AMPLIFIER
No. 88A

Weight—Approximately 760 Pounds

INDEX

Instructions for Use

GENERAL DESCRIPTION

The Western Electric No. 88A Amplifier is a single-stage power amplifier capable of raising the modulated output of a 50-watt ultra high frequency radio telephone transmitter to 500 watts of carrier power. It may be adjusted to operate on any frequency in the range from 30 to 42 MC. Provision is made for operating it into a single open wire, a double open wire or a coaxial transmission line. The amplifier is equipped with a mercury vapor rectifier and the necessary transformers for plate and filament supplies. Approximately 4.6 KW of power is required from a 3-phase 220-volt 50 or 60-cycle supply.

The components of this amplifier are assembled in a steel cabinet having a welded structural steel frame. The meters are located on a panel at the top

of the cabinet behind a glass window. Directly below are two glass paneled doors permitting observation of the amplifier tubes and providing access to the radio frequency equipment. Centrally located on the front of the cabinet is a control panel on which are mounted three screw-driver operated controls for adjusting the grid input circuit, the neutralizing condenser and the plate circuit. Two tumbler switches are also provided for controlling the power supply circuits. Below this panel are two hinged metal doors providing access to the lower portion of the cabinet where the rectifier and power equipment are located. Safety switches are provided on all doors for the protection of the operator. A horizontally mounted fan, located between the power and radio equipment, provides ventilation by sucking air in through an opening near the bottom and forcing it up through the set and out through perforations at the top of the cabinet. The air entering the set is cleaned by a spun glass filter covering the opening at the base of the cabinet.

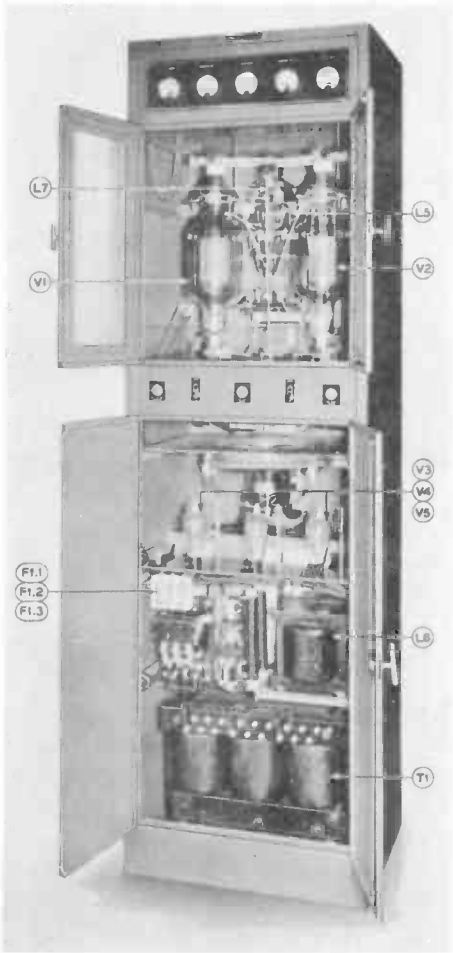

Figure 1—Front View with Doors Open

DESCRIPTION OF CIRCUITS

For purposes of discussion, the circuits of this amplifier shown on schematic diagram Figure 2 and wiring diagram Figure 3, are divided into three groups: radio-frequency, power-supply and control.

Radio-Frequency Circuits

Two Western Electric No. 251A Vacuum Tubes are used in a single neutralized stage of push-pull amplification. The RF input terminals connect to a coupling coil (L1) which is inductively coupled to a variable inductance (L2). This variable inductance with the fixed condensers C2, C12, C13, and C14, comprise the grid input tuned circuit. Grid bias voltage supplied from the 50-watt transmitter is applied to the grids of the tubes through a grid current meter (M1) and two RF choke coils (L3 and L4). A filament transformer (T3) supplies the filament power and condensers C5 and C6 by-pass each side of the filament to ground.

Neutralization is accomplished by means of the balanced variable condenser C4 connected between the grids and plates of the opposite tubes.

The plates of both tubes are connected to a center tapped inductance (L5) and a balanced variable condenser (C3). Plate voltage is fed into the center of the inductance (L5) through an RF choke coil (L7) and a plate current meter (M5).

The output circuit is conductively coupled to the antenna transmission line by means of taps on the plate circuit inductance (L5). Blocking condensers (C9 and C10) remove the DC potential from the transmission line and meters M2 and M4 provide an indication of the RF current in the two transmission lines. When a balanced two wire transmission line is used for connecting the output to the radiator, it is connected to terminals 17 and 18, and a second harmonic shunt similar to HS1 must be provided and connected to terminal 17. When the amplifier is used with a single open wire or a coaxial transmission line transmission line meter (M4), blocking condenser (C10) and the corresponding output coil tap are not used. Output terminal 18 which is located on the same side of the transmitter as the connected coil tap, should be used for a single open wire line and the transmission line running to the base in the bottom of the set should be connected and used for terminating a coaxial transmission line.

The harmonic shunt (HS1) connected between ground and output terminal 18 reduces the second harmonic to a negligible value. This suppressor consists of a section of coaxial transmission line one quarter wavelength at the operating frequency or one-half wavelength long at the second harmonic frequency and is short-circuited at the far end. When correctly adjusted as described under *"Installation"* it produces a short circuit across the output terminal of the amplifier to the second harmonic frequency and has negligible effect on the fundamental frequency.

