ROUTINE TEST AND ADJUSTMENT METHODS.

TWELVE-CHANNEL OPEN WIRE CARRIER TELEPHONE SYSTEM (TYPE J2).

WESTERN ELECTRIC CO. MANUFACTURE.

(Previously E.I. TRANSMISSION Long Line Equipment T 5615 now cancelled.)

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TERMINALS.

1. TESTS AND ADJUSTMENTS OF VACUUM TUBES AND GRID BATTERIES.

1.1 Vacuum Tube Heater Circuit Operation.

(i) Description. A terminal must be taken out of service before the heater circuits of the amplifiers are opened. The heater circuit of the pilot channel amplifier-rectifiers may be opened at any time without affecting service. The regulating equipment will lock up during this period, but this will not affect operation of the system unless there is a large change in the line attenuation before the system is restored to normal.

For vacuum tube replacements, it is necessary to open the heater circuit before removing the tube from or placing a tube in its socket.

In order to prevent possible damage to the tubes in feedback amplifiers, whenever practicable the input to the amplifier (carrier leak, pilot channel energy, or test tone) should be removed before the heater circuit is opened, and no input should be applied to the amplifier until after all tubes have been energised for at least three minutes. This can be done readily for each of the amplifiers, except the intermediate amplifier and the transmitting amplifier for which satisfactory arrangements for preventing input are not readily available.

(ii) Apparatus. Open Plugs (258C).

(iii) Procedure.

(a) To open the heater circuit of any of the tubes in the terminal equipment, insert an open plug in the appropriate jack indicated in the following table -

Unit	Jack Designation	Tubes
GROUP TERMINAL EQUIPMENT		
Transmitting Amplifier	A	1, 2
	B	3, 4
	C	5, 6
W Regulating Amplifier *	F Fil	F1, F2
	S Fil	S1, S2
E Regulating Amplifier *	Fil	1, 2
Intermediate Amplifier	Fil	1, 2
Auxiliary Amplifier *	Fil	1, 2
Pilot Amplifier-Rectifier	Fil	1, 2
Supplementary Amplifier **	Fil	1, 2
CARRIER SUPPLY EQUIPMENT		
Carrier Generator (Reg. or Emer.)	Con Fil	(Con)1, (Osc)2
	Amp Fil	(Amp T)1, (Amp R)2
5 kc/s Oscillator (Reg. or Emer.)	Fil	1
306, 484, 541 and 543 kc/s Amplifier	Fil	1, 2
308, 340 and 364 kc/s Amplifier	Fil	1 or 2
Carrier Generator Transfer Circuit	Fil A	A
	Fil B	B
Pilot Channel Supply	Fil	1, 2
CHANNEL TERMINAL EQUIPMENT		
Modulator-Demodulator	Fil	1, 2

* Before opening heater circuit, insert a 125-ohm plug in EQ jacks if terminal is not switched out of the circuit.

** If amplifier is patched into the circuit, insert a 125-ohm plug in EQ jacks before opening heater circuit.

(b) To close the heater circuit, remove the open plug from the filament jack. After the heater circuit has been energised for at least three minutes, the 125-ohm plug may be removed from the EQ jacks and test power may be applied to the input of the amplifier.

(c) If only one tube of a series heater circuit is replaced, wait at least three minutes before closing the heater circuit in order to prevent damage to the tubes.

1.2 Grid Battery Voltage Measurement and Adjustment.

(i) Description. The grid bias for the output stage of the transmitting amplifier is provided by a KS-7105 battery located on the grid battery panel at the bottom of the bay in which the amplifier is mounted.

Dry battery voltage measurements may be made on systems in service without service reaction due to level changes, provided proper care is taken. The meters employed should have a resistance of 1,000 ohms per volt, and the test picks should be held at all times so that the hands are in contact only with the insulated handles of the picks and metallic contact is made only with the battery terminals of the battery to be tested.

(ii) Apparatus. 1 Weston Volt-ohmmeter per KS-8295, ranges 0-15 volts, 0-30 volts, 0-150 volts and 0-300 volts.

Note. If another type of voltmeter is used, it must have a resistance of at least 1,000 ohms per volt.

(iii) Procedure.

(a) Connect the voltmeter across the +GT and -GT punchings of a grid battery panel. The battery voltage should be between 17 and 19 volts.

(b) If the requirement is not met, the group terminal must be taken out of service and the heater circuits of tubes 3, 4, 5 and 6 of the transmitting amplifier must be opened, Paragraph 1.1. After waiting about three minutes for the tubes to cool somewhat, adjust the grid battery voltage to bring it within limits or, if this is not possible, replace the grid battery.

