

Western Electric

NO. 23A

RADIO TRANSMITTER

PRELIMINARY INSTRUCTIONS

843-P

WESTERN ELECTRIC
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No. 843P

WESTERN ELECTRIC COMPANY

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GENERAL DESCRIPTION

The Western Electric No. 23A Radio Transmitter will deliver a maximum of 250 watts of completely modulated radio frequency carrier power at any frequency between 550 and 1600 kc. Normally it operates from a 200-240 volt single-phase, 50-60 cycle, power source, requiring approximately 2300 watts at a 90% power factor for 250-watt operation and approximately 1900 watts at a 90% power factor for 100 watt operation. An auto-transformer, which must be ordered separately, can be supplied for 100-120 volt, single-phase, 50-60 cycle operation where 200-240 volt power is not available.

The No. 310A and No. 310B Radio Transmitting Equipments each consist of a fully equipped No. 23A Radio Transmitter and differ only in the number of vacuum tubes used in the final radio frequency amplifier. The No. 310A Radio Transmitting Equipment uses four vacuum tubes for 100-watt service and the No. 310B Radio Transmitting Equipment uses six vacuum tubes in the final amplifier for 100/250 watt service.

The No. 23A Radio Transmitter consists of a quartz-controlled oscillator, a buffer amplifier, a balanced modulating amplifier followed by two radio-frequency balanced linear amplifiers, two stages of audio-frequency amplification, a feedback rectifier and a plate voltage rectifier with associated filter and control circuits. A flashing signal lamp indicates the proper operation of the oscillator temperature-

control circuit.

Modulation in the No. 23A Radio Transmitter is effected in the multi-element tubes of the second amplifier. The radio frequency voltage is applied to the control grids, and the audio frequency voltages are applied to the suppressor grids. This is essentially grid bias modulation in that the bias on the suppressor grids is varied in accordance with the audio frequency voltage applied to them.

Stabilized feedback is used in the transmitter to reduce the noise and the audio frequency harmonic distortion normally present in the output wave of radio transmitters.

INSTALLATION

When the No. 23A Radio Transmitter has been installed and connected in accordance with the installation information furnished with the equipment, the procedure indicated below should be followed.

Vacuum Tubes and Fuses

Place two No. 249B Vacuum Tubes in the sockets, VS15A and VS16A. Place the clip leads on the anodes of the tubes. Insert from left to right a No. 244A, a No. 262A, a No. 271A, and three RCA 837 Vacuum Tubes, designated V12A, V13A, V14A, V3A, V2A and V1A, respectively in the sockets of the audio and radio frequency amplifiers. Connect the clip leads to vacuum tubes V1A, V2A, V3A and V13A.

Place six (or eight) No. 242C Vacuum Tubes, as required, in the sockets VS4A to VS9A or VS11A, inclusive. Place a two-watt, 18-volt, G.E.Co. type 4 Lamp in each of the candelabra sockets, ES1A and ES2A.

Insert two 5-ampere, 250-volt Cartridge Fuses in cut-outs FM1.1A and FM1.2A, two 2-ampere, 250-volt Cartridge Fuses in cut-outs FM3.2A and FM3.3A and a 2-ampere, 2500-volt Western Union Telegraph Fuse in cut-out FM2A. Do not install a fuse in cut-out FM3.1A.

No. 702A Oscillator

The No. 702A Oscillators, the No. 7A Quartz Plates and the KS-7754 Thermometers are shipped separately and should be assembled as specified in the Instruction Bulletin accompanying the No. 702A Oscillator. Place a No. 247A Vacuum Tube in the oscillator tube socket, V1, and then replace the tube shield. Slide and lock the No. 702A Oscillator in place on the lower set of guide rails. If a spare No. 702A Oscillator is installed, slide and lock it in place on the guide rails provided above the regular oscillator.

ADJUSTMENT AND TUNING PROCEDURE

The No. 23A Radio Transmitter may be adjusted and tuned in accordance with the following procedure:

CAUTION:- DUE TO THE HIGH VOLTAGES EMPLOYED IN THIS TRANSMITTER ALL FRONT AND SIDE PANELS SHOULD BE IN PLACE AND THE REAR DOOR CLOSED BEFORE ANY ATTEMPT IS MADE TO OPERATE THE EQUIPMENT.

With all switches in the "Off" position, connect power to the transmitter. Set the "Voltage Control" to the extreme counter-clockwise position and close the "Power Supply" switch (D3A) located in the rear of the transmitter. With the voltage control transformer, T3A, connected 1-4, as wired in the factory, the "Supply Voltage" (M1A) should read between 200 and 212 volts. If the reading is higher, move the connections on T3A to 1-5 and if it is too low, move the connections to 1-3. Open "Power Supply" switch.

Close the "Oscillator Heater Supply" switch, (D1A), located in the rear and to the left and above the "Power Supply" switch. This permits the heating of the No. 702A Oscillator while the remainder of the adjustments are being made. The oscillator heater indicator lamp E1A (and E2A if a spare oscillator is used) will remain lighted only until the associated oscillator is at the proper temperature, at which time the corresponding lamp will flash intermittently. The exact time of the "On" and "Off" intervals is dependent upon the ambient temperature.

Adjust the taps on inductance coils L3A, L8A, L11A, L18.1A and L21A and set controls of condensers C11A, C12A, C20A and C21A in accordance with Table I.

Connect link switch D11A to terminal No. 21. Place "Power Transfer" switch (D12A) in the "High" position. Place link switches D9A and D10A in position No. 1, and close link switch, D8A.

Preliminary Tuning

Close "Power Supply" switch and close the rear door. Operate "Master Control" switch (D4A) clockwise to the "Fil." position. Adjust "Voltage Control" until "Supply Voltages" indicates 220 volts.

After approximately 30 seconds turn "Master Control" switch clockwise to the vertical position and then to the "Plate" position*. Then close "High Voltage" switch (D5A) and observe the indication on "Plate Voltage" meter (M4A) which should be approximately 1300 volts. If this voltage is low, (approximately 750 volts)

*Note - It is essential that the filaments of new mercury vapor tubes be heated at least 15 minutes before the high voltage is applied. (See Vacuum Tubes under "Maintenance").

check operation of relay S2A in accordance with the information given under "Location of Trouble". In the following tuning procedure the controls are adjusted with a spanner wrench furnished with the equipment. Place "Test Meter Switch" (D7A) in each of the eight positions, and note that in no case is the "Test Meter" (M2A) off scale.

Set "Test Meter Switch" in position "1st R.F. Amp. Plate" and adjust "1st Amp. Tuning" control (C4A and C5A) until "Test Current" meter reads a minimum. Change "Test Meter Switch" to "2nd R.F. Amp. Grid" and readjust "1st Amp. Tuning" slightly for a maximum on "Test Current" meter.

Adjust "1st Amp. Output" control (R8A) until "Test Current" meter reads approximately midway between the limits given in Table II. Set "Test Meter Switch" to "2nd R.F. Amp. Plate" and adjust "2nd Amp. Tuning" control (C13A) until "Test Current" meter reads a minimum. Change "Test Meter Switch" to "3rd R.F. Amp. Plate" and adjust "3rd Amp. Tuning" control (C24A) until "4th Amp. Plate Current" reads a maximum. Check "2nd R.F. Grid" and "3rd R.F. Amp. Plate" currents with Table II.

Set "4th Amp. Coupling" control at zero and "4th Amp. Input" control (R20A) to approximately mid-position. Adjust "4th Amp. Tuning" control (C32A) until "4th Amp. Output Current" meter (M5A) reads a maximum. This is obtained by alternately adjusting "4th Amp. Input" control and "4th Amp. Tuning" control until "4th Amp. Output Current" reads a maximum at approximately 1.0 ampere. The "Transmission Line Current" meter (M6A) should read zero.

NEUTRALIZING

The third and fourth amplifiers must now be neutralized in the following manner: Shut down the transmitter and disconnect the thermocouple end of the lead between C34A and TC1A. With a temporary jumper connect the free end of this lead to the clip on L21A. Set the test meter switch to the "Feedback Rec" position. Open Link Switches D9A and D10A. Start the transmitter and increase the "4th Amp. Coupling" a slight amount. Adjust the "Coupling Circuit Tuning" control (L21A) for a maximum indication of the "Test Meter". Full scale reading of the "Test Meter" should not be exceeded during this process, a reduction in the setting of "4th Amp. Input" control being made if necessary to reduce the "Test Meter" reading to somewhat less than full scale. If insufficient reading of the "Test Meter" is obtained to give a good indication the capacity of C34A should be increased until a satisfactory value is obtained. Neutralize the fourth amplifier by adjusting the "4th Amp. Neutralizing" (C26A) and (C27A) control for a minimum indication of the "Test Meter". Shut down the transmitter, open link switch D8A and close link switches D9A and D10A to position 1 as before. Start the transmitter and neutralize the third amplifier by adjusting the "3rd Amp. Neutralizing" control (C18A) and (C19A) for a minimum indication of the "Test Meter". Shut down the transmitter, close link switch D8A, remove of the temporary jumper, reconnect C34A to TC1A, set the "4th Amp. Output Coupling" and C34A to zero.

For transmitters prior to serial #126, a modification of the connection changes to be made preparatory to neutralizing is necessary. In these transmitters the condenser C34A is connected to coil L22A

instead of to TC1A. Therefore in this case the lead connecting L22A to C34A should be removed from C34A and connected by means of a temporary jumper to the point between C35A and C36A. With this change in connections the neutralizing procedure should be carried out exactly as previously described.

OUTPUT TUNING

Increase "4th Amp. Coupling" a slight amount and then tune the coupling circuit by adjusting "Coupling Circuit Tuning" control until the "4th Amp. Output Current" meter indicates a minimum.

Then check the tuning of the 4th amplifier for minimum plate current.

Adjust alternately the "4th Amp. Input" control and the "4th Amp. Coupling" until the "4th Amp. Plate Current" is in accord with Table II when the "Plate Voltage" is 1250 volts, the "Supply Voltage" is 220 volts, the "4th Amp. Output Current" is in accordance with Table II and the "Transmission Line Current" meter (M6A) indicates the proper output for the power of the transmitter as shown in Table II.

The "4th Amp. Plate Current" meter, is normally connected to indicate the total plate current in the vacuum tubes of the final amplifier. The plate current indication on this meter of tubes V6A and V8A or V6A, V8A and V10A when D9A is in position 1 and D10A is in position 2 should be within 10 ma. of the plate current indication of tubes V7A and V9A or V7A, V9A and V11A when D9A is in position 2 and D10A is in position 1. This balance can be obtained by adjusting the relative positions of the contact arms on resistors R20.1A and R20.2A. The amount that either of these controls should be moved depends upon the unbalance indicated on "4th Amp. Plate Current" meter.

When all tuning adjustments are completed, and the transmitter is delivering the desired output power, the meter readings shall be in accordance with Table II, "Typical Meter Reading", with the exception of the "Feedback Rec." current which will be adjusted later.

The transmitter is now ready to be connected to the concentric transmission line by connecting link switch D11A to terminal 20. This line connects the output of the transmitter to the Antenna Coupling Unit which is adjusted and tuned in accordance with Instruction Bulletin accompanying it.

Set the feedback rectifier input control until the "Feedback Rec." current is as indicated in Table II. If an audio oscillator is available a more accurate setting of feedback may be made as follows. With the single frequency audio input level to the transmitter adjusted to the value of Table II the output for complete modulation should be observed as an increase of 22-1/2% on the "Transmission Line" meter. If the current increase is either more or less than this increase or decrease, respectively, C34A until the proper percentage is attained. This will provide the proper amount of stabilized feedback. The "Feedback Rec." current indicated on the "Test Current" meter should be within the limits given in Table II.

OPERATING PROCEDURE

Normal Operation of the 310A or 310B Equipment

When the No. 23A Radio Transmitter is adjusted and tuned as described in the preceding paragraphs, the routine operation is as follows.

The "Oscillator Heater Supply" switch (D1A) is always left "On" in order to furnish power to the oscillator heater circuits.

Before starting the transmitter, the antenna-ground switch shall be connected to the antenna position, the link switch D11A in the transmitter shall be connected to terminal No. 20, and the "Power Transfer" switch shall be either in the "High" position for 250-watt operation or in the "Low" position for 100-watt operation. The position of "Power Transfer" switch for 100-Watt operation refers to either the No. 310A or No. 310B Radio Transmitting Equipment.

Note:- Never operate the 310A Radio Transmitting Equipment with the "Power Transfer" switch in the "High" position.

The "Power Supply" switch is closed, followed by the operation of the "Master Control Switch" to the "Fil." position and after a pause of at least 30 seconds to the "Plate" position. If the "High Voltage" switch is "On" the transmitter will deliver power to the antenna. If the "High Voltage" switch is "Off", it may be operated at the convenience of the operator at any time after the "Master Control Switch" has been operated to the "Plate" position. The output power may be slightly high at first but will be normal as soon as the equipment has attained the operating temperature.

CAUTION:- In the event of power failure the "High Voltage" switch, should be operated immediately to the "Off" position. The plate voltage may be applied after a 15 second delay following the return of the power as indicated by the "Supply Voltage" meter.

The transmitter is shut down by operating the "Master Control" switch clockwise to the "Off" position. The transmitter may be shut down for a short interval by the "High Voltage" switch. For long shut down periods operate the "Power Supply" switch to "Off" in addition to the "Master Control" switch.

Modulation and Monitoring

The single frequency level of audio power required to completely modulate the transmitter is given in Table II. For fine quality, the program level for complete modulation should be 6 db lower than the single frequency level. Visual monitoring of the carrier may be accomplished by connecting a cathode ray oscilloscope to terminals Nos. 12 and 13. A simple anti-resonant circuit across the input of the oscilloscope may be used to increase the deflection.

Monitoring of the transmitter is accomplished by connecting transmitter terminals Nos. 9 and 10 to the monitoring equipment. The impedance of this monitoring circuit is 500 ohms and it should be so terminated.

Reduced Power Operation for the No. 310B Equipment

In order to reduce the power output from 250 watts to 100 watts the "Power Transfer" switch is operated to the "Low" position. The "4th Amp. Coupling" and "4th Amp. Input" controls are adjusted until the proper plate current and transmission line currents are obtained as given in ~~table II~~. The audio input level is reduced 5 db below the level required for 250 watt operation as indicated in Table II.

MAINTENANCE

General

Cleanliness is essential to the best operation of this equipment and the unit must be kept free from dust and dirt. Compressed air or equivalent is recommended for cleaning the apparatus inside the enclosure, but a soft clean cloth may be used with good results. Waste or oily cloth should never be used.

Care of Cabinet

The lacquered surfaces and chromium trim may be polished by rubbing them with a piece of soft cloth moistened with metal polish and finally wiping with a dry, clean soft cloth. Any visible grease, oil or wax should first be removed with carbon tetrachloride before applying the polish.

Air and Electrolytic Condensers

The variable air condensers in the shielded compartments should be cleaned at least once a month with compressed air or equivalent. This prevents the collection of dust which may result in the arcing of the condensers thereby taking the station "off the air". C32A shall not be opened as it is sealed against dust.

The electrolytic condenser (C29A), associated with the monitoring circuit, has a life of approximately one and one-half years and should be replaced about once a year. In replacing this condenser it is essential that the correct polarity be maintained.

Voltage Control Transformer (T3A)

The sliding surface of the voltage control transformer (T3A) should be cleaned at weekly intervals with a lintless cloth slightly moistened with carbon tetrachloride. In general T3A

should be given the same care as that required by the commutator and brushes of a motor.

Vacuum Tubes

In order to obtain both maximum life and satisfactory performance, it is important that vacuum tubes be operated within their voltage limits. (See Table II). As far as possible the operator should anticipate tube failures and make the required tube replacements. Tube failures may be guarded against to some extent by keeping a careful record of the length of time the tubes have been in service and by observing from time to time the condition of the tube elements.

When the glow of the mercury vapor rectifier tubes V15A and V16A changes from the normal bluish-green to a very pale blue, the tubes have reached the end of their useful life and should be replaced.

It is essential that the filaments of new mercury vapor tubes be heated at least 15 minutes before the high voltage is applied.

This is in order to remove any particles of mercury adhering to the sides or elements of the tubes which might result in flashovers. Spare rectifier tubes should be prepared for service in advance by placing them in the equipment when not in use and giving the filaments the necessary preheating with the "High Voltage" switch (D5A) in the "Off" position. This procedure should be repeated at least once a month. Spare rectifier tubes thus preheated should be kept in an upright position until they are required.

Thermocouples

Whenever damaged external heating elements associated with the radio frequency meters are sent in for repairs, the heating elements

must be accompanied by the associated meter for calibration purposes.

Additional Routine

Once a month test all nuts, bolts and screws and tighten any loose ones. Also, check all connections and if any loose contacts are found they should be made secure. Cases of trouble can often be prevented by such precaution.

LOCATION OF TROUBLE

General

If this equipment is regularly and carefully maintained very little trouble will be experienced. A new operator should endeavor to become familiar with the circuits, their functions and the location of apparatus as quickly as possible. A complete detailed schematic diagram of all radio frequency, audio frequency, power and power control circuits is given in this bulletin.

In case of trouble in any of the control or protection circuits, the operator should remember that these circuits are interlocked so that the failure of one piece of apparatus often prevents other pieces from functioning. For example, should the plate voltage relay (S1A) fail to operate, the "High Voltage" switch (D5A), door switch (D6A), and the door switch in the Antenna Coupling Unit should be investigated. Any one of these may be causing the trouble. This method of checking through circuits should be continued until the defective piece of apparatus is located.

Trouble in the radio frequency circuits is usually caused by improper adjustment. The first step in case of trouble in these circuits should be to see that all adjustments are in accordance with

those described in this bulletin, as well as with the adjustments recorded in the station log.

Surge Suppression Relay

Should relay S2A fail to operate as indicated by low (Approximately 750 volts) "Plate Voltage" on meter M4A, adjust the slider tap on R49.1A until the voltage between this tap and ground measures approximately 100 volts when the transmitter is delivering its rated output power. Under this condition relay S2A should operate a fraction of a second after "High Voltage" switch (D5A) is operated.

SPARE PARTS

The list of "Spare Parts" on Table III is recommended as a complement of spare equipment which may be purchased at the customer's option. Spare electrolytic condensers are not recommended as the self life may be no longer than the service life. These condensers should be purchased only when replacements are to be made.

Detailed information is given in Table II which will be of value in locating causes of improper operation.

ENGINEERING SERVICE AND INFORMATION FOR

ORDERING REPLACEMENTS

Engineering Service may be obtained through the nearest Branch House of the Graybar Electric Company, and authorization for such service should be placed with them. In Canada, this service may be obtained through the Northern Electric Company, Ltd., and in other foreign countries with the International Standard Electric Corporation.

Orders for replacement apparatus should specify the apparatus designation (such as, R2B) shown on the drawings and usually stamped on the apparatus as well as the name, catalog number, nameplate data and serial number of radio transmitter and other pertinent information which is available.

Instruction Bulletin No.

The Equipment Described in This Bulletin Was Designed and

Developed for the Western Electric Company

by

BELL TELEPHONE LABORATORIES

WESTERN ELECTRIC COMPANY

Table I

Western Electric No. 23A Radio Transmitter
 APPROXIMATE RADIO FREQUENCY ADJUSTMENTS
 To Accompany Temporary Instruction Bulletin

550 to 1600 KC.

f KC	*L3A Total Turns	L18.1A Total Turns	**L21A Total Turns		C11A C12A Div.	C20A C21A Div.	C30A C31A Mfd.	C35A ***C36A Mfd.
			(1)	(2)				
			550	130				
600	120	34	63	34	50	65	.0004	.0006
690	110	30	58	29	50	65	.0004	.0006
700	108	30	54	30	45	60	.0004	.0005
750	104	28	51	26	45	60	.0004	.0005
770	102	26	50	24	45	60	.0004	.0005
780	102	26	49	22	45	60	.0004	.0005
840	98	24	47	20	45	60	.0004	.0005
850	96	24	44	25	40	60	.0004	.0004
900	92	22	42	23	40	60	.0004	.0004
910	92	24	41	22	40	50	.0002	.0004
950	86	24	38	19	40	50	.0002	.0004
990	82	24	35	16	40	50	.0002	.0004
1000	80	24	33	15	40	50	.0002	.0004
1090	74	22	30	13	40	50	.0002	.0004
1100	72	22	27	19	35	40	.0002	.0003
1150	68	22	25	17	35	40	.0002	.0003
1200	64	22	23	15	35	40	.0002	.0003
1250	60	20	21	13	35	40	.0002	.0003
1300	58	18	20	10	35	40	.0002	.0003
1310	58	18	24	10	35	40	.0002	.0003
1350	54	18	23	9	30	30	.0002	.0003
1400	50	18	22	7	30	30	.0002	.0003
1450	46	18	20	6	30	30	.0002	.0003
1500	44	16	18	5	30	30	.0002	.0003
1510	44	16	17	13	30	30	.0002	.0002
1600	38	16	15	10	30	30	.0002	.0002

Note:

*L3A - Use Detail 1, ESO-609199 for 550 to 990 KC.
 Detail 2, ESO-609199 for 1000 to 1600 KC.

L8A) - End turns left open for 550 to 800 KC.

L11A) - End turns short-circuited for 810 to 1600 KC.

**L21A - Use column (1) for transmitters prior to serial #126.
 Use column (2) for all subsequent transmitters.

***C36A - Omitted in transmitters subsequent to serial #125.

In transmitters prior to serial #126 the condenser changes were made at 780, 1000, and 1310 KC instead of as shown.

TABLE II

TYPICAL METER READINGS

<u>Circuit Designations</u>	<u>Meter Scale</u>	<u>No. 310A</u>	<u>No. 310B</u>
Power Supply Voltage (M1A)		220 volts	220 volts
Osc. Plate Current (M2A)	0-5 ma.	2-4 ma.	2-4 ma.
1st R.F. Amp. Plate Current (M2A)	0-50 ma.	7-13 ma.	7-13 ma.
2nd R.F. Amp. Grid Current (M2A)	0-2 ma.	.4-1.5 ma.	.4-1.5 ma.
2nd R.F. Amp. Plate Current (M2A)	0-300 ma.	30-60 ma.	30-60 ma.
3rd Amp. Plate Current (M2A)	0-300 ma.	145-200 ma.	145-200 ma.
4th Amp. Plate Current (M3A)	-	237-243 ma.	580-620 ma. 237-243 ma. for 100 watts
Plate Voltage (M4A)	-	1250 ± 25 volts	1250 ± 25 volts
4th Amp. Output Current (M5A)	-	0.4-1.1 amp.	0.4-1.1 amp.
Transmission Line Current (M6A)	-	1.21-1.27 amp.	1.9-2.1 amp. 1.21-1.27 amp. for 100 watts
Feedback Rect. Current (M2A)	0-1 ma.	0.2-0.4 ma.	0.4-0.6 ma.
1st A.F. Amp. Plate Current (M2A)	0-5 ma.	2-4 ma.	2-4 ma.
2nd A.F. Amp. Plate Current (M2A)	0-5 ma.	35-50 ma.	35-50 ma.

*50ma?
scale*

Speech Input Levels

The following speech input power levels at terminals 7 and 8 are required for complete modulation of the carrier.

	<u>No. 310B - 100 Watts</u>	<u>No. 310A - 100 Watts</u>	<u>No. 310B - 250 Watts</u>
Single Tone Level	-6 db*		-1 db
Program Level	-12 db		-7 db

*Zero Level reference is 6 milliwatts.

Filament Voltages

The following ac filament voltages should be measured with an external ac voltmeter having a range of 0 - 7.5 - 15 volts. The filaments should be energized and connections of the meter to the terminals indicated below should be made with No. 14 B&S gauge wire in order to minimize the potential drop when low values of voltage are measured.

No. 702A Oscillator (Terms. No. 4 & 9 on Osc. Term. Strip)	2 volts ± 5%
Modulating Amplifier Unit (Terms No. 1 and 2)	12.6 " ± 5%
3rd Amplifier (Fil. Terms. on V4A & V5A)	10 " ± 5%
4th Amplifier (Fil. Terms. on V6A to V11A)	10 " ± 5%
Feedback Rect. V12A (Terms. No. 16 & 17 on A.F. Amp. Unit)	2 " ± 5%
1st A.F. Amp. V13A (Terms. No. 3 & 4 on A.F. Amp. Unit)	10 " ± 5%
2nd A.F. Amp. V14A (Terms. No. 5 & 6 on A.F. Amp. Unit)	5 " ± 5%
Plate Voltage Rect. (Fil. Terms. on V15A & V16A)	2.5 " ± 5%
Oscillator Heater Voltage (Terms. 1 & 6 on Osc. Term. Strip)	110 " ± 5%

To measure these resistors, first remove wire from second slider from left-hand end of R411 being certain not to leave the wires connected together.

Grid Bias Voltages

The following values of grid bias voltages are obtained by using an external dc voltmeter having a range of 0-150 volts, 1000 ohms per volt. Connect the negative terminal of the meter to ground and the positive terminal to the circuit as indicated. Whenever a connection of the meter is made, the plate voltage should be removed by operating the "High Voltage" switch (D5A) to the "Off" position. The bias voltages should be measured with normal output of the transmitter.

Modulating Amp. Unit (Between Ground Term. & Slider of R48A)	52 ± 2 volts
Modulating Amp. Unit (Across R48A)	70 ± 4 volts
3rd Amplifier (Center Tap of R18A)	110 ± 5 volts
4th Amplifier (Center Tap of R22A)	110 ± 5 volts

Should any of the bias voltages be incorrect when the plate currents are correct, check the values of the resistances and make the necessary adjustments. The values of the resistances are:

<u>Apparatus Designation</u>	<u>Resistance * (Ohms)</u>
* R26A (Total)	480 ± 20
* R26A (Fixed end to tap No. 1)	16 ± 2
* R26A (Fixed end to tap No. 2)	180 ± 20
* R43A	500 ± 10
R48A (Total)	1000 ± 100
R48A (Gr. to Tap)	700 ± 10

*To measure these resistors first remove both wires from second slider from left hand end of R49.1 being careful not to leave the wires connected together.