Volume III.

WESTERN ELECTRIC D-156000 RADIO TRANSMITTER

DESCRIPTION, OPERATION, AND MAINTENANCE BULLETIN

D-156000 RADIO TRANSMITTER

1. GENERAL

1.01 The D-156000 Radio Transmitter is designed for either twin-channel single sideband or single-channel double sideband transmission. Equipment arrangements for the double sideband chann 1 are optional. The type of transmission may be selected at the transmitter or by remote control from a distant control terminal. The transmitter is capable of delivering a peak envelope power of 2 kilowatts to suitable open-wire or concentric transmission line on any frequency within the range of 4,500 to 22,000 kilocycles per second. This is equivalent to 500 watts carrier power for double sideband operation. A modification can be made in the transmitter to permit operation in the frequency range from 4,000 to 20,000 kilocycles if this range is more desirable. Refer to page 117. The equipment may be quickly tuned to any one of six pre-selected frequencies by front-of-panel adjustments. When used for single sideband transmission, the transmitted carrier wave may be adjusted to any desired level between the maximum output power and approximately 30 db below the sideband. The speech volume required at the input terminals of each channel is + 5 VU. The 1,000 cycle test tone power required is 1 milliwatt.

1.02 The D-156000 Radio Transmitter is housed in two welded steel cabinets which are bolted together. The assembly is 88" high, 60-3/4" wide and 30" deep, these dimensions being overall measurements. The transmitter weighs approximately 2,400 pounds. Power for its operation may be obtained from a 3-phase, 220 to 235-volt, alternating current source the frequency of which shall be 60 cycles or 50 cycles as specified on page 1 of the Inspection Test Data. The power required is approximately 5 kilowatts.

1.03 The operation, maintenance and description of this transmitter are described in the following sections:

D-156000 RADIO TRANSMITTER

1. PLACING TRANSMITTER IN SERVICE

(A) Single-Sideband

1.01 Procedure

(1) Open each input channel by placing the keys in the telegraph position and adjust the transmission selector key for single-sideband transmission.

(2) See that the 3,000-volt rectifier control switch is off.

(3) Close the 230-volt service switch.

(4) Compare adjustments with settings prescribed on tuning chart for the desired frequency.

(5) Adjust output of harmonic generator.

(6) Adjust output of monitor harmonic generator.

(7) Adjust monitor input selector.

(8) Turn on the 3,000-volt supply.

(9) Adjust the carrier level for tuning.

(10) Tune amplifiers 3, 4, and 5.

(11) Reduce the carrier level to a minimum.

(12) Apply test tone to one channel.

(13) Adjust harmonic generator output for normal test tone output of amplifier 5.

(14) Remove the test tone.

(15) Adjust the carrier level for output of amplifier 5 which is one-tenth* that obtained with test tone.

(16) Check the operating voltages.

(17) Operate the channel keys as required.

(18) Re-tune and check after 10 minutes operation.

(B) Double-Sideband Transmission

1.02 Procedure

(1) Complete procedure given in subdivision 1.01 through step (14), omitting steps (6), (7).

(2) Adjust the transmission selector key for double-sideband transmission and start the wobbler.

* One-third when used for single channel operation.

Note: If the wobbler is not required, stop the wobbler condenser at its mid-position.

(3) Check tne output of amplifier 5.

(4) Normal both channel keys.

(5) Adjust the transmission selector key for local or remote control, as desired.

2. REMOVING TRANSMITTER FROM SERVICE

2.01 Procedure

(1) Open the 230-volt service switch.

3. CHANGING CARRIER FREQUENCY

3.01 Procedure

(1) Turn off the 3,000-volt supply.

(2) Adjust controls according to the tuning chart.

(3) Place the transmitter service.

D-156000 RADIO TRANSMITTER

1. GENERAL

1.01 The D-156000 Radio Transmitter may be used for either twin-channel single-sideband or single channel double-sideband transmission on any frequency in the range of 4,500 to 22,000 kilocycles. The following subdivisions enable an operator to (a) start the equipment, (b) remove it from service, (c) change the frequency of transmission, and (d) adjust the equipment for operation on either the single-sideband or the double-sideband condition. Equipment controls are parenthetically designated for reference to the schematic diagram, ESXX-782860, page 106.

2. PLACING THE TRANSMITTER IN SERVICE

(A) Single-Sideband Transmission

2.01 Procedure

(1) Adjust both the channel keys (S2, S3) to the TELEGRAPH position. See that the transmission selector key is in the SSB position.

(2) See that the 3,000 VOLT CONTROL switch (S1) is OFF.

(3) Insert key No. 1 from the key transfer interlock into interlock 1-1 on the 230-volt service switch (S2) and close the switch.

(4) Following information similar to that given in subdivision 2.03 of this section, adjust the transmitter controls to the settings specified for the desired carrier frequency.

(5) Adjust the OUTPUT HARMONIC GENERATOR control (R13) for the I_p MODULATOR NO. 3 milliammeter (M3) reading specified on the tuning chart.

(6) Adjust the OUTPUT MONITOR H.G. control (R2) for a reading of 1.0 milliampere on the I_p 1ST DETECTOR MONITOR milliammeter (M1).

(7) Adjust the INPUT SELECTOR MONITOR switch (S3) to the desired position.

(8) Operate the 3,000 VOLT CONTROL switch to ON.

(9) Adjust the CARRIER LEVEL control (R21) for an indication on the e_p AMPLIFIER NO. 1 milliammeter (M2) of approximately 15 microamperes.

(10) Tune amplifiers 3, 4 and 5, in the order named, by adjusting the INDUCTANCE AMPLIFIER NO. 3 (L1, L2), INDUCTANCE AMPLIFIER NO. 4 (L1, L2) and INDUCTANCE AMPLIFIER NO. 5 (L3, L4) for a maximum reading of the OUTPUT INDICATOR AMPLIFIER NO. 5 milliammeter (M9). Balance amplifier 5 by adjusting its differential inductance control for equal readings on the I_s AMPLIFIER NO. 5 ammeters (M7, M8).

(11) Turn the CARRIER LEVEL control to the extreme counter-clockwise position.

(12) Place channel B key in the normal position and CHANNEL A key in TEST TONE position.

(13) Adjust the OUTPUT HARMONIC GENERATOR control for the normal test tone output (see tuning chart) of amplifier 5 as indicated by the OUTPUT INDICATOR AMPLIFIER NO. 5 milliammeter.

(14) Operate both of the CHANNEL keys to the TELEGRAPH position.

(15) Adjust the CARRIER LEVEL control for a reading of the OUTPUT INDICATOR AMPLIFIER NO. 5 milliammeter which is one-tenth* of the reading obtained by step (13).

(16) Operate the VOLTMETER SWITCH (S1) and read the LOW VOLTAGE SUPPLIES voltmeter (M11) to determine the supply potentials in the low voltage system. Observe the 3,000 VOLT SUPPLY voltmeter (M10). Compare these readings with the table given in subdivision 2.55, Part 4, of this volume.

(17) Operate either or both CHANNEL keys, as required, to NORMAL.

(18) After the transmitter has been in operation about 10 minutes repeat step (10) and check step (13) and step (6) in the order given.

<u>(B) Double-Sideband Transmission</u>

2.02 <u>Procedure</u>

(1) Complete the procedure given in subdivision 2.01 above through step (14) omitting steps (6) and (7).

(2) Operate the transmission selector key to the DSB position and operate the WOBBLER key to the ON position. Note that the OUTPUT INDICATOR AMPLIFIER NO. 5 milliammeter reading is within 5% of the value observed in step (13) of subdivision 2.01.

* One-third when used for single channel operation.

(3) If double sideband operation <u>without</u> the wobbler is desired, depress the WOBBLER STOP button, and while depressed operate the WOBBLER key to OFF.

(4) Operate both of the CHANNEL keys to NORMAL.

(5) If remote control of transmission is desired, operate the transmission selector key to REMOTE.

Note: The illuminated indicator plate will indicate the transmitting conditions.

2.03 Typical Tuning Chart

Frequency: 18.34 mc

Operation: Into open-wire transmission line

CRYSTAL SELECTOR	Position 1
TUNED CIRCUIT SELECTOR MONITOR	Position 1
TUNED CIRCUIT SELECTOR	Position 1
TUNED CIRCUIT SELECTOR AMPLIFIER NO. 2	Position 1
INPUT SELECTOR MONITOR	Position 1
INPUT ATTENUATOR MONITOR	70
OUTPUT LOADING AMPLIFIER 3	Position 2
OUTPUT LOADING AMPLIFIER 4	Position 1
INDUCTANCE AMPLIFIER 3	4.6
INDUCTANCE AMPLIFIER 4	5.0
INDUCTANCE AMPLIFIER 5	2.7
NEUTRALIZE AMPLIFIER 5	20
FREQUENCY RANGE AMPLIFIER NO. 5	High
OUTPUT TRANSFORMER INDUCTANCE	15.7
OUTPUT TRANSFORMER CAPACITANCE	25
OUTPUT TRANSFER	Antenna
I_p MODULATOR NO. 3	1.10 ma
e_p AMPLIFIER NO. 1 (Test Tone Input, Minimum Carrier)	30 μa
OUTPUT INDICATOR (Test Tone Input, Minimum Carrier)	0.7 ma

3. ATTENTION DURING OPERATION

3.01 The transmitter ordinarily needs no attention after the 10 minute warm-up period. If the equipment appears to be in trouble, refer to the maintenance methods given in Part 4 of this volume.

4. REMOVING TRANSMITTER FROM SERVICE

4.01 Procedure

(1) Open the 230-volt service switch.

5. CHANGING CARRIER FREQUENCY

5.01 Procedure

(1) If the transmitter is in service, operate the 3,000 VOLT CONTROL switch to OFF.

(2) Set the tuning controls as directed by the tuning chart.

(3) Place the transmitter in service as directed in subdivisions 2.01 or 2.02.

D-156000 RADIO TRANSMITTER

1. GENERAL

1.01 This Section outlines routine maintenance tests and adjustments for the D-156000 Radio Transmitter together with suggested maximum testing intervals.

1.02 The schedule of tests is given in the following table which includes references to the subdivision in the Maintenance Methods Part in which each test is described.

Test	For Method of Making Test See Part 4 Subdivision	Test Interval
Single Sideband		
Volume of Test Tone	2 (A)	As Required
Multivibrator Adjustment	2 (B)	As Required
Carrier Balance in First Modulators	2 (C)	As Requir d
Gain of Low Frequency Equipment	2 (D)	As Required
Neutralization of Amplifier 5	2 (E)	As Required
Audio Frequency Response	2 (F)	Annually
Signal-to-Distortion Measurement	2 (G)	Weekly on each Frequency Used
Signal-to-Noise Measurement	2 (H)	Monthly
Carrier Frequency Adjustment	2 (I)	As Required
Double Sideband		
Electric Oscillator Frequency and Frequency Wobbler	2 (J)	As Required
Modulated Amplifer Excitation	2 (K)	As Required
Double Sideband Panel Carrier Output	2 (L)	As Required
Modulation Level	2 (M)	As Required
Audio Frequency Response	2 (N)	Annually
Signal-to-Distortion Measurement	2 (O)	Weekly
Signal-to-Noise Measurement	2 (P)	Weekly
Supplementary		
Vacuum Tube Tests	2 (Q)	Monthly
Supply Voltages	2 (R)	As Required
Fan Lubrication	2 (S)	Quarterly
Renewal of Dust Filters	2 (T)	As Required
Lubrication of Roller Coils	2 (U)	Quarterly

D-156000 RADIO TRANSMITTER

CONTENTS

1. GENERAL

1.01 This section describes the method to be employed in making certain tests and adjustments which will insure that the transmitter functions properly. A brief discussion of some possible sources of trouble is included as a guide in the event of failure of the equipment.

1.02 The transmitter is provided with meters, test jacks, voltage and tuning adjustments, two monitoring arrangements and a means of energizing the low power equipment with the doors open, all of which facilitate testing and maintenance of the equipment. Screwdriver tuning controls are provided at several points; but these are principally for use during initial adjustments at the time of installation.

1.03 IT IS TO BE ESPECIALLY NOTED THAT ALL TUNING ADJUSTMENS ON THE TRANSFORMERS ASSOCIATED WITH THE CRYSTAL FILTERS, namely, the output transformers of the first modulators, the output transformer of the carrier re-supply amplifier and the input transformer of the second modulator, ARE NOT TO BE ALTERED. The overall frequency response of the transmitter is dependent on the adjustment of these transformers.

1.04 The monitor panel permits single-sideband testing of the transmitter by providing an audio frequency output which is representative of transmitter performance for single-sideband transmission. Provision is made for using this monitor either on the output of the D-156000 transmitter or on the several stages of power amplifiers which may follow this transmitter.

1.05 The OUTPUT INDICATOR permits double-sideband testing of the transmitter by providing an audio frequency output which is representative of transmitter performance for double-sideband transmission and for single-sideband signal-to-noise measurement.

1.06 The tests on the low frequency equipment which are to be described may be made, with one exception only, from the rear of the unit and with power applied. To enable these tests to be made without disabling the protective interlocking system, there is provided a special lead equipped with polarized connectors for supplying 115 volts to the low power circuits. This lead should always be used when making these tests. It supplies power to rectifiers 1, 2, 5, the monitor panel, and the modulator and amplifier units to and including amplifier 2.

2. DESCRIPTION OF TESTS AND ADJUSTMENTS

2.01 No adjustments are necessary in routine operation with the exception of the carrier level control. There are, however, certain tests that should be made periodically or when changing tubes. The same tests will be found helpful in remedying faulty operation. Methods for making these tests are indicated in the following. The special 115-volt lead equipped with polarized connectors is specified for use in each case although the check of test tone volume, subdivision 2.02, may be made with the transmitter in operation, if desired.

Single Sideband

(A) Volume of Test Tone

2.02 Since test tone is used as a reference when making transmitter adjustment, it is important that the volume of this tone remains constant. A method of checking the test tone volume at the transmitter input is given in the following test.

2.03 Apparatus

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.

2.04 Procedure

(1) Apply power to the low power equipment by means of the special 115-volt lead.

(2) Check the operating voltages.

(3) Adjust the CARRIER LEVEL control to the extreme counterclockwise position.

(4) Operate the CHANNEL A key to the TEST TONE position.

(5) Adjust the OUTPUT HARMONIC GENERATOR control to the value of I_p MODULATOR NO. 3 given on the appropriate tuning chart.

(6) Send 1,000 cycles at a level of + 5 db referred to 1 milliwatt into the input of channel A.

(7) Operate the CHANNEL A key first to NORMAL and then to TEST TONE noting the readings on the e_p AMPLIFIER NO. 1 meter for each position of the key.

(8) Repeat steps (6) and (7) for channel B.

Requirement: The readings observed in step (7) shall not differ by more than 1 microampere.

(B) Multivibrator Adjustment

2.05 The multivibrator is a resistance-capacity oscillator held in step by the 625 kc crystal oscillator. It is necessary that the natural period of oscillation of the multivibrator be within the range that it will be held in step by the 625 kc control frequency. A variable condenser, C9, in one of the capacity arms of the multivibrator provides a means of adjustment.

2.06 Apparatus

1 - 525-Type receiver and cord having an insulated 47-type plug or equivalent.
1 - Receiver-type alignment screwdriver.

2.07 Procedure

(1) Apply power to the low power equipment by means of the special 115-volt lead.

(2) Check the operating voltages.

(3) Adjust the CARRIER LEVEL control to approximately the level used in normal operation.

(4) Operate the CHANNEL A key to the TEST TONE position.

(5) Plug the receiver into jack J1 of the multi-circuit low frequency panel and note the tone heard.

(6) Adjust condenser C9 for mid-position of the angle within which a 1,000-cycle tone is heard.

Requirement: The presence of a 1,000-cycle tone and the absence of other tones indicates the multivibrator is operating properly.

(C) Carrier Balance in First Modulators

2.08 The adjustment of carrier balance in the first modulators is not critical and is of importance only when the carrier resulting from an unbalance is an appreciable fraction of the carrier being transmitted. This may be determined by observing the reading of the OUTPUT INDICATOR AMPLIFIER NO. 5 meter, first with test tone applied to the set, then with no input signal and the CARRIER LEVEL control set to the extreme counter-clockwise position. The ratio of these readings should be greater than 10. If the ratio is less than 10, the procedure given below shall be followed.

2.09 Apparatus

1 - 525-Type receiver and cord having a 47-type plug or equivalent.
1 - Receiver-type alignment screwdriver.

2.10 Procedure

(1) Apply power to the low power equipment by means of the special 115-volt lead.

(2) Check the operating voltages.

(3) Adjust the CARRIER LEVEL control to the extreme counter-clockwise position.

(4) Operate the CHANNEL A key to the TEST TONE position.

(5) Insert a dummy plug into jack J1 of modulator 1B.

(6) Plug the receiver into jack J1 of amplifier 2 and note the volume of tone heard.

(7) Adjust potentiometer R7 and condenser C5 in modulator 1A for a minimum tone volume.

(8) Remove the dummy plug from jack J1 of modulator 1B.

(9) Adjust potentiometer R7 and condenser C5 in modulator 1B for a minimum tone volume.

Requirement: An adjustment shall be obtained for each modulator which results in a minimum tone volume in the receiver.

(D) Gain of Low Frequency Equipment

2.11 This test provides a check on the gain of modulators 1A and 1B, modulator 2, and the associated equipment up to the grid of modulator 3.

2.12 Apparatus

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.
1 - Milliammeter, 0-2 milliamperes scale range.
1 - Microammeter, 0-20 microampere scale range.
2 - Cords equipped with spade terminals and 47-type plugs or the equivalent.

2.13 Procedure

(1) Apply power to the low power equipment by means of the special 115-volt lead.

(2) Check the operating voltages.

(3) Remove the high frequency quartz plate corresponding to the carrier frequency in use.

(4) Plug the milliammeter into jack J1 of modulator 1A and adjust R6 of modulator 1A for reading of 1.0 milliampere.

(5) Plug the milliammeter into jack J1 of the multi-circuit low frequency panel and adjust R27 for a reading of 1.5 milliamperes.

(6) Apply 1,000-cycle tone at a level of + 10 db referred to 1 milliwatt into the input of channel A.

(7) Plug the microammeter into jack J2 on the jack panel and adjust R30 on the low power high frequency unit for a reading of 4.0 microamperes.

(8) Transfer the testing tone from channel A to channel B and adjust R6 of modulator 1B for a reading of 4.0 microamperes on the microammeter.

Requirement: With the 1,000-cycle input tone level specified in step (6) above, the microammeter shall read 4.0 microamperes.

(E) Neutralization of Amplifier 5

2.14 Careful neutralization of amplifier 5 aids in the reduction of distortion. This describes a method for securing a satisfactory adjustment of neutralizing condenser C5.

2.15 Apparatus

None required.

2.16 Procedure

(1) Place the transmitter in operation, single sideband condition on the frequency for which a neutralizing setting is required.

(2) Place the OUTPUT TRANSFER switch in "mid-position". The object of this step is to disconnect the load from the amplifier.

(3) Detune the INDUCTANCE AMPLIFIER NO. 5 adjustment and adjust the CARRIER LEVEL control for I_s AMPLIFIER NO. 5 meter readings of about 0.2 ampere.

(4) Adjust the NEUTRALIZE AMPLIFIER NO. 5 control to such a setting that the OUTPUT INDICATOR AMPLIFIER NO. 5 meter reads a maximum coincident with a minimum reading of the I_s AMPLIFIER NO. 5 meters as the amplifier tuning is turned through resonance.

Requirement: An adjustment of the neutralizing control should be obtained such that a maximum output indicator deflection and a minimum amplifier 5 I_s occur at the same setting of the tuning control.

(5) Record the NEUTRALIZE AMPLIFIER NO. 5 setting which satisfies the above requirement.

(F) Audio Frequency Response

2.17 The audio frequency response of the transmitter is determined primarily by the frequency characteristic of the crystal filter associated with the first modulator upon which the input signal is impressed. Insertion loss characteristics of two typical filters, using a linear frequency scale, are shown on ES-762915 and ES-791123, pages 107 and 108, respectively. The transmitter audio frequency response curves, while closely similar to these characteristics, exhibit small variations due to slight impedance mismatches. Typical frequency characteristics of the two channels of the transmitter are shown on ES-794933 and ES-794934, pages 109 and 110, respectively. These characteristics may be measured in the following manner.

2.18 Apparatus

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.

2.19 Procedure

(1) Place the transmitter in operation, single sideband condition.

(2) Set the sensitivity control of the OUTPUT INDICATOR AMPLIFIER NO. 5 meter to the clockwise position.

(3) Operate the CHANNEL A key to the NORMAL position.

(4) Set up patches for channel A as shown on III, Fig. 2, ES-557478. Send 1,000 cycles from the audio oscillator. Adjust the oscillator output control for a 1.0 milliampere reading of the OUTPUT INDICATOR AMPLIFIER NO. 5 meter.

(5) Measure the volume of the 1,000-cycle tone.

(6) Successively adjust the audio frequency oscillator to 700, 500, 300, 200, 100, 50, 1,500, 2,000, 2,500, 3,000, 3,500, 4,000, 4,500, 5,000, 5,500, 6,000, 6,300, and 1,000 cycles, keeping the reading of the OUTPUT INDICATOR AMPLIFIER NO. 5 meter constant.

(7) Measure the input volume of each tone in step (6).

(8) Repeat the above procedure for channel B.

Requirement: The input volumes shall not differ from the Factory Test Data on the specific channel filters used in a specific transmitter by more than 0.5 db between 100 and 6,000 cycles.

(G) Signal-to-Distortion Measurement

2.20 Distortion tests are made with two input tones of equal amplitude and different frequency (1,000 and 1,575 cycles, respectively). The volume of the distortion product (425 cycles) caus d by non-linearity of the transmitter is determined with reference to the volume of either of the two input tones. Therefore, it is necessary to correct the measured ratio by a factor which depends upon the type of measuring device used. The correction factor is 3 db for the case of a root-mean-square device (6A Transmission Measuring Set). In the case of an averaging device (amplifier-rectifier and db meter) the correction factor is 2 db. In order to facilitate determining whether the 25 db signal-to-distortion requirement is met, the difference in gain of the filter branch and the signal branch of the measuring equipment (see ES-797649, page 112) shall be 28 db when using a root-mean-square instrument, or 27 db when using an averaging instrument. A block diagram of the arrangement of equipment for making two-tone distortion m asurements is shown on the sketch mentioned above. The outputs of the 1,000-cycle oscillator and the 1,575-cycle oscillator are combined in a hybrid coil. The combined output passes through an adjustable attenuator to the input of the transmitter. A transmission measuring set is arranged to compare the two-tone volume, as measured at the monitor output, with the volume of the 425-cycle distortion product as measured through a 425-cycle bandpass filter and an associated amplifier. The circuit of a complete distortion measuring equipment and associated apparatus is shown in simplified form on ES-557478, page 113.

2.21 Apparatus

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.

2.22 Procedure

(1) Warm up the test equipment for about 15 minutes before beginning the test.

(2) Place the transmitter in operation, single sideband condition, about 15 minutes prior to the test.

(3) Adjust the CARRIER LEVEL control to the extreme counterclockwise position.

(4) Set up patches as shown on I, Fig. 2 of ES-557478. In case the amplifiers are wired as in Fig. A and Fig. B the first four patches may be omitted.

(5) Operate the FILTER key to the IN position. Set the attenuator for 24 db loss. Operate the VOLTMETER key to MEAS OSC and set the oscillator to 425 cycles. Adjust the frequency for maximum transmission, as observed on Amplifier Rectifier meter.

