TYPE C CARRIER TELEPHONE EQUIPMENT.

(Reprinted with only one amendment (on page 2) figures however have been renumbered; previously E.I. TRANSMISSION Long Line Equipment CO 5300).

I N D E X

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1. INITIAL AND ROUTINE TESTS AND ADJUSTMENTS.

1.1 The tests and adjustments given below provide means for initially adjusting the C5 terminal and C1 repeater and for maintaining the equipment while in service. Before making any of the tests the terminal transmitting levels, the repeater output levels, and the desired overall circuit net loss for the system should be specified. These are determined by the line over which the system is to be operated and any other pertinent considerations.

★ All of the tests should be performed before the equipment is placed in use and thereafter for general maintenance at the periodicity set down in E.I. LONG LINE EQUIPMENT General R 1310. Before making any of the tests or adjustments, the vacuum tubes in the terminals and repeaters should be allowed to heat for at least 5 minutes after the power supply connection has been made.

For making transmission tests, 1000-cycle test power at 1 milliwatt and 13 db below 1 milliwatt is employed. To facilitate making such tests, a test-current supply circuit is included as a part of the C5 terminal. This circuit includes two sets of jacks located in the terminal jack field. One set is designated TST CURR and the other SEND - 13. A 13-db pad is wired between these jacks and the circuit is so arranged that with 1 milliwatt of 1000 cycle test power connected to its input, 1 milliwatt is obtained at the TST CURR jacks and 13 db below 1 milliwatt at the SEND - 13 jacks.

The tests outlined assume the use of suitable testing equipment and a 600-ohm measuring circuit capable of operating in both the voice and carrier frequency ranges and calibrated to read in db referred to 1 milliwatt. Such a circuit, which is shown schematically in Fig. 1, is included in the 30A transmission measuring set.

The component units of the 30A transmission measuring set have been designed to have an impedance of 135 ohms. Accordingly, when this measuring set is used with type C equipment, the various units of which have an impedance of approximately 600 ohms, impedance-matching transformers must be employed between the 30A set and the type C equipment. Two such transformers, each having an impedance ratio of 600:130 ohms are provided as a part of the 30A set. Where accurate measurements are required, the losses afforded by these transformers when used in the measuring circuit should be taken into account.

1.2 A.C. Power-Supply Equipment. When the C5 terminal or C1 repeater is operated from a 50 to 60-cycle, 105-125 volt A.C. source, suitable power-supply equipment as described under "Power Supply" is employed. Since the power-supply equipments for the terminal and repeater are generally similar, the tests and adjustments outlined below apply to either equipment.

22- and 55- Volt A.C. Supplies. 22 volts A.C. for the heaters of the tubes and 55 volts A.C. for the regulator motors are obtained by means of a step-down power transformer. Initially and at any time the voltage of the A.C. supply is changed, connection should be made to the proper step on the primary winding of this transformer in accordance with the information on Drawing SD-80724-01. When making actual connections, care should be taken that the A.C. supply is disconnected from the equipment by opening the main control fuse, removing the 3-ampere fuse, or other appropriate means.

When the proper connection has been made to the transformer, energise the equipment and check the 22-volt A.C. voltages at the carrier terminal or repeater, measuring at the proper terminals as indicated on Drawing SD-64360-01 or Drawing SD-64359-01. The tubes should be energised during this test.

Requirement. All heater circuit voltages should be within the range of 22 to 24 volts.

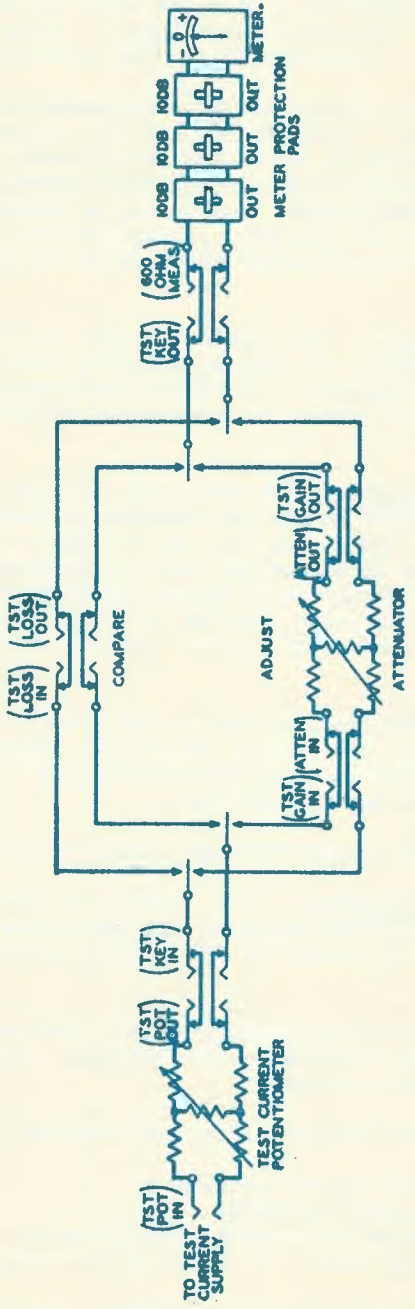
150 and 130- Volt Plate Supplies. D.C. voltage at 150 volts is obtained from the A.C. supply by means of one or more regulated tube rectifiers per J86207B, List 2. Where required, the 150 volts is reduced to 130 volts by means of the voltage drop through a resistance.

Before doing any work inside the rectifier case, disconnect first the A.C. and then the D.C. circuit by means external to the rectifier, such as removal of plugs from receptacles or fuses where provided.

Before putting a regulated tube rectifier into service, check to see that -

1. The tubes are in the correct sockets.
2. The relays are properly adjusted.
3. Connection is made to the correct primary taps on the transformer.
4. The grid battery (90 volts) is connected into the circuit.

To initially adjust the regulated tube rectifier, turn the regulating rheostat to its maximum counter-clockwise position. Connect the A.C. power service and allow the tube to heat for 20 seconds or more. Then, with the normal load connected to the rectifier, adjust the regulating rheostat until the voltage as read on the rectifier voltmeter is 150 volts,



TRANSMISSION MEASURING CIRCUIT.

FIG. 1.

The grid battery has an initial peak voltage which usually wears off in a few days or weeks. Its voltage then remains almost constant, dropping off gradually during almost all of its life. Towards the end, there is a second period of relatively fast loss of voltage. The regulating rhoestats turn through 300 degrees. The first 50 to 100 degrees are usually used up quickly as the battery initial peak voltage wears off. Adjustments then become small and infrequent and remain so for almost the entire life of the grid battery. The last quarter or third of the rheostat is used up by larger and more frequent adjustments as the grid battery again loses voltage quickly. The grid battery must be replaced when all of the regulating rheostat is turned out and very little useful battery life is lost if the grid battery is replaced at any time after the first two-thirds of the rheostat are cut out. The rapidly approaching end of grid battery life can usually be recognised by the larger and more frequent adjustments at that time.

The regulated tube rectifiers should be adjusted as required. After adjusting the rectifiers the voltage supplied to the carrier equipment should be checked under load at the proper terminals as indicated on Drawings SD-64359-01 or SD-65460-01.

Requirement. Each 150-volt supply circuit should measure within 2 volts of 150 volts. All 130-volt supply circuits should measure 130 $\pm$ 10 volts.

24-Volt D.C. Signal Supply. The 24-volt D.C. signal supply is obtained with a copper-oxide rectifier unit J86205F. This unit is mounted on the panel with the power transformer referred to above. Before operating, the proper connection should be made to the secondary winding of the transformer associated with the rectifier unit. This is accomplished by removing the cover and connecting terminals 3 and 4 of the varistor (A) to terminals A and either 1, 2 or 3, respectively, of the transformer until a D.C. voltage of 28 volts under "no-load" conditions is obtained across terminals 1 and 2 of the varistor. If necessary, shift the connection from terminal A to terminal B or C to increase the voltage. When making actual connections, the plug associated with the unit should be removed from the A.C. outlet. Since the copper-oxide unit deteriorates slowly with age, this adjustment should be made annually.

After the proper adjustment has been obtained, the unit should be energised and the 24-volt D.C. signal voltage checked at the carrier equipment at the proper terminals, as indicated on Drawings SD-64359-01 or SD-64360-01.

Requirement. Each signal circuit voltage should be within the range of 20 to 28 volts.

1.3 C5 Terminal. Grid Battery Voltage Adjustment. An external grid bias is employed in the last stage of the amplifier at both terminals and repeaters. This is provided by means of a tapped dry battery, one battery unit being provided for each amplifier. The voltage adjustment is made to obtain the desired operating characteristic of the last stage tube and should be checked monthly. It will be desirable to remove the system from service when adjusting the battery taps, but the battery voltage may be measured while the system is in service if due care is taken to prevent grounding the battery and the adjustment is made within 2 or 3 seconds.

Apparatus. D.C. Voltmeter, 0-30 volts.

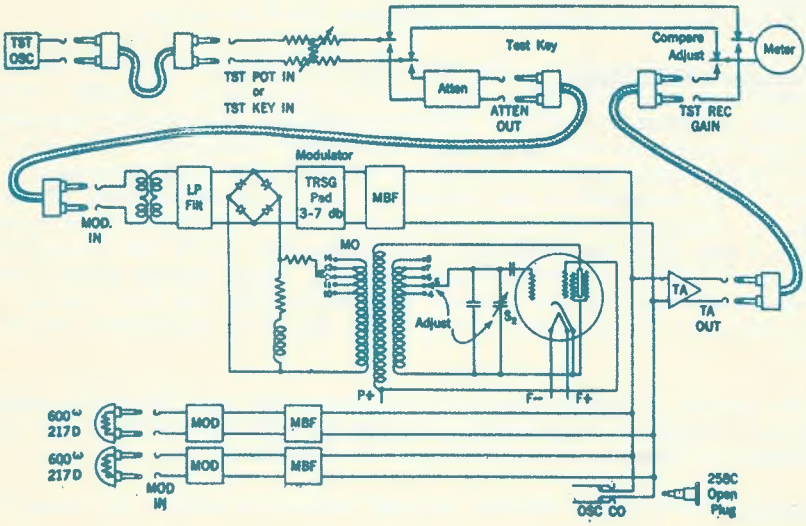
Procedure. (1) Check the overall voltage of the battery.
Requirement. The battery voltage should be at least 20 volts.

(2) Adjust the variable connection to the grid battery (GT) so that the voltage supplied by the battery to the amplifier is between 18 and 19 volts.

Modulator-Oscillator Frequency Adjustment. This test provides a means for checking the modulator-oscillator frequencies. Variations in frequency may occur with temperature and aging of the oscillator circuit elements but, in general, the carrier frequencies will not require checking. The oscillator of the corresponding demodulator at the other terminal is adjusted to synchronism with the modulator-oscillator periodically to reduce the difference in frequency of the two oscillators.

The modulator-oscillator frequency is adjusted by measuring the transmitting gain at voice-frequency inputs of 200 and 2800 cycles and changing the oscillator frequency by means of the air condenser and taps on the oscillator coil until the difference in transmitting gains at the two frequencies meets the required value. The band filters have substantially a symmetrical loss frequency characteristic at the two ends of the pass band at east terminals so that the desired carrier frequency can be obtained using this method of adjustment. At west terminals a slight variation of the method is required to take account of differences in loss at the two ends of the pass band.

Apparatus. Voice-Frequency Oscillator. Measuring Circuit. 2-217D Plugs (600 ohms). 1-258C Plug (open circuit).



MODULATOR-OSCILLATOR FREQUENCY ADJUSTMENT.

FIG. 2.

Procedure. (See Fig. 2).

(1) Insert a 258C plug in the pilot OSC CO jack, if provided, and terminate the MOD IN jacks of the other two channels not under test with 217D plugs.

(2) Set the test oscillator for a frequency of 200 cycles and patch its output to the TST POT IN or the TST KEY IN jacks.

(3) Operate the TEST key to the COMPARE position and adjust the output for a reading of 0 db on the meter. (1 milliwatt).

(4) Patch from the ATTEN OUT jacks to the MOD IN jacks of the channel under test and set the attenuator for a loss of 10 db.

(5) Patch from the TA OUT jacks to the TST REC GAIN jacks or TST GAIN OUT jacks.

(6) Operate the TEST key to the ADJUST position and note the reading on the meter with one of the 10 db protection keys in the OUT position. A reading of 0 db on the meter indicates a transmitting gain of 20 db.

(7) Set the oscillator for a frequency of 2800 cycles and repeat (3), (4), (5) and (6).

(8) Note the difference in the transmitting gains for the two frequencies as obtained in (6) and (7).

(9) Change condenser S2 from the front of the panel and, if necessary, change the tap lead to another terminal between 4 and 8 on coil MO until the requirements are met. If the transmitting gain for the 200-cycle input is too high to meet requirements increase the condenser setting by turning in a clockwise direction at all east terminals and for a CU west terminal. At a CS west terminal decrease the condenser setting. If the 2800-cycle input is too high, decrease the condenser setting at all east terminals and for a CU west terminal. Increase the setting for a CS west terminal.

(10) Continue to measure the transmitting gain for inputs of 200 and 2800 cycles until the requirements are met.

Requirements. At east terminals the transmitting gain for an input of 200 cycles should be within 0.5 db of that for an input of 2800 cycles. At CS west terminals the gain for an input of 200 cycles should be 2.0 $\pm$ 0.5 db less than the gain for an input of 2800 cycles. At CU west terminals the gain for an input of 2800 cycles should be 2.0 $\pm$ 0.5 db less than the gain for an input of 200 cycles.

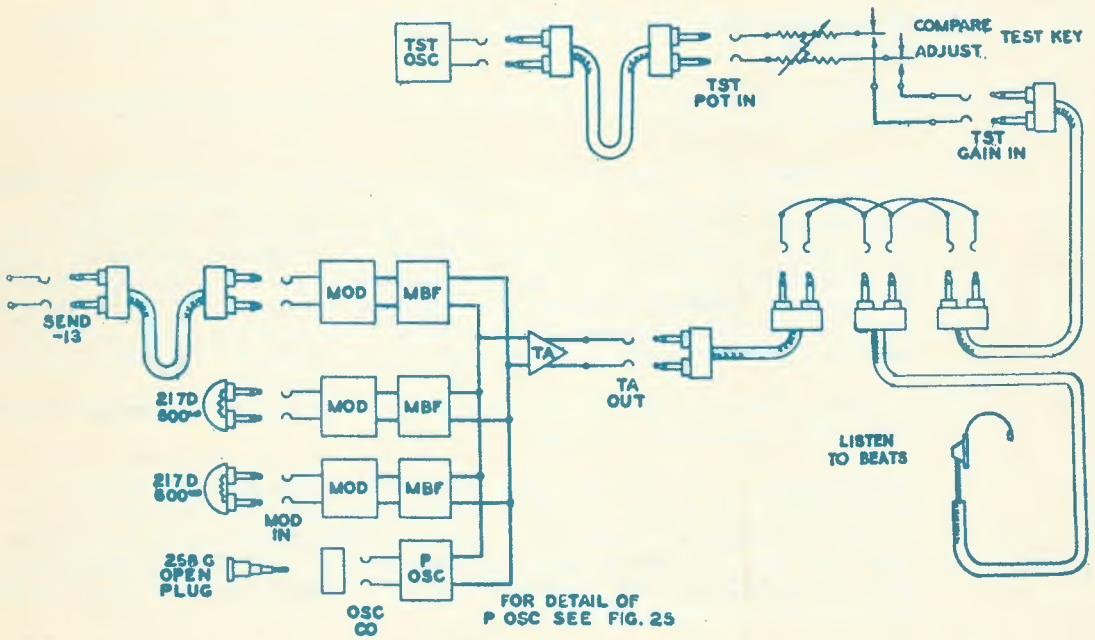
(11) Repeat the test for each of the other channels.

