WAR DEPARTMENT TECHNICAL MANUAL

TM11-300-AF RESTRICTED

FREQUENCY METER SET

SCR-211-AF

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WAR DEPARTMENT **13 October 1943**

WAR DEPARTMENT,
WASHINGTON 25, D. C., 13 OCTOBER 1943

TM11-300AF, Frequency Meter Set SCR-211-AF, is published for the information and guidance of all concerned.
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By order of the Secretary of War:

G. C. MARSHALL
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OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION:
(For explanation of symbols see FM 21-6)

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LIST OF ILLUSTRATIONS

DESTRUCTION NOTICE

WHY — To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN — When ordered by your commander, or when you are in immediate danger of capture.

HOW — 1. Smash — Use sledges, axes, hand-axes, pick-axes, hammers, crowbars, heavy tools, etc.

2. Burn — Use gasoline, kerosene, oil, flame-throwers, incendiary grenades, etc.

3. Disposal — Bury in slit trenches, fox-holes, other holes. Throw in streams. Scatter.

4. USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT — 1. Smash — Cabinet or case, chassis, tubes, tuning capacitor, instrument panel and every electrical and mechanical part. Rip out all wiring in the unit. Destroy nameplates and circuit labels.

2. Burn — Calibration book, technical manual and other printed matter.

3. Bury or scatter — Any or all of the above pieces after demolishing the equipment.

DESTROY EVERYTHING

WARNING

WHEN BATTERIES ARE BEING LOADED INTO THE BATTERY COMPARTMENT DO NOT TOUCH THE CONNECTING TERMINALS OR YOU WILL GET A SEVERE SHOCK.

WARNING: — In using this meter to calibrate a transmitter, never make any direct connection between the meter and the transmitter.

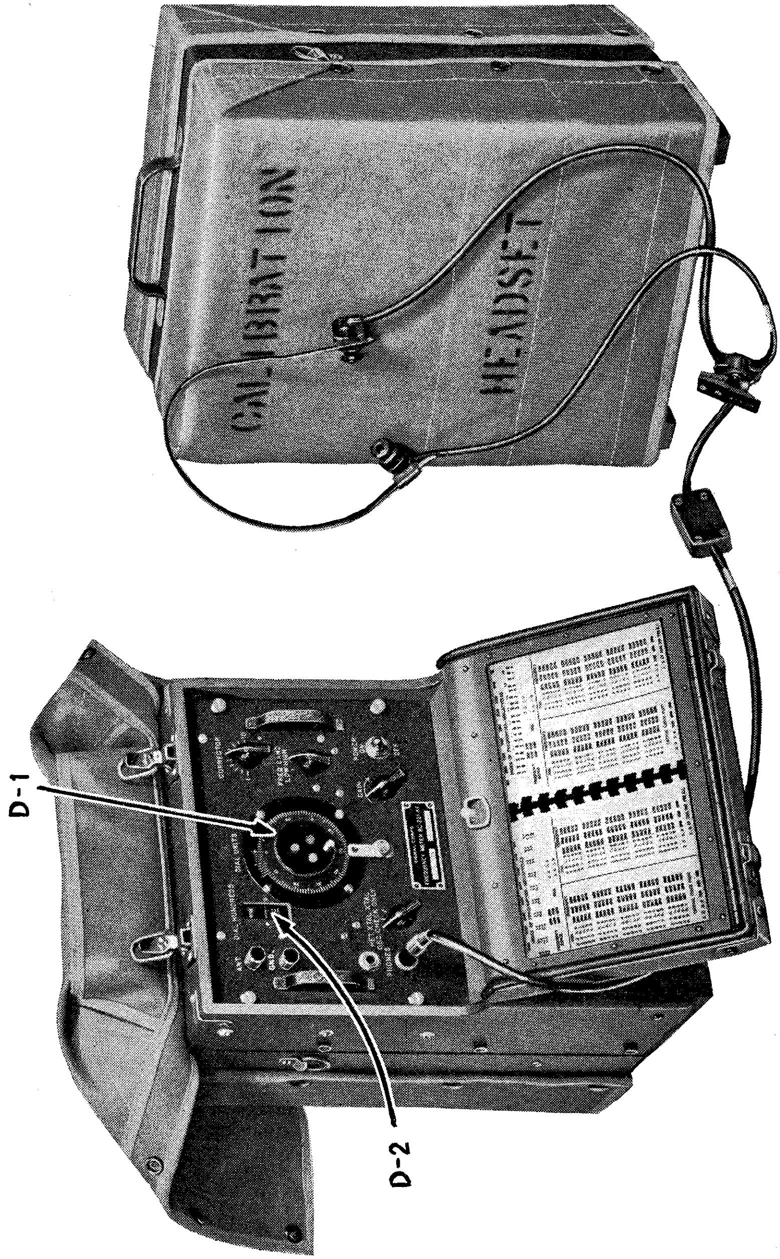


FIGURE 1—Frequency Meter Set SCR-211-AF, Composite View

FREQUENCY METER SET SCR-211-AF

SECTION 1. DESCRIPTION

1. General.

Frequency Meter Set SCR-211-AF is a simple accurate and reliable crystal calibrated frequency indicating instrument.

The greatest possible error that you will find in using this equipment will be at 4 megacycles (and its harmonics) when the temperature is 30° below zero, Centigrade.

Most frequent caused of error are:

1. Small shocks (caused by handling and the thrust on the dial and pressure on the panel when using the equipment).	100	cycles	max.
2. The action of locking the dial.	30	"	"
3. Warming up.	100	"	"
4. Changing of load on antenna post.	50	"	"
5. A drop of 10% in battery voltage or a change of 5° Centigrade, in the surrounding temperature.	325	"	"
6. Error in calibration.	500	"	"
7. Error in crystal frequency.	250	"	"
	1,355	"	"

or 0.34% at 4 megacycles.

This is only the theoretical maximum error. You must remember that even normal handling of the instrument, such as handling the controls, locking the dial, etc., may cause errors as noted in the table. Also, variation in the value of the battery supply, antenna load and calibration, as well as deviations in crystal frequency and during warm-up of the tube, may cause errors.

In actual operation, however, the errors listed will not necessarily be cumulative, as some may cancel others. Locking the dial and change of antenna load for example, may not result in an error totaling exactly 80 cycles.

Actual tests show that, in most cases, the average error can be assumed to be no greater than 50% of the values given in the table. Maximum possible errors at other frequencies are:—

985 cycles at 2 megacycles; 180 cycles at 250 kilocycles; and 180 cycles at 125 kilocycles.

a. Frequency Meter BC-221-AF contains:

A crystal controlled oscillator used as a reference standard;

A heterodyne oscillator with two fundamental tuning ranges which, with their useful harmonics, are calibrated to provide continuous coverage from 125 to 20,000 kc;

A high gain detector provided with means for coupling to each of three sources of excitation;

An audio frequency amplifier.

b. There are seven operating controls:

A POWER switch (29*a*-29*b*), which breaks both the filament and plate supplies;

Output PHONES jacks (15-1*a*, 15-2*a*) with series filament supply switches (15-1*b*, 15-2*b*) built internally;

OPERATION switch (28*a*, 28*b*) which controls the crystal and heterodyne oscillators;

A two position FREQ BAND switch (27*a* thru 27*e*) for the heterodyne oscillator;

The heterodyne oscillator worm and gear tuning control together with its DIAL UNITS and DIAL HUNDREDS scales;

The CORRECTOR control;

The output GAIN control (26).

c. All controls as well as the antenna and ground binding posts (33) and (32) are mounted on the front panel of the frequency meter chassis, which is completely housed within the upper compartment of a portable cabinet in which batteries, headphones and spare tubes are also carried. The 3-contact power input plug (34), on the chassis, engages with corresponding jacks on the cabinet when the chassis is secured in place. 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, which can be reached through a hinged door at the rear. Calibration book MC-177-AF 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. The headphones, cord and special wrench for the No. 8 Bristo set screw used in the assembly of the equipment are stored in the headphones compartment at the bottom front of the cabinet. Spare tubes are mounted inside the cabinet and can be reached by removing the chassis. A carrying handle is fastened on the top of the cabinet and rings attached to the sides to permit the use of Strap ST-19-A for carrying. The external surfaces are finished in olive drab. Figures 1 to 11, inclusive, show the general construction, arrangement of parts, and overall dimensions.

2. Components.

Each Frequency Meter Set SCR-211-AF consists of the following components:

Quantity	Component	Weight, Lbs.
1	Frequency Meter BC-221-AF. (see fig. 13 for dimensions) Includes: 1 Calibration Book MC-177-AF 1 Crystal Unit DC-9-(*) (in operating position); 1 Wrench for Bristo No. 8 set screw;	22.0
2	Sets of vacuum tubes (1 each of VT-116, VT-116-B, and VT-167) (1 set in use, 1 spare set)	0.30
1	Strap ST-19-A	0.70
2	Technical Manuals TM 11-300-AF	0.50
1	Cord for Headphones CD-874	0.34

3. Additional Equipment Required.

The following additional equipment is required to complete each Frequency Meter Set SCR-211-AF:

Quantity	Description
1	Headset HS-30(*)
6	Batteries BA-2
4	Batteries BA-23

4. Total Weight

Frequency Meter Set SCR-211-AF ready for service with one set of batteries installed, weighs 39.5 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:

Filaments: 5.4 to 6.0 volts, 0.86 to 0.92 amp.

Plates: 121.5 to 135.0 volts, 0.015 to 0.017 amp.

These values are typical for operation with the operation switch at XTAL CHECK, under which condition maximum plate current is drawn.

(*) Asterisk with parenthesis indicates applicable issue letter.

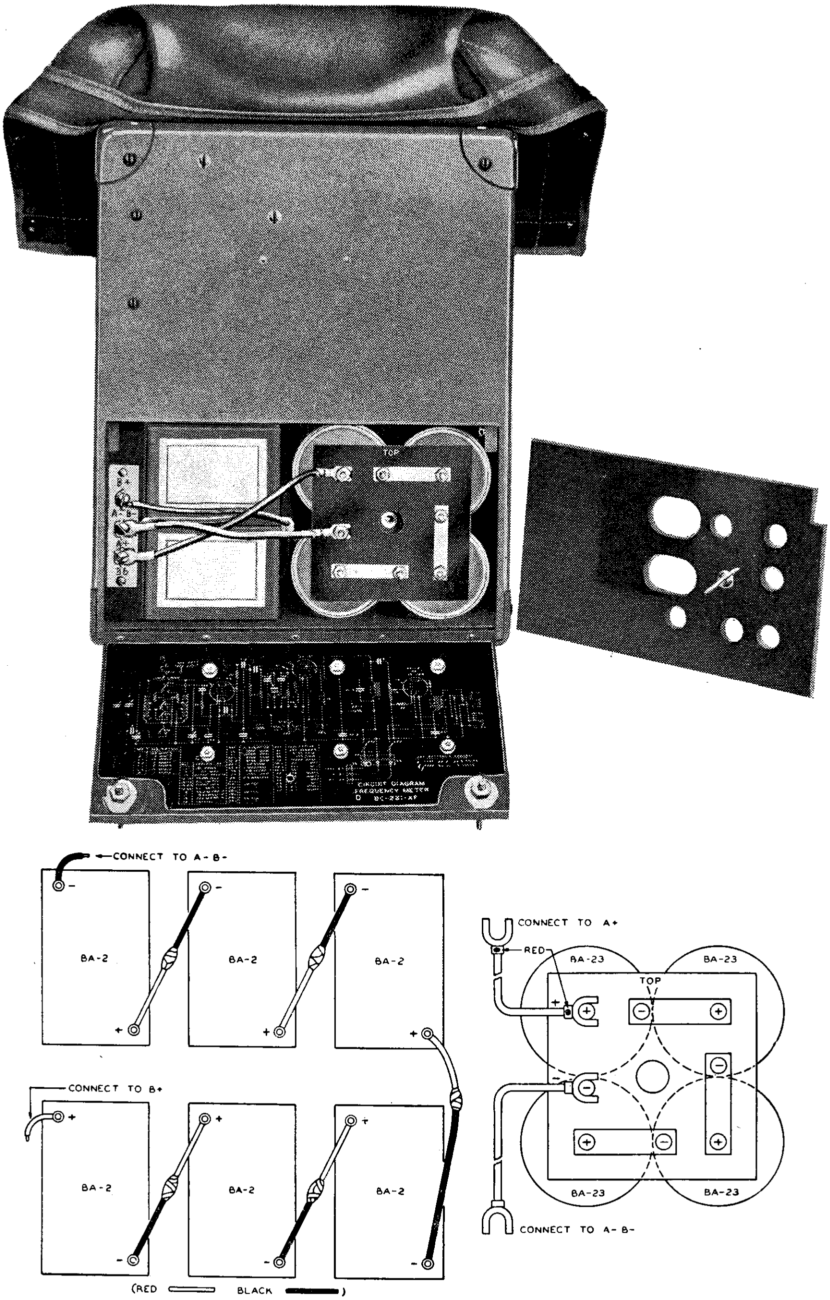


FIGURE 2—Frequency Meter BC-221-AF, Rear of Cabinet, Battery Compartment

SECTION II. INSTALLATION AND OPERATION

6. Initial Procedure.

Frequency Meter BC-221-AF is issued complete, with hoods and all vacuum tubes inserted and clamped into their respective sockets. After unpacking, thoroughly inspect all compartments of the frequency meter cabinet for possible damage during shipment.

7. Installation.

a. Batteries. Frequency Meter BC-221-AF obtains its operating voltage from batteries. These are not ordinarily included when shipped. Before the instrument can be operated, the batteries must be installed as follows:

(1). Select four "A" Batteries BA-23, and six "B" Batteries BA-2 from fresh stock when possible.

(2). Unsnap the back hood, marked BATTERIES, and open the battery compartment door at the lower rear of the cabinet.

(3). Turn the thumbscrew to the left and remove the battery retaining board. Be certain that the POWER ON-OFF switch is OFF before installing batteries.

(4). Connect the six "B" Batteries BA-2 as shown in figure 2, taping all joints securely so as to prevent a short circuit. Arrange the batteries in two layers of three each, in accordance with figure 2. The batteries in the bottom row are right side up, while those on the top row are upside down. Connect the positive (red) lead of the +B terminal of the strip (36) at the left side of the battery compartment. Connect the negative (black) lead to the −A −B terminal of the same strip.

(5). Remove the nuts from the binding posts of the four "A" Batteries BA-23. Install the batteries as shown in figure 2 so that the battery connecting board will fit over the binding posts. Before replacing binding post nuts, install leads from the batteries to terminal board at left hand side of cabinet.

(6). Before replacing battery retaining board make sure all connections are tightened securely.

Caution: When batteries are being loaded into the battery compartment, do not touch the connecting terminals as a severe shock will result.

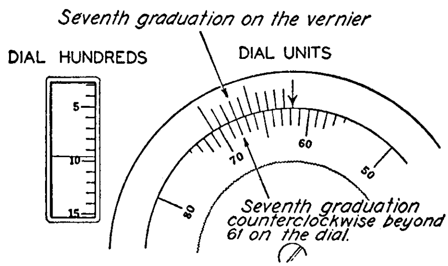
b. Antenna. A short antenna must be provided for coupling to the receivers and transmitters which are to be adjusted. Use a rigid wire, such as No. 12 wire, not over 3 feet long. Secure this wire to the antenna terminal on the front panel of the frequency meter and bend it so that its remote end will run parallel, and close to the transmitter or receiving antenna lead. Where conditions prevent this arrangement, such as in an airplane, use a flexible insulated pick-up wire with means provided to prevent its becoming a flight hazard. 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 fasten the lead at various coupling points, as desired, without grounding.

Caution: Never make any direct connection between the frequency meter and the transmitter under test.

c. Headset. Remove Headset HS-30-(*) and extension Cord CD-874 from headphone compartment at lower front portion of cabinet. Insert Plug PL-55 into the jack marked PHONES.