Caution. In order to avoid damaging the tubes while the grid battery is disconnected, the heater circuits of the output tubes must be open during the entire time the grid circuit is being adjusted.

(c) Close the heater circuits, Paragraph 1.1, check the transmission of the transmitting group equipment, Paragraph 3.1, and place the terminal back in service.

1.3 Vacuum Tube Tests.

(i) Description. The vacuum tubes are tested by means of the 1R tube test set, which makes it possible to test the tubes without interfering with service. The circuit arrangements provide for the measurement of the heater and space currents and cathode activity.

In regulated battery offices, heater current adjustments should be made in accordance with the information contained on the circuit drawings.

Where ballast lamps are provided in the heater circuits, no maintenance adjustments are required. The limits for the tests described below are based on filament battery voltages between 21 and 27 volts. If the voltage is outside this range, vacuum tubes may not meet the requirements. If heater currents are found to be out of limits in offices having non-regulated battery, the battery voltage should be checked and, if the voltage is inside the 21-27 volt range, the ballast lamp in the circuit under test should be

replaced. If the ballast lamp change does not bring the heater current within limits, replace the vacuum tubes one at a time.

Vacuum tube tests should not be made when the battery voltage is changing rapidly or when it is outside its normal operating range.

The space current limits given in Tables 1, 2, 3 and 4 should be met when the heater currents are normal, that is, before the heater current adjustments for the cathode activity tests are made.

Caution. When the heater current is changed in making tube tests, time should be allowed for the heater current and space current to become stabilised before making the final readings as discussed in the information covering the 1R Tube Test Set.

When it is necessary to replace vacuum tubes, the procedure given in Paragraph 7.6 should be followed.

Heater current adjustments should not be made using the 1R Tube Test Set. Where such adjustments are shown to be necessary, they should be made with a meter having an accuracy of ± 1/2 of one per cent.

310A and 311A tubes should normally fall within a heater current range of 0.300 to 0.335 ampere or 0.600 to 0.670 ampere respectively for normal battery voltage conditions. If a large group of tubes in an office falls outside this range, the adjustment of the heater current should be checked.

(ii) Apparatus.

1R Tube Test Set.
1 M11D Cord equipped with 307A Plug and Yaxley 625 Pin Plug.
10 600-ohm Plugs (217D).

(iii) Procedure. Transmitting, Intermediate, Auxiliary, Supplementary and Regulating Amplifiers and Pilot Amplifier-Rectifier -

(a) General. Make heater current, space current and cathode activity tests in the order shown on Tables 3 and 4.

Requirements. Refer to Tables 3 and 4.

(b) Procedure - Channel Demodulator Amplifier.

(1) Make heater current and cathode activity tests as shown on Tables 3 and 4. Tube 1 is in odd numbered demodulators and Tube 2 in succeeding even numbered demodulators. The two demodulators use a common filament jack.

Requirements. Refer to Tables 3 and 4.

(2) After completing the space current measurement, the demodulator gain should be adjusted to give the proper operating level.

(3) If the range of the SPACE PER CENT. ZERO ADJUSTMENT rheostats of the 1R tube set will not permit of adjusting the space current to give a zero reference for the cathode activity tests, the space millivolts should be read at normal heater current and at the decreased heater current. The Per Cent. Cathode Activity should be determined by taking the difference between the two space millivolt readings and basing the per cent. on the space millivolts at normal heater current.

(c) Procedure - Regular Carrier Generator, 5 kc/s Oscillator and Carrier Supply Amplifiers.

(1) There are two heater circuits on each generator panel, one for the OSC and CON tubes and the other for the AMP T and AMP R tubes. The former is measured at the CON FIL jack and the latter at the AMP FIL jack.

The two tubes in the 340 kc/s amplifier and the 308 kc/s amplifier are in series and are designated, respectively, 1 and 2. The current in the series circuit is measured at the FIL jack in the 340 kc/s amplifier.

(2) If the regular generator and the regular carrier supply amplifiers are carrying the load, the tube tests may be made on them while in service. Lock-in the regular equipment by operating the white REG key on the carrier transfer panel. This is necessary in order to provide the proper grid conditions for meeting the test requirements.

(3) Make heater current, space current and cathode activity tests as shown on Tables 1 and 2.

Requirements. See Tables 1 and 2.

(4) At the completion of the test, operate the black RLS key on the carrier transfer panel restoring the circuit to normal.