(6) Adjust the gain of the TEST amplifier and setting of GAIN ADJ potentiometer for a gain of 27 db with FILT IN compared to FILT key normal as measured with the Amplifier Rectifier.

(7) Operate the VOLTMETER key to MEAS 1,000~ and adjust the 1,000~ ADJ control for a voltmeter deflection to the red mark (+ 11 db referred to 1 milliwatt).

(8) Operate the VOLTMETER key to MEAS OSC and set the oscillator to 1,575 cycles. Adjust the output control, the gain of the OSC amplifier and the OSC ADJ potentiometer to the same voltmeter deflection as in (7).

(9) Adjust the attenuator to 6 db loss.

(10) Adjust the INPUT SELECTOR MONITOR control to the desired pick-up position.

(11) Operate the FILTER key to OUT and adjust the INPUT ATTENUATOR MONITOR control for a two-tone output volume of -10 db referred to 1 milliwatt.

(12) Operate the FILTER key to IN and measure the volume of the 425-cycle distortion product.

(13) Obtain the signal-to-distortion ratio by the following calculation:

Signal-to-Distortion ratio =
(Volume with key OUT) - (Volume with key IN)
+ (27-2).

Example -

Volume with key OUT	=	-10 db
Volume with key IN	=	-15 db
Signal-to-Distortion ratio	=	(-10)-)-15)+(27-2)
Signal-to-Distortion ratio	=	30 db

(14) Increase the loss of the attenuator in 2 db steps to a final setting of 16 db, repeating steps (11), (12) and (13) for each setting.

Requirement: The signal-to-distortion ratio shall be greater than 25 db.

(H) Signal-to-Noise Measurement

2.23 Signal-to-noise values depend upon several characteristics of the measuring equipment utilized and, in general, it is not feasibl to convert measurements made with one measuring device into terms of those made with a dissimilar device.

2.24 Noise measurements must be made with the aid of the output indicator. The use of a reduced carrier necessitates the use of a low level test signal to secure proper demodulation of the signal in the output indicator. The relative levels of carrier and test signal used are 10 db and 20 db below normal level of test tone (+ 5 db referred to 1 milliwatt at channel input terminals). Since the signal-to-noise ratio is expressed in decibels referred to the peak envelope power capability of the transmitter, the test signal is 26 db below the peak power of the equipment. The signal-to-noise ratio is determined by, (a) observing the signal output from the output indicator with a -20 db test signal applied, (b) observing the noise output from the output indicator in the absence of a signal input, (c) computing the arithmetical sum of step (a) + step (b) + 26 db.

2.25 Apparatus

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.

2.26 Procedure

(1) Place the transmitter in operation, single sideband condition.

(2) Adjust the CARRIER LEVEL control to the extreme counter-clockwise position.

(3) Set up patches as shown on V, Fig. 2 of ES-557478. Operate VOLTMETER key to MEAS GEN and set attenuator for 6 db loss.

(4) Observe the reading of the OUTPUT INDICATOR AMPLIFIER NO.5 meter and operate both CHANNEL keys to TELEGRAPH.

(5) Adjust the CARRIER LEVEL control for an OUTPUT INDICATOR AMPLIFIER NO. 5 reading of one-third the value noted in step (4).

(6) Adjust the gain of the TEST amplifier for a noise reading of -20 to -30 db referred to 1 milliwatt and observe the reading.

(7) Set attenuator to 26 db loss and restore CHANNEL keys to normal. (VOLTMETER key remains at MEAS GEN.) Measure the volume of the tone at the TEST amplifier output.

(8) Calculate the signal-to-noise ratio as follows:
Signal-to-Noise ratio =
Step (7) - Step (6) + 26 db.

Example -
Step (7) reading = + 7 db
Step (6) reading = -29 db
Signal-to-Noise ratio = + 7 - (29) + 26
Signal-to-Noise ratio = 62 db

<u>Requirement</u>: The signal-to-noise ratio shall be greater than 50 db.

(9) Calculate the signal-to-noise ratio as follows:
Signal-to-Noise ratio =
Step (8) - Step (7) + 26 db.

Example -
Step (8) reading = + 7 db
Step (7) reading = -29 db
Signal-to-Noise ratio = + 7 - (-29) + 26
Signal-to-Noise ratio = 62 db

<u>Requirement</u>: The signal-to-noise ratio shall be greater than 50 db.

<u>(I) Carrier Frequency Adjustment</u>

2.27 Any small adjustment of the emitted carrier frequency which is necessary may be effected by means of the frequency correcting condenser in the holder containing the high frequency quartz plate.

2.28 <u>Apparatus</u>

1 - Receiver-type alignment screwdriver.

2.29 <u>Procedure</u>

(1) Place the transmitter in operation, single sideband condition.

(2) Request a frequency measuring station to measure the carrier frequency. (If increased carrier power output is necessary, adjust the CARRIER LEVEL control clockwise, but first guard against application of audio input by operating both of the CHANNEL keys to the TELEGRAPH position.)

(3) Shut down the transmitter, and having identified the particular quartz plate being used, change the setting of the frequency correcting condenser by means of the screwdriver adjustm nt provided. (Clockwise adjustment causes the carrier frequency to increase and counter-clockwise adjustment causes the carrier frequency to decrease.)

(4) Repeat the preceding steps until the carrier frequency is within the required limits.

<u>Requirement</u>: The emitted carrier frequency must be within 0.01 percent of the authorized value. If the transmitter has been in operation long enough to be thoroughly warmed up, adjust the carrier frequency to within 0.001 percent of the authorized value.

<u>Double Sideband</u>

<u>(J) Electric Oscillator Frequency and Frequency Wobble</u>

2.30 The electric oscillator on the double sideband input panel is adjusted to 125 kilocycles per second by zero beating its output frequency with the output frequency of the carrier re-supply amplifier.

2.31 <u>Apparatus</u>

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.

1 - Receiver-type alignment screwdriver.

1 - 525-Type receiver or equivalent and cord having an insulated 47-type plug or equivalent.

1 - Small Universal clip.

2.32 <u>Procedure</u>

(1) Pinch the upper center group of contacts of REL 1 on the double sideband input panel together with the universal clip. <u>CAUTION</u>: <u>Do this before applying test power as these contacts are at + 180 volts potential when power is on. Remove test power before removing the clip</u>.

(2) Apply power to the low power equipment by means of the special 115-volt lead.

(3) Check the operating voltages. Operate the transmission selector key to the DSB position.

(4) Plug the receiver into jack J1 on amplifier 2 and listen for a beat note as the CARRIER LEVEL control is adjusted clockwise.

(5) See that the wobbler condenser is set to the mid-position.

(6) Adjust C14 for zero beat note.

(7) Adjust the wobbler condenser rotor to the minimum capacity position, and determine the value of the resulting beat note by sending an equal frequency (zero beat) from the oscillator in the J68318D Distortion measuring equipment.

(8) Repeat step (7) with the wobbler condenser rotor set t the maximum capacity position.

(9) Adjust the wobble (sum of frequencies measured in steps (7) and (8) to 500 cycles). Wobble adjustment is made by altering the condenser stator position by means of the dial or sliding bar, whichever is provided. The sliding bar position is fixed by means of a lock screw.

(10) Set the wobbler condenser to the mid-position and adjust C14 for zero beat note.

Requirement: The wobble shall be between 480 and 520 cycles and the electric oscillator frequency shall zero beat with the output of the carrier re-supply amplifier.

(11) Operate Channel A key to TEST TONE position. Adjust for a low modulation rate of the tone heard in the receiver.

Note: Be sure to remove the universal clip from REL 1 when adjustments have been completed.

(K) Modulated Amplifier Excitation

2.33 The modulated amplifier excitation is adjusted by observation of the modulated amplifier plate current.

2.34 Apparatus

1 - Milliammeter, 0-1 milliampere scale range.

1 - Cord equipped with spade terminals and 47-type plug or equivalent.

1 - Receiver-type alignment screwdriver.

2.35 Procedure

(1) Apply power to the low power equipment by means of the special 115-volt lead.

(2) Check the operating voltages and operate the transmission selector key to the DSB position.

(3) Plug the milliammeter into jack J2 on the double sideband input panel and adjust R14 to the extreme counter-clockwise position.

(4) Turn R14 clockwise gradually and observe point at which milliammeter reading ceases to decrease.

Requirement: Adjust R14 to setting for which plate current of modulated amplifier ceases to decrease.

(L) Double Sideband Panel Carrier Output

2.36 The carrier output of the double sideband input panel is adjusted for the same input to modulator 2 as test tone for single sideband transmission. This adjustment should follow that given in subdivision (J) above.

2.37 Apparatus

None required.

2.38 Procedure

(1) Apply power to the low power equipment by means of the special 115-volt lead.

(2) Check the operating voltages and operate the transmission selector key to the SSB position.

(3) Apply test tone by operating the CHANNEL A key to TEST TONE and observe the reading of the e_p AMPLIFIER NO. 1 meter reading.

(4) Remove the test tone and operate the transmission selector key to the DSB position.

(5) Adjust R8 on the double sideband input panel for the same e_p AMPLIFIER NO. 1 meter reading observed in step (3).

Requirement: The e_p AMPLIFIER NO. 1 meter reading shall be the same for double sideband carrier as for single sideband test tone transmission.

(M) Modulation Level

2.39 The percent modulation is determined with the aid of a nomographic chart, ES-795426, page 116. The method of using the chart is detailed in the following description.

2.40 Apparatus

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.

1 - Milliammeter, 0-10 milliampere scale range.

2.41 Procedure

(1) Place the transmitter in operation, double sideband condition.

(2) Operate the CHANNEL A key to the NORMAL position.

(3) Set up patches as shown on VI, Fig. 2, ES-557478.

(4) Operate VOLTMETER key to MEAS GEN. Adjust ATTEN for 0 db loss.

(5) Note the OUTPUT INDICATOR AMPLIFIER NO. 5 meter reading (multiply by 6 if multiplier switch is in counter-clockwise position) and measure the volume of tone output from the output indicator into 600 ohms.

(6) Lay a straight edge on ES-795426 so as to intersect scale No. 1 at the reading of the OUTPUT INDICATOR AMPLIFIER NO. 5 meter and scale No. 2 at the measured level of tone output from the output indicator. Read percent modulation from scale No. 3 where intersected by the straight edge.

(7) Adjust potentiometer R1 on the double sideband input panel to secure 80 to 90 percent modulation.

(N) Audio Frequency Response

2.42 A typical double sideband frequency response characteristic is shown on ES-795404, page 115. The characteristic may be measured in the following manner.

2.43 Apparatus

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.

2.44 Procedure

(1) Place the transmitter in operation, double sideband condition.

(2) Operate the CHANNEL A key to the NORMAL position.

(3) Set up patches as shown on IV, Fig. 2, ES-557478.

(4) Send 1 milliwatt of 1,000 cycles from the audio frequency oscillator into the input of channel A.

(5) Measure the volume of the 1,000-cycle tone from the output of the output indicator.

(6) Successively adjust the audio frequency oscillator to 500, 200, 100, 50, 3,000, 5,000, 6,000, 8,000 and 1,000 cycles, keeping the channel A input volume constant.

(7) Measure the output indicator volume of each tone in step (6).

Requirement: The output indicator volume shall not differ from the curve shown on ES-795404 by more than 1.0 db between 100 and 6,000 cycles.

(O) Signal-to-Distortion Measurement

2.45 The arrangement of equipment for this test is the same as that used for single sideband signal-to-distortion measurements (See subdivision 2.20 of this section) except that the output indicator is substituted for the monitor panel and a 1,425-cycle oscillator is substituted for the 1,575-cycle oscillator during part of the test. Both second and third-order distortion products are measured in this test.

2.46 Apparatus

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.

2.47 Procedure

(1) Warm up the test equipment for about 15 minutes before beginning the test.

(2) Place the transmitter in operation, double sideband condition, about 15 minutes prior to the test.

(3) Set up patches as shown on II, Fig. 2, ES-557478. In case the amplifiers are wired as in Fig. A and Fig. B the first four patches may be omitted.

(4) Operate the FILTER key to the IN position. Set the attenuator for 24 db loss. Operate the VOLTMETER key to MEAS OSC and set the oscillator to 425 cycles. Adjust the frequency for maximum transmission as observed on the Amplifier Rectifier meter.

(5) Adjust the gain of the TEST amplifier and setting of the GAIN ADJ potentiometer for a gain of 27 db with FILT IN compared to FILT key normal as measured with the Amplifier Rectifier.

(6) Operate the VOLTMETER key to MEAS 1,000~ and adjust the 1,000~ ADJ control for a voltmeter deflection to the red mark (+ 11 db referred to 1 milliwatt).

(7) Change first sentence to read, "Operate the VOLTMETER key to MEAS OSC and set the oscillator to 1,575 cycles."

(8) Adjust the attenuator to 6 db loss.

(9) Operate the FILTER key to OUT and measure the volume of the two-tone output from the output indicator.

(10) Operate the FILTER key to IN and measure the volume of the 425-cycle distortion product.

(11) Obtain the signal-to-distortion ratio by the following computation:

Signal-to-Distortion ratio =
(Volume with key OUT) - (Volume with key IN) + (27-2).

Example -

Volume with key OUT	=	-5 db
Volume with key IN	=	-15 db
Signal-to-Distortion ratio	=	(-5)-(-15)+(27-2)
Signal-to-Distortion ratio	=	35 db

(12) Increase the loss of the attenutator in 2 db steps to a final setting of 16 db, repeating steps (9), (10) and (11) for each setting.

(13) Adjust the oscillator to 1,425 cycles.

(14) Repeat (9), (10), (11) and (12) to determine the signal-to-distortion ratios for the second-order distortion product.

Requirement: The signal-to-distortion ratios shall be greater than 25 db for each tone combination.

(P) Signal-to-Noise Measurement

2.48 Double sideband signal-to-noise measurements are made in much the same way as single sideband measurements. (See subdivision 2.23 of this section.)

2.49 Apparatus

1 - J68318D Distortion measuring equipment as shown on ES-557478 or the equivalent.

2.50 Procedure

(1) Place the transmitter in operation, double sideband condition.

(2) Set up the patches as shown on V, Fig. 2, ES-557478. Operate CHANNEL A key to TELEGRAPH.

(3) Adjust gain of TEST amplifier for a noise reading between -10 and -20 db referred to one milliwatt as measured on the Amplifier Rectifier. Observe this reading.

(4) Set attenuator for 24 db loss. Restore CHANNEL A key to normal. Observe reading of the tone on the Amplifier Rectifier.

(5) Remove patches from the TEST amplifier and patch from the OUT IND (or RECT MON) to MEAS 600 w. Measure the volume of the tone out of the OUT IND with the Amplifier Rectifier. The difference between the output volume of the amplifier (4) and this volume is the gain of the amplifier.

(6) Set the attenuator for 0 db loss. Observe the reading of the tone on the Amplifier Rectifier.

(7) Compute the signal-to-noise ratio as follows:

Signal-to-Noise ratio =
[Volume of tone (6)] + [amplifier gain (5)]
[- noise reading (3)]

Example -

Volume of 1,000 cycle tone	=	+ 7 db
Amplifier gain	=	+ 21 db
Noise reading	=	-15 db
Signal-to-noise ratio	=	(+7)+(21)-(-15)
Signal-to-noise ratio	=	43 db

Requirement: The signal-to-noise ratio shall be greater than 40 db.

Supplementary

(Q) Vacuum Tube Tests

2.51 The vacuum tubes used may be divided into two classes: receiving-type tubes and power-type tubes. The two classes may be tested in accordance with subdivisions 2.53 and 2.54, respectively.

2.52 Apparatus

1 - Weston Model 686, Type 7, vacuum tube test set or the equivalent.

2.53 Procedure

The receiving-type vacuum tubes, which are listed below, may be tested in accordance with the instructions given in R70.130- "Weston Model 686, Type 7, Vacuum Tube Test Set".

Tube Type	Tube Type
RCA 36	WE 244A
" 41	" 259A
" 76	" 262B
" 874	" 274A
" 6B7	" 311A
" 6C7	" 337A
" 6D6	
" 6L7G	
" 25Z5	

2.54 Faulty peration of the power tubes used in amplifiers 3, 4 and 5, other than the obvious cases of filament failures or inter-electrode short-circuits, will almost invariably lead to increased distortion. When the signal-to-distortion requirement given in subdivision 2.22 is exceeded, therefore, the tests to find the source of distortion should include an investigation of vacuum tube conditions. If distortion requirement is satisfied by inserting a new tube, the tube replaced may be considered faulty.

(R) Supply Voltages

2.55 The d-c supply voltages of the transmitter are read by means of the 3,000-VOLT SUPPLY and LOW VOLTAGE SUPPLIES voltmeters. The following table of supply voltages is furnished for reference in routine operation. Readings should be taken with minimum carrier output power and no input to either channel.

Setting of Voltmeter Switch	Potential	
PLATE SUPPLY RECTIFIER 1	180-190	volts
PLATE SUPPLY RECTIFIER 2	165-175	"
GRID SUPPLY RECTIFIER 1	17.5-19	"
GRID BIAS MODULATORS	11.5-12.5	"
GRID BIAS AMPLIFIER 3	30-35	"
GRID BIAS AMPLIFIER 4	35-40	"
GRID BIAS AMPLIFIER 5	270-290	"
FILAMENT SUPPLY AMPLIFIER 3	10.0-10.2	"
FILAMENT SUPPLY AMPLIFIER 4	10.0-10.2	"
3,000-VOLT SUPPLY	2.9-3.2 Kilovolts	

2.56 The filament voltages for amplifier 3 and amplifier 4 may be adjusted by means of taps on the secondary windings of the two transformers, each designated T1, on the mat sides of the rectifier 5 and rectifier 6 panels. The transformers are exposed by removing the front mat of the cabinet containing these rectifiers. Two sets of taps appear on each transformer; one set bearing letter designations, the other set bearing numeral designations. The letter-designated taps are for adjustments approximating 1.0 volt each and the number-designated taps are for adjustments approximating 0.2 volt each. The filament potential may be increased by changing to the next higher letter or number taps, and vice versa.

(S) Fan Lubrication

2.57 The ventilating fans should be lubricated with Socony-Vacuum Oil Company B.R.B. No. 2 grease. Pull off the grease cup covers (two on each motor) and fill with grease. Place a finger over th air exit hole on the cover and push the cover into place.

(T) Renewal of Dust Filters

2.58 The dust filters on the rear doors of the transmitter should be replaced when they become excessively clogged with dust. Replacement filters may be ordered from the Western Electric Company. Their specifications are: Dust-Stop No. 1 Air Filter for use in the D-156000 Radio Transmitter, 10 x 15 (+ 0, -1/8) x 1 (± 1/16) inches. To remove the filters, remove the three screws holding the top section of each filter holder, and pull the filter up and out of the frame. The replacement filter should be placed in the holder with the arrow on the label pointing in the direction of air flow. The top section of the holder should then be replaced.

2.59 The roller type coils in Amplifiers 3, 4, 5 and the antenna matching unit should be lubricated with KS-8559 Lubricant. This lubricant should be applied sparingly to the shafts on which the rollers turn. When a coil is removed or upon installing a new coil it should also be applied to the center bearings. It should not be allowed to reach the outer edges of the rollers or the wire of the coil itself. The graphite in the lubricant is a conductor and should be kept away from all insulating surfaces.

3. LOCATION OF TROUBLE

3.01 CAUTION: Electrical and mechanical interlock devices are provided for safety. Never disable or attempt to circumvent these devices.

CAUTION: Always ground high potential parts and wiring with the ground stick before touching anything within the cabinets.

3.02 The nature of abnormal operation may usually be determined from observation of the transmitter meters, by distortion tests, or by vacuum tube tests. The more obvious causes of outage (filament burn-outs and fuse failures) are easily located. However, many factors contribute to possible excessive distortion. The following discussion concerns the causes and location of distortion.

(A) General

3.03 Distortion in an amplifier produces frequencies in the output which are not present in the input. This is the result of a non-linear amplifier characteristic. An investigation of the various distortion products shows that on single sideband only certain odd order products of the frequencies present in the amplifier output fall in the received band. The third order products have been found to be the greatest in amplitude and to behave in a manner representative of the other odd order products. Consequently, measurements made of a third order product of two equal tones may be taken as indicative of transmitter performance. On double sideband these same factors may also result in apparent second order distortion. A satisfactory set of distortion measurements on single sideband will, with the exception of distortion occurring in the double sideband panel itself, indicate satisfactory conditions for double sideband. Consequently, this portion is written to specifically apply to single sideband operation.

3.04 Inasmuch as some of the amplifiers of a single sideband transmitter must be of the Class B variety and Class B amplifiers are subject to relatively high distortion at low amplitudes, it is necessary to measure the distortion over a wide range of amplitudes up to the maximum amplitude which it is expected to transmit.

3.05 It would be difficult to separate the third order distortion product from the closely spaced tones in the high frequency output of the transmitter. Therefore, the monitor is provided. In the monitor, a small amount of the high frequency output of the amplifier in question is demodulated with frequencies obtained from the transmitter sources. The result is a reproduction of the audio-frequency input and the distortion products which fall in the band. An audio-frequency filter may then be used to separate the product which is to be measured.

3.06 In a transmitter in which there are successive stages of amplification, it is well to remember that the distortion in the output is the vector sum of the distortion in all the stages; and that it is entirely possible for distortion which is present in an early stage to be cancelled by distortion in a succeeding stage. It is not meant to suggest such a procedure for the correction of distortion; but to point out that a decrease in the measured distortion due to the adjustment of some variable, such as the grid bias of a particular stage, does not mean that the source of the distortion has been corrected unless the distortion was determined to be the result of the variable corrected. While such a procedure might be satisfactory for an amplifier which is operated on but one frequency and at one gain, it is obvious that if the operating frequency is changed or the gain is changed for any reason; the correction in one stage for distortion occurring in another will very likely be incorrect and distortion will result from both sources.

(B) Causes of Distortion

3.07 The correction of a distorting condition becomes relatively simple when the cause for the distortion has been isolated. The principal causes for distortion in any stage of the transmitter may be enumerated as follows:

Low Emission

3.08 This will be most frequently encountered with old tubes. The effect of low emission is to limit the plate current of the tube. This results in distortion which is present at high amplitudes. The low emission may or may not be evident on circuit meter readings inasmuch as the peak emission required is always much greater than the idle currents. The simplest check is to try a new tube.

Load Impedances

3.09 Distortion at high amplitudes may result from either too high or too low a load impedance. This applies particularly to amplifier 5 when operating near the 2-kw peak output. Too high a load impedance is indicated by a large difference between the in and out-of-tune plate currents with test tone input. This results in radio frequency peak voltages which exceed the d-c supply. A non-linearity in the input-to-output characteristic results. A low load impedance is indicated by a very small difference between the in and out-of-tune plate currents. This results in very low efficiency and at large amplitudes will result in distortion due to filament saturation. The antenna matching transformer adjustment may be changed to present the proper load impedance to the amplifier tubes. A ratio of 0.6 in-tune to out-of-tune plate currents is approximately correct.

3.10 If the coil rollers within either amplifier 3 or 4 are on dissimilar points the effect will be much the same.

Grid Bias Adjustment

3.11 Class B amplifiers are especially critical to grid bias adjustment. Either too low or too high a bias voltage will result in amplifier non-linearity and consequent distortion. This type of distortion is likely to appear at relatively low amplitudes. If the bias is too high, the result may be a peak in the distortion curve which is followed at some higher amplitude by a cancellation effect which will result in a pronounced dip. If the bias is too low, there is not likely to be any cancelling effect and the distortion remains high or continues to increase as the amplitude is increased. The most critical stage is amplifier 4. Bias adjustments are provided for amplifiers 3 and 4.

3.12 Class A amplifiers and modulator stages are also subject to distortion due to improper bias. However, such changes must be relatively large before distortion results.

Matched Tubes

3.13 In a multi-tube, Class B amplifier for single sideband operation, it is highly desirable that all the tubes in a stage have closely matched characteristics near the cut-off end. In amplifier 5, this may be determined from the idle currents of each tube. In amplifier 4, it may be determined by measuring the idle current with one tube at a time in place. Distortion at low amplitudes will be the result of variation in the characteristics of the tubes in a stage.

Reaction

3.14 Reaction in an amplifier stage does not, in itself, result in distortion. However, if the reaction results in a change in the operating condition of the tubes to the extent of causing overloading, distortion will result. The remedy is to reduce the reaction.

Conversion Frequency Supply to Modulator

3.15 Distortion may be caused by either too much or too little conversion frequency voltage being supplied to the modulator. If the amplitude of the conversion frequency becomes so low as to be comparable with signal input amplitude, distortion results. Also, if the amplitude is so great that the grids go positive when signal voltage is applied distortion results. In general, if the conversion frequency supplied to the modulator is kept within the limits specified and excessive input amplitudes are not applied, the modulator is relatively free from distortion.

3.16 The monitor detectors are essentially modulators and are subject to the same causes of distortion.

Grid Current

3.17 Grid current in an amplifier results in distortion due to the variations it introduces in the amplifier input impedance. In some cases this is unavoidable. However, the plate load impedance may in some cases affect the grid current. This is particularly true in amplifier 5; and observations on the amplifier 5 grid bias voltage while increasing the drive will indicate the extent of the grid current in that stage.

Poor Contacts, Corona, Etc.

3.18 Distortion may result from poor contacts or anything of a nature which will cause sparking or corona discharge. Such arcs do not occur until the voltage at the troublesome point reaches a value where discharge occurs. This, of course, causes a non-linearity in the circuit which results in distortion.

(C) Location of Distortion

3.19 The determination of the point in a single sideband transmitter at which distortion is being introduced is often a complex problem. Familiarity with the equipment and its behavior results in the early elimination of many possible sources. Consequently, it is felt that an outline of detailed procedure would be cumbersome and, in general, useless. However, an analysis of the means of determining whether any one stage is the principal contributor may serve as a guide to the experienced operator.

Monitor

3.20 A quick check of the monitor may be made by reducing the monitor input volume by means of the attenuator. If the signal-to-distortion ratio remains unchanged it is probable that the measured distortion is not originating in the monitor. A marked change in the signal-to-distortion ratio of the monitor output indicates possible trouble in the monitor. The monitor operating conditions should then be checked.

Amplifiers 4 and 5

3.21 An indication as to whether amplifier 5 is contributing to the distortion may be obtained by first measuring the distortion at various values of input. Then if the loading on the output of amplifier 4 is increased, and the measurements made again, a comparison may be made. If the same distortion-input curve is obtained the indication is that the distortion is occurring ahead of the point where the additional loading was introduced. A change in the distortion-input curve, and especially a reduction of the distortion ratio, will indicate that the distortion is occurring beyond the point of change in gain; that is, amplifier 5 or beyond.

3.22 The same method may be used to determine whether the distortion is occurring in amplifier 4 or ahead of it.

Amplifiers 1, 2 and 3

3.23 These amplifiers are essentially Class A amplifiers. With the exception of low emission, most changes which cause distortion in these stages show by the meter readings. The monitor may be used to determine the distortion down as low as the output of amplifier 2, in case it is found necessary. To do this, the plug connection is removed which connects the pick-up loops to the monitor. A short piece of lead-covered single conductor wire is prepared by making a loop on one end and the other is temporarily connected into the monitor block with the shield grounded. The loop is then placed in position to couple to the output circuit which it is desired to measure. Great care should be used to provide sufficient clearance in the amplifier stages to prevent grounding of the plate supply and the shield should be securely grounded.

Modulators

3.24 It is not expected that distortion in the modulators will occur as long as the operating conditions are maintained within the specified limits. There is no convenient method of observing the output directly.

D-156000 RADIO TRANSMITTER

CONTENTS

1. GENERAL

1.01 The D-156000 Radio Transmitter may be used for either twin-channel single-sideband or single-channel double-sideband transmission. The type of transmission desired may be selected at will by remote control from a distant control terminal or by operating a key on the transmitter panel. When used as a double-sideband transmitter, the carrier frequency may be "wobbled" plus and minus 250 cycles from the mean value, if additional privacy is desired. When used as a single-sideband transmitter, two channels may be transmitted. The two channels are present in the output as two independent sidebands, one on each side of the carrier frequency. The amplitude of the carrier for single-sideband operation is adjustable between the full power output capability of the transmitter and a value about 30 db below either sideband. When but one single-sideband channel is being transmitted, there is present only the carrier and one sideband.

1.02 The transmitter is designed to op rate on any frequency b - tween 4,500 to 22,000 kc per s cond. A modification can be made in amplifiers 3 and 4 to permit operation in the frequency range from 4,000 to 20,000 kilocycles if this range is more desirable. The equipment may be quickly tuned to any of six pre-selected frequencies by front-of-panel adjustments. It is capable of delivering a peak envelope power of 2 kilowatts to an open-wire transmission line having an impedance of from 400 to 800 ohms, or to a balanced concentric transmission line having an impedance of about 200 ohms. This is equivalent to 500 watts carrier power for double sideband operation. The speech volume level required is + 5 VU at the input terminals of each channel. The single-tone testing power level required is 1 milliwatt.

1.03 Power for operation of the transmitter may be obtained from a 3-phase, 220 to 235 volt, alternating current source the frequency of which shall be 60 cycles or 50 cycles as specified on page 1 of th Inspection Test Data. The maximum power required is approximately 5 kilowatts at 95 per cent power factor.

2. CIRCUIT DESCRIPTION

(A) Gen ral Information

2.01 Photograph A, page 101, and Photograph B, page 102, are front and rear views, respectively, of the transmitter. As viewed in Photograph B, the left-hand bay contains the low frequency equipment, the center bay contains the high frequency equipment, and the right-hand bay contains the power equipment. Drawing ES-794688, page 104, shows the location of the individual panels in the equipment.

2.02 A block diagram of the transmitter circuits, omitting the power circuits, is shown on ES-794932, page 105. A complete schematic diagram is shown on ESXX-782860, page 106. (Repeated reference is made to these drawings in the course of the following description.)

(B) Principles of Operation

2.03 The transmitter circuits are so designed that the carrier frequency may be shifted to any one of six pre-selected frequencies with a minimum of time and effort. Three steps of modulation are employed as is shown on ES-794932, page 105. A 625 kc crystal oscillator is the source from which conversion frequencies for the first two stages of modulation are derived. A 125 kc multi-vibrator, which is held in step by the 625 kc crystal oscillator, supplies a source of 125 kc. The oscillator frequency is also multiplied to 2,500 kilocycles by means of the 2,500 kc harmonic generator which is driven by the oscillator.

The 125 kc frequency serves as a conversion frequency for the first step of modulation, which occurs in modulators 1A and 1B for channel A and channel B, respectively. The upper sideband is selected from the output of modulator 1A and the lower sideband is selected from the output of modulator 1B by crystal filter A and crystal filter B, respectively. The outputs of the two crystal filters are combined and impressed upon the input of the second modulator, modulator 2, together with the output of a carri r resupply amplifier. The 125 kc output of the carrier resupply amplifier is adjustable between the full output power and a value of about 30 db below either sideband. The 2,500 kc frequency serves as a conversion frequency for the second step of modulation which occurs in modulator 2. The output of this modulator passes through a 2,619 to 2,631 kc B.P. filter which suppresses the 2,500 kc conversion frequency and the lower sideband resulting from the action of modulator 2. The upper sideband contains a 2,625 kc carrier frequency and two independent sidebands; the upper one of which contains frequencies dependent upon the input to channel A, and the lower one of which contains frequencies dependent upon the input to channel B. the 2,625 kc carrier and the two independent sidebands then modulate a conversion frequency (modulator 3) derived from a high frequency crystal oscillator and a harmonic generator in the low power high frequency unit. The frequency of the high frequency crystal oscillator is determined by the required final carrier frequency. If the assigned frequency is f, the high frequency crystal oscillator and harmonic generator must be so adjusted that the output frequency of the latter is either f + 2,625 kc or f - 2,625 kc. With the former adjustment, which is used for assigned carrier frequencies below 10,000 kilocycles, the lower sideband produced by modulator 3 is transmitted. With the latter adjustment, which is used for assigned frequencies above 10,000 kilocycles, the upper sideband is transmitted. Hence, to shift the carrier frequency it is only necessary to change the conversion frequency supplied to modulator 3 and retune the transmitter.

2.04 A series of five amplifiers follow modulator 3. These amplifiers increase the power level of the desired sideband obtained from the third step of modulation to a peak envelope power of 2 kilowatts. The output of amplifier 5 may be switched to either an antenna matching transformer or a balanced coaxial transmission line. The output circuit of amplifier 5 is designed to operate into a balanced load of about 200 ohms impedance. The antenna matching transformer permits matching the amplifier output to a balanced open-wire transmission line having an impedance of from 400 to 800 ohms.

2.05 While the preceding description applies to the case of single-sideband transmission, the principle of operation is essentially the same for double-sideband transmission. In the latter case, the channel A input is switched from modulator 1A to an audio-frequency amplifier in the double-sideband input panel. The double-sideband input panel also contains a 125 kc electric oscillator, a frequency wobbler, and a modulated amplifier. The output of the modulating amplifier passes to modulator 2 and thence through the remainder of the transmitter. The channel A input may be switched to the double-sideband panel by a locally operated key or by a remotely controlled relay. When the equipment is being used for double-sideband transmission, the 125 kc multivibrator is disabled to prevent operation of the single-sideband components. A second key controls operation of the wobbler. A stop button is provided for stopping the wobbler in its mid-position when desired.

2.06 Single-sideband transmissions may be monitored by means of the monitor panel. A small portion of the output of amplifier 5 is demodulated in the first demodulator by a conversion frequency derived from the crystal frequency amplifier in the low power high frequency unit and a harmonic generator in the monitor panel. The output of the first demodulator passes to the second demodulator where it beats with a 2,625 kc conversion frequency derived from the 2,625 kc monitor supply modulator. (The 2,625 kc frequency is generated in the supply circuit by mixing 125 kilocycles from the 125 kc multivibrator with 2,500 kilocycles from th 2,500 kc harmonic generator.) The voice-frequency output of th second demodulator is brought out to a terminal strip and to a jack.

2.07 Double-sideband transmissions may be monitored by using the rectifier (output indicator) circuit provided in amplifier 5. The audio-frequency output is brought out to a terminal strip.

(C) Circuit Details

2.08 A complete schematic diagram of the transmitter circuits is shown on drawing ESXX-782860, page 106. The operation of the various circuits is described in detail in the following subdivisions.

(1) Transmitter Input Control

2.09 Preceding the first modulators there is an arrangement of keys and resistance pads for regulating and controlling the application of input signals. Control key S3 is for channel A and control key S2 is for channel B. Operating a control key to the normal position completes the channel circuit from the terminal room to the appropriate first modulator. Operating a key to the downward position opens the channel circuit and applies a 1,000-cycle test tone derived from an external source. Operating a key to the upward position opens the channel circuit and completes a like connection to the 1,000-cycle source, but places the input tone under control of a normally open telegraph key, S1. A control key should be operated upward when it is desired to transmit brief telegraph signals, such as call letters, or when it is desired to remove all input to the channel. Attenuator panels, each mounting two H-type pads, are provided for each channel. The first pad inserts a loss of 5 db ahead of the channel key. The second pad inserts a loss of 14 db between the channel key and the first modulator.

(2) First Modulators and Crystal Filters

2.10 Modulators 1A and 1B are identical with the exception that there is a slight difference between their output transformers to correspond with the sideband selected in the associated filter. In each modulator, the audio-input is applied in series with the grids of V1 and V2 and the 125 kc conversion frequency from the multi-vibrator is applied in parallel. Potentiometer R6 is for controlling the level of the conversion frequency. Potentiometer R7 and condenser C5 are for balancing the modulator for maximum carrier suppression. A jack, J1, provides a means for determining the plate current of the modulator. The output of modulator 1A is passed through crystal filter A, which has the loss characteristic shown on drawing ES-762915; it has a pass band of 125.1 to 131 kilocycles and transmits the upper sideband only. The output of modulator 1B is passed through crystal filter B, which has the loss characteristic shown on drawing ES-791123, it has a pass band of 119 to 124.9 kilocycles and will transmit the lower sideband only. The two circuits are then combined through a resistance network R1, R2, R3. Thus, the modulating and filtering equipment is arranged to deliver to the output terminals of the resistance network two unrelated sidebands, one on either side of a 125 kc (suppressed) carrier.

(3) Double-Sideband Input Panel

2.11 The double-sideband input panel contains equipment for producing a modulated 125 kc carrier frequency which may be wobbled plus and minus 250 cycles from the mean value. Controls are provided for remote or local selection of the type of transmission.

2.12 The channel A transmitter input may be transferred from modulator 1A to the double-sideband input panel, or vice versa, by operation of relay REL 1. The signal then passes through an amplifier stage, V1, to the modulated amplifier, V2. The radio frequency input to the modulated amplifier is derived from a potentiometer, R14, in the plate circuit of the 125 kc oscillator, V3. The carrier frequency is wobbled by a synchronous motor which drives condenser C13, a part of the oscillator tuned circuit. Potentiometer R8 is for adjusting the output of the double-sideband input panel. Jacks, J1, J2, and J3, provide a means for observing screen and plate currents in this unit. In addition to transferring the channel A input, REL 1 also operates to disable the 125 kc multi-vibrator on the multi-circuit low frequency panel. The transmitting condition of the equipment may be controlled by operation of relay REL 1 from a remote control terminal if the transmission selector key, S1, is placed in the REMOTE position. For local operation, the key may be placed in either the DSB or the SSB position. An illuminated nameplate covering two lamps, either of which is illuminated at any one time, indicates whether the transmitter is in the single-sideband or double-sideband transmitting condition.

(4) Multi-Circuit Low Frequency Panel

2.13 The input to modulator 2 on the multi-circuit low frequency panel is either the single-sideband output from crystal filters A and B or a 125 kc carrier with double-sideband modulation from the double-sideband input panel. In order that the carrier may be transmitted and regulated to any desired level when transmitting single-sideband, an adjustable-gain carrier resupply amplifier is provided. The gain of this amplifier, which employs a screen grid tube, V6, is controlled through the CARRIER LEVEL potentiometer, R21, from the front of the transmitter. The resupplied carrier is combined with the sideband inputs and applied to the second modulator in series with the grids of V8 and V9. A jack, J1, provides a means for determining the total cathode current of these tubes.

2.14 Conversion frequencies for the first two steps of modulation are derived from a 625 kc crystal oscillator, V1. The circuit employs a quartz crystal having a low temperature coefficient. The output of this oscillator controls the frequency of a 125 kc multi-vibrator, which provides the 125 kc conversion frequency delivered to the first modulators. The multi-vibrator may be identified on the diagram by triodes, V2 and V3. An associated amplifier employs a screen grid tube, V5. The output of the 625 kc crystal oscillator is also delivered to a 2,500 kc harmonic generator which uses a screen grid tube, V7. The harmonic generator provides the 2,500 kc conversion frequency applied to the second modulator in parallel with the grids of V8 and V9.

2.15 The second modulator is similar to the first modulators except that no adjustments are provided for balancing out the conversion frequency. A potentiometer for controlling the conversion frequency volume is designated R27. In the output circuit of the second modulator, conversion is made from the balanced arrangement used up to this point to a single-sided circuit. The upper sideband from this modulator, consisting of either one or two transmission bands 5,900 cycles in width and an associated 2,625 kc carrier of any desired level, is selected by a 2,619 to 2,631 kc filter. A typical insertion loss characteristic of this filter is shown on drawing ES-794935, page 111.

2.16 The 2,625 kc monitor supply modulator for supplying conversion frequency to the monitor uses a pentagrid converter tube, V4. It receives its inputs of 125 kilocycles from the 125 kc multivibrator and 2,500 kilocycles from the 2,500 kc harmonic generator. By combining these to form a 2,625 kc conversion frequency for use in the monitor, it enables demodulation of the single-sideband output to be completed in two steps instead of three.

2.17 All of the vacuum tubes on the multi-circuit low frequency panel have heater-type cathodes. The heaters are supplied from a filament transformer, T1, having two secondary windings. One winding supplies the heater of the 625 kc crystal oscillator tube and the 2,625 kc monitor supply modulator; the second winding supplies the other vacuum tubes.

(5) Lower Power High Frequency Unit

2.18 The input to the low power high frequency unit is a 2,625 kc carrier of any desired level, and either one or two adjacent sidebands. This input is restricted to the frequency range 2,619 to 2,631 kilocycles by the 2,619 to 2,631 kc filter and is passed through the 2,625 kc amplifier employing pentode, V3, before being impressed upon the control grid of screen grid tube, V4, in the third modulator. An adjustable potentiometer, R30, provides a gain adjustment at this point.

2.19 The high frequency crystal oscillator, V1, is of the resistance type. Low temperature coefficient quartz plates are employed. The oscillator is provided with a selector switch and positions for six quartz plates. The output of the oscillator is impressed upon the harmonic generator, V2, which is equipped with a selector switch and may be provided with six pre-tuned circuits. The frequency of the oscillator is determined by the required final sideband frequency. If for the final sideband the frequency corresponding to the carrier (the assigned frequency) is f, the high frequency crystal oscillator and the harmonic generator must be so adjusted that the output frequency of the latter is either f + 2,625 kilocycles or f - 2,625 kilocycles. With the former adjustment, which is used for assigned frequencies below 10,000 kilocycles, the lower sideband produced by the third modulator is the required sideband; with the latter adjustment, which is used for assigned frequencies above 10,000 kilocycles, the upper sideband is the one required. The crystal frequency is either one-half, one-third, or one-fourth of the third modulator conversion frequency.

2.20 The output of the harmonic generator (modulator 3 conversion frequency) is applied to the input of the third modulator along with the 2,625 kc carrier and the sidebands from the low frequency unit. The amplitude of the conversion frequency (for which the i_p MODULATOR NO. 3 meter, M3, serves as an indicator) is controlled by the OUTPUT HARMONIC GENERATOR potentiometer, R13, from the front of the transmitter. The third modulator is equipped with a selector switch and may be provided with six pre-tuned output circuits adjusted and arranged to pass the required final sideband. Its output is delivered to the control grid of the duo-diode pentode, V5, in amplifier 1.

2.21 The diode plates of V5 are connected as a peak voltmeter using the e_p AMPLIFIER NO. 1 meter, M2, to provide a means of checking the output of amplifier 1. The amplifier is equipped with a selector switch and may be provided with six pre-tuned output circuits.

2.22 The output of the high frequency crystal oscillator is also delivered to the crystal frequency amplifier, V6. This amplifier is used for supplying the crystal oscillator frequency to the monitor.

2.23 All of the tubes in the low power high frequency unit have heater-type cathodes. The heaters are supplied from filament transformer T1.

(6) Power Amplifiers and Antenna Matching Transformer

2.24 The sideband from the low power high frequency unit is applied to the control grid of pentode V1 in amplifier 2. The cathode current in this tube is indicated on the I_s AMPLIFIER NO. 2 meter, M4. In the plate circuit, conversion is made from the single-side circuit to the push-pull arrangement used throughout the remainder of the power amplifier system. The amplifier is equipped with a selector switch and may be provided with six pre-tuned output circuits.

2.25 Amplifier 3 employs two pentodes. The plate circuit of this amplifier is a balanced pi-type network which is tuned by continuously variable inductances. Four pairs of load resistances and a dual selector switch are provided for controlling the gain of this stage. The I_s AMPLIFIER NO. 3 milliammeter, M5, in the ground return lead from the filament supply rectifier, RECTIFIER 5, indicates the total plate and screen current of the stage. The heater of V1 in amplifier 2 is supplied from the same rectifier. A jack, J1, facilitates tuning of amplifier 2.

If operation in the frequency range from 4,000 to 20,000 kilocycles is desired, the condensers regularly supplied in positions C2 and C16 should be replaced with larger condensers as specified in the Apparatus and Designation List.

2.26 The circuit of amplifier 4 is similar to that of amplifier 3. The I_s AMPLIFIER NO. 4 milliammeter, M6, in the ground return lead from rectifier 6, indicates the current drawn by this stage and serves as an indicator for tuning the previous stage.

If operation in the frequency range from 4,000 to 20,000 kilocycles is desired, the condensers regularly supplied in positions C2 and C8 should be replaced with larger condensers as specified in the Apparatus and Designation List.

2.27 The triodes in amplifier 5, the final amplifier, are operated in a bridge-neutralized circuit. The small inductances, L1 and L2, are for the purpose of preventing high frequency "singing". The same type of output circuit is used for this amplifier stage as is used in amplifiers 3 and 4; but since the inductance ranges of L3 and L4 are limited to smaller values by the larger current carrying capacity required, it is necessary to provide a means for adding additional capacity to the circuit. Therefore, a quadruple switch is provided which in one operation adds capacitance to both the high and low impedance ends of the circuit. These capacitances must be connected for operation on frequencies below 6,000 kilocycles. Provision is made in the tuning adjustment of L3 and L4 to permit a differential of $\pm$ 1/2 turn in the settings of the two inductances. A provision for balance adjustment is required because of the wide mechanical separation of the inductances and the resulting small mutual between them. The degree of balance, as well as the total output, is indicated on the I_s AMPLIFIER NO. 5 ammeters, M7 and M8. The filaments of the amplifier 5 triodes are supplied from two filament transformers, T1 and T2. Scott-connected primary windings provide secondary voltages in a quadrature relationship. Meters M7 and M8 are connected in the center tap lead of each secondary winding. A full-wave rectifier tube, V3, and output indicator meter, M9, are connected as a peak voltmeter for this amplifier. A key, S3, associated with a resistance, R1, makes two ranges available. This circuit is used as a monitoring rectifier for double sideband transmission and for certain tests of single sideband operation.

2.28 The output circuit of amplifer 5 is arranged to operate into a balanced load of about 200 ohms impedance. If it is desired to operate this equipment directly into an open-wire line having a nominal impedance of 600 ohms, the antenna matching transformer should be used. The transformer may be used for working into balanced impedances within the range of 400 to 800 ohms. A transfer switch is provided for connecting the output of the transmitter either to the coaxial line terminals or to the antenna matching transformer. A key interlock is provided on the switch. The output of the transformer is connected to outlet bushings mounted on the top of the transmitter.

(7) Monitor Panel

2.29 The monitor panel is provided for converting a portion of the output of the transmitter back to speech frequencies in order to check operation of the transmitter. A small amount of the output power of the transmitter is picked up by the monitor loop, adjacent to L4 in amplifier 5. In case additional amplifier stages are employed after this equipment, additional pickup loops are used and the output of the desired one may be selected by the INPUT SELECTOR MONITOR switch, S3. The INPUT ATTENUATOR MONITOR condenser, C14, is a balancing condenser in which the rotor rotates between two sets of stator plates. The incoming voltage is connected to one set of stator plates and the other set is grounded. The potential between the rotor plates and ground is a function of the position of the rotor.

2.30 The signal voltage from the capacity attenuator is impressed across the cathode resistor of the first demodulator tube, V3. Conversion frequency at a multiple of the crystal frequency is supplied to the demodulator from a harmonic generator, V1, which is driven by the crystal frequency amplifier in the low power high frequency unit. The output of the harmonic generator is controlled by the OUTPUT MONITOR H.G. potentiometer, R2. The plate current of the first demodulator is indicated by the I_p first DETECTOR MONITOR meter, M1.

2.31 The output of the first demodulator consists of sidebands about a frequency of 2,625 kilocycles. Transformer T2 impresses this output voltage in push-pull on the grids of the second demodulator, V4 and V5. A conversion frequency of 2,625 kilocycles is introduced in the center tap of transformer T2 from the output of the 2,625 kc amplifier, V2. The output of the second demodulator is at audio-frequency. No arrangement is made for separation of channel A and channel B in the monitor, and consequently the output of either or both channels may be monitored. The principal purpose of the monitor is to enable measurements to be made on the distortion introduced in the amplifiers, and for this purpose there is no necessity for separating the channels.

(8) <u>Rectifiers, Voltage Regulators and Voltmeters</u>

2.32 Rectifier 1 supplies plate, screen and grid voltages for the low frequency units and grid bias for the low power high frequency unit and the monitor panel.

2.33 Plate voltages for the monitor panel, the low power high frequency unit and amplifier 2 are obtained from rectifier 2.

2.34 Rectifier 3 supplies the grid bias to amplifiers 3, 4 and 5. In order to maintain a constant bias to amplifiers 3 and 4 with variations in potentiometer voltage caused by the varying grid current in amplifier 5, and also to minimize the effect of grid current in amplifier 4 on amplifier 3; a gas-type voltage regulator tube, V2, is used across the portion of the potentiometer supplying amplifiers 3 and 4. Adjustable potentiometers, R1 and R2, afford a manual adjustment of the bias voltage on these stages. Interlocking control of the grid bias and the plate supply for these amplifiers is obtained by using the potentiometer current for operating a contactor, A2, which controls the 230-volt supply to the 3,000-volt rectifier.

2.35 Rectifier 4 is a 3,000-volt, three-phase, full-wave bridge-type rectifier supplying amplifiers 3, 4 and 5. A time-delay relay, A1, is provided to prevent application of plate supply voltage to the rectifier before the rectifier filaments have reached a safe operating temperature. The 3,000-VOLT CONTROL switch, S1, will control the operation of contactor A2, which applies power to rectifier 4, only after rectifier 3 is in operation and relay A1 has closed. The rectifier employs six mercury vapor rectifier tubes and is provided with its own voltmeter, M10. A filter inductor, L1, is in the negative lead of the rectifier output. A 4 mfd filter capacitor is represented by C1, C2, C3 and C4 on the screen supply regulator panel.

2.36 The screen supply regulator panel serves as a distribution panel for the output of rectifier 4. Resistances R5 and R6 in series with the plate circuits of amplifiers 3 and 4, respectively, are mounted on this panel. R2 is a small resistance in series with the high voltage filter condenser; and its purpose is to reduce the shunt resonant impedance of the filter circuit. The screen supply regulator employs a triode regulator tube, V1. Resistors, R1, R3 and R4, are for the purpose of controlling the bias of the tube. Any variation in the current drawn by the screens of the amplifiers produces a change in the bias of the regulator tube. The change of bias causes a change in the resistance of the tube in such a direction as to maintain a constant voltage on the screens. Adjustment of the screen supply voltage is provided by the variable potentiometer, R1.

2.37 Rectifiers 5 and 6 are of the copper-oxide type and provide d-c filament supply for amplifiers 2, 3 and 4. The transformer secondaries are equipped with both coarse and fine adjustment taps for adjusting the output voltage, and there are metering positions on the VOLTMETER SWITCH for measuring this voltage. Rectifier 5 is supplied from the 115-volt circuit ahead of the voltage regulator. Rectifier 6 is supplied directly from the 230-volt circuit.

2.38 A voltage regulator panel is provided for maintaining the constancy of the 115-volt supplies to the low power equipment. A 230/115-volt transformer, T1, supplies 115 volts from the 230-volt input. The 115-volt circuit from this transformer is completed through a fourth blade on the 230-volt service switch, S2. This allows transformer, T1, to function in stepping down 230 volts to 115 volts when the service switch, S2, is closed, and prevents it from functioning in the reverse direction when 115 volts are supplied via a 115-volt test lead and the service switch is open. The arrangement provides for using a special test lead to connect an external source of 115 volts to the low power circuits, with the doors of the set unlocked and the service switch open. This facility is of convenience in testing the equipment.

2.39 A multi-point VOLTMETER SWITCH is provided with 0-35, 0-350-volt d-c voltmeter. The switch has 10 points and an "off" position, and is used for reading the lower supply voltages of the transmitter. One position reads the positively polarized portion of the output of rectifier 1, which supplies plate and screen voltages to the low frequency equipment. The second position indicates the output of rectifier 2, which supplies plate and screen voltages to the lower power units of the high frequency equipment. The third position connects the voltmeter to the negatively polarized portion of the output of rectifier 1 which supplies bias to the low power high frequency equipment; and the fourth position connects it to a fixed fraction used for grid bias on the first and second modulators. On the fifth position is read the output from the R2 potentiometer of rectifier 3, which supplies grid bias to amplifier 3; and the sixth position indicates the output from the R1 potentiometer of the same rectifier which supplies grid bias to amplifier 4. On the seventh position is read the full output of rectifier 3 which supplies grid bias to amplifier 5. The eighth position indicates the filament voltage of amplifier 3; and the ninth position indicates the filament voltage of amplifier 4. The tenth position is not used; and the eleventh is designated OFF.

2.40 Jacks J1 and J2 mounted on the jack panel may be used to determine the signal levels at the inputs to the second and third modulators.

3. EQUIPMENT FEATURES

(A) General Information

3.01 The general construction and arrangement of the transmitting equipment is shown in Photographs A, B, and C, pages 101, 102, and 103, respectively, and on drawing ES-794688, page 104. The equipment is housed in two welded steel cabinets. One cabinet is a single relay rack in width so as to accommodate a single tier of standard 19-inch panels. The other cabinet is twice as wide so as to accommodate two tiers of apparatus. The low frequency equipment is mounted in the smaller unit and the larger unit houses the high frequency equipment and its associated power supplies. Removable mats on the front of each cabinet provide access to apparatus mounted between the mats and the panels.

3.02 A key-operated interlock system protects the operating personnel from accidental contact with dangerous potentials within the transmitter. The system is arranged as shown on ES-795100, page 114. Assuming the equipment to be operating, the keys are disposed as follows:

Key Tag D signation		Position
1-1	1-2	1-1, Service Switch Lock
2-1	2-2	2-1, Key Transfer Interlock
3-1	3-2	3-1, Key Transfer Interlock
4-1	4-2	4-1, Key Transfer Interlock
5-1	5-2	5-1, Key Transfer Interlock
6-1	6-2	6-1 or 6-2, as required

Not : The arrow indicates the direction in which the key passes when being used. All keys must be returned to the positions h re given before power may be applied.

The transmitter may be started or stopped and the frequency may be changed while the keys are in the positions given. The transmitter output may be connected either to the coaxial line terminals or to the antenna matching transformer. If access to the transmitter is desired, the service switch must be opened and the service switch key used to operate the lock designated 1-2 on the key transfer interlock. Any or all other keys in the key transfer interlock may be removed for use in opening the transmitter mats and door. The key to the service switch lock cannot be removed while any key is absent from the key transfer interlock. A similar lock and key on the output transfer switch prevents operation of the switch to the AMPLIFIER position while the key is removed from the lock. This feature prevents accidental application of radio frequency power to an associated power amplifier. The associated equipment should, of course, require the use of this key to gain access to components operating at dangerous potentials.

3.03 A typical key tag is shown on ES-795100. One side of each tag bears the lock designation numbers which the key operates and an arrow indicating the sequence of lock operation starting with the transmitter in condition for operation. The other side of each tag bears a brief description of the lock designation numbers. In the case illustrated, the key is intended for interlocking the service switch with the key transfer interlock.

3.04 The mat locks are provided with studs for installation of a seal, if desired. All meters have one slotless mounting screw to prevent removal of a meter without having removed the power. The transformers supplying rectifiers 1 and 2 are covered to afford protection while using the special 115-volt test lead required for some tests. The cover may be sealed, if desired.

3.05 Ventilating fans are mounted on the top of each unit (in ES-794688, page 104) to remove the heated air and to draw cool air through air vents at the bottom of the doors.

(B) Low Frequency Equipment

3.06 Photograph B, page 102, is a rear view of the interior of the transmitter. (Also see ES-794688, page 104.) Above the distribution panel in the low frequency cabinet (left unit) are two rectifier panels for supplying the filaments of amplifiers 2, 3 and 4. These are called rectifiers 5 and 6. Above these are the jack panel, rectifier 1, the first modulators, the crystal filters, the double sideband input panel, and the multi-circuit low frequency panel. Two attenuator panels are mounted at the top of the unit. A key panel, which is a sub-panel mounted between the multi-circuit low frequency panel and the front mat, is not shown in this photograph, but is shown in Photograph C, page 103.

(1) Rectifiers 5 and 6

3.07 Rectifiers 5 and 6 employ copper-oxide elements. These units are identical with the exception of the primary connection of their transformers. Rectifier 5 is supplied from the 115-volt circuit and the primary windings are connected in parallel whereas rectifier 6 is supplied from the 230-volt circuit and the primary windings are connected in series. Taps are provided on the secondaries of these transformers to permit adjustment of the output voltage to compensate for aging of the rectifier units. A choke coil and an 8,000-mfd dry electrolytic condenser filter the d-c output of each rectifier. Rectifier 5 supplies amplifiers 2 and 3. Rectifier 6 supplies the filaments of amplifier 4.

(2) Rectifier 1

3.08 Rectifier 1 supplies voltages for the equipment in this cabinet and grid bias for the low power high frequency unit and monitor panel. A W.E. 274A high vacuum rectifier tube is used.

(3) First Modulators and Crystal Filters

3.09 Modulators 1A and 1B are identical in appearance. W.E. 259A screen grid tubes are used. Potentiometers for carrier level, R6, and for carrier suppression, R7, are mounted on each panel. With modulator 1A is associated the D-156023 crystal filter, A, and with modulator 1B is associated the D-156024 crystal filter, B. The two filters are mounted back-to-back.

(4) Multi-Circuit Low Frequency Panel

3.10 Near the top of the low frequency unit is the multi-circuit low frequency panel. On this panel are mounted the 625 kc crystal oscillator, the multivibrator and its associated amplifiers, the 2,500 kc harmonic generator, the carrier resupply amplifier, the second modulator, and the modulator for combining the 125 kc and 2,500 kc frequencies to obtain a 2,625 kc frequency supply for the monitor. The 625 kc crystal oscillator uses an RCA 41 pentode, V1. A W.E. 7B quartz plate is employed. The multivibrator uses W.E. 244A triodes, V2 and V3, and the associated amplifier uses a W.E. 259A screen grid tube, V5. The 2,500 kc harmonic generator also uses a W.E. 259A screen grid tube, V7. A potentiometer, R27, is used to control its output. The adjustable-gain carrier resupply amplifier employs another W.E. 259A tube, V6. The gain adjustment potentiometer, CARRIER LEVEL, is operated from the front of the transmitter. The second modulator is similar to the first modulators except that there is no adjustment for balance. The modulator uses two W.E. 259A tubes, V8 and V9. Associated with the second modulator is a filter, one-half being mounted on this panel and the other half on the low power high frequency unit. The modulator for supplying 2,625 kc conversion frequency to the monitor employs a RCA 6L7G tube, V4.

(5) Attenuator Panels

3.11 Two attenuator panels, one for each channel, are provided. Each panel contains two H-type pads; one having a loss of 5 db, the other a loss of 14 db.

(6) Double Sideband Input Panel

3.12 The double sideband input equipment is mounted on a depressed panel located immediately below the multi-circuit low frequency panel. Control keys project through the front mat. Gain controls of the screwdriver adjustment type are accessible from the rear of the transmitter when the dust cover is removed. Four vacuum tubes are employed: two W.E. 262B, one W.E. 337A, and one W.E. 311A.

(C) High Frequency Equipment

3.13 The low power portion of the high frequency equipment is arranged in such a way that pre-tuned circuits and crystals for six frequencies may be available by means of selector switches. The pre-tuned circuits and crystals may be removed and other units inserted in the transmitter without disturbing the adjustments of the units. For tuning the high power portion of the equipment, continuously variable inductances are used. Hence, the transmitter may be adjusted to any one of six pre-determined frequencies without opening the doors.

3.14 Mounted on the left-hand side of the high frequency unit as viewed from the rear of the transmitter, viewed from bottom to top, are the monitor panel, the low power high frequency unit, the successive amplifier units, and the antenna matching transformer. The right-hand side is occupied by the voltage regulator for the 115-volt a-c circuits and rectifiers 2, 3 and 4. Rectifier 2 supplies the plate voltages for the monitor panel, the low power high frequency unit, and amplifier 2. Rectifier 3 supplies grid bias potential for the power amplifier stages. Rectifier 4 is a 3,000-volt rectifier supplying amplifiers 3, 4 and 5, and is controlled by the 3,000-VOLT CONTROL switch. The screen voltage regulator and resistance panel makes up the remainder of the equipment on this side of the unit.

(1) Low Power High Frequency Unit

3.15 The low power high frequency unit contains the high frequency crystal oscillator, harmonic generator, 2,625 kc amplifier, third modulator and amplifier 1, as well as the crystal frequency amplifier for supplying the crystal oscillator frequency to the monitor panel. This unit is constructed on a removable chassis. Power supply leads are connected by means of a multi-circuit plug and a receptacle arrangement and the various leads are filtered at the point where they enter the unit. The 2,625 kc sideband input is brought in through a concentric-type plug and jack to maintain effective shielding. The output connection is made to the grid of the tube in amplifier 2. The tube is inserted from the low power high frequency unit into an inverted socket in the unit above. Three controls are brought out of the low power high frequency unit: one is the CRYSTAL SELECTOR switch which may select the desired one of six crystals in the unit; the center control is the TUNED CIRCUIT SELECTOR, which selects the proper tuned circuits in the harmonic generator, modulator 3, and amplifier 1 plate circuits; and the third control, OUTPUT HARMONIC GENERATOR to provide a control of the amount of conversion frequency supplied to the third modulator. The plate current of the modulator 3 screen grid tube is indicated on the I_p MODULATOR NO. 3 meter. The meter designated e_p AMPLIFIER NO. 1 is an output peak voltmeter for that amplifier. W.E. 5AA quartz plates are used in the high frequency crystal oscillator.

3.16 The vacuum tubes used in the low power high frequency unit are as follows:

V1 Crystal Oscillator	RCA 41 Pentode
V2 Harmonic Generator	RCA 6C6 Pentode
V3 2,625 kc Amplifier	RCA 6C6 Pentode
V4 Modulator 3	RCA 36 Screen Grid
V5 Amplifier 1	RCA 6B7 Duo-Diode Pentode
V6 Crystal Frequency Amplifier	RCA 6D6 Pentode

(2) Power Amplifiers and Antenna Matching Transformer

3.17 The amplifier 2 unit contains the socket and supply circuits of the W.E. 311A pentode, V1, of amplifier 2; the plate circuit of amplifier 2; the grid circuits of amplifier 3; and the sockets for the amplifier 3 tubes, V2 and V3. The cathode current of V1 is indicated on the I_s AMPLIFIER NO. 2 meter. In the plate circuit of amplifier 2 there may be up to six plug-in pre-tuned circuits, any one of which may be switched into place by means of the TUNED CIRCUIT SELECTOR AMPLIFIER NO. 2 switch.

3.18 The tubes used in amplifier 3 are W.E. 332A pentodes. They project through into the amplifier 3 assembly from their sockets in the unit below. Grid bias for this stage is obtained from rectifier 3, and a potentiometer for adjustment of the bias voltage is provided on the rectifier panel. The plate and screen power is supplied by rectifier 4. Screen bias is supplied through the screen supply regulator. The plate circuit of this amplifier employs continuously variable inductances for tuning. Two modified W.E. 15B inductances are operated through a set of gears from a common control designated INDUCTANCE AMPLIFIER NO. 3. A counter geared to this control indicates the position of the inductance. Four pairs of load resistances are provided. The required pair of loading resistances may be selected by the OUTPUT LOADING AMPLIFIER NO. 3 switch. The I_s AMPLIFIER NO. 3 meter indicates the total plate and screen current of the stage. The sockets for the tubes of amplifier 4 are mounted in the amplifier 3 unit; but the tubes are inserted through the amplifier 4 assembly. The tube type is the same and the mechanical arrangement of the circuit is only slightly different from that of amplifier 3. The I_s AMPLIFIER NO. 4 meter indicates the total plate and screen current of the stage.

3.19 W.E. 279A triodes are used in amplifier 5. The same type of output circuit is used for this amplifier stage as is used in amplifiers 3 and 4. The cam switch mounted in the center of this unit is a multiple-cam type, designated FREQUENCY RANGE, AMPLIFIER NO. 5, which in one operation adds capacity to both the high and low impedance ends of the circuit. There is an arrangement on the INDUCTANCE AMPLIFIER NO. 5 gearing mechanism to allow a differential of $\pm$ 1/2 turn in the settings of the two inductances. The current drawn by this stage is indicated by the I_s AMPLIFIER NO. 5 meters. A NEUTRALIZE AMPLIFIER NO. 5 adjustment is provided for this amplifier. An RCA 25Z5 rectifier tube is associated with the OUTPUT INDICATOR AMPLIFIER NO. 5 meter as a peak voltmeter. A key mounted directly underneath this meter makes two ranges of the peak voltmeter available.

3.20 The amplifier 5 output circuit is arranged to operate into the 200-ohm impedance presented by a balanced coaxial line. However, if it is desired to operate this equipment directly into an open-wire line, the antenna matching transformer may be used. An OUTPUT TRANSFER switch connects the output of the transmitter to the coaxial line terminals or to antenna matching transformer. The transformer is provided with tuning controls, OUTPUT TRANSFORMER INDUCTANCE and OUTPUT TRANSFORMER CAPACITANCE, and is connected to outlet bushings on the top of the transmitter.

(3) Monitor Panel

3.21 A small amount of the output power is picked up by a monitor loop loosely coupled to inductance L4 in amplifier 5. The energy so derived is passed through a coaxial conductor to the monitor panel. In case it is desired to check the operation of additional power amplifier stages following this equipment, provision is made for additional pickup loops; the desired one of which may be selected by the INPUT SELECTOR MONITOR switch on the monitor panel. A condenser, designated INPUT ATTENUATOR MONITOR, is provided for controlling the input level. The OUTPUT MONITOR H.G. adjustment is for regulating the conversion frequency voltage applied to the first demodulator, and the meter designated first DETECTOR MONITOR provides an indication of the level of the introduced voltage. The audio-frequency output of the monitor appears at the MONITOR jack on the front mat for monitoring with head telephones, and it may also be connected to jacks on the terminal room test board.

3.22 The vacuum tubes used in the monitor are as follows:

V1 Harmonic Generator	RCA 36	Screen Grid
V2 2,625 kc Amplifier	RCA 6D6	Pentode
V3 1st Demodulator	RCA 36	Screen Grid
V4 2nd Demodulator	RCA 76	Triode
V5 2nd Demodulator	RCA 76	Triode

(D) Rectifiers and Voltage Regulators

3.23 Rectifier 2, for plate voltage supply to the lower powered units, employs a W.E. 274A high vacuum rectifier tube. The rectifier is mounted on the right side of the high frequency cabinet, as viewed from the rear, above the voltage regulator for the 115-volt a-c circuits.

3.24 Rectifier 3, for grid bias supply, employs a W.E. 274A high vacuum rectifier tube, V1. It is mounted just above rectifier 2. A voltage regulator tube, V2, is connected across a portion of the potentiometer supplying grid bias to amplifiers 3 and 4.

The regulator tube is an RCA 874. Adjustable potentiometers, R1 and R2, afford a manual adjustment of the bias on amplifiers 4 and 3, respectively.

3.25 Rectifier 4 is mounted on panels A, B and C. On panel A are mounted the main supply fuses in the 230-volt supply, the time delay relay, the contactor controlling the 230-volt supply and one of the plate transformers. On panel B are mounted the other two plate supply transformers. The fuses in the transformer secondary circuits are mounted between panels B and C. The mercury vapor rectifier tubes, W.E. 267B vacuum tubes, are mounted on panel C with the filament supply transformer, T4, and the filter reactor, L1. On the mat side of the panel, between the panel and the mat, is mounted the voltmeter multiplier, R1, for the 3,000-VOLT SUPPLY voltmeter. Condensers for the high voltage filter are mounted on the mat side of the screen supply regulator panel at the top of the cabinet. The 3,000-VOLT CONTROL switch for this rectifier appears on the front of the set.

3.26 On the screen supply regulator panel, in addition to the regulator, are mounted resistances, R5 and R6, for the circuits of amplifiers 3 and 4, respectively. R2 is a current limiting resistance in the filter circuit. The screen supply regulator consists of the regulator tube, V1, which is a W.E. 212E tube, and a potentiometer, R1, R3, and R4. Adjustment of the screen bias supply is provided by the variable potentiometer, R1. A filter, consisting of choke, L1, and condenser, C6, reduces the ripple on the output of the regulator.

3.27 A voltage regulator for maintaining the constancy of the 115-volt supply to the low power equipment is mounted below rectifier 2. A 230/115-volt transformer mounted on the mat side of this panel supplies 115 volts from the 230-volt input. An arrangement is provided for connecting an external source of 115 volts to the low power circuits with the doors of the set unlocked. This arrangement includes a special test lead and a polarized connector mounted on the distribution panel at the bottom of the rack, just below the voltage regulator. A fuse, F1, in the 115-volt circuit, is mounted on the same panel.

3.28 A double scale, 0-35 and 0-350 volt d-c voltmeter and an associated multi-point switch, are provided on the front of the transmitter for reading the lower supply voltages. Their designations are LOW VOLTAGE SUPPLIES and VOLTMETER SWITCH, respectively.

4. TRANSMISSION CHARACTERISTICS

(A) Input Volume Level

4.01 The speech volume required at the input terminals of each channel is +5 vu into an impedance of 600 ohms. The 1,000-cycle test tone power required is 1 milliwatt.

(B) Audio-Frequency Response

4.02 Typical audio-frequency characteristics of the two channels are shown on ES-794933 and ES-794934, pages 109 and 110, respectively.

(C) Signal-to-Distortion Ratio

4.03 The level of one of the third-order distortion products resulting from intermodulation of two input tones (1,000 and 1,580 cycles) of equal level is more than 25 db below either input tone for any volume of input tone below +5 db referred to 1 milliwatt.

(D) Signal-to-Noise Ratio

4.04 The unweighted signal-to-noise ratio is in excess of 50 db for single-sideband transmission.

5. TUBE AND FUSE LISTS

(A) Tube List

5.01

Unit	Designation	Type
Multi-Circuit Low Frequency Unit	V1	RCA 41
	V2	WE 244A
	V3	WE 244A
	V4	RCA 6L7G
	V5	WE 259A
	V6	WE 259A
	V7	WE 259A
	V8	WE 259A
	V9	WE 259A
Modulator 1A	V1	WE 259A
	V2	WE 259A
Modulator 1B	V1	WE 259A
	V2	WE 259A
Rectifier 1	V1	WE 274A
Monitor	V1	RCA 36
	V2	RCA 6D6
	V3	RCA 36
	V4	RCA 76
	V5	RCA 76

Unit	Designation	Type
Double Sideband Panel	V1	WE 262B
	V2	WE 262B
	V3	WE 337A
	V4	WE 311A
Low Power High Frequency Unit	V1	RCA 41
	V2	RCA 6C6
	V3	RCA 6C6
	V4	RCA 36
	V5	RCA 6B7
	V6	RCA 6D6
Amplifier 2	V1	WE 311A
	V2	WE 332A
	V3	WE 332A
Amplifier 3	V1	WE 332A
	V2	WE 332A
Amplifier 5	V1	WE 279A
	V2	WE 279A
	V3	RCA 25Z5
Rectifier 2	V1	WE 274A
Rectifier 3	V1	WE 274A
	V2	RCA 874
Rectifier 4	V1	WE 267B
	V2	WE 267B
	V3	WE 267B
	V4	WE 267B
	V5	WE 267B
	V6	WE 267B
Screen Supply Regulator	V1	WE 212E

(B) Fuse List

5.02

Unit	Designation	Information
Rectifier	F1) F2) F3)	15 amp., 250 V D & W Fuse, Cat. #91138
	F4) F5) F6)	2 amp., 2,500 V D & W Western Union Fuse
High Frequency Distribution Panel	F1	5 amp., 250 V D & W Fuse, Cat. #91127
Double Sideband Input Panel	F1	1 amp. Littlefuse Type 3AG

6. PHOTOGRAPHS, DRAWINGS AND REFERENCES

(A) Photographs

	Supplementary Page
D-156000 Radio Transmitter, Front View	101
D-156000 Radio Transmitter, Rear View, Doors Open	102
D-156000 Radio Transmitter, Front View, Mats Removed	103

(B) Drawings

(C) References

R70.310, "Weston Model 686, Type 7, Vacuum Tube Test Set."

D-156000 Radio Transmitter, Installation and Assembly Information, Volume II.

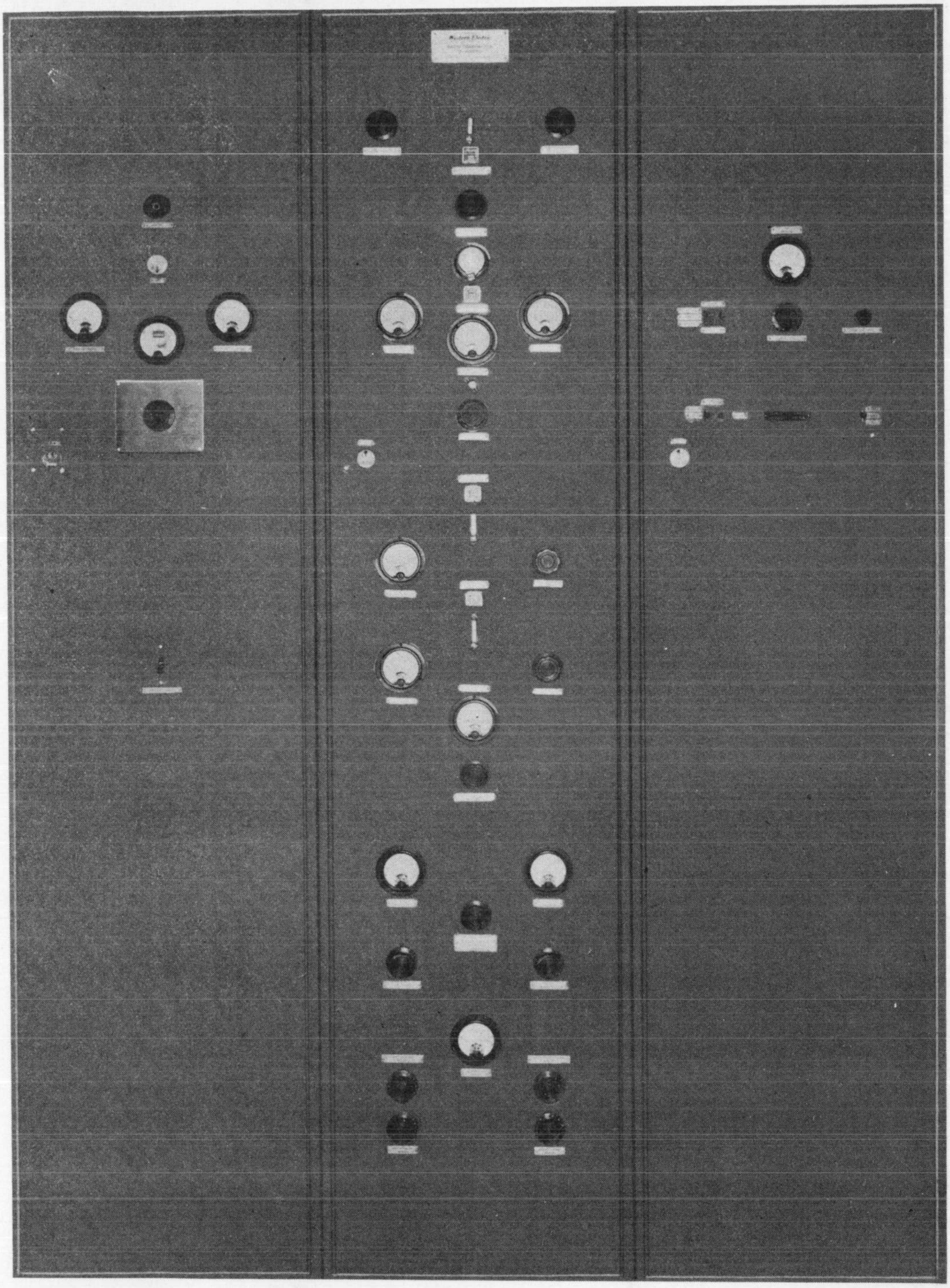
Factory Test Data.

The equipment described in this bulletin was designed and developed for the

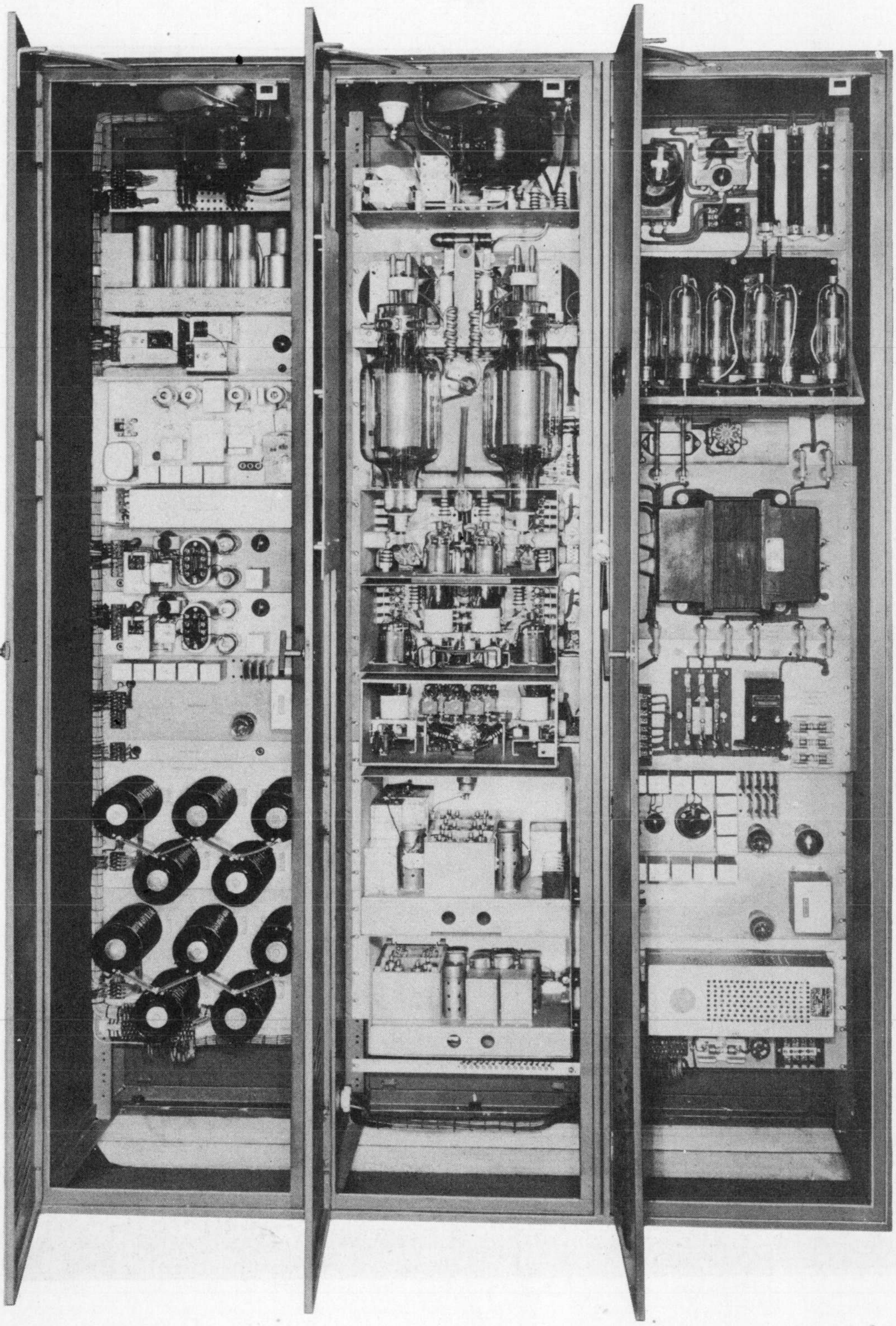
Western Electric Company

by

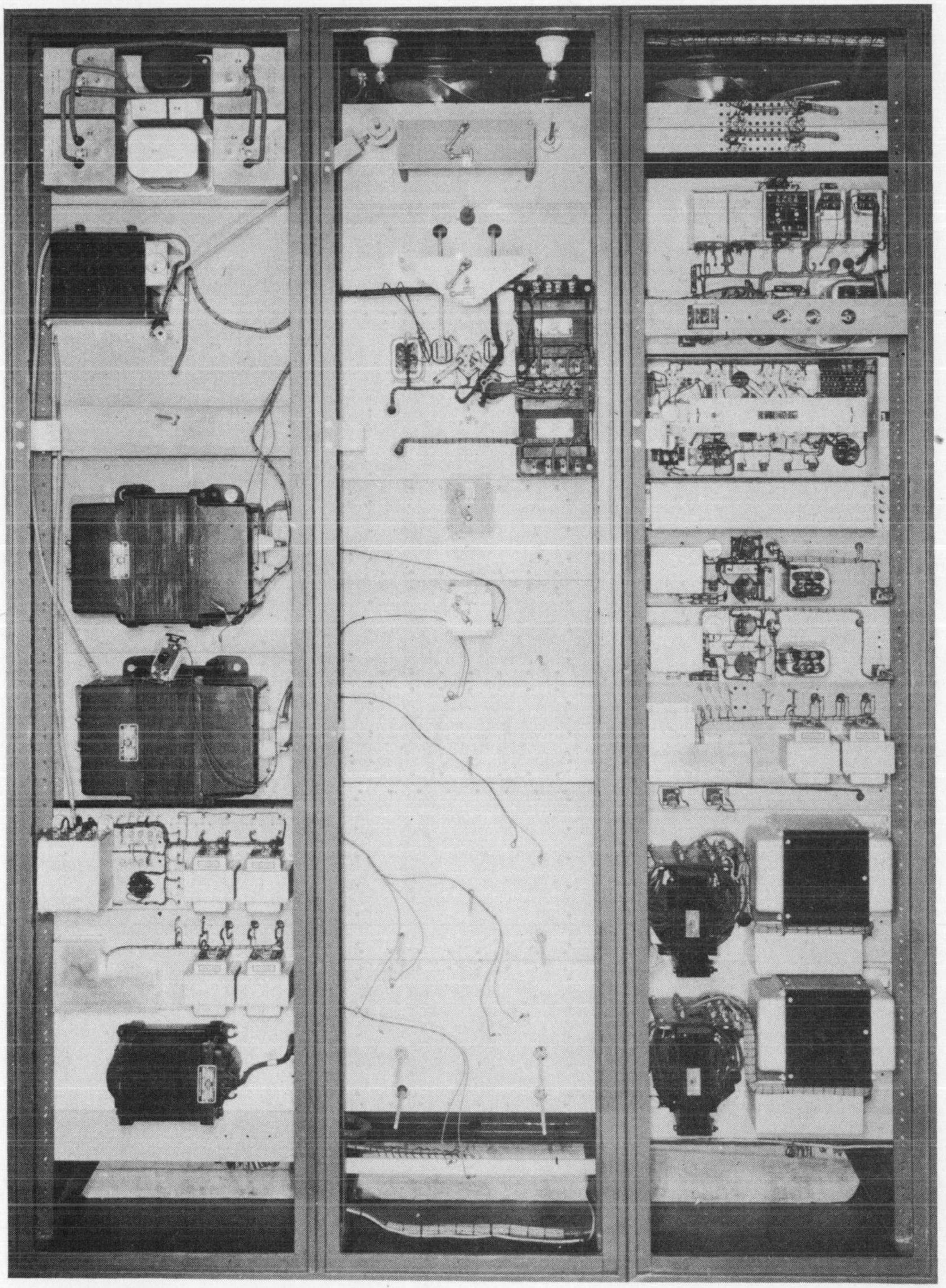
BELL TELEPHONE LABORATORIES



D-156000 Radio Transmitter - Front View 89725



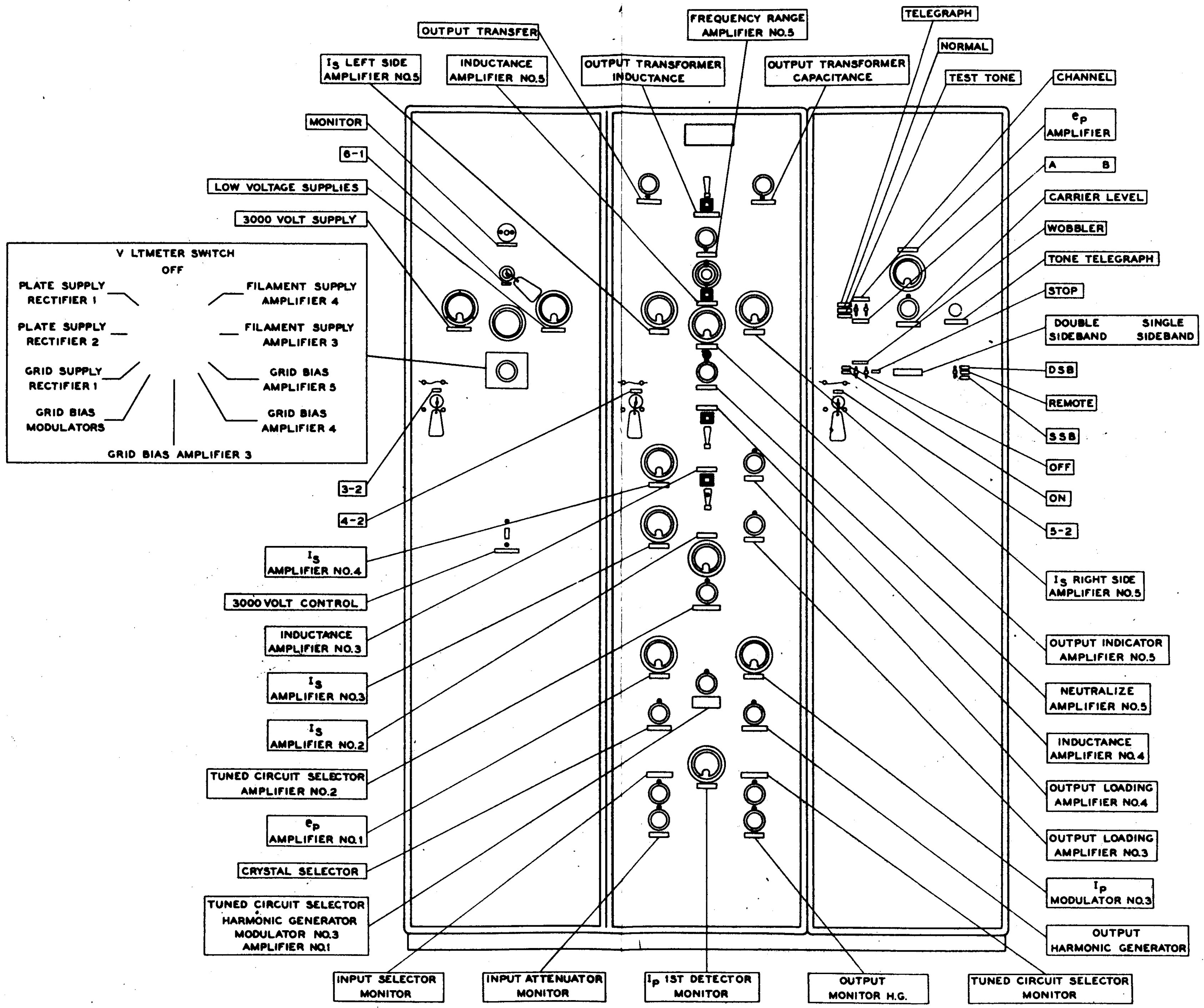
89722 D-156000 Radio Transmitter, Rear View, Doors Open



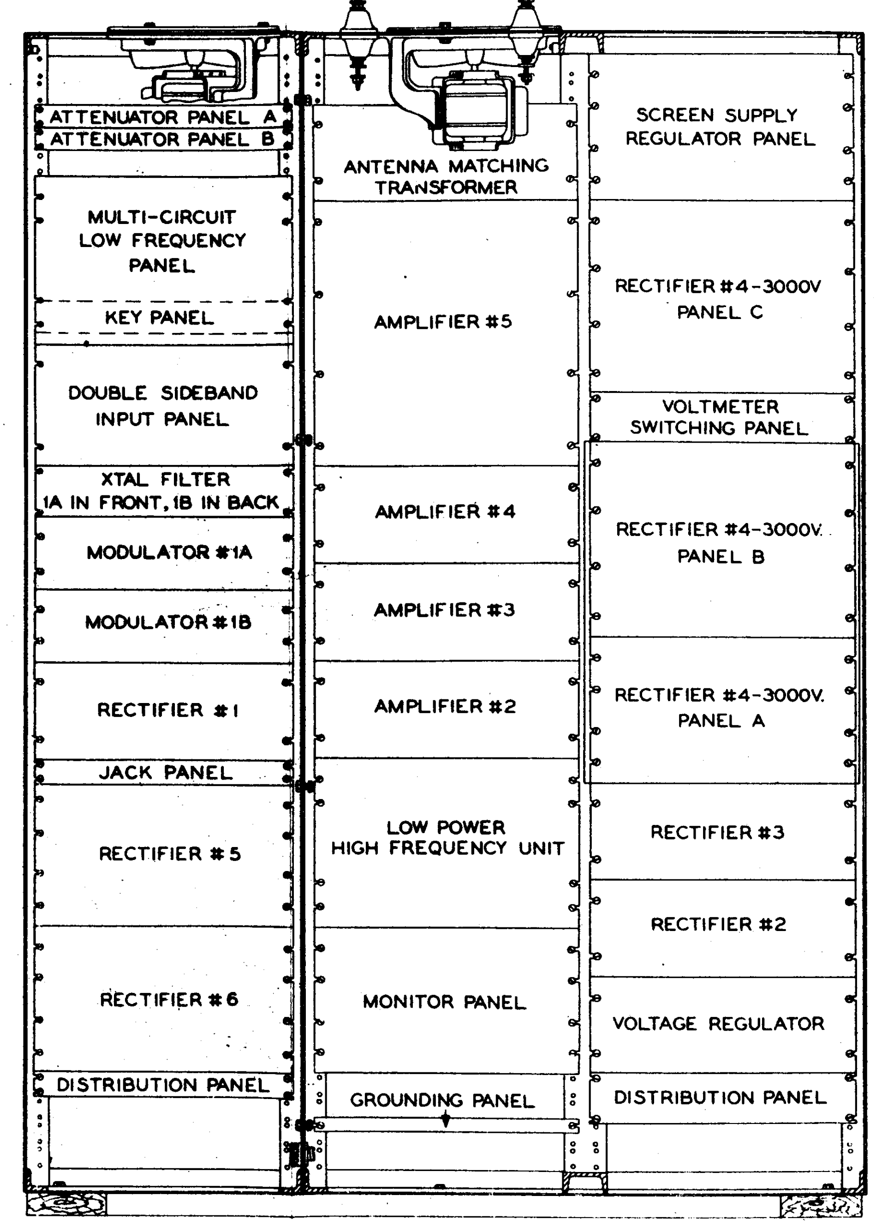
D-156000 Radio Transmitter, Front View, Mats Removed 89726

D-156000 RADIO TRANSMITTER

LOCATION OF CONTROLS AND PANELS

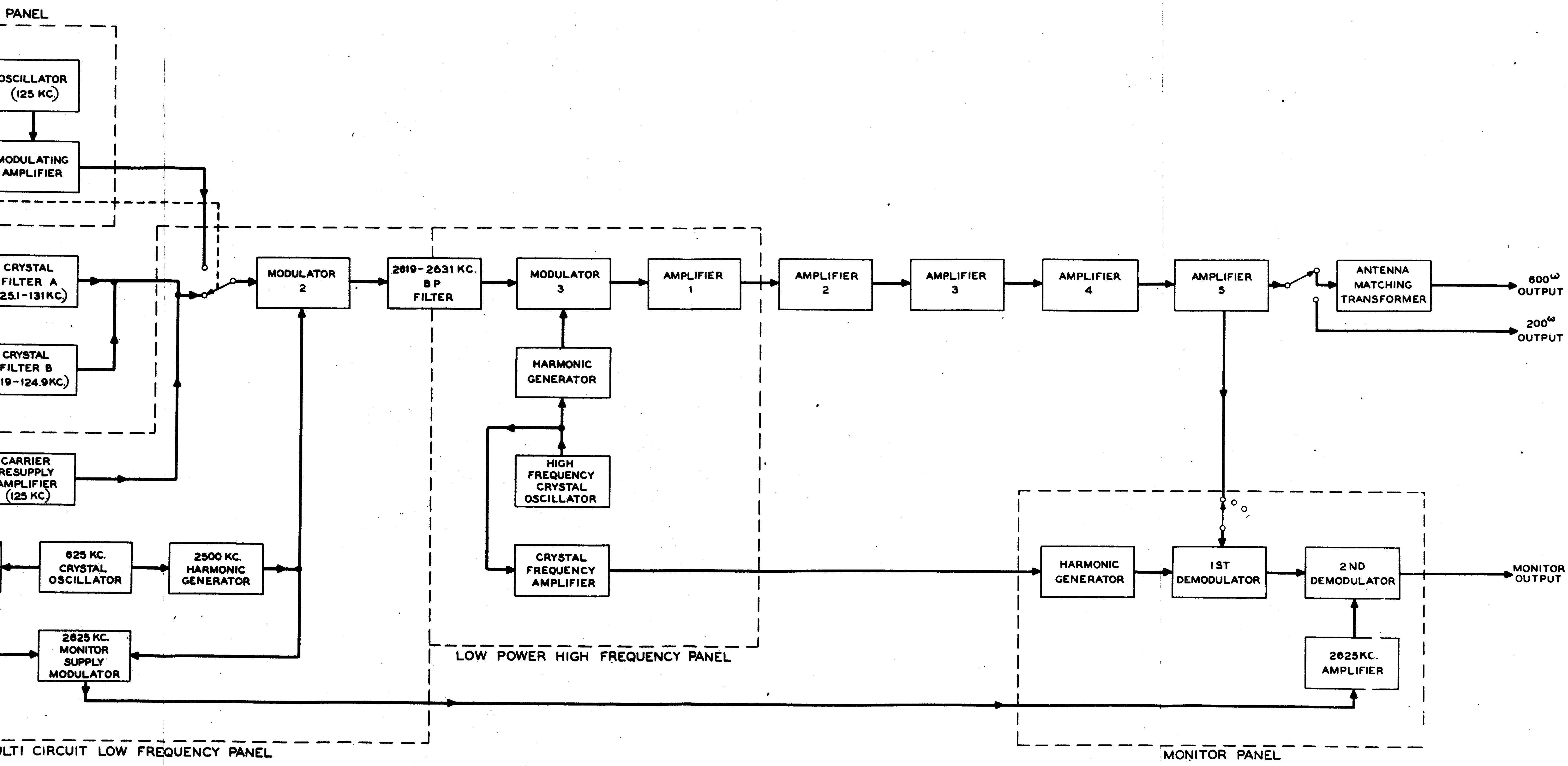


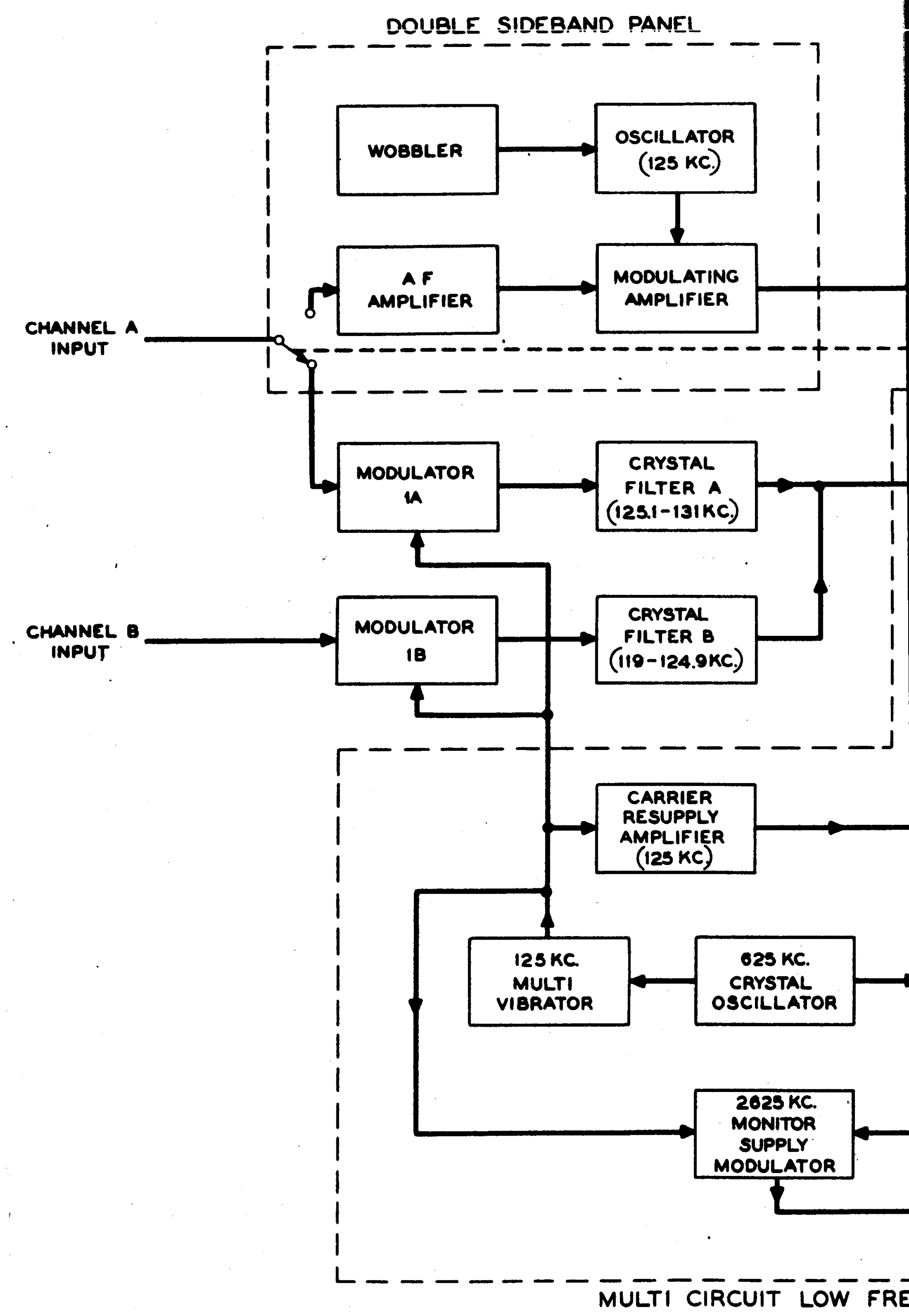
FRONT VIEW, CONTROL LOCATION

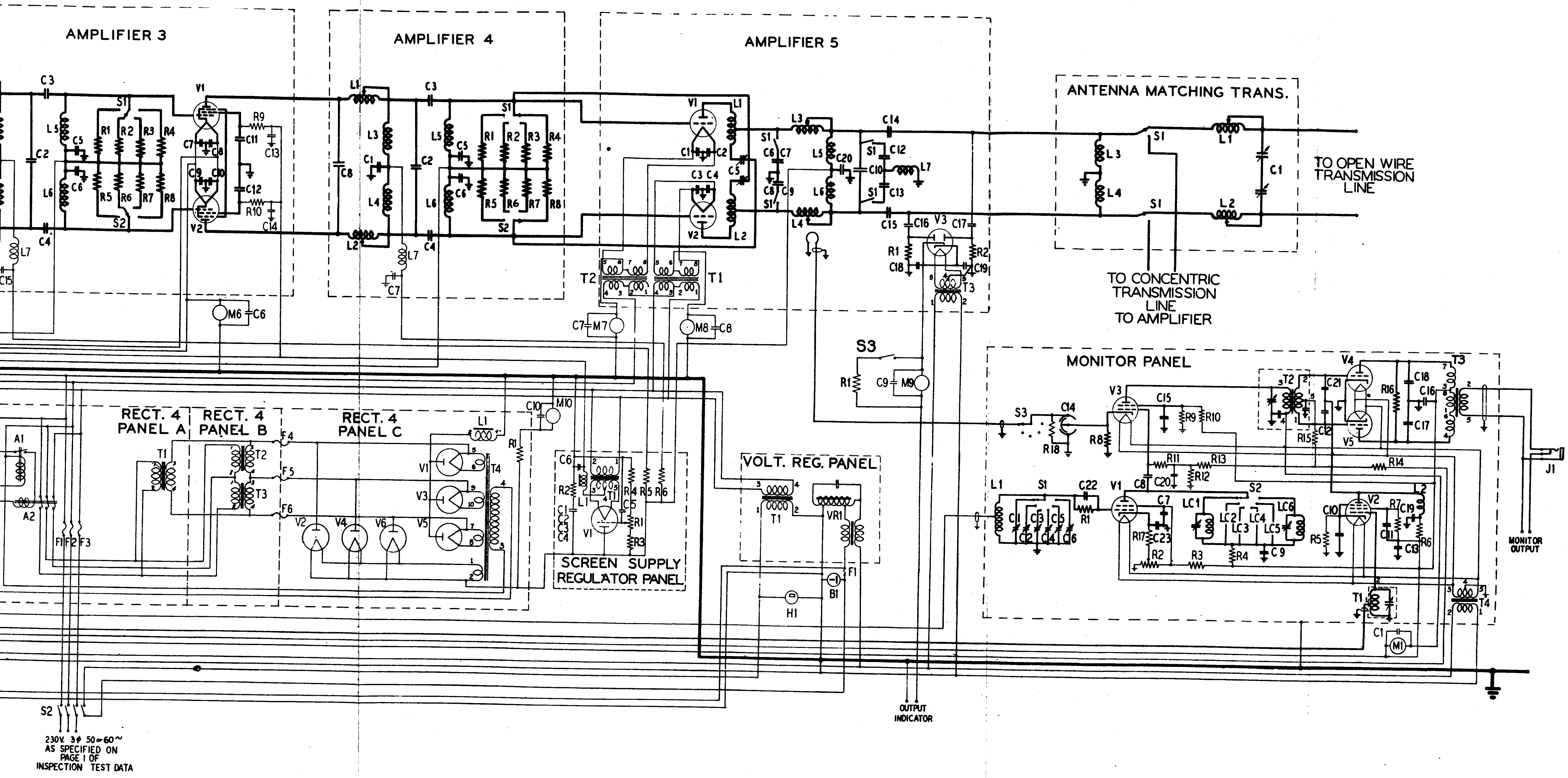


REAR VIEW, PANEL LOCATION

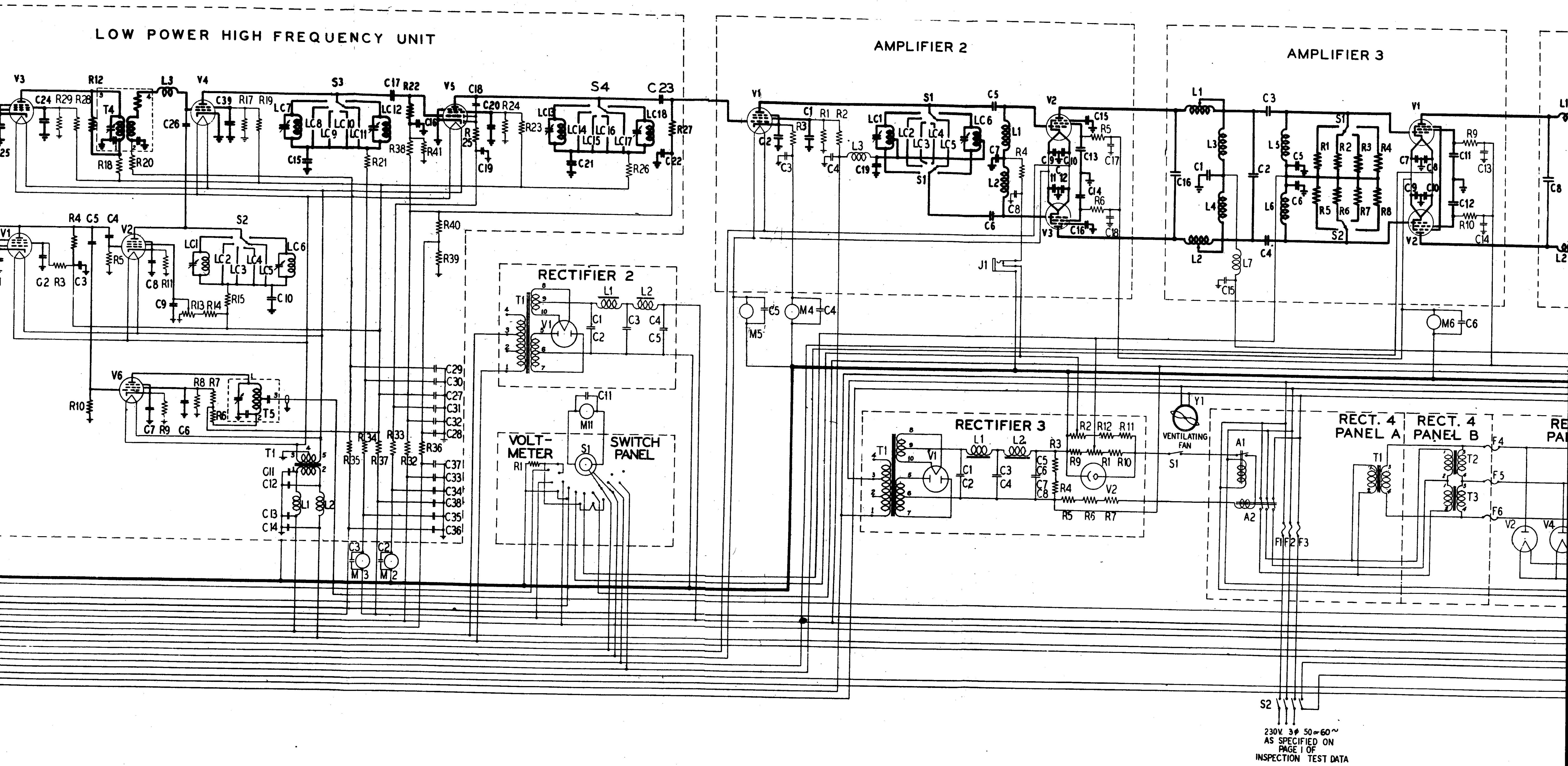
D-156000 RADIO TRANSMITTER
BLOCK DIAGRAM



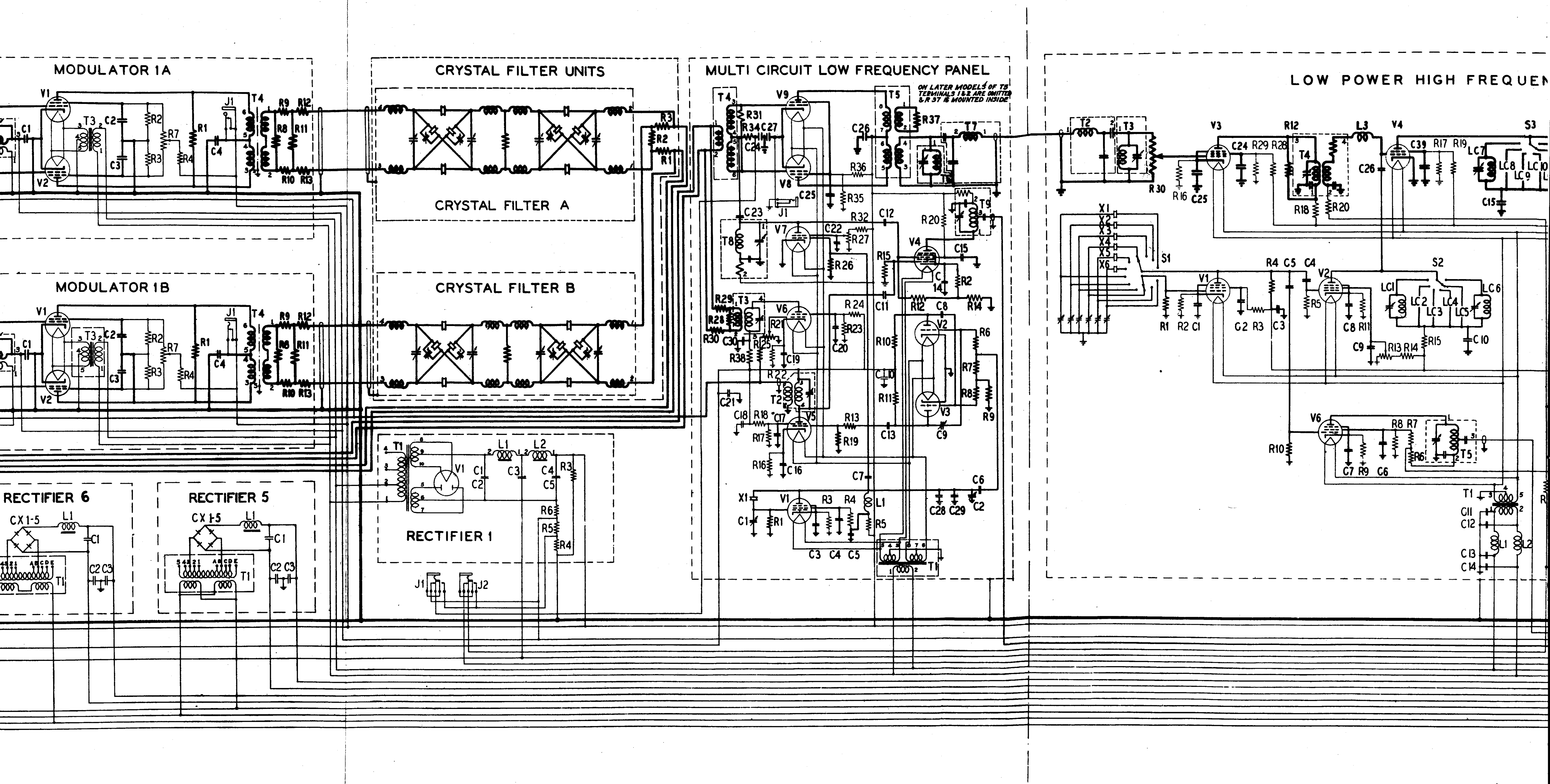

DOUBLE SIDEBAND PANEL
WOBBLER
OSCILLATOR (125 KC.)
A F AMPLIFIER
MODULATING AMPLIFIER
CHANNEL A INPUT
CHANNEL B INPUT
MODULATOR 1A
MODULATOR 1B
CRYSTAL FILTER A (125.1-131 KC.)
CRYSTAL FILTER B (119-124.9 KC.)
CARRIER RESUPPLY AMPLIFIER (125 KC.)
125 KC. MULTI VIBRATOR
625 KC. CRYSTAL OSCILLATOR
2625 KC. MONITOR SUPPLY MODULATOR
MULTI CIRCUIT LOW FRE



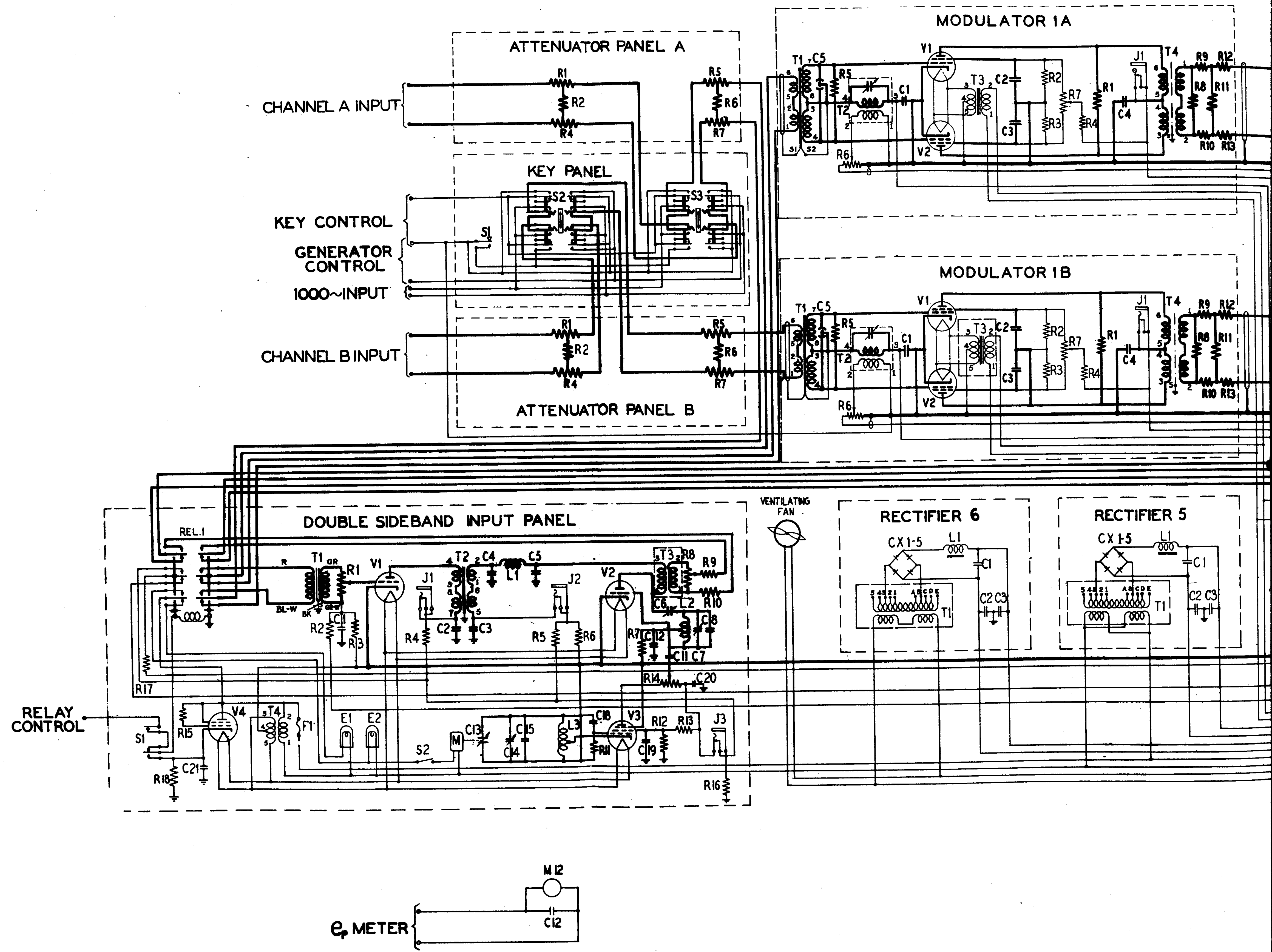
ESXX-782860
Issue 14



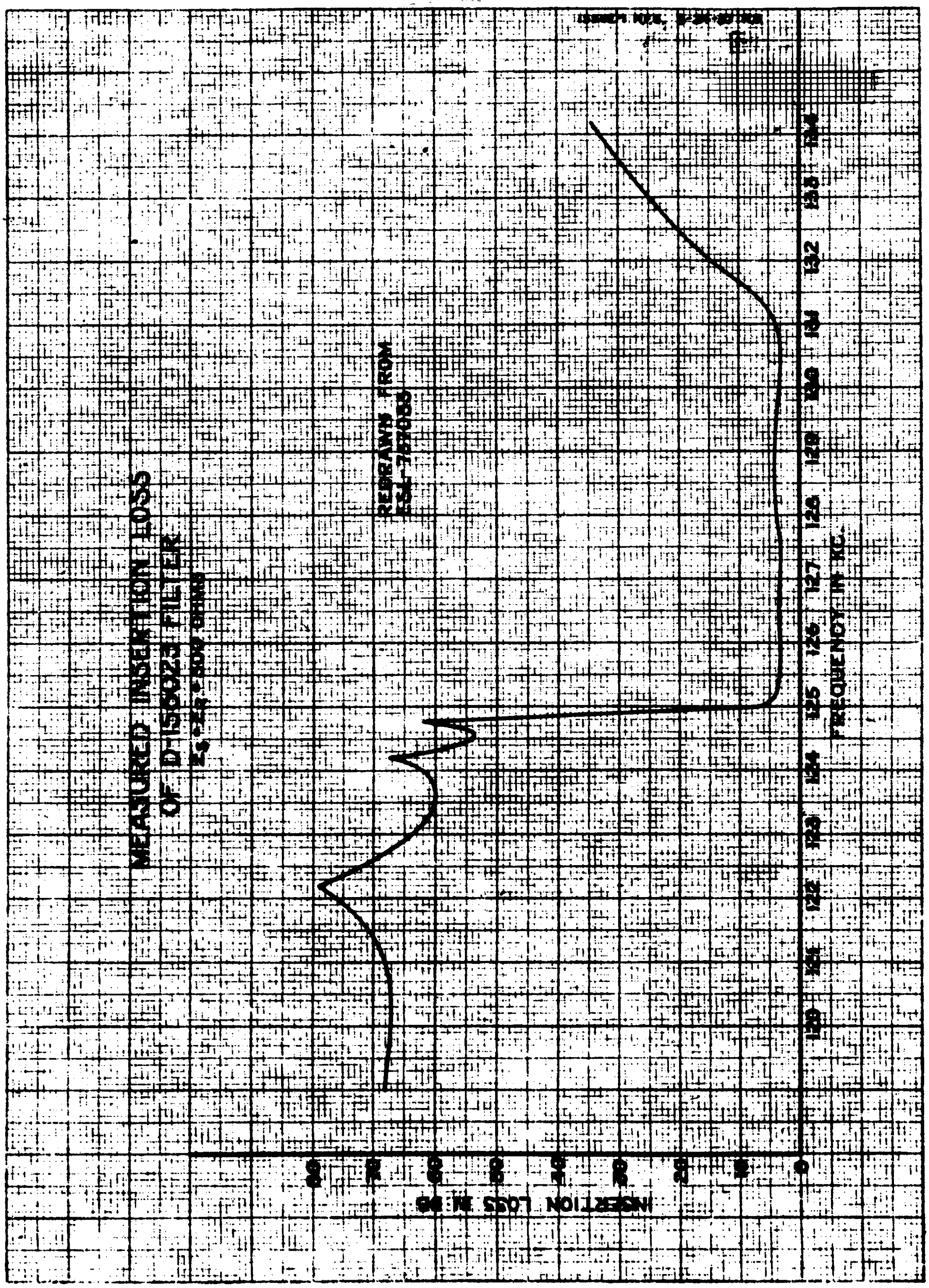
LOW POWER HIGH FREQUENCY UNIT
AMPLIFIER 2
AMPLIFIER 3
RECTIFIER 2
RECTIFIER 3
VOLT-METER
SWITCH PANEL
VENTILATING FAN
RECT. 4 PANEL A
RECT. 4 PANEL B
230V. 3φ 50~60~ AS SPECIFIED ON PAGE I OF INSPECTION TEST DATA