8. Reading Dial.

The drum behind the small window (D-2, figure 1) indicates the reading of the dial setting in hundreds. The large dial (D-1) provides the units; and the vernier scale above and concentric with the large dial provides the tenths place of the setting. To read the vernier, find that line of the vernier scale which coincides most closely with a line of the large dial. The number of this vernier line (counting the arrow as zero) gives the tenths place of the complete dial setting. The sketch shows the dial set for a reading of 0961.7. Before using the frequency meter for actual measurements, you should practice on the dial until settings can be determined or read off quickly and accurately. Note that on the large dial the line to the right of the arrow gives the proper value. If, for example, the dial is set at exactly 50 divisions and the vernier reads both 0 and 10 x .1 (ten tenths), the correct reading is



49 + 1.0 = 50, and not (50 + 1.0) = 51. The large dial is provided with a simple friction lock which keeps a predetermined setting fixed. This is particularly useful when the instrument is used in aircraft.

9. Correcting to Calibration.

a. Before attempting to make any frequency adjustments, correct the heterodyne oscillator to agree with the calibration by 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 use of the fundamental or harmonic frequencies of either or both oscillators.

To correct the heterodyne oscillator before setting it to any desired frequency within the calibrated range:

(1) With Headphones HS-30-(*) plugged in, turn POWER to ON and operation switch to XTAL CHECK. For highest possible accuracy, turn the set ON and allow the vacuum tube filaments to warm for at least 20 minutes.

(2) Turn FREQ. BAND switch to LOW if the desired frequency is between 125 kc and 2000 kc or to HIGH if the desired frequency is between 2000 kc and 20,000 kc.

(3) Open the calibration book to the page containing the dial setting for the frequency desired. Set the tuning dial to CRYSTAL CHECK POINT dial setting as listed on the bottom of the page.

(4) Turn the GAIN control about half way to the right or until a sound is heard in the headset.

(5) Turn the CORRECTOR until you have exact zero beat.

(6) Turn the knob in the lower left corner to HET OSC position and proceed to make measurements desired on a transmitter or receiver as described in paragraphs 10 and 11.

b. Accuracy of Calibration. A check of accuracy can be made by using the tabular list of crystal check points. (Par. 9*c*). Compare the dial reading for each beat point not listed in the calibration book. The meter is brought to zero beat, and the difference between the dial reading and the calibration book listing noted, and the difference evaluated in cycles. Assuming that the internal crystal is accurate, the frequency meter will be found accurate within the limits given in paragraph 1 provided the surrounding temperature does not vary more than $\pm 5°$ centigrade and the filament and plate voltages do not vary individually or collectively by more than $\pm 10\%$.

The overall accuracy of the meter can be checked (if you are within the range of American broadcast stations which are required by law to hold their frequency) within very close limits. Follow the procedure outlined in paragraph 12*d.*, and *compare* the reading with the known frequency of the broadcast station.

c. Beat Point Identification. It was stated in paragraph 9*a* that "comparison between the crystal and heterodyne oscillator may be made at many points over the calibrated range through the use of the fundamental or harmonic frequencies of either or both oscillators." When correcting the heterodyne oscillator to calibration, it will be found that there are numerous beat points at various harmonic combinations which are not listed as crystal check points in the calibration book. In most cases, the intensity of these unlisted beat points is relatively low. To eliminate confusion as to the actual crystal check points, the beat points of the various lowest harmonic combinations of the two oscillators (and the relative outputs for a typical Frequency Meter BC-221-AF, with 6.0 volt filament and 135.0 volt plate supplies, GAIN control at maximum) are given in the following tabulation (the calibrated crystal check points are marked with asterisks):

Beat Point Het. Fund Freq. (In Kilocycles) *(a) Low Band*	Lowest Het. Har.	Lowest Crystal Harmonic	Output Milliwatts
125.00*	8	1	115.0
128.21	39	5	1.2
129.03	31	4	5.0
130.43	23	3	16.5
131.57	38	5	1.7
133.33*	15	2	44.0
135.13	37	5	1.9
136.36	22	3	17.0
137.93	29	4	5.5
138.88	36	5	1.4
142.86*	7	1	120.0
147.05	34	5	4.6
148.14	27	4	12.0
150.00	20	3	18.0
151.51	33	5	1.9
153.85*	13	2	85.0
156.25	32	5	4.8
157.89	19	3	50.0
160.00	25	4	20.0
161.29	31	5	9.0
166.67*	6	1	130.0
172.41	29	5	4.0
173.91	23	4	19.0
176.47	17	3	52.0
178.57	28	5	9.0
181.82*	11	2	95.0
185.18	27	5	6.5
187.50	16	3	35.0
190.47	21	4	13.5
192.31	26	5	2.0
200.00*	5	1	130.0
208.33	24	5	3.0
210.53	19	4	18.0
214.29*	14	3	38.5
217.39	23	5	3.0
222.22*	9	2	110.0
230.77*	13	3	58.0
235.29	17	4	38.5
238.09	21	5	1.8
250.00*	4	1	120.0

Beat Point Het. Fund Freq. (In Kilocycles) *(b) High Band*	Lowest Het. Har.	Lowest Crystal Harmonic	Output Milliwatts
2000*	1	2	150.0
2125	8	17	16.5
2143	7	15	27.0
2167*	6	13	49.0
2200	5	11	73.0
2250*	4	9	90.0
2286	7	16	18.5
2333*	3	7	120.0
2375	8	19	8.0
2400	5	12	60.0
2429	7	17	12.0
2500*	2	5	140.0
2571	7	18	13.2
2600	5	13	46.0
2625	8	21	5.0
2667*	3	8	110.0
2714	7	19	9.0
2750*	4	11	70.0
2800	5	14	40.0
2833	6	17	12.0
2857	7	20	6.9
2875	8	23	2.4
3000*	1	3	150.0
3125	8	25	2.7
3143	7	22	5.5
3167	6	19	12.0
3200	5	16	20.0
3250*	4	13	56.0
3286	7	23	3.5
3333*	3	10	83.0
3375	8	27	1.6
3400	5	17	16.5
3429	7	24	3.3
3500*	2	7	130.0
3571	7	25	2.3
3600	5	18	12.8
3625	8	29	1.0
3667*	3	11	77.0
3714	7	26	2.0
3750*	4	15	29.0
3800	5	19	10.3
3833	6	23	3.0
3857	7	27	1.2
3875	8	31	.4
4000*	1	4	138.0

10. Transmitter Adjustments.

To set a transmitter to a specified frequency with the aid of this frequency meter, the transmitter frequency is adjusted for zero beat in the phones connected to the frequency meter. The method of coupling the frequency meter to a receiver or transmitter is described in paragraph 7*b*. The procedure is as follows:

a. Correct the heterodyne oscillator to calibration at the crystal check point nearest to the desired frequency (see Par. 9).

b. Turn the operation switch to HET. OSC.

c. Turn the frequency meter tuning control to the dial setting of the desired frequency, as given in the calibration book. Don't disturb the CORRECTOR capacitor adjustment made in *a.*

d. With the frequency meter antenna loosely coupled to the transmitter output, tune the transmitter to give an audible beat in the phones at approximately the proper transmitter dial setting. If the approximate dial setting is unknown the transmitter should first be set with an absorption type wavemeter such as Frequency Meter I-129.

e. Adjust the GAIN control to obtain a comfortable signal level in the headphones.

f. Tune the transmitter to zero beat with the frequency meter.

11. Receiver Adjustments.

a. To adjust a receiver to a desired frequency tune the receiver to the proper output frequency of the heterodyne oscillator, and make the comparison by means of a pair of headphones connected to the receiver output circuit. The method varies with the character of signal reception involved (see Par. 10*b* and *c*).

b. To tune a CW receiver to a desired frequency, proceed as follows:

(1) Correct the heterodyne oscillator to calibration at the crystal check point nearest the desired frequency (see Par. 9).

(2) Turn the operation switch to HET. OSC. and change to another headset connected to the receiver output jack.

(3) Turn the frequency meter tuning control to the dial setting of the desired frequency, as given in the calibration book, and

lock the dial. Don't disturb the CORRECTOR capacitor adjustment described in paragraph 11*b*(1).

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

(5) Adjust the receiver tuning to that side of zero beat which results in best reception conditions for the individual operator.

c. To tune a MCW receiver to a desired frequency:

(1) Correct the heterodyne oscillator to calibration at the crystal check point nearest to the desired frequency, as explained in par. 9.

(2) 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).

(3) Turn the operation switch to HET. OSC.

(4) Adjust a local unmodulated transmitter (that can be modulated) to zero beat with the frequency meter, proceeding as outlined in par. 10*d*., 10*e*., and 10*f*.

(5) Change over to another headset connected to the receiver output jack, modulate the transmitter output, and tune the receiver for maximum undistorted response.

12. Frequency Measurements.

a. Frequency Meter Set SCR-211-AF also may be used for accurately measuring a frequency emitted from an outside source, whether it be of local or remote origin, provided that such frequency lies within the calibrated range.

b. To measure accurately the emitted frequency of an adjacent transmitter or oscillator, the approximate frequency of which is known, the heterodyne oscillator is first corrected to the crystal check point nearest to the approximate known frequency (see Par. 9). To determine the actual frequency (after loosely coupling the frequency meter antenna to the source and turning the operation switch to HET. OSC.) first turn the frequency meter tuning control to the zero beat point found nearest the setting given for the approximate frequency, and read from the frequency column, opposite the resultant dial setting, in the calibration book.

c. *To* measure accurately the emitted frequency of an adjacent transmitter or oscillator, the frequency of which is unknown, it may first be determined to an approximation most readily with the aid of an absorption type wave-meter or a radio receiver, following which the actual frequency is determined as explained in par. 12*b*.

d. To measure accurately a frequency of remote origin, the signal is first tuned in on a radio receiver, and the approximate frequency noted from the receiver calibration. The heterodyne oscillator is next corrected to calibration at the crystal check point nearest to it. The operation switch is then thrown to HET. OSC. and the frequency meter antenna loosely coupled to the receiver antenna lead and the frequency meter tuning control turned until its signal is heard in the receiver headset. If the signal in question is CW, the receiver is tuned to zero beat, and the frequency meter is tuned to zero beat with the receiver. If the signal is modulated, the receiver is first adjusted for maximum response to the signal in the MCW condition when it is changed over for CW reception; the frequency meter is tuned to zero beat. In both cases, the frequency read for the resultant frequency meter dial setting from the appropriate column in the calibration book, is the frequency of the signal in question.

13. Circuits.

a. The crystal controlled oscillator utilizes the cathode, inner grid, and anode grid of Tube VT-167 (see Figs. 15 and 16). The oscillator operates at the fixed frequency of 1000 kc., when operation switch (28) is at XTAL ONLY. The circuit is designed to generate considerable harmonic energy so that it may be used to calibrate the heterodyne oscillator at several points over its entire range. The necessary plate circuit impedance is built up across an untuned inductance (18), which is thoroughly sealed against moisture. The crystal (19) is supplied in a hermetically sealed metal holder which provides permanent protection against humidity, corrosion and dirt intrusion. One of the smaller type metal tube envelopes is used in the construction of this holder, so that it plugs into the standard otcal tube socket (14). The cut of the crystal and the internal construction of the holders are such that, under any conditions of barometric pressure, humidity, voltage, vibration, shock or tilt, only the specified output frequency and its harmonics are obtained. The crystal is ground for operation at a normal temperature of plus 68° F. The temperature coefficient of the combined crystal, holder and circuit, as expressed in frequency shift is less than one cycle per degree F. as measured from −22° F. to +122° F.

b. The heterodyne oscillator uses Tube VT-116-B in an electron coupled circuit. There are two continuously variable ranges which may be manually selected by the FREQ BAND switch (27*a* thru 27*e*). In the frequency position, a fundamental range of 125 to 250 kc. is used; which, by calibrating the first, second, fourth and eighth harmonics, gives continuous coverage over the range from 125 to 2000 kc. In the high frequency position, a fundamental range of 2000 to 4000 kc. is used; which, by calibrating the 1st, 2nd, 4th, and part of the 5th harmonics, gives continuous coverage throughout the range from 2000 to 20,000 kc. The two inductors (16 and 17), in the tuned circuits, are wound on ceramic forms and are 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, in addition to the variable corrector capacitor (2), and the adjustable low and high frequency trimmer capacitors 3-1 and 3-2. The main tuning capacitor (1) is capable of continuous rotation in either direction without stops. 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 drum, or DIAL HUNDREDS, scale is marked with 50 divisions, and the vernier dial is marked with 100 DIAL UNITS divisions. This arrangement provides 5000 effective readable divisions. The calibrated ranges occupy approximately that portion between 250 and 4750 (see Fig. 14). Backlash in the gear mechanism has been reduced to less than two-tenths of one division. A dial lock is provided to prevent any accidental movement of the dial after the desired setting has been made.

c. The heterodyne oscillator circuits are calibrated at a temperature of 68° F, and the dial settings of the successive 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 0.001 per cent per degree F, as measured over a range of 144° F. The corrector capacitor 2, which is connected in parallel with 1, makes it possible to reset the heterodyne oscillator to agree with the crystal calibration at any harmonic for any surrounding temperature between the limits of minus 22° and plus 122° F.

d. The three inner elements of Tube VT-167 are used in the crystal oscillator circuit. The remaining elements of this tube (comprising the control grid, screen grid and 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 (21) in the plate output circuit of the electron coupled heterodyne oscillator is coupled to the control grid of this detector through a small fixed capacitor (5-1). The antenna post, mounted on the front panel, is coupled to the control grid of the detector through the coupling capacitor 5-2 in series with 5-1. As a result of these three coupling means, and dependent on the position of the operation switch, the detector functions to mix the heterodyne oscillator output either with the fundamental and successive harmonics of the crystal oscillator, or with the transmitter frequency to be measured. When the operation switch is at HET. OSC., the crystal oscillator is off. Variable air trimmer 50 is used to adjust crystal assembly 19 accurately during manufacture. Its adjustment must not be altered unless the instrument has been damaged, or if other than the original crystal is used. Under such

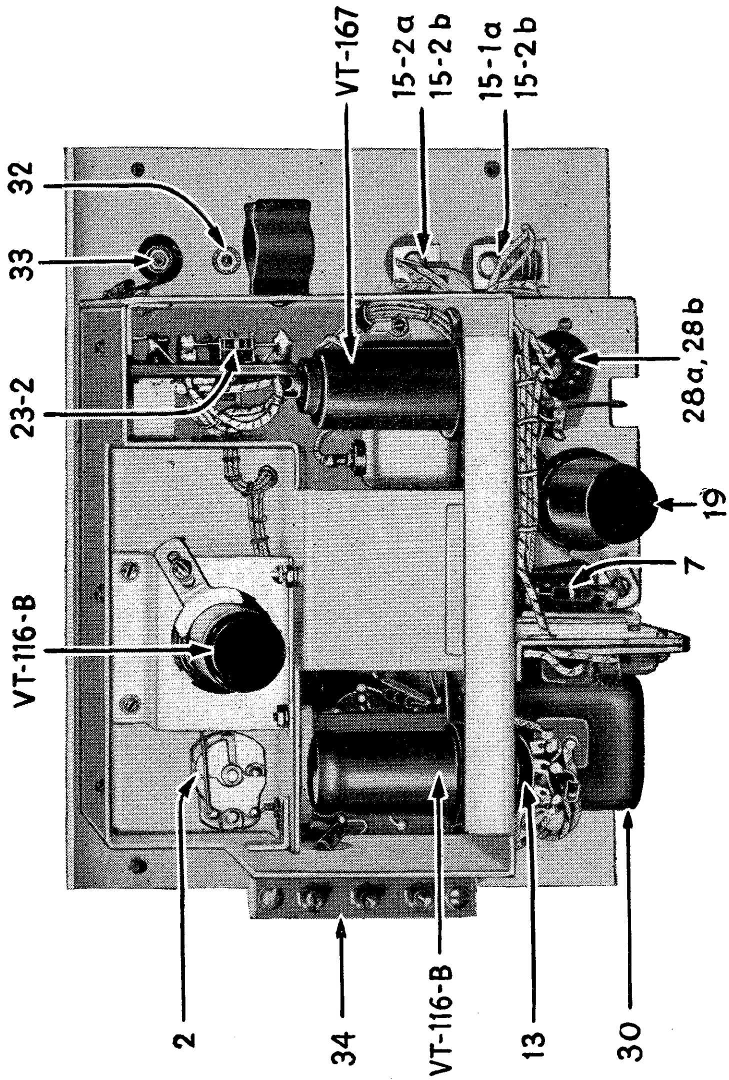


FIGURE 3—Frequency Meter BC-221-AF, Rear View of Chassis

circumstances it should only be adjusted by use of an extremely accurate external standard frequency of 1,000 kc.

