TYPE

BTA-5F

BROADCAST TRANSMITTING EQUIPMENT

RCA

TYPE

BTA-5F

BROADCAST TRANSMITTING EQUIPMENT

RCA

BPA-10

ANTENNA TUNING UNIT

MI-28902-B

INSTRUCTIONS

INSTALLATION—OPERATION—MAINTENANCE

IB-30168-1

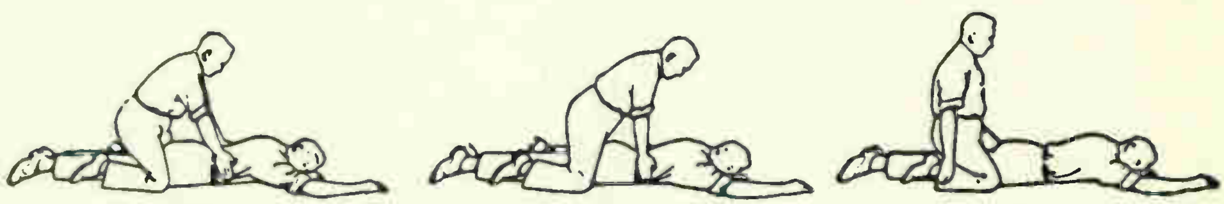
WARNING

THE VOLTAGES EMPLOYED IN THIS EQUIPMENT ARE SUFFICIENTLY HIGH TO ENDANGER HUMAN LIFE AND EVERY REASONABLE PRECAUTION HAS BEEN OBSERVED IN DESIGN TO SAFEGUARD THE OPERATING PERSONNEL. THE POWER SHOULD BE REMOVED COMPLETELY BEFORE CHANGING TUBES OR MAKING INTERNAL ADJUSTMENTS.

FIRST AID IN CASE OF ELECTRIC SHOCK

1. PROTECT YOURSELF with dry insulating material.
2. BREAK THE CIRCUIT by opening the power switch or by pulling the victim free of the live conductor.

   DON'T TOUCH VICTIM WITH YOUR BARE HANDS until the circuit is broken.



(A) (B) (C)

3. LAY PATIENT ON STOMACH, one arm extended, the other arm bent at elbow. Turn face outward resting on hand or forearm.
4. REMOVE FALSE TEETH, TOBACCO OR GUM from patient's mouth.
5. KNEEL STRADDLING PATIENT'S THIGHS. See (A).
6. PLACE PALMS OF YOUR HANDS ON PATIENT'S BACK with little fingers just touching the lowest ribs.
7. WITH ARMS STRAIGHT, SWING FORWARD gradually bringing the weight of your body to bear upon the patient. See (B).
8. SWING BACKWARD IMMEDIATELY to relieve the pressure. See (C).
9. AFTER TWO SECONDS, SWING FORWARD AGAIN. Repeat twelve to fifteen times per minute.
10. WHILE ARTIFICIAL RESPIRATION IS CONTINUED, HAVE SOMEONE ELSE:
    (a) Loosen patient's clothing.
    (b) Send for doctor.
    (c) Keep patient warm.
11. IF PATIENT STOPS BREATHING, CONTINUE ARTIFICIAL RESPIRATION. Four hours or more may be required.
12. DO NOT GIVE LIQUIDS UNTIL PATIENT IS CONSCIOUS.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

