Western Electric

450A-1 AND 451A-1 RADIO TRANSMITTING EQUIPMENTS

Instruction Bulletin No. 988P

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450A-1 AND 451A-1 RADIO TRANSMITTING EQUIPMENTS

Introduction

The 451A-1 Radio Transmitting Equipment is a complete transmitting apparatus for 250-watt broadcasting, police or emergency communication service and may be operated at any frequency from 550 to 2750 kilocycles. It is composed of a D-151170 Radio Transmitter and all the accessories necessary for operation. The 450A-1 Radio Transmitting Equipment is used for 100-watt service and is identical with the 451A-1 Equipment except for the number of tubes in the final radio-frequency stage.

The D-151170 Radio Transmitter consists of a single unit containing the radio and audio-frequency circuits, complete power supply equipment, and all the necessary control and protective circuits. Modulation is secured by applying the audio-frequency potential to the grids of the final radio-frequency stage.

The transmitting equipments operate from a 200 to 240-volt, 50 or 60-cycle, single phase supply and require the powers given in the following table at a power factor of approximately 85 per cent:

Code No.	*Carrier Output*	*Carrier or Any Percentage of Modulation*
450A-1	100 watts	1200
451A-1	250 watts	1750

Description of Apparatus

The electrical apparatus of this transmitter is mounted on a vertical central structure. Essentially the lower third of the space is devoted to rectifiers and a-c power supply and control circuit apparatus. Above this is the audio equipment with the associated tubes, the 702A Oscillator and the first radio-frequency stage. The upper third is devoted to the second and third radio-frequency stages with the associated radio-frequency filter and antenna or transmission line coupling circuits. Direct current potentiometers and bleeders are also located at the top where the air leaves the unit. Practically all components are located in accordance with this grouping. The cabinet of this transmitter is actually only an enclosure for the vertical central structure and has no electrical components or controls mounted on it.

To facilitate reference to particular pieces of apparatus, each piece is designated by a combination of two letters with a numeral between them, such as C3A. These designations are used throughout the text of this instruction bulletin and on the drawings. In the transmitter these designations are marked either on the piece of apparatus itself or adjacent to it. The first letter of the

designation indicates the type of apparatus. For example, a condenser is designated by the letter "C". The number distinguishes between pieces of apparatus of the same type and the last letter refers to the unit in which the apparatus is located. Since this is a single unit transmitter, the letter "A" follows all apparatus designations. The letters designating the several types of apparatus are:

C—Condenser
D—Switch and Magnetic Circuit Breakers
L—Inductance
M—Meter
MB—Motor Blower
R—Resistance
S—Relay or Magnetic Contactor
T—Transformer or Regulator
V—Vacuum Tube
VS—Vacuum Tube Socket

Installation

Instructions for removing the crate and for handling the transmitter are contained on and within the crate and should be carefully followed. The transmitter should be installed in accordance with the installation drawings furnished with the equipment.

Description and Adjustment of Power Supply and Control Circuits
702A Oscillator Heater Circuit

Separate power supply terminals are provided for the 702A Oscillator heater circuit. The primary terminals of transformer T6A should be strapped for 115 or 230 volts according to the following table:

Heater Supply Voltages	*115*	*230*
Terminal Strapping	1 to 3 2 to 4	2 to 3
Input Connections	1 and 2	1 and 4

Switches D5A and D6A in the supply line transformer T6A serve as overload circuit breakers and should be closed after the oscillator is in position. The oscillator should be allowed to reach its normal operating temperature of approximately 60 degrees centigrade before final transmitter tuning adjustments are made.

The magnetic circuit breakers used in this transmitter also serve as switches and bear a switch designation, such as D1A, in all drawings and in this text. The power for the operation of the transmitter is controlled by "Power" switch

D1A which also provides the necessary overload protection to the entire transmitter. Operation of this switch applies filament power to all tubes and energizes a pair of contacts on S1A.

The manual regulator T1A is provided to adjust the input voltage to the transmitter to 230 volts, as indicated by the "Power Supply" voltmeter M2A. Adjustments are made by means of the control designated "Power Supply."

Switch D4A provides overload protection to the bias supply rectifier and, in case of an overload on the bias supply rectifier, also opens one side of the plate rectifier transformer primary circuit. Normally, this switch should be left in the "On" position.

Operation of "Bias" switch D2A energizes magnetic contactor S1A which applies 230 volts to the bias rectifier and to the contacts of "Plate" switch D3A. Closing switch D3A energizes the high voltage rectifier transformer T5A. The series coil of switch D3A provides overload protection to the high voltage rectifier while the trip coil, shunting R12A, provides overload protection to the final radio frequency stage tubes V3A and V4A. The a-c potential to the rectifier is first applied through resistor R10A. After the rectifier output voltage reaches a predetermined value, relay S2A operates and shorts the resistor. Surge free starting of the transmitter is accomplished by the use of this two-step rectifier starting system.

The two door switches that are provided cause contactor S1A to be de-energized when any one of the doors is opened. This removes all plate and bias potentials from the transmitter.

Only the final radio frequency stage receives its bias from the bias rectifier. All other radio and audio frequency stages are self-biased.

Plate potential for the entire transmitter is obtained from a single-phase full-wave, 1250-volt rectifier. The second and third radio frequency stages receive their plate power directly from the rectifier, while the remaining radio and audio frequency tubes receive their plate and screen potentials through either series resistors or from potentiometers. Taps 2, 3 and 4 are provided on the primary of the plate transformer to adjust for the required plate voltage.

Radio Frequency Circuits

Oscillators

A 702A Oscillator is mounted in the slide rail assembly in the front section of the vertical structure. All connections to the oscillator unit are made by means of spring contacts which engage when the unit is properly inserted. The oscillator contains the quartz crystal Y1, the vacuum tube V1, and associated circuits, and the temperature control circuit consisting of the heater resistance R6 and thermostat TD1. The 702A Oscillator is adjusted as a unit to the operating frequency and will maintain its calibration well within ± 10 cycles from 550

to 1500 kilocycles, and within ± 20 cycles from 1500 to 2750 kilocycles.

The radio frequency output obtained from terminal 3 of the oscillator is connected to the grid of the first radio frequency amplifier tube V1A. Plate power for the oscillator is obtained from a slider on resistance R7A.

First Radio Frequency Amplifier Stage

The radio frequency input voltage to the first amplifier tube V1A is impressed across resistance R63A. The gain of this stage, and thus the output of the transmitter is controlled by changing the setting of the "RF Output" control R1A which varies the bias voltage applied to the grid of V1A through resistance R63A. The potential drop across R1A is obtained from resistance R2A. The plate of V1A works into an anti-resonant circuit, consisting of the inductance L7A in parallel with the variable condenser C25A, which is tuned by the control designated "Plate V1." Condenser C23A serves only as a plate blocking condenser. The plate potential for V1A is supplied through L7A and resistance R67A from a slider on resistance R3A. Screen potential is obtained from another slider on R3A. Plate current of V1A is measured by the potential drop across resistance R66A and is indicated by test meter M1A when the "Test Meter" switch D8A is in the "P. V1 X 100" position. "Plate Current," as measured by the drop across cathode resistance in this equipment, indicates the total current from the tube cathode, a portion of which may flow to other elements of the tube than the plate, such as the grid and screen.

Second Radio Frequency Amplifier Stage

The output of V1A is coupled to the grid circuit of the second amplifier tube V2A through condenser C23A. Resistances R68A and R69A* provide a grid load and path for the negative bias which is obtained by the potential drop in resistance R20A** and R21A, between cathode and ground. Grid current in this tube is indicated by the potential drop across R69A and is obtained with the "Test Meter" switch in the "G. V2 X 20" position. Total space current is indicated by the potential drop in R20A and is obtained with the test meter switch in the "P. V2 X 200" position. The plate of V2A works into the anti-resonant circuit consisting of inductance L11A, the rotor of transformer L12A, and variable condenser C32A which is tuned by the control designated "Plate V2."

Plate potential for V2A is obtained directly from the rectifier while the screen potential is reduced to the required value by the use of series resistance R57A.

*Resistance R69A is a meter shunt of negligible resistance.
**Resistance R20A is a meter shunt of negligible resistance.

Third Radio Frequency Amplifier Stage

Throughout this bulletin, when referring to the third radio frequency stage tubes, the singular designations V3A and V4A will be used whether two (450A-1) or three (451A-1) tubes are used in each circuit position.

The stator of L12A couples the output of V2A directly to the push-pull grid input circuit of V3A and V4A. This circuit is tuned by means of condenser C33A which is operated by the control designated "Grid V3 + V4." Resistances R72A and R73A provide a radio frequency load for this circuit.

The fixed bias potential is fed through the winding of audio input choke L5A and the stator of radio frequency transformer L12A to the grids of V3A and V4A. Modulation is secured by impressing the audio voltage upon the grids of these tubes through the stator of this radio frequency transformer. C37A and L14A provide a series resonant radio frequency by-pass circuit which presents a high impedance to the audio frequency modulating voltages.

The push-pull output circuit of V3A and V4A contains the output transformer L23A which is tuned by the "Plate V3 + V4" condenser C50A. Cross-neutralization is provided by the "Neutralizing V3 + V4" condenser C36A. Plate power is fed through the stator of L23A to both sets of tubes.

The radio frequency output is inductively coupled to the harmonic suppression circuit composed of C53A, C54A, and L24A, the antenna or transmission line coupling circuit composed of C55A and L25A and meter M5A to either an antenna or a transmission line. A sample of the radio frequency output of the transmitter is obtained through the "Modulation Monitor" condenser C56A for modulation monitoring purposes.

Test meter multiplier resistors R14A, R15A, R16A, R17A, R18A and R19A in conjunction with "Test Meter" switch D8A and meter M1A permit reading the individual cathode currents of the output circuit tubes. Meter M4A indicates the total plate current of these tubes.

Audio Frequency Amplifier

The amplifier which provides the necessary audio frequency modulating voltage has two resistance coupled stages employing tube V6A in the first stage and tubes V7.1A and V7.2A in parallel in the second stage. The input to the first stage is the difference of two voltages, one the signal from the speech input equipment through the input transformer T7A effectively across R27A, the other a portion of the signal fed back from the output of the transmitter through L26A, demodulated by the half-wave rectifier tube V5A and applied in series with the speech input voltage, through C10A, R25A and R26A to ground. The grid bias of V6A is obtained by means of self-biasing resistance R33A. The parallel tubes, V7A, of the second stage obtain their bias from self-biasing resistances R39A and R44A. Each tube space current is measured by the drop

across meter shunts R34A, R40A, and R45A that are connected in the cathode circuits of the tubes. The output of V7A is connected to the grids of V3A and V4A through C19A.

The radio frequency rectifier tube V5A in conjunction with the audio frequency output transformer T8A also furnishes an audio frequency monitor supply, rectified from the transmitter output.

Circuits Adjustments

The positions of the slider taps that are provided on some of the resistors should be checked before applying power to the unit. Table 1 gives the approximate physical location of these sliders and the voltages to ground under normal carrier output conditions. Final slider adjustments should be made after all other transmitter adjustments are completed.

The value of plate current required to trip "Plate" circuit breaker D3A is governed by the position of the slider on R12A. This slider should normally be in the mid-position of the resistance. The position of this slider also affects the audio frequency voltage fed back to the cathode of V6A through resistance R51A and condenser C59A.

Preliminary adjustments of the radio frequency coils and condensers should be made in accordance with tables 2 and 3.

With the "Power" and "Plate" switches in the "Off" position place all vacuum tubes in their respective sockets according to table 4. Due to the stabilizing effect of the audio frequency tubes upon the final radio-frequency stage, these tubes must be placed in position before proceeding with the tuning of the transmitter.

Turn the "Power" switch "On" and allow sufficient time for all vacuum tube filaments to become properly heated. For normal operation the heating time should be at least 30 seconds before operating the "Bias" and "Plate" switches. However, the filaments of new mercury vapor tubes should be heated at least 15 minutes before the high voltage is applied. This preheating removes any particles of mercury adhering to the sides or elements of the tubes after shipment or handling, thus minimizing the possibility of flashovers.

Insert the 702A Oscillator and apply the heater power by placing switches D5A and D6A in the "On" position. When starting from room temperature the time for the oscillator to reach its normal operating temperature of 60 degrees centigrade is approximately one hour. The final tuning adjustments of the transmitter should be made *after* the oscillator has reached its normal operating temperature.

In the following instructions for adjusting the transmitter, reference to controls will be made in accordance with the title provided on the controls. The following table shows the title and location of the controls as well as the

corresponding designation number of the apparatus with which it is associated. Other apparatus will be referred to in accordance with its designation number.