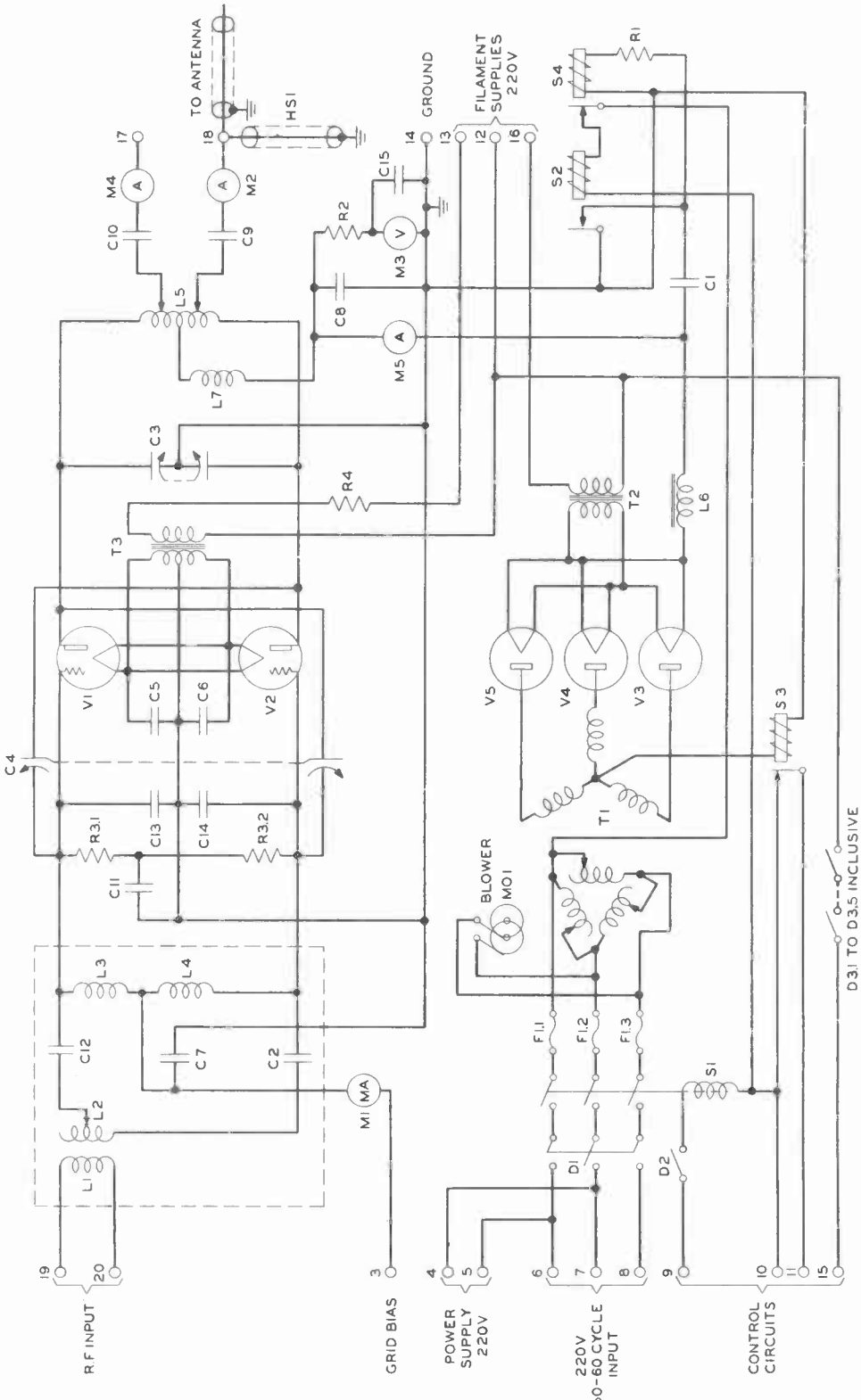

Figure 2—Schematic

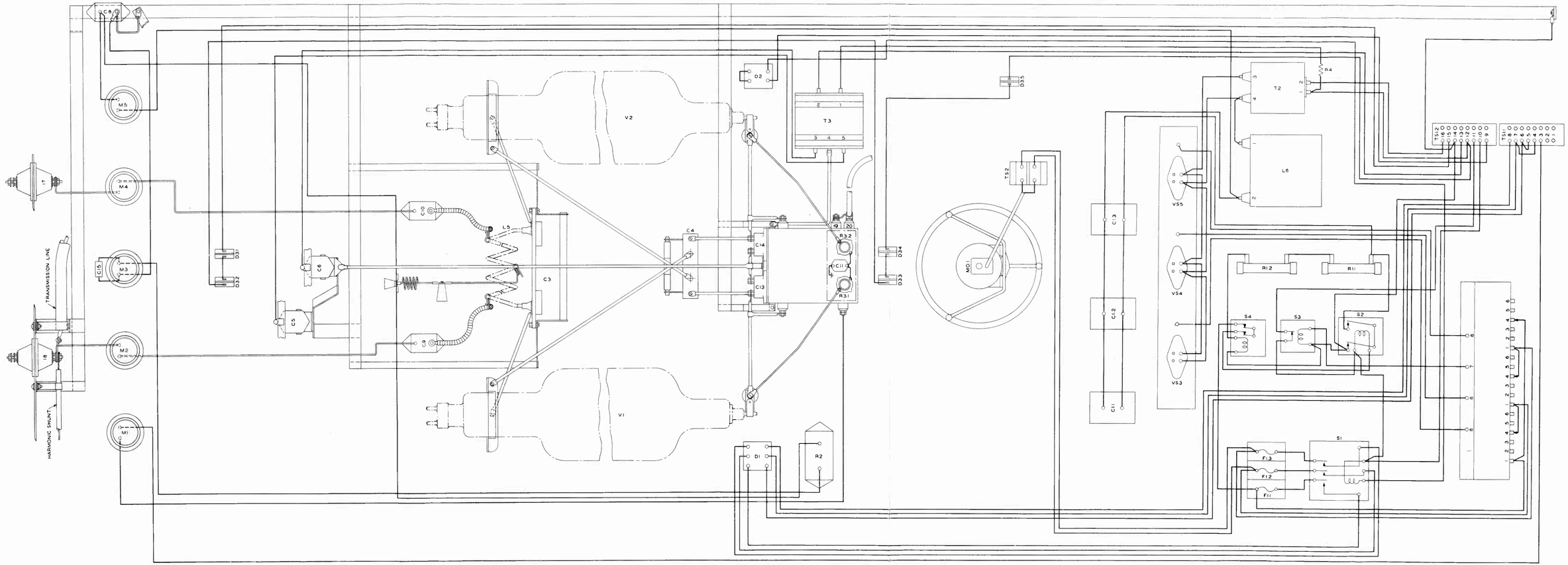

Figure 3—Wiring Diagram

Power Supply Circuits

Filament voltage for the amplifier tubes (V1 and V2) and the rectifier tubes (V3, V4 and V5) is supplied from filament transformers T3 and T2 respectively. The 220-volt primary voltage for these transformers and the 200-volt grid bias voltage are obtained from the associated transmitter, where they are adjusted to the proper value.

The plate supply consists of a 3-phase mercury vapor rectifier and a single section filter. The primary windings of the three-phase high-voltage transformer (T1) are tapped to provide adjustment of the high-voltage supply. The center tap of the secondary of this transformer (T1) is connected to ground through the coil circuit of an overload relay (S3). The high-voltage direct current is indicated by a voltmeter (M3) and the current drawn by the amplifier is indicated by an ammeter (M5).

Control Circuits

The control circuits of this amplifier operate in conjunction with some of the circuits of the associated transmitter to provide the necessary sequence of switching operations.

The power supply switch (D1) is a three-circuit main line switch for the high-voltage rectifier. It supplies power to the contacts of relay S1 which completes the primary circuit of the high voltage transformer (T1). The plate supply switch (D2) is connected in series with the coil circuit of relay S1, which is energized with power supplied from the associated transmitter when it is operating. The contacts of the overload relay (S3) are connected in series with the overload relay of the associated transmitter so that if either relay momentarily opens when the transmitter is operating, both equipments will be turned off and cannot be started again until the plate control switch of the associated radio transmitter is turned off and on.

The door switches (D3.1 to D3.5 inclusive) are connected to circuits in the associated transmitter so that when any door is opened the high-voltage supply in both units is removed.

Relays S2 and S4, and resistance R1 constitute a protective circuit for reducing the initial charging current of the filter condenser (C1). Resistor R1 is automatically connected in series with the filter condenser (C1) while it is being charged, thus protecting the rectifier tubes from a heavy surge of current when the equipment is turned on. The relays operate as follows: When the plate supply of the amplifier is turned on, the condenser charging current operates relay S4 through resistor R1. When condenser C1 is fully charged, the charging current stops, relay S4 releases and relay S2 operates and connects the negative terminal of the condenser (C1) to ground.

INSTALLATION

Dimensions of the amplifier and the location of terminal blocks are shown on Figure 4. Sufficient space should be allowed around the amplifier, partic-

ularly in the rear, to provide free entrance of the incoming air, to facilitate the installation of the power transformer (T1) and power supply wires, and to enable the operator to remove the rear panel for cleaning the air filter.

The amplifier may be placed alongside the 50-watt transmitter and the conduits placed underneath the floor. If the latter is impractical the equipment may be raised up from the floor by wood spacers to provide room for the interconnecting wires. When this is done it is necessary to close all of the space between the base of the amplifier and the floor so that air cannot be drawn into the unit at this point.

R. F. Input Circuit

The input circuit of the amplifier should be connected to the output of the transmitter by means of a length of Western Electric No. D-96800 Transmission Line. A section of this line is connected to input terminals 19 and 20 and extends to the bottom of the amplifier as shown on Figure 4. The line from the transmitter should be spliced at this point.

R. F. Output Tuned Circuit Inductance

There are four sizes of output tuned circuit inductances (L5) to cover the complete frequency range from 30 to 42 megacycles. The correct one should be specified when ordering (see apparatus list). When installing the coil the lugs should be bolted to the terminals of the variable condenser (C3) and a short length of No. 14 wire should be connected between the center tap of the coil and the terminal on the stand-off insulator which supports the front end of the RF choke coil (L7) located directly above the tuning inductance.