Pilot Oscillator Frequency Adjustment. The pilot oscillator frequency is set for a value of 50 cycles inside of the transmitted band of the middle channel in each direction of transmission. Since the pilot and channel oscillators have similar performance the 50-cycle separation should be maintained over long periods of time for normal variations in temperature, humidity, battery voltages, and tube changes. The pilot oscillator frequency should be checked whenever the channel modulator-oscillator frequency is changed.

The method of setting the pilot frequency is complicated by the fact that it must be set accurately with respect to the channel frequency, which in turn depends upon the characteristics of the modulator band filters. The pilot oscillator frequency should therefore, be set after the modulator oscillator has been adjusted. Two methods are given, one of which depends upon whether a test oscillator accurately calibrated to permit a shift of 50 cycles in the carrier range (such as the 17B oscillator) is available. The method using such an oscillator is preferred and should be used whenever possible.

A high-frequency test oscillator is first synchronised by the beat method with the modulator-oscillator of the middle channel. The test will usually be facilitated by introducing a third frequency as described in the procedure below to aid in making the beats more clearly audible. After the test oscillator frequency is adjusted to that of the modulator-oscillator its frequency is changed 50 cycles, in accordance with the sideband transmitted, to the pilot frequency. The pilot oscillator frequency is next adjusted for synchronism with the test oscillator. In the case of the 17B or other finely calibrated oscillator this completes the test since the 50-cycle change in frequency can be accurately made. This is not the case when an oscillator not calibrated to permit an accurate 50-cycle shift in frequency is used, and an extra step is necessary. This consists in using the test oscillator to supply a 50-cycle input to the middle channel and setting the pilot oscillator accurately from the sideband frequency.

Apparatus. Test Oscillator. 2-217D Plugs (600 ohms). 1-258C Plug (open circuit). Head Receiver equipped with cord and plug.



PILOT OSCILLATOR FREQUENCY ADJUSTMENT. FIRST STEP.

FIG. 3.

Procedure. First Step (See Fig. 3).

(1) Patch the test power obtained from the SEND - 13 jacks to the MOD IN jacks of channel 3 at a CS or CU east terminal or CS west terminal. At a CU west terminal use channel 2. This procedure introduces a third tone approximately 2000 to 3000 cycles away from the carrier frequency of the middle channel.

(2) Terminate the MOD IN jacks of the other channels in 217D plugs and the OSC CO jack in a 258C plug.

(3) Set the test oscillator for the nominal carrier frequency of the middle channel as given below -

Terminal.	Frequency.
CS or CU East	9.4 kc
CS West	24.4
CU West	21.4

(4) Patch the oscillator output to the TST POT IN or the TST KEY IN jacks and with the TEST key in the COMPARE position adjust the oscillator output for approximately 1 milliwatt.

(5) Patch the TST GAIN IN jacks to one pair of MULT jacks and operate the TEST key to the ADJUST position.

(6) Patch the TA OUT jacks to a second pair of MULT jacks.

(7) Patch the head receiver to a third pair of MULT jacks and listen for beats between the channel carrier leak and the test oscillator.

(8) Change the setting of the test oscillator until zero beat is obtained. The test oscillator is now adjusted to the carrier frequency of the middle channel.

(9) Change the frequency of the test oscillator in accordance with the following table interpolating from the calibration chart if necessary.

Terminal.	Change in Frequency.
CS or CU East	Increase 50 Cycles
CS West	Decrease 50 Cycles
CU West	Increase 50 Cycles

(10) Remove the 258C open plug from the OSC CO jack.

(11) Listen for beats between the test oscillator and the pilot oscillator. Adjust Condenser C2, and if necessary change the tap lead to another terminal between 4 and 8 on the OSC transformer on the P OSC panel until zero beat is obtained. Using a lower numbered tap on the transformer increases the frequency of the pilot oscillator. As a check vary the setting of the test oscillator and notice if there is a change in the frequency of the beat in order to insure that the pilot oscillator is being set with respect to the test oscillator and not to the carrier leak.

(12) Where a 17B or other finely calibrated oscillator is used this is the setting of the pilot oscillator. Where an oscillator, the frequency of which cannot be accurately shifted, is used this is an approximate setting of the pilot oscillator and it will be necessary to proceed with the second step of the procedure in order to obtain the final setting.

Procedure. Second Step.

In this step the 50-cycle sideband frequency is used to set the pilot frequency accurately.

(1) Short-circuit the A1 condenser in the modulator circuit during the test.

(2) Remove the patch between the TST GAIN IN jacks and the MULT jacks. Set the oscillator for a frequency of 50 cycles.

(3) Adjust the output of the test oscillator for 12 db below a milliwatt as follows - Patch the test oscillator to TST POT IN or TST KEY IN jacks and with the TEST key in the COMPARE position, adjust the oscillator output and the test potentiometer to give a reading of 0 db on the meter. Then set the attenuator for a loss of 12 db and operate the TEST key to the ADJUST position.

(4) Patch the ATTEN OUT jacks to the MOD IN jacks of channel 2 at an east terminal, or channel 1 at a west terminal.

(5) Listen to beats between the pilot oscillator and the sideband frequency resulting from the 50-cycle input.

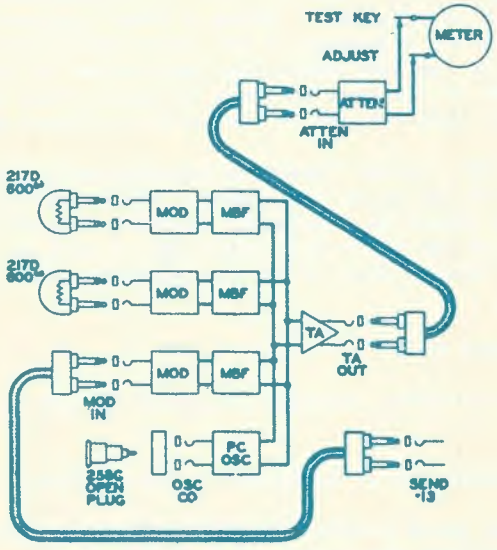
(6) Adjust the C2 condenser on the P OSC panel until zero beat is obtained. This should be obtained with a small adjustment of the C2 condenser.

This is the required pilot frequency. If a large change in the setting of the C2 condenser is necessary repeat (9) through (12) of the first step of the procedure.

Adjustment of Transmitting Level. The level of each channel is the same at the input to the modulator, that is, - 13 db. However, it is necessary to adjust the transmitting level of each channel because of variations in the individual channel units. This test provides a method for adjusting the level of each channel. After each channel is adjusted to approximately the same level at the amplifier output, that is, + 18 db, the output pads are set for the required line level if it is less than + 18 db for co-ordination with paralleling systems.

The test is made by applying a 1000-cycle tone at a level of 13 db below 1 milliwatt to each channel in turn and adjusting the gain of the channel by means of pads in the individual modulator circuits. The transmitting amplifier operates at a fixed gain of approximately 52 db. Because of the low level at the output of the modulator band filters, it will be possible to make measurements only at the output of the transmitting amplifier.

Apparatus. Measuring Circuit. 2-217D Plugs (600 ohms). 1-258C Plug (open circuit).



ADJUSTMENT OF TRANSMITTING LEVEL.

FIG. 4.

Procedure. (See Fig. 4).

(1) Terminate the MOD IN jacks of channels 2 and 3 in 217D plugs.

(2) If provided, cut off the pilot oscillator output by inserting a 258C plug in the OSC CO jack.

(3) Patch from the TA OUT jacks to the ATTEN IN jacks. Set the attenuator for 18 db, which is the nominal amplifier output level and operate the TEST key to the ADJUST position. If 18 db cannot be obtained on the attenuator, take the difference into account when reading the meter.

(4) Patch from the SEND - 13 jacks to the MOD IN jacks of channel 1.

(5) Strap the TRSG pad on the MODEM CH1 panel in accordance with the table given under note 106 of Drawing SD-64361-01 to obtain as nearly as possible a 0-db reading on the meter.

(6) The transmitting level is the setting of the attenuator corrected for the meter reading.

Requirement. The transmitting level should be as close as possible to + 18 db.

(7) Repeat (4), (5) and (6) for the other two channels.

(8) If the specified line level is below + 18 db the following procedure is used in setting the line level.

(9) Change the patch from the TA OUT jacks and place in the DIR FLT LINE jacks.

(10) Set the attenuator for a loss equal to the specified line level.

(11) Send on the middle channel (Channel 2) by patching from the SEND - 13 jacks to the MOD IN jacks of that channel.

(12) Adjust the T1 and T2 pads in accordance with note 108 on Drawing SD-64360-01 to obtain as nearly as possible a reading of 0 db on the meter with the protection keys in the OUT position. The attenuator setting plus or minus the residual meter reading is the line level.

Requirement. The line level should be adjusted as closely as possible to the specified level without exceeding it.

Pilot Oscillator Output Adjustment. The pilot current at the intermediate repeaters and receiving terminal is used as an indication of the system levels and thus initiates changes in the regulating circuit to compensate for variations in level. The pilot current transmitted from the terminal is set after the transmitting level adjustment has been made.

The pilot is set to have a power of 8 db above 1 milliwatt into a 600 ohm load at the output of the transmitting amplifier. This power is obtained by changing the output control condenser. Taps are also provided on the oscillator coil if additional range is required. Jacks are provided on the oscillator panel for use in ascertaining if the pilot oscillator is functioning when the system is in service.

Apparatus. Transmission Measuring Circuit. 3-217D Plugs (600 ohms).

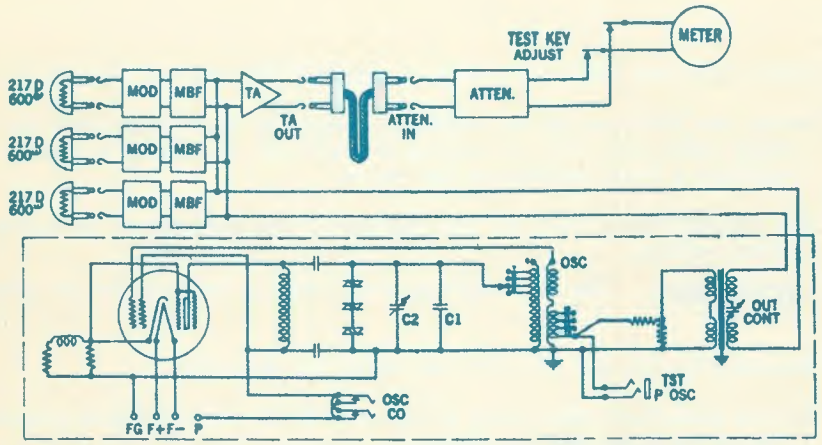
Procedure. (See Fig. 5).

(1) Terminate the MOD IN jacks of all three channels in 217D plugs.

(2) Patch from the TA OUT jacks to the ATTEN IN jacks of the measuring circuit.

(3) Set the attenuator for a loss of 8 db. If 8 db cannot be obtained on the attenuator, take the difference into account when reading the meter.

(4) Operate the TEST key to the ADJUST position and note the reading on the meter. The pilot power is the attenuator setting corrected for the meter reading.



PILOT OSCILLATOR OUTPUT ADJUSTMENT.

FIG. 5.

(5) Adjust the pilot oscillator output by means of the OUT CONT condenser, and if necessary, change the tap lead to another terminal between 10 and 13 on the OSC coil until a reading of as nearly as possible to 0 db is obtained on the meter. Using a higher numbered tap will decrease the pilot power.

Requirement. The pilot power should be within 0.2 db of the required power of + 8 db.

Pilot Control Circuit Tuning and Sensitivity Adjustment. The sensitivity of the pilot channel control system is adjusted at the time the operating levels of the overall system are set. After the amplifier output level is adjusted at the repeater or receiving terminal, pilot current is transmitted from the transmitting terminal. The control circuit is tuned to the pilot frequency by adjusting the tuning condenser until a maximum deflection is obtained on the CON relay. Tuning is facilitated by employing the MAN CON dial to obtain a reading on the ALM relay using the ALM relay reading as a coarse indication and then completing the condenser adjustment by using the finer scale provided on the CON relay. The sensitivity is adjusted by means of taps provided on the pilot filter until normal pilot current is indicated on the control meter. In some equipments the adjustment is made on the coil terminals in the pilot filter on the back of the panel, while in a later modification, leads run from these terminals to a terminal block detail mounted on the front of the panel and the adjustment is made at this point.

Apparatus. 1-217D Plug (600 ohms). 1-258C Plug (Open Circuit).

Procedure.

(1) Insert a 258C plug in the PULSE CO jack and a 217D plug in the PC IN jacks.

(2) Remove the cover from the PIL FILT on the rear of the REGT panel.

(3) If the circuit is being adjusted initially, make the following connections on the secondary side of the repeating coil associated with the filter -

Terminal	With A Repeating Coil	With B Repeating Coil
West	Strap lugs 7 and 11 Connect filter leads to lugs 6 and 12.	On Coil. Connect filter leads to lugs 5 and 6, the grounded lead being connected to lug 5.

Terminal	With A Repeating Coil	With B Repeating Coil
		On Front of Panel Place bar in (H) position and connect the flexible lead to post (1).
East	Strap lugs 8 and 9 Connect filter leads to lugs 6 and 13.	On Coil. Connect filter leads to lugs 4 and 5, the grounded lead being connected to lug 5. On Front of Panel. Place bar in (H) position and connect the flexible lead to post (1).

This provides 15 turns in the low group and 28 turns in the high group.

(4) Note the setting of the MAN CON dial on the REGT panel.

(5) Remove plugs from the PC IN and PULSE CO jacks and note reading of the ALM relay adjusting the MAN CON dial, if necessary, to bring the reading on scale.

(6) With a screwdriver tune the pilot filter by changing the setting of the condenser TUNE on the front of the REGT panel until a maximum reading is obtained on the scale of the ALM relay. It will be necessary to move the condenser slowly to allow for the reset every four seconds. Use the MAN CON dial to keep the reading on the scale of the ALM relay.

(7) Restrap the lugs on the repeating coil until the ALM relay and then the CON relay read as closely as possible to 0 db with the MAN CON dial on the setting noted in (4). The tables below show the number of turns of the different lug connections. The sensitivity varies directly as the number of turns. One turn represents a change of about 0.2 db.

Filters Equipped with A Repeating Coil.

Lugs.	No. of Turns.
3 and 4	56
4 and 5	28
6 and 7	14
7 and 8	7
9 and 10	4
10 and 11	1
11 and 12	1
12 and 13	1

Filters Equipped with B Repeating Coil.

Lugs.	No. of Turns.
3 and 4	56
4 and 5	28
5 and 6	15
7 and 8	1
8 and 9	1
9 and 10	1
10 and 11	1
11 and 12	1
12 and 13	1
13 and 14	1

In those equipments employing the B repeating coil the turns between lugs 3 and 6 are used for coarse adjustment and are connected as required with the lower numbered lug always being connected to the ground punching. The other lead connects to the common post of the (H), (L) switch on the front of the panel. The lugs 7 to 14 inclusive are connected to numbered posts on the front of the panel, lug 7 connecting to post numbered 1, lug 8 to post 2, etc. Lug 7 is also connected to the (H) post and lug 14 to the (L) post. Thus when the switch blade is on the (H) post the winding between lugs 7 and 14 is in series aiding to the winding connected for the coarse adjustment. When the blade is on the (L) post the two windings are in series opposing. For example, when the leads are connected to lugs 4 and 5 on the filter and the lead is connected to post 8 on the front of the panel with the switch on the (H) post, the total turns will be 28 + 7 or 35 turns. If the switch is on the (L) post, however, the total turns will be 28-7 or 21 turns.

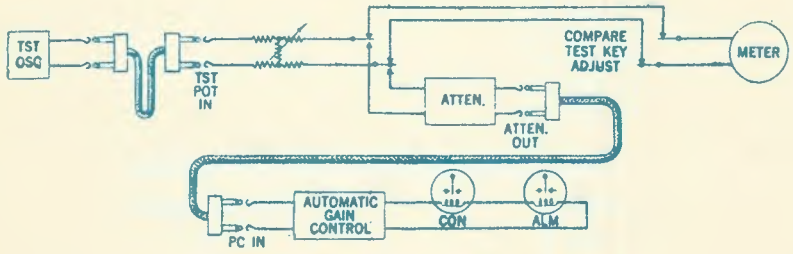
(8) Record the number of turns in use on the coil as determined by the lug setting, or the setting of the (H), (L) switch and the post number to which the flexible lead is connected, as the case may be.

Requirement. The reading of the CON relay shall be within 0.25 db of 0 db.

Check of Regulator Operation and Alarms. The alarm features incorporated in the C5 Terminal (and C1 repeater) are provided by the automatic control circuit. These include (a) an alarm after the received pilot power has departed more than 3 db above or 5 db below normal for more than 20 to 30 seconds, and (b) alarms indicating that the regulator is at either end of its range and the level is still outside of the $\pm$ 0.5 db limits. An alarm is also provided in the case of battery operated equipment for the regulator in the 55-volt A.C. supply signifying that the A.C. power supply for the regulator motor has been interrupted.

The purpose of this test is to assure that the regulator is operating satisfactorily and the alarm circuits are working. The system is removed from service and pilot current from a local oscillator is varied to operate the control condenser over its range. To check the A.C. supply failure alarm the A.C. supply circuit is opened.

Apparatus. Carrier-Frequency Oscillator. Measuring Circuit.



CHECK OF REGULATOR ALARMS.

FIG. 6.

Procedure. Regulator Alarms (See Fig. 6).

(1) Set the test oscillator for the nominal pilot frequency of the regulator under test as indicated in the table below and patch it to the TST POT IN or TST KEY IN jacks.

Type of System	Location of Regulator	Nominal Pilot Frequency
CS	East Terminal or W-E Repeater	24.35 kc
	West Terminal or E-W Repeater	9.45
CU	East Terminal or W-E Repeater	21.45
	West Terminal or E-W Repeater	9.45

(2) With the TEST key in the COMPARE position adjust the output of the test oscillator for approximately 15 db above 1 milliwatt. This may be done by adjusting to obtain a reading of - 5 db on the meter with one 10 db protection key in the OUT position.

(3) Set the attenuator for maximum attenuation.

(4) Patch from the ATTEN OUT to the PC IN jacks.

(5) Adjust the MAN CON dial for a reading of 50.

(6) Operate the TEST key to the ADJUST position and adjust the attenuator and the test potentiometer until the CON sensitrol relay reads as closely as possible to 0 db.

(7) Increase the attenuator setting 1 db if possible, otherwise 2 db.

Requirement. The CON sensitrol relay should operate and the regulator begin to reduce the network setting as noted by a reduction in the scale reading.

(8) Increase the attenuator setting 10 db.

Requirement. The ALM sensitrol relay should operate on the - 5 db contact immediately, and the ALM lamp on the REGT panel should light and the regulator cease to change. After 20 to 30 seconds, the audible and visible alarms should operate.

(9) Operate the ALM CO button on the REGT panel.

Requirement. The audible alarm should cease to operate, but the ALM lamp should remain lighted as long as the pilot level is below - 5 db.

(10) Readjust the attenuator and the test potentiometer until the CON relay reads 0 db.

Requirement. Following the resetting of the ALM sensitrol relay, the ALM lamp should go out after 3 to 5 seconds.

(11) Decrease the setting of the attenuator by 1 db if practicable, otherwise by 2 db.

Requirement. The CON sensitrol relay should operate and the regulator begin to increase the network setting as noted by an increase in the scale reading.

(12) Decrease the setting of the attenuator 5 db.

Requirement. The ALM sensitrol relay should close its + 3 db contact immediately and the ALM lamp should light. The regulator should cease to change. After 20 to 30 seconds the audible and visible alarms should operate.

(13) Repeat (9) and (10).

(14) Set the MAN CON dial for a scale reading of 95.

(15) Decrease the attenuator setting by 1 db if practicable, otherwise by 2 db.

Requirement. The regulator should step about every 4 seconds until all the network is in the circuit, at which point the regulator will cease to change. The ALM lamp should light and the audible and visible alarms operate.

(16) Operate the ALM CO button to silence the audible alarms.

(17) Increase the attenuator setting 5 db.

Requirement. The regulator should begin to change the network loss, and the ALM lamp should go out.

(18) By means of the MAN CON dial decrease the setting to a scale reading of 5.

Requirement. The regulator should continue to reduce the value of the network until it is all out of the circuit at which point the regulator will cease to change. The ALM lamp should light, and the audible and visible alarms should operate.

(19) Repeat (16).

(20) Decrease the attenuator setting 5 db.

Requirement. The regulator should begin to increase the setting of the network. The ALM lamp should go out.

(21) Change the setting of the attenuator until the CON sensitrol reads 0 db.

Procedure - A.C. power Alarm (Battery Operated Equipment Only).

(1) To check the A.C. no-voltage alarm, open the 110-volt A.C. supply.

Requirement. The audible and visible no-voltage alarms should operate.

(2) Restore the 110-volt A.C. supply.

Requirement. The visible no-voltage alarm should go out and the audible no-voltage alarm cease to operate.

1.4 C1 Repeater. The tests and adjustments for the C1 repeater are similar to certain of those specified for the C5 terminal. The adjustment of the transmitting level and gain are covered in the Section on "Overall System" tests.

Grid-Battery Voltage Adjustment. Same as "Grid Battery Voltage Adjustment" section under C5 terminal on page 5.

Pilot Control Circuit Tuning and Sensitivity Adjustment. Same as "Pilot Control Circuit Tuning and Sensitivity Adjustment" section under C5 terminal on page 12.

Check of Regulator Operation and Alarms. Same as "Check of Regulator Operation and Alarms" section under C5 terminal on page 14.

Output Level Measurement. This test is usually made at the request of the control office in connection with lineup and equalisation tests on the system.

Apparatus. Measuring Circuit.

Procedure.

(1) Patch the E-W AMP OUT jacks at the repeater to the ATTEN IN jacks. Set the attenuator for 18 db and operate the TEST key to the ADJUST position.

(2) The measured level is the attenuator setting correct for the meter reading.

Requirement. The measured level should be as close as possible to + 18 db.

(3) When testing in the other direction patch from the W-E AMP OUT jacks to the ATTEN IN jacks and follow procedures (1) and (2) above.

(4) Where output pads are employed to obtain a lower output level, the level at the output of the repeater is measured by patching from the E DIR FILT jacks to the ATTEN IN jacks and following procedures (1) and (2) above. For transmission in the other direction, patch from the W DIR FLT jacks to the ATTEN IN jacks and follow procedures (1) and (2) above.

(5) Output pads are adjusted by strapping the E-W OUT and W-E OUT pads in accordance with Note 103 on Drawing SD-64359-01.

1.5 Overall System. Overall System Equalisation and Lineup. The purpose of this test is to equalise the overall system and adjust the repeater levels so that the system will perform with minimum impairment to service through wide variations in weather conditions. It should be made initially in adjusting the system for service and at least annually thereafter to insure that the system levels are being maintained. Before making the lineup adjustment all the terminal, repeater and pilot channel tests, except pilot channel tuning and sensitivity operating adjustments should have been made. It is not necessary that all these tests be made on the day of the lineup.

The system is lined up in each direction from the transmitting terminal through each repeater in successive order to the receiving terminal under the control of the transmitting terminal. After the transmitting level has been set at the transmitting terminal the lineup at each repeater station is completed by adjusting the output level and making the pilot-channel adjustments before proceeding with equalisation at the next station. For convenience in discussing the procedure of lining up, the channels for either direction are referred to as the high, middle and low channels, respectively, based on the carrier frequency employed for each. Channel assignments are as follows -

	Low	Middle	High
E-W (low frequency group)	Chan. 3	Chan. 2	Chan. 1
W-E (high frequency group)	Chan. 2	Chan. 1	Chan. 3

All modulators, terminal and repeater amplifiers, pilot oscillators, pilot indicator and alarm circuits should be turned on at least two hours prior to the beginning of the system lineup in order to allow the vacuum tubes time to become stabilised.

Since the line attenuation increases with frequency, the level of the high channel would drop progressively below the level of the low channel in each repeater section if no equalisation were provided. The purpose of the equalisation procedure is to utilise the equalisers, regulating networks and building-out networks so that the three channels will remain approximately alike in level under service conditions, both at successive repeater stations and at the receiving terminal.

For systems not equipped with the 2B carrier pilot channel, satisfactory operation through changing weather conditions is best obtained by over-equalisation under dry weather conditions. ("Over-equalisation" is an equaliser arrangement which more than

compensates for the increased line attenuation at the higher frequencies so that the high channel leaves the repeater at a higher level than the low channel.)

For systems employing the 2B carrier pilot channel it is desirable that the system should be lined up to have as much regulating range as feasible so that it will operate satisfactorily through extreme weather conditions. This also will usually result in some over-equalisation.

The test-circuit setup, test-current adjustment and detailed method of measurement at the transmitting terminal, the detailed method of measuring and adjusting repeater output level, of checking the pilot oscillator output, and of adjusting tuning and sensitivity of the pilot indicator for the operating condition at repeaters and receiving terminals should be in accordance with the methods given in sections on the C5 terminal and C1 repeater on pages 5-16.

The method for equalisation and lineup given below is based on the tests being made under dry weather conditions. If it is necessary to make tests under other conditions, judgment should be used in determining the setting of the regulating networks, building-out networks and equalisers.

The procedure covers the lineup in equalisation for one direction of transmission; the same procedure should be followed for the other direction of transmission.

C5 Terminals Without 2B Carrier Pilot Channel. C5 terminals not equipped with pilot channel equipment will normally be used in systems having no repeaters. The equalisation and lineup procedure for such systems is as follows -

Apparatus at Terminals. Measuring circuit. 2-217D plugs (600 ohms).

Preliminary Procedure. Transmitting and Receiving Terminal.

(1) Check and if necessary adjust the transmitting output level of each channel. This should normally be + 18 db.

(2) At the transmitting terminal terminate the MOD IN jacks of the channels not in use with 217D plugs.

(3) At the receiving terminal set the REC GAIN CONT potentiometer on Step 5. Connect the BO2 network into the circuit and also 10 db of the REC pads.

Procedure with Reference to Receiving Terminal.

(1) The transmitting terminal should send on the high channel.

(2) At the receiving terminal read and record the output level as measured at the RA OUT jacks.

Requirement. The level should be approximately + 18 db.

(3) The transmitting terminal should send on the low channel.

(4) At the receiving terminal measure the output level.

(5) Note the difference between the two levels. To equalise the difference between the two levels change the BO networks. If the level of the low channel is above that of the high channel remove the BO2 network. If it is below add the BO1 network.

(6) Again send on the high and low channels and re-measure the receiving amplifier output after each change in the BO network. Record the BO network settings.

Requirement. The difference in level between the high and low channels should be less than 4 db and the level of the high channel should be above that of the low channel, if possible.

(7) Transmit on the middle channel and measure and record the level at the RA OUT jacks.

(8) Transmit on the channel having the highest level at the amplifier output.

(9) Adjust the amplifier output by means of the REC pads.

Requirement. The amplifier output level for the highest level channel should be as close as possible to + 18 db and should not exceed + 19 db.

(10) Remove the 217D plugs from the MOD IN jacks and proceed with the next test.

Systems with 2B Carrier Pilot Channel Equipment. When the terminals and repeaters are equipped with the 2B carrier pilot channel equipment, the following procedure should be employed.

Apparatus. Measuring circuit at terminals and repeaters. 3-217D plugs (600 ohms) at terminals. 2-258C plugs (open circuit) at terminals and repeaters.

Preliminary Procedure. Repeaters and Receiving Terminals.

(1) Stop the pulsing of the regulators by removing the 55-volt A.C. supply fuse at all offices.

(2) Adjust the gain of the pilot channel regulator amplifier for approximately 0 db by setting the GAIN ADJ potentiometer at midway between the upper and lower limits and set the regulator manually for a reading of 85 on the condenser dial for tests made under dry weather conditions.

Preliminary Procedure. Transmitting Terminal.

(1) Check and if necessary adjust the transmitting output level of each channel. This is normally + 18 db.

(2) Check and if necessary adjust the pilot output power. This is normally 8 db above 1 milliwatt.

(3) Terminate the MOD IN jacks of the channels not in use with 217D plugs and place a 258C plug in the OSC CO jack.

Procedure with Reference to Repeater and Receiving Terminal.

(1) The transmitting terminal should send on the high channel.

(2) At the repeater, read the output level as measured at the AMP OUT jacks, and adjust if necessary by means of the IN pads. At the terminal, read the output level at the RA OUT jacks and adjust if necessary by means of the REC pads.

Requirement. The level should be approximately + 18 db.

(3) At the transmitting terminal, transmit on the low channel.

(4) At the repeater or receiving terminal, measure the output level.

(5) Note the difference between the two levels. To equalise the difference between the two levels, change the BO networks. If the level of the high channel is above that of the low channel, increase the BO network setting; while if the level of the low channel is above that of the high channel, reduce the BO network setting.

(6) Again send on the high and low channels and remeasure the levels at the repeater output after each change in the BO network. Record the BO network settings.

Requirement. The difference in level between the high and low channels should be less than 4 db and the level of the high channel should be above that of the low channel, if possible.

4

(7) Transmit on the middle channel and measure and record the level at the repeater at the AMP OUT jacks (RA OUT jacks at the receiving terminal).

(8) Transmit on the channel having the highest level at the amplifier output.

(9) Adjust the amplifier output by means of the IN pads at the repeater or the REC pads at the terminal and the GAIN ADJ potentiometer.

Requirement. The amplifier output level for the highest level channel should be as close as possible to + 18 db and should not exceed + 19 db.

(In the case of a long section, it may not be possible to obtain a level of + 18 with all pads out when the condenser dial of the regulator is set at 85. In such a case, reduce the setting of the condenser dial).

(10) This level is also the repeater output level unless a level below + 18 db is to be employed. In this case adjust the OUT 1 and OUT 2 pads to give the required repeater output level, measured at the DIR FILT jacks.

(11) When satisfactory repeater output level adjustment and equalisation have been obtained, remove all patches at the repeater and proceed with the lineup with respect to the pilot channel, as follows -

(12) Terminate the MOD IN of each channel at the transmitting terminal with 217D plugs, remove the open circuit plug from the OSC CO jack and transmit normal pilot current from the terminal.

(13) At the repeater, measure and record the power of the pilot at the AMP OUT jacks.

(14) Remove the patch from the AMP OUT jacks and adjust the tuning and sensitivity of the pilot control circuit, making sure that the regulating network setting is the setting used in the lineup. Record the final reading of the CON sensitrol relay and the number of turns in use on the PIL FILT.

Requirement. The reading of the CON relay should be within 0.25 db of zero db.

(15) Remove all patches at the repeater and place a 258C plug in the OSC CO jack at the terminal preparatory to the lineup at the succeeding station. Make sure that a 258C plug is placed in the PULSE CO jack so that the regulating network will not step.