Left Control Panel (from top to bottom):

Control Title	*App. Desig. Number*
Output V3 + V4	C53A
(Test Meter, no title)	M1A
Test Meter (Switch)	D8A
Plate V3 + V4	C50A
Output Coupling V3 + V4	L23A
Grid V3 + V4	C33A
Plate V2	C32A
(Fil. C.T. Adj., no title)	R58A
RF By-Pass	C37A
Plate V1	C25A

Right Control Panel (from top to bottom):

Control Title	*App. Desig. Number*
F.B. Adj. (near V5A)	R25A

METERS

Title of Meter	*App. Desig. Number*
(Test Meter, no title)	M1A
Volts-Power Supply	M2A
Kilovolts-Plate	M3A
Amperes-Plate	M4A
Amperes-Trans. Line or Antenna	M5A

Control Title		*App. Desig. Number*
Modulation Monitor		C56A
RF Output		R1A
Neutralizing V3 + V4		C36A
Output Coupling V2		L12A
Plate	On Off	D3A
Bias	On Off	D2A
Power	On Off	D1A

Inside Controls (Front Section):

Circuit current readings on the test meter are obtained by multiplying or dividing the actual meter indication by the factor indicated by the setting of the "Test Meter" switch.

First Radio Frequency Amplifier Tuning

Resonance is obtained in all plate circuits by adjustment for minimum d-c plate current of the tube whose tuned output circuit is being adjusted. In tuning any of the the radio frequency circuits care should be taken that no circuit is tuned to the second harmonic of the fundamental frequency, Should two points of resonance be found with the coil setting specified the one at which the capacitance of the variable condenser is maximum is the correct adjustment. This will correspond to the point of higher dial reading and higher output current.

Before applying plate voltage open link switch D7A (located above V4A). The link of this switch consists of two plugs with a flexible interconnection. When the plugs are inserted into the associated insulated jacks the circuit is closed.

Caution: When switch D7A is open and the plate rectifier switch is opened, the condition of charge of the high voltage condensers should be observed on the "Plate" voltmeter before working on any apparatus. This safety measure is advised for the protection of operating personnel in addition to the door switches that are provided within the transmitter.

Place the "Test Meter" switch in the "P.V1X100" position and apply bias and plate power by means of the "Bias" and "Plate" switches. With the "RF Output" control set at about 80 adjust the "Plate V1" tuning control until the test meter indicates a minimum or until the test meter indicates a maximum when the "Test Meter" switch is turned to the "G.V2X20" position.

Second Radio Frequency Amplifier Tuning

Before tuning this amplifier the coupling between L10A and L11A should be reduced to the minimum possible value. The final adjustment of L10A is covered under the heading "Adjustment of Frequency Monitor Coupling Coil L10A." With the "Output Coupling V2" control set at zero* and the "Test Meter" switch in the "P.V2X200" position adjust the "Plate V2" tuning control until the test meter indicates a minimum. Adjustments of this circuit should be made only with the "Output Coupling V2" control set at zero.

*For zero coupling, the mechanical axis of the rotor of L12A should be at approximately 90 degrees to the stator when the "Output Coupling V2" control is set at zero. The electrical zero can be determined after the transmitter has been adjusted for the normal carrier output. Turning the "Output Coupling V2" control to zero should reduce the "Plate" or "RF Output" meter readings to zero. The mechanical linkage should be readjusted if zero coupling cannot be obtained.

TABLE 1

Resistance Adjustments

Desig. No.	*Slider*	*Slider Position*	*Voltage*
R2A	1st slider from left	3⅛ in. from left terminal	34 ± 5
R2A	2nd slider from left	4 in. from left terminal	28 ± 5
R3A	1st slider from left	3¼ in. from left terminal	200 ± 10
R3A	2nd slider from left	6½ in. from left terminal	300 ± 25
R5A		1⅝ in. from left terminal	230 ± 20
R7A	1st slider from left	3¼ in from left terminal	110 ± 10
R7A	2nd slider from left	4¾ in. from left terminal	190 ± 10
R7A	3rd slider from left	5¾ in. from left terminal	270 ± 10
R9A*	1st slider from left	1 in. from left terminal	26 ± 2
R9A*	2nd slider from left	6⅝ in. from left terminal	300 ± 5
R9A*	3rd slider from left	7¼ in. from left terminal	300 ± 5
R9A			300 ± 25
R12A		Mid-position	
R48A		½ in. from left terminal	
R111A		4⅛ in. from left terminal	

*Used only in 451A-1 Radio Transmitting Equipment under power change conditions.

TABLE 2

Preliminary Coil Adjustments

Desig. No.	*Freq. kc*	*Active Taps*
L7A	550-780	1 + 6
	790-1130	2 + 5
	1140-1600	3 + 4
	1601-2100	1 + 4
	2101-2750	2 + 3
L14A	550-750	1
	760-950	2
	960-1600	3
	1601-1900	1
	1901-2200	2
	2201-2750	3
L26A*	550-750	4
	760-1250	3
	1260-1600	2
	1601-2000	4
	2001-2400	3
	2401-2750	2

*The taps used for this coil are a function of the coupling between L26A and L23A.

Third Radio Frequency Amplifier Grid Input Circuit Tuning

With the "Output Coupling V2" control set at about 20 and the "Test Meter" switch in the "P.V2X200" position adjust the "Grid V3 and V4" control for a maximum deflection of the test meter. The actual position of the "Output Coupling V2" control for which a desirable indication can be obtained on the test meter will depend upon the station frequency. The minimum coupling that will permit making this adjustment should be used. Under no circumstances should adjustments of the "Grid V3 + V4" control be made at other than the minimum coupling conditions.

RF By-Pass Tuning

Remove the plate and grid power and disconnect the lead to L26A by means of the wing nut on the through bushing. Place a temporary connector from this through bushing to the junction of C33A and C37A. With the plate and grid power on, adjust the "RF Output" and "Output Coupling V2" controls until the test meter indicates approximately 15 milliamperes when the "Test Meter" switch is in position "GV3 + V4X100." The "Test Meter" switch should then be turned to the "Mon.X20" position and the "RF By-Pass" control should be adjusted for a minimum deflection of the test meter. The deflection increases rapidly when turning the control to either side of the minimum position. Care should be taken in making this adjustment since improper adjustment causes an unbalance in the plate current of the push-pull third amplifier. If a greater deflection of the test meter is desired a temporary short circuit should be placed around R23A. This short circuit and the temporary connector to the junction of C33A and C37A should be removed as soon as the by-pass circuit is tuned. Reconnect the lead from L26A to the through bushing and adjust this coil for maximum coupling to the stator of L23A.

Neutralizing of the Third Radio Frequency Amplifier.