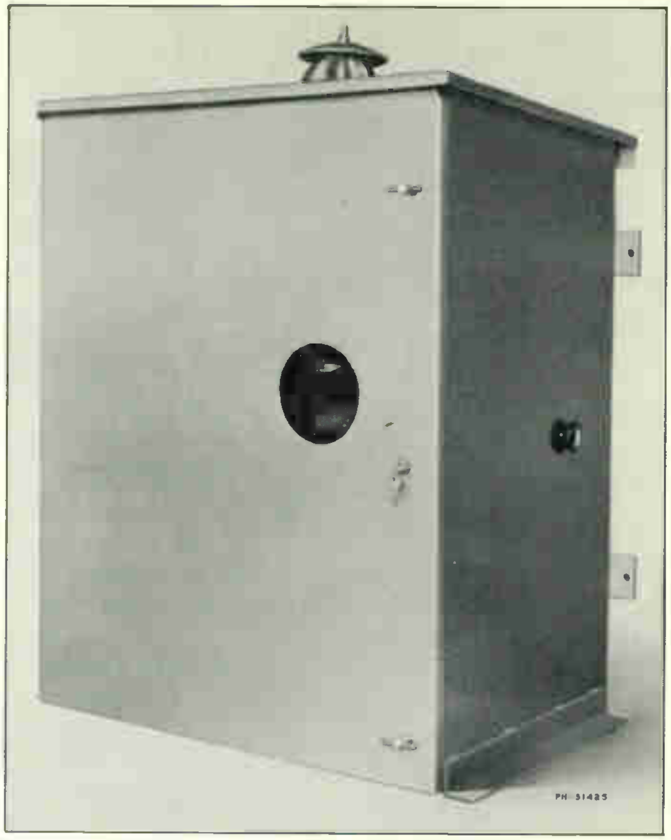


Figure 1—Type BPA-10 Antenna Tuning Unit (Exterior View)

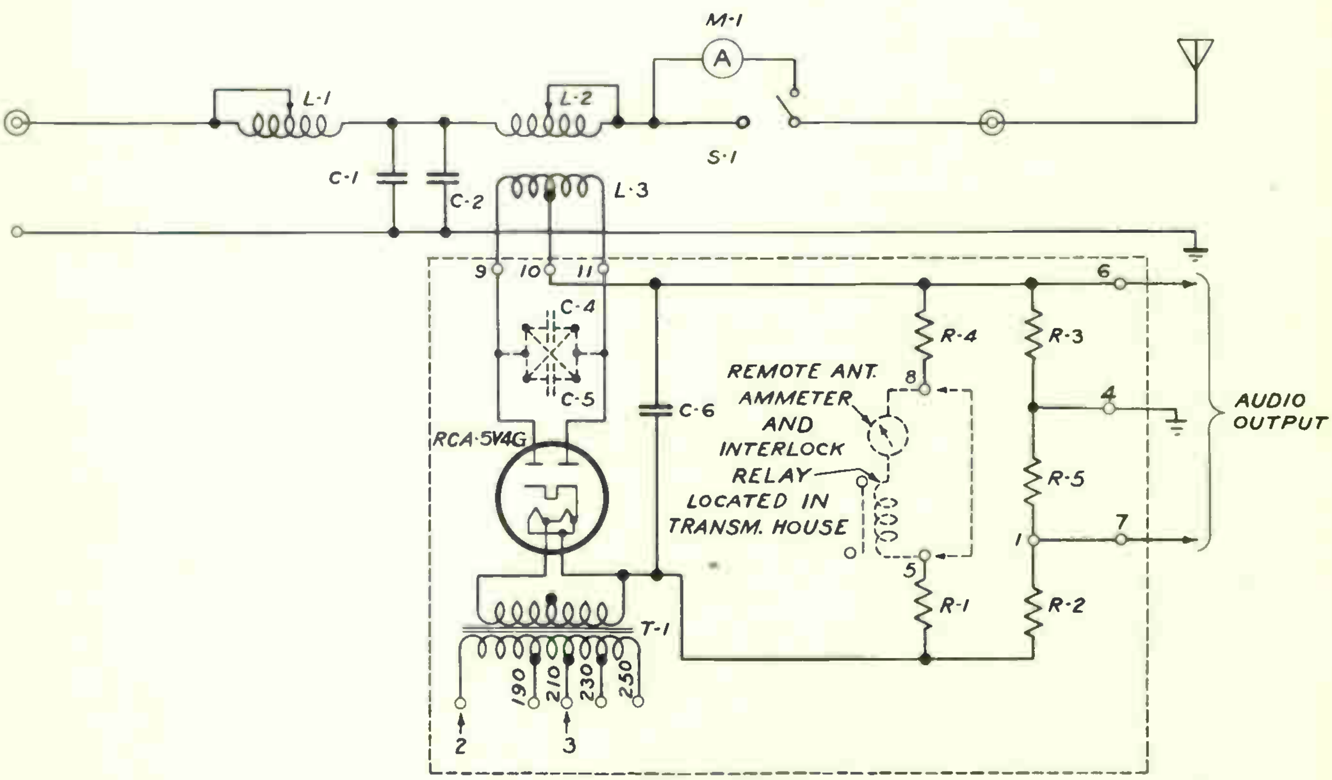


Figure 2—Antenna Tuning Unit Schematic Diagram (M-428316)

TECHNICAL SUMMARY

ELECTRICAL CHARACTERISTICS

Operating Limits:

Carrier Frequency .... 540 kc to 1700 kc

Transmitting Power (maximum) .... 10 kw

Antenna Resistance:

Output 5 kw or less .... 10 ohms to 1100 ohms

Output 10 kw or less .... 20 ohms to 1100 ohms

Line Impedance .... 50 ohms to 350 ohms

Antenna Reactance .... +j500 to –j500 ohms

(Can be extended in a positive direction by the addition of a series capacitor, and in a negative direction if operated from a line of lower impedance than the antenna resistance.)

Monitoring Rectifier:

Output Impedance .... For operation into 20,000-ohm bridging load

Output Level (Single-tone sine wave, 100% modulation—not including bridging loss),

At 5-10-kw output .... +17 dbm

At 1-kw output .... +10 dbm

Rectified current .... 75 ma d.c. maximum into a maximum of 1000 ohms

Frequency Characteristic .... Substantially flat to 10,000 cycles

Power Supply .... 230 volts, 60 cycles

TUBE COMPLEMENT (Available on separate order)

Rectifier .... One RCA-5V4-G

MECHANICAL SPECIFICATIONS

Dimensions:

Height .... 44 inches

Width .... 34 inches

Depth .... 23 inches

Weight (net) .... 330 pounds

DESCRIPTION

PURPOSE

The RCA Type BPA-10 Antenna Tuning Unit (MI-28902-B) serves the double purpose of matching antennas of widely divergent characteristics to either concentric or open-wire transmission lines and of suppressing carrier harmonics on transmitters up to ten kilowatts output.

CONSTRUCTION

All parts of this equipment are enclosed in a weather-proof metal housing equipped at the front with a door affording ready access to the interior. This door is provided with a lock. The antenna ammeter, which may be read through a circular window in the door, is protected from lightning surges by a SPDT switch operated by means of a knob extending through the side of the housing. A monitoring rectifier unit *(MI-7488-A) is contained within the housing to furnish, if desired, audio-frequency voltage for program monitoring and rectified carrier current for remote antenna current indication.

* MI-28902-B only. MI-28902-A does not contain monitoring rectifier.

CIRCUIT

The circuit of this antenna tuning unit consists essentially of a single T-section low-pass filter which reduces the number of elements to a minimum. Referring to the schematic diagram, Figure 2, two series inductors (L1, L2) are employed to adjust independently the respective terminating impedances of the transmission line and the antenna circuit. The capacitive shunt leg, which is common to the two branches, is fixed at a value determined by the operating frequency of the station.

Signal energy for operation of the monitoring rectifier is obtained from a tuned pickup coil (L3) which is coupled to the antenna loading inductor (L2). This energy is rectified in a full-wave circuit using a 5V4G tube and the output is balanced to ground for excitation of a monitoring amplifier. Terminals also are provided for connection to a remote antenna ammeter and interlock relay located in the transmitter house. A 230-volt, 60-cycle power supply is required for energizing the rectifier filament transformer (T1).

INSTALLATION

MOUNTING

The unit is designed for mounting on a wooden platform or a steel angle cradle by means of the side flanges at the bottom of the housing. Rear mounting strips also are provided to permit installing the unit on two upright posts. Dimensions are given in the outline drawing, Figure 6.

Care should be taken at installation to select a position where the antenna lead will be as short as possible. It is also important to insure adequate grounding by connecting the housing to the ground system through a heavy conductor or copper bus.