e. The detector plate works into an audio choke 30, which is tuned by the capacitor 40-3, and the beat frequency voltages built up across it are coupled through capacitor (9) and the GAIN control potentiometer (26), to the grid of Tube VT-116. The grid of VT-116-B returns to ground through the potentiometer (26), the desired bias potential being obtained by the drop in the cathode resistor (25). Tube VT-116-B is coupled to the PHONES jacks 15-1a, 15-2a, through output transformer (10) to match Headset HS-30-(*). Either 250 ohm or 600 ohm headsets can be used without change-over adjustments.

f. 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 6.00 milliwatts (beat frequency of 300 cycles). Regardless of whether the heterodyne oscillator is beating with energy from an external source of radio frequency or with the crystal calibrator, the output will vary with audio frequency as follows:

Beat Note Frequency	Output
100 Cycles	5 Milliwatts
300 Cycles	15 Milliwatts
1000 Cycles	4 Milliwatts

g. The antenna post is coupled to the control grid of the detector through capacitors 5-2 and 5-1 respectively, in series. Look at figures 15 and 16, and you will see that the antenna post is also coupled directly to the heterodyne oscillator output through capacitor 5-2 alone. The antenna post (33) serves the dual purposes 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 used 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.

h. All power required for the operation of this unit is introduced through the battery terminal board (36). The common negative filment and negative plate battery leads are connected to

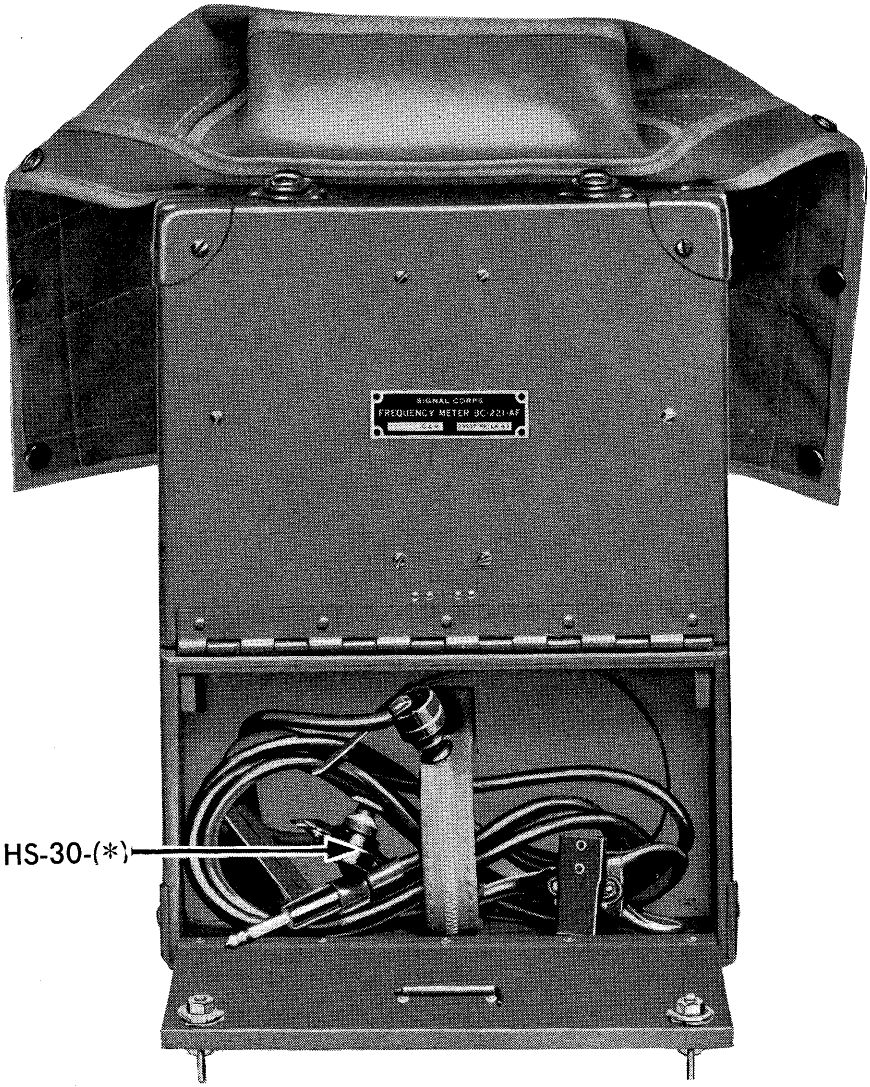


FIGURE 4—Frequency Meter BC-221-AF, Front of Cabinet, Spare Parts Compartment

the middle terminal, which is grounded to the chassis. A fabricated wiring harness is provided for inter-cell 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 auxiliary switches 15-1b, 15-2b (when the headset plug is inserted in either of 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 discharged accidently when the set is not in use, even though the power switch is left ON.

i. Because of extreme refinements involving the type and design of the basic circuits, the relative arrangements 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 either 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 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 can be heard.

14. Vacuum Tubes.

The vacuum tubes used in this equipment, and their maximum operating characteristics, are shown in the following tabulation:

Reference:	VT-116-B	VT-167	VT-116(B)
Function:	Heterodyne Oscillator	Crystal Osc. & Detector	AF Amplifier
Type:	Triple Grid Amplifier	Converter	Triple Grid Amplifier
Signal Corps Type Nomenclature:	VT-116-B	VT-167	VT-116B
Nearest Com'l. Equivalent:	6SJ7Y	6K8	6SJ7(Y)
Base:	Octal 8 pin	Octal 8 pin	Octal 8 pin
Heater Voltage (E_f):	6.3v	6.3v	6.3v
Control Grid Voltage (E_{g^1}):	−3.0v	−3.0v	−3.0v
Screen Voltage (E_{g2})	100.0v	100.0v	100.0v
Plate Voltage (E_{p^1}):	250.0v	250.0v	250.0v
Anode Grid Voltage (E_{p2}):		100.0v	
Heater Current (I_f):	300ma	300ma	300ma
Screen Current (I_{g2}):	0.8ma	6.0ma	0.8ma
Plate Current (I_{p^1}):	3.0ma	2.5ma	3.0ma
Anode Grid Current (I_{p2}):		3.8ma	
Transconductance (S_m):	1650μmho	350μmho	1650μmho

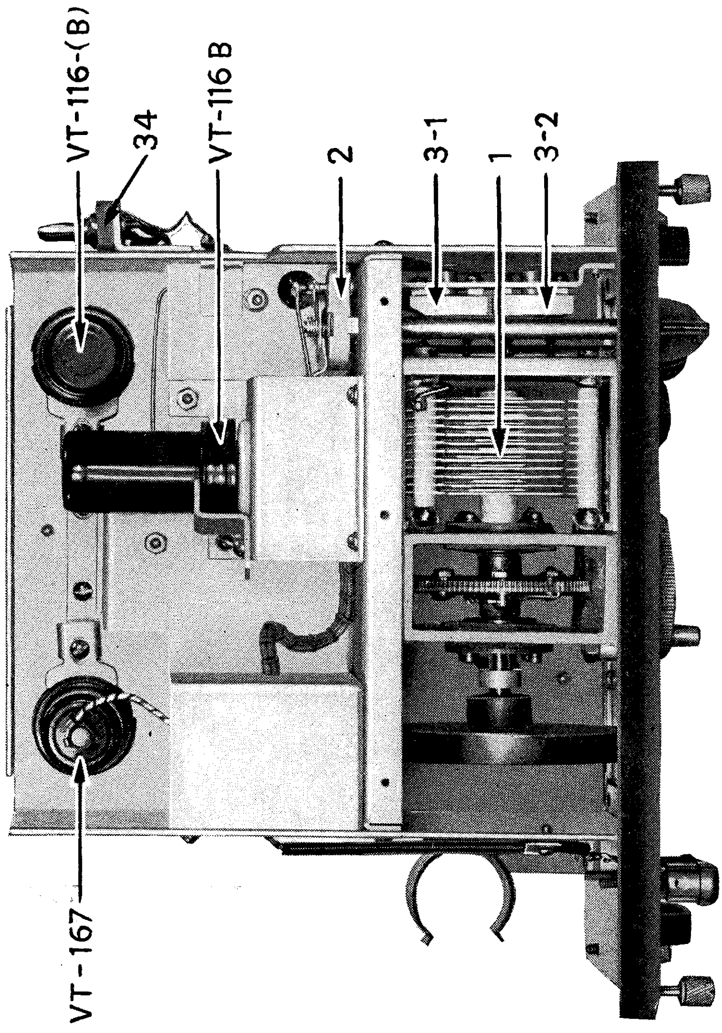


FIGURE 5—Frequency Meter BC-221-AF, Top View of Chassis, Condenser Shield Removed

15. Calibration Book MC-177-AF.

The low frequency fundamental range of the heterodyne oscillator is calibrated at each one-tenth kilocycle between 125 and 250 kc, or a total of 1251 points. The high frequency fundamental range is calibrated in increments of one kilocycle steps between 2000 and 4000 kc. or a total of 2001 points. These fundamental frequencies are printed in tabular form on the successive pages of the calibration book, together with associated columns listing the second, fourth and eight harmonics 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.

The nearest crystal check points are also shown in red across the bottom of each page and the first and last frequencies and the dial settings tabulated are indicated across the top. There are 72 inside pages, indexed as to page number. Page 28 is an index to the dial settings in the low range and page 31 contains a similar listing for the high range. In addition, an index of frequencies in the high range is printed on page 30, and another for the low frequency range is given on page 29. A brief summary of the essential steps in operating the equipment is given on page 72. The calibration is printed on oiled and waterproofed paper. The calibration book has two 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.

Take care of your calibration book. **It is a valuable tool, a very important part of the equipment and takes a great deal of time to duplicate.**

16. Covers BG-81-AF.

Covers of flexible waterproof material are provided to fit over the front and rear of the frequency meter cabinet to protect the instrument from damage from the rain but if you drop it **these covers won't protect the instrument in water.** The covers are secured to the cabinet at the top by a metal strip held in place by screws, and are held in contact with the sides of the cabinet by means of snap fasteners. A pocket inside of the rear cover contains the technical manual.

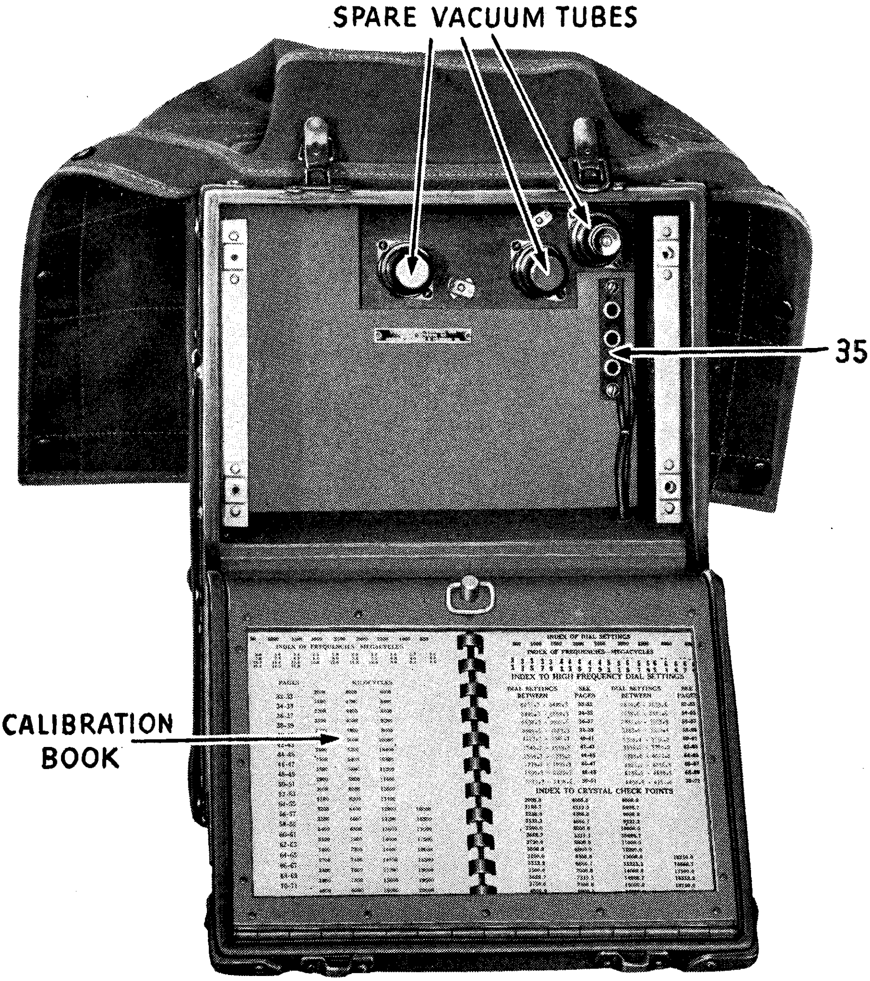


FIGURE 6—Frequency Meter BC-221-AF, Front of Cabinet, Chassis Compartment

SECTION IV. MAINTENANCE

17. General.

Frequency Meter BC-221-AF is built to withstand shocks and strains in the field. **This equipment is extremely accurate and sensitive, and therefore must be handled as carefully as you would any precision instrument!**

CAUTION: CERTAIN PARTS OF FREQUENCY METER SET SCR-211-AF AREN'T REPLACEABLE WITHOUT SPECIAL TEST EQUIPMENT. IN PARTICULAR, THE MAIN TUNING CAPACITOR, THE HIGH AND LOW FREQUENCY COILS, AND CERAMIC OR TEMPERATURE COMPENSATING CAPACITORS AREN'T REPLACEABLE WITHOUT COMPLETE RECALIBRATION OR READJUSTMENT OF TEMPERATURE COEFFICIENT. WITH THE SMALL REQUIREMENT FOR REPAIRS OF THIS TYPE, IT IS STRONGLY RECOMMENDED THAT WHEREVER POSSIBLE SUCH REPAIRS SHOULD BE MADE ONLY AT THE MANUFACTURER'S PLANT.

18. Inspection. (See Par. 6).

19. Servicing.

a. Normally, the only servicing required should be the replacement of batteries and vacuum tubes. This must be done at regular intervals, depending upon how much you use your SCR-211-AF. Place a single drop of the oil issued for this purpose on the gear teeth of the heterodyne-oscillator capacitor driving mechanism occasionally. Don't lubricate any other part of the equipment.

b. Faulty operation may be due to failure of the power supply, the crystal circuit, variable frequency oscillator circuit, the detector circuit, the amplifier circuit or the head set. If the following simple tests are applied, the particular section of the circuit that is defective may be easily located.

(1) To check the batteries under normal load; Plug a head set into the phone jack, turn the POWER switch ON, allow about a minute for the tubes to warm up. Open the battery compartment and on terminal strip 36 measure the "B" voltage between +B and −B −A terminals with a voltmeter with a full scale range of at least 150 volts. **Caution: Don't touch both terminals or you will get a shock.** Measure "A" voltage between +A and −A terminals with a voltmeter having a full scale range of at

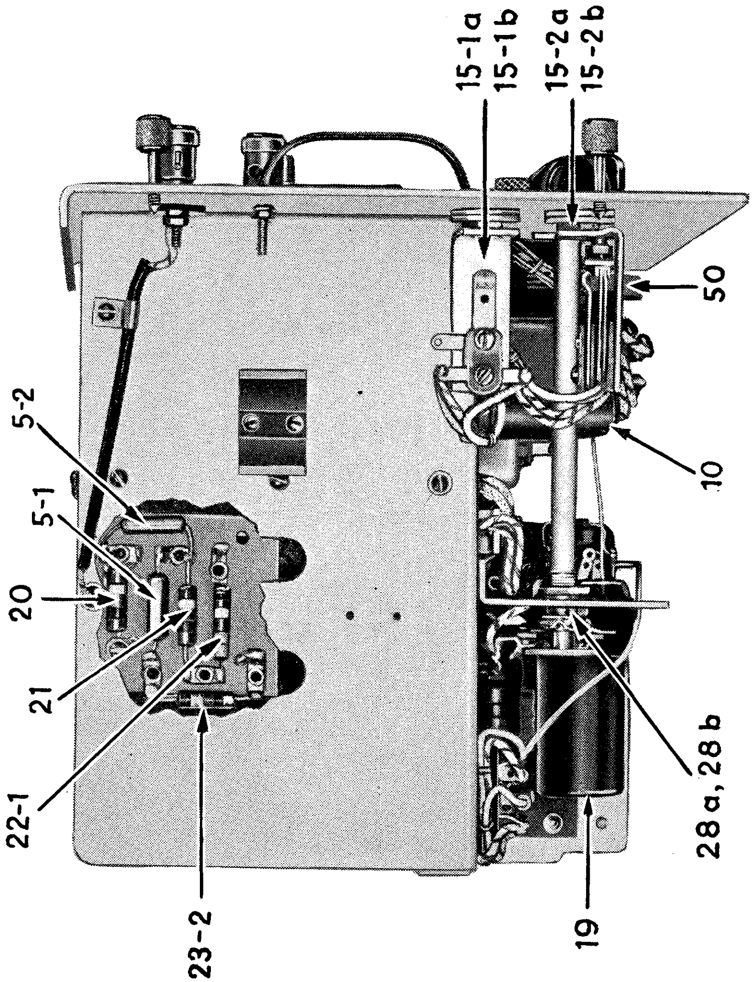


FIGURE 7—Frequency Meter BC-221-AF, Left Side of Chassis

least 6 volts. If the total "B" is below 120 volts or the total "A" voltage is below 5.4 volts, check each battery individually and replace those which are low.

(2) To check the headset; Plug the headset into the phone jack, throw the POWER switch ON and allow the tubes to heat for a few minutes. Snap the POWER switch OFF and ON rapidly several times. If loud clicks result in the headset, the phones are obviously working. If no sounds are heard, either the headset or the frequency meter may be defective. To test the headset further, remove the phone plug from the frequency meter, open the battery compartment and listen to the headset. At the same time the tip of the phone plug is touched several times to one terminal of a 1.5 volt, "A" battery (known to be good) while the sleeve of the plug is held in contact with the other terminal of the dry cell. A distinct click should be heard each time the contact is made or broken. If no click is heard, the headset or cord is defective. An alternate method of testing is to check the circuit by means of an ohmmeter or continuity meter making connections to the tip and sleeve of the plug.

(3) The simplest way to find out whether the variable frequency oscillator is oscillating is to remove the meter from the case, connect the batteries by means of temporary leads, or more conveniently, by means of an adapter cable made up for that purpose. Plug in a headset, throw the POWER switch ON, turn the operation switch to XTAL CHECK and allow the tubes to warm up. Turn the GAIN control clockwise (to the right), and then touch the finger a few times in rapid succession to the rigid lead connected to the stator of the CORRECTOR capacitor. A loud click should be heard each time the finger makes or breaks contact with the wire. These clicks are evidence that the heterodyne oscillator is working. Their absence does not necessarily indicate that the oscillator is not working because the failure of either the headset, the audio amplifier, or the detector would prevent the clicks from being heard. The most positive check for oscillator performance is to listen in on a receiver (adjusted for CW reception and coupled to the frequency meter) while the meter is tuned through the frequency range to which the receiver is adjusted. At this frequency you should get the familiar beat note.

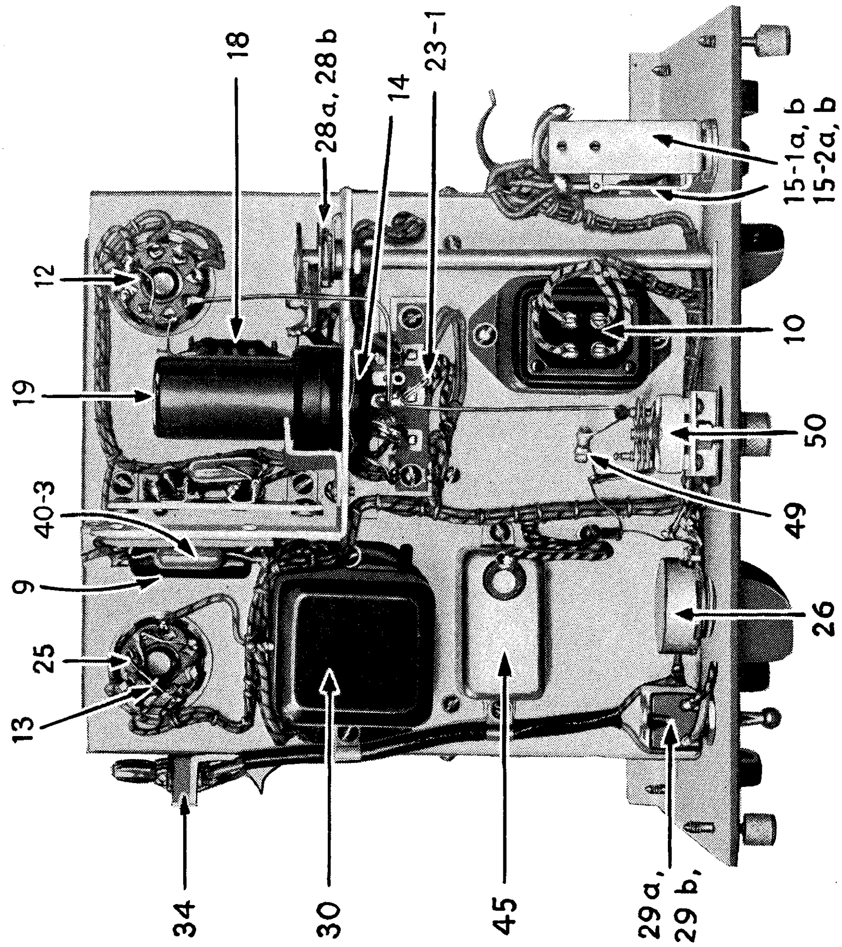
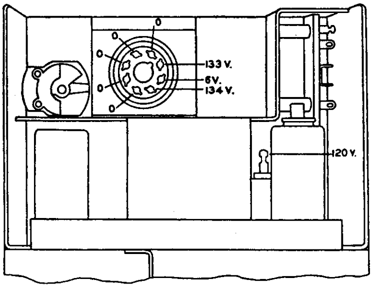


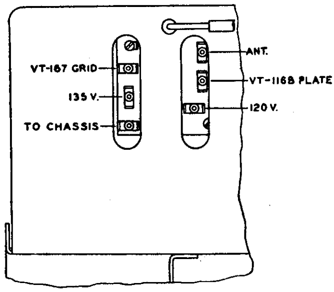
FIGURE 8—Frequency Meter BC-221-AF, Bottom View of Chassis

(4) The simplest way to check the crystal oscillator circuit for oscillation is to proceed as in (3), except in this case the test is made by turning the chassis upside down, holding one end of a wire (or other metallic object such as a screw driver) in contact with the chassis while the other end is touched several times to the lead which connects the crystal socket to the small variable capacitor, (50) mounted behind the nameplate. With the GAIN control well advanced clockwise (to the right), a loud click should be heard each time contact is made. The absence of clicks does not mean definitely that the crystal circuit is not oscillating because as in (3), the failure of the detector, the audio amplifier or the phones could prevent the clicks from being heard. An alternate and more positive method of testing the oscillator is to couple a receiver to the frequency meter, throw the operation switch to XTAL ONLY and tune the receiver (adjusted for CW reception) in the vicinity of any integral megacycle, such as 2, 3, 4, etc. megacycles, listening for the familiar beat note as the receiver frequency passes the frequency of the crystal or its harmonics.

(5) The audio amplifier and detector may be most simply tested as follows; Connect and warm up the unit as in (2), advance the GAIN control clockwise (to the right), and listen in the headset for a loud click as TUBE VT-167 is removed from the socket. This is actually a combined test for the audio amplifier and for the plate circuit of the detector tube. The remainder of the detector circuit must be checked by a voltage and resistance test.

(6) When one of the above tests shows a failure in the instrument, and if changing tubes does not remedy the situation, the next procedure is to measure the voltages on the various socket connections and at various key points in the meter. Using a meter with a resistance of 1000 ohms per volt and with a scale of at least 150 volts for "B" voltage measurements and at least 6 volts for "A" voltage measurements, check for voltages shown in figure 9. Since there are slight manufacturing differences in both tubes and resistors, the voltages measured may vary at least 15 per cent from the values shown. If any test shows zero where a voltage should be present, trace the circuit with the aid of the schematic diagram in figure 15 until a point is reached where the voltage present agrees reasonably well with the voltage specified.





VT-116B Voltages measured from top of socket—Tube removed.

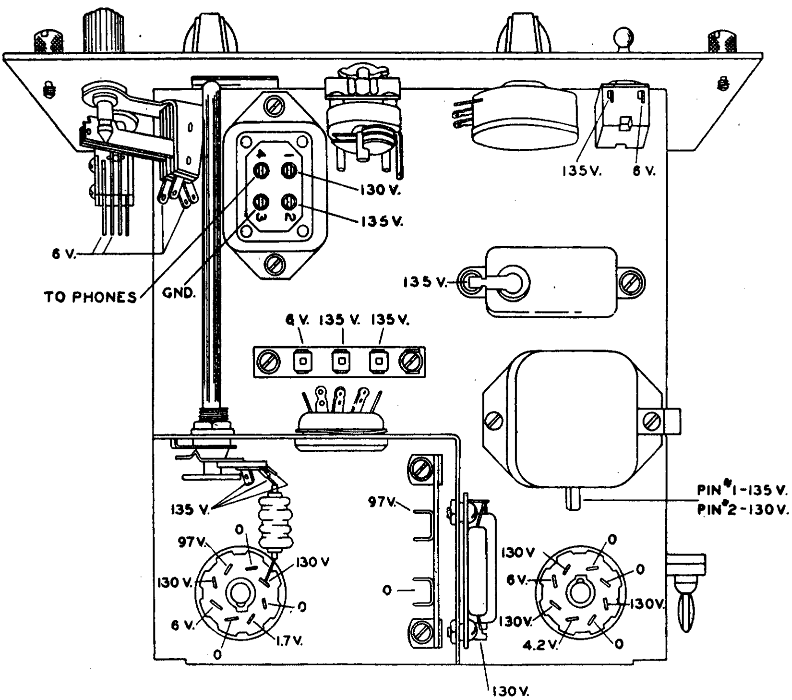


FIGURE 9—Voltage Check Points

The defective element can then be easily found and should be replaced by a spare. In case there is a capacitor connected from the chassis to the point of zero voltage, first check the capacitor with a continuity meter or ohmmeter with the POWER switch OFF. If the resistance is virtually zero it is more likely that the capacitor is shorted than that the resistor feeding it is open or has materially increased in resistance; however, both should be checked.

20. Readjustment of Trimmer Capacitors.

Warning: Do not attempt to make the following re-adjustments except in case of extreme emergency. Return the frequency meter to a Signal Corps repair depot. These are adjustments that can best be made at the factory.

a. It may be found that the heterodyne oscillator cannot be corrected to agree with the calibration as explained in paragraph 9, particularly if the frequency meter is being used in a locality where there is extremely high or extremely low humidity. Under such conditions, and then only, it becomes necessary to reset the heterodyne trimmer capacitors 3-1 and 3-2. You can reach the trimmer adjusting screws 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 (see Fig. 10). 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 screw driver will be required to make these adjustments, the necessary procedure being as follows:

(1) Place the unit in operation by throwing POWER switch to ON. Throw the FREQuency BAND switch to LOW and allow at least ten minutes for warm-up before proceeding.

(2) Set the DIAL UNITS and DIAL HUNDREDS scales to agree with the reading given for 250 kc. on Page 27 of the calibration book. Set the CORRECTOR dial at midscale (4.5 divisions). Throw the operation switch to XTAL CHECK.

(3) With a small screw driver rotate the LOW band trimmer (capacitor 3-1) toward the right, while listening in the phones, until the heterodyne oscillator is set to zero beat of a strong beat with the crystal calibrator.

(4) Check the ability of the corrector capacitor to reset to zero beat at all crystal check points listed in the calibration book, proceeding as outlined in paragraph 9.

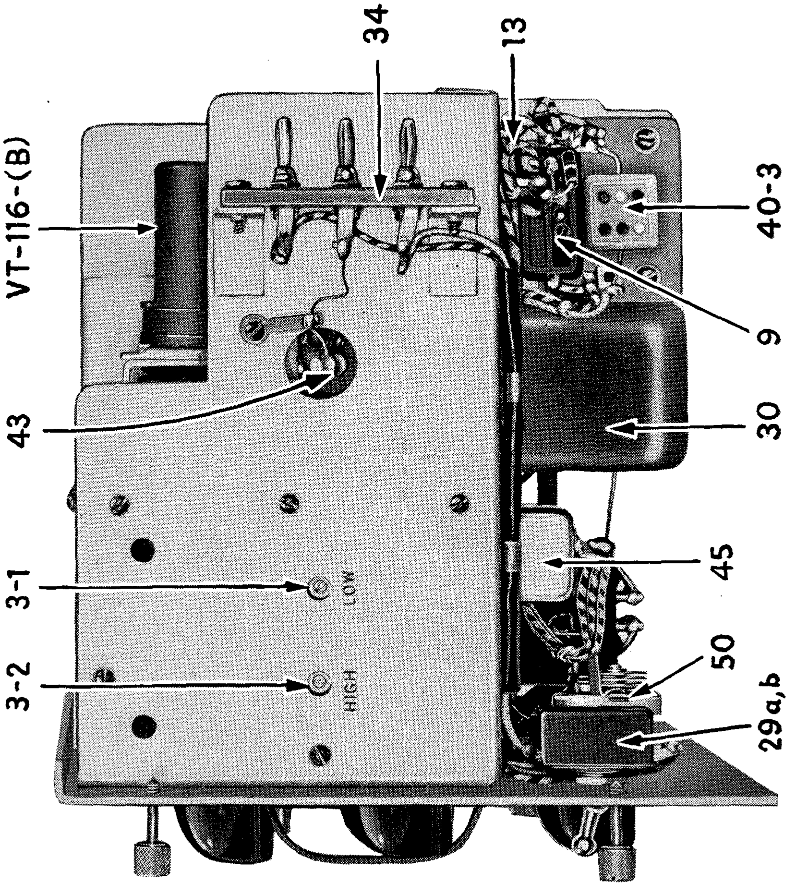


FIGURE 10—Frequency Meter BC-221-AF, Right Side of Chassis

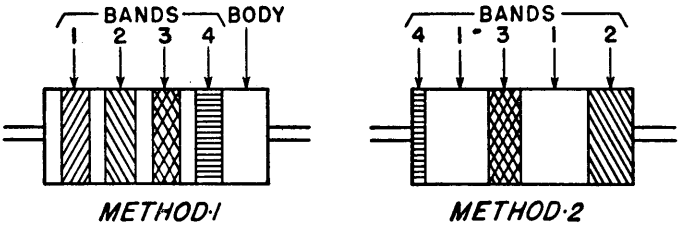
(5) If the unit cannot be corrected at all crystal check points in the low band with the trimmer adjustment that was made with the CORRECTOR dial set at 4.5 for 250 kc. the proceedure outlined in (3) and (4) should be repeated, with the CORRECTOR dial set to 6 divisions for 250 kc.

(6) In this way, a setting of the low frequency trimmer will be found where it will be possible, using 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.

(b) Repeat this procedure with the FREQuency BAND switch at HIGH and the DIAL UNITS and DIAL HUNDREDS scales set to agree with the reading given for 4000 kc. given on page 71 of the calibration book. Adjust the HIGH band trimmer (capacitor 3-2) to a 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.

21. Resistors.

The insulated resistors supplied in this equipment are marked in accordance with the RMA Standard Color Code below:



Color	1st BAND	2nd BAND	3rd BAND	4th BAND
	1st Digit	2nd Digit	Decimal Multiplier	Tolerance
Black	0	0	1	
Brown	1	1	10	
Red	2	2	100	
Orange	3	3	1,000	
Yellow	4	4	10,000	
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7	10,000,000	
Gray	8	8	100,000,000	
White	9	9	1,000,000,000	
Gold	—	—	—	±5%
Silver	—	—	—	±10%
No Color	—	—	—	±20%

V. SUPPLEMENTARY DATA

22. Table of Replaceable Parts

Ref. No.	Stock No.	Quan. Used	Name and Description	Function	Mfr.	Drawing Number
1		1	*CAPACITOR*, variable, air; capacity, maximum 160 $\mu\mu f$, minimum 11.5 $\mu\mu f$; 360° rotation; pyrex glass insulators supplied with gears mounted on rotor shaft, driven by Vernier worm; approx. overall dimensions 3 in. x 3 in. x 4¾ in. SPECIAL	Osc. Tuning	Z	SG785
2	3D9003V-6	1	*CAPACITOR*, variable, air; two plate; air gap .040 in.; maximum capacity, 3 $\mu\mu f$ +15% −0; ¼ in. diameter shaft 3 13/16 in. long; ceramic insulator; 9/32 in. diameter bearing bushing. Type 550-AT	Corrector	A3 S O	22G9
3-1	3D9010V-6	2	*CAPACITOR*, variable, air; two rotor plates, two stator plates; air gap .030; 360° rotation; maximum capacity 10 $\mu\mu f$; ceramic insulation; shaft 9/32 in. dia. x 5/16 long; Type 550-AT	L.F. Trimmer	A3 O	22G5
3-2	3D9010V-6	—	*CAPACITOR*, same as 3-1	H.F. Trimmer		
5-1	3D9010-32	2#	*CAPACITOR*, fixed, mica; 10 $\mu\mu f$ (±20%) 500 V. D.C.W; Brown moulded bakelite case 3/16 in. x 23/64 in. x 25/32 in.; axial wire leads, #20 AWG tinned copper wire 1¼ in. long. Type 5S	Osc. Coupling	C5	22G6
5-2	3D9010-32	—	CAPACITOR, same as 5-1	Ant. Coupling		
6	3D9007	1#	*CAPACITOR*, fixed, silver on ceramic; 7 $\mu\mu f$ (+2 $\mu\mu f$ −0 $\mu\mu f$) 500 V. D.C.W. temperature coefficient −.0024 $\mu\mu f$ /C°; 5/32 in. dia. x 7/16 in. long; wire leads, #22 AWG tinned copper wire 1½ in. long. Type 809-126	L.F. Compensator	C M2 E	22G14
7	3Z6018-1	1#	RESISTOR, fixed; 180 ohms (±10%) ½ W; Carbon, insulated; 5/32 in. dia. x 3/8 in. long; axial wire leads, #20 AWG tinned copper wire 1½ in. long. Type EB-1811	Cathode Bias	A I	63G23 SC-D-970-W

22. Table of Replaceable Parts—Continued

Ref. No.	Stock No.	Quan. Used	Name and Description	Function	Mfr.	Drawing Number
9	3DA20-39	1#	CAPACITOR, fixed, paper dielectric; 20000 $\mu\mu f$ (±20%) 400 V. D.C.W; black moulded bakelite case, 3/8 in. x 3/4 in. x 1 7/16 in.; axial wire leads, #20 AWG tinned copper wire 1 1/2 in. long. Type 342-12	Audio Coupling	M3	22G478
10		1	TRANSFORMER, output; primary 5675 turns #41 A.W.G. enamel copper wire, secondary 747 turns #36 A.W.G. enamel copper wire; four split lug type terminals mounted on bakelite strip on top of case for external connections; overall dimensions 1.410 in. x 2 in. x 2 3/8 in. Type No. 10070	Output Transformer	C2	95G39
11	2Z8762-2	1	SOCKET, tube, octal; steatite; 8 contacts, overall dimensions including contacts 1 1/4 in. diameter x 13/16 in.; supplied with steel retaining ring. Type 55-8M	For Tube VT-116B	A2 C4	78G4
12	2Z8799-137	3	SOCKET, tube, octal; black moulded bakelite; 8 contacts, overall dimensions including contacts 1 1/4 in. diameter x 13/16 in.; supplied with steel retaining ring. Type 78-S8M	For Tube VT-167	A2	78G2
13	2Z8799-137	—	SOCKET, same as 12	For Tube VT-116B		
14	2Z8799-137	—	SOCKET, same as 12	For Crystal		
15-1a,b	2Z5598-1	2#	JACK, single circuit filament control; 3/8-32 thread mounting bushing 3/8 in. long; overall dimensions 3/4 in. x 1 11/16 in. x 1 11/16 in. Type 703	Phone Jack, Fil. Switch	M U	44G1
15-2a,b	2Z5598-1	—	JACK, same as 15-1a,b	Phone Jack, Fil. Switch		
16		1	*COIL*, oscillator, high frequency; single winding; 32 1/4 turns 7 strands #42 (LITZ) double Celanese enamel copper wire; taps at 18 1/2 and 6 1/2 turns; four solder lugs for external connections; Isolantite form 1 1/8 in. dia. x 1 15/16 in. long; assembly impregnated with Wax. SPECIAL	Het. Osc. Inductance	Z	SG573

#Indicates item furnished in maintenance parts group. Italics indicates parts that affect calibration.

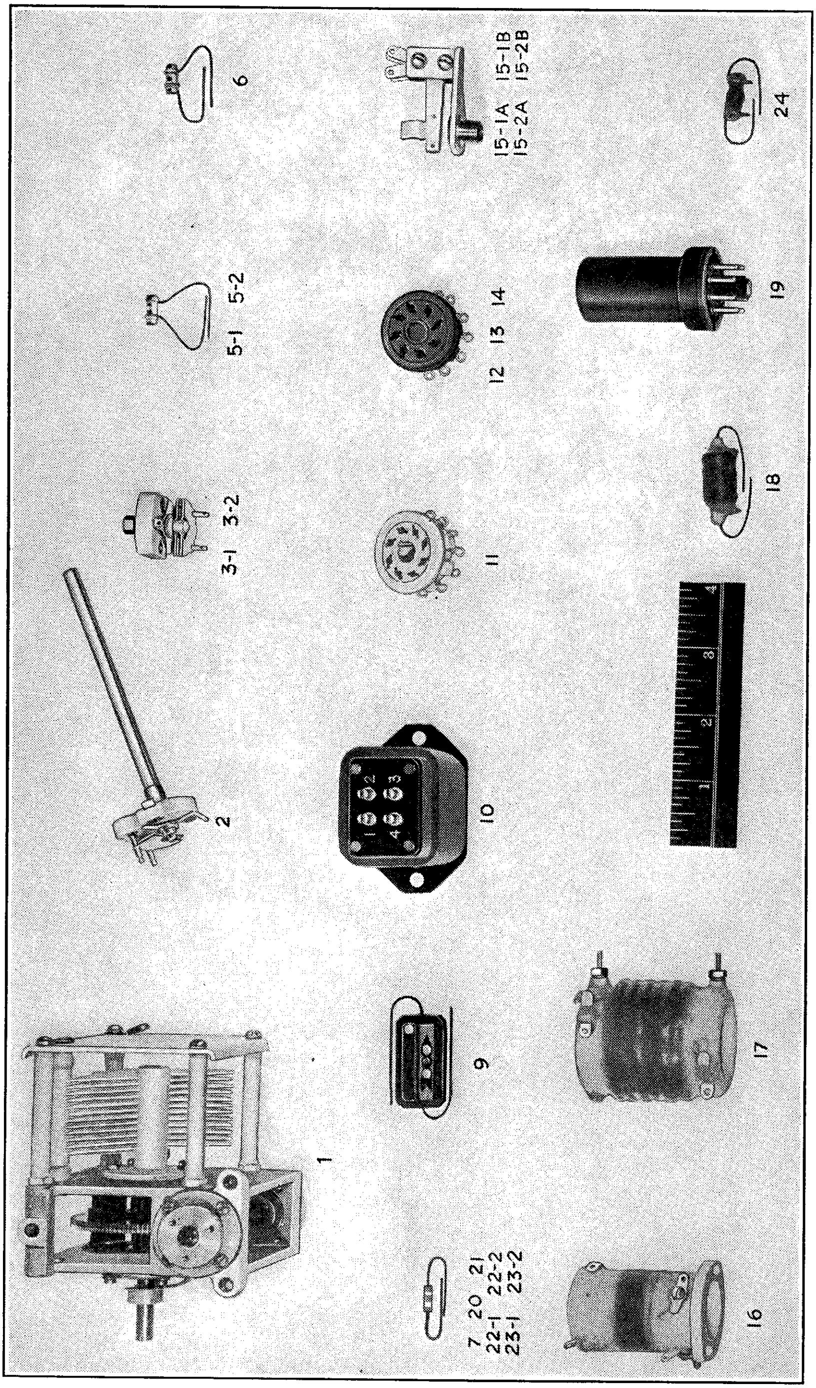


FIGURE 11—Replaceable Parts

22. Table of Replaceable Parts—Continued

Ref. No.	Stock No.	Quan. Used	Name and Description	Function	Mfr.	Drawing Number
17		1	*COIL*, oscillator, low frequency; six PI Universal winding, four solder lugs for external connections; Isolantite form 1½ in. dia. x 2 in. long; assembly impregnated with Wax. SPECIAL	Het. Osc. Inductance	Z	SG12
18		1	COIL, radio frequency choke; four PI Universal winding; winding form 9/32 dia. x 7/8 in. long; leads, #20 AWG tinned copper wire 1½ in. long. SPECIAL	Crystal Plate Choke	Z	SG538
19	2Z3501-9T	1	CRYSTAL, type DC-9; metal shell, overall dimensions 15/16 in. dia. x 2⅝ in. long. Signal Corps specification 71-1355, Type MS432	Crystal Oscillator	B C-6	103G6
20	3Z4528	1*	RESISTOR, fixed; 5000 ohms (±10%) ½ W; carbon, insulated; 3/16 in. dia. x ⅝ in. long; axial wire leads, #20 AWG tinned copper wire 1½ in. long. Type BT-½	R.F. Output	A I	63G6 SC-D-970-W
21	3Z4531	1*	*RESISTOR*, fixed; 50000 ohms (±10%) ½ W; carbon, insulated; 3/16 in. dia. x ⅝ in. long; axial wire leads, #20 AWG tinned copper wire 1½ in. long. Type BT½	Het. Plate	A I	63G4 SC-D-970-W
22-1	3Z6587	3*	*RESISTOR*, fixed; 8750 ohms (±10%) ½ W; carbon, insulated; 3/16 in. dia. x ⅝ in. long; axial wire leads, #20 AWG tinned copper wire 1½ in. long. Type BT-½	Het. Osc. Screen	A I	63G8 SC-D-970-W
22-2	3Z6587	—	RESISTOR, same as 22-1	Det. Screen		
23-1	3Z4534	2*	RESISTOR, fixed; 1.0 megohm (±10%) ½ W; carbon, insulated; 3/16 in. dia. x ⅝ in. long; axial wire leads, #20 AWG tinned copper wire 1½ in. long. Type BT½	Crystal Osc. Grid	A I	63G7 SC-D-970-W
23-2	3Z4534	—	RESISTOR, same as 23-1	Det. Grid		

* Indicates item furnished in maintenance parts group. Italics indicates parts that affect calibration.

22. Table of Replaceable Parts—Continued

Ref. No.	Stock No.	Quan. Used	Name and Description	Function	Mfr.	Drawing Number
24		1	COIL, radio frequency choke; inductance 15.8 microhenries; moulded bakelite form 3/16 in. dia. x 5/8 in. long with axial wire leads #22 AWG tinned copper wire 1½ in. long. SPECIAL	Cathode Choke	Z	SG529
25		1*	RESISTOR, fixed; 1000 ohms (±10%) ¼ W; carbon, insulated; 1/8 in. dia. x 3/8 in. long; axial wire leads #20 AWG tinned copper wire 1½ in. long. Type BTS	Audio Cathode	A I	63G12 SC-D-970-W
26	2Z7285-1	1*	POTENTIOMETER, gain control; 500000 ohms (±10%) 1 W; body dimensions, 9/16 in. deep x 1 3/8 in. diameter; 3/8-32 thread x 3/8 in. long bushing; ¼ in. dia. shaft; solder lug type terminals. Type S1-010-1578	Gain Control	C1, S1 C	63G1
27a 27b 27c 27d 27e	3Z9825-59	1*	*SWITCH*, rotary; single section, 6 pole—2 position; ¼ in. dia. shaft; 3/8-32 thread mounting bushing 3/8 in. long, overall length 3 13/16 in. Type 26141QHC	High-Low Range Switch	O	85G14
28a,b	3Z9825-58	1*	SWITCH, rotary; single section; 2 pole—3 position; ¼ in. diameter shaft; 3/8-32 thread mounting bushing 3/8 in. long; overall length 4 15/16 in. Type TW6360	Crystal ON-OFF	O C	85G15
29a,b	3Z9858-8	1*	SWITCH, toggle; double pole—single throw; body dimensions 5/8 in. x 11/16 in. x 1¼ in.; 15/32-32 thread mounting bushing x 11/32 in. long; Type 81009-S	Power ON-OFF	A4	85G1
30	3C317-3	1*	COIL, choke, audio frequency; inductance 450 henries at .001 ampere D.C.; steel case, 1 23/32 in. x 1 29/32 in. x 2 in.; two split type terminals mounted on bakelite terminal board, spaced 3/8 in. apart; Type 7477	Det. Plate Choke	C2	95G1

22. Table of Replaceable Parts—Continued

Ref. No.	Stock No.	Quan. Used	Name and Description	Function	Mfr.	Drawing Number
32	3Z739	2#	POST, binding; push type; body dimensions, ½ in. dia. x ¾ in. long; threaded stud 9⁄16 long; overall length 15⁄16 in.; Type Z-714	Ground Post	S1 A5	8G31
33	3Z739	—	POST, same as 32	Antenna Post		
34	2Z9403.2	1	PLUG, power, assembly; composed of three banana type plugs mounted ⅝ in. apart on phenolic strip 3⁄16 in. thick x ½ in. wide x 29⁄16 in. long; "B+", "−AB" & "A+". SPECIAL	Power Input	Z	SG4
35	2Z9403.1	1	JACK STRIP ASSEMBLY; composed of three single plug jacks mounted ⅝ in. apart on phenolic strip 3⁄16 in. thick x ½ in. wide x 2⅝ in. long; marked "B+", "−AB" & "A+". SPECIAL	Power Input	Z	SG26
36	2Z9403.3	1	BOARD, terminal; composed of three screw and solder lug type terminals mounted ¾ in. apart on phenolic strip ⅛ in. thick x ¾ in. wide x 3⅛ in. long; marked "B+", "−AB" & "A+". SPECIAL	Battery Connector	Z	SG24
37	3Z6587	—	*RESISTOR*, same as 22-1	Het. Osc. grid., Low freq.		
38	3Z4523	1#	*RESISTOR*, fixed; 350 ohms (±10%) ½ W; carbon, insulated; 3⁄16 in. dia. x ⅝ in. long; axial wire leads, #20 AWG tinned copper wire 1½ in. long. Type BT½	Het. Osc. grid., High freq.	A I	63G10 SC-D-970-W
39	3Z6715-1	1#	*RESISTOR*, fixed; 150000 ohms (±10%) ½ W; carbon, insulated; 3⁄16 in. dia. x ⅝ in. long; axial wire leads, #20 AWG tinned copper wire 1½ in. long. Type BT½	Osc. Grid Leak	A I	63G9 SC-D-970-W
40-1	3DA1-50	3#	CAPACITOR, fixed, mica; 1000 $\mu\mu f$ (±20%) 500 V. D.C. W.; brown moulded bakelite case, 3⁄16 in. x 29⁄64 in. x 25⁄32	Fil. Bypass	C5	22G17

# Indicates item furnished in maintenance parts group. Italics indicates parts that affect calibration.

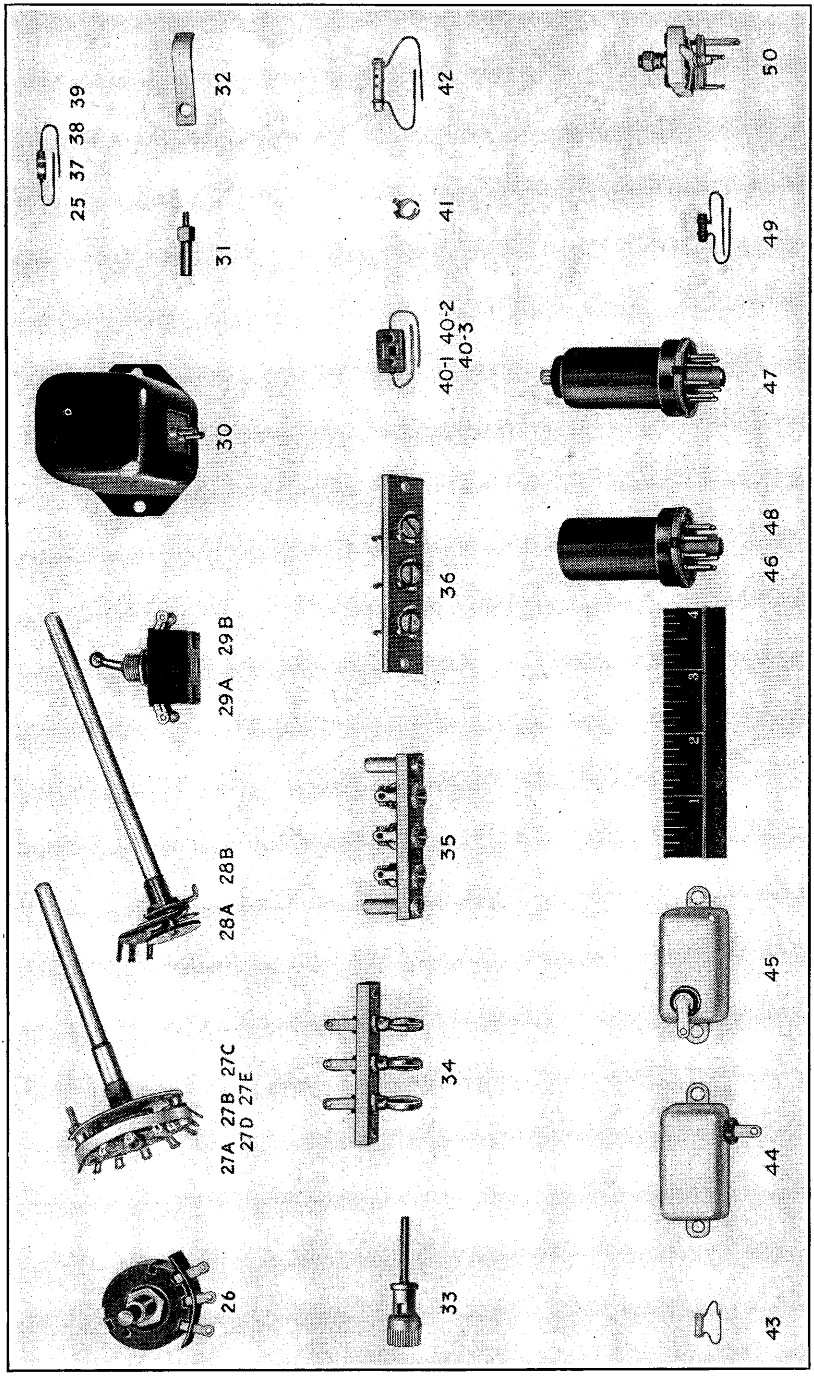


FIGURE 12—Replaceable Parts

22. Table of Replaceable Parts—Continued

Ref. No.	Stock No.	Quan. Used	Name and Description	Function	Mfr.	Drawing Number
			in.; axial wire leads, #20 A.W.G. tinned copper wire 1¼ in. long. Type 5WS			
40-2	3DA1-50	—	CAPACITOR, same as 40-1	Det. Screen		
40-3	3DA1-50	—	CAPACITOR, same as 40-1	Det. Plate		
41		1	CLIP, tube grid; steel; ¼ in. I.D. x ¼ in. long; clip formed to accommodate soldering of wire lead. Type 223	For Tube VT-167	Z1	19G3
42	3D9100-89	1*	*CAPACITOR*, fixed, mica; 100 $\mu\mu f$ (±20%) 500 V. D.C. W.; moulded bakelite case, 3/16 in. x 29/64 in. x 2 5/32 in.; axial wire leads, #20 A.W.G. tinned copper wire 1¼ in. long. Type 5WLS	Grid Coupling	C5	22G16
43	3D9010-31	1*	*CAPACITOR*, fixed, silver on ceramic; 10 $\mu\mu f$ (±1.0 $\mu\mu f$) 500 V. D.C.W.; temperature coefficient—.0020 $\mu\mu f$/C°; 5/32 in. dia. x 7/16 in. long; wire leads #22 A.W.G. tinned copper wire 1½ in. long. Type N200K	Compensator	C E	22G187
44	3DA100-138	1*	CAPACITOR, fixed, paper; wax impregnated; 100,000 $\mu\mu f$ (±20%) 200 V. D.C.W.; one insulated terminal; metal case ⅞ in. x 1 in. x 1 13/16 in. Type No. XDRAHTWZ—.1—614	Het. Osc. Screen Bypass	S2	22G127
45	3DA-700	1*	CAPACITOR, fixed, paper; wax impregnated; 700,000 $\mu\mu f$ (±20%) 200 V. D.C.W.; one insulated terminal; one side grounded to case; metal case, ⅞ in. x 1 in. x 1 13/16 in.; Type No. XDRAHTWZ —.7—614	Audio Screen Bypass	S2	22G128
46	2T116	1	*TUBE*, vacuum, VT-116; triple grid, type 6SJ7	Het. Osc.	RCA	100G3
47	2T167	1	TUBE, vacuum, VT-167; converter, type 6K8	Crystal Osc. & Det.	KenRad	100G27

*Indicates item furnished in maintenance parts group.

Italics indicates parts that affect calibration.

22. Table of Replaceable Parts—Continued

Ref. No.	Stock No.	Quan. Used	Name and Description	Function	Mfr.	Drawing Number
48	2T116B	1	TUBE, vacuum, VT-116B; triple grid, type 6SJ7Y	Audio Amplifier	RCA	100G55
49	3D9006-4	1*	CAPACITOR, fixed, silver on ceramic; 6.0 $\mu\mu f$ (± 0.5 $\mu\mu f$) 500 V. D.C.W.; zero temperature coefficient; wire leads, #22 A.W.G. tinned copper wire 1½ in. long. Type No. 812-156	Crystal Shunt	C M2	22G151
50		1	CAPACITOR, variable, air; 3 rotor plates, 2 stator plates; air gap .030; 360° rotation; maximum capacity 14.5 $\mu\mu f$, minimum 2.5 $\mu\mu f$; ceramic insulation; shaft 17/32 in. long. Type No. 22G150	Crystal Shunt	A3 S	22G150
65		1*	KNOB, tuning control, assembly; composed of bakelite knob, handle, stud & washer. SPECIAL	Tuning Control	Z	SG715
66		4*	KNOB, bar; black bakelite 1¼ in. long, ⅝ in. high; for ¼ in. dia. shaft; index line filled with permanent white; supplied with #8/32 bristo set screw. SPECIAL	Control Knob	Z	SG2651
67		1	KNOB, dial lock; threaded stud type; #8/32 thread 9/16 in. long; knurled head ½ in. dia.; overall length ⅞ in.; SPECIAL	Dial Lock	Z	46G16

*Indicates item furnished in maintenance parts group.

23. LIST OF MANUFACTURERS

Mfr. Code No.	Name	Address
A	Allen-Bradley Co.	Milwaukee, Wisconsin
A-1	American Lava Corporation	Chattanooga 5, Tennessee
A-2	American Phenolic Corporation	1830 South Fifty-Fourth Avenue Chicago, Illinois
A-3	American Steel Package Company	Defiance, Ohio
A-4	Arrow-Hart & Hegeman Electric Co., The	103 Hawthorn Street Hartford, Connecticut
A-5	American Radio Hardware Co., Inc.	476 Broadway New York, N. Y.
B	Bliley Electric Company	Union Station Building Erie, Pennsylvania
B-1	Bristol Company, The	Waterbury, Connecticut, U.S.A. Zone 91
C	Centralab	900 E. Keefe Ave. Milwaukee, Wisconsin
C-1	Chicago Telephone Supply Co.	Elkhart, Indiana
C-2	Chicago Transformer Corporation	3501 Addison Street Chicago 18, Illinois
C-3	Crowley & Company, Inc., Henry L.	One Central Avenue West Orange, New Jersey
C-4	Cinch Manufacturing Corporation	2335 West Van Buren Street Chicago, Illinois
C-5	Cornell-Dubilier	605 W. Washington Blvd. Chicago, Illinois
C-6	Crystal Research Laboratories	29 Allyn St. Hartford 3, Connecticut
E	Erie Resistor Corporation	Erie, Pennsylvania, U.S.A.
G	Max Goldberg	270 Lafayette St. New York, N. Y.
I	International Resistor Company	401 North Broad Street Philadelphia, Pa.
I-1	Industrial Spring	1632 North Wells St. Chicago, Illinois
J	Johnson Company, E. F.	Waseca, Minnesota
K	Kurz Kasch Company	608 S. Dearborn St. Chicago, Illinois
M	Mallory & Co. Inc., P. R.	Indianapolis, Indiana
M-1	Molded Insulation	Price St. nr. Germantown Ave. Philadelphia, Pennsylvania

List of Manufacturers (cont'd)

Mfr. Code No.	Name	Address
M-2	Muter Company, The	1255 South Michigan Ave. Chicago, Illinois
M-3	Micamold	1087 Flushing Ave. Brooklyn, New York
N	National Lock Company	Rockford, Illinois
O	Oak Manufacturing Company	1260 Clybourn Avenue Chicago, Illinois
P	Peerless Molded Plastics, Inc.	Hamilton & Division Streets Toledo, Ohio
S	Sickles Company, F. W.	P. O. Box 920 Springfield, Mass.
S-1	Soreng-Mangold Company	1901-09 Clybourn Avenue Chicago, Illinois
S-2	Solar Manufacturing Corporation	285 Madison Avenue New York 17, N. Y.
U	Utah Radio Products Company	812-20 Orleans Street Chicago 10, Illinois
Z	Zenith Radio Corporation	6001 Dickens Chicago 39, Illinois
Z-1	Zierick	385 Gerard Avenue New York, N. Y.

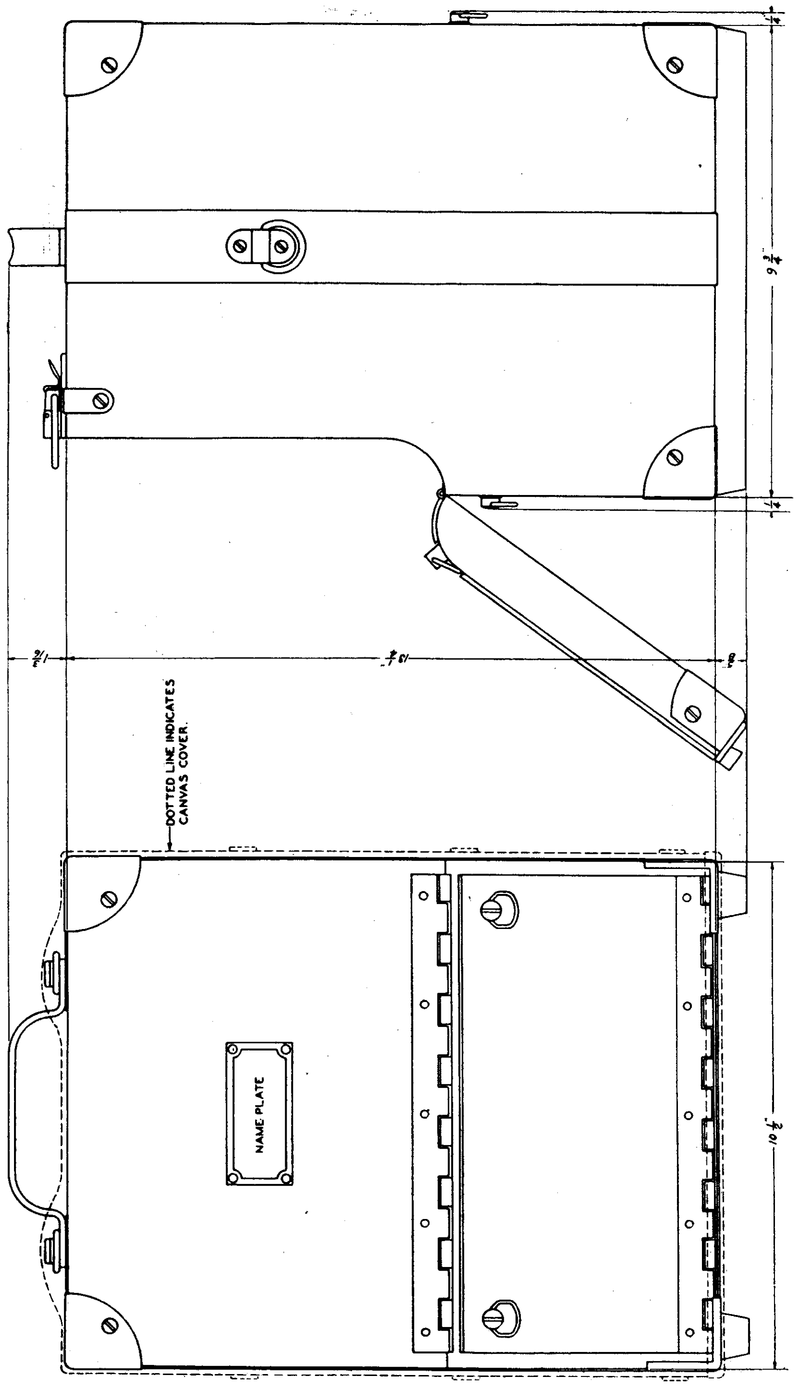


FIGURE 13—Frequency Meter Set SCR-211-AF, Outline Dimensions

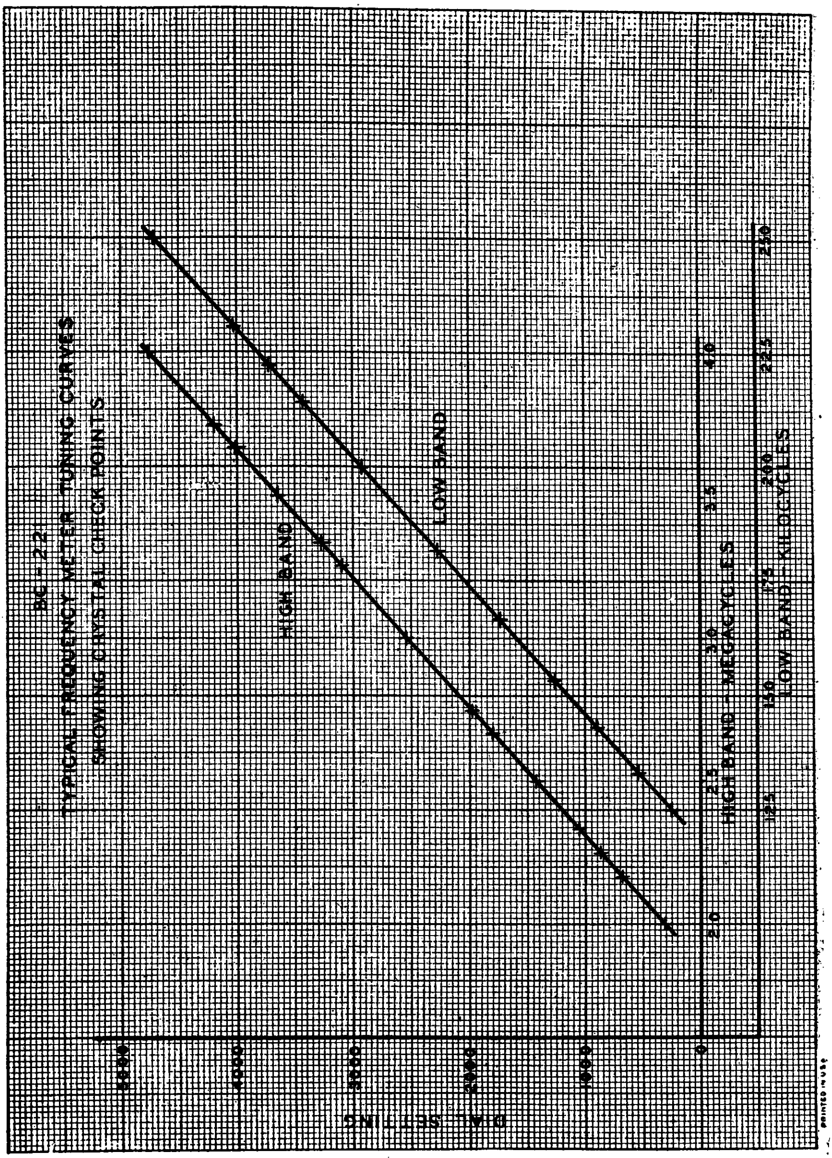
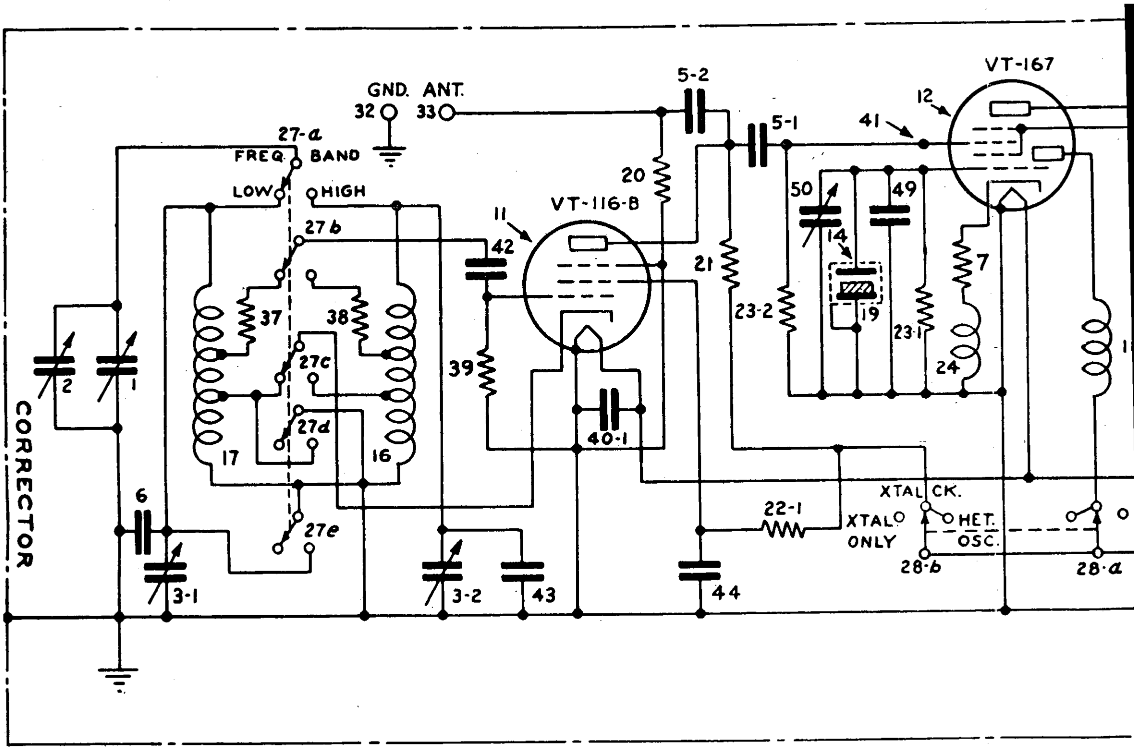
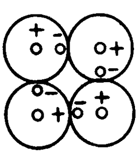


FIGURE 14—Frequency Meter BC-221-AF, Typical Het. Osc. Tuning Curves





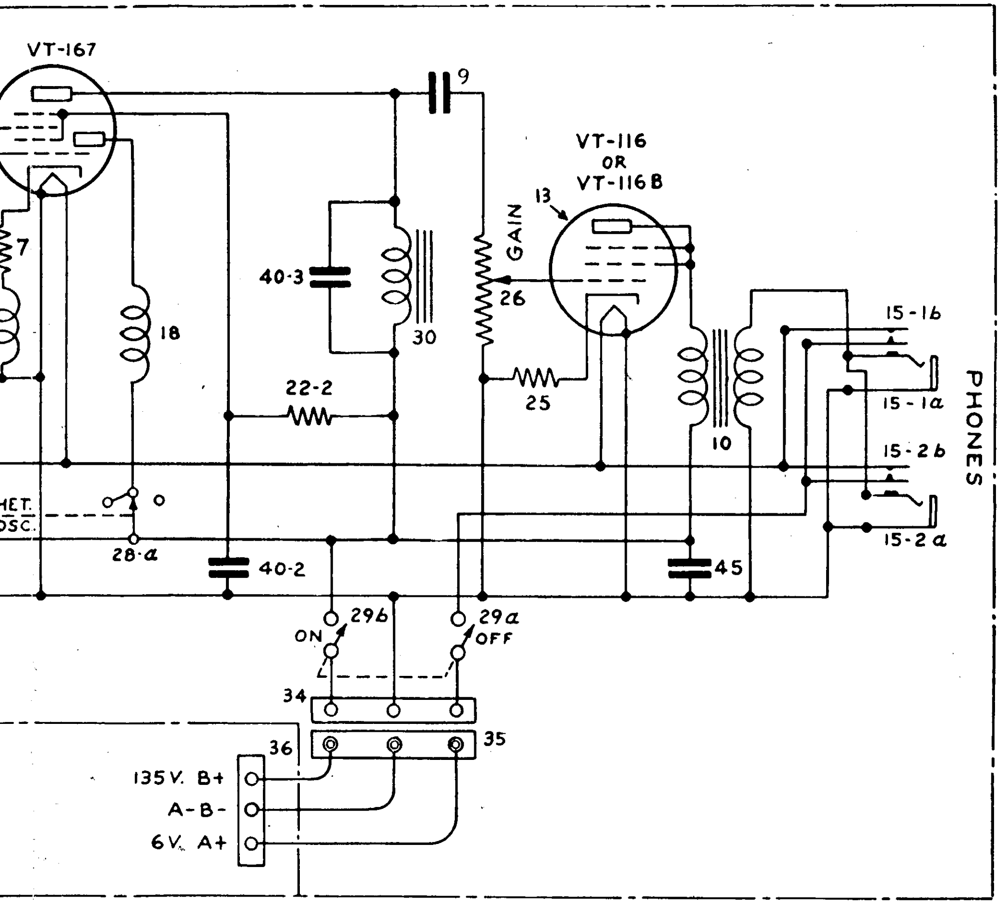
ORIENTATION
OF FILAMENT
BATTERY CELLS

BATTERIES REQUIRED
6 TYPE BA-2, (22.5 VOLTS)
4 TYPE BA-23, (1.5 VOLTS)

135
6

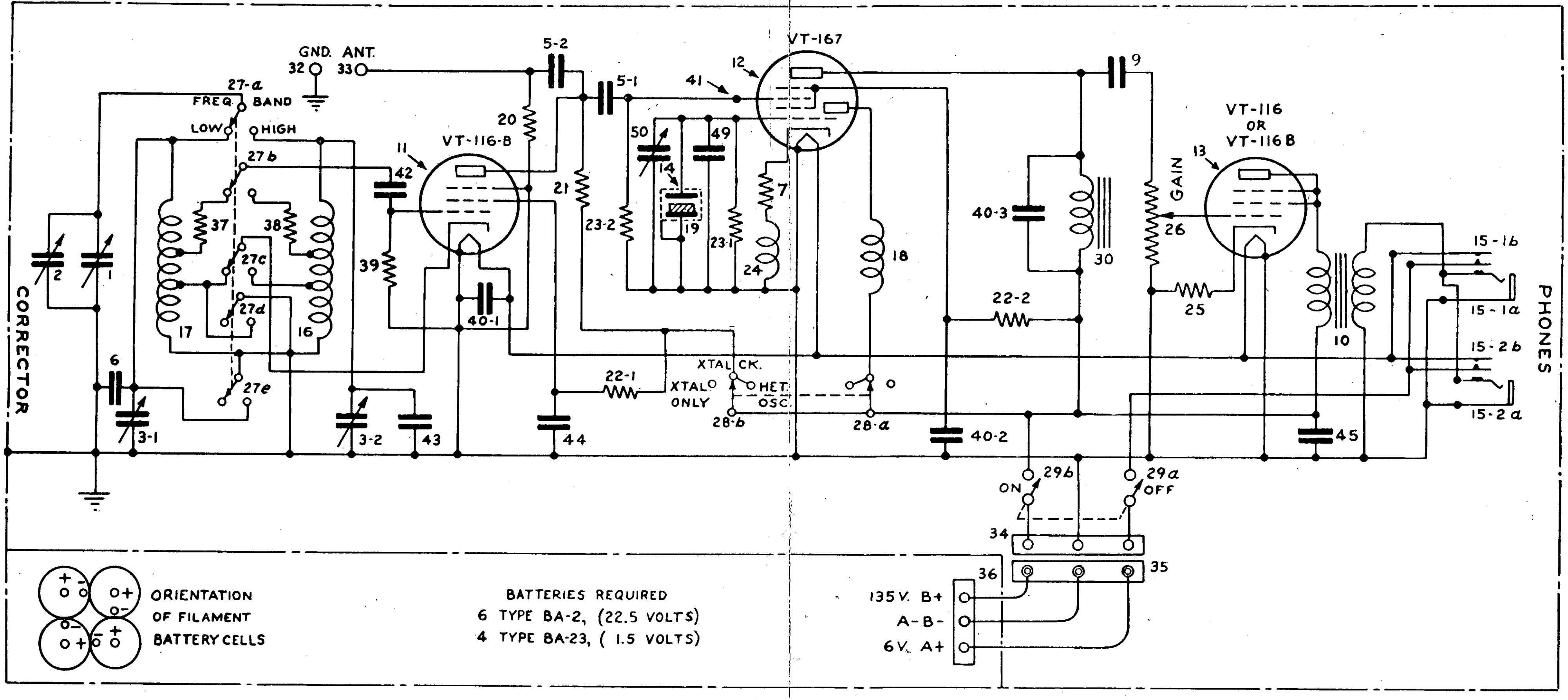
REF.	DESCRIPTION	REF.	DESCRIPTION	REF.	D
1	160 $\mu\mu f$	15-2a	Phone Jack	15-2a	15.
2	3 $\mu\mu f$	15-2b	Fil. Switch	15-2b	1,
3-1	10 $\mu\mu f$	16	34.0 Micro-H	16	0.5
3-2	10 $\mu\mu f$	17	9.05 Milli-H	17	
5-1	10 $\mu\mu f$	18	735 Micro-H	18	Sw
5-2	10 $\mu\mu f$	19	Crystal	19	
6	7 $\mu\mu f$	20	5,000 Ohm	20	Sw
7	180 Ohms	21	50,000 Ohm	21	
9	.02 μf	22-1	8,750 Ohm	22-1	Sw
10	0.5 μf	22-2	8,750 Ohm	22-2	Sw
15-1a	Phone Jack	23-1	1 Megohm	23-1	
15-1b	Fil. Switch	23-2	1 Megohm	23-2	8

Figure 1



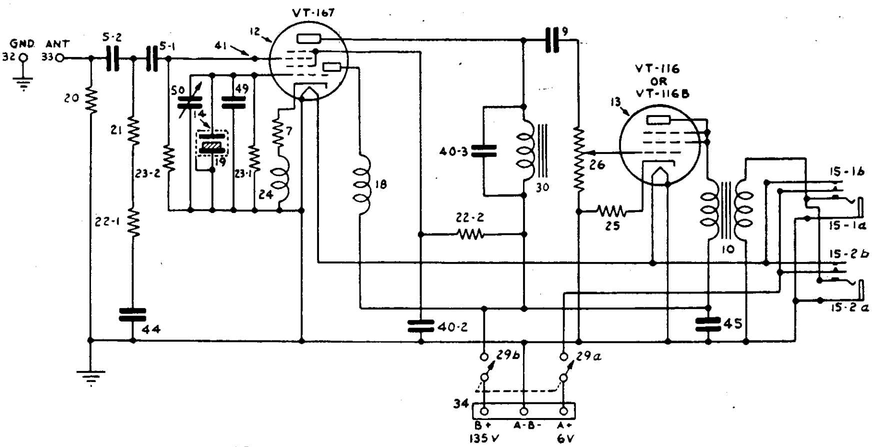
REF.	DESCRIPTION	REF.	DESCRIPTION
15-2a	15.8 Micro-H	38-1	350 Ohm
15-2b	1,000 Ohm	39	150,000 Ohm
16	0.5 Megohm	40-1	.001 µf
17		40-2	.001 µf
18	Switch	40-3	.001 µf
19		42	100 µµf
20	Switch	43	10 µµf
21		44	0.1 µf
22-1	Switch	45	0.7 µf
22-2	Switch	49	6.0 µµf
23-1	450 Henries	50	14.5 µµf
23-2	8,750 Ohm		