With the "Output Coupling V3 + V4" control set at zero operate the bias and plate controls to "On" and adjust the drive to the final stage for a grid current of approximately 15 milliamperes. Set the "Neutralizing V3 + V4" control at 100 and adjust the "Plate V3 + V4" control for a maximum indication on the test meter when the "Test Meter" switch is turned to the "Mon.X20" position. Since table 2 on the adjustment of turns for L23A is approximate, it may be necessary to modify slightly the value indicated to obtain resonance. After resonance is obtained the "Neutralizing V3 + V4" control should be adjusted for a minimum indication on the test meter. When properly neutralized the settings of the "Neutralizing V3 + V4" control will be found to be approximately 80 and 40 for 6-tube (451-1 Radio Transmitting Equipment) and 4-tube (450A-1 Radio Transmitting Equipment) operation, respectively.

Third Radio Frequency Amplifier Circuit Tuning

For an antenna or transmission line of 65 ± j10 ohms, L25A and C55A should be adjusted according to tables 2 and 3. For other load impedances the settings for L25A and C55A should be calculated from Figure 2, as outlined at the end of this section (page 19).

Reduce the coupling between L26A and the stator of L23A to a minimum, set the "F.B. Adj." control at zero and close switch D7A. With the "RF Output" control set at approximately 80 and the "Output Coupling V2" control set at zero, apply grid and plate power. Turn the "Output Coupling V2" control clockwise until the "Plate" ammeter reading is approximately 0.1 ampere and adjust the "Plate V3 + V4" control for a minimum indication of the "Plate" Ammeter. When this circuit is properly tuned, increase the drive by turning the "Output Coupling V2" control until the third amplifier grid current is between 10 and 20 milliamperes. The "Output Coupling V3 + V4" control should then be turned clockwise until a slight increase is noticed in the "Plate" current meter reading. Then adjust the "Output V3 + V4" control for a maximum indication on the "Plate" meter. This maximum indication should practically coincide with a maximum indication of the antenna or transmission line current meter. Due to the limited range of condenser C53A, which is associated with the "Output V3 + V4" control, it may be necessary to make turn by turn adjustments of L24A until resonance is obtained. After these circuits are properly tuned, the output coupling of the third amplifier should be increased by means of the "Output Coupling V3 + V4" control until essentially the normal plate current is obtained for the required output as shown in table 5. It will be necessary to adjust the "Output Coupling V2" control in conjunction with the "Output Coupling V3 + V4" control to obtain the desired meter readings. The high value of resistance introduced into the output circuit makes it necessary to readjust the "Plate V3 + V4" control for a minimum plate current. The new setting will be found to be at a lower capacity value and, due to the limited range of C50A, may necessitate a reduction of one or two turns in the active section of L23A to obtain resonance. This final adjustment is essential for proper performance of this modulated stage.

After these preliminary adjustments are completed the adjustments of the circuits under the headings entitled "First Radio Frequency Amplifier Tuning," "Second Radio Frequency Amplifier Tuning" and "Third Radio Frequency Amplifier Grid Input Circuit Tuning" should be checked in accordance with the procedure outlined under those headings.

Final adjustments of the "Output Coupling V2" and "Output Coupling V3 + V4" controls can now be made for the required output power and plate efficiency. At this point the procedure in adjusting the "Output Coupling V2" control is changed from that previously outlined. Set this control at 100 and

apply grid and plate power. Turn this control counter-clockwise and the "Output Coupling V3 + V4" clockwise until the rated output power is obtained at the required efficiency. When these adjustments are completed the setting of the "Output Coupling V2" control should be such that turning this control counter-clockwise will increase the radio frequency output of the final stage.

The division of plate current of the final stage tubes is a function of the adjustment of the "RF By-Pass" control, the slider position of R50A and the capacity tolerances of C34A and C35A. If the "RF By-Pass" control has been properly adjusted and condensers C34A and C35A are reasonably well matched, a balance of the plate current of the two sides of the push-pull circuit can be obtained by adjusting the slider on R50A.

Operation Into Other Than a 65 Ohm Antenna or Transmission Line

If the transmitter is to work into an impedance having a resistance component other than 65 ohms, obtain the required approximate value of reactance of C55A from Figure 2; then compute the capacity from the formula

$$C = \frac{159.2 \times 10^6}{f x_c}$$

with f in kilocycles, x_c in ohms, and C in micro-microfarads.

Note: The value of capacity supplied for C55A is a stock value approximating the value computed from the load circuit information included in the order.

Obtain the required value of reactance of L25A from Figure 2, and compute the inductance from the formula

$$L = \frac{159.2\ X_L}{f}$$

with X_L in ohms, f in kilocycles, and L in microhenries. From this value of inductance, the number of turns for L25A may be obtained from Figure 2.

Note: Either of two coils may be furnished for position L25A, depending on antenna characteristics and frequency. Figure 2 shows the inductance-turns relation for both, and the correct curve should be selected by referring to the tag marking on the coil furnished.

If the load impedance (antenna or transmission line) has a reactance component exceeding ± 10 ohms, L25A must be further adjusted. In such case the reactance indicated in Figure 2 for L25A is actually the combined reactance of the load and coil L25A and the correct reactance of the coil may be obtained by subtracting (if positive) or adding (if negative) the load reactance, and the combined reactance indicated for L25A in Figure 2. The inductance and number of turns may then be obtained from the formula and Figure 2 as described above.

Note: If a direct connected antenna has a positive reactance exceeding 100 ohms, series condenser C58A is supplied and its reactance must be subtracted from the antenna reactance to give the load reactance, referred to above.

The adjustment of C55A is independent of the load reactance, depending only on the load resistance.

Adjustment of Radio Frequency Rectifier Coupling Coil L26A

With the tap on L26A set according to Table 2, adjust the coupling to L23A until the test meter reading is 4 to 10 milliamperes for the normal carrier output when the "Test Meter" switch is in position "F.B. x 20." If necessary the tap adjustment on L26A can be modified by one tap in either direction.

Adjustment of Feedback and Associated Circuits

After the entire transmitter has been tuned, adjustments of the feedback circuit and associated circuits should be made. To measure the feedback remove the feedback rectifier tube V5A and modulate the transmitter with a single frequency of 400 cycles. The required input level for 100 per cent modulation should be approximately −10 db. When the tube is replaced the audio input level for 100 per cent modulation should be approximately +6 db (+14 VU). The difference of the two input levels is then the value of feedback which should be between 15 and 16 db. To obtain the proper value of stable feedback, adjust the setting of R25A until the input level is +8 db (+16 VU) for 100 per cent modulation and observe the wave form on a cathode ray oscilloscope for different values of modulation. If a spurious oscillation appears it will be necessary to adjust the values of one or more of the elements designated C12A, C18A, C62A, C59A, R46A, R55A, R51A and the slider on R12A. These components are composed of parallel or variable elements and can be changed, but in general it will be found that the values connected at the factory will give satisfactory performance.

The following table indicates the designation numbers for components for which only one item is installed in the transmitter but for which spare apparatus of a different value is supplied for making adjustments if necessary.

C12A	C-D Type 3 W	.000025 mfd	Installed
	C-D Type 3 W	.000050 mfd	Spare
R46A	IRC BT1	25,000 ohms	Installed
	IRC BT1	50,000 ohms	Spare
R51A	IRC BT1	1,000 ohms	Installed
	IRC BR1	600 ohms	Spare
	IRC BT1	2,000 ohms	Spare
R55A	IRC BT1	600 ohms	Installed
	IRC BT1	1,000 ohms	Spare
	IRC BT1	2,000 ohms	Spare

Should any adjustment of these components be necessary it is suggested that the adjustments be first confined to C12A, R55A and R12A. Should a sing exist increase the capacity of C12A and/or decrease the resistance values of R55A and R12A.

The procedure of observing the waveform at different levels of modulation should be repeated for 50-cycle modulation. When the tests indicate no spurious oscillations the feedback should be reduced 2 or 3 db by reducing the setting of R25A.

Whenever major adjustments of the radio frequency circuits of the transmitter are to be made, the feedback should be removed by changing the setting of R25A to zero or by removing V5A.

Audio Frequency Monitoring Rectifier

The radio frequency rectifier tube V5A and some of its associated circuits furnish a source of audio frequency monitoring output from the transmitter. The output transformer terminating resistance R49A should be removed when the output is 500 to 600 ohms impedance. The output level with single-frequency 100 per cent modulation is approximately +10 db (+18 VU).

Modulating the Transmitter and Final Adjustments of Radio Frequency Circuits

With the final stage adjusted to the proper operating condition at the unmodulated carrier output, it is necessary next to observe the operation with modulation applied.

For ideal distortionless operation with no carrier shift the antenna current should rise 22.5 per cent at 100 per cent modulation. In transmitters not employing negative feedback, a failure of the antenna current to rise to this extent ordinarily indicates distortion in the modulated wave. With the distortion removed by feedback, the only result of such carrier shift is a slight decrease in transmitted signal; for example, if the antenna current rises only 19 per cent the loss in transmitted signal with a distortionless wave is 0.25 db. This equipment is designed to permit 100 per cent modulation with no carrier shift when adjusted to the recommended plate efficiencies indicated in table 5.

The antenna current increase for 100 per cent modulation is governed by the setting of the "Output Coupling V2" control. The greatest increase will be obtained at settings toward 100 from the point where the greatest value of carrier output is obtained. The "RF Output" control must be adjusted in conjunction with the "Output Coupling V2" control to obtain the required carrier output. If, for a given setting of the "Output Coupling V2" control, the antenna current increase is too great, the coupling should be reduced by turning the control toward zero and the setting of the "RF Output" control readjusted for normal carrier output. With this procedure a setting will be found that gives the required antenna current increase. If the required increase cannot be obtained

and there is any doubt about the impedance of the antenna system into which the equipment operates, the adjustments of L25A and C55A should be checked. The proper adjustment of these components is indicated by a current of 1.6 ± .1 ampere for 250 watts output and 1.0 ± .1 ampere for 100 watts output in coil L24A.

The impedance of the second radio frequency plate circuit is governed by the adjustment of the "Output Coupling V2" control. Since the noise level of a vacuum tube is a function of the load impedance into which the tube operates, the overall transmitter noise is affected by the final position of the "Output Coupling V2" control. Slight modifications of this control setting can be made without a noticeable effect upon the carrier current increase but with a measurable improvement in the noise level. The best overall performance will be obtained when the "Output Coupling V2" control is such that the test meter reading for normal carrier output is approximately 2 milliamperes when the "Test Meter" switch is in the "G.V2X20" position.

Final Adjustment of Sliders on R2A

The sliders on R2A should be adjusted to provide a smooth acting control for the radio frequency output over the entire range of the "RF Output" control. They should be adjusted to give the normal carrier output when the "RF Output" control is at 80. Under these conditions the carrier output current is approximately 50 per cent and 120 per cent of normal when the "RF Output" control is at zero and 100, respectively. The spacing between the two sliders will govern the maximum available output while the spacing from these sliders to the grounded end of R2A will govern the value of carrier output when the "RF Output" control is set at zero.

Adjustment for Minimum Noise Level

Potentiometer R58A is provided to adjust the filament center tap of the second radio frequency stage for a minimum noise level. The slider position will be found to be reasonably near the mid-position when it is adjusted for the minimum noise level for the equipment.

Adjustment of Frequency Monitor Coupling Coil L10A

A source of RF voltage for frequency monitoring purposes is obtained by means of inductive coupling between L10A and L11A. The position of L10A can be adjusted to supply the required voltage through a transmission line to terminal 11 and to the frequency monitoring equipment. After this adjustment has been made recheck the second radio frequency amplifier tuning.

Adjustment of "Modulation Monitor" Control

The radio frequency supply for modulation monitoring purposes is obtained from terminal 12. The control designated "Modulation Monitor" provides a means for adjusting this supply to the required level for the proper performance of the modulation monitoring equipment.

Operation at Reduced Power

The equipment required for the instantaneous switching of power is optional and is only necessary for stations whose day and night time power ratings are different. This equipment consists fundamentally of a magnetic contactor S102A, relay S101A and the "Output Power" switch D101A. Magnetic contactor S102A changes the bias and plate potentials, relay S101A switches the feedback circuit while switch D101A is used to control the operation of the contactor and the relay. Figure 1 shows the circuit schematic.

Transmitter adjustments should first be completed with the "Output Power" switch in the "High" position. Then with the switch in the "Low" position, adjust the sliders of R111A and R9A that furnish the plate and bias voltages to V3A and V4A under the reduced power condition until the required carrier output is obtained. The required plate and bias voltages are shown in tables 4 and 5. When these adjustments are properly made the correct value of carrier output will be obtained for both power conditions without changing the setting of the "RF Output" control.

Operation of the "Output Power" switch causes contactor S1A to drop out, thereby removing plate and grid power before magnetic contactor S102A operates. The "Bias" switch must therefore be operated to reapply the bias and plate power for the new power condition.