R-F CONNECTIONS

The antenna lead-in post is located on the top of the unit, and provision is made for mounting a similar post (bowl insulator) on the left-hand side of the housing in case an open-wire line is used. Concentric line when employed should be brought in through a hole in the bottom of the cabinet and connection made to the upper terminal of coil L1. When a remote antenna ammeter is not used, terminals No. 5 and No. 8 should be connected together by a jumper.

REMOTE METERING AND AUDIO MONITORING

An a-c supply of 230 volts, 60 cycles will be required to operate the rectifying equipment for remote metering. The associated filament transformer is tapped for operation at 190, 210, 230, or 250 volts and should be adjusted to the tap nearest the existing line voltage. Terminals No. 2 and No. 3 are used for connection of the power supply input.

STATIC DRAIN

No provision for static drain is made in this unit. If no conductive path to ground exists elsewhere, a static drain should be mounted across the antenna horn gap, or at some other suitable place.

TOWER LIGHTING

No complication as to tower lighting is introduced since the shunt arm is open-circuit to power frequencies.

TUNING

CAUTION—*Remove the transmitter plate voltage prior to each adjustment of the antenna and transmission-line circuits. Full power should not be applied to the line before proper adjustments have been completed. Dangerous voltages may occur through improper termination and result in damage to the line and equipment.*

GENERAL CONDITIONS

Although the network used in this unit serves the double function of impedance matching and antenna tuning simultaneously, it is desirable to consider these operations separately.

For antenna tuning, the coil L2 can be used to series-resonate the reactive component of a capacitive antenna; or, if the antenna is inductive, the reactive component can be thought of as being absorbed into the antenna tuning coil. In either case, only the resistive portion of the antenna impedance is left. The impedance matching function can be regarded as taking place between purely resistive impedances, inasmuch as the characteristic impedance of most lines is resistive.

Under these conditions, the values of reactance employed are determined by the values of the impedances to be matched, with the phase shift through the network as a parameter. Since the circuit is a section of a low-pass filter, the phase shift may be anywhere between zero and −180 degrees, making possible a wide range of reactance values. However, it is not advisable to work too close to the −180 degree (or cut-off) point of the section, or with such low values of phase shift that the second harmonic will not be sufficiently attenuated, hence a value near −90 degrees will usually be found most suitable. These statements will be clarified by examining the equations relating to the reactances of the arms of the network and the antenna and line impedances. Referring to Figure 3, which shows a simplified circuit diagram, the reactances are:

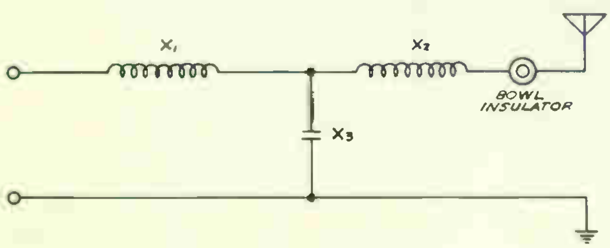


Figure 3—Simplified Circuit Diagram of Tuning Unit (K-861732)

$$X_1 = -\frac{\sqrt{R_1R_2}\left[1 - \frac{\sqrt{R_1}}{\sqrt{R_2}}\cos\beta\right]}{\sin\beta}$$

$$X_2 = -\frac{\sqrt{R_1R_2}\left[1 - \frac{\sqrt{R_2}}{\sqrt{R_1}}\cos\beta\right]}{\sin\beta}$$

$$X_3 = +\frac{\sqrt{R_1R_2}}{\sin\beta} \qquad (1)$$

where: R_1 = Line impedance
R_2 = Antenna resistance
β = Phase shift through network

It will be appreciated that choice of β near zero or −180 degrees leads to large values of reactance in all arms since sin β approaches zero for these values. On the other hand, if β is taken equal to −90 degrees, these equations simplify to:

$$X_1 = +\sqrt{R_1R_2} \qquad (2)$$
$$X_2 = +\sqrt{R_1R_2}$$
$$X_3 = -\sqrt{R_1R_2}$$

If this leads to inconvenient sizes of X_1, X_2, or X_3, a new value of β can be chosen to yield proper values for the desired reactance.

TUNING PROCEDURE WITH R-F BRIDGE

The use of a radio-frequency bridge is recommended to insure accurate tuning adjustment, and the application of this instrument will be assumed during the following description of the tuning procedure. In cases where a bridge is not available, measurements can be made by a substitution method, also described.

To determine the values of inductance and capacitance for proper line matching and antenna tuning, it is essential to know the impedance of the antenna at the operating frequency. For purposes of comparison, the resistances and reactances for various heights of typical insulated towers of the guyed-mast and self-supporting types are shown in Table I.

TABLE I

Antenna Height* in Electrical Degrees	Self-Supporting Type		Guyed-Mast Type	
G	R	jX	R	jX
50	7	−j100	8	−j220
60	9	−j 70	13	−j170
70	14	−j 25	19	−j 75
80	20	+j 11	28	−j 28
90	40	+j 35	36	+j 0
100	60	+j 80	80	+j140
110	90	+j 90	140	+j320
120	175	+j 80	220	+j500
130	190	+j 15	370	+j600
140	165	−j 70	660	+j480
150	130	−j 85	1100	+j 0
160	82	−j 55	550	−j250
170	60	−j 25	280	−j450
180	40	−j 5	180	−j500
190	28	+j 25	120	−j430
200	23	+j 50	80	−j400

* Height in electrical degrees = Height in feet $\times$ frequency in kilocycles $\times$ 1.016 $\times 10^{-6}$ $\times$ 360.

Substitution of the resistive components of line and antenna impedances in equations (1) gives the values of X_1, X_2, and X_3 necessary for impedance matching. Examination of the reactive components indicates the reactance necessary for tuning. For example, suppose use of a 60-ohm line and a 120-degree antenna with 175 ohms of resistance and +j80 ohms of reactance. Substitution of the values 60 and 175 ohms in equations (2) gives the value of 102.5 ohms for X_1, X_2, and X_3.

To tune out the antenna reactance in this case, it is necessary only to assume that this reactance is a part of the required value of X_2. Subtracting the 80 ohms of antenna reactance from 102.5 ohms leaves 22.5 ohms to be obtained in the coil L2. When the other arms of the network have been adjusted to the proper value of 102.5 ohms, a condition of impedance match will exist between the line and the antenna resistance, and the antenna reactance will have been removed as a cause of loss.

In making these adjustments, the line should be disconnected and the impedance bridge connected across the input terminals to determine when the desired value of 60 ohms has been obtained. When measurements show that the input impedance of the tuner with the antenna connected is 60 ohms resistive, the line may be reconnected for a final check before turning on full power.

Calculation of the current in the capacitive branch should be made to insure that the rating of the capacitor will not be exceeded. Proper capacitors are supplied on the basis of information received with the order.

To enable an intelligent estimate to be made of the inductances obtained by tapping down on coils L1 and L2, it should be noted that their combined maximum inductance is 120 microhenries.

TUNING PROCEDURE WITHOUT R-F BRIDGE

If no impedance bridge is available, a simple substitution method may be used to determine when a proper adjustment has been obtained, by arranging to switch the line from the tuner to a resistance equal to the line impedance, noting the change in line current accompanying the switching. When no change occurs, the tuner is in proper adjustment. Because it is not desirable to apply full power to the test resistor, which will usually have a rating of only a few watts, connection should be made to a low-power stage in the transmitter during this adjustment. To make the operation simple, a test coupling circuit with a series tuning capacitor can be used, as shown in Figure 4.

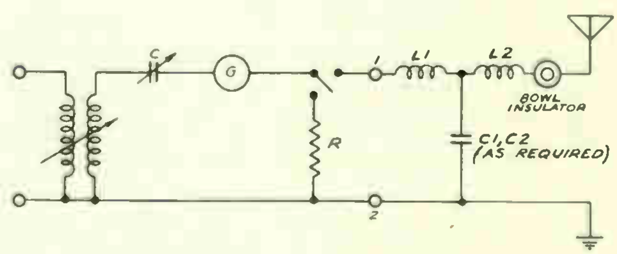


Figure 4—Test Coupling Circuit and Tuning Unit Network (K-861757)

With the switch in the resistor position, capacitor C can be tuned for a maximum current reading in meter G. Then, on switching to the tuner input, the direction in which capacitor C must be turned to again increase the current to a maximum indicates the sign of the reactance in the antenna circuit. If the capacitance must be increased, the load is capacitively reactive; if the capacitance must be decreased, the load is inductively reactive; if no change is necessary, the load is resistive. Similarly, if the current reading at resonance is greater than previously obtained, the load resistance is less than Z_0; if that reading is less, the load resistance is greater than Z_0; if there is no change, the load resistance is equal to Z_0.

CAUTION—Remove unused jumpers.

This method may be used to determine unknown resistances simply by using a calibrated test resistor; likewise, unknown reactance values may be determined by using a calibrated capacitor at C.

FINAL CHECK

Upon completing the tuning procedure outlined in the preceding paragraphs, the adjustments should be checked before full power is applied to the line and antenna. The recommended method of check is as follows:

With the measuring equipment disconnected from the tuning unit, attach the transmission line and insert a low-range thermal milliammeter in the ungrounded side at each end of the line. Apply sufficient power to provide a readable deflection on each meter and note the current values. These values should agree within 15 per cent when the tuning adjustment has been correctly performed. Under such conditions, full power may be applied to the line after removing the milliammeters.

Upon application of full power, the current through each of the tuning capacitors (C1, C2) should be measured under conditions of full modulation. The maximum permissible current values for these capacitors at three nominal frequencies are shown on the nameplates. At other frequencies, the maximum values will be approximately proportional to those listed. If such currents are found to be excessive, the capacitors should be rearranged in the circuit.

REMOTE METERING EQUIPMENT

The antenna tuning unit includes the necessary equipment for installation of a remote meter for measuring antenna current and, in addition, furnishes audio-frequency energy for operation of a monitoring amplifier. The method of remote antenna-current indication outlined herein has been approved by the Federal Communications Commission.

The remote meter should be of the type requiring 25 to 50 milliamperes of direct current for full-scale deflection and should have a scale corresponding to that of antenna ammeter (M1). The remote meter should be equipped with an adjustable shunt so that the deflections of both meters will be identical. In most cases, a 5-ohm variable shunt will be satisfactory for this purpose.

As shown by the schematic diagram, Figure 2, terminals No. 5 and No. 8 are used for connection to the remote meter and transmitter interlock relay. Sufficient output for proper deflection of the remote meter may be obtained by adjusting the coupling between the antenna loading inductor (L2) and the monitoring pick-up coil (L3), and by tuning the latter to the carrier frequency. A wide tuning range is afforded by the six taps on the pick-up coil and by the use of two capacitors (C4, C5) which may be employed singly, in series, or in parallel. Jumpers are provided to facilitate interconnection of these capacitors.

Maximum output will be secured as the pick-up coil is tuned to resonance. It is not advisable, however, to approach resonance too closely since the increasing selectivity of this circuit will seriously impair the audio-frequency response characteristic. At resonance, the response at 10,000 cycles will be down approximately 4 db. Under no conditions should the current through the series resistors (R1, R4) be allowed to exceed 75 ma d.c.

When an audio monitor is to be used, an output level of approximately +17 dbm is available from this tuning unit, the circuit of which is balanced to ground and may be used to feed a 500-ohm load. The load in this case must be capable of handling 25 ma of direct current and it is desirable, therefore, to feed a 20,000-ohm or greater bridging load. If the monitoring amplifier has only a 500-ohm input, a 20,000-ohm carbon resistor may be inserted in series with the 500-ohm transformer. Under this condition, the direct-current flow is negligible and the output level from the rectifier is reduced to −1 dbm at 5-kw operation and to −7 dbm at 1-kw operation.

MAINTENANCE

The antenna ammeter should not be kept in the circuit except when readings are being taken. At all other times the switch should be thrown to the other position.

All connections, especially the coil connector clips, should be inspected regularly to insure tightness and thus avoid undue heating at these points. Screens and ventilation openings should be unobstructed to permit free circulation of air.

REPLACEMENT PARTS LIST

When ordering replacement parts, please give Symbol, Description, and Stock Number of each item ordered.

The part which will be supplied against an order for a replacement item may not be an exact duplicate of the original, however, it will be a satisfactory replacement, differing only in minor mechanical or electrical characteristics. Such differences will in no way impair the operation of the equipment.

Symbol	Description	Stock No.
C1, C2	Capacitor	*
C4	Capacitor, plate tuning, fixed, 300 mmfd, ±5%, 5,000-volt	69860
C5	Capacitor, plate tuning, fixed, 200 mmfd, ±5%, 5,000-volt	69864
C6	Capacitor, 1,000 mmfd	42335
L1, L2	Coil, antenna loading	MI-7487-A
L3	Coil, pickup	17895
M1	Meter	MI-7147**
R1	Resistor, interlock, fixed, wire-wound, 6400 ohms, ±10%, 90 watts	17899
R2	Resistor, audio, fixed, wire-wound, 10,000 ohms, ±10%, 90 watts	17900
R3	Resistor, 250 ohms, 10 watts	17901
R4	Resistor, 125 ohms, 10 watts	17902
R5	Same as R3.	
S1	Switch, knife, SPDT, 30 amp, 250-volt	54586
T1	Transformer, rectifier filament	17897

Symbol	Description	Stock No.
X1	Socket, tube, ceramic, octal	18007
	Insulator, lead-in	MI-19413-1
	Insulator, ceramic, pillar, 1¼" long, ¾" square	92430
	Insulator, ceramic, bushing (outer) ½" long, ⅞" diameter	51784
	Insulator, ceramic, bushing (inner) ⅞" long, ⅞" diameter	51783
	Insulator, ceramic, cylindrical, ⅝" long, ½" diameter	50889
	Insulator, coil mounting, ceramic, conical, 5¾" long, 2⅝" base dia.	52475
	Insulator, meter panel mounting, ceramic, cylindrical, 6" long, 1" dia.	90037
	Insulator, switch shaft, ceramic, cylindrical, 6" long, ¾" dia.	90039
	Knob, switch	43346
	Clamp, coil tap	18140

* For capacitor replacement, quote the information on the nameplate of the defective unit.
** For meter replacement, quote the MI reference and scale range, as indicated on the defective unit.