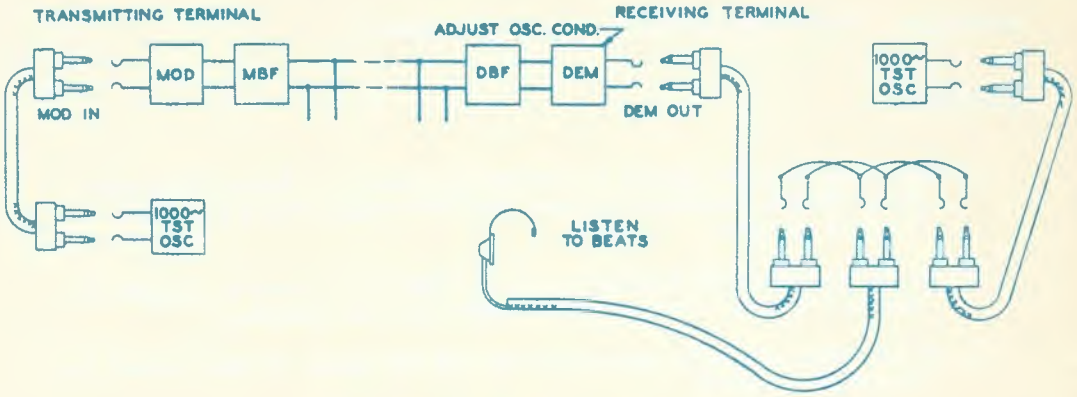
(16) Perform the tests listed in the paragraphs above at the succeeding repeaters and the receiving terminal. At the completion of the lineup in both directions, remove the 258C plug from the OSC CO jacks and replace the 55-volt supply fuses.

Synchronisation Adjustment. The purpose of synchronisation is to adjust the frequency of the demodulator oscillator at the receiving terminal to synchronise with the frequency of the modulator oscillator at the transmitting terminal. If there is an appreciable difference in frequency between the two carriers there will be some degradation in the quality of the channel. The adjustment should always be made by changing the frequency of the demodulator oscillator.

The test is made by transmitting 1000 cycles over the channel and comparing it at the receiving terminal with a local source of 1000 cycles. The demodulator oscillator frequency is then changed until beats, denoting a difference in frequency, practically disappear. The test should be made on each channel in each direction of transmission. The system should be operating normally when the test is made. Test sources should be used at each end which have been adjusted in frequency to be within 1 cycle of

each other, by utilising a physical circuit for transmitting the frequency of one source to the distant terminal so that the frequency of the distant source may be adjusted by the beat method. If desired the local test power obtained from the SEND - 13 jacks may be used for one source. In adjusting the test sources to have the same frequency either may be changed since the absolute frequency is not important.

Apparatus. Each terminal. Frequency source which has been synchronised at about 1000 cycles with the distant source to within 1 cycle. Head receiver equipped with cord and plug.



SYNCHRONISATION ADJUSTMENT.

FIG. 7.

Procedure (See Fig. 7).

Transmitting Terminal.

(1) Adjust the 1000-cycle source to a level of 13 db below one milliwatt and patch it to the MOD IN jacks of channel 1.

Receiving Terminal.

(1) Patch from the DEM OUT jacks of channel 1 to one pair of MULT jacks.

(2) Adjust the local 1000-cycle source to 1 milliwatt and patch it to the second pair of MULT jacks.

(3) Connect the head receiver to the third pair of MULT jacks.

(4) Listen for beat between the local source of 1000 cycles and the demodulated test tone from the far terminal. Adjust the level of the local test power if necessary to get a satisfactory beat.

(5) Adjust the variable T2 condenser on the front of the MODEM CH 1 panel to reduce the beats. If necessary, change the connection to taps 4 to 8 on the DO coil on the back of the same panel.

Requirement. The number of beats should be less than 1 per second.

(6) Repeat on the other two channels in the same direction and on all three channels in the other direction of transmission.

Channel Gain Adjustment. Each carrier channel is operated as a four-wire circuit and has a gain of 17 db in each direction of transmission. The level at the input to the modulator is - 13 db and that at the output from the demodulator + 4 db. A range of adjustment of about 10 db is provided in the demodulator for obtaining the desired + 4 db level at the demodulator output. This test provides a method for finally adjusting the gain of each channel and is made by applying 1000-cycle test power at the proper level at the transmitting terminal and measuring the level of the 1000-cycle output at the receiving terminal.

Apparatus. Measuring circuit at receiving terminal.

Procedure.

(1) Make sure that the system is operating normally. Where 2B carrier pilot channel equipment is used, the CON relays should be within ± 0.5 db of zero.

(2) At the transmitting terminal patch the SEND - 13 jacks to the MOD IN jacks of Channel 1 to send test power over the channel.

(3) At the other terminal patch from the DEM OUT jacks of this channel to the ATTEN IN jacks.

(4) Set the attenuator for a loss of 4 db and operate the TEST key to the ADJUST position.

(5) Adjust the CH GAIN CONT potentiometer of Channel 1 until the meter reads 0 db.

(6) Repeat (2) through (5) on the other two channels.

(7) Repeat the test to adjust the channel gains in the opposite direction of transmission.

Adjustment of 4-Wire Terminating Sets. Where it is desired to derive a 2-wire circuit from a carrier channel a 4-wire terminating set is employed. This equipment is adjusted to provide an outgoing level of - 13 db at the modulator input and to reduce the + 4 db level at the demodulator output to the required incoming level at the 2-wire side of the circuit in accordance with the specified circuit net loss. Two separate adjustments are required; one for the transmitting branch of the circuit and one for the receiving branch. These adjustments are made by selecting and inserting in the circuit suitable 89 plug type resistance pads, one for each branch.

The loss through the transmitting branch of the 4-wire terminating set with a zero loss 89 type resistance pad is approximately 7 db and that in the receiving branch also equipped with a zero loss pad is approximately 3.5 db. From these data, the modulator input and demodulator output levels and the desired circuit net loss the required losses for the 89 type resistances can be determined. If the carrier channel is extended over voice-frequency facilities or if switching pads are employed, the losses introduced by them should be included in determining the required losses for the 89 type resistances. The specific 89 type resistances to be employed can be found from the table below, which shows the code numbers for 89 type resistances having various losses.

LOSSES OF 89 PLUG TYPE RESISTANCES.

Code No.	Loss	Code No.	Loss
89A	0 db	89AL	7.5 db
89C	.5	89AN	8.0
89E	1.0	89AR	8.5
89G	1.5	89AT	9.0
89J	2.0	89AW	9.5
89L	2.5	89BA	10.0
89N	3.0	89BB	10.5
89R	3.5	89BC	11.0
89T	4.0	89BD	11.5
89W	4.5	89BE	12.0
89AA	5.0	89BF	12.5
89AC	5.5	89BG	13.0
89AE	6.0	89BH	13.5
89AG	6.5	89BJ	14.0
89AJ	7.0	89BK	14.5
		89BL	15.0

Example. Assume the carrier circuit is to be connected directly to the switchboard and a circuit net loss of 9 db is desired. A loss of 13 db is accordingly required in the transmitting branch of the 4-wire terminating set and a loss of 4 db + 9 db or 13 db in the receiving branch. For the transmitting branch the 89 type resistance should have a loss of 13 db - 7 db or 6 db, calling for an 89AE resistance. In the receiving branch the required loss for the resistance pad is 13 db - 3.5 db or 9.5 db and an 89AW resistance should be used.

Channel Net Loss Frequency Measurement. The channel band characteristics are obtained by measuring the net loss at representative frequencies in each direction of transmission. This may be accomplished either on a 4-wire basis or, when 4-wire terminating sets are provided, on a 2-wire basis. In order to avoid overloading the carrier system, it is necessary that the test power put into the channel at the modulator input be not greater than 1 milliwatt down 13 db.

Channels Tested on a 4-Wire Basis. In this case, the measurement is made between the modulator input at one terminal and the demodulator output at the opposite terminal. A 17-db pad is employed at the transmitting terminal so that one milliwatt power may be used at the sending end and one milliwatt will be automatically received at the receiving end. The attenuator associated with the measuring circuit is employed to provide this pad.

Apparatus. Adjustable voice-frequency oscillator at transmitting terminal. Measuring circuit at transmitting terminal. Measuring circuit at receiving terminal. 258C (open circuit) plug for repeater points and terminals equipped with 2B pilot channel.

Procedure.

(1) At all repeaters and receiving terminals equipped with 2B carrier pilot channel, place a 258C (open) plug in the PULSE CO jack.

(2) Establish communication between the two terminals over an order wire or one of the channels of the carrier system under test.

(3) At the receiving terminal, patch from the DEM OUT jacks to the 600 OHM MEAS jacks of the measuring set.

(4) At the transmitting terminal, patch the test oscillator to the TST POT IN or TST KEY IN jacks and patch from the ATTEN OUT jacks to the MOD IN jacks of the channel under test.

(5) Set the attenuator for a loss of 17 db.

(6) Set the oscillator for a frequency of 800 c/s and with the TEST key in the COMPARE position adjust the oscillator output to give a reading of zero db on the meter.

(7) Throw the TEST key to the ADJUST position to send 17 db below 1 milliwatt over the channel.

(8) At the distant terminal, note the reading of the received current on the meter.

(9) Repeat (6) through (8) for each of the frequencies -

Frequency	Frequency
800 c/s	2200 c/s
300 c/s	2400 c/s
400 c/s	2500 c/s
600 c/s	2600 c/s
800 c/s	2700 c/s
1000 c/s	2800 c/s
1600 c/s	800 c/s
2000 c/s	

Requirements. The three 800 c/s measurements are made for check purposes and the series of measurements should be repeated until the 800 c/s readings check each other within 0.5 db.

The losses should lie within the limits set out on Form TRM56.

(10) Repeat for the other two channels and for all three channels in the opposite direction of transmission.

(11) Remove all patches and restore the system to normal operating condition.

Channels Tested on a 2-Wire Basis. This measurement is made between the voice-frequency drop jacks of the channel under test at each terminal. These jacks are ordinarily designated D EQ. One milliwatt sending power is employed at the transmitting terminal, which is reduced in the 4-wire terminating set to 13 db below 1 milliwatt at the modulator input. If the transmitting branch of the 4-wire terminating set is adjusted for a loss other than 13 db, the transmitting power differs from 1 milliwatt and should be such as to provide a power of 13 db below 1 milliwatt at the modulator input. At the receiving terminal the 89 type resistance pad normally employed in the receiving branch of the 4-wire terminating set is removed and an 89A resistance (0 db) is used instead to obtain a receiving power of approximately 1 milliwatt.

Apparatus. Voice frequency oscillator at transmitting terminal. Measuring circuit at transmitting terminal. Measuring circuit at receiving terminal. 89A resistance at receiving terminal. 258C plugs (open circuit) at all repeater points and terminals equipped with 2B carrier pilot channel.

Procedure.

(1) At all repeaters and receiving terminals equipped with 2B carrier pilot channel, place a 258C plug in the PULSE CO jack.

(2) Establish communication between the two terminals over an order wire or one of the channels of the carrier system under test.

(3) At the receiving terminal, replace the 89 type resistance in the receiving branch of the 4-wire terminating set associated with the channel under test, with an 89A resistance.

(4) Patch from the D EQ jacks to the 600-OHM MEAS jacks of the measuring set.

(5) At the transmitting terminal, patch the test oscillator to the TST POT IN or TST KEY IN jacks and patch from the TST TR GAIN jacks to the D EQ jacks of the channel under test.

(6) Set the oscillator for a frequency of 1000 cycles and with the TEST key in the COMPARE position, adjust the oscillator output power to 1 milliwatt or other output power required to give 13 db below 1 milliwatt at the MOD IN jacks.

(7) Throw the TEST key to the ADJUST position, and send test current over the channel.

(8) At the distant terminal, record the power received.

(9) Repeat (5) through (7) for each of the frequencies specified under (9) page 24.

(10) Repeat for the other two channels and for all three channels in the opposite direction of transmission.

Requirement. The requirement for this test is the same as that given under (9) on page 24.

(11) Restore all original 89 type resistances in the 4-wire terminating sets, remove all patches and restore the system to normal operating conditions.

2. TROUBLE LOCATION TESTS.

2.1 This section describes tests which may be employed to locate trouble in the equipment. It is recommended that before carrying out any of the tests on the terminal or repeater the voltages supplied to these equipments be checked.

2.2 A.C. Power-Supply Equipment. Heater and Regulator Motor A.C. Supplies. If the heater or regulator motor voltages as outlined in the section "22 and 55 Volt A.C. Supplies" page 3 are not obtained.

(1) Check the 105-125-volt A.C. supply and the connections to the power transformer.

(2) With an A.C. voltmeter measure the voltage across terminals 1 and 3 and across terminals 4 and 5 of the power transformer (T1).

Requirement. The voltage across terminals 1 and 3 should be approximately 24 volts and that across terminals 4 and 5 should be approximately 55 volts. If these voltages are not obtained, trouble in the transformer is indicated.

D.C. Plate Supply. If no output voltage is obtained from the regulated tube rectifier check -

(1) The A.C. supply for a disconnected plug or blown fuse.
(2) The rectifier tube (VT1).
(3) The series tube (VT2).
(4) The filter condenser (C) for a short circuit.

If the A.C. input fuse is blown upon replacement and the filter condenser (C) is not short-circuited, the rectifier tube (VT1) is probably faulty and should be replaced.

If the D.C. voltage is low and cannot be raised by further clockwise rotation of the regulating rheostat, check -

(1) The 90-volt grid battery.
(2) The series tube (VT2).
(3) The rectifier tube (VT1).
(4) The amplifier tube (VT3) for grid emission.

If the D.C. voltage is high, failure of the regulating tube (VT3) is indicated. In this case the protective tube (VT4) will operate.

If loss of regulation occurs with the protective tube (VT4) operated and the tube (VT3) is functioning properly, turn the rheostat to its maximum counter-clockwise position until control is regained. Then turn clockwise to give the desired voltage. If this fails to bring back control replace tube (VT4).

Failure of the rheostat to perform its function or erratic control by the rheostat may be due to dirt on rheostat contacts. Dirty rheostats should be cleaned or replaced.

D.C. Signal Supply. The D.C. voltage of the copper-oxide rectifier unit should meet the limit specified in section "24 Volt D.C. Signal Supply", page 5. If not, proceed as follows -

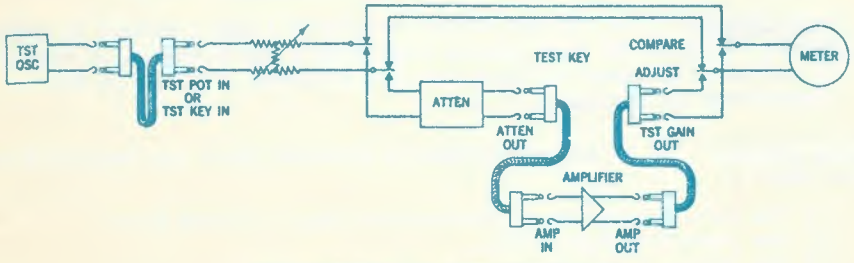
(1) Check the A.C. supply for a disconnected plug or blown fuse.

(2) Check the connection to the secondary winding of the transformer. The open-circuit A.C. voltage supplied to the varistor should be at least 32.5 volts.

(3) If, with the A.C. voltage connected to terminals 3 and 4 of the varistor the required D.C. voltage across terminals 1 and 2 cannot be obtained replace the varistor.

2.3 C5 Terminal. Measurement of Amplifier Gain. The feed-back-type amplifier used in the C5 terminal and the C1 repeater is inherently stable for normal battery voltage fluctuations and tube replacements. This test is made to insure that the performance of the amplifier is satisfactory since variations in gain will generally indicate trouble in the amplifier. To avoid overloading, the amplifier should be measured with an output power not greater than 20 db above 1 milliwatt. The repeater and receiving terminal amplifiers will usually be operated at a gain of 50 db while the transmitting amplifier will operate at a gain of 52 db.

Apparatus. Carrier Frequency Test Oscillator. Measuring Circuit.



MEASUREMENT OF AMPLIFIER GAIN.

FIG. 8.

Procedure. (See Fig. 8).

(1) Set the attentuator for maximum loss.

(2) Adjust the test oscillator for one of the frequencies given in the table below -

Amplifier	Freq.	Gain.	Freq.	Gain.
Transmitting	7.3 kc	51.9 db	27.4 kc	51.9 db
Receiving (or Repeater)	7.3 kc	50.0 db	27.4 kc	50.0 db

(3) Patch from the test oscillator to the TST POT IN or the TST KEY IN jacks of the measuring circuit.

(4) Patch from the ATTEN OUT jacks to the AMP IN jacks and from the AMP OUT jacks to the TST GAIN OUT jacks.

(5) Operate the TEST key to the COMPARE position and adjust the test potentiometer until 0 db is read on the meter with all the protection keys in the OUT position.

(6) Operate the TEST key to the ADJUST position and adjust the attentuator so as to obtain a reading as near as possible to 0 db on the meter with one of the 10-db protection keys in the OUT position.

(7) The amplifier gain is equal to the setting of the attenuator corrected for the reading indicated on the meter. With one 10-db protection key in the OUT position the meter reading is increased 20 db.

(8) Repeat (2), (5), (6) and (7) using the second frequency given in the table.

Requirement. The gain of the amplifier should be within 0.5 db of the values given in the table below.

(9) If the requirement is not met, check the tubes associated with the amplifier under test. Before removing any tube be sure the heater supply is turned off.

Measurement of Receiving Gain. The receiving circuit of each channel includes the demodulator, demodulator band filter, and the equipment common to all three channels, i.e. directional filter, receiving pad, basic equaliser, building-out networks, regulating equipment, receiving amplifier and a fixed 20-db pad. This test provides a method for checking the transmission performance of the receiving terminal equipment.

The test is made by first measuring and adjusting the receiving amplifier-demodulator unit, and then adding the other units to this unit, thus permitting localisation of any possible trouble. A high-frequency input which results in a demodulator output of 1000 cycles is used to measure the gain of each channel.

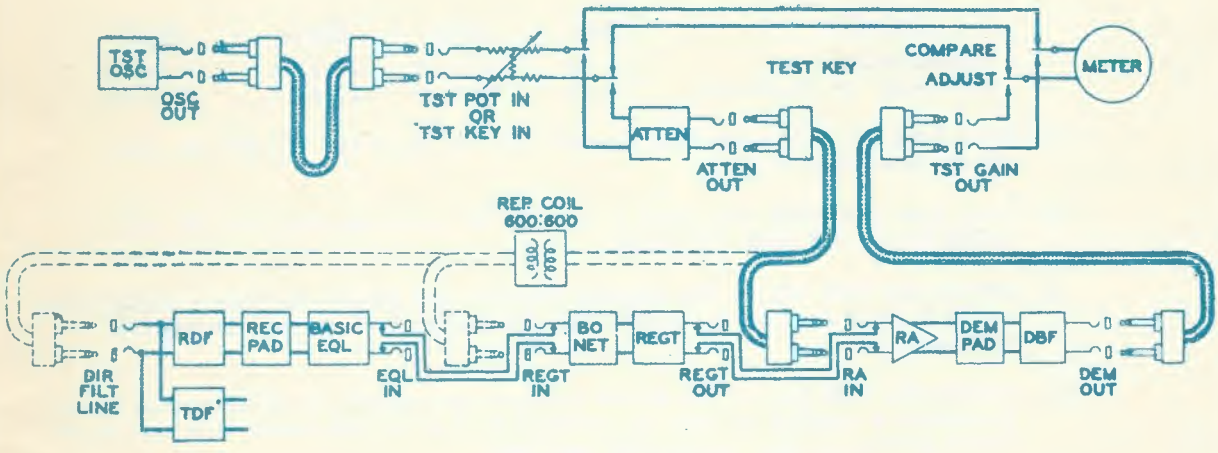
Apparatus. Measuring Circuit. Carrier-Frequency Oscillator. 600:600 Ohm Repeating Coil (An external coil is not required if 30A Transmission Measuring Set is used.) 1-285C Plug.

Procedure. (See Fig. 9).

(1) The DEM A and DEM B pads are strapped for a loss of 20 db at the factory.

(2) Set the high-frequency oscillator for the frequency of the middle channel in accordance with the following table -

Terminal	Channel	Frequency
CS or CU West	2	10.4 kc
CS East	1	23.4 kc
CU East	1	22.4 kc



MEASUREMENT OF RECEIVING GAIN.

FIG. 9.

(3) Patch from the OSC OUT jacks to the TST POT IN or TST KEY IN jacks.

(4) Patch from the ATTEN OUT jacks to the RA IN jacks.

(5) Patch from the TST GAIN OUT jacks to the DEM OUT jacks.

(6) With TEST key in the COMPARE position adjust the output of the oscillator until the meter reads 0 db.

(7) Set the attenuator for 36 db.

(8) Operate TEST key to the ADJUST position and adjust the GAIN CONT potentiometer associated with the demodulator amplifier circuit for a reading of 0 db on the meter. The portion of the circuit from the input of the receiving amplifier to the output of the demodulator amplifier is now adjusted for normal operating gain.

Requirement. The meter reading should be within 0.2 db of zero.

(9) If the above limit cannot be met the following procedure should be followed -

(a) Check the tubes associated with the demodulator and receiving amplifier circuits under test, observing the precaution of turning off the heater supply before removing any tube.

(b) Check the demodulator oscillator output as explained in a subsequent test.

(c) Check the gain of the receiving amplifier.

(10) Remove the plug from the RA IN jacks and connect to the input of a 600:600 ohm repeating coil.

(11) Patch from the other side of the repeating coil to the REGT IN jacks.

If 2B carrier pilot channel equipment is provided proceed as follows -

(12) Insert a 258C plug in the PULSE CO jack and set the MAN CONT dial to 0.

(13) Repeat (6) and (7) above.

(14) Operate TEST key to the ADJUST position and adjust the GAIN ADJ potentiometer on the automatic gain control panel for a reading of 0 db on the meter. This adjusts the gain of the automatic gain control circuit together with the repeating coil for 0 db. This setting should be retained for the remainder of the test.

Requirement. The meter reading shall be within 0.2 db of zero.

(15) If the above limit cannot be met the tube in the automatic gain-control circuit should be checked. Observe precaution of turning off the heater supply before removing tube.

If the 2B carrier pilot channel equipment is not provided -

(16) Connect the B01 and B02 networks to the OUT position and set the REC GAIN CONT potentiometer on step 10.

(17) Repeat (6) and (7) above.

(18) Operate the TEST key to the ADJUST position and note meter reading.

Requirement. The meter reading should be within 0.3 db of zero.

(19) Set the REC GAIN CONT potentiometer on step 9.

(20) Set the attenuator for 34 db.

(21) Repeat (6) and (18) above.

Requirement. The meter reading should be within 0.4 db of zero.

(22) Repeat (19), (20) and (21) for the other potentiometer steps down to and including step 1. In each case 2 db is removed from the attenuator for each step reduced.

Requirement. The meter reading should be within 0.4 db of zero in each case.

(23) Reset the REC GAIN CONT potentiometer on step 10. This setting should be retained for the remainder of the test.

The following procedure applies for all terminals regardless of the type of regulating equipment employed -

(24) Remove the plug from the REGT IN jacks and insert in the DIR FILT LINE jacks.

(25) Set the REC pads to the OUT condition.

(26) Set the attenuator in accordance with the table under (28) below for the channel under test.

(27) Repeat (6) and (18) above.

Requirement. The meter reading should be within 1.0 db of the value given in (28) below.

(28) Repeat (26) and (27) on the other two channels using frequencies and attenuator settings as listed below.

Terminal	Channel	Freq.	Attenuator Setting	Meter Reading
CS or CU West	1	13.9 kc	16 db	+ 0.3 db
	2	10.4	20	0
	3	7.3	25	0
CS East	1	23.4	25	+ 0.2
	2	19.7	18	- 0.1
	3	27.4	32	+ 0.5
CU East	1	22.4	24	- 0.2
	2	18.7	27	- 0.3
	3	27.4	31	+ 0.3

Requirement. The meter reading should be within 1.0 db of the value given in the table.

The above measurements provide a check of the losses of the receiving directional filter, the REC repeating coil and the basic equaliser.

Check of BO Networks. (For Terminal Not Equipped with 2B Pilot Channel).

(1) Change the connection of the BO1 network to the IN position.

(2) Remeasure the receiving gain of the highest frequency channel. The difference in gain between that measured in (28) above and this measurement is the loss of the network at the upper test frequency.

(3) Remeasure the receiving gain of the lowest frequency channel. The difference between the gain measured in (28) above and this measurement is the loss of the network at the lower test frequency.

(4) Reset the BO1 network to the OUT position.

(5) Repeat (1), (2), (3) and (4) for the BO2 network.

Requirement. The loss of each network should be within 0.5 db of limits given below.

Terminal	Pad	Upper Test Frequency Kc	Loss (db)	Lower Test Frequency Kc	Loss (db)
CS or CU West	BO1 or BO2	13.9	7.7	7.3	5.2
CS East	BO1 or BO2	27.4	11.8	19.7	9.3
CU East	BO1 or BO2	26.4	11.5	18.7	9.2

Check of REC pads.

(1) Measure the receiving gain of the highest frequency channel in accordance with the procedure outlined above with the REC pads and the BO networks in the OUT position.

(2) Change the 2 db unit of the REC pad to the IN position.

(3) Readjust the attenuator for a zero db reading on the meter to obtain a new receiving gain value.

(4) Reset the 2 db pad to the OUT position.

(5) Repeat (2), (3) and (4) for each REC pad.

Requirement. The difference in receiving gain measured with each pad IN and OUT should be within 0.25 db of the nominal value of the pad.

Modulator and Demodulator Oscillator Output Measurement. Satisfactory performance of the modulator and demodulator circuit is dependent to some extent upon the amount of carrier power impressed upon the varistor circuits. The amount of power will vary with differences in the oscillator circuit and varistor elements and with aging of the units. The carrier power will be adjusted initially at the factory and should normally not require readjustment thereafter. The carrier voltage is measured by unsoldering the wiring to the varistor and measuring the output of the oscillator.

Apparatus. Measuring circuit. Cord equipped with clips at one end and 241A plug on opposite end. 1-217D Plug (600 ohms).

Procedure.

(1) Terminate the MOD IN jacks of the channel under test with a 217D plug. For testing a demodulator oscillator no special termination is required.

(2) Remove the wire from terminals 4 and 6 of the MOD or DEM varistor.

(3) Clip one end of the cord to the two wires removed under (2) above. Patch the other end of the cord to the ATTEN IN jacks.

(4) With the TEST key in the ADJUST position, reduce the attenuator setting until a satisfactory reading is obtained on the meter.

Requirements. The modulator carrier power should be 3.5 db $\pm$ 1.5 db below 1 milliwatt at an east terminal or 1 db - 1.5 db below 1 milliwatt at a west terminal. The demodulator carrier power, as read on the meter, should be 3 db $\pm$ 2 db above 1 milliwatt.

(5) If the requirements are not met, change the M1 or D1 tube.

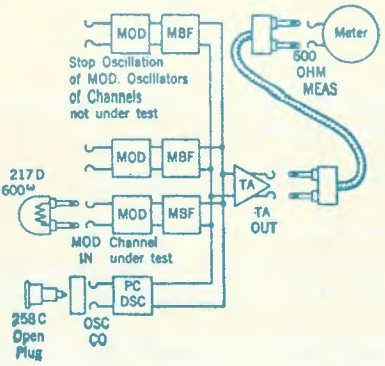
(6) When the requirements are not met and a new tube is placed in service, proceed as outlined in items (1), (3) and (4) and, if necessary, in order to meet the requirements in (4), change the tap lead to another terminal between 10 and 14 on the MO or DO input transformer.

Measurement of Carrier Leak. The degree of balance in the copper-oxide modulators is normally sufficient to maintain the carrier leak within the requirements. However, the balance may be upset if, for instance, the modulator is subjected, accidentally, to high voltages. This test provides a means for determining if the carrier leak is within limits. The copper-oxide unit must be replaced if the limits are not met. All channels of the system must be out of service to permit making the test.

Apparatus. Measuring Circuit. 3-217D Plugs (600 ohms). 1-258C Plug (Open Circuit).

Procedure. (See Fig. 10)

(1) Insert a 258C plug in the OSC OO jack, when provided, to remove the pilot current.



CARRIER LEAK MEASUREMENT.

FIG. 10.

(2) Insert 217D plugs in the MOD IN jacks of all three channels of the system under test.

(3) Patch from the TA OUT jacks to the 600 OHM MEAS jacks.

Requirement. The meter reading which is the resultant of the carrier leak from the three channels, should not exceed -5 db (5 db below 1 milliwatt).

(4) If the requirement is not met, proceed as outlined below to measure the carrier leak of each channel.

(5) Stop oscillation of the modulator oscillators of the two channels not under test, by removing the 130-volt fuses associated with these channels.

(6) Patch from the TA OUT to the 600 OHM MEAS jacks.

(7) The filament current of the modulator under test should be checked to make sure that it meets requirements.

(8) Read the carrier leak on the meter, operating the protection keys as required, to get satisfactory reading.

Requirement. The carrier leak on any channel should not exceed 12 db below 1 milliwatt.

(9) If the requirements are not met, check for possible defective varistor elements as follows.

(10) Disconnect all wires from the MOD or the DEM varistor.

(11) Check for possible short-circuited varistor elements with a Wheatstone bridge having a nominal battery voltage of 1.5 volts.

Requirement. The resistance between the various terminals of the varistor should be as given in the table below.

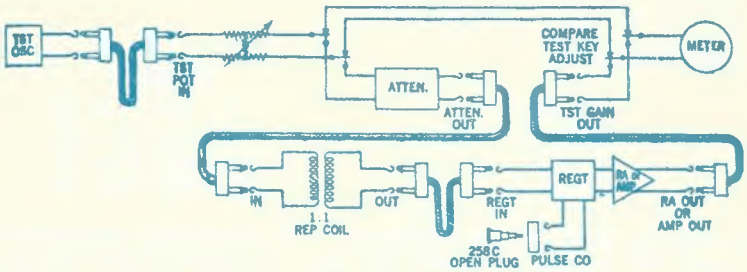
Measured Between Terminals.	Forward Resistance in Ohms. Min.	Forward Resistance in Ohms. Max.	Reverse Resistance in Ohms at 70°F
1 - 2	250	500	*30,000
2 - 3	250	500	*30,000
4 - 5	250	500	*30,000
5 - 6	250	500	*30,000

* For every 10 degree increase in temperature, the resistance may decrease approximately 5000 ohms.

Check of Regulator Characteristic. The regulator is set initially at the time of the overall system lineup. Its loss-frequency characteristic is equivalent to a certain length of open-wire line, depending upon the amount of building-out network used and the setting of the control condenser. In addition the regulator provides a small amount of flat gain which is variable within a small range and is used in accurately setting the amplifier output level. The purpose of this test is to check the loss-frequency characteristic of the regulator and the flat gain range provided.

The regulator is measured at each end of its range, using a frequency near the top of the working frequency band. The results indicate the range of the regulator at that frequency. It is then remeasured at the top of its range using a lower frequency. This gives the slope of the regulating network at the top of its range. The BO networks are then added one at a time and the measurements repeated to determine the slope of the BO networks and the regulating network combined. A transformer is required for this test since the regulator input is unbalanced. If the loss of the transformer is not known, it should be determined by measurement.

Apparatus. Carrier-frequency oscillator. Measuring Circuit. 1-258C (open) plug at a terminal. 2-258C (open) plugs at a repeater. 600:600 Ohm Repeating Coil (or repeating coil in 30A set).



CHECK OF REGULATOR NETWORK CHARACTERISTIC.

FIG. 11.

Procedure. Regulator Network Characteristic. (See Fig. 11).

(1) Place a 258C plug in the PULSE CO jack at a terminal. At a repeater place a 258C plug in the PULSE CO jack for each direction of transmission.

(2) Do not change the setting of the potentiometer associated with the regulating amplifier. Since the requirement data given below consist of differences between measured values of gain or loss, the potentiometer may be left on its working setting.

(3) Connect the straps of all the building-out networks to the OUT position.

(4) Patch from the test oscillator to the TST POT IN or TST KEY IN jacks.

(5) Using one of the test frequencies stated below, operate the TEST key to the COMPARE position and adjust the test current for a reading of zero db on the meter.

(6) Make the following patches -

ATTEN OUT jacks to INPUT of the 600:600 ohm coil.
OUTPUT of the coil to REGT IN jacks.
AMP OUT or RA OUT jacks to TST GAIN OUT jacks.

(7) Set the attenuator for maximum attenuation. Measure the gain for each of the conditions noted in items (9), (10) and (11) below by proceeding as follows -

(8) Operate the TEST key to the ADJUST position and adjust the attenuator for as close as possible to zero db reading on the meter. If necessary, use the protection keys to extend the range of the meter. Correct the attenuator setting by the reading of the meter and record the corrected value.

(9) With the MAN CON dial on zero, make gain measurements at 13.9 and 7.3 kc for west terminals and E-W repeaters or at 27.4 and 19.7 kc for east terminals and W-E repeaters. Denote the measured gains by the letters A, B, C and D, respectively.

Requirements. The differences in gain should be as indicated in the following table -

A - B not more than 0.2 db.
C - D not more than 0.2 db.

(10) Set the MAN CON dial on 100 and repeat the gain measurements at 13.9 and 7.3 kc for west terminals and E-W repeaters or at 27.4 and 19.7 kc for east terminals and W-E repeaters. Denote these gains by the letters A', B', C' and D', respectively.

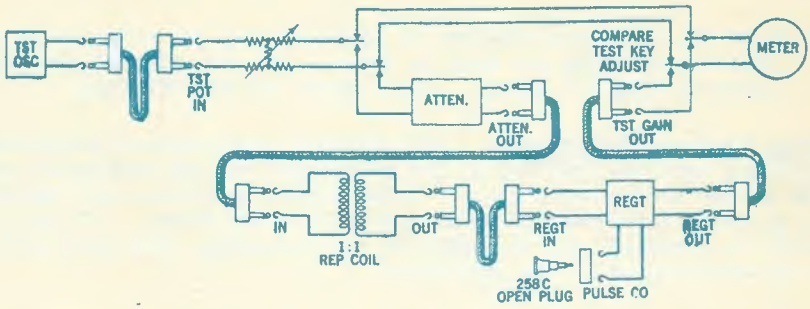
Requirements.

	Between
A - A'	18.4 and 19.8 db
B - B'	12.1 and 13.5 db
C - C'	19.0 and 20.4 db
D - D'	15.0 and 16.4 db

(11) Connect in both the BO networks. The following requirements table also gives the limits to be met for the individual networks in case the overall requirements are not met. With the MAN CON dial on 100, make gain measurements at 13.9 and 7.3 kc for west terminals and E-W repeaters or at 27.4 and 19.7 kc for east terminals and W-E repeaters. Denote these gains by the letters A", B", C" and D", respectively.

Requirements.

	West Terminal or E-W Repeater		East Terminal or W-E Repeater	
BO Net	Decrease in Gain db at 13.9 kc	Slope of BO Net db	Decrease in Gain db at 27.4	Slope of BO Net db
	A' - A"	(A' - A") - (B' - B")	C' - C"	(C' - C") - (D' - D")
Both	10.8 to 12.2	3.2 to 4.2	11.1 to 12.5	2.0 to 3.0
BO1 (4 db)	3.1 to 4.5	0.7 to 1.7	3.2 to 4.6	0.4 to 1.4
BO2 (8 db)	7.0 to 8.4	2.0 to 3.0	7.2 to 8.6	1.1 to 2.1



REGULATOR FLAT GAIN MEASUREMENT.

FIG. 12.

Procedure. Regulator Flat Gain Measurement (See Fig. 12).

(1) Set the test oscillator for a frequency of 13.9 kc for an E-W regulator or 27.4 kc for a W-E regulator.

(2) Patch from the test oscillator to the TST POT IN or TST KEY IN jacks.

(3) With the TEST key in the COMPARE position, adjust the testing power for a reading of zero db on the meter.

(4) Place a 258C (open) plug in the PULSE CO jack.

(5) Make the following patches.

ATTEN OUT jacks to INPUT of the 600:600 ohm coil.
OUTPUT of the coil to REGT IN jacks.
REGT OUT jacks to TST GAIN OUT jacks.

(6) Set the MAN CON dial for a reading of zero.

(7) Operate the TEST key to the ADJUST position and adjust the attenuator to obtain a reading as close as possible to zero db on the meter.

(8) The setting of the attenuator corrected for the reading of the meter and the loss in the 600:600 ohm coil is the flat gain of the regulator. If the regulator is operating at a loss, the attenuator setting will be zero and the meter reading will give the loss of the regulator and the transformer. Note the setting of the GAIN potentiometer if the system is in service by marking the panel temporarily.

(9) Set the GAIN potentiometer on the REGT panel for minimum gain by operating it in a counter-clockwise direction.

(10) Repeat (7) and (8).

Requirement. The loss of the regulator when corrected for the coil loss should be between 2.0 and 4.0 db.

(11) Set the GAIN potentiometer for maximum gain by operating it in a clockwise direction.

(12) Repeat (7) and (8).

Requirement. The gain of the regulator when corrected for the coil loss should be between 2.0 and 4.0 db.

(13) Reset the GAIN potentiometer at approximately the midpoint of its range or, if the system has been in service, to its original position as noted in Item (8) above. Also, reset the MAN CON dial.

Amplifier Overload Measurement. Satisfactory inter-channel modulation of the system is dependent upon the limiting in the modulators and the modulation and load-carrying ability of the system amplifiers. Under normal conditions the amplifiers operate at levels at which inter-channel modulation will seldom occur. If high inter-channel crosstalk is obtained, and an amplifier is suspected, this test should be used to check the performance of the amplifier.

The amplifier overload ability is checked by measuring the change in amplifier gain as the output power is increased. If the amplifier is operating satisfactorily the change in gain should be practically zero for outputs below the sharp breaking point of the amplifier. The regulating amplifier may be measured in conjunction with the line amplifier if desired.

Apparatus. Carrier-frequency oscillator. Measuring circuit. 600:600 Ohm Repeating Coil (or repeating coil in 30A set).

Procedure.

(1) Set the test oscillator for a frequency of 13.9 kc and patch the output to the TST POT IN or TST KEY IN jacks.

(2) Operate the TEST key to COMPARE and adjust the output for 1 milliwatt.

(3) Patch from the ATTEN OUT to the AMP IN jacks and from the AMP OUT to the TST GAIN OUT jacks.

(4) Where 2B carrier pilot channel equipment is provided the regulating amplifier should be included in the test of the receiving amplifier by patching from the ATTEN OUT jack to the INPUT to the 600:600 ohm repeating coil and from the OUTPUT of the coil to the REGT IN jacks. The MAN CON dial should be set on 0.

(5) Set the attenuator for a loss of 32 db when testing a transmitting amplifier or 30 db when testing a repeater or receiving amplifier.

(6) Operate the TEST key to ADJUST and vary the test potentiometer and if necessary the gain potentiometer on the REGT panel until 0 db is read on the meter with one 10-db protection key in the OUT position. (This indicates power of 20 db above 1 milliwatt.).

(7) Release the 10-db protection key and reduce the setting of the attenuator 10 db. Read the meter with all protection keys normal (This indicates a power of 30 db above 1 milliwatt.)

Requirement. The meter reading should be within 0.3 db of zero.

(8) Replace first the AMP (2) tube, then the AMP (1) tube or the REGT (1) tube or all three tubes if necessary to make the amplifier meet requirements. When removing tubes, be sure heater supply is turned off.

2.4 C1 Repeater. Measurement of Amplifier Gain. Same as "Measurement of Amplifier Gain" for C5 terminal on Page 26.

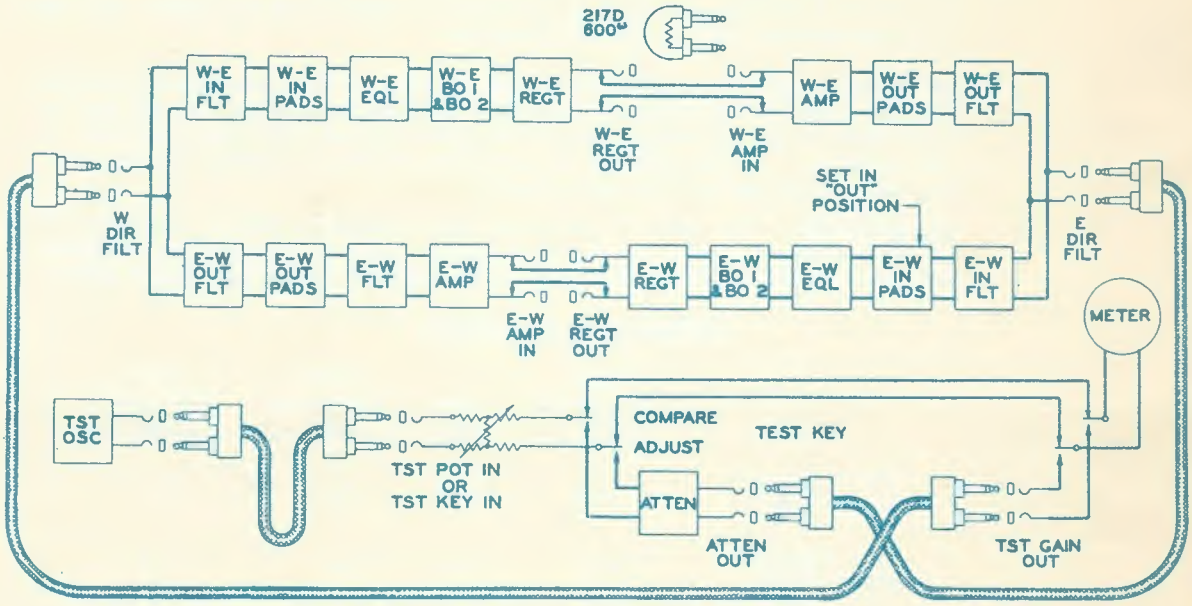
Measurement of Repeater Gain. The overall gain of the repeater will vary with the gain of the amplifier and also with the losses of the filters, equalisers, networks and pads. Each unit will change slightly due to aging, etc., but the total change

will in general be small. Measurements are made to insure that the gain-frequency performance is satisfactory.

While the amplifier gain is substantially flat with frequency, the losses in the equalisers, filters and networks differ with frequency and it is desirable to measure the overall gain at frequencies in the upper and lower channels in each direction of transmission. The change in repeater gain as the pads and networks are cut in and out of the circuit will check the performance of these elements.

The gain in each direction of transmission is measured by noting the input and output testing power. Two representative frequencies are specified in each direction of transmission. An output power of 20 db above 1 milliwatt is used in the measurement.

Apparatus. Carrier-Frequency Oscillator. Measuring Circuit. 1-217D Plug (600 Ohms). 2-258C Plugs (Open).



MEASUREMENT OF REPEATER GAIN (E-W).

FIG. 13.

Procedure. (See Fig. 13).

(1) Insert a 258C plug in the PULSE CO jack in each direction of transmission.

(2) Note the setting of the IN pads, and the OUT pads. Reset the bar controls of the IN pads for the OUT position.

(3) Set the regulating amplifier for maximum gain by operating the GAIN rheostat to the extreme clockwise position. Set the regulator for minimum regulating network by setting the MAN CON dial on zero.

(4) Terminate the amplifier input of the direction not under test by placing a 217D plug in the AMP IN jacks.

(5) To measure the overall repeater gain make the following patches. For E-W Gain - ATTEN OUT to E DIR FLT jacks and W DIR FLT to TST GAIN OUT jacks. Set the attenuator for maximum loss.

For W-E Gain - Interchange the connection to the E DIR FLT and W DIR FLT jacks, remove the 217D plug from the W-E AMP IN jacks and terminate the E-W amplifier input by means of a 217D plug in the E-W AMP IN jacks.

(6) Set the test oscillator first for the upper test frequency and then for the lower test frequency as specified in the table below. Patch from the oscillator to the TST POT IN or the TST KEY IN jacks of the measuring circuit.

(7) For each frequency operate the TEST key to the COMPARE position and adjust the test potentiometer until zero db is read on the meter with all protection keys in the OUT position.

(8) Operate the TEST key to the ADJUST position and adjust the attenuator so as to obtain a reading as close as possible to zero db on the meter with one 10 db protection key in the OUT position.

(9) The repeater gain is equivalent to the setting of the attenuator corrected for the reading indicated on the meter plus 20 db. When the OUT pad is less than 10 db, allowance should be made for any OUT pads connected in the circuit. If the OUT pad is more than 10 db, it should be strapped for zero db in making the measurement.

Requirements. The gain of the upper test frequency should be within 2.0 db of the values given in the table below. The difference in the gains at the two specified frequencies should be within 1 db of the values given.

OVERALL GAIN OF REPEATER

	Upper Frequency kc	Gain db	Lower Frequency kc	Gain Difference db
Low Frequency Group (E-W)	13.9	40.9	7.3	8.6
High Frequency Group (W-E)	27.4	48.5	19.7	7.5

(10) To check the loss of any IN pad, note the difference in gain at the higher test frequency as each pad unit is connected into the circuit by setting the bar control to the IN position. The protection keys should be used when necessary to obtain a reading on the meter. The difference in gain is the pad loss.

Requirements. The loss for each unit should be within 0.2 db of the value of the pad unit.

(11) The loss of each output pad can be checked using the method and requirements given in (10) above, and connecting the pads in one at a time.

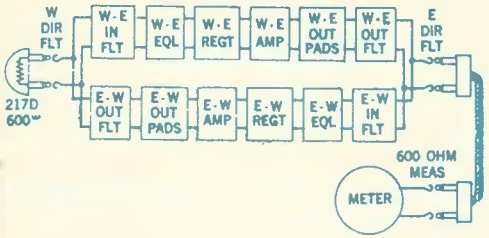
(12) Reset pads and regulating condenser to their original value before placing the repeater back into service. Remove the 258C plugs from the PULSE CO jacks.

Check of Regulator Characteristic. Same as "Check of Regulator Characteristic" under C5 terminal on Page 33.

Amplifier Overload Measurement. Same as "Amplifier Overload Measurement" under C5 terminal on Page 36.

Singing Test of Directional Filters. The directional filters will provide sufficient loss around the repeater loop if no trouble exists in the circuit. If trouble does exist, it should show up when the singing margin is measured by arranging the repeater for maximum gain. The test is made by noting if any singing current appears in the repeater loop when the gain of the repeater is increased by removing the pads and networks and setting the regulators for maximum gain.

Apparatus. Measuring Circuit. 1-217D Plug (600 Ohms). 2-258C Plugs (Open). 1-Patch Cord.



SINGING TEST OF DIRECTIONAL FILTERS.

FIG. 14.

Procedure (See Fig. 14).

(1) Place a 258C plug in the PULSE CO jacks for each direction.

(2) Terminate the W DIR FLT jacks by inserting a 217D plug.

(3) Patch from the E DIR FLT jacks to the 600 OHM MEAS jacks.

(4) Note the setting of the OUT pads in each direction and strap each one to the OUT position.

(5) Set the W-E IN pads and the E-W IN pads to the OUT position.

(6) Note the position of each gain potentiometer on the REGT panel and reset for maximum regulating amplifier gain.

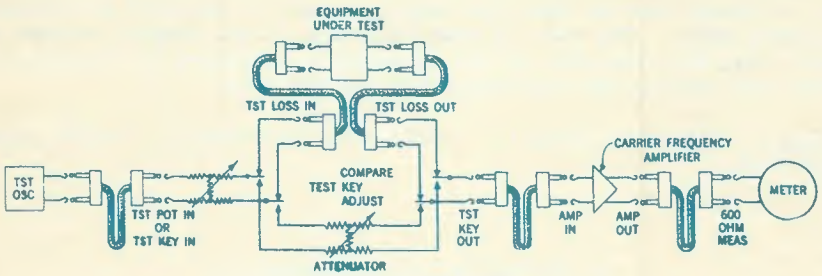
(7) Set first the W-E regulator and then the E-W regulator for minimum regulating network by operating the MAN CON dial in a counter-clockwise direction in steps of about 20 divisions. After each change in dial setting, operate the protection keys carefully and note the reading of the meter.

Requirements. It should be possible to set all pads and networks for zero db loss, using maximum gain in both regulating amplifiers and using minimum regulating network in both regulators, without the repeater singing. A singing condition is shown by a sudden large deflection of the meter. A gradual change in meter reading as the MAN CON dial setting is changed may be due to noise.

(8) Reset the IN and OUT pads, MAN CON dials and GAIN potentiometers to their normal settings.

2.5 Miscellaneous. Loss Measurement. This test is given primarily for use in locating trouble.

Apparatus. Testing Oscillator. Measuring Circuit.



LOSS MEASUREMENT.

FIG. 15.

Procedure (See Fig. 15).

(1) Patch the equipment to be tested to the TST LOSS IN and the TST LOSS OUT jacks of the measuring circuit.

(2) Patch the test oscillator to the TST POT IN jacks, if available, otherwise to the TST KEY IN jacks.

(3) Set the test oscillator for the test frequency and with the TEST key operated to COMPARE adjust the test potentiometer and, if necessary, the output of the test oscillator to give a reading on the meter on some scale division, preferably at zero db. (Since the meter is being used in this test as an indicating device in making the measurement on a comparison basis and not to measure a specific power, it is not essential that the meter reading be adjusted to any particular value. For convenience, however, the reading should be on some scale division.)

(4) When making a measurement near the cut-off of a filter, it is important that the test current be as free as practicable from harmonics. In general as low a value of test current as possible should be used.

(5) Operate the TEST key to ADJUST and adjust the attenuator to give a reading on the meter as close as possible to the reading noted in (3).

(6) The loss of the equipment to be tested is the setting of the attenuator corrected for the difference between the scale readings in (3) and (5).

(7) When the loss to be measured is too great to permit obtaining a satisfactory reading with the maximum output from the oscillator, it will be necessary to patch a carrier-frequency amplifier in the input of the meter circuit between the TST KEY OUT and 600 OHM MEAS jacks and to proceed as in (3), (5) and (6).

(8) If the amplifier employed is equipped with a gain adjustment, this may be used in adjusting the output as specified in (3) above.

(9) If the amplifier is not equipped with a gain adjustment, the protection keys in the meter circuit should be used together with adjustment of the oscillator output and the test potentiometer in order to obtain a satisfactory reading in (3) above. In no case should the meter reading used be above zero db with the protection keys in the IN position.

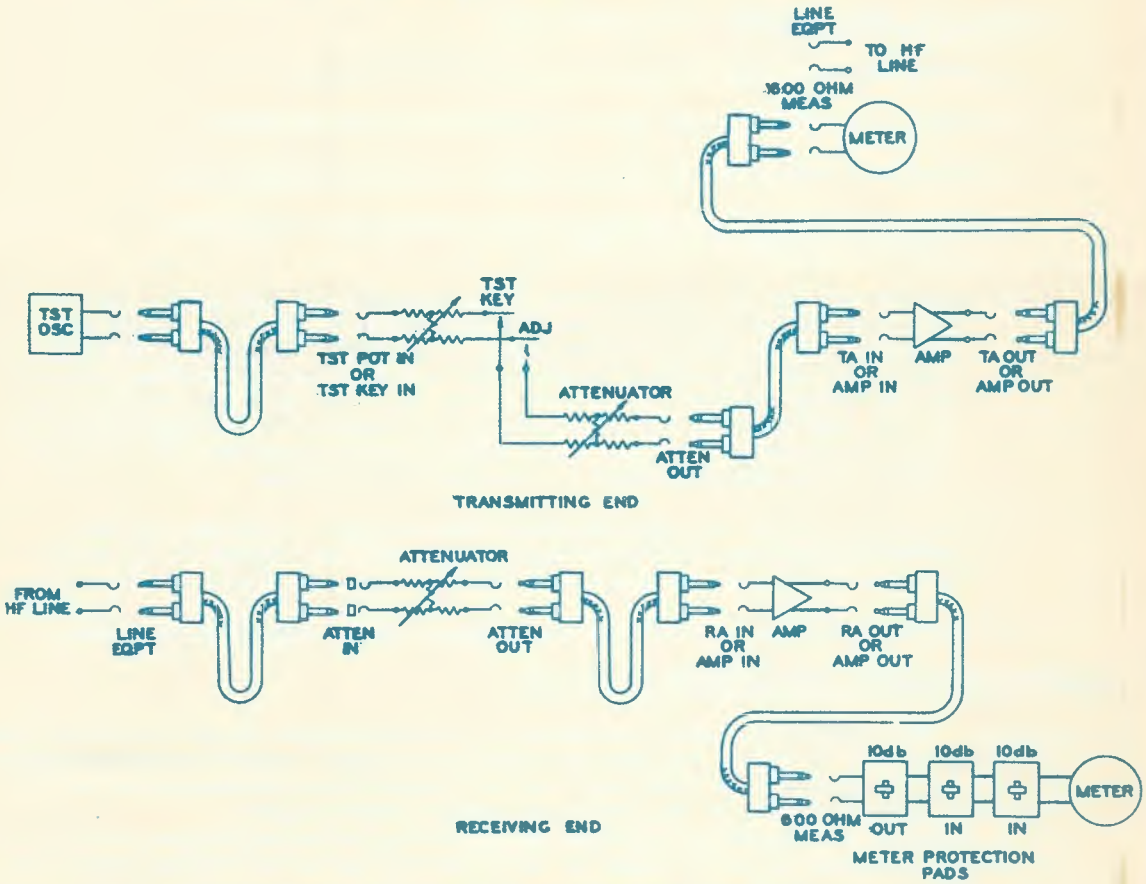
Overall High-Frequency Line Attenuation. The purpose of this test is to measure the high-frequency line loss of any line section at various frequencies. The method includes the use of an amplifier at each end of the line section. The loss of the line section can be obtained by subtracting the gains of the two amplifiers from the overall measurements.

Apparatus. Carrier-Frequency Oscillator at Transmitting End. Measuring Circuit at Each End. 1-258C (Open) Plug at Each End Equipped with 2B Pilot Channel.

Preliminary Procedure.

(1) Insert a 258C plug in all the PULSE CO jacks of the 2B pilot channel at the receiving end where provided.

(2) Insert a 258C plug in the OSC CO jacks of the 2B pilot channel at the transmitting end where provided.



MEASUREMENT OF OVERALL HIGH-FREQUENCY LINE ATTENUATION.

FIG. 16.

Procedure at Transmitting End. (See Fig. 16).

(1) Patch from test oscillator to TST POT IN if provided, otherwise to TST KEY IN jacks.

(2) Patch from the ATTEN OUT to the TA IN or AMP IN jacks. Set the attenuator for maximum attenuation.

(3) Patch from the TA OUT or AMP OUT to the 600 OHM MEAS jacks.

(4) Operate the TEST key to the ADJUST position and set the test oscillator for the frequency required.

(5) Adjust the attenuator and the test potentiometer to give a reading of zero db on the meter. Adjust the oscillator output if necessary to obtain the desired setting.

(6) Remove the plug from the 600 OHM MEAS jacks and insert in the LINE EQPT jacks.

(7) Reduce the attenuator setting 20 db thereby transmitting to the line a power equivalent to 20 db above 1 milliwatt.

Procedure at Receiving End. (See Fig. 16).

(1) Patch from the LINE EQPT jacks to the ATTEN IN jacks.

(2) Patch from the ATTEN OUT jacks to the RA IN or AMP IN jacks.

(3) Patch from the RA OUT or AMP OUT jacks to the 600 OHM MEAS jacks.

(4) Set the attenuator for maximum loss and operate one of the 10 db protection pad keys to the OUT position.

(5) Upon advice that the sending terminal is transmitting test power, the receiving terminal should adjust the attenuator to obtain as nearly as possible zero db reading on the meter. The power expressed in db above 1 milliwatt at the point of measurement is the attenuator setting corrected for the meter reading if this is not zero db. If the meter reading in db is less than zero db, the meter reading in db should be subtracted from the attenuator setting. If the meter reading is more than zero db, the meter reading in db should be added to the attenuator setting.

(6) The attenuation of the high frequency line is equal to the gain of the receiving amplifier (approximately 50 db) minus the reading in (5) above. Accurate measurements require that the receiving amplifier be calibrated.

(7) Remove all patches and restore the system to normal operating condition.

3. APPARATUS REQUIREMENTS AND ADJUSTING PROCEDURES.

3.1 General. This section includes information on the maintenance of the individual pieces of apparatus such as relays and keys employed in the type C carrier telephone system. It will not, in general, be found practicable to repair other apparatus in the field and such apparatus should be replaced when serious defects appear.
It is essential that parts and contacts be kept clean, since the failure of a circuit to function properly is often traced to dirty contacts or dirty or gummy parts. It is important that the inside of relay covers should be kept clean and that covers should not be left off longer than absolutely necessary.

The Test Requirements listed herein are current maintenance tests. When it is found necessary to readjust the apparatus because it does not meet these Test Requirements the Readjust Requirements should be used.

If it becomes necessary to check for a reliable contact, this may be done by bridging a receiver across a made contact through which current is flowing. Absence of fluttering in the receiver is evidence of a reliable contact.

Carbon tetrachloride used in flushing relay contacts should be chemically pure to avoid leaving foreign material on the contacts after cleaning.

Unless otherwise specified, contact pressure should be measured at the point of contact just as the contacts break. It should be measured on normally closed contacts with the apparatus normal and on normally open contacts with the apparatus operated. Other spring tensions should be measured at the points indicated.

3.2 Tools, Gauges, Meters, Etc. The following tools, gauges, and test sets or the equivalent are recommended for the maintenance of the apparatus covered in this section.

TOOLS

Code	Name	Used on
259	Spring Adjuster	R type relays
265C	Contact Burnisher	Relays
*361B	Terminal Clip	R type relays
KS-6015	Duck-bill Pliers	Relays

* An 893 cord equipped with 360A tools should be available for use with the terminal clip in adjusting relays.

GAUGES

Code	Name	Used on
70D	50-0-50 gram gauge	R type relays
70E	150-0-150 gram gauge	R type relays
74D	Thickness gauge (0.003-0.018 inch)	General

Meters. The Western Electric 35C Test Set should be used for adjusting relays to meet their electrical requirements if it is available. If not, a milliammeter and a variable resistance can be used for this purpose.

3.3 Keys. Cleaning. The blades of contact burnishers and thickness gauges used on the contacts should be kept clean by wiping with a clean cloth dampened with carbon tetrachloride.

Burnishing Contacts. To burnish the contacts use a 265C Contact Burnisher or the equivalent. In burnishing normally open contacts, press the contacts together manually, or operate the key giving a slight pressure only on the blade of the burnisher. In the case of normally closed contacts, the tension of the springs themselves will usually furnish sufficient pressure against the burnisher. Usually rubbing the burnisher back and forth between the contacts two or three times is sufficient.

Pitted Contacts. Pitted contacts should be treated by burnishing until the pits are reduced. Abrasives other than contact burnishers should never be used.

Flushing Contacts. Clean and flush the contacts with carbon tetrachloride in the following manner - Dip the flat end of a clean toothpick in the carbon tetrachloride to a depth of about 1/4 inch and deposit the liquid on the contacts (held slightly separated). Then rub the flat end of the toothpick back and forth two or three times between the contacts. Then with the contacts held slightly apart, flush them with the liquid taken up on the clean point of the toothpick. Be sure that sides as well as the tops of the contact points and disc are flushed. Following the use of carbon tetrachloride, burnish the contacts as outlined above.

Adjusting. The wiring to keys is left long enough to permit them to be pulled out in front of the panel for inspection and adjustment. Care should be exercised not to break off the skinners. While the key is removed, inspect the entire key for possible faults and make any adjustments that may appear necessary before it is remounted. In the event that troubles appear in a key which prevent satisfactory operation, and which cannot be readily corrected, the key should be replaced.

3.4 Relays. General. The requirements on relays for adjustment and maintenance are either mechanical or electrical. The mechanical requirements pertain to cleaning, contact alignment, contact separation and pressure, etc., and the electrical requirements are primarily direct-current flow values for operation or non-operation of the relay. Some of the requirements are given in this section and the remainder are covered in the circuit requirement tables on the individual circuit drawings, an explanation of which is given in Fig. 17.

Cleaning Non-Pitted Contacts.

(a) Burnish all contacts by using a 265C contact burnisher or the equivalent.

(b) In burnishing normally open contacts place the blade of the burnisher between the contacts, press them together manually, or operate the relay manually at the same time moving the blade back and forth. In the case of normally closed contacts, the tension of the springs themselves will usually furnish sufficient pressure against the burnisher.

(c) After burnishing make sure that the contact follow and contact separation requirements are still met.

(d) When unable to clear contact trouble by burnishing only, clean and flush the contacts with carbon tetrachloride. Dip the flat end of a clean toothpick into the carbon tetrachloride to a depth of about 1/2 inch and deposit the liquid on the contacts (held slightly separated). Where possible, rub the flat end of the toothpick back and forth two or three times between the contacts. Then with the contacts held slightly apart flush them with carbon tetrachloride taken up on the clean point of the toothpick. Be sure that the sides as well as the tops of the contact points and discs are flushed.

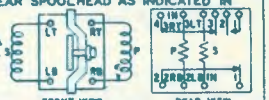
(e) Take care to keep the carbon tetrachloride from coming in contact with insulators or spoolheads.

(f) When the contacts are thoroughly dry burnish them to insure that no deposit or residue from the solution, or any foreign matter, remains.

Cleaning Pitted Contacts. Burnish pitted contacts but do not attempt to remove pits or build-ups unless it appears that their presence may cause the relay to fail in service.

SD- PAGES — CIRCUIT REQUIREMENTS

TITLE

APPARATUS		MECH. REQ.			CIRCUIT PREPARATION				TEST SET PREP.	SEE TEST NOTE NO.	DIRECT CURRENT FLOW REQ.				REMARKS
DESIG.	CODE	B&P FIG.	CONT. ARM. PRES. TRVL.		BLOCK OR INSULATE	TEST CLIP DATA: CONN. BAT	TEST CLIP DATA: CONN. GRD.				TEST WDG. FOR	TEST AFTER SOAK MA	TEST MA	READJ. MA	
FUNCTIONAL DESIGNATION OF APPARATUS	WESTERN ELECTRIC COMPANY CODE NUMBER OF RELAY	INFORMATION IN THESE COLUMNS MAY BE DISREGARDED SINCE THE INFORMATION IS GIVEN IN THE TEXT UNDER THE REQUIREMENTS FOR THE INDIVIDUAL RELAYS	GAP BETWEEN CORE AND ARMATURE (OR NEAREST STOP PIN) GIVEN IN THOUSANDTHS OF AN INCH		BLOCK THE ARMATURE OF DESIGNATED RELAYS IN THE CIRCUIT IN EITHER AN OPERATED (O) OR NON-OPERATED (NO) POSITION	THE POINT OR POINTS IN THE CIRCUIT UNDER TEST TO WHICH BATTERY OR GROUND IS TO BE CONNECTED IN MAKING THE SPECIFIED ELECTRICAL TESTS. THESE POINTS OF CONNECTION ARE USUALLY THE WINDINGS OF THE RELAYS. THE METHOD OF DESIGNATING THE WINDING TERMINALS AND CONTACTS IS EXPLAINED IN NOTE 1 UNDER "REMARKS" COLUMN. LETTERS IN PARENTHESES INDICATE APPARATUS TO WHICH CONNECTION IS REQUIRED.		DESIGNATES WAY IN WHICH TEST SET IS TO BE APPLIED TO CIRCUIT. SEE NOTE 2 IN "REMARKS" COLUMN FOR EXPLANATION OF SYMBOLS	REFERENCE TO TEST NOTES AT BOTTOM OF THIS TABLE	NO INFORMATION REQUIRED IN THIS COLUMN FOR THIS EQUIPMENT	FUNCTION OF RELAY TO BE TESTED. O: OPERATE; R: RELEASE; NO: NON-OPERATE	STRENGTH OF CURRENT TO BE PASSED THROUGH WINDING TO ESTABLISH DEFINITE MAGNETIC CONDITION IMMEDIATELY BEFORE TEST OR READJUST	MAGNITUDE OF TESTING CURRENT IN MILLIAMPERES	MAGNITUDE OF TESTING CURRENT IN MILLIAMPERES	NOTES: 1. WINDING AND CONTACT TERMINALS ARE DESIGNATED SO THAT THEY MAY BE LOCATED WITHOUT USE OF A WIRING DIAGRAM. THE UPPER AND LOWER ROWS OF RELAY CONTACT AND WINDING TERMINALS ARE DESIGNATED T (TOP) AND B (BOTTOM). THE LETTERS L AND R, USED ONLY FOR DESIGNATING WINDING TERMINALS, INDICATE THE LEFT AND RIGHT SIDE RESPECTIVELY FACING THE CONTACT SIDE OF RELAY. CONNECTION MAY BE MADE TO TERMINALS DESIGNATED BY LETTERS ALONE FROM THE FRONT OF THE RELAY. THE TERMINALS ARE LOCATED ON THE REAR SPOOLHEAD AS INDICATED IN THE DIAGRAM AND MAY BE REACHED WITH A 301B TOOL. WHERE A TERMINAL IS DESIGNATED BY A NUMERAL OR A NUMERAL AND TWO LETTERS, CONNECTION MUST BE MADE FROM THE TERMINAL SIDE OF THE RELAY. CONTACT TERMINALS ARE NUMBERED FROM RIGHT TO LEFT FACING THE TERMINAL SIDE OF RELAY. WHERE A WINDING TERMINAL IS DESIGNATED BY A NUMERAL AND TWO LETTERS, THE NUMERAL IS THE SAME AS THAT OF THE CONTACT TERMINAL AT THE IMMEDIATE RIGHT OF THE WINDING TERMINAL. WHEN THE NUMERAL FOLLOWS THE LETTERS IT INDICATES THAT THE WINDING TERMINAL IS LOCATED AT THE EXTREME RIGHT END OF A ROW OF TERMINALS OR THAT IT IS IN A ROW OF WINDING TERMINALS ONLY. IN 206 TYPE RELAYS THE CONTACT AND WINDING TERMINALS ARE NUMBERED CONSECUTIVELY FROM RIGHT TO LEFT FACING THE TERMINAL SIDE OF RELAY.  FRONT VIEW (CONTACT SIDE) REAR VIEW (TERMINAL SIDE) 2. "B/G" BATTERY AND GROUND BOTH HAVE TO BE FURNISHED OVER TESTING LEADS "BAT" BATTERY ALONE MUST BE FURNISHED OVER TESTING LEADS "GRD" GROUND ALONE MUST BE FURNISHED OVER TESTING LEADS "NGB" NON-GROUNDED BATTERY REQUIRED TO REVERSE DIRECTION OF CURRENT FLOW	

TEST NOTES:
THESE NOTES ARE REFERRED TO IN COLUMN HEADED "SEE TEST NOTE NO." THEY GIVE SPECIAL CONDITIONS FOR TESTING RELAYS OPPOSITE WHICH TEST NOTE NUMBER APPEARS.

EXPLANATION OF CIRCUIT REQUIREMENT TABLE.

FIG. 17.

Requirements for R Type Relays. Contact and Spring Alignment.

(a) The point of contact should fall wholly within the boundary of the opposing contact except for opposing contacts having the same diameter, in which case their centers shall not be out of alignment more than 25 per cent of the diameter of the contact points. Springs should not touch the relay cover.

(b) If the contacts do not line up properly, or if the tang does not overlap the spoolhead sufficiently, or the stud rubs on the spring, attempt to correct the trouble by applying pressure to the end of the springs using a 259 spring adjuster and exercising care not to distort or otherwise damage the springs. If the springs cannot be shifted, remove the relay from the mounting plate and loosen the spring assembly clamping screws sufficiently to shift the springs so as to correct the fault.

Armature Travel.

(a) The armature travel should be in accordance with the value specified in the "ARM TRVL" column on the circuit requirement table. Use the 74D gauge.

(b) To adjust the armature travel insert the proper thickness gauge between the armature and the core and turn the adjusting nut until the gauge fits snugly.

Contact Pressure.

(a) The contact pressure should be in accordance with the information in the following table. Use the 70D gauge. T indicates test and R indicates readjust, minimum allowable values in grams. See Fig. 17 for number of contacts. Where the relay has top and bottom spring combination the values given apply to each of them, unless specified separately.

Relay	Spring Pressure in Grams.							
	1		2		3		4	
R 1274	T	R	T	R	T	R	T	R
	15	17	A	A	15	17	A	A
R 910								
Top	15	17	25	27	15	17	25	27
Bottom	15	17	A	A	15	17	A	A
R 923								
Top	15	17	15	17	25	27		
Bottom	15	17	15	17	25	27		
R 1314								
Top	15	17	A	A				
Bottom	15	17	A	A				

"A" appearing in the spring tension column designates springs which should be tensioned against the armature stud. The tension of such a spring together with the tension of all other springs on the relay that rest against the armature studs should be sufficient to hold the armature against the adjusting nut.

(b) To adjust the springs place the 259 spring adjuster about 1/4 inch from where the spring leaves the clamping plates of the spring assembly and

twist the spring slightly to the left or right as required, exercising care not to disturb adjacent springs.

Contact Separation and Follow.

(a) The separation between any pair of contacts normally open or between any pair of contacts that are opened when the relay is operated should be -

Min. 0.005 inch.

(b) The contact follow on all normally open contacts should be approximately 0.005 inch.

(c) If necessary adjust the springs as outlined under "Armature Travel" on page 46.

Electrical Requirements.

(a) The relay shall meet the electrical requirements specified on the circuit requirement table. These requirements should be met with the cover off the relay unless otherwise specified.

(b) If necessary to meet the operate or hold requirement decrease the spring tension towards the minimum, reduce the contact follow towards the minimum or increase the stud gap.

(c) If necessary to meet the non-operate or release requirement, increase the spring tension or the follow or decrease the stud gap.

4. VACUUM TUBES.

4.1 General. The following Western Electric vacuum tubes, ballast lamps and resistances are employed in the C5 terminal, the C1 repeater and the power supply equipment required for operating these units from an A.C. source.

Terminal

A.C. or Non-regulated Battery	Regulated Battery
Automatic Gain Regulation	
13-328A Vacuum Tubes	13-310A Vacuum Tubes
2-329A Vacuum Tubes	2-311A Vacuum Tubes
5-120A Ballast Lamps	7-116A Resistances
2-121A Ballast Lamps	
Manual Gain Regulation	
11-328A Vacuum Tubes	11-310A Vacuum Tubes
2-329A Vacuum Tubes	2-311A Vacuum Tubes
5-120A Ballast Lamps	7-116A Resistances
2-121A Ballast Lamps	

Repeater

4-328A Vacuum Tubes	4-310A Vacuum Tubes
2-329A Vacuum Tubes	2-311A Vacuum Tubes
2-121A Ballast Lamps	2-116A Resistances

A.C. Power Supply Equipment

Terminal	Repeater
2-274A Vacuum Tubes	1-274A Vacuum Tube
2-300A Vacuum Tubes	1-300A Vacuum Tube
2-310A Vacuum Tubes	1-310A Vacuum Tube
2-313C Vacuum Tubes	1-313C Vacuum Tube

While the vacuum tubes and ballast lamps can be expected to have a reasonable life, they should be checked periodically to insure satisfactory performance of the carrier equipment. The KS-8235 Vacuum Tube Test Set is recommended for testing the vacuum tubes, and the ballast lamps can be checked by a simple measurement of the current flowing through them. The KS-8235 vacuum tube tester provides means for testing tubes for short circuits between elements and for measuring transconductance, filament activity, and grid current. In addition, it includes provision for making rectifier tube tests. It cannot, however, be used for testing the 313C vacuum tube, which is a cold cathode tube employed as a protective tube in the A.C. power-supply equipment. The circuit and general method of operation are given in the manufacturer's booklet supplied with the set. Detailed test procedures and the limits to be met by the several tubes used in the type C equipment are given below.

All of the vacuum tubes, with the exception of the 313C tube, should be tested on a routine basis every three months. The 313C tube should last practically indefinitely. It is recommended that the 120 and 121A ballast lamps also be checked at quarterly intervals.

As a general precaution, before removing any tube for test the heater supply for the tube should be turned off. Do not remove the grid cap before this is done.

4.2 Detailed Test Procedures. Methods for testing the various tubes are given in the following section which is divided in three parts. The first part contains procedures which are general to all of the tests and should be performed prior to testing any particular tube. The second part gives the subsequent procedure for testing the tubes having control grids such as amplifier, oscillator, modulator and demodulator tubes. The third part pertains to the rectifier tube tests.

General. The following general procedure should be followed before performing the tests for any specific tube.

Procedure.

(1) With the power switch thrown to OFF, plug the attachment cord into a source of 105-125 volt 60-cycle power. Operate power switch to OFF after each test unless the same type of tube is to be tested in sequence, in which case it is only necessary to unlock the AMPL TEST button.

(2) Insert tube to be tested into the socket which is proper for the tube base and attach grid clip lead if tube has a top terminal.

(3) Set the FIL selector switch to the OFF position. Then operate the POWER switch to ON. Adjust LINE ADJUSTMENT potentiometer until the needle of the VOLTS A.C. voltmeter rests on the TEST calibration mark (red). Check this adjustment from time to time during the tests.

(4) In following the succeeding detailed instructions, to permit the tube to become stable before making any test involving meter readings an important precaution is to allow a minimum of one and one-half minutes for heater type and one-half minute for filamentary tubes after turning on the power or making any change in filament voltage. This precaution should be observed after operating the FIL ACT switch to TEST during an activity test as well as after first turning on the power.

Tubes with Grids. The following tests should be carried out for testing 300A, 310A, 311A, 328A and 329A tubes. Four tests are outlined namely - short-circuit, transconductance, grid current and filament activity. All of these tests should be made for each tube.

Short-Circuit Test. The purpose of this test is to insure that none of the elements within the tube are in contact with one another.

Procedure.

(1) Adjust the A and B selector switches, the FIL selector switch and the L and R potentiometers to the proper values for the type of tube to be tested as given in the table on Page 50. The A, B or FIL selectors should never be operated with the AMPL TEST button in the locked (operated) position.

(2) Set the FIL ACT key to NORM.

(3) Operate the SHORT TEST switch slowly through positions 1 to 5, inclusive. If the neon lamp designated SHORT lights continuously in any of these positions, a short circuit between elements is indicated. Intermittent shorts can be detected by tapping the tube with the finger. In this test an intermittent flash may be obtained instead of a steady light.

Note. An instantaneous flash as the switch is moved from one position to another should be disregarded. This is caused by the discharging of the condenser in the short test circuit.

Transconductance Test. The transconductance or mutual conductance of a tube is an important criterion of its performance and the purpose of this test is to measure the transconductance of the tube.

Procedure.

(1) Adjust the A and B selector switches, the FIL selector switch and the L and R potentiometers to the proper values for the type of tube to be tested as indicated on the table on page 50.

(2) With the FIL ACT test switch in the NORM position and the SHORT switch in the TUBE TEST position, operate the AMPL TEST button and lock in position.

(3) Recheck line adjustment voltage reading.

(4) Note deflection of mutual conductance meter. If the L potentiometer is on step 40 or 60 the meter is direct reading. If the L potentiometer is on step 70.5 multiply the meter reading by 2 before applying the requirement below.

Requirement. The reading should be above the minimum value of transconductance given in the table on Page 50 for the tube under test. If not, replace the tube.

Filament Activity Test. This test is made to insure that the emission from the filament of the tube under test is sufficient for satisfactory operation. It is accomplished by measuring the transconductance of the tube with the filament current normal, reducing the filament current 10 per cent and again measuring the transconductance. The percentage reduction in transconductance is then taken as a criterion of the filament activity.

Procedure.

(1) Repeat the transconductance test as outlined above.

(2) Operate FIL ACT switch to TEST position and after waiting the time specified under General above, note again the reading of the mutual conductance meter.

(3) Compute the percentage change in transconductance observed between (1) and (2).

Requirement. The percentage change in transconductance should not be greater than that indicated in the table below for the tube under test. Tubes which fail in this test should be replaced.

(4) After each filament activity test restore the FIL ACT switch to the NORM position and unlock the AMP TEST button.

Grid-Current Test. The purpose of this set is to determine wheather undue grid current is flowing in the tube.

Procedure.

(1) Repeat (1), (2) and (3) under Transconductance Test above.

(2) Make sure that the FIL ACT switch is in the NORM position.

(3) Increase the grid bias by turning potentiometer R to the right until a reading of 100 micromhos (2 scale divisions) is obtained on the mutual conductance meter.

(4) Depress the GAS TEST button and note any increase in the meter reading.

Requirement. If the increment is over two scale divisions the grid current exceeds a few micro-amperes and the tube should be replaced.

WESTERN ELECTRIC TUBE TEST DATA.

KS-8235 Vacuum Tube Test Set

Tube	Selectors A	B	FIL	Potent. L	R	Nominal Transconductance	Minimum Transconductance FIL NORM	Max. % FIL ACT
300A	2	10	5	70.5	55	3200	2500	25
310A	2	5	10	40	25	1750	1200	25
311A	7	6	10	60	30	2450	1700	20
328A	2	5	7.5	40	25	1750	1200	25
329A	7	6	7.5	60	30	2450	1700	20

Rectifier Tubes. The following procedure should be followed in testing the 274A full-wave rectifier tube. The AMPL TEST button should be unlocked and never operated during a rectifier tube test.

Procedure.

(1) Perform operations under section headed General above.

(2) Adjust the A and B selector switches, the FIL selector switch and the L and R potentiometers as follows -

A	B	FIL	L	R
2	7	5	35	0

(3) See that FIL ACT key is operated to NORM and the SHORT selector switch is turned to TUBE TEST.

(4) See that the AMPL TEST button is unlocked.

(5) Depress the RECTIFIER TEST ST'D BUTTON and note deflection on the mutual conductance meter.

(6) Change the setting of the A selector switch from 2 to 3 and repeat (5).

Requirement. The deflection of the mutual conductance meter for both (5) and (6) should fall in the GOOD (green) portion of the scale. If deflection is below this replace the tube.

Ballast Lamps. The ballast lamps are tested by measuring the current flowing through each lamp. If the current is outside the limits specified below the lamp should be replaced. When this test is made for terminals and repeaters operated from an A.C. supply, the supply should meet the voltage limits specified in the Power Supply section and should be connected to the proper step on the primary winding of the power transformer.

Procedure.

(1) Connect the proper ammeter (1 ampere range, A.C. or D.C. as required) equipped with cord and 304A plug to the jacks listed below and in each case observe the reading of the meter.

120A Ballast Lamps.

MOD FIL Channel 1
MOD FIL Channel 3
DEM FIL Channel 1
DEM FIL Channel 2
DEM FIL Channel 3
FIL Repeater Amplifiers

Requirement. The meter reading should fall between 0.37 and 0.48 ampere.

121A Ballast Lamps.

FIL Transmitting Amplifier
FIL Receiving Amplifiers.
FIL Repeater Amplifiers

Requirement. The meter reading should fall between 0.75 and 0.96 ampere.

END.