Coupling Coil L26A and resistance R25A should now be adjusted to obtain the desired feedback at the two power conditions. With the "Output Power" switch in the "Low" position, adjust coupling coil L26A until the desired feed back is obtained or until the audio input level for 100 per cent single frequency modulation is +6 db (+14 VU). With this adjustment completed, place the "Output Power" switch in the "High" position and adjust R25A until the same audio input level is required for 100 per cent modulation.

Time Delay and Recycling Circuit

The tube filaments of this transmitter should be heated for not less than 30 seconds before applying the grid and plate power. Normally this delay is manual, but a time delay and recycling circuit may be installed as an optional feature. Figure 1 shows the circuit.

In case of a power supply interruption the recycling feature provides a delay in the reapplication of grid and plate power proportional to the duration of the interruption. The reapplication of power is instantaneous for interrup-

tions of less than one-half second. A d-c potential is obtained across condenser C101A by means of rectox unit X101A. The delay is obtained by charging condenser C102A through resistance R102A. When the condenser voltage reaches a predetermined value, discharge takes place across two elements of the three-element gas-filled tube V101A. This causes a flow of current from the third to the common element which energizes relay S103A, thereby completing the circuit to magnetic contactor S1A. When the time delay circuit is supplied "Bias" switch D102A which is of the toggle type, replaces D2A shown on Figure 1. The operating time of the delay circuit can be changed by means of the slider on R101A. The normal d-c voltage across R101A is shown in table 4.

MAINTENANCE

Motor Blower

The motor bearings should be oiled with a few drops of light machine oil every two weeks.

Voltage Regulator T1A

While the voltage regulator T1A should require very little attention the carbon brushes and commutator surface should be inspected occasionally and serviced if necessary. Continued use over a period of time may result in poor contact and excessive heating, due either to uneven wear of the brushes or a dirty or corroded commutator surface. Poor brush contact will quickly cause damage to the commutator surface or brushes in one of the following ways: (1) an excessive deposit of carbon will partially short circuit adjacent conductors and cause sparking at the brushes; (2) the commutator surface may become pitted as a result of continued sparking; (3) groups of commutator conductors may become depressed and offer an uneven commutator surface as a result of continued excessive heat; (4) encrusted accumulations on the commutator surface or uneven conductors may tear away sections of the contact surface of the brushes.

Should the brushes show signs of an irregular surface a very fine grade of sandpaper should be placed under them and the brushes run up or down until they are smooth. If the commutator surface needs cleaning a strip of the sandpaper should be inserted under the brush with the sand side against the commutator surface. Coarse sandpaper should not be used, as it would score the commutator surface and necessitate return of the unit for regrinding.

Relays and Magnetic Contactors

The contacts of relays and magnetic contactors should be kept free of dust and any substance that might produce sticking. A fine grade of sandpaper should be used only when the contacts become pitted. Sticky or otherwise dirty contacts or relay mechanisms should be washed with a grease solvent such as gasoline or carbon tetrachloride.

Preliminary Coil Adjustments

Frequency	*L11A*	*L12A Each Section*		*L23A Each Section*		*L24A*	*L25A*
550	55	28	28	19	19	37	24
600	50	25	25	18	18	35	23
700	43	23	23	17	17	30	20
800	37	21	21	17	17	26	18
900	32	20	20	16	16	21	17
1000	28	18	18	15	15	17	16
1010	28	18	18	15	15	29	16
1100	24	17	17	15	15	27	14
1200	21	16	16	14	14	25	13
1250	19	15	15	14	14	23	12
1260	19	15	15	12	12	23	12
1300	18	14	14	11	11	21	11
1400	15	14	14	11	11	18	10
1500	13	13	13	11	11	16	9
1600	11	12	12	10	10	14	8
1601	31	17	17	10	10	15	12
1700	29	16	16	10	10	14	11
1800	27	15	15	10	10	13	10
1900	26	14	14	9	9	12	9
2000	25	14	14	9	9	12	9
2100	23	13	13	9	9	11	8
2200	22	12	12	9	9	10	7
2300	21	12	12	8	8	9	6
2400	19	11	11	8	8	8	5
2500	18	11	11	8	8	7	4
2600	17	10	10	7	7	6	3
2700	16	10	10	7	7	5	2
2750	15	10	10	7	7	5	2

Note: The unused turns of the above coils should be shorted whenever the number of unused turns is equal to or greater than the number of active turns.

The turns used for L11A, L12A and L25A should be as tabulated. The turns shown for L23A and L24A may vary slightly due to the change in fixed condensers associated with those coils.

TABLE 3

Condenser Adjustments

C25A

Freq. (kc)	
500-2000	Use both sections
2001-2750	Use one section

C26A

Freq. (kc)	*Cap. (mfd)*
550-570	.0005
580-900	.00025
910-2750	0

C34A and C35A each

Freq. (kc)	*Cap. (mfd)*
550-700	.0006
710-1100	.0004
1110-1800	.0002
1801-2750	0

C51A, C52A, C54.1A and C54.2A furnished according to frequency.

C55.1A and C55.2A furnished according to frequency and transmission line or antenna impedance.

Total Value of C55A (C55.1A plus C55.2A)
when operating into 65 ohm antenna or transmission line

Freq. (kc)	*Cap. (mfd)*	*Freq. (kc)*	*Cap. (mfd)*
550	.00263	1700	.00085
600	.00243	1800	.00081
700	.0021	1900	.00076
800	.00183	2000	.00072
900	.00162	2100	.00069
1000	.00145	2200	.00066
1100	.00133	2300	.00063
1200	.00121	2400	.0006
1300	.00111	2500	.00057
1400	.00103	2600	.00055
1500	.00097	2700	.00053
1600	.00091	2750	.00052

TABLE 4

VACUUM TUBE VOLTAGES

Designation No.	*Code No.*	*Grid Voltage*	*Screen Voltage*	*Plate Voltage*	*Filament Voltage*
V1A	350B	25 ± 5	180 ± 10	300 ± 20	6.3 ± .2
V2A	312A	60 ± 10	350 ± 25	1200 ± 50	10.2 ± .19
V3.1A, V3.2A, V3.3A, V4.1A, V4.2A, V4.3A *	242C	340 ± 25		1250 ± 25	10.0 ± .2
V5A	351A				6.3 ± .2
V6A	350B	12 ± 2	180 ± 10	350 ± 10	6.3 ± .2
V7.1A, V7.2A	350B	15 ± 2	220 ± 10	350 ± 10	6.3 ± .2
V8A	274A				5.0 ± .15
V9A, V10A	249B				2.5 ± .1
V101A**	313C			115 ± 10	

*The bias and plate voltages are for both the 450A-1 and 451A-1 Radio Transmitting Equipment when operating at the full rated output. When operating the 451A-1 Radio Transmitting Equipment at the reduced power output rating of 100 watts, the grid voltages are within the limits shown above while the plate voltage is as indicated in Table V.

**The 313C Vacuum Tube is used only when the option feature, the time delay and recycling circuit is used. The junction of C101A, R101A and X101A should be at a positive potential of 115 ± 10 volts with respect to the junction of C101A and C102A.

TABLE 5

Typical Meter Readings

Designation No.	*Title*	*Reading*
M1A	(No title) "Test Meter" Switch Position	
	Mon. x 20	7 ± 3 milliamperes
	F.B. x 20	5 ± 3 milliamperes
	PV6 x 100	25 ± 5 milliamperes
	PV7.1 x 100	65 ± 7 milliamperes
	PV7.2 x 100	65 ± 7 milliamperes
	G Osc. No. 2 ÷ 2	0 to 100 microamperes
	G Osc. No. 2 ÷ 2	0 to 100 microamperes
	P Osc. x 10	2.5 ± .5 milliampere
	PV1 x100 —	15 ± 10 milliamperes
	GV2 x 20 —	2 ± 1 milliampere
	PV2 x 200	110 ± 10 milliamperes
	GV3 & V4 x 100	Function of power
	PV3.1 x 200	Function of power
	PV3.2 x 200	Function of power
	PV3.3 x 200	Function of power
	PV4.1 x 200	Function of power
	PV4.2 x 200	Function of power
	PV4.3 x 200	Function of power
M2A	Volts Power Supply	230 volts
M3A	Kilovolts Plate	1.250 ± .025 for 450A-1 and 451A-1 Radio Transmitting Equipment at full rated output power
M4A	Amperes Plate	Function of power
M5A	Amperes (Transmission Line or Antenna)	Function of power and antenna or transmission line

TABLE 5 (Continued)

TYPICAL METER READINGS

Radio Transmitting Equipment No.	*Carrier Output Power Watts*	*M3A Kilovolts Plate*	*M4A Amperes Plate*	*Plate Efficiency Per cent*	*M1A PV3.1 x 200 PV3.2 x 200 * PV3.3 x 200 PV4.1 x 200 PV4.2 x 200 * PV4.3 x 200*	*M1A GV3 + 4 x 100 (Carrier)*	*M1A GV3 + 4 x 100 (100 Per cent single frequency modulation)*
450A-1	100	1.25 ± .025	.23 ± .01	35	58 ± 10 ma.	5 ± 2 ma.	11 ± 3 ma.
451A-1	250	1.25 ± .025	.570 ± .01	35	95 ± 10 ma.	12 ± 2 ma.	22 ± 4 ma.
**451A-1	250	1.25 ± .025	.6 ± .01	33	100 ± 10 ma.	12 ± 2 ma.	22 ± 4 ma.
451A-1	100	.8 ± .02	.36 ± .01	35	60 ± 10 ma.	12 ± 2 ma.	22 ± 4 ma.
**451A-1	100	.87 ± .02	.39 ± .01	30	65 ± 10 ma.	12 ± 2 ma.	22 ± 4 ma.

*V3.3A and V4.3A not used in 450A-1 Radio Transmitting Equipment.

**Recommended operating conditions.

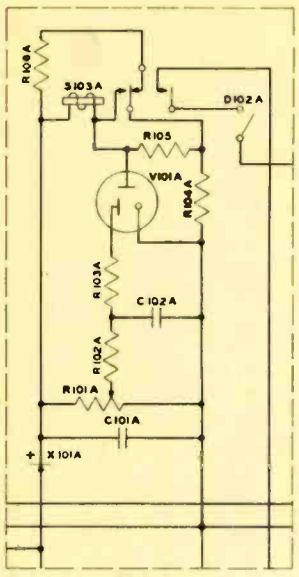


FIG. 2

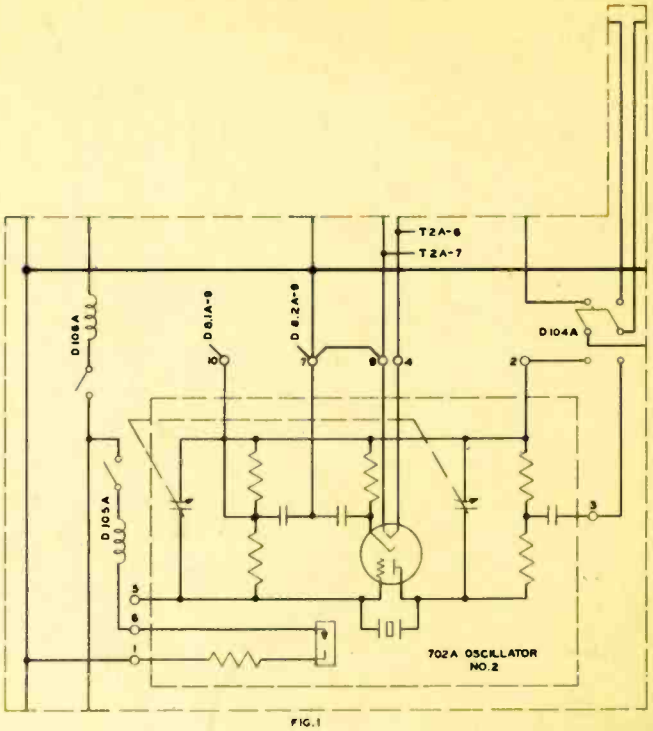


FIG. 1

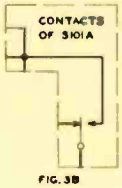


FIG. 3B

FIG. 3A

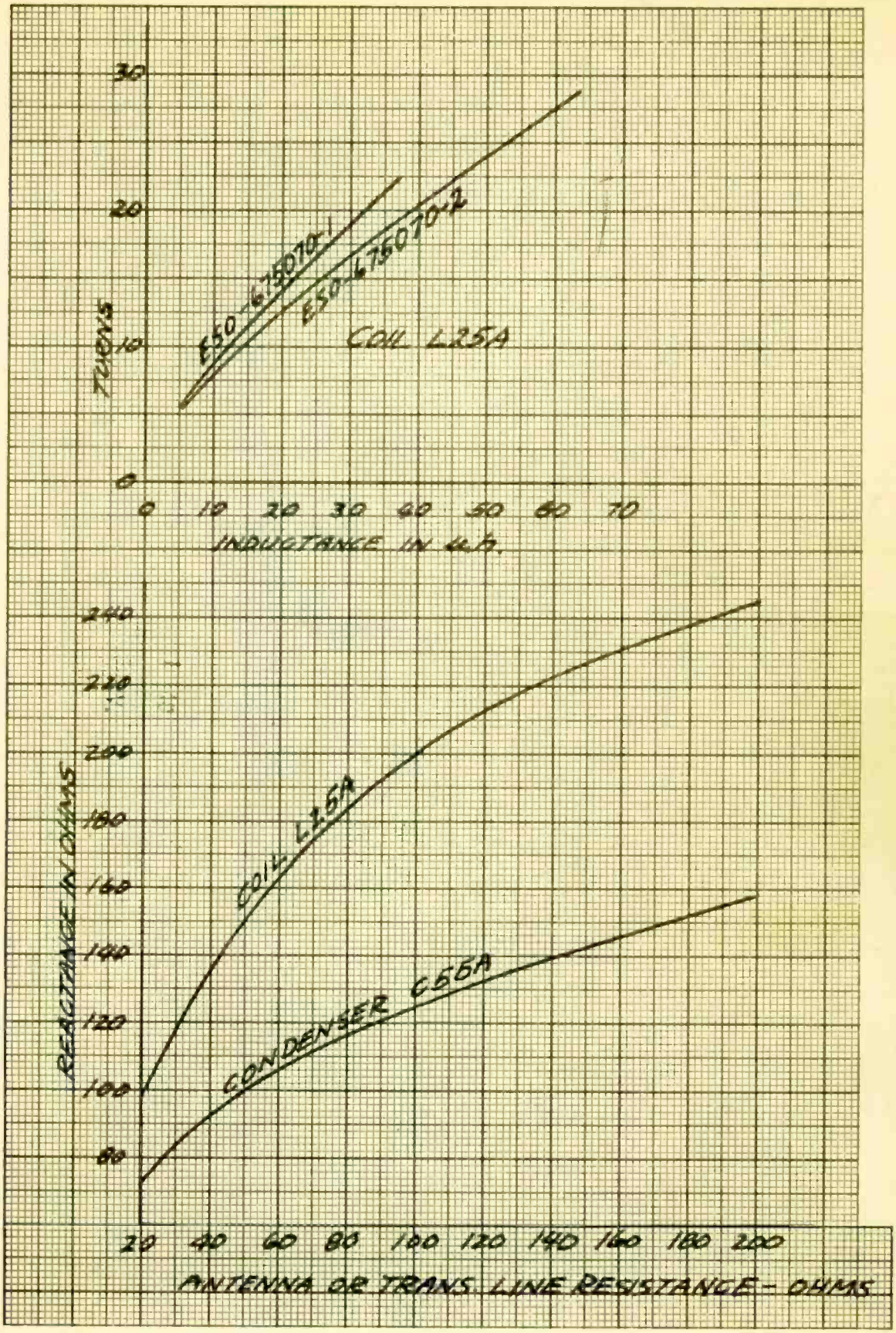
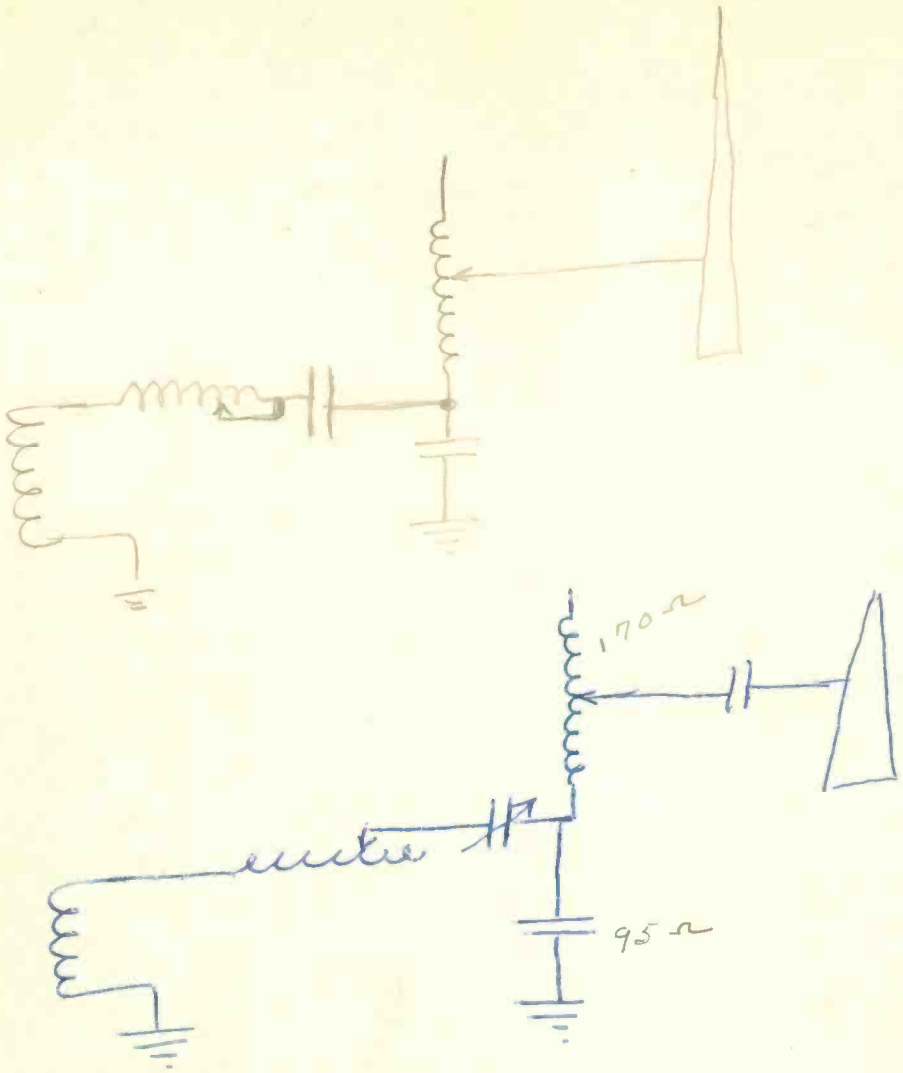


FIGURE 2—*Tuning Chart for L25A and C55A*


170 Ω
95 Ω