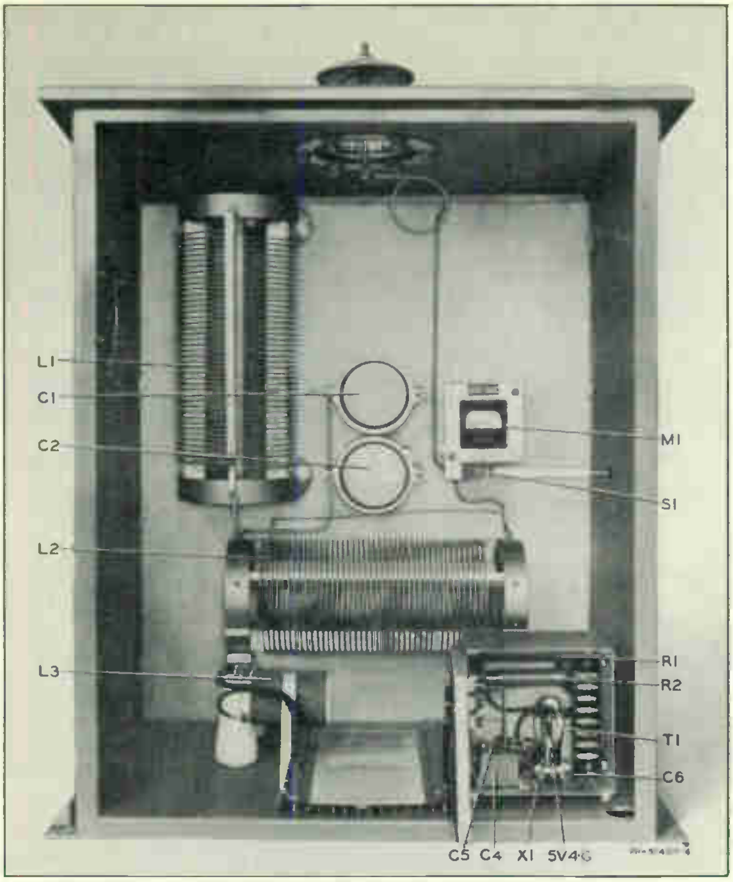


Figure 5—Antenna Tuning Unit (Interior View)

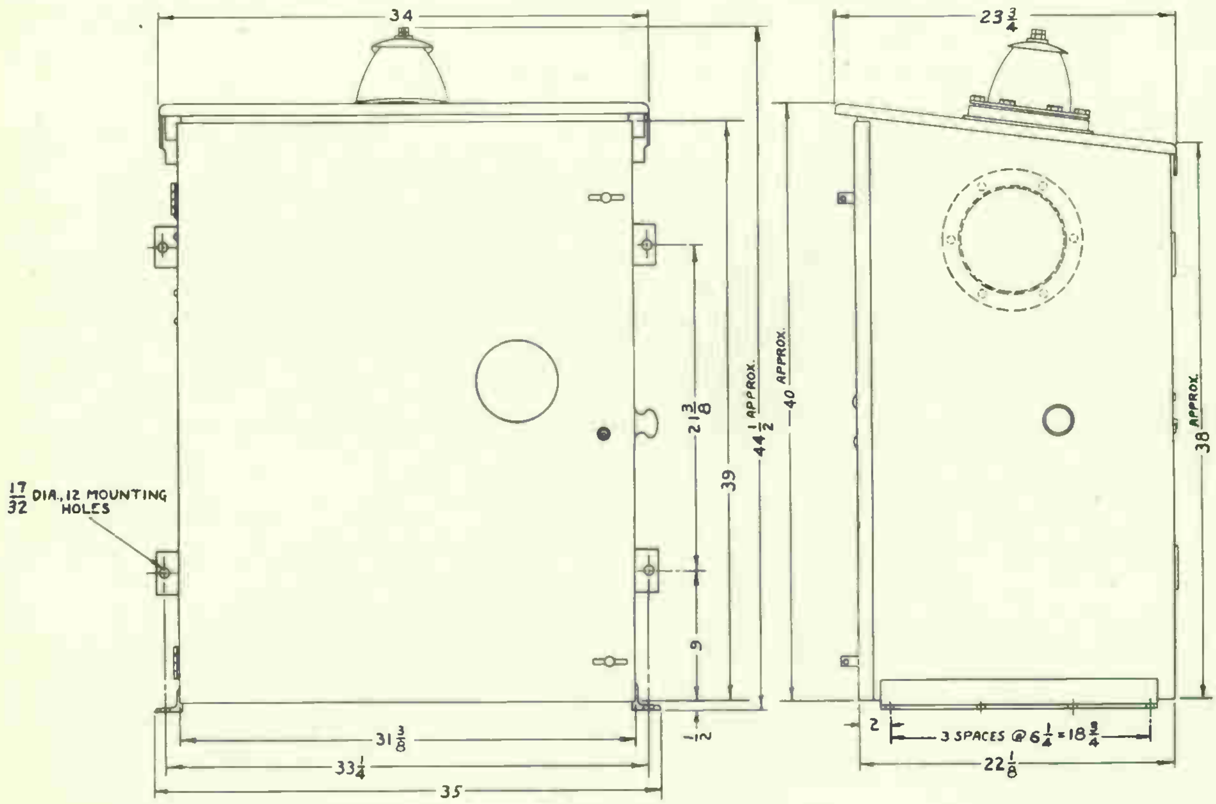


Figure 6—Antenna Tuning Unit Outline (M-428610)