Figure 15—Frequency Meter BC-211-AF, Schematic Diagram

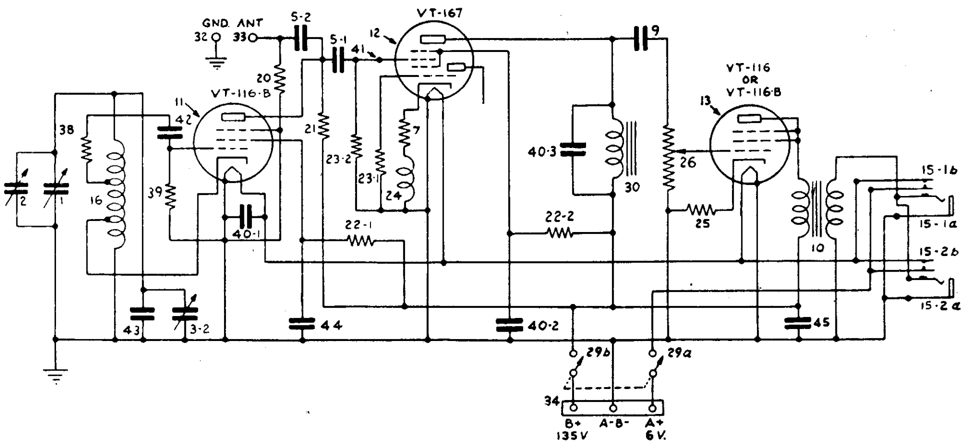


REF.	DESCRIPTION	REF.	DESCRIPTION	REF.	DESCRIPTION	REF.	DESCRIPTION
1	160 μμf	15-2a	Phone Jack	15-2a	15.8 Micro-H	38-1	350 Ohm
2	3 μμf	15-2b	Fil. Switch	15-2b	1,000 Ohm	39	150,000 Ohm
3-1	10 μμf	16	34.0 Micro-H	16	0.5 Megohm	40-1	.001 μf
3-2	10 μμf	17	9.05 Milli-H	17		40-2	.001 μf
5-1	10 μμf	18	735 Micro-H	18	Switch	40-3	.001 μf
5-2	10 μμf	19	Crystal	19		42	100 μμf
6	7 μμf	20	5,000 Ohm	20	Switch	43	10 μμf
7	180 Ohms	21	50,000 Ohm	21		44	0.1 μf
9	.02 μf	22-1	8,750 Ohm	22-1	Switch	45	0.7 μf
10	0.5 μf	22-2	8,750 Ohm	22-2	Switch	49	6.0 μμf
15-1a	Phone Jack	23-1	1 Megohm	23-1	450 Henries	50	14.5 μμf
15-1b	Fil. Switch	23-2	1 Megohm	23-2	8,750 Ohm		

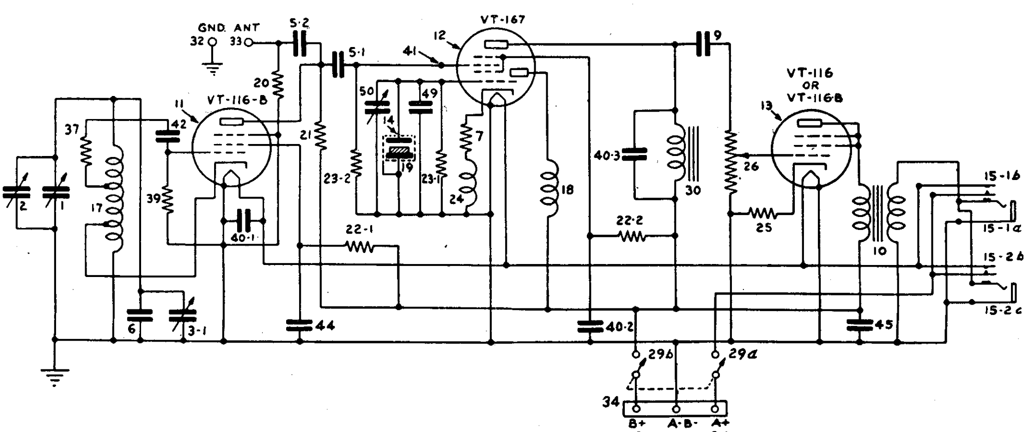
Figure 15—Frequency Meter BC-211-AF, Schematic Diagram



CRYSTAL ONLY POSITION



HET. OSC. POSITION



CRYSTAL CHECK POSITION

Figure 16—Frequency Meter BC-211-AF, Functional Diagrams

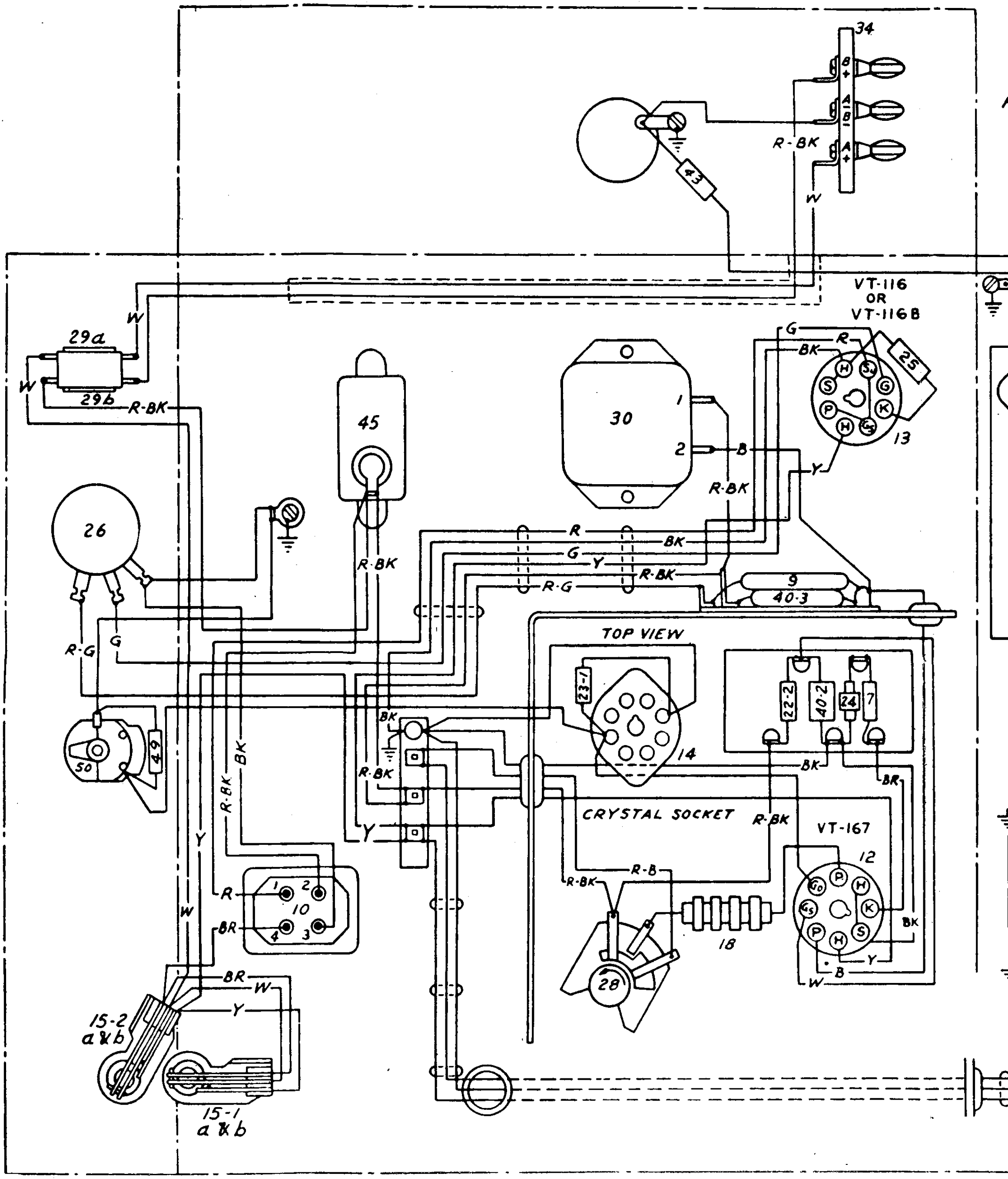

34
R-BK
W
43
VT-116
OR
VT-116B
G
R
BK
25
13
Y
B
29a
29b
W
R-BK
45
30
1
2
26
R-BK
R
BK
G
Y
R-G
9
40-3
TOP VIEW
23-1
14
22-2
40-2
24
7
R-G
G
50
49
BK
R-BK
Y
CRYSTAL SOCKET
R-BK
VT-167
12
R-B
18
28
R
BR
10
BR
W
Y
15-2
a & b
15-1
a & b

Figure 1

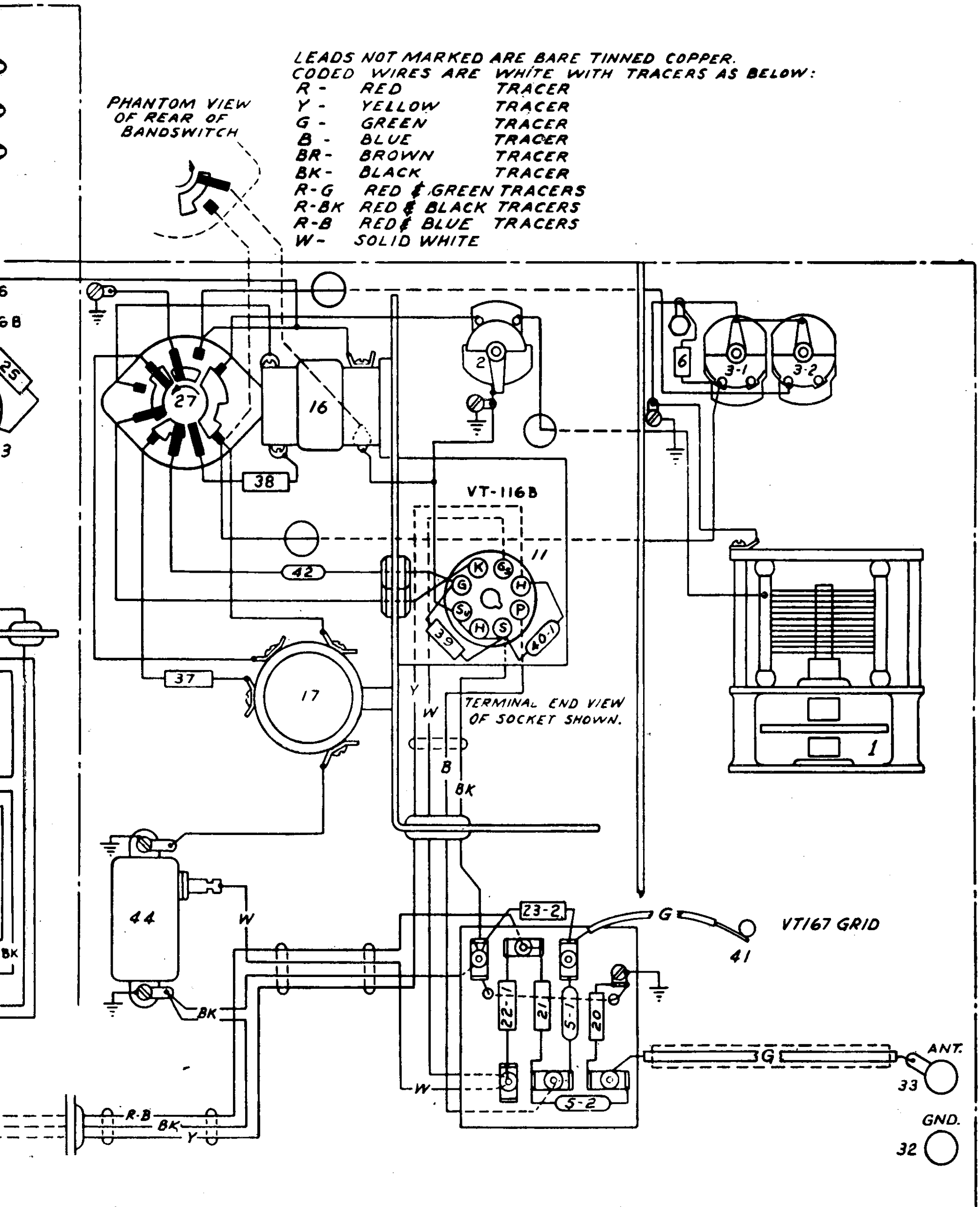


Figure 17—Frequency Meter BC-221-AF, Chassis Wiring Diagram

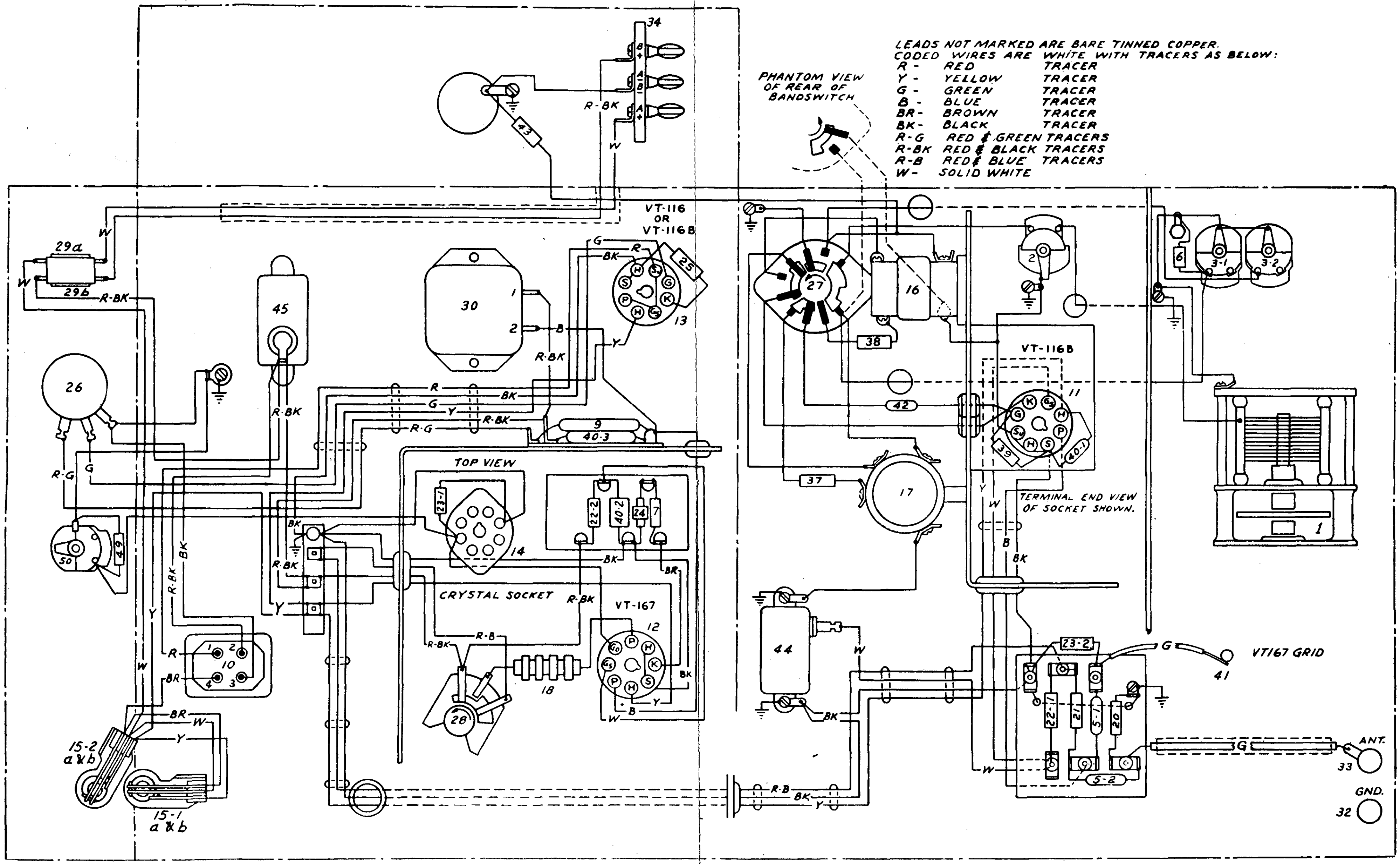


Figure 17—Frequency Meter BC-221-AF, Chassis Wiring Diagram