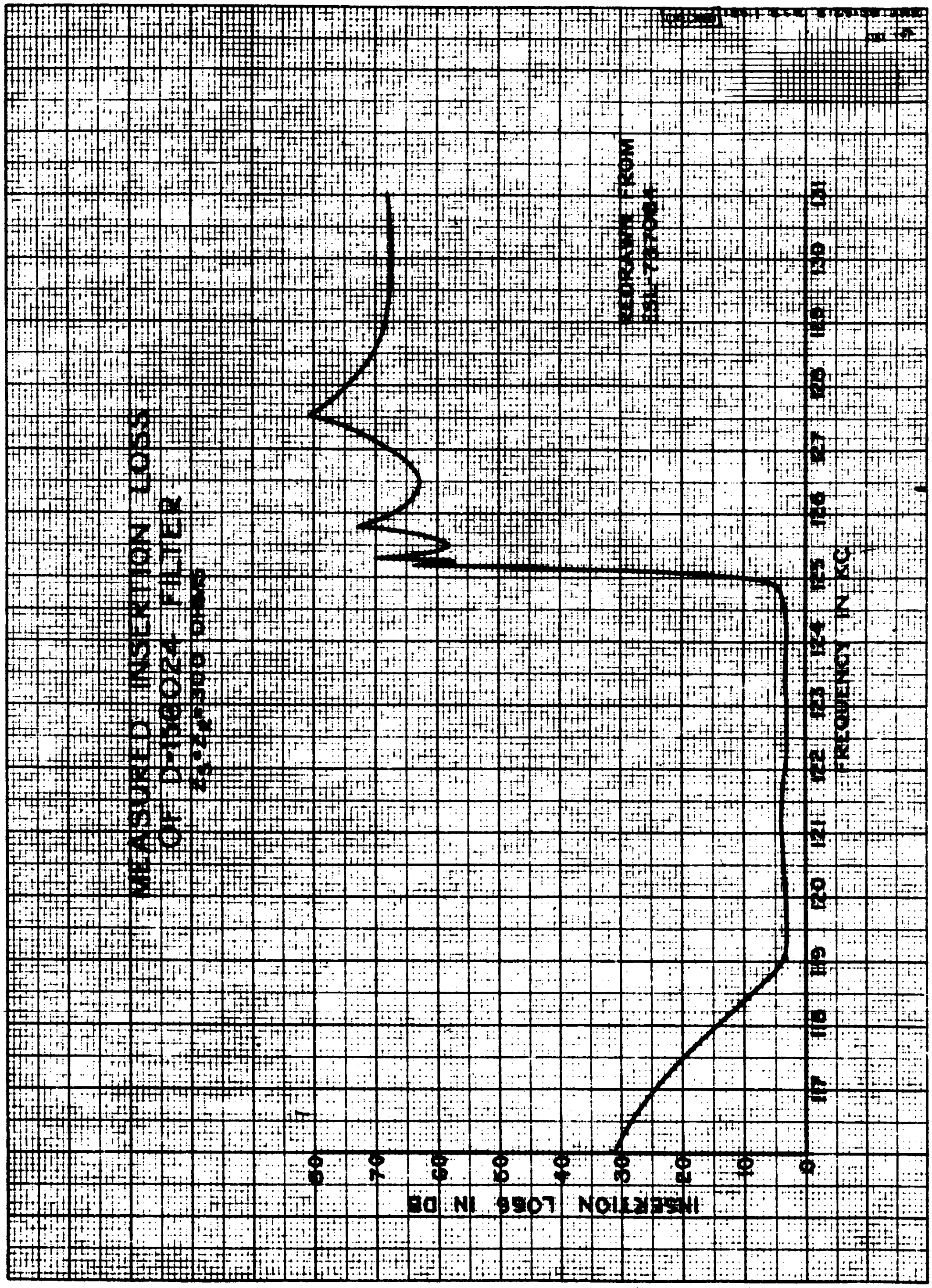


MODULATOR 1A
MODULATOR 1B
CRYSTAL FILTER UNITS
CRYSTAL FILTER A
CRYSTAL FILTER B
MULTI CIRCUIT LOW FREQUENCY PANEL
ON LATER MODELS OF T5 TERMINALS 1 & 2 ARE OMITTED & R 37 IS MOUNTED INSIDE
LOW POWER HIGH FREQUEN
RECTIFIER 6
RECTIFIER 5
RECTIFIER 1



MODULATOR 1A
MODULATOR 1B
ATTENUATOR PANEL A
KEY PANEL
ATTENUATOR PANEL B
CHANNEL A INPUT
KEY CONTROL
GENERATOR CONTROL
1000~INPUT
CHANNEL B INPUT
DOUBLE SIDEBAND INPUT PANEL
VENTILATING FAN
RECTIFIER 6
RECTIFIER 5
RELAY CONTROL
e_p METER

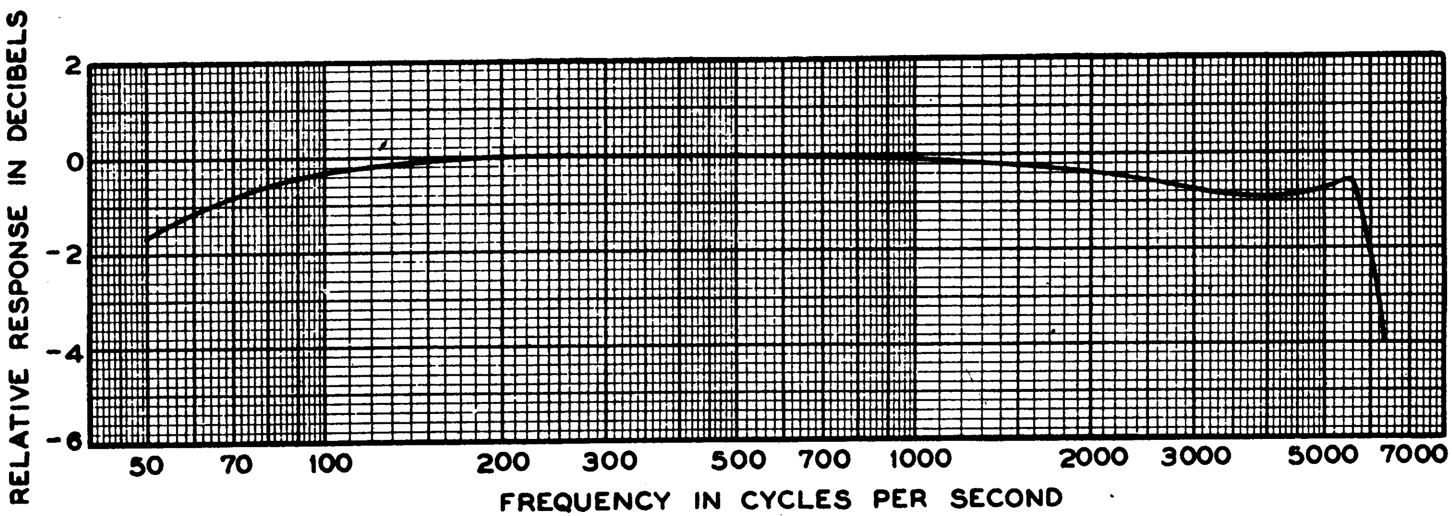

MEASURED INSERTION LOSS
OF D-156023 FILTER
REDRAWN FROM
FREQUENCY IN KC.
INSERTION LOSS IN DB


MEASURED INSERTION LOSS
INSERTION LOSS IN DB
0
10
20
30
40
50
60
70
80
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
FREQUENCY IN KC
REDRAWN FROM

D-156000 RADIO TRANSMITTER

TYPICAL AUDIO FREQUENCY RESPONSE CHARACTERISTIC

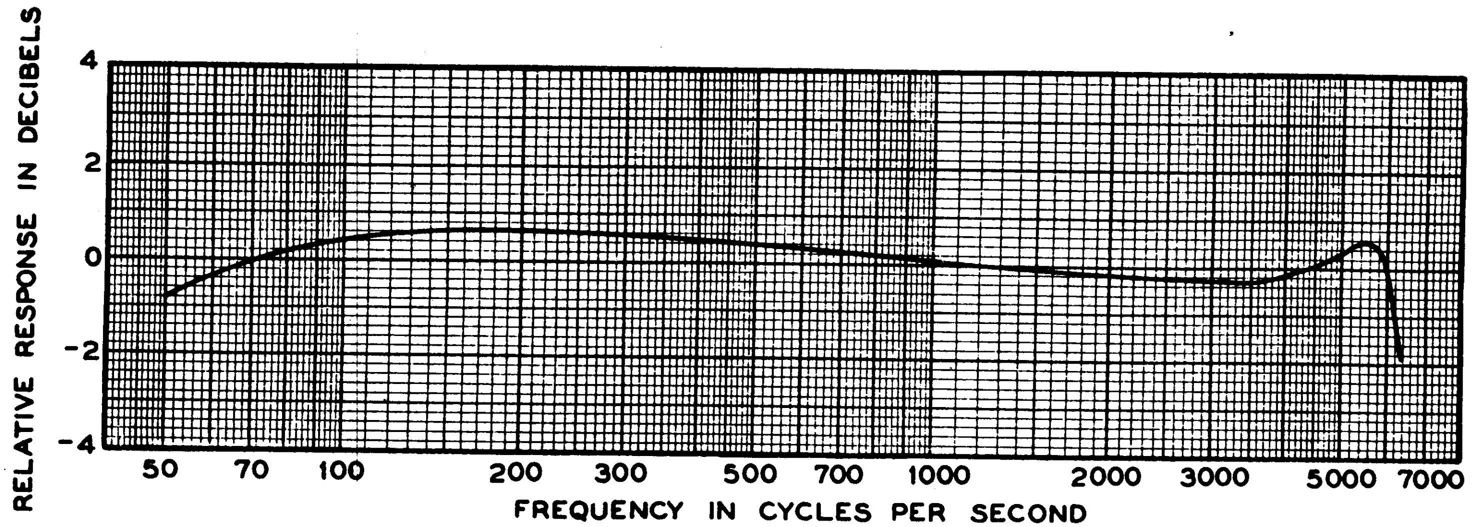
CHANNEL A



D-156000 RADIO TRANSMITTER

TYPICAL AUDIO FREQUENCY CHARACTERISTIC

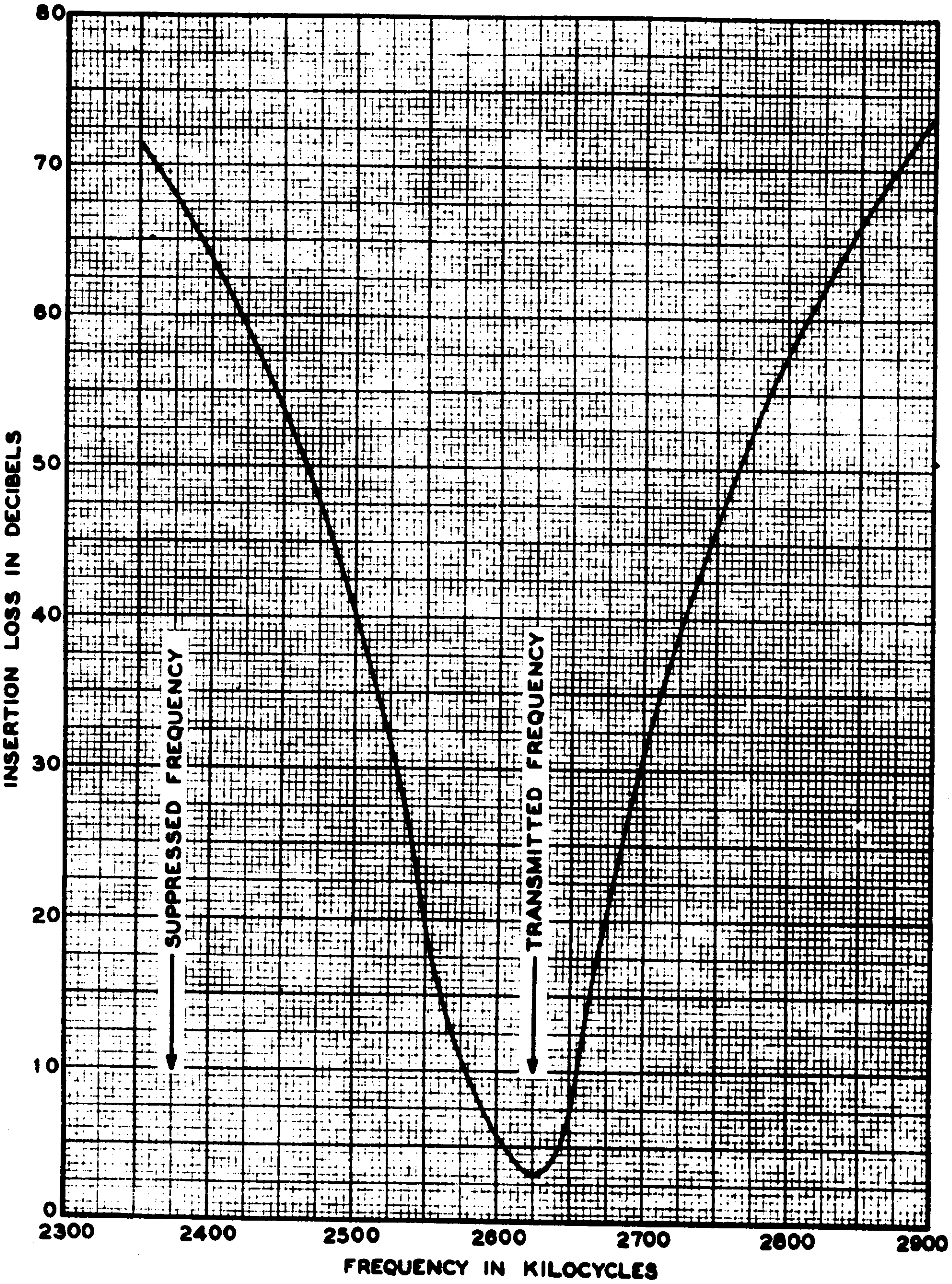
CHANNEL B



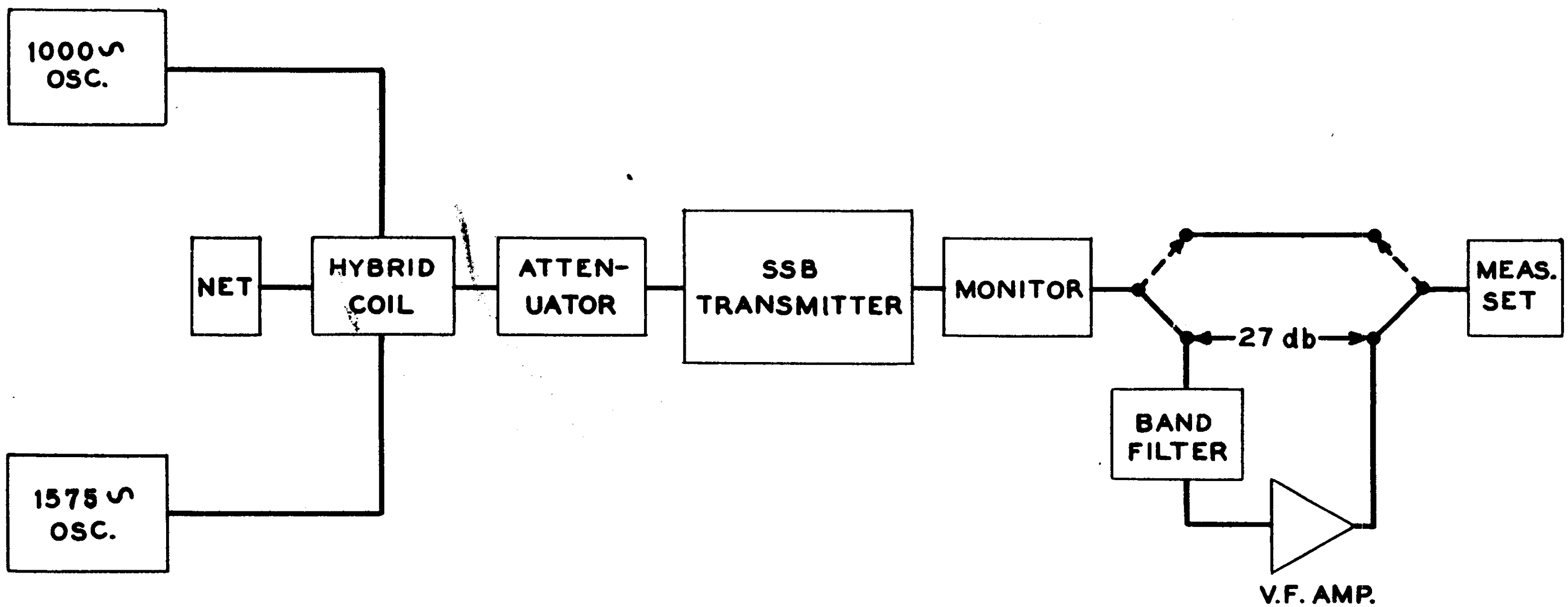
ES-794935
L.R.R. 5-1-40

TYPICAL INSERTION LOSS CHARACTERISTIC OF 2625KC. FILTER

PAGE 111



ARRANGEMENT OF EQUIPMENT FOR TWO-TONE DISTORTION MEASUREMENTS



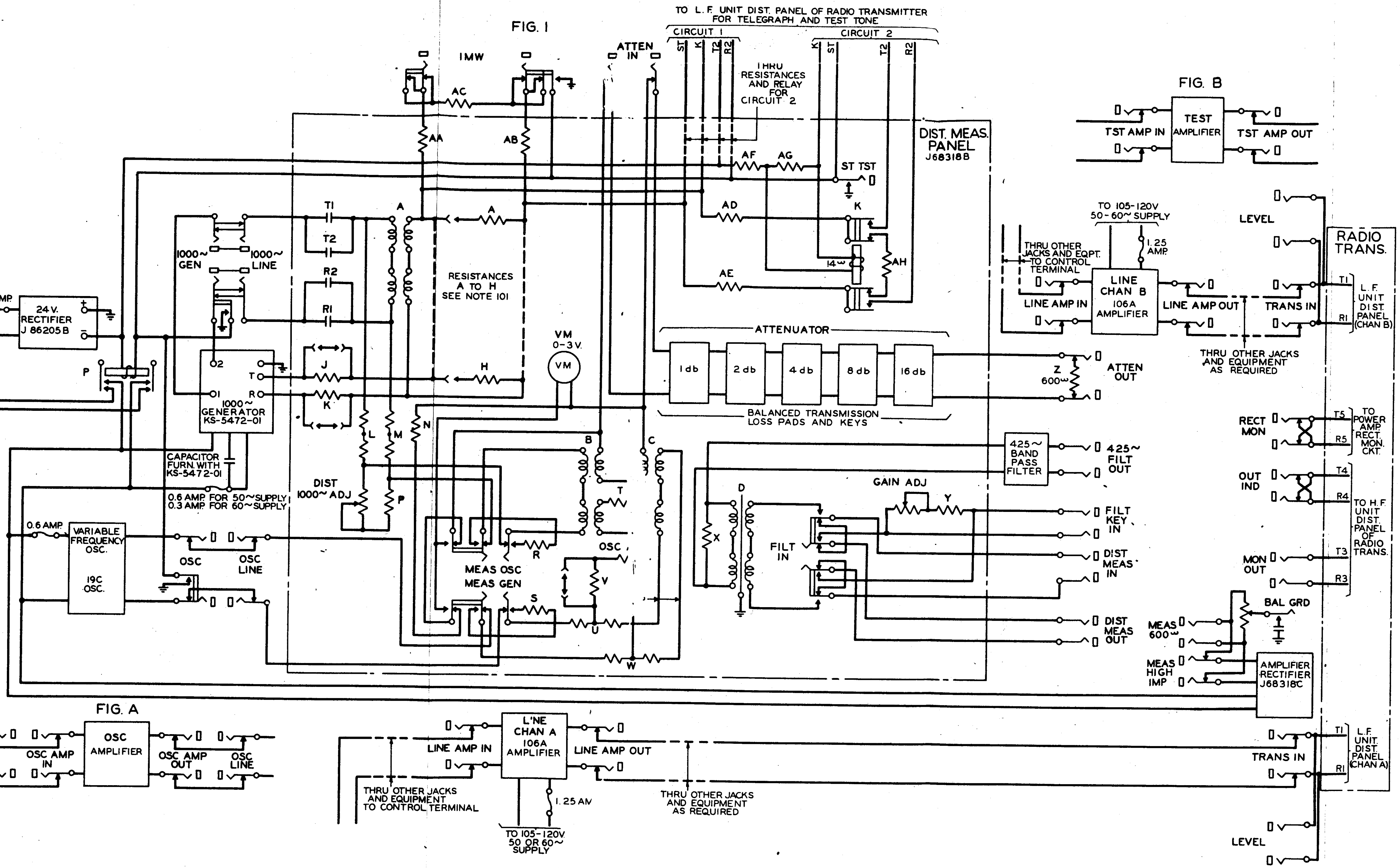


FIG. 2
PATCHING NOTES

	FROM	TO
I	DISTORTION MEASURING - SINGLE SIDE BAND	
	FROM	TO
	OSC.	CHAN A LINE AMP IN
	CHAN A LINE AMP OUT	OSC LINE
	425~ FILT OUT	CHAN B LINE AMP IN
	CHAN B LINE AMP OUT	FILT KEY IN
	MON OUT	DIST MEAS IN
	DIST MEAS OUT	MEAS 600ω
	ATTEN OUT	CHAN (A OR B) TRANS IN
II	DISTORTION MEASURING - DOUBLE SIDE BAND	
	FROM	TO
	OSC	CHAN A LINE AMP IN
	CHAN A LINE AMP OUT	OSC LINE
	425~ FILT OUT	CHAN B LINE AMP IN
	CHAN B LINE AMP OUT	FILT KEY IN
	DIST MEAS OUT	MEAS 600ω
	ATTEN OUT	CHAN (A OR B) TRANS IN
	OUT IND (OR RECT MON)	DIST MEAS IN
III	FREQUENCY RESPONSE - SINGLE SIDE BAND	
	FROM	TO
	OSC	CHAN (A & B) TRANS IN
	LEVEL	MEAS HIGH IMP
IV	FREQUENCY RESPONSE - DOUBLE SIDE BAND	
	FROM	TO
	OSC	CHAN A TRANS IN
	OUT IND	MEAS 600ω
V	NOISE MEASUREMENT SINGLE AND DOUBLE SIDE BAND	
	FROM	TO
	ATTEN OUT	CHAN A TRANS IN
	OUT IND (OR RECT MON)	CHAN B LINE AMP IN
	CHAN B LINE AMP OUT	MEAS 600ω
VI	MODULATION - DOUBLE SIDE BAND	
	FROM	TO
	ATTEN OUT	CHAN A LINE TRANS IN
	OUT IND (OR RECT MON)	MEAS 600ω

CIRCUIT NOTES:

101. WHEN AMPLIFIERS ARE NOT REQUIRED IN THE LINE CIRCUITS THE AMPLIFIERS (LINE)(CHAN A) AND (LINE)(CHAN B) ARE WIRED INTO THE DISTORTION MEASURING CIRCUIT INSTEAD OF PATCHED. THEIR A-C SUPPLY IS CONTROLLED BY THE (P) RELAY AND THE JACKS ARE DESIGNATED AS SHOWN IN FIGS. A AND B.