Transmission Line Current Meters

Since the output circuit is arranged so that either a high impedance (single or double open wire) transmission line or a low impedance coaxial transmission line can be used, two ranges of transmission line current meters are available. 0-3 ampere meters for transmission lines of approximately 500 ohms or 0-5 ampere meters for transmission lines of approximately 70 ohms impedance should be specified when ordering. To install these meters it is necessary to remove the meter panel heat shield inside the amplifier and the front glass meter protecting panel. The heat shield is held in place by six screws around its periphery and the glass panel by three flat head screws located in the upper jamb of the glass paneled observation doors. These panels should be replaced after the meters are installed.

Second Harmonic Shunt

The amplifier as supplied contains one coaxial transmission line type of second harmonic shunt mounted on the left side wall of the cabinet and connected to output terminal 18. This shunt when cut to the proper length as described below is all that is required when a single conductor (coaxial or open type) transmission line is used. When a two wire transmission line is used an

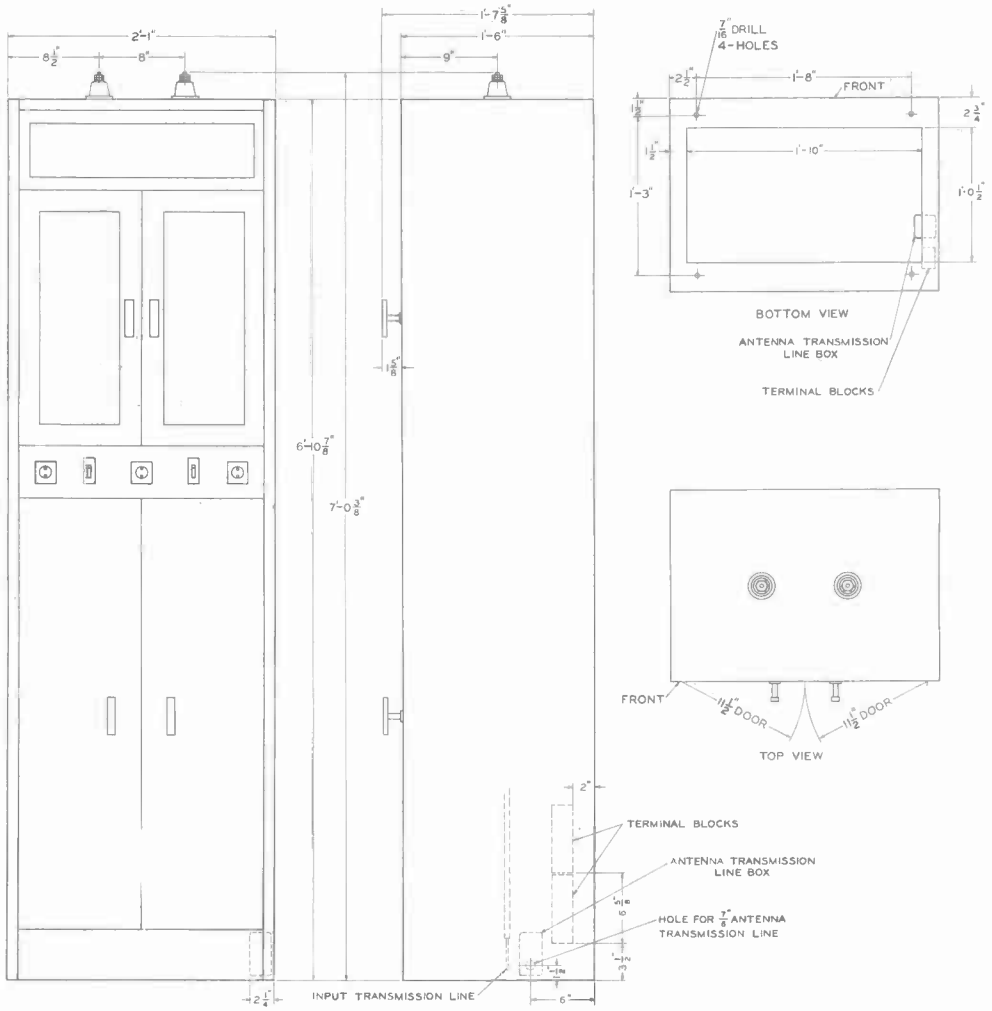

Figure 4—Dimensional Diagram

additional second harmonic suppressor should be specified when ordering (see Apparatus List). This shunt should be adjusted as described below, clamped in the other side of the amplifier, and connected to terminal 17.

The suppressor should be adjusted to the operating frequency by cutting it to the correct length. As supplied it is 86 inches long and the outer conductor is notched every two inches. Remove the suppressor from the amplifier and cut off the inner end of the spiral so that the remainder has a length as specified on Figure 5. To do this cut through both conductors with a hack saw so that the shunt is ¼ inch longer than the required length and then cut through the outer conductor alone at the prescribed point. This procedure will enable the inner conductor to extend beyond the outer conductor. Thread the knurled plug over the center conductor and force it into the end of the tubing. Solder the center conductor to the plug and replace the suppressor in the amplifier.

Transmission Line Connections

When a single conductor transmission line of the open wire or coaxial type is used, only one coil clip in addition to the center tap on the tuning inductance (L5) is required and the unused clip and lead should be removed from the amplifier.

When a coaxial transmission line is used it should be run from the antenna underneath the floor and be terminated at the junctior. box in the bottom of the amplifier where the conductors should be securely spliced and soldered.

When an open wire, single or double conductor transmission line is used, the section of ⅞-inch coaxial transmission line in the amplifier should be disconnected from terminal 18. A single open wire transmission line should be connected to terminal 18 and a two wire line to terminals 17 and 18 on top of the amplifier.

Antenna

The length and type of the antenna to be used depends upon the radio frequency employed, the service for which the equipment is to be used, and the location of the transmitting site. For these reasons no specific constructional details of the antenna are included in this bulletin.

Ground

A copper strip located alongside of the terminal blocks is provided for grounding the amplifier frame. This strip should be connected by means of a similar strip to ground. For best results it should be connected to as good an external ground as possible.

Transformers

The power transformer (T1) and retardation coil (L6) should be installed after all wiring is completed. These units are shipped separately and should be mounted as shown on Figure 1. The leads in the amplifier which connect to these units are tagged and should be connected to the correspondingly

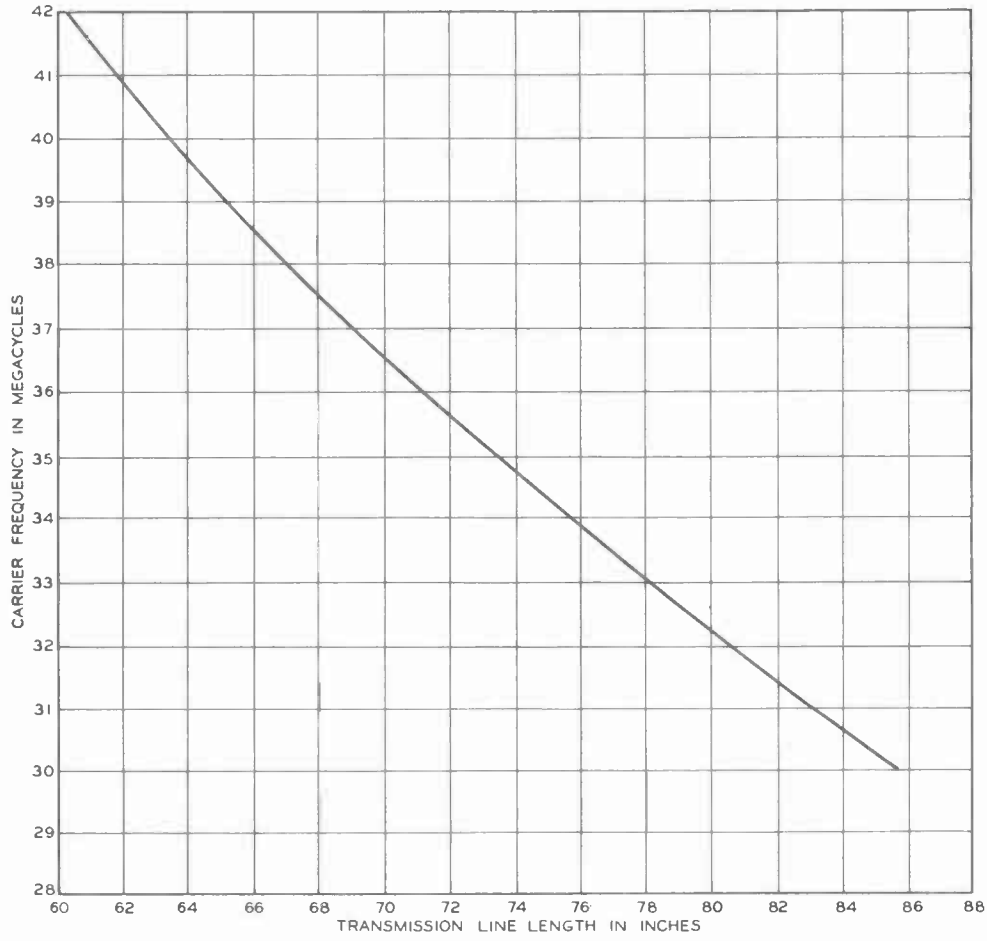

Figure 5—Calibration of Second Harmonic Shunt

numbered terminals on the transformer. Connect the three adjustable leads of transformer T1 to terminal 6 of each primary winding. These are shown on Figure 1 connected to terminal 2 of each primary winding.

Inspection

Before power is applied to the amplifier a careful check should be made of the connections described above and of the interconnections described in the instruction bulletin for the system. The amplifier should also be thoroughly inspected and any loose connections that may have developed during shipment should be tightened.

TUNING PROCEDURE

CAUTION: Remove plate voltage by opening the power supply switches in both the 50 watt radio transmitter and No. 88A Amplifier before adjusting or touching anything within the amplifier.

In tuning the amplifier for the first time it should be adjusted to operate into an artificial antenna in order to check the output power, and obtain approximate settings for the controls. The antenna transmission line should then be connected in place of the artificial antenna and the amplifier controls readjusted.

An artificial antenna suitable for this purpose can be made by connecting four 120 watt 110 volt lamps, preferably carbon filament lamps, in two parallel strings of two lamps each. Sockets should not be used. The connections between the tubes should be as short as possible and made by soldering heavy wire directly to the lamp bases. If a two wire transmission line is used connect the lamps between terminals 17 and 18 on top of the amplifier using short leads. If a single conductor transmission line is used connect the lamps between terminal 18 and the screw on the top cover which holds the clamp for the coaxial transmission line. Disconnect the antenna transmission lines and harmonic shunts from the output terminals.

Figure 1 in conjunction with the apparatus list shows the correct position for all tubes and fuses. With this equipment in place, the tuning procedure is as follows:

Operation of Amplifier into an Artificial Antenna

1. Connect the transmission line clip or clips on output inductance L5 midway between the center tap and the coil ends. Use the left clip (looking from the front) if a single wire transmission line is used or both clips if a two wire transmission line is used.

2. Close all doors, apply power to the 50 watt transmitter and adjust the output for 50 watts as described in the instruction bulletin for that unit.

3. Adjust the *"Amp. Grid Tuning"* control and the *"Neutralizing Capacitor"* for maximum power amplifier grid current or for maximum brilliancy of the green lamps which are located underneath the power amplifier tubes.

4. Turn on the *"Plate Supply"* switch (D2), the *"Power Supply"* switch (D1), and turn the *"Amp. Plate Tuning"* control thru its range. Notice where maximum power output is obtained and compress or spread the turns of the output inductance (L5) so that this point occurs when the plates of the tuning condenser (C3) are between one-quarter and one-half meshed. If the circuit tends to tune when the plates of the condenser are completely meshed compress the turns of the inductance. If the condenser plates are out, spread the turns.

5. Connect the three adjustable leads to the taps (terminal 2-6) on the primary windings of transformer T1, using the same numbered tap of each winding, so that the plate voltage is as close as possible to 2500 volts.

6. Adjust the *"Amp. Plate Tuning"* control and the position of the clip on inductance L5 so that the following operating conditions are fulfilled: (a) The artificial antenna lamps should light to full brilliancy when compared to a similar lamp lighted from a 120 volt supply. (b) The plate current should be approximately 0.9 amperes for 30 mc operation, 1.0 ampere for 42 mc or a proportional value of current for intermediate frequencies. (c) The output transmission line current of the amplifier should increase between 18 and 22 per cent when the associated transmitter is modulated with a tone sufficiently to increase the transmission line current of that unit 22 per cent. (d) The amplifier should provide no power output when the crystal of the 50 watt transmitter is removed and both equipments are turned on.

   The procedure for obtaining these results takes the following form:

   Adjust the *"Amp. Plate Tuning"* control until the lamps are lighted to full brilliancy and notice the plate current. If this current is below the value prescribed in *"b"* (above), move the clip or clips on inductance L5 toward the ends of the coil (or vice versa). During these adjustments keep the 50 watt transmitter adjusted for 50 watts output, and the *"Amp. Grid Tuning"* control for maximum brilliancy of the green lamps (R3.1 and R3.2). If the correct power output and plate current cannot be obtained readjust the neutralizing capacitor a small amount at a time until the requirements are fulfilled. Modulate the transmitter with a single tone as described in *"c"*. If an audio oscillator is not available for this test, modulate the transmitter with voice making sure that the transmission line current of the transmitter and amplifier increase in approximately the same proportion. Finally check requirement *"d"* to see that the set is properly neutralized and that the crystal has control of the carrier frequency.

Operation of Amplifier into Antenna Transmission Line

Disconnect the artificial antenna and connect the antenna transmission line. Follow the procedure as described in adjustment 6 except that instead of requirement "*a*" the various controls should be adjusted so that a maximum of antenna transmission line current is obtained which will also fulfill the other operating conditions.

When a two-wire transmission line is used the two clips on the output inductance should be adjusted so that the same transmission line current is obtained in each line.

The transmission line current meters serve only as an indication that the equipment is functioning properly. The value of current cannot be used to determine power into the antenna transmission line because the meters are not accurate at ultra-high frequencies and the current at the meter is of a different value from that in the transmission line due to a standing wave which exists on the connecting wire.

The power amplifier grid current meter is used only in the tuning procedure for initially adjusting the grid input circuit. Under normal operating conditions the grid current varies with different amplifier tubes and with their age.

MAINTENANCE

Inspection

The air filter practically eliminates the difficulty of cleaning the equipment inside the amplifier. However, if it is not operated for long periods of time some dust may settle in the equipment, and should be removed with high pressure dry air. The air filter should be cleaned regularly with a warm solution of soap and water. To remove the filter it is necessary to remove the rear panel which is held in place by two knurled screws.

As far as possible anticipate tube failures and make the required tube replacements. Tube failures may be guarded against to some extent by keeping a record of the length of time the tubes have been in use and of the various meter readings.

Occasionally check and tighten all connections, nuts, screws and bolts. Cases of trouble can often be prevented by such tests.

The fan motor should be oiled once a month with *not more than two to four drops* of high quality machine oil such as Western Electric KS-2245 oil, Gulf Security Oil A, Sinclair Commodore Oil, Texaco Regal Oil B; or an equivalent. Too much oil may cause failure of the starting mechanism with subsequent burn-out of the motor.

Relays

The relays in this amplifier have been carefully adjusted before the equipment was shipped. They are of rugged construction and should need little attention other than the occasional inspection and cleaning of the contacts with C. P. carbon tetrachloride.

Should one of the relay springs become accidentally bent the defect may be remedied by the careful use of a pair of long nose pliers. Visual inspection, coupled with a thorough knowledge of the functions of the relays, should be sufficient to enable a skilled maintenance man to readjust them after minor damages.

Relay S1 is a heavy duty plate supply contactor. It has no adjustments and should require no servicing.

Relay S2 completes the circuit of the filter condenser C1. This relay is adjusted by bending the contact arms so that the contacts make at the same instant and also make before the armature has traveled its full distance. This distance traveled by the armature after the contacts have just made measured between the end of the armature and the pole face should be between $\frac{1}{32}$ inch and $\frac{1}{16}$ inch.

Relay S3 is an overload relay. Its purpose is to turn off the equipment when the plate current exceeds a safe value. The two contact arms should be bent so that the contacts break at the same instant. The knurled screw at the bottom of the relay should be adjusted so that the relay will just not operate under normal operating conditions when the set is started. This adjustment

can be checked by turning the screw clockwise until the amplifier cannot be turned on, and then turned counter-clockwise two turns. When making this test it is important that the amplifier be properly tuned as described under *"Tuning Procedure"*.

Relay S4 is part of the protection circuit. Its function is to operate relay S2 when condenser C1 is fully charged. There are no adjustments on this relay and the only service it should ever require is the occasional cleaning of the contacts with CP carbon tetrachloride.

LOCATION OF TROUBLE

CAUTION: Be sure that high voltage is off before measuring any voltages or touching anything within the amplifier.

Every effort has been made in the design of this equipment to simplify the circuits so that possibilities of trouble are reduced to a minimum. The most important factor in the successful location of trouble is a thorough understanding of the functions of the various pieces of apparatus in the amplifier and in the associated transmitter. When difficulties arise which cannot be solved by the suggestions mentioned in this chapter the circuits should be tested with an ohmmeter and references should be made to the schematic and wiring diagrams in this bulletin and those in the bulletin for the associated radio transmitter.

Failure to Start

If the 50-watt radio transmitter does not operate when the necessary switches of that unit are turned on, check the doors of both equipments to see that they are securely closed. If the 50-watt transmitter operates normally but the amplifier does not operate when the control switches (D1 and D2) are closed, test the fuses (F1.1, F1.2 and F1.3) for continuity and notice if the power supply relay (S1) operates when both equipments are turned on. If this relay does not operate the difficulty probably is in the control circuits of the 50-watt radio transmitter or amplifier. If this relay operates, measure the voltage of each phase of the 220-volt supply and check the circuits to the various pieces of apparatus associated to this circuit until the defective part is found.

If the amplifier turns on but both units immediately turn off due to excessive plate current operating the overload relay (S3), check the adjustment of the grid tuning, neutralizing and amplifier-plate tuning controls as described under *"Tuning Procedure"*. Check to see that relays S2 and S4 in the protection circuit operate as described under *"Description of Circuits"*.

Low Plate Voltage

If the plate voltage is low, notice the color of the rectifier tubes (V3, V4 and V5) by observing them through the glass window in the rear panel. If one tube does not glow or has a whitish color, replace it with a new one. Remove

and check the fuses (F1.1, F1.2 and F1.3) with an ohmmeter. If the trouble persists, turn off the plate supply and measure the filament voltage of the rectifier tubes. This voltage should be between the limits 2.4 and 2.6 volts a-c.

Low RF Power Output

If the output power is low and the 50-watt transmitter is operating normally as indicated by the meter readings, check the tuning of the amplifier and replace each of the amplifier tubes (V1 and V2) with a new one. Measure the filament voltage and the grid bias voltage applied to these tubes. The filament voltage should be between the limits 10 to 10.6 volts a-c. and the grid bias voltage measured between each grid terminal (bottom terminal of tube) and ground should be −200 volts d-c. If the difficulty continues, check the operation of the transmitter into an artificial antenna as described under *"Tuning Procedure"*.

Failure to Modulate Properly

If the 50-watt transmitter modulates up as shown by an increase in the transmission line current of that unit but the antenna transmission line current does not increase in the same proportion, check the adjustment of the radio-frequency circuits, replace the amplifier tubes with new ones, measure the filament and grid bias voltage of the output tubes (V1 and V2) (described in the previous paragraph), and inspect relay S2 of the protection circuit to make sure that it operates as described under *"Description of Circuits"*.

Poor quality with normal meter readings of the amplifier and equal percentage increases of the transmitter transmission line current and amplifier antenna transmission line current, probably indicates a difficulty in the 50-watt transmitter (see instruction bulletin for that unit).

APPARATUS LIST

Circuit Symbol	*Circuit Use*	*Ordering Information*
C1	Plate Voltage Filter Condensers	3 Western Electric No. 279A Condensers 2 mf. each, 3000 volts.
C2	Grid Coupling Condenser	Western Electric No. D-96889 Condenser 50 mmf.
C3	Plate Tuning Condenser	Cardwell No. S-3862 Variable Air Condenser.
C4	Neutralizing Condenser	Cardwell No. S-3853 Variable Air Condenser
C5	Filament By-Pass Condenser	Dubilier Type 9 No. 12050 Condenser, 0.005 mf.
C6	Filament By-Pass Condenser	Dubilier Type 9 No. 12050 Condenser, 0.005 mf.
C7	Grid By-Pass Condenser	Dubilier Type 9 No. 12010 Condenser, 0.001 mf.
C8	Plate By-Pass Condenser	Dubilier No. PL-246-6 Condenser, 0.001 mf.
C9	Transmission Line Blocking Condenser	Dubilier No. PL-246-6 Condenser, 0.001 mf.
C10	Transmission Line Blocking Condenser	Dubilier No. PL-246-6 Condenser, 0.001 mf.
C11	Load Resistor By-Pass Condenser	Dubilier Type 9 No. 12010 Condenser 0.001 mf.
C12	Grid Coupling Condenser	Western Electric No. D-96889 Condenser, 50 mmf.
C13	Grid Coupling Condenser	Western Electric No. D-96889 Condenser, 50 mmf.
C14	Grid Coupling Condenser	Western Electric No. D-96889 Condenser, 50 mmf.
C15	Voltmeter By-Pass Condenser	Dubilier No. 3W-12060 Condenser, 0.006 mf.
D1	3 Phase Power Supply Switch	H & H Switch, Cat. No. 80104
D2	Plate Supply Switch	H & H Switch, Cat. No. 3989
D3.1 D3.2 D3.3 D3.4 D3.5	Door Switches	H & H Door Switches No. 3592
F1.1 F1.2 F1.3	Power Supply Fuses	*25 Amp. 250 Volt Cartridge Fuses

*Not furnished as part of Amplifier, must be ordered separately.

APPARATUS LIST (Cont'd.)

Circuit Symbol	*Circuit Use*	*Ordering Information*
L1	Grid Coupling Coil	Coil Assembly per Detail 9A, ESO-605470, Issue 4
L2	Grid Tuning Inductance	Same as L1
L3	Grid RF Choke Coil	Coil Assembly per Detail 23A, ESO-604301, Issue 6
L4	Grid RF Choke Coil	Same as L3
L5	Plate Tuning Inductance**	30—31.5 MC 6 turns, coil per drawing ESO-606573, det. 4-A 31.5—35 MC 5 turns, coil per drawing ESO-606573, det. 3-A 35—38.8 MC 4 turns, coil per drawing ESO-606573, det. 2-A 38.8—42 MC 3 turns, coil per drawing ESO-606573, det. 1-A
L6	Plate Voltage Filter Coil	Western Electric No. D-96783 Retardation Coil
L7	Plate RF Choke Coil	Coil per detail 9A, ESO-606573, Issue 3
M1	Grid Current Meter	Weston Model 301 D.C. Milliammeter, Zero Center—flush type bakelite case—100-0-100 ma. for 60 degrees C. ambient temperature
M2	Transmission Line Current Ammeter	*Weston Model 425 RF Ammeter, flush type, bakelite case, 0-3 amps. or 0-5A* for operation at 60 degrees C. ambient temperature
M3	Plate Voltage Voltmeter	Weston Model 301 DC Voltmeter, flush type, bakelite case, 0-3000 volts, for operation at 60 degrees C. ambient temperature
M4	Transmission Line Current Ammeter	*Weston Model 425 RF Ammeter, flush type, bakelite case, 0-3 amps. or 0-5A for operation at 60 degrees C. ambient temperature
M5	Plate Current Ammeter	Weston Model 301 DC Ammeter, flush type, bakelite case, 0-2 amps. for 60 degrees C. ambient temperature
R1	Condenser Charging Current Limiting Resistors	2—Ward-Leonard Type D 8½ inch Resistors, each 10,000 ohms ±10 per cent with No. 754 Mounting, connected in series

*When ordering specify type of transmission line used
0-3 amp. meter for open wire transmission lines
0-5 amp. meter for coaxial transmission lines
**When ordering specify frequency at which amplifier is to operate.

APPARATUS LIST (Cont'd.)

Circuit Symbol	*Circuit Use*	*Ordering Information*
R2	Voltmeter Multiplier	Type 4, No. 1 Multiplier supplied with Meter M3
R3.1, R3.2	Grid Circuit Load Resistors	**25 Watt 250 Volt Mazda Lamps, Green Glass
R4	Power Amplifier Filament Resistor	Ward-Leonard 2 inch Type O Resistor, 2.75 ohms
S1	Plate Voltage Supply Relay	Ward-Leonard Magnetic Switch, Cat. No. 10-A3 per K-40509
S2	Rectifier Protection Relay	Ward-Leonard Type B, 1 Pole normally open relay. Cat. No. 81104 with insulating bar
S3	Overload Relay	Signal Engineering Co. Relay No. B2-Z1
S4	Rectifier Protection Relay	Ward-Leonard Midget Type Relay. Cat. No. 106-521
T1	3 Phase Plate Supply Transformer	Western Electric No. D-96781 Transformer
T2	Rectifier Filament Transformer	Western Electric No. D-96782 Transformer
T3	Amplifier Filament Transformer	Western Electric No. D-96172 Transformer
V1, V2	Amplifier Tubes	**Western Electric No. 251A Vacuum Tubes
V3, V4, V5	Rectifier Tubes	**Western Electric No. 249B Vacuum Tubes
MO1	Air Blower	"Propellair" exhaust fan, multi-propeller, horizontal Mounting, Cat. No. 701, 200 V. AC, 60 cycles
HS1	2nd Harmonic Shunt	*Shunt per detail 1A, drawing ESO-607076
	Air Filter	Filter per detail 2A, ESO-604704, Issue 2

*For 2 wire transmission lines an additional 2nd harmonic suppressor should be ordered.
**Not furnished as part of Amplifier, must be ordered separately.

The apparatus described in this Bulletin
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by
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