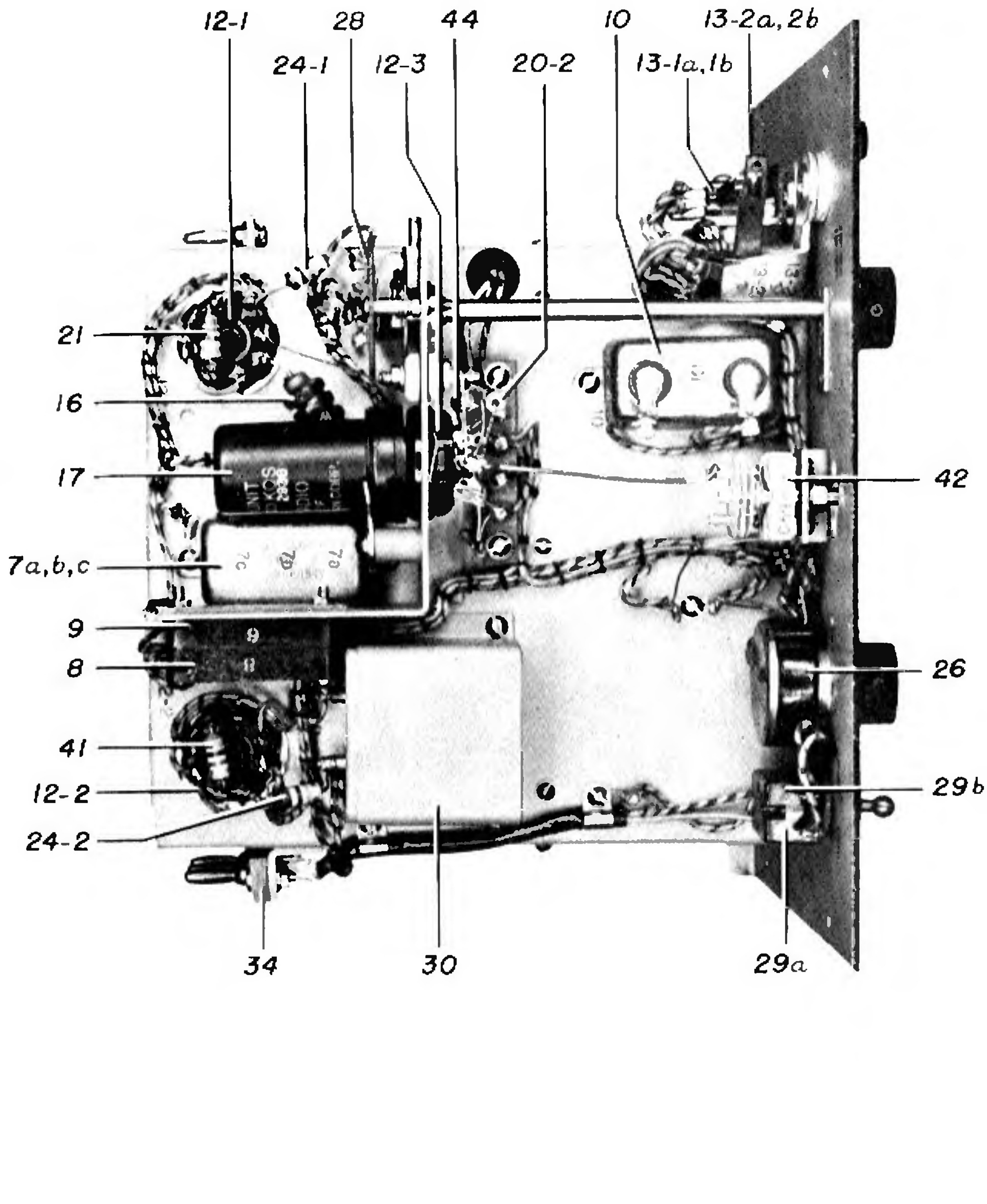


FIGURE 4 — FREQUENCY METER BC-221-M, CHASSIS, BOTTOM VIEW

SECTION III
FUNCTIONING OF PARTS

13. FREQUENCY METER BC-221-M.—*a*. Frequency Meter BC-221-M contains a crystal controlled oscillator used as a reference standard, a heterodyne oscillator having two fundamental tuning ranges which, with their useful harmonics, are calibrated to provide continuous coverage from 125 to 20,000 kcs; a high gain detector provided with means for coupling to each of three sources of excitation, and an audio frequency amplifier. There are eight operating controls, a POWER switch 29a–29b, which breaks both the filament and plate supplies; two output PHONES jacks, 13-1a and 13-2a with two filament supply switches 13-1b and 13-2b built integral therewith; a HET. OSC.-XTAL CHECK-XTAL ONLY oscillator switch 28; a two-position FREQuency BAND switch 27a, b, c, d for the heterodyne oscillator; the heterodyne oscillator worm and gear tuning control together with its DIAL UNITS and DIAL HUNDREDS scales; the CORRECTOR control; and the output GAIN control 26. All of these controls are mounted on the front panel of the frequency meter chassis, which is completely housed within the upper compartment of a portable aluminum cabinet in which batteries and spare parts are also carried. The removal of the nameplate from the front panel of Frequency Meter BC-221-M exposes the slotted shaft of the crystal trimmer capacitor 42, which can be adjusted if the accuracy of the crystal oscillator calibration is suspected. An antenna plug 31 and the 3-contact power input plug 34, on the chassis engage with corresponding jacks on the cabinet when the chassis is secured in place. The antenna jack 32 is connected directly to an antenna terminal post 33 on the top of the cabinet, and the power input jack 35 is connected through cabling to a battery terminal board 36 in a lower compartment. Provision is made for installing the batteries in this lower compartment, access to which may be had through a hinged door at the rear. Calibration Book MC-177-M is mounted within a dual hinged door assembly at the top front of the cabinet. This door covers the frequency meter panel when closed, and supports the calibration book at a convenient angle for use when opened (see Figure 5). The spare set of vacuum tubes and two special wrenches for the #6 and #8 Bristo setscrews used in the assembly of the equipment are stored in the spare parts compartment at the bottom front of the cabinet (see Figure 6). A rigid carrying handle is welded on the top of the cabinet and, in addition, suitable fixtures are fastened to the sides to permit the use of a carrying Strap ST-19-A. The external surfaces are finished in a durable black wrinkle enamel. Figures 1 to 11 inclusive, show the general construction, arrangement of parts, and overall dimensions.

b. The cathode, triode-grid and triode-plate of Tube VT-167 (see Figure 12) constitute the active elements of the crystal controlled oscillator which operates at a frequency of 1000 kcs when the HET. OSC.-XTAL CHECK-XTAL ONLY switch 28 is placed in the XTAL CHECK and XTAL ONLY positions. The circuit is of a design which generates considerable harmonic energy in order that it may be employed to calibrate the heterodyne oscillator at several points over its entire range. If the accuracy of the crystal oscillator calibration is suspected, the crystal frequency may be adjusted by trimmer capacitor 42. The compensation provided by capacitor 42 is augmented by fixed capacitor 44, inserted in the circuit parallel with trimmer capacitor 42. The necessary plate circuit impedance is built up across an untuned inductance 16, which is [redacted] thoroughly sealed against moisture. Likewise, the crystal unit 17 is supplied in a hermetically sealed and evacuated metal holder which provides permanent protection against humidity, corrosion and dirt intrusion. One of the smaller type metal tube envelopes is employed in the construction of this holder, so that it plugs into the standard octal tube socket 12-3 in mounting. The cut of the crystal and the internal construction of the holder are such that, under any conditions of barometric pressure, humidity, voltage, vibration, shock or tilt, only the specified output frequency and the harmonics thereof are obtained. The crystal is ground for operation at a normal temperature of plus 20°C. The temperature coefficient of the combined crystal, holder, and circuit, as expressed in percentage of the frequency is less than 0.0001 per cent per degree C as measured over an ambient range of 80°.

c. Tube VT-116B is used in an electron coupled circuit as the heterodyne oscillator (Figure 12). As previously stated, there are two continuously variable ranges which may be manually selected by the FREQuency BAND switch 27a-27b-27c-27d. In the low frequency position, a fundamental range of 125 to 250 kcs is employed; which by calibrating the first, second, fourth and eight harmonics, gives continuous coverage throughout the range from 125 to 2000 kcs. In the high frequency position of 27a-27b-27c-27d, a funda-

FUNCTIONING OF PARTS

mental range of 2000 to 4000 kcs is employed; which by calibrating the first, second, fourth and part of the fifth harmonics, gives continuous coverage throughout the range from 2000 to 20,000 kcs. The two inductors 14 and 15, in the tuned circuits, are wound on ceramic forms and thoroughly sealed against moisture. Tuning over both fundamental ranges is accomplished by a single variable capacitor 1, which is especially designed to have a low temperature coefficient, augmented by the variable corrector capacitor 2, the thermal compensator 4, inserted in the circuit parallel with capacitors 1 and 2, and the adjustable low and high frequency trimmer capacitors 3-1 and 3-2, respectively. The main tuning capacitor 1 is capable of continuous rotation in either direction without stops, and the dial assembly includes a 100/1 ratio worm gear drive mechanism so that 50 revolutions of the vernier dial are required for 180° rotation of the main scale (on the capacitor shaft). The main, or DIAL HUNDREDS scale is engraved with 50 divisions over its useful 180° sector and the DIAL UNITS scale is marked with 100 divisions over the entire 360°. The arrangement thus provides 5000 effective readable divisions, of which the calibrated ranges occupy approximately the portion between 250 and 4750 (see Figure 15). Backlash in the gear mechanism has been reduced to less than one-half of one division on the DIAL UNITS scale, and a dial lock is provided to prevent any accidental movement of the dial after the desired setting has been obtained.

d. The heterodyne oscillator circuits are calibrated at a temperature of plus 20°C, and the dial settings of the crystal check points are noted along the calibration. The temperature coefficient of each range of the heterodyne oscillator, expressed in percentage of frequency, is less than 0.008 per cent per degree C, as measured over a range of 80°C. The CORRECTOR capacitor 2, which is connected in parallel with 1, makes it possible to reset the heterodyne oscillator to agreement with the crystal calibration at any harmonic for any ambient temperature between the limits of minus 30° and plus 50°C. Thus, after the tube filaments have been lighted for at least 20 minutes, and the heterodyne oscillator has been corrected to the nearest crystal check point, the heterodyne oscillator frequency may be set and will not deviate more than 145 cycles at any point in the low frequency fundamental range nor more than 550 cycles or 775 cycles at the 2000-kc limit and the 4000-kc limit, respectively, of the high-frequency fundamental range under the most unfavorable combined influences due to ±5°C variations in ambient temperature within the range from −30° to +50°C, a −10% change in plate and/or filament voltage, errors in calibration, crystal grinding errors, and mechanical backlash, provided the heterodyne oscillator is corrected to the nearest crystal check point at intervals not exceeding 15 minutes.

e. It was previously stated that the triode portion (comprising the cathode, triode-plate and-grid) of the Tube VT-167 is used in the crystal oscillator circuit. The remaining elements of this tube, the hexode portion, (comprising the cathode, hexode grids, G1, G2, G3 and G4 and the hexode plate) are used as a high-gain screen-grid detector, to which, by structure, the crystal oscillator is electronically coupled. The r-f voltage developed across the load resistor 19 in the plate output circuit of the electron coupled heterodyne oscillator is coupled to the grid (G3) of this detector through a small fixed capacitor 5. The antenna plug 31, mounted on the chassis, is also coupled to the grid (G3) of the detector through the coupling capacitor 45 (in series with capacitor 5). As a result of these three coupling means, and dependent on the position of the HET. OSC.-XTAL CHECK-XTAL ONLY switch, the detector functions to mix the heterodyne oscillator output either with the fundamental and successive harmonics of the crystal oscillator, or with the radio transmitter frequency to be measured.

f. The detector plate works into an audio choke 30, which is bypassed by the capacitor 8, and the beat frequency voltages built up across it are coupled through capacitor 9 and the GAIN control potentiometer 26 to the control grid of Tube VT-116. The control grid of Tube VT-116 returns to ground through the potentiometer 26. The plate, screen grid and suppressor grid of Tube VT-116 return to the positive filament supply through the load resistor 24-2. The plate, screen grid and suppressor grid of Tube VT-116 are also coupled to the PHONES jacks 13-1a and 13-2a through capacitor 10, so that no d-c potentials are present in the output. The characteristics of the output circuit are such that either high-impedance (15,000 ohms) or low-impedance (2500 ohms) headsets may be used without any change-over adjustments being required.

g. The detector and audio amplifier combination is so designed that the output impressed across the phones is essentially a linear function of the input voltage for the output range of 1.0 to 6.0 milliwatts (beat frequency of 300 cycles). Regardless of whether the heterodyne oscillator is beating with energy from an external

FUNCTIONING OF PARTS

source of radio frequency or with the crystal calibrator, the following minimum outputs will be available:

Beat Note Frequency	Output
100 Cycles	2.8 Milliwatts
500 Cycles	6.0 Milliwatts
1000 Cycles	3.0 Milliwatts

h. It was previously stated that the antenna plug 31 is coupled to the grid (G3) of the detector through capacitors 45 and 5 respectively, in series. By further reference to Figure 12, it will be seen that the antenna plug 31 is also coupled directly to the heterodyne oscillator output through capacitor 45 alone. Thus, the antenna post 33 serves the dual purpose of a detector input terminal for the measurement of frequencies of external origin and of a heterodyne oscillator output terminal for use in calibrating receivers. When the unit is employed for the latter purpose, 2000 microvolts or more of radio frequency energy will be available between the antenna terminal and ground (the chassis) at any frequency within the calibrated range.

i. All power required for the operation of this unit is introduced through the battery terminal board 36. The common negative filament and negative plate battery leads are connected to the middle terminal thereof, which is grounded to the chassis. A fabricated wiring harness is provided for intercell and filament battery to terminal board connections. The section 29a of the POWER switch closes the positive 6-volt supply terminal (A+) to the vacuum tube filaments through the auxiliary switches 13-1b and 13-2b (when the headset plugs are inserted into the PHONES jacks); and section 29b connects the positive 135-volt supply terminal (B+) to all plate and screen circuits. Since the door assembly containing the calibration book cannot be closed when the headset plug is in place, the A batteries cannot be inadvertently discharged when the set is decommissioned, even if the power switch is left in the ON position.

j. By reason of extreme refinements involving the type and design of the basic circuits, the relative arrangement of parts, character of intercircuit couplings, shielding, etc., the performance of this unit has been developed to a degree where no "locking in" will occur between the heterodyne oscillator and any source of r-f with which it may be coupled, at any difference or beat frequency down to 5 cycles per second in the low fundamental range or down to 50 cycles per second in the high fundamental range. Although the phones become rapidly less efficient in audibly reproducing beat tones below 100 cycles per second, characteristic "rushes" coincident with the rise and fall of the beat frequency pulses are aurally recognizable well below the low frequency limit of audibility.

14. VACUUM TUBES.—The vacuum tubes employed in this equipment, and their maximum operating characteristics, are shown in the following tabulation:

Reference Designation:	VT-116-B	VT-167	VT-116
Function:	Heterodyne Oscillator	Crystal Osc. and Detector	AF Amplifier
Type:	Triple-Grid Amplifier	Triode-Hexode Converter	Triple-Grid Amplifier
Signal Corps Type Nomenclature:	Tube VT-116-B	Tube VT-167	Tube VT-116
Nearest Com'l. Equivalent:	6SJ7Y	6K8	6SJ7
Base:	Small 8 pin	Small 8 pin	Small 8 pin
Heater Voltage (E_f):	6.3v	6.3v	6.3v
Control Grid Voltage (E_{g1}):	−3.0v	−3.0v	−3.0v
Screen Voltage (E_{g2}):	100v	100v	100v
Plate Voltage (E_{p1}):	250v	250v	250v
Triode Plate Voltage:	.	100v	.
Heater Current (I_f):	300 ma	300 ma	300 ma
Screen Current (I_{g2}):	0.8 ma	6 ma	0.8 ma
Plate Current (I_{p1}):	3 ma	2.5 ma	3 ma
Triode Plate Current:	.	3.8 ma	.
Transconductance (S_m):	1650		1650

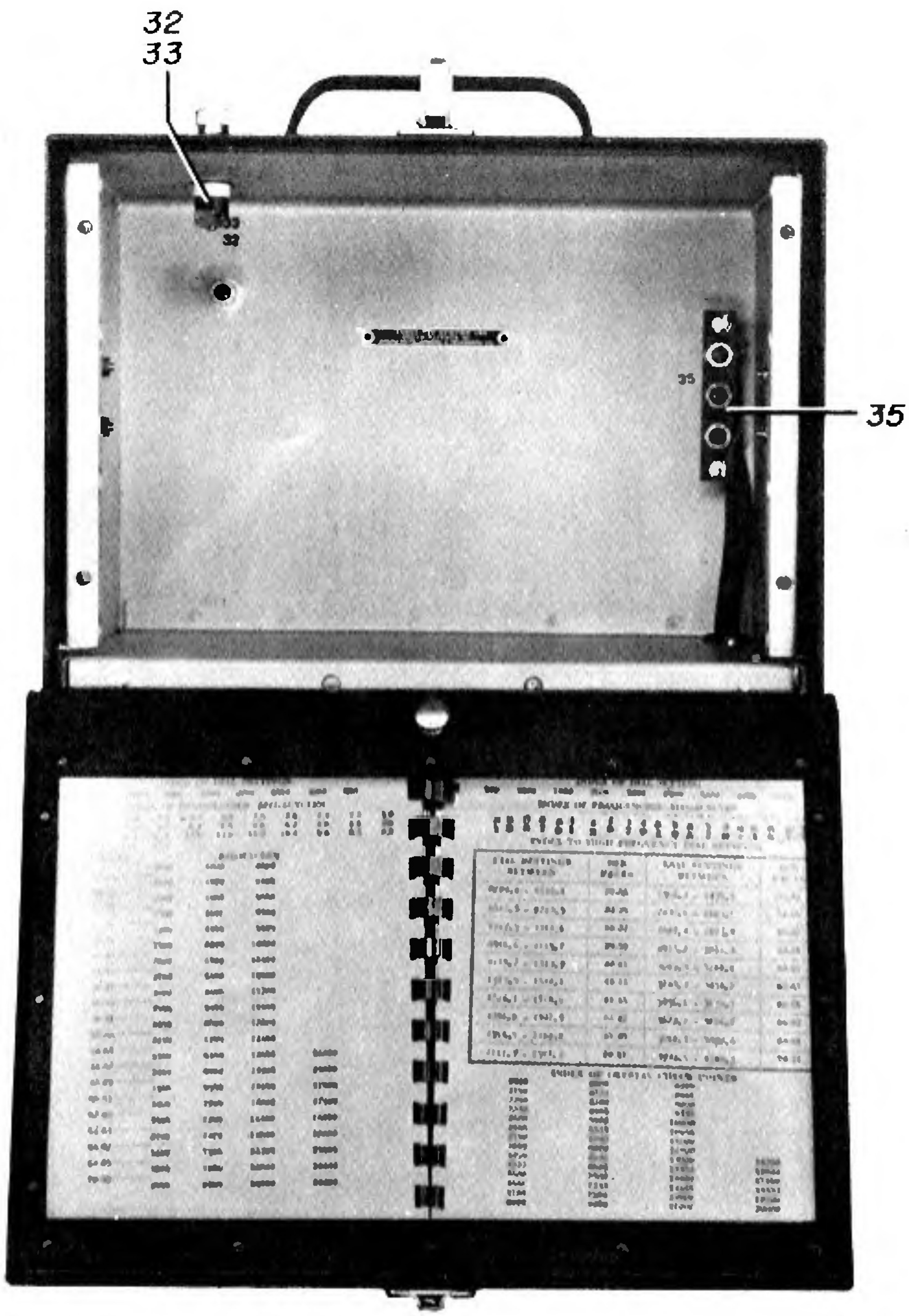


Figure 5 — Frequency Meter BC-221-M, Front View with Chassis Removed

FUNCTIONING OF PARTS

15. CALIBRATION BOOK MC-177-M.—The low frequency fundamental range of the heterodyne oscillator is calibrated at each one-tenth kilocycle between 125 and 250 kcs, or a total of 1251 points. Likewise, the high frequency fundamental range is calibrated in increments of one kilocycle between 2000 and 4000 kcs, or a total of 2001 points. These fundamental frequencies are legibly printed in columnar formation on the successive pages of the calibration book, together with associated columns listing the second, fourth and eighth harmonics thereof for the low range, and the second, fourth, and portions of the fifth harmonics for the high range. The dial settings, as determined by individual calibration, are then typed in opposite each such group. All figures representative of ordinary frequencies and their dial settings are both printed and typed in black while those which refer to the crystal oscillator and its harmonics (crystal check points) are shown in red. The first and last frequencies and dial settings tabulated thereon are indicated across the top. There are 70 inside pages (including pages 3 to 72) thumb tabbed as to page number. In the front of the calibration book opposite page 3 is an index to the dial settings in the low range. The page facing page 72 in the back of the book contains a similar listing for the high range. In addition, an index of frequencies in the high range is printed on pages 30 and 31, and another for the low frequency range is given on pages 28 and 29. A brief summary of the essential steps in operating the equipment is given on page 72. The calibration is printed on high quality white rag index paper which is both oil- and waterproof. The printed cover boards, especially selected for durability, are augmented by sheet metal covers, each of which is fitted with three threaded metal inserts for securing the book in open position within the door assembly of the frequency meter cabinet. A spiral spring type of binding is employed, so that the book lies flat when opened to any page.

The calibration should be carefully preserved, as the cost of duplication constitutes an appreciable percentage of the total cost of the equipment.

16. BAG BG-81-D.—The carrying bag (see Figure 1) is designed to include all components of the Frequency Meter Set SCR-211-M. It is fabricated from hard texture olive-drab duck, the bottom being felt padded and the inner and outer walls reinforced with pigskin at the wear-points. The top is hinged at the rear, with overhanging sides and front to exclude dust and precipitation. This cover is fitted with webbing straps so that it may be conveniently secured by buckles on the front of the bag, and a similarly secured pocket is provided on the top for a headset. Suitable rings are secured with webbing to each side of the bag, to which an adjustable Strap ST-19-A may be attached

SECTION IV
MAINTENANCE

17. GENERAL.—Frequency Meter BC-221-M is ruggedly constructed to withstand the shocks and strains which may be expected in military service. Nevertheless, this equipment is extremely accurate and sensitive, and is therefore deserving of the careful handling normally accorded to precision instruments.

18. SERVICING.—Normally, the only servicing required should be the replacement of batteries and vacuum tubes. This should be done at regular intervals, dependent on the amount of usage to which the equipment is subjected.

19. RESISTORS AND CAPACITORS.—The cartridge resistors and small moulded capacitors supplied in this equipment are marked in accordance with the following RMA Standard Color Code.

RMA COLOR CODE FOR RESISTORS AND CAPACITORS

Color	Significant Figure	Decimal Multiplier	Tolerance	Voltage Rating
Black	0	1	..	..
Brown	1	10	1%	100 Volts
Red	2	100	2%	200 Volts
Orange	3	1,000	..	300 Volts
Yellow	4	10,000	..	400 Volts
Green	5	100,000	5%	500 Volts
Blue	6	1,000,000	..	600 Volts
Violet	7	10,000,000	..	700 Volts
Gray	8	100,000,000	..	800 Volts
White	9	1,000,000,000	..	..
Gold	..	0.1	±5%	..
Silver	..	0.01	±10%	..
No Color	..	..	±20%	500 Volts

RESISTORS

The nominal resistance value of fixed composition resistors is indicated in two manners. The one in most common use indicates the value by bands of color as follows:

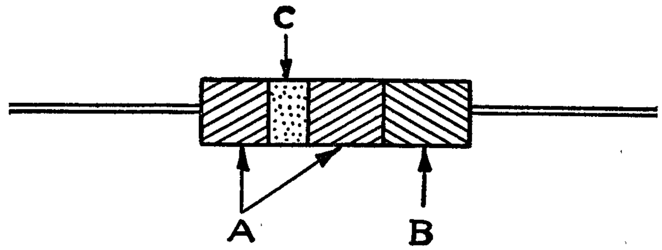
Band A indicates the first significant figure of the resistance of the resistor.

Band B indicates the second significant figure.

Band C indicates the decimal multiplier.

Band D, if any, indicates the tolerance limits about the nominal resistance value.

The less common system used for indicating nominal resistance value is as follows:

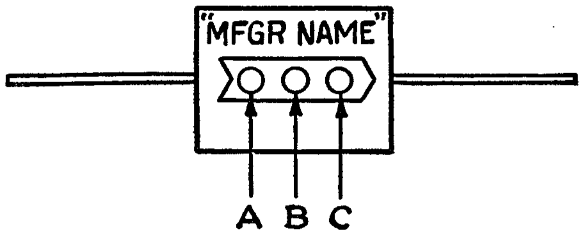


The body (A) of the resistor is colored to represent the first significant figure of the resistance value. One end (B) is colored to represent the second significant figure and a band, or dot (C) of color, located within the body color, indicates the decimal multiplier.

CAPACITORS

Two systems for color coding small fixed capacitors are in use. In either case, capacity is expressed in micromicrofarads and some means to avoid ambiguity in interpretation of colors provided. An arrow pointing from left to right or the manufacturer's name is generally used.

In general, capacitors having a working voltage of 500 volts are coded by means of three dots of color as follows:



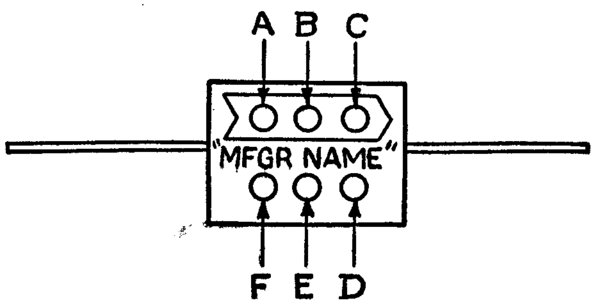
Dot A indicates the first significant figure of the capacitance of the capacitor.

Dot B indicates the second significant figure.

Dot C indicates the decimal multiplier.

An additional dot is sometimes shown when the working voltage is other than 500 volts. This dot indicates the voltage rating of the condenser.

A second system now coming into common use involves six dots of color as follows:



Dot A indicates the first significant figure of the capacitance of the capacitor.

Dot B indicates the second significant figure.

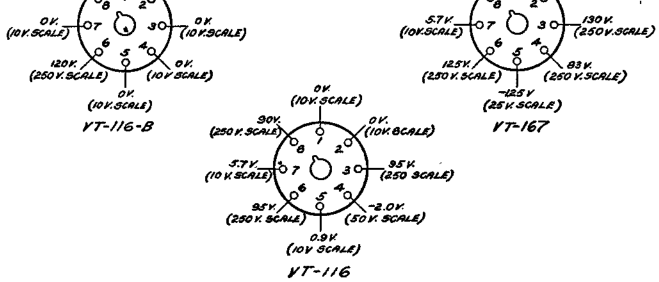
Dot C indicates the third significant figure.

Dot D indicates the decimal multiplier.

Dot E indicates the tolerance about the nominal capacitance value.

Dot F indicates the voltage rating of the capacitor.

20. TUBE VOLTAGES.—The following diagram, showing vacuum tube terminal voltages with respect to ground (chassis), is typical for Frequency Meter BC-221-M, with 6.0-volt filament and 135-volt plate supply, GAIN control set at maximum:



NOTE: The above values were obtained with a voltmeter having a resistance of 1000-ohms per volt, with a headset plugged into the PHONES jack and the various switches on Frequency Meter BC-221-M set to the following positions:

Switch	Position
FREQ. BAND	LOW
CRYSTAL	XTAL CHECK
POWER	ON

21. READJUSTMENT OF CRYSTAL TRIMMER CAPACITOR.—*a.*—*Procedure.*—If the accuracy of the crystal oscillator calibration is suspected, check the frequency meter unit against a frequency standard whose accuracy is better than ±1 part per million (Radio Station WWV of the U. S. Bureau of Standards, or a laboratory primary frequency standard). To accomplish this comparison:

(1) Set the HET. OSC.-XTAL CHECK-XTAL ONLY switch to XTAL ONLY, plug a headset in either of the PHONES jacks and throw the POWER switch ON. Allow the frequency meter to warm up for at least twenty minutes.

(2) Tune a radio receiver to Station WWV or to the frequency standard (tune the receiver to 1 mc or a multiple thereof).

(3) Couple a lead from the antenna terminal on the frequency meter to the antenna lead of the radio receiver. A beat-note should be heard in the radio receiver headset.

(4) Compare the beat-note produced in the radio receiver with an accurately calibrated beat-frequency oscillator and determine its frequency.

(5) Convert the beat-frequency to frequency deviation at 1 megacycle. The permissible deviation is ±5 cycles at 1 megacycle.

(6) If the observed deviation exceeds this tolerance, remove the nameplate from the front panel of Frequency Meter BC-221-M. Removal of the nameplate exposes the slotted shaft of the crystal trimmer capacitor.

(7) Using a small screwdriver, rotate the capacitor a fraction of a turn. This capacitor permits a total variation in crystal frequency of approximately 15 cycles.

(8) Check the deviation in crystal frequency as described in the preceding subparagraphs (4) and (5).

(9) Repeat the operations described in subparagraphs (7) and (8) until the deviation is less than ±5 cycles at 1 megacycle.

(10) Replace the nameplate.

b. Numerical Example.—(1) The following example will assist the reader to understand the foregoing instructions. If a 5-megacycle standard frequency transmission of Station WWV is used as a reference, tune the radio receiver to this frequency. The crystal fundamental frequency is 1 megacycle and its fifth harmonic will beat against the 5-megacycle signal. Suppose, under this condition, a beat frequency of 35 cycles is produced. Since this beat is produced by the fifth harmonic, the resultant beat-frequency must be divided by the order of the harmonic to convert the deviation to frequency deviation at 1 megacycle. In this instance, divide 35 cycles (resultant beat-frequency) by 5 (order of harmonic), the quotient of which is 7 cycles. Since this deviation is in excess of the allowable tolerance, adjust the crystal trimmer capacitor to produce a beat-frequency less than 25 cycles at 5 megacycles.

22. TROUBLE LOCATION AND REMEDY DATA.—
a. If Frequency Meter BC-221-M fails to operate, the following procedure should be followed to determine and eliminate the cause of failure.

(1) Check the operating control settings and position of the knobs on their respective shafts.

(2) Check the headset by removing and inserting in the phone jack. A click should be heard in the headset when inserted in the circuit.

(3) Check the operation of the heterodyne oscillator by introducing an external signal of known frequency. A beat-note should be heard in the headset when the heterodyne oscillator is tuned to this frequency. This same procedure applies to either band.

(4) If the heterodyne oscillator is operating satisfactorily, check the crystal oscillator circuit operation by setting the heterodyne oscillator to a crystal check point and turning the crystal switch on and off. A beat-note should be heard in the headset when the crystal is turned on. If no beat-note is heard, set the frequency band switch to the other band, set the heterodyne oscillator to a crystal check point, and repeat the operation described above. If no beat-note is heard under either condition, the crystal oscillator circuit is inoperative.

b. If no indication of operation is noted from the above checks, remove the unit from the case and check the battery potentials on the jack strip 35 in the rear of the case. The voltages should check to within the following limits:

A−B− to B+	121.5 to 135 volts d-c
A−B− to A+	5.4 to 6.0 volts d-c

c. If the voltages check within specified limits and the equipment still does not operate, interconnect the jack strip 35 with the plug strip 34 by means of a patch cord, and set up the unit for operation outside its case. Follow the following procedure to locate and isolate the cause of failure.

(1) With the gain control set to maximum (full clockwise rotation) touch the center lug of the gain control 26 with the point of a screwdriver. A click or hum should be heard in the headset.

(2) Repeat above procedure touching the grid cap of Tube VT-167. A click or hum should again be heard in the headset.

d. If trouble is indicated by one of the above checks, replace the tube in the circuit in which trouble is indicated and repeat the procedure. If the trouble still persists, check the tube socket terminal voltages of the tubes. These values should check to within ±10% of the values given in paragraph 20. Should any of the tube socket terminal voltages be outside of the required limits, disconnect the set and check the circuit components.

e. If, after a defect has been localized, the circuit components found to be in good condition, the unit is still not functioning properly, check the wiring for continuity. Inspect the unit for broken or frayed insulation in the wiring, and loose or corroded connections to the components. Check the switch, jack, plug, and tube socket contacts for loose or corroded connections. Check the tube socket clamps for tightness. If the unit functions normally except that the output is below normal, check the residual magnetism of the headphones. There should be enough residual magnetism present to hold the diaphragm in place when the retaining cap is removed and when no current is flowing through the phones.

SECTION V.—SUPPLEMENTARY DATA AND LIST OF REPLACEABLE PARTS

23. TABLE OF REPLACEABLE PARTS

Ref. No.	Stock No.	Name	Description	Function	Mfr.	Drawing Numbers Bendix	Drawing Numbers Sig. Corp.
1		Capacitor	10-185 $\mu\mu f$, Variable, Air dielectric	Heterodyne Tuning	3	AL73588-1	
2		Capacitor	3 $\mu\mu f$, Variable, Air dielectric	Heterodyne Corrector	9	AA18927-1	
3-1		Capacitor	10 $\mu\mu f$, Adjustable, Air dielectric	L.F. Heterodyne Trimmer	10	C59400	
3-2		Capacitor	10 $\mu\mu f$, Adjustable, Air dielectric	H.F. Heterodyne Trimmer	10	C59400	
4		Capacitor	5 $\mu\mu f$, ±10%, Ceramic, 500v, dcw	Heterodyne Compensating	7	A107158-050	
5		Capacitor	8 $\mu\mu f$, ±10%, 500v dcw, Molded mica	Heterodyne Coupling	1	C56315-080	
7a 7b 7c		Capacitors	0.1 x 0.1 x 0.1 μf + 14% −6%, 200v dcw, Paper dielectric, Wax impregnated	Crystal Anode, Detector Screen Bypass	1	A18933-1	
8		Capacitor	0.001 μf ±10%, 600v dcw, Molded mica	Detector Plate Bypass	1	A18936-1	
9		Capacitor	0.02 μf ±10%, 600v dcw, Molded mica	Audio Input Coupling	1	A18936-2	
10		Capacitor	0.5 μf ±12%, 200v dcw, Paper dielectric, Wax impregnated	Audio Output Coupling	1	A18932-1	
11		Socket	8 Contact, Octal, Isolantite	For Tube VT-116B	2	A18168-6	
12-1		Socket	8 Contact, Octal	For Tube VT-167	2	A18955-7	
12-2		Socket	8 Contact, Octal	For Tube VT-116	2	A18955-7	
12-3		Receptacle	8 Contact, Octal	Crystal	2	A18955-7	
13-1(a)		Jack	Single circuit,	Telephone	11	A18946	
1(b)		Switch	Filament Control	Filament Switch			
13-2(a)		Jack	Single circuit,	Telephone	11	A18946	
2(b)		Switch	Filament Control	Filament Switch			
14		Inductor	Assembly, for details see Note (1)	(1) Heterodyne High Frequency	3	AL73578-1	
15		Inductor	Assembly, for details see Note (2)	(1) Heterodyne Low Frequency	3	AL73577-1	
16		R.F. Choke	844 microhenries ±5% Universal winding	Crystal Anode Plate	3	AA107310-1	
17		Crystal	Assembly, for details see Note (3)	Unit	3	AL73580	
18		Resistor	5600Ω ±10%, ¼w, Metallized, Insulated	R.F. Output Terminating	7	A18151-562	
19		Resistor	56,000Ω ±10%, ¼w, Metallized, Insulated	Heterodyne Plate	7	A18151-563	
20-1		Resistor	1.0 Megohm ±10%, ¼w, Metallized, Insulated	Detector Grid Leak	7	A18151-105	
20-2		Resistor	1.0 Megohm ±10%, ¼w, Metallized, Insulated	Crystal Oscillator Grid	7	A18151-105	
21		Resistor	150Ω ±10%, ¼w	Crystal Oscillator Cathode	7	A18151-151	
22		Resistor	9100Ω ±5%, ¼w	Heterodyne Screen Dropping	7	A18001-912	
23		Resistor	150,000Ω ±10%, ¼w	Heterodyne Oscillator Grid	7	A18151-154	
24-1		Resistor	15,000Ω ±10%, ¼w, Metallized, Insulated	Detector Screen	7	A18151-153	

SECTION V.—SUPPLEMENTARY DATA AND LIST OF REPLACEABLE PARTS—(*Concluded*)

23. TABLE OF REPLACEABLE PARTS—(*Concluded*)

Ref. No.	Stock No.	Name	Description	Function	Mfr.	Drawing Numbers Bendix	Drawing Numbers Sig. Corp.
24-2		Resistor	15,000Ω ±10%, ¼w, Metallized, Insulated	Audio Plate Load	7	A18151-153	
26		Potentiometer	500,000Ω ±10%, 1w, Impregnated Strip, Curve No. 1	Gain Control	5	A18948	
27		Switch	4 PDT Rotary	Frequency Band	10	C59061	
28		Switch	SP3T Rotary	Crystal	10	C59302	
29		Switch	DPST (On-Off) Toggle	Power	6	A106846	
30		Reactor	450h ±10% at 1.0 Milliampere d.c.	Audio Choke	3	AA16988-1	
31		Plug	Single contact	Antenna	3	A18986	
32, 33		Terminal	Screw plunger type, Assembly. For details see Note (4)	Antenna Post	4	A10236	
34		Plug	3 Contact	Power Input	3	AA18994-1	
35		Jack	3 Contact	Power Input	3	AA25002-1	
36		Terminal Board	3 Contact, Screw Terminals	Battery	3	AA25732	
37		Resistor	7500Ω ±10%, ¼w	L.F. Heterodyne Grid Coupling	7	A18151-752	
38		Resistor	100Ω ±10%, ¼w	H.F. Heterodyne Grid Coupling	7	A18151-101	
39		Capacitor	.001 μf ±10%, 500v dcw, Molded mica	Filament Bypass	1	C56315-102	
40		Capacitor	100 μμf ±10%, 500v dcw, Molded mica	Heterodyne Grid Coupling	1	C56315-101	
41		Resistor	300Ω ±10%, ¼w	Audio Cathode	7	A18151-301	
42		Capacitor	12 μμf, Adjustable, Air dielectric	Crystal Oscillator Trimmer	9	C59209	
43a, 43b		Capacitor	0.1 x 0.1 μf, 200v dcw, +14% −10%, Paper, Dielectric, Wax impregnated	Het. Screen & Plate Bypass	1	C59099	
44		Capacitor	5 μμf ±1.0 μμf, Ceramic, 500v dcw	Crystal Oscillator Padder	7	A109935-050	
45		Capacitor	15 μμf ±10%, 500v dcw, Molded mica	Antenna Coupling	1	C56315-150	
46		Capacitor	47 μμf ±10%, 500v dcw, Mica, wax imp.	Antiresonant Shunt	7	A103772-470	
VT-116		Tube	Triple grid detector amplifier	Audio Amplifier	12	.	
VT-116B		Tube	Triple grid detector amplifier	Heterodyne Oscillator	12	.	
VT-167		Tube	Triode-Hexode converter	Crystal Oscillator and Detector	12	.	
		Grid Clips	Spring type	VT-167	18	A25590	
		Knob	Knurled grip	Corrector	3	AC59469-1	
		Knob	Knurled grip	Band Switch	3	AC59469-1	
		Knob	Knurled grip	Volume Control	3	AC59469-1	
		Knob	Knurled grip	Crystal Switch	3	AC59469-1	
		Ring Assembly	Mounting plate, Two used	For Fastening Dee Ring to Cabinet	3	A11756	
		Ring Assembly	Dee ring, Two used	For Fastening Strap ST-19-A to Cabinet	3	A10363	
		Box Catch	Self locking type		8	A10242	

SUPPLEMENTARY DATA AND LIST OF REPLACEABLE PARTS

Ref. No.	Stock No.	Name	Description	Function	Mfr.	Bendix	Sig. Corp.
		Bushings	Isolantite, Used in pairs	Feed Through	13	A11319	
		Supports	Isolantite, Used in pairs	Wire	13	A1693	
		Plugs	Banana type, Part of Ref. No. 34, Three used	Power	14	•	
		Jacks	For banana plugs, Part of Ref. No. 35, Three used	Power	14	•	
		Wire	Lenz r-f	Hook-up	15	•	
		Cable	Rubber covered, Single conductor #18	Battery	16	A8848-1	
		Terminals	Single connector, Three used	Battery	17	A7737	

	Dwg. No.
Note No. (1)	
Heterodyne Oscillator High Frequency Coil Assembly, Wax Impregnated	AL73578-1
Coil Form, Isolantite	L73576
Wire, #7-42 Litz Single Celanese Enameled	A326
Note No. (2)	
Heterodyne Oscillator Low Frequency Coil Assembly, Wax Impregnated	AL73577-1
Coil Form, Isolantite	L73575
Mounting Block	A1697
Wire, 7-42 Litz Single Celanese Enameled	A326
Note No. (3)	
Crystal Unit Assembly, DC-9-M	AL73580

	Dwg. No.
Adjustable Electrode	AA107450
Crystal, 1 mc A-cut	
Fixed Electrode	A29426
Shell, 6C5 Tube Type	A106868
Header, Metal Tube, One Lead	A106890
Base, Octal Tube	A3178
Note No. (4)	
Spring	A25606
Spacer	A7254-1
Guide Pin	A7255
Post, Screw Plunger Type	A10236
Bushing, Isolantite, Pair	A18945
Washer, Untreated, Fishpaper	A25046-1
Washer, Untreated, Fishpaper, Pair	A10859-1

24. IDENTICAL AND INTERCHANGEABLE PARTS

Ref. No.	Stock No.	Name	Description	Function	Mfr.	Drawing Numbers Bendix	Drawing Numbers Sig. Corp.
3-1		Capacitor	10 $\mu\mu f$, Adjustable, Air dielectric	L.F. Heterodyne Trimmer	10	C59400	
3-2		Capacitor	10 $\mu\mu f$, Adjustable, Air dielectric	H.F. Heterodyne Trimmer	10	C59400	
12-1		Socket	8 Contact, Octal	For Tube VT-167	2	A18955-7	
12-2		Socket	8 Contact, Octal	For Tube VT-116	2	A18955-7	
12-3		Receptacle	8 Contact, Octal	Crystal	2	A18955-7	
13-1(a)		Jack	Single circuit,	Telephone	11	A18946	
1(b)		Switch	Filament Control	Filament Switch			
13-2(b)		Jack	Single circuit,	Telephone	11	A18946	
2(b)		Switch	Filament Control	Filament Switch			
20-1		Resistor	1.0 Megohm ±10%, ¼w, Metallized, Insulated	Detector Grid Load	7	A18151-105	
20-2		Resistor	1.0 Megohm ±10%, ¼w, Metallized, Insulated	Crystal Oscillator Grid	7	A18151-105	
24-1		Resistor	15,000Ω ±10%, ¼w, Metallized, Insulated	Detector Screen	7	A18151-153	
24-2		Resistor	15,000Ω ±10%, ¼w, Metallized, Insulated	Audio Plate Load	7	A18151-153	

24. IDENTICAL AND INTERCHANGEABLE PARTS—(*Concluded*)

Ref. No.	Stock No.	Name	Description	Function	Mfr.	Drawing Numbers Bendix	Drawing Numbers Sig. Corp.
		Knob	Knurled grip	Corrector	3	AC59469-1	
		Knob	Knurled grip	Band Switch	3	AC59469-1	
		Knob	Knurled grip	Volume Control	3	AC59469-1	
		Knob	Knurled grip	Crystal Switch	3	AC59469-1	
		Ring Assembly	Mounting Plate, Two used	For Fastening Dee Ring to cabinet	3	A11756	
		Ring Assembly	Dee Ring, Two used	For Fastening Strap ST-19-A to Cabinet	3	A10363	
		Bushings	Isolantite, Used in pairs	Feed Through	13	A11319	
		Supports	Isolantite, Used in pairs	Wire	13	A1693	
		Plugs	Banana type, Part of Ref. No. 34, Three used	Power	14	.	
		Jacks	For banana plugs, Part of Ref. No. 35, Three used	Power	14	.	
		Terminals	Single connector, Three used	Battery	17	A7737	

25. ADDRESSES OF MANUFACTURERS

1. Aerovox Corporation
New Bedford, Mass.

2. American Phenolic Corp.
1830 South 54th Avenue
Chicago, Ill. (Cicero P.O.)

3. Bendix Radio
Div. of Bendix Aviation Corp.
Baltimore, Maryland.

4. Eby, Inc.
2066 Hunting Park Avenue
Philadelphia, Pa.

5. Centralab
900 Keefe Avenue
Milwaukee, Wis.

6. Arrow-Hart and Hegeman
Hartford, Conn.

7. Erie Resistor Corp.
Erie, Penna.

8. Excelsior Hardware Co.
Stamford, Conn.

9. Hammarlund Mfg. Co.
424 W. 33rd Street
New York, N. Y.

10. Oak Mfg. Co.
711 W. Lake Street
Chicago, Ill.

11. Yaxley Mfg. Co.
3029 E. Washington St.
Indianapolis, Ind.

12. R.C.A. Mfg. Co.
Camden, N. J.

13. Isolantite Corp.
Belleville, N. J.

14. Johnson Co.
Waseca, Minn.

15. Lenz Co.
1751 N. Western Avenue
Chicago, Ill.

16. Simplex Wire & Cable Co.
79 Sidney Street
Boston, Mass.

17. Howard B. Jones
2300 Wabansia Avenue
Chicago, Illinois.

18. Zierick Mfg. Co.
385 Gerard Avenue
New York, N. Y.

19. Zophar Mills, Inc.
100 26th Street
Brooklyn, N. Y.

20. Acme Wire Company
New Haven, Conn.

21. Bakelite Corp. of America
247 Park Avenue
New York City, N. Y.

22. Raytheon Prod. Co.
190 Willow Street
Waltham, Mass.

23. Westinghouse Elect. and
Mfg. Company
East Pittsburgh, Penna.

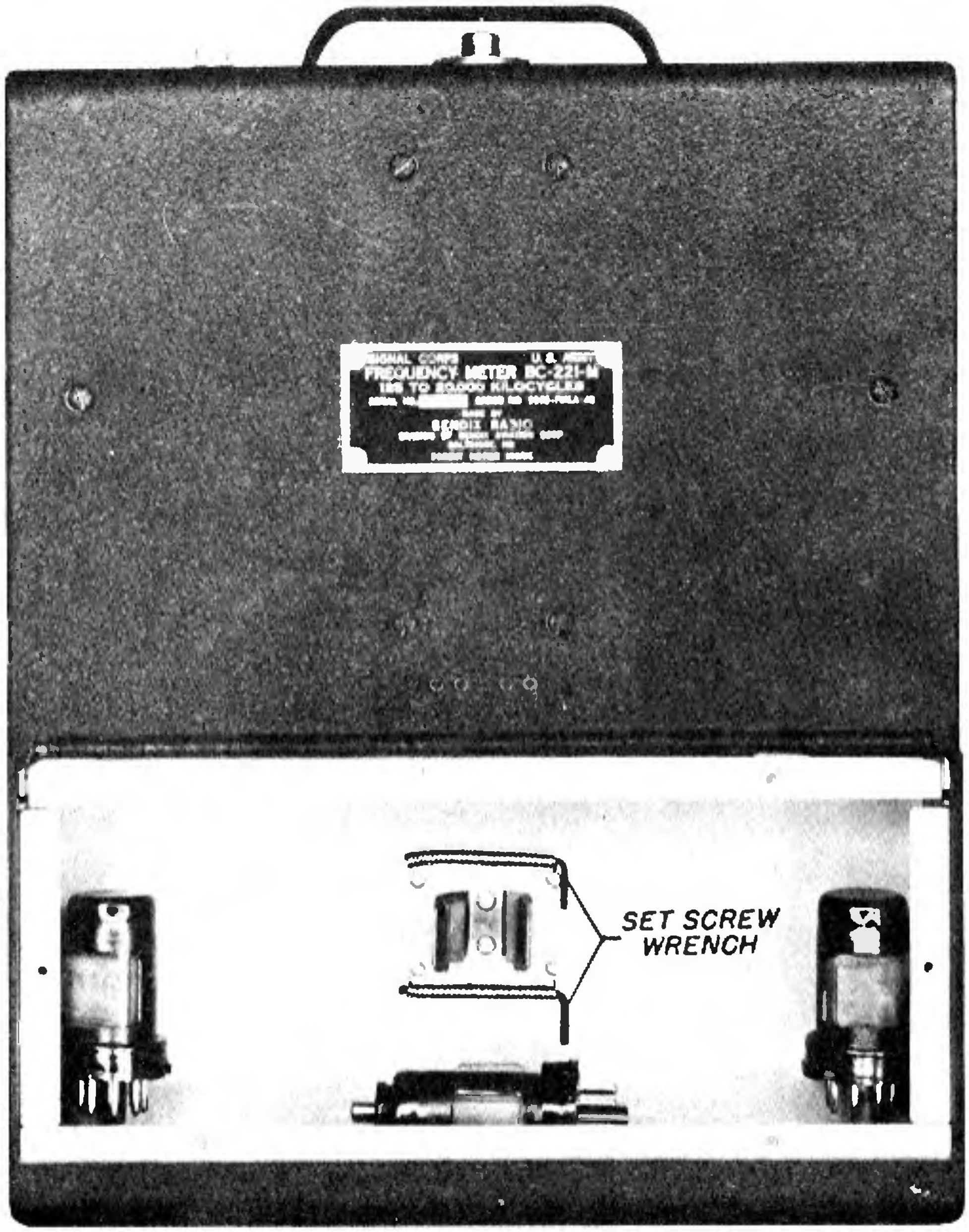


Figure 6 — Frequency Meter BC-221-M, Front View Showing Spare Parts Compartment

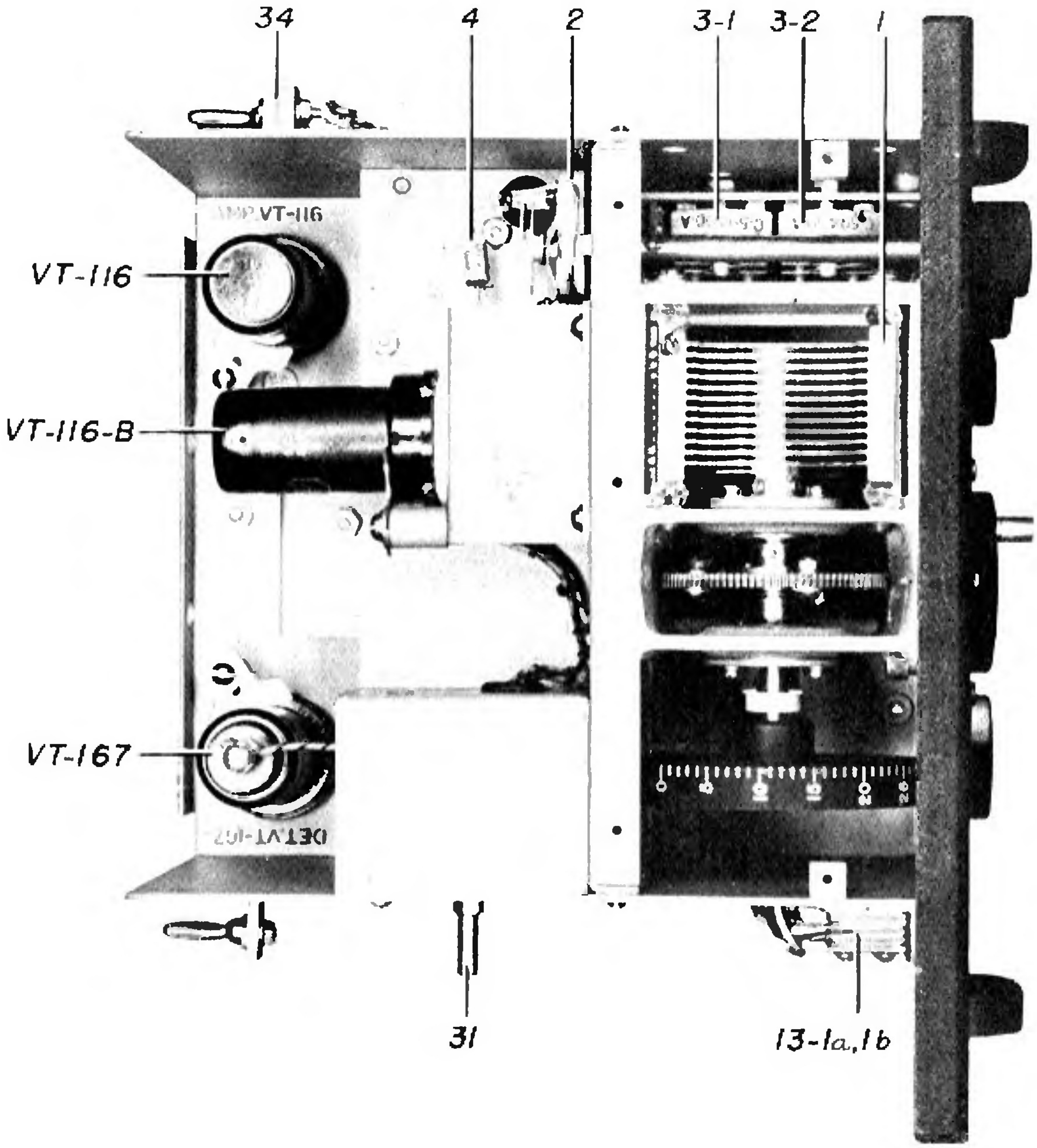


FIGURE 7 – FREQUENCY METER BC-221-M, CHASSIS TOP VIEW WITH CAPACITER SHIELD REMOVED

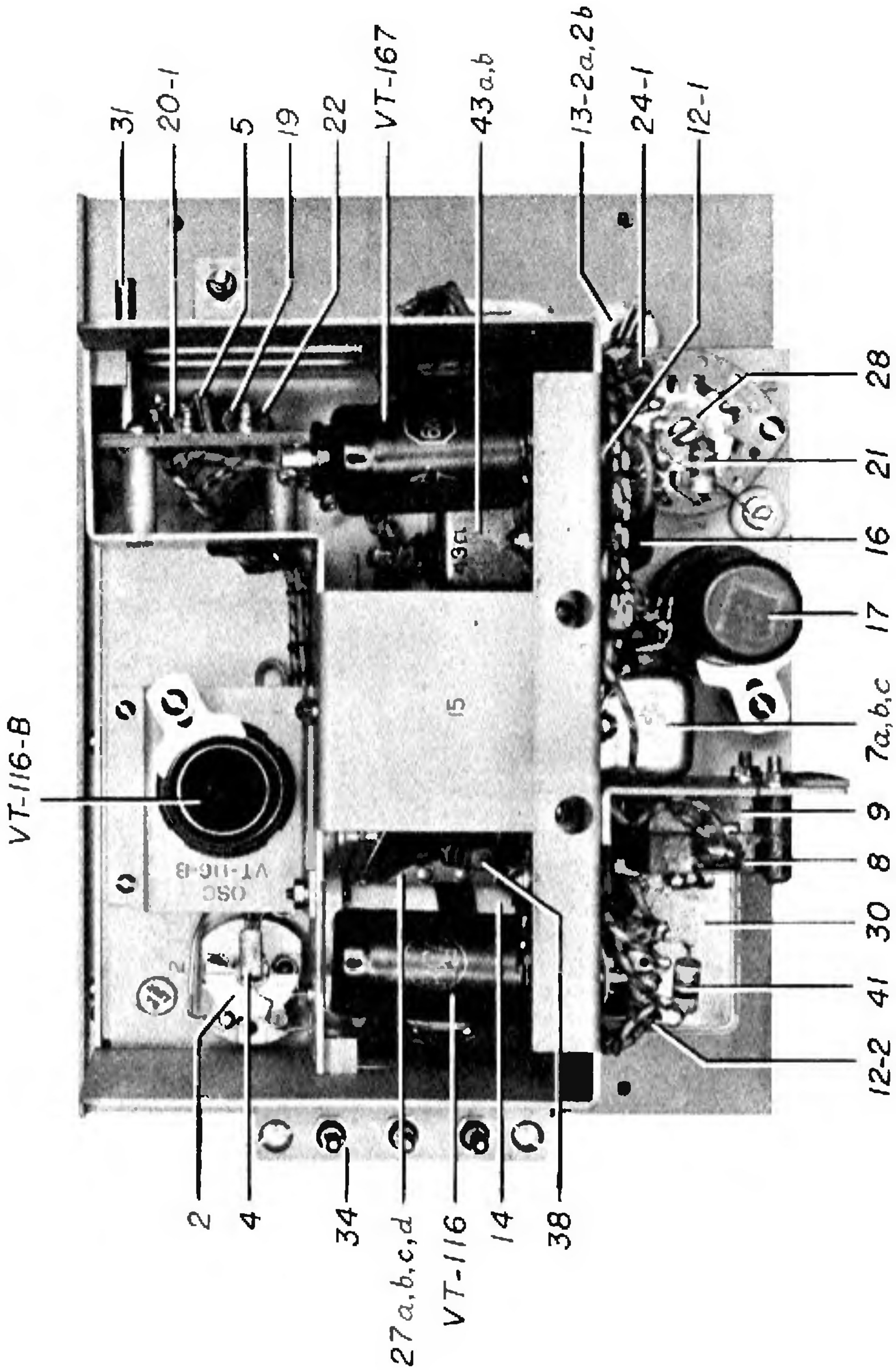


FIGURE 8 — FREQUENCY METER BC-221-M, CHASSIS REAR VIEW

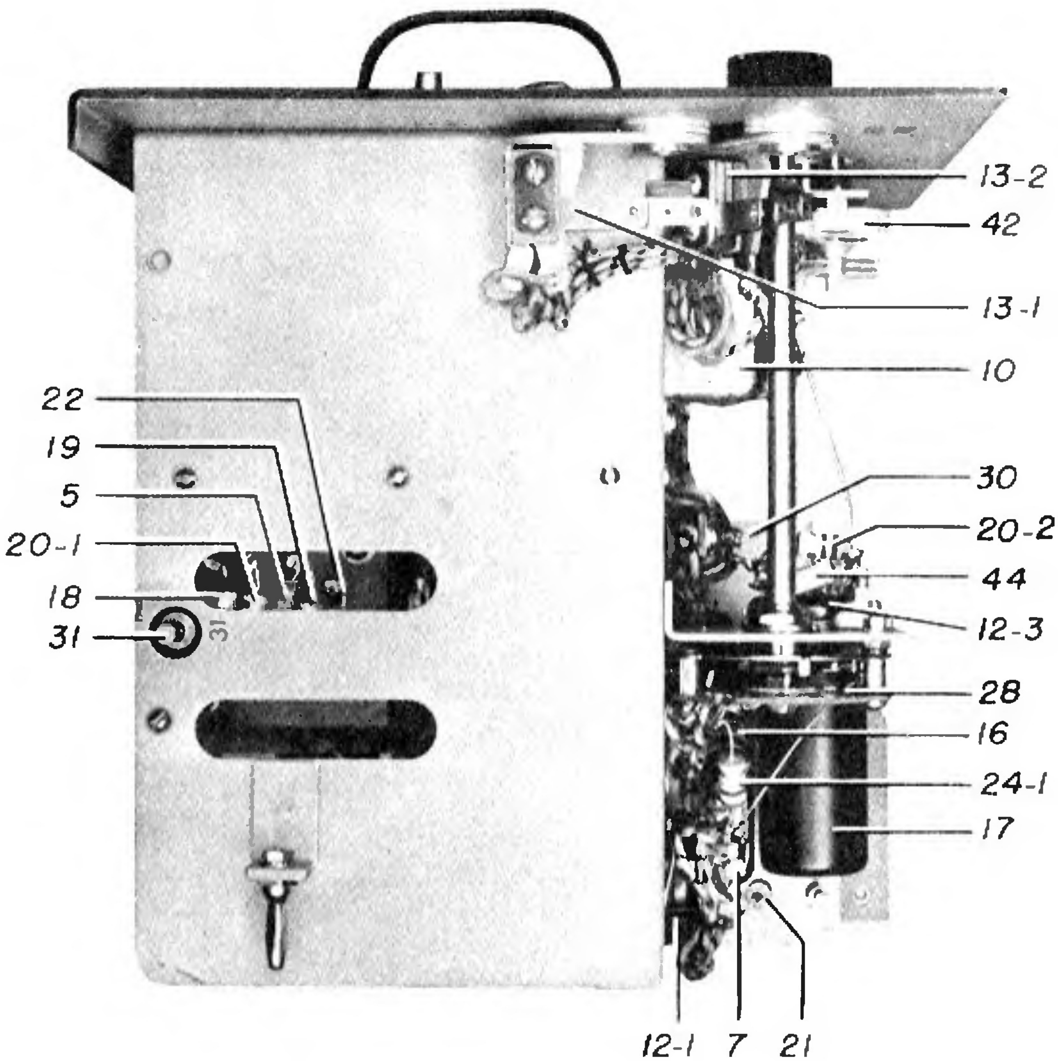


Figure 9 — Frequency Meter BC-221-M, Chassis Left Side

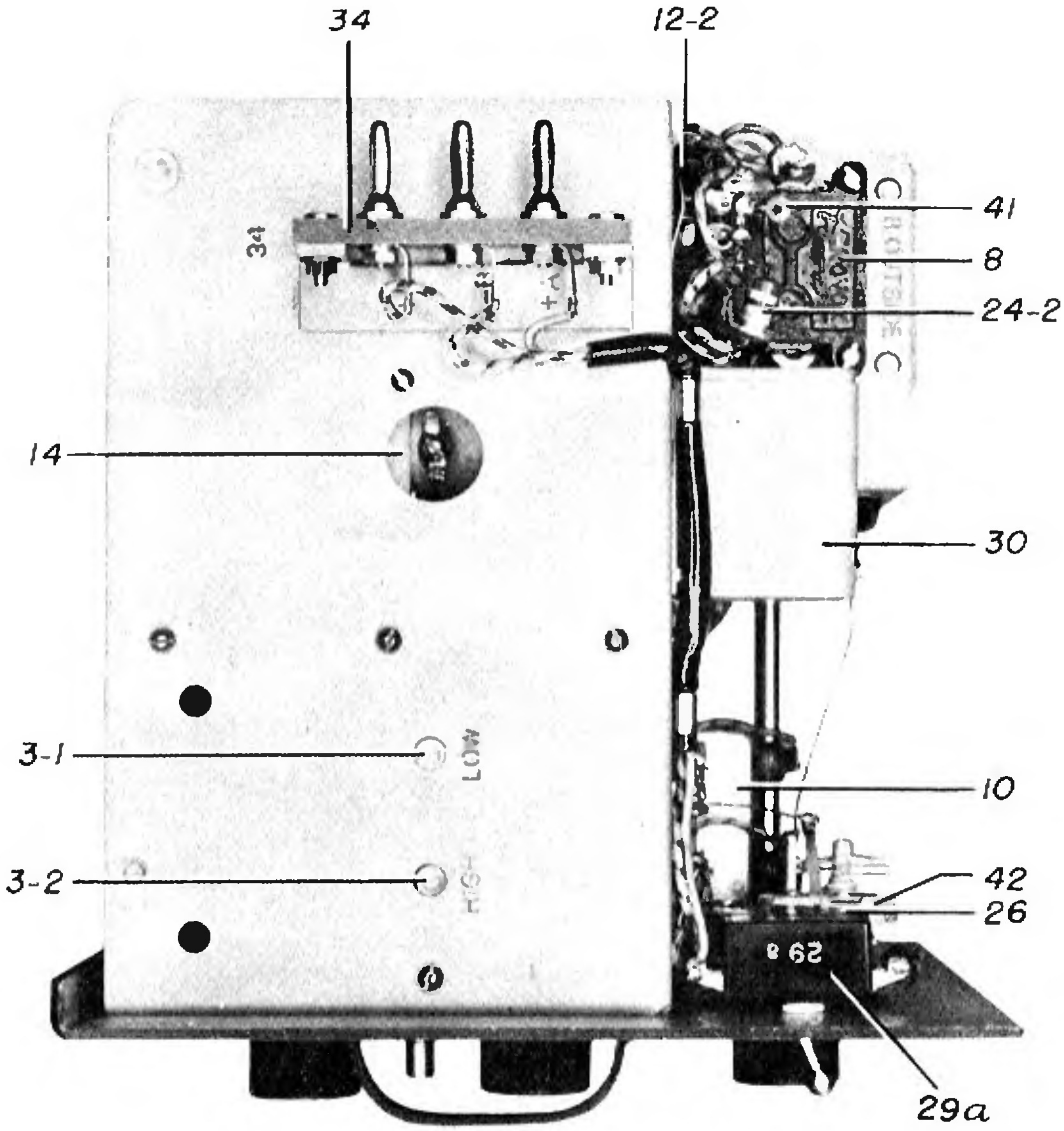


FIGURE 10 — FREQUENCY METER BC-221-M, CHASSIS RIGHT SIDE

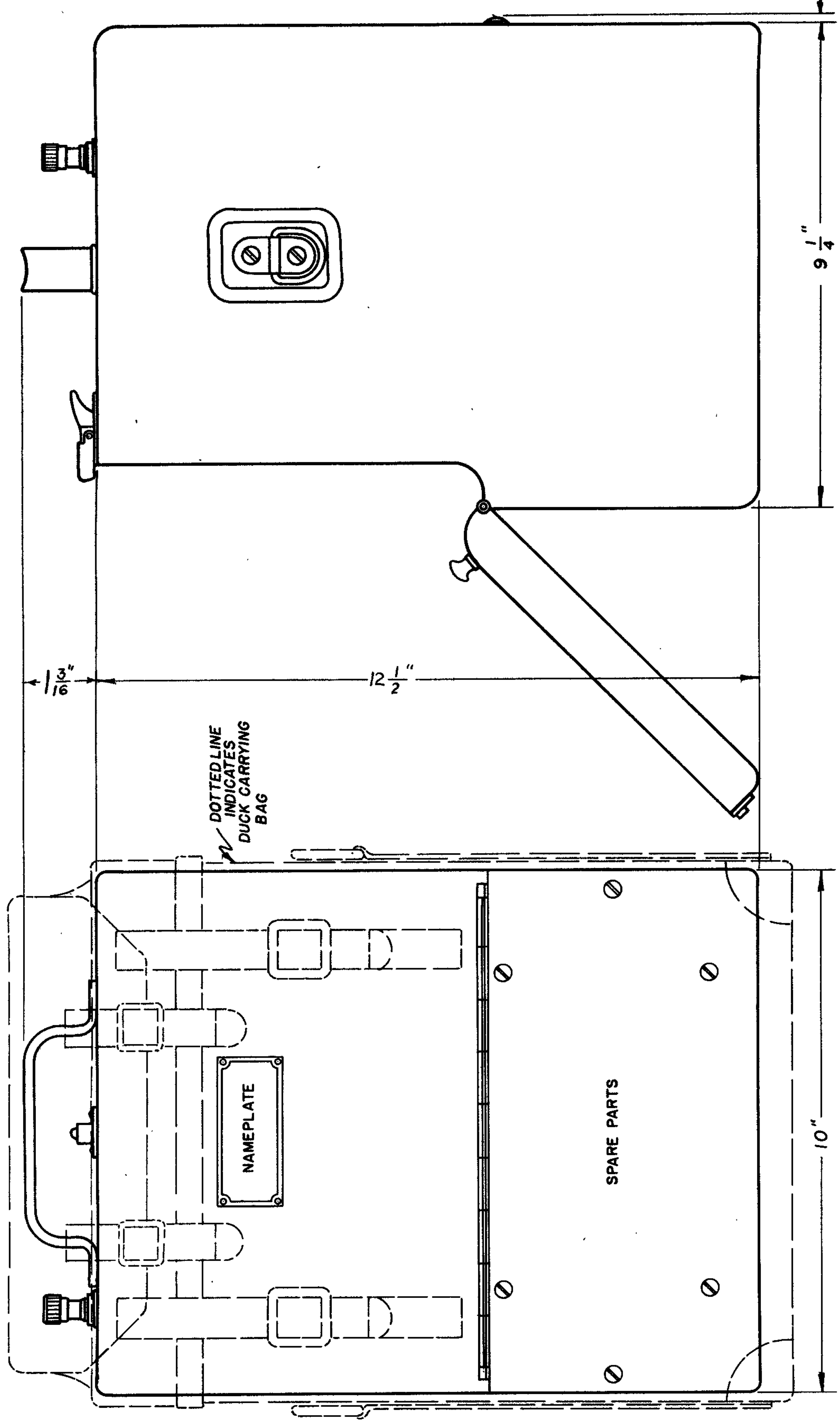
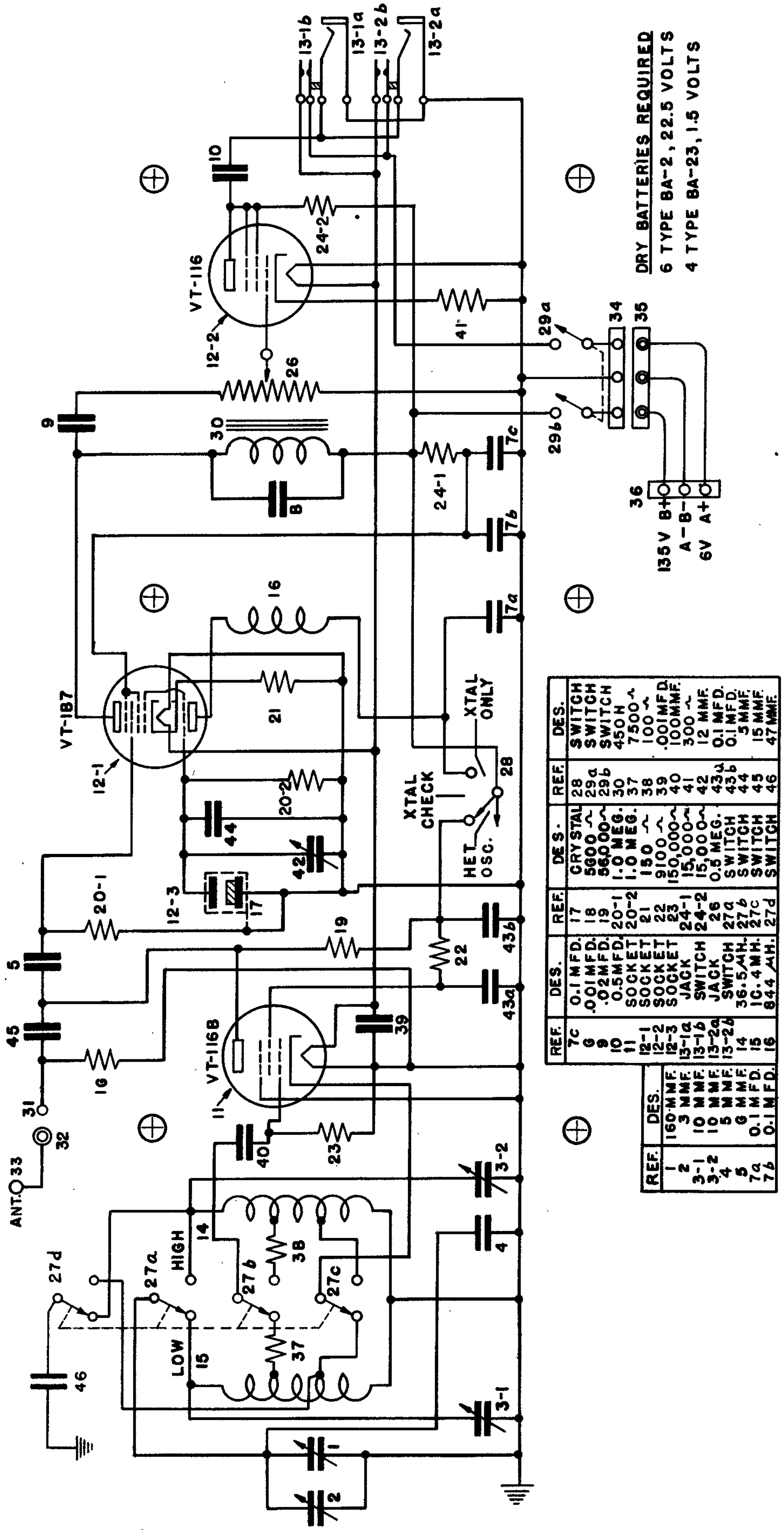
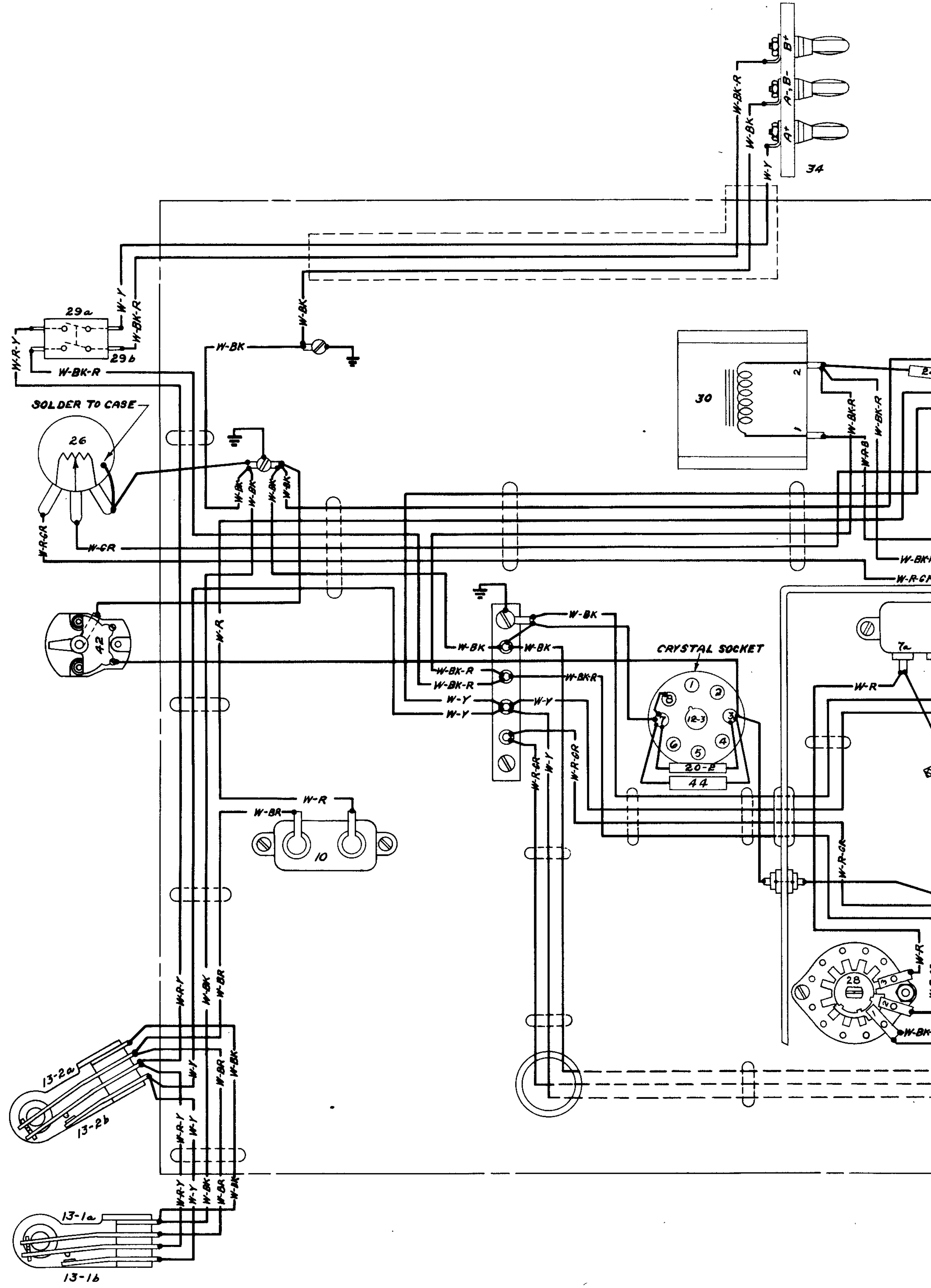


Figure 11 — Frequency Meter Set SCR-211-M, Outline Dimensions



REF.	DES.	REF.	DES.	REF.	DES.	REF.	DES.
1	160 MMF.	7c	0.1 MFD.	17	CRYSTAL	28	SWITCH
2	3 MMF.	6	.001 MFD.	18	5600 ~	29a	SWITCH
3-1	10 MMF.	9	.02 MFD.	19	56,000 ~	29b	SWITCH
3-2	10 MMF.	10	0.5 MFD.	20-1	1.0 MEG.	30	450 H
4	5 MMF.	11	SOCKET	20-2	1.0 MEG.	37	7500 ~
5	6 MMF.	12-1	SOCKET	21	150 ~	38	100 ~
7a	0.1 MFD.	12-2	SOCKET	22	9100 ~	39	.001 MFD.
7b	0.1 MFD.	12-3	SOCKET	23	150,000 ~	40	100 MMF.
		13-1a	JACK	24-1	15,000 ~	41	300 ~
		13-1b	SWITCH	24-2	15,000 ~	42	12 MMF.
		13-2a	JACK	26	0.5 MEG.	43a	0.1 MFD.
		13-2b	SWITCH	27a	SWITCH	43b	0.1 MFD.
		14	36.5 μH.	27b	SWITCH	44	5 MMF.
		15	10.4 MH.	27c	SWITCH	45	15 MMF.
		16	844 μH.	27d	SWITCH	46	47 MMF.

FIGURE 12 — FREQUENCY METER BC-221-M, SCHEMATIC DIAGRAM



34
A+
A-, B-
B+
W-BK-R
W-BK
W-Y
29a
29b
W-R-Y
SOLDER TO CASE
26
W-R-GR
W-GR
42
W-R
W-BR
10
30
CRYSTAL SOCKET
12-3
20-B
44
W-BK-R
W-R-B
W-R-GR
28
7a
13-2a
13-2b
13-1a
13-1b

WIRING LEGEND	
CODE	COLOR
B	BLUE
BK	BLACK
BR	BROWN
GR	GREEN
OR	ORANGE
R	RED
W	WHITE
Y	YELLOW

NOTES:
1.-ALL JOINTS ARE TO BE MECHANICALLY SECURE BEFORE SOLDERING.
2.-ALL INSULATED WIRE IS #20 R.F. WIRE.
3.-LACING INDICATED IS PART OF ITEMS.

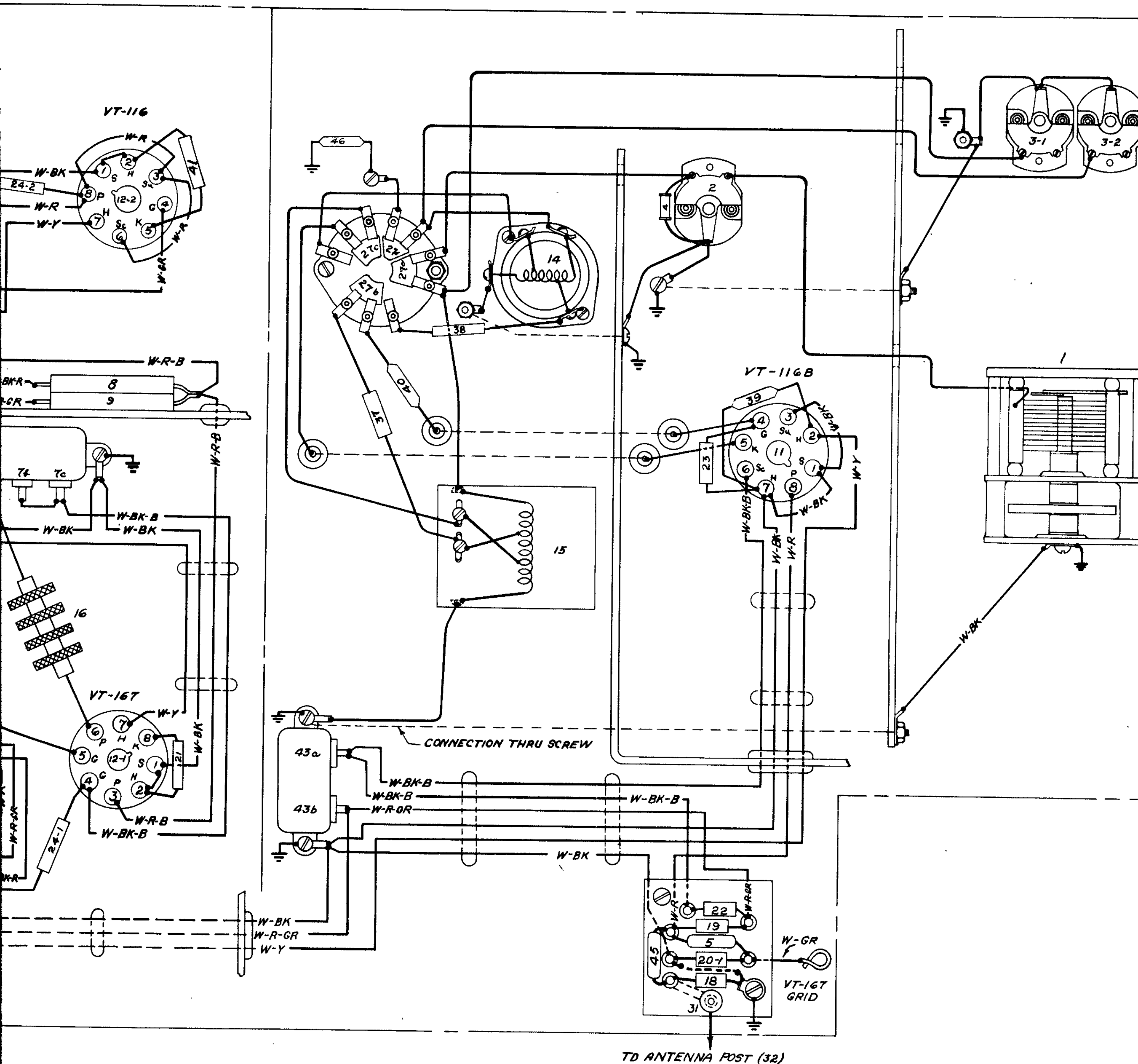


FIGURE 13

FREQUENCY METER BC-221-M, CHASSIS WIRING DIAGRA

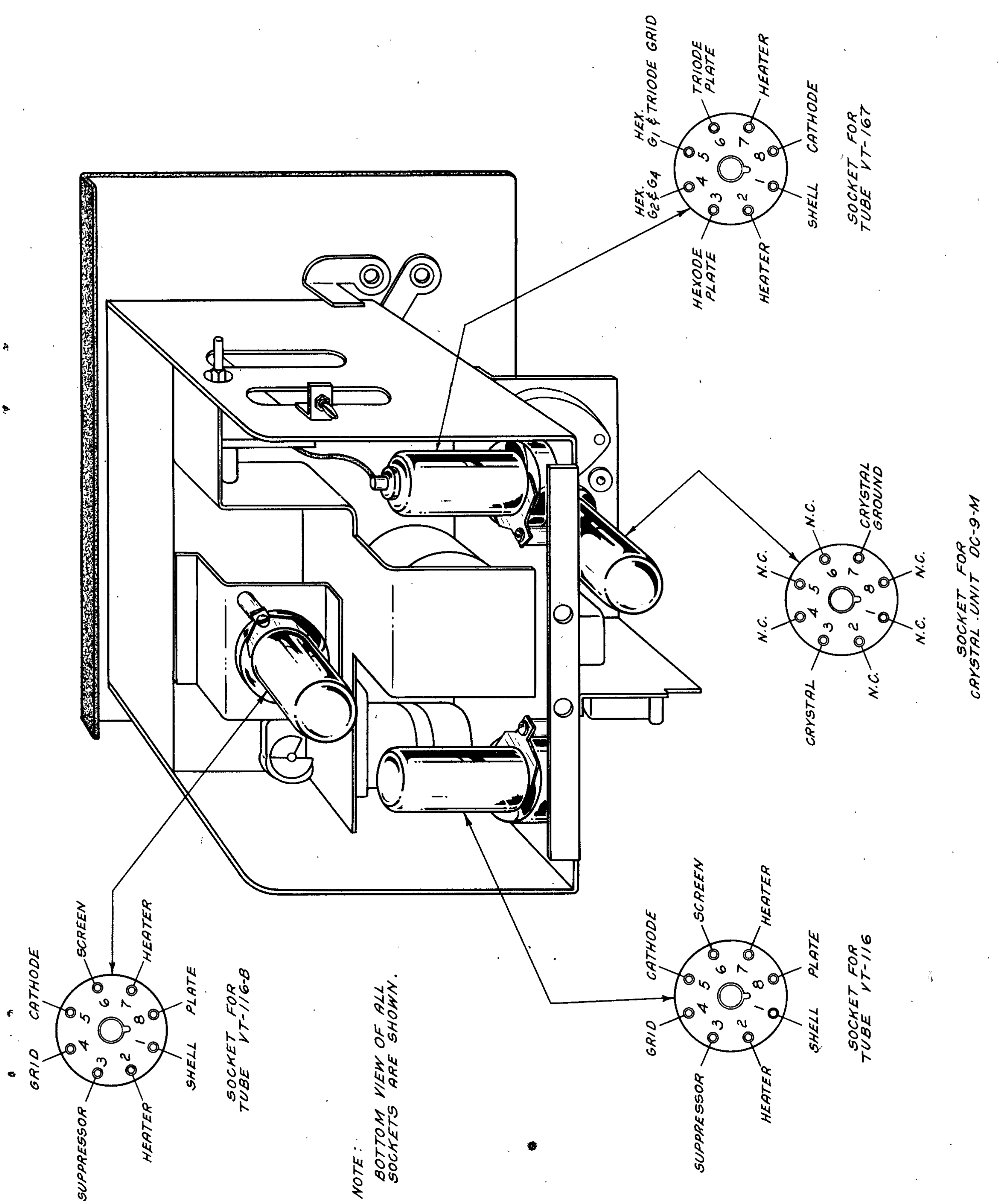


FIGURE 14 — FREQUENCY METER SET SCR-211-M, VACUUM TUBE LOCATIONS

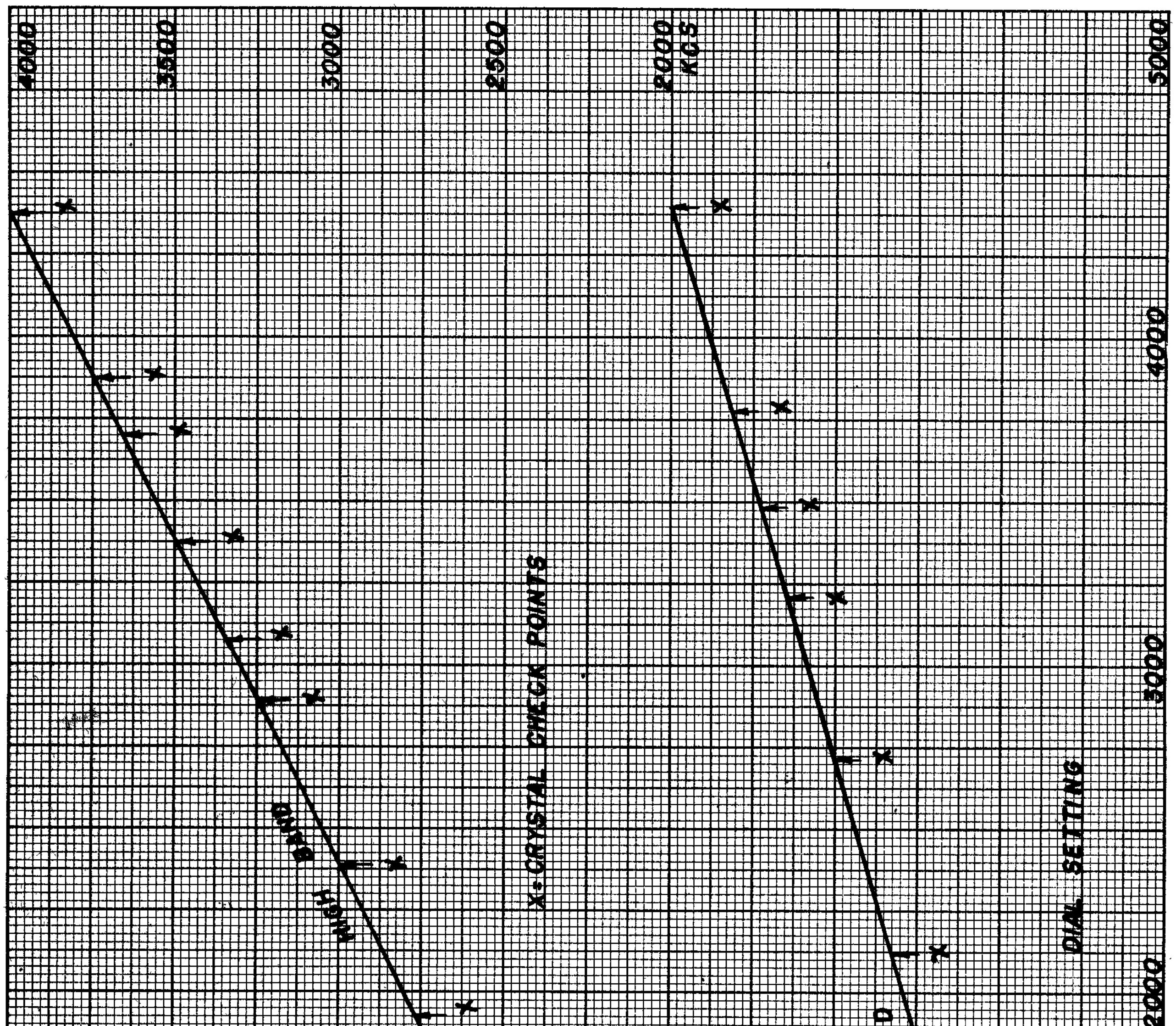


FIGURE 15 — FREQUENCY METER BC-221-M, TYPICAL HET. OSC. TUNING CURVES