TOLL SYSTEMS
DISTORTION MEASURING EQUIPMENT

ES-557478
Issue 1

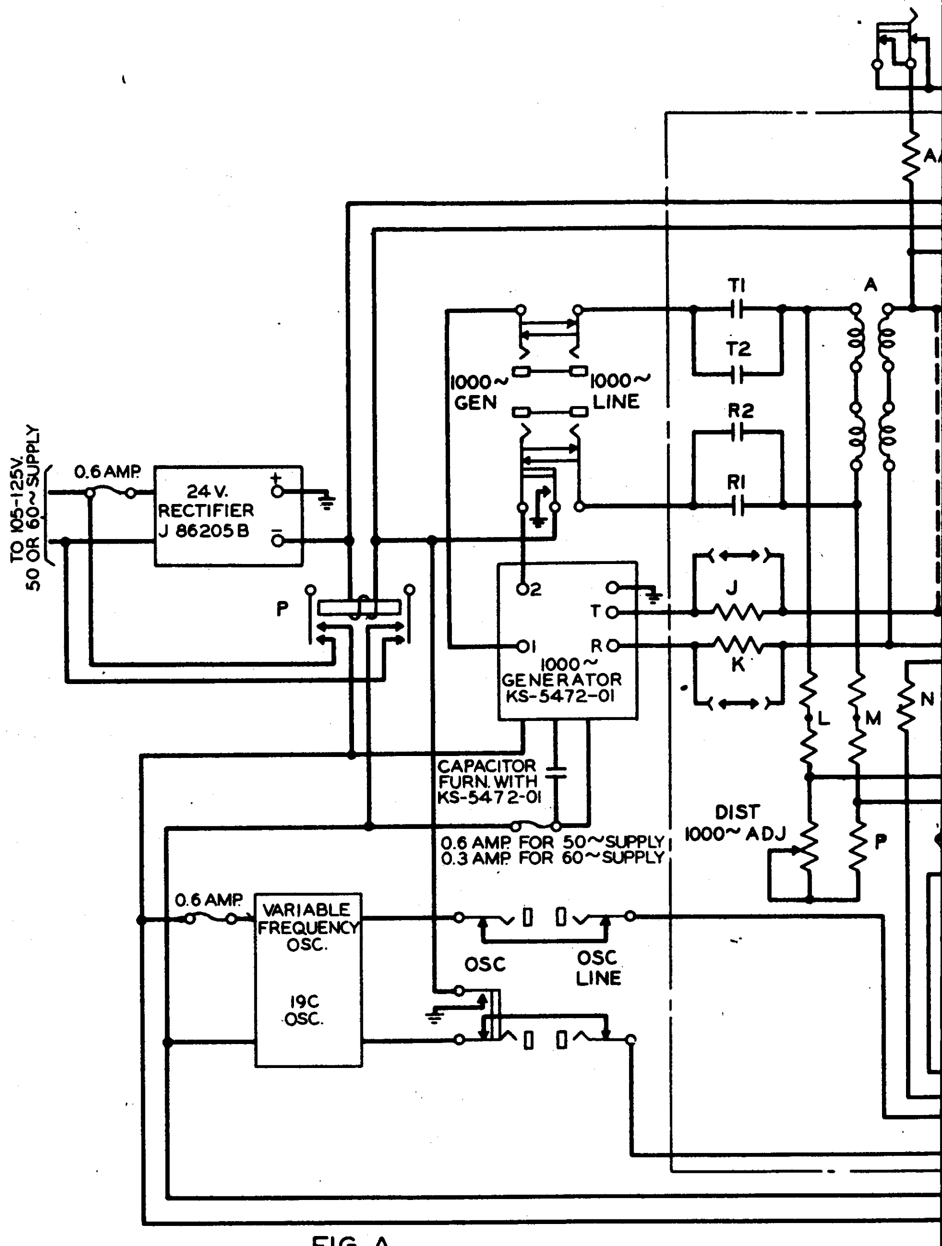
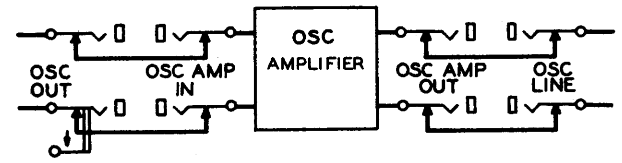
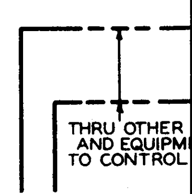

TO 105-125V. 50 OR 60~ SUPPLY
0.6 AMP.
24 V. RECTIFIER J 86205 B
P
1000~ GEN
1000~ LINE
T1
T2
R2
R1
A
J
K
T
R
2
1
1000~ GENERATOR KS-5472-01
CAPACITOR FURN. WITH KS-5472-01
0.6 AMP. FOR 50~SUPPLY
0.3 AMP. FOR 60~SUPPLY
DIST 1000~ ADJ
L
M
N
P
0.6 AMP.
VARIABLE FREQUENCY OSC.
19C OSC.
OSC
OSC LINE

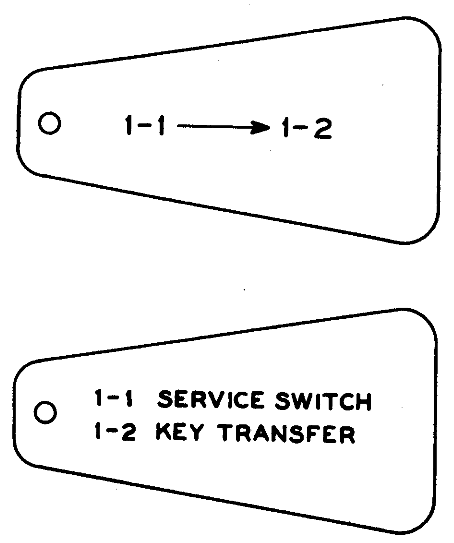
FIG. A


OSC OUT
OSC AMP IN
OSC AMPLIFIER
OSC AMP OUT
OSC LINE

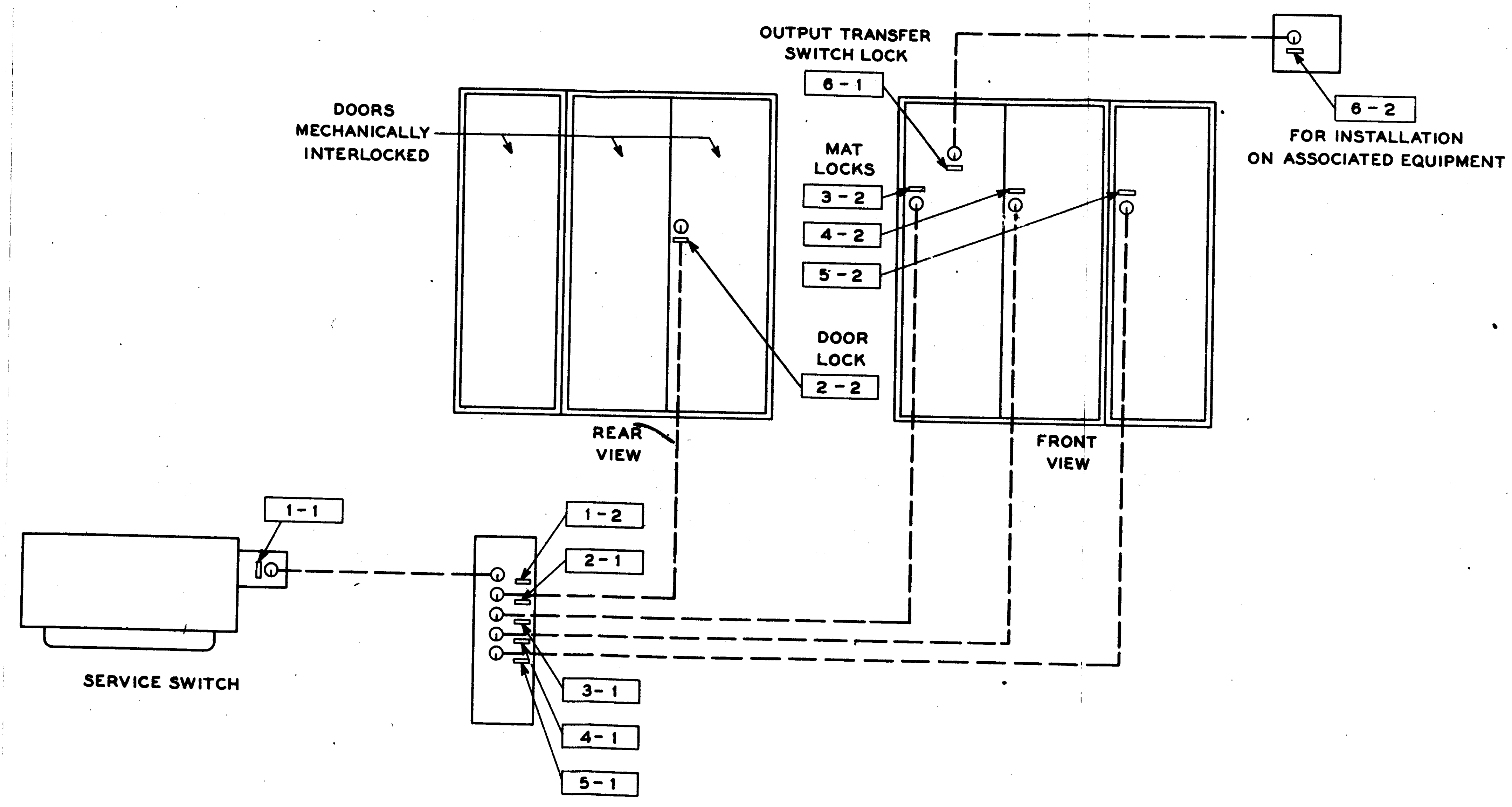

THRU OTHER
AND EQUIPM
TO CONTROL

D-156000 RADIO TRANSMITTER

KEY INTERLOCK SYSTEM

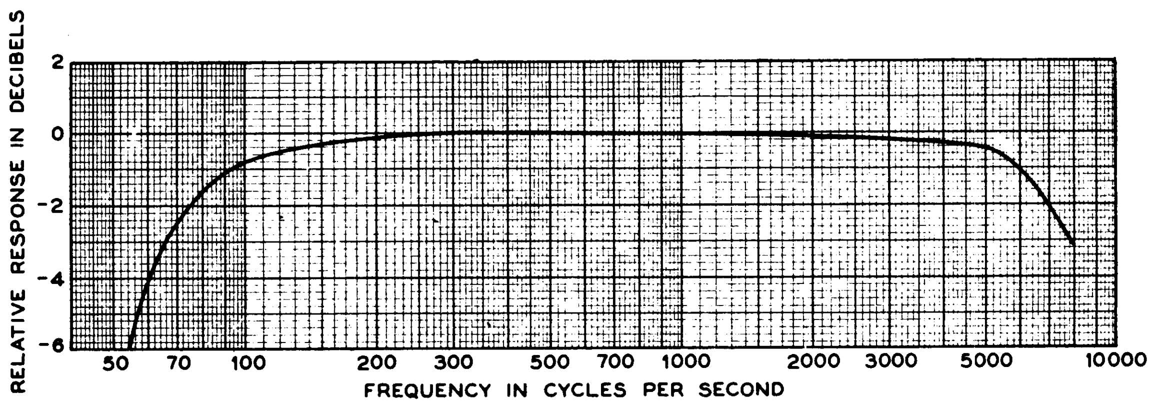


TYPICAL KEY TAG



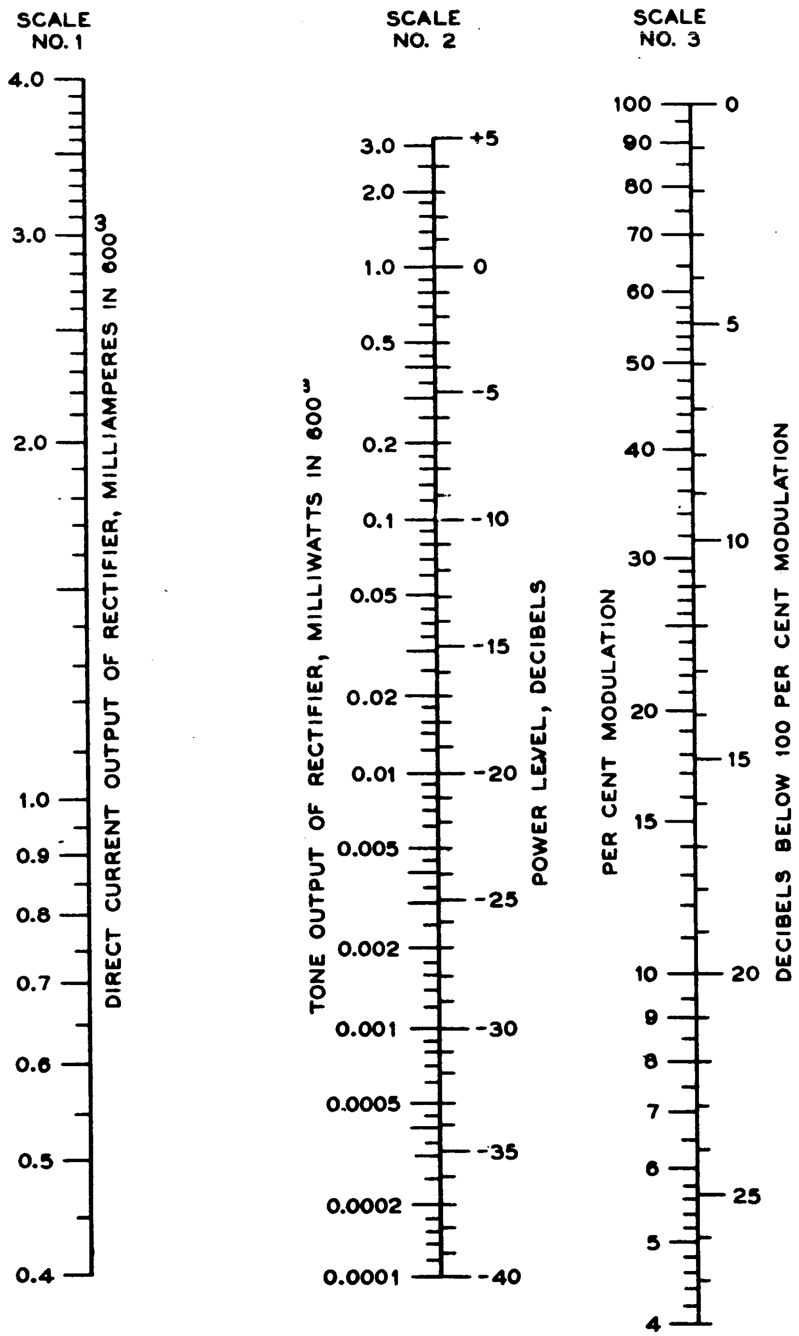
D-156000 RADIO TRANSMITTER

TYPICAL AUDIO FREQUENCY RESPONSE CHARACTERISTIC
DOUBLE SIDEBAND TRANSMISSION



ES-795426
L.R.R. 5-29-40

MODULATION MEASUREMENT OF DOUBLE SIDEBAND RADIO TRANSMITTERS



Change of Frequency Rang

The D-156000 Radio Transmitter as normally supplied can be tuned to any frequency in the range of 4500 kc. to 22,000 kc. when equipped with the appropriate crystals and plug-in type tuned circuits. This frequency range may be changed to 4000 kc. to 20,000 kc. by changing two condensers in Amplifier 3 and two condensers in Amplifier 4.

To modify Amplifier 3 remove C2 (D-156095 - 60 mmf.) and substitute the D-160097, 120 mmf. condenser. Remove C16 (D-156095 - 30 mmf.) and substitute the D-156095 - 60 mmf. condenser. The leads of the replacing condensers should be bent and drilled so that the condensers will mount in the same way as the condensers which are removed.

To modify Amplifier 4 add in parallel with C2 (D-156096 - 60 mmf.) another D-156096 - 60 mmf. condenser. The capacity of C8 is increased by reducing the spacing between the two plates. Unscrew the two round head screws which fasten the two plates to the coils and remove the condenser. Remove th mycalex spacer (ESP-759368, Detail 1) which is 1/4" thick and substitute the spacer (ESP-759368, Detail 2) which is 3/16" thick. Remount the plates in the transmitter, being sure that the plates are parallel when the mounting screws are tightened.

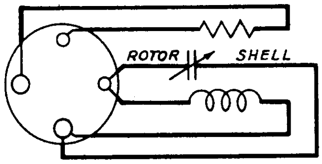
D-156.000 RADIO TRANSMITTER

TUNED CIRCUIT IDENTIFICATION

TUNED CIRCUITS OF HARMONIC GENERATOR, MODULATOR #3, AMPLIFIER #1 & MONITOR

* T.C. NO.	TURNS	WIRE SIZE	* RESISTANCE
1 A	4⅓	16	
2 A	5½	16	
3A-3B	7½	16	30 000 ω
4A-4B	9	20	15 000 ω
5A-5B	12⅔	20	15 000 ω
6A-6B	13¾	20	15 000 ω
7B	19	20	10 000 ω
8B	24	22	10 000 ω

* "A" & "B" COILS ARE IDENTICAL EXCEPT THAT "B" HAS A RESISTOR, OF VALUE STATED, CONNECTED THUS,—



BOTTOM VIEW

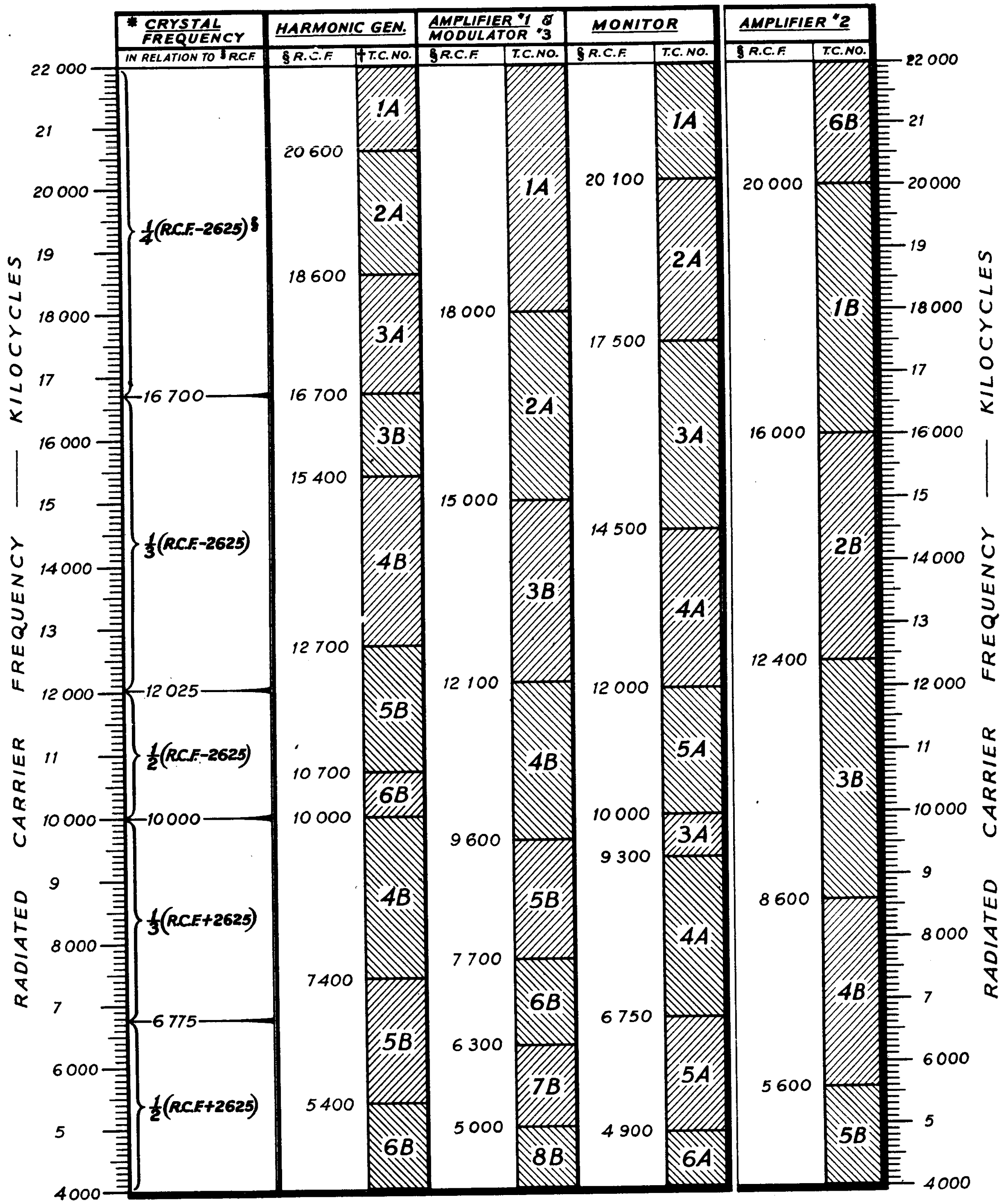
TUNED CIRCUITS OF AMPLIFIER #2

Ø T.C. NO.	TURNS (EACH HALF)	WIRE SIZE	Ø RESISTANCE
1 B	5	16	3 000 ω
2 B	7	16	3 000 ω
3 B	11	16	3 000 ω
4 B	14	22	2 000 ω
5 B	24	22	2 000 ω
6 B	4	16	3 000 ω

Ø THIS RESISTOR IS AN I.R.C. TYPE BT ½ MOUNTED BENEATH THE COIL WINDING.

D-156000 RADIO TRANSMITTER

①CRYSTAL FREQUENCY & TUNED CIRCUIT REQUIREMENTS



CRYSTAL FREQUENCY & TUNED CIRCUIT REQUIREMENTS

NOTES & INSTRUCTIONS: ① LAY STRAIGHT-EDGE HORIZONTALLY ACROSS CHART AT POINT ON SCALE CORRESPONDING TO DESIRED RADIATED CARRIER FREQUENCY.
THE CROSS-HATCHED AREAS THUS INTERSECTED INDICATE REQUIRED TUNED CIRCUIT FOR EACH STAGE.

✱ SPECIFY THE 5AA QUARTZ CRYSTAL FREQUENCY TO SEVEN SIGNIFICANT FIGURES.
§ R.C.F. = RADIATED CARRIER FREQUENCY.
† T.C. NO. = TUNED CIRCUIT NUMBER.