(5) If the emergency generator and emergency carrier supply amplifiers are carrying the load, terminate with 600-ohm plugs the TST EVEN and TST ODD jacks on the regular generator panel and the TST jacks on each of the regular carrier supply amplifiers. The terminations are provided as a substitute for the working load, the condition on which the requirements are based.

(6) Make heater current, space current and cathode activity tests as shown on Tables 1 and 2.

Requirements. See Tables 1 and 2.

(7) At the completion of the tests, remove the 600-ohm plugs.

(d) Procedure - Emergency Carrier Generator, 5 kc/s Oscillator and Emergency Carrier Supply Amplifiers.

(1) If the emergency generator and emergency carrier supply amplifiers are carrying the load, the tube tests may be made on them while in service. Operate the red EMER key in order to provide the proper grid conditions for meeting the test requirements.

(2) Make heater current, space current and cathode activity tests as shown on Tables 1 and 2.

Requirements. See Tables 1 and 2.

(3) After completion of the tests, except when it is necessary for the emergency generator and emergency carrier supply amplifiers to continue to carry the load, operate the black RLS key on the carrier transfer panel, restoring the circuit to normal.

(4) If the regular generator and regular carrier supply amplifiers are carrying the load, operate the white REG key on the carrier transfer panel. This locks-in the regular equipment so that automatic transfer cannot take place. Terminate with 600-ohm plugs the TST EVEN and TST ODD jacks on the emergency generator panel and the TST jacks on each of the emergency carrier supply amplifiers.

Requirements. Refer to Tables 1 and 2.

(5) After completion of the test, remove the 600-ohm plugs and operate the black RLS key on the carrier transfer panel, restoring the circuit to normal.

(e) Procedure - Pilot Channel Supply Circuit.

(1) Make heater current, space current and cathode activity tests as shown on Tables 1 and 2.

Requirements. Refer to Tables 1 and 2.

(f) Procedure - Carrier Generator Transfer Circuit.

(1) Operate the RLS and then the EMER key on the generator transfer panel, which switches the terminal to the emergency supply. This operation lights the green lamp on the transfer panel and also the green lamps on the regular carrier generator, the carrier supply amplifier panels and the 5 kc/s oscillator panel. It also causes the ionisation of one or both of the 338A tubes on the transfer panel, as indicated by the blue gaseous discharge in the tube.

(2) Remove the cover from the generator transfer panel, being certain that the green lamp is lighted on that panel.

(3) Insert 600-ohm plugs in TST EVEN, TST ODD jacks of the regular carrier supply and the TST jacks of the regular carrier supply amplifiers. This prevents the regular carrier supply from feeding the load in multiple with the emergency carrier supply in case the transfer tubes fail to ionise.

(4) Remove tube B from its socket. This will cause tube A to ionise if it has not already done so. Proceed with measurements on tube A.

(5) Make the heater current and space current tests as shown on Tables 1 and 2.

(6) Restore tube B to its socket and allow several seconds for it to heat up enough to ionise. Remove tube A and tube B should ionise. Repeat the tests under Item (5) for tube B. The same limits should be met.

(7) If tube A meets requirements, restore it to its socket. If it does not meet requirements, replace it by another tube and repeat the tests until the requirements are met.

(8) If tube B does not meet requirements, replace it by another tube and repeat the tests until the requirements are met.

(9) After both tubes meet requirements and are restored to their sockets, make sure that the 600-ohm plugs are removed from the TST EVEN, TST ODD, and TST jacks.

(10) If both tubes meet the required limits initially, replace the can cover and operate the RLS key, thus restoring the carrier supply to normal operation.

(11) If it was found necessary to replace one or both tubes, operate the RLS key and then the REG key, locking the regular carrier supply in service. Make Ionisation of Gas Tubes in Carrier Generator Transfer Circuit Test (see Paragraph 2.8).

(12) After the requirements of this test are met, replace the can cover and operate the RLS key, thus restoring the carrier supply to normal operation.

CARRIER SUPPLY.

TUBE TEST REQUIREMENTS - REGULATED BATTERY SUPPLY.

	Carrier Generator				5 kc/s Osc.	340 kc/s Amplifier	308 kc/s Amplifier	364 kc/s Amplifier	306, 484, 541 and 543 kc/s Amplifiers		Pilot Channel Supply	Carrier Generator Transfer
	(Con)	(Osc)	Amp T	Amp R								
TUBE DESIGNATION	1	2	1	2	1	1	2	1	1	2	1, 2	A, B
TYPE OF TUBE TESTED	310A	310A	311A	311A	310A	311A	311A	311A	310A	311A	310A	338A
FILAMENT JACK	Con Fil	-	Amp Fil	-	Fil	Fil	-	Fil	-	Fil	Fil	Fil A, Fil B
Heater Current (In Amperes) (See Paragraph 1.3(i)) Min.	0.290	-	0.580	-	0.290	0.580	-	0.580	-	0.580	0.290	0.468
Max.	0.350	-	0.700	-	0.350	0.700	-	0.700	-	0.700	0.350	0.528
Normal Space Current Switch on 1R Set	P1	P2	P1	P2	P1	P1	P2	P1	P1	P2	P1-P2	P1-P2
Space-Millivolts 130 V Battery, Min.	470	490	450	450	400	350	350	350	400	350	400	70
Max.	720	800	700	700	600	650	650	650	700	650	600	ø 320
152 V Battery, Min.	*	*	*	*	450	400	400	400	450	400	450	*
Max.					750	800	800	800	850	800	750	
Cathode Activity Switch on 1R Set	P1	P2	P1	P2	P1	P1	P2	P1	P1	P2	P1-P2	-
Decrease Heater Current (Amperes)	0.02	-	0.04	-	0.02	0.04	-	0.04	-	0.04	0.02	-
Max. % Activity	8	15	25	25	15	25	25	25	15	25	15	-

* These circuits operate only on 130 volt battery.

ø Where regulated A battery minimum voltage is less than 21 volts, use a maximum of 190 millivolts.

TABLE 1.

TABLE 1.

CARRIER SUPPLY.

TUBE TEST REQUIREMENTS - NON-REGULATED BATTERY SUPPLY.

	Carrier Generator				5 kc/s Osc.	340 kc/s Amplifier	308 kc/s Amplifier	364 kc/s Amplifier	306, 484, 541 and 543 kc/s Amplifiers		Pilot Channel Supply	Carrier Generator Transfer
	(Con)	(Osc)	Amp T	Amp R								
TUBE DESIGNATION	1	2	1	2	1	1	2	1	1	2	1, 2	A, B
TYPE OF TUBE TESTED	328A	328A	329A	329A	328A	329A	329A	329A	328A	329A	328A	338A
FILAMENT JACK	Con Fil	-	Amp Fil	-	Fil	Fil	-	Fil	-	Fil	Fil	Fil A, Fil B
Heater Current (In Amperes) Min.	0.385	-	0.770	-	0.385	0.770	-	0.770	-	0.770	0.385	0.770
Heater Current (In Amperes) Max.	0.465	-	0.930	-	0.465	0.930	-	0.930	-	0.930	0.465	0.930
Space Current Switch on 1R Set	P1	P2	P1	P2	P1	P1	P2	P1	P1	P2	P1-P2	P1-P2
Space-Millivolts Min.	470	490	450	450	400	350	350	350	400	350	400	70
Space-Millivolts Max.	720	800	700	700	600	650	650	650	700	650	600	200
Cathode Activity Switch on 1R Set	P1	P2	P1	P2	P1	P1	P2	P1	P1	P2	P1-P2	-
Decrease Heater Current (Amperes)	0.025	-	0.05	-	0.025	0.05	-	0.05	-	0.05	0.025	-
Max. % Activity	8	15	25	25	15	25	25	25	15	25	15	-

TABLE 2.

TABLE 2.

GROUP TERMINAL EQUIPMENT AND CHANNEL BANK.

TUBE TEST REQUIREMENTS - REGULATED BATTERY SUPPLY.

TABLE 3.

	Transmitting Amplifier			Intermediate Amplifier		Auxiliary Amplifier		Suppl. Amp.	Regulating Amp.			Pilot Amp. Rec.	Chan. Demod. Amp.
									East Term.	West Terminal			
TUBE DESIGNATION	1, 2	3, 4	5, 6	1	2	1	2	1, 2	1, 2	F1,F2	S1,S2	1, 2	1, 2
TYPE OF TUBE TESTED	310A	311A	311A	310A	310A	310A	310A	310A	310A	310A	310A	310A	310A
FILAMENT JACK	A	B	C	Fil	Fil	Fil	Fil	Fil	Fil	F Fil	S Fil	Fil	Fil
Heater Current (In Amperes) (See Paragraph 1.3(i)) Min.	0.290	0.580	0.580	0.290	-	0.290	-	0.290	0.290	0.290	0.290	0.290	0.290
Heater Current (In Amperes) (See Paragraph 1.3(i)) Max.	0.350	0.700	0.700	0.350	-	0.350	-	0.350	0.350	0.350	0.350	0.350	0.350
Space Current Switch on 1R Set	P1-P2	P3-P4	P5-P6	P1	P2	P1	P2	P1-P2	P1-P2	P1-P2	P1-P2	P1-P2	P1-P2
Space-Millivolts 130 V Battery, Min.	410	300	300	450*	430*	450	420	300	300	300	300	350*	300*
130 V Battery, Max.	670	850	850	700*	590*	610	580	500	500	500	500	650*	440*
152 V Battery, Min.	450	300	300	500*	500*	500	500	340	340	340	340	450*	-
152 V Battery, Max.	850	850	850	850*	750*	750	750	600	600	600	600	750*	-
Cathode Activity Switch on 1R Set	P1-P2	P3-P4	P5-P6	P1	P2	P1	P2	P1-P2	P1-P2	P1-P2	P1-P2	P1-P2	P1-P2
Decrease Heater Current (Amperes)	0.02	0.04	0.04	0.02	-	0.02	-	0.02	0.02	0.02	0.02	0.02	0.02
Max. % Activity	15	25	25	15	15	15	15	15	15	15	15	8	15

* These space current measurements are for trouble location purposes and should be made with the GAIN potentiometer set for maximum gain (extreme clockwise position). In the case of the pilot amplifier-rectifier, the M1 or M2 resistance in the cathode circuit should be strapped out.

TABLE 3.

GROUP TERMINAL EQUIPMENT AND CHANNEL BANK.

TUBE TEST REQUIREMENTS - NON-REGULATED BATTERY SUPPLY.

	Transmitting Amplifier			Intermediate Amplifier		Auxiliary Amplifier		Suppl. Amp.	Regulating Amp.			Pilot Amp. Rec.	Chan. Demod. Amp.
									East Term.	West Terminal			
TUBE DESIGNATION	1, 2	3, 4	5, 6	1	2	1	2	1, 2	1, 2	F1,F2	S1,S2	1, 2	1, 2
TYPE OF TUBE TESTED	328A	329A	329A	328A	328A	328A	328A	328A	328A	328A	328A	328A	328A
FILAMENT JACK	A	B	C	Fil	Fil	Fil	Fil	Fil	Fil	F Fil	S Fil	Fil	Fil
Heater Current (In Amperes) Min.	0.385	0.770	0.770	0.385	-	0.385	-	0.385	0.385	0.385	0.385	0.385	0.385
Heater Current (In Amperes) Max.	0.465	0.930	0.930	0.465	-	0.465	-	0.465	0.465	0.465	0.465	0.465	0.465
Space Current Switch on 1R Set	P1-P2	P3-P4	P5-P6	P1	P2	P1	P2	P1-P2	P1-P2	P1-P2	P1-P2	P1-P2	P1-P2
Space-Millivolts Min.	410	300	300	450*	430*	450	420	300	300	300	300	350*	300*
Space-Millivolts Max.	670	850	850	700*	590*	610	580	500	500	500	500	650*	440*
Cathode Activity Switch on 1R Set	P1-P2	P3-P4	P5-P6	P1	P2	P1	P2	P1-P2	P1-P2	P1-P2	P1-P2	P1-P2	P1-P2
Decrease Heater Current (Amperes)	0.025	0.05	0.05	0.025	-	0.025	-	0.025	0.025	0.025	0.025	0.025	0.025
Max. % Activity	15	25	25	15	15	15	15	15	15	15	15	8	15

* These space current measurements are for trouble location purposes and should be made with the GAIN potentiometer set for maximum gain (extreme clockwise position). In the case of the pilot amplifier-rectifier, the M1 or M2 resistance in the cathode circuit should be strapped out.

TABLE 4.

TABLE 4.

2. TESTS AND ADJUSTMENTS OF CARRIER SUPPLY.

2.1 Switching of Regular and Emergency Carrier Supplies.

(i) Description. The following procedure describes the method of manually switching from one carrier supply to the other for routine tests, and the procedure to be followed in restoring the regular supply circuit to service after there has been an automatic switch to the emergency supply.

(ii) Procedure.

(a) Procedure - Locking-in Regular or Emergency Carrier Supply.

(1) Assume the carrier supply circuits to be operating in their normal condition with all keys normal.

(2) To lock-in the regular carrier supply, operate the white REG key, or, to lock-in the emergency supply, operate the red EMER key.

(3) To restore the transfer circuit to the condition whereby an automatic transfer from the regular to the emergency supply can take place, operate the black RLS key.

(b) Procedure - Transferring from a Locked-in Regular Carrier Supply to a Locked-in Emergency Supply, or Vice Versa.

(1) When transferring from one locked-in condition to another, it is desirable to go through the intermediate release condition in order to prevent momentary operation of the regular and emergency carrier supplies in parallel.

(2) To transfer from the locked-in regular supply to the emergency supply, operate first the RLS key and then the EMER key.

(3) To transfer from the locked-in emergency supply to the regular supply, operate first the RLS key and then the REG key.

(c) Procedure - Operations Preceding Adjustment of Equipment Under the Can Covers.

(1) Before testing or adjusting equipment on the carrier generator or transfer panels requiring removal of can covers, the carrier supply to be left in service must be locked-in.

(2) Thus, when making any adjustments on the regular carrier generator, the emergency supply must be locked-in by operating the EMER key. This operation also lights the green lamps on the transfer panel, the regular carrier generator panel, the regular carrier supply amplifier panels and the 5 kc/s oscillator panel.

Caution. Do not remove a can cover from a carrier generator panel, a carrier supply amplifier panel or a 5 kc/s oscillator panel unless the green lamp associated with that panel is lighted.

(3) Before testing or adjusting the emergency carrier supply or the transfer circuit, the REG key should be operated, causing the lamps on the panels of the emergency carrier supply to light.

(4) When tests are completed, the RLS key should be operated to restore the transfer circuit to its normal condition.

(d) Procedure to be followed after an Automatic Switch to the Emergency Carrier Supply.

(1) Operate the EMER key to silence the alarm.

(2) An automatic transfer to the emergency carrier supply indicates interruption or failure of the regular carrier generator or a regular carrier supply amplifier, or trouble in the wiring between panels.

(3) Before attempting to transfer back to the regular supply, the regular carrier generator and carrier supply amplifiers should be checked as described in Paragraph 2.7, omitting the test of the channel busbar output. If this test does not disclose the trouble, the vacuum tubes should be tested as covered in Paragraph 1.3.

(4) After the trouble in the regular carrier supply has been found and repaired, it should be restored to service by operating the RLS key.

2.2 4 kc/s Carrier Generator Output.

(i) Description. This test provides a procedure for adjusting the 4 kc/s output to the harmonic producer, and is also for use in checking the loss through the tuning fork so that it may be replaced if requirements are not met. The procedure also provides for the selection of vacuum tubes to secure the proper 4 kc/s generator output.

When making this test on either the regular or emergency carrier supply, the other carrier supply must be locked-in so that service will not be interrupted by an accidental operation of the transfer circuit.

(ii) Apparatus.

30A Transmission Measuring Set.
2A or 2B Noise Measuring Set.
1 - 1W2AY Cord Equipped with 289A Plug (2W24A).
1 - P3P Cord Equipped with 305A Plugs (3P20B).
9 - 600-ohm Plugs.
2 - Test Clips.
1 - 1 Megohm Resistance.

(iii) Procedure.

(a) Procedure - Bridged Measurement at AMP T and AMP R Tubes. (See Fig. 1.)

(1) Lock-in the emergency carrier supply and test the regular carrier supply. (See Paragraph 2.1.)

(2) Make the vacuum tube test on the OSC and CON tubes as covered in Paragraph 1.3 and replace the tubes if requirements are not met.

(3) Insert 600-ohm plugs in the TST ODD and TST EVEN jacks of the carrier supply under test and the TST jacks of the carrier supply amplifiers of the carrier supply under test.

(4) Insert the plug of the 2W24A cord in the 600-ohm jacks of one of the transformers of the 30A set, and patch from the 135-ohm jacks of the same transformer to the 135-ohm TC jacks.

(5) Connect the test clips of the 2W24A cord across the grid terminals of the AMP T and AMP R tubes and read the 30A set meter. No correction should be made for the transformer.

Requirements. Between -3 and -5 dbm.

(6) If requirements are not met, adjust U, V, W and X resistances.

(7) If the requirements are met after readjustment of these resistances, remove the 600-ohm plugs from the TST ODD, TST EVEN and TST jacks and restore the carrier supply to normal operation by operating the black RLS key.

(8) If requirements cannot be met by adjusting the U, V, W and X resistances, measure the loss through the tuning fork as covered in (b) below.

(9) Lock-in the regular carrier supply and repeat the above test for the emergency carrier supply. (See Paragraph 2.1.)

(b) Procedure - Loss Measurement Through 4 kc/s Tuning Fork. (See Fig. 1.)

(1) The 2A or 2B noise measuring set is used to measure the voltage across the input and output of the tuning fork in terms of noise, thus determining the loss through the fork. The input plug from the 4 kc/s oscillator should be inserted in the PROG jack of the measuring set, and the set should be calibrated as outlined in the information covering the noise measuring set.

(2) Two single test leads, not over 2 feet long, should be arranged with test clips at one end to connect to the tuning fork terminals. One of the leads should be equipped with a 1 megohm resistance at the end which is connected to the test clip.

(3) Connect the set to terminals 1 and 2 of the tuning fork. The test lead equipped with the resistance at the test clip end should be connected to terminal 1.

(4) Adjust the db dial on the set and note the reading in db.

(5) Connect the set to terminals 3 and 4 of the tuning fork. The test lead equipped with the resistance at the test clip end should be connected to terminal 3.

(6) Adjust the db dial and note the reading in db.

Requirements. The difference between the readings noted in Items (4) and (6), that is, the loss through the tuning fork, should not exceed 25 db.

(7) If the requirement is not met for a 54A tuning fork, the matter should be reported.

(8) If the requirement is met but the output requirement of (a) above cannot be met, replace the OSC tube, regardless of the results of the tube tests, and repeat the procedure of (a) above.

(9) If the requirement of (a) above cannot be met after replacing the OSC tube, then replace the CON tube and repeat the procedure of (a) above.

2.3 5 kc/s Oscillator Output.

(i) Description. This test provides a procedure for checking the output of the 5 kc/s oscillator, and also one for use in checking the loss through the tuning fork so that it may be replaced if requirements are not met. The procedure also provides for the selection of vacuum tubes to secure the proper 5 kc/s oscillator output.

When making this test on either the regular or emergency carrier supply, the other carrier supply must be locked-in so that service will not be interrupted by an accidental operation of the transfer circuit.

(ii) Apparatus.

30A Transmission Measuring Set.
2A or 2B Noise Measuring Set.
2 - P3P Cords equipped with 305A Plugs (3P20B).
2 - 1 Megohm Resistances.
2 - Test Clips.
1 - 289A Plug.

(iii) Procedure.

(a) Procedure - Measurement at TST Jacks. (See Fig. 2.)

(1) Lock-in the emergency carrier supply and test the regular carrier supply. (See Paragraph 2.1.)

(2) Make the vacuum tube test on the tube employed in the oscillator as covered in Paragraph 1.3, and replace the tube if requirements are not met.

(3) Patch from TST jacks on the 5 kc/s oscillator panel to the ATTEN IN jacks of the 30A set.

(4) With the TST KEY in the ADJUST position, adjust the attenuator to obtain a reading as close as possible to zero on the meter with all three protection keys in the OUT position. The attenuator setting corrected for the meter reading is the output of the 5 kc/s oscillator at the TST jacks.

Requirements. The output of each 5 kc/s oscillator should be at least +14 dbm.

(5) If the requirements are met, remove the patches and restore the carrier supply to normal operation by operating the black RLS key.

(6) If requirements are not met, measure the loss through the tuning fork as covered in (b) below.

(7) Lock-in the regular carrier supply and repeat the above test for the emergency carrier supply, see Paragraph 2.1.

(b) Procedure - Loss Measurement through 5 kc/s Tuning Fork. (See Fig. 2.)

(1) The 2A or 2B noise measuring set is used to measure the voltage across the input and output of the tuning fork in terms of noise, thus determining the loss through the fork. The input plug from the 4 kc/s oscillator should be inserted in the PROG jack of the measuring set, and the set should be calibrated as outlined in the information covering the noise measuring set.

(2) Two single test leads should be arranged with test clips at one end to connect to the tuning fork terminal. The other end of the leads should be connected to a 289A plug. Each lead should be equipped with a 1 megohm resistance at the end which is connected to the test clip.

(3) Connect the test clips to terminals 1 and 2 of the tuning fork and insert the 289A plug in the 135-ohm jacks of Coil 1. Patch from the 600-ohm jacks of Coil 1 to the noise measuring set.

(4) Adjust the db dial on the set and note the reading in db.

(5) Connect the clips to terminals 3 and 4 of the tuning fork.

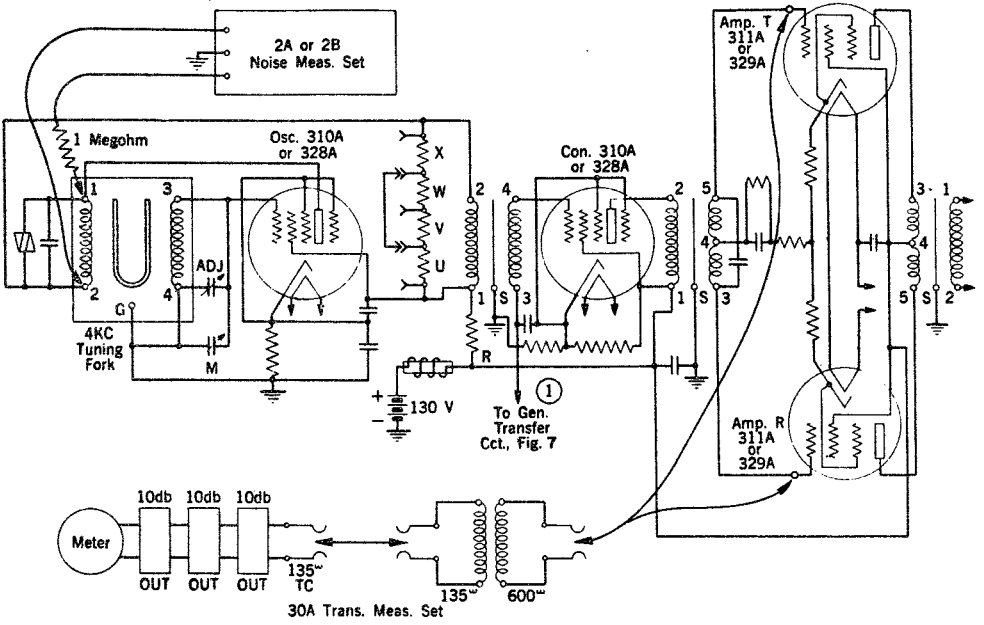
(6) Adjust the db dial and note the reading.

Requirements. The difference between the readings noted in Items (4) and (6), that is, the loss through the tuning fork, should not exceed 25 db.

(7) If the requirement is not met, the matter should be reported.

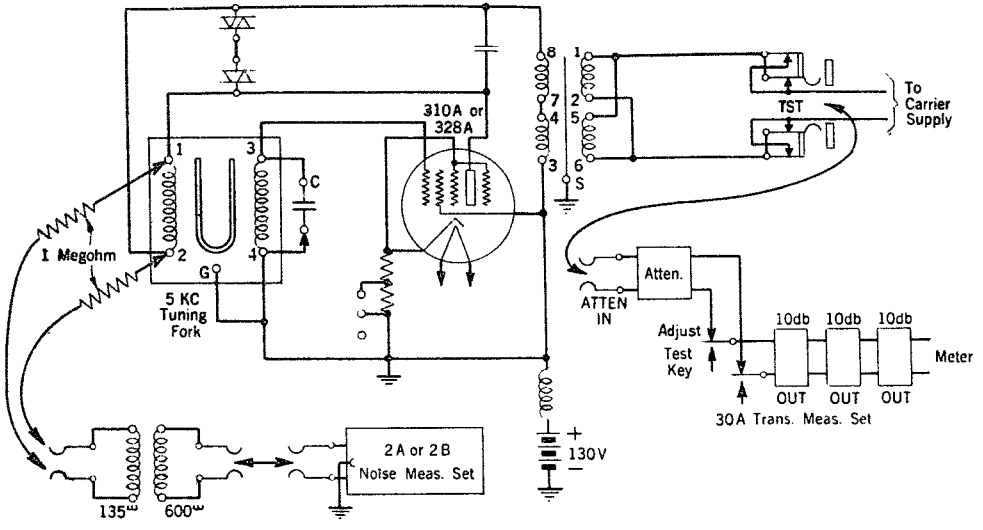
(8) If the requirement is met but output requirements of (a) above cannot be met, replace the vacuum tube in the 5 kc/s oscillator, regardless of the results of the tube tests, and repeat the procedure of (a) above.

(9) After the requirements of (a) above are met, remove all patches and test connections and restore the carrier supply to normal operation by operating the black RLS key.



4 kc/s CARRIER GENERATOR OUTPUT.

FIG. 1.



5 kc/s OSCILLATOR OUTPUT.

FIG. 2.

2.4 Synchronisation of the Carrier Supply with 4 kc/s Reference Frequency.

(i) Description. A harmonic producer in the output of the 4 kc/s tuning fork oscillator and amplifier circuit is used to provide the carrier frequencies required in the channel and group modulators and demodulators. Any error in the basic frequency will be multiplied in the harmonic producer in direct proportion to the number of the harmonic. Thus, a one-cycle error at 4 kc/s will be a 15-cycle error at 60 kc/s.

The frequency of the oscillator may be adjusted within narrow limits by means of variable condensers in the circuit. This test provides a procedure for checking the frequency of the carrier generator using the 4 kc/s reference frequency (Fork-Tone, Research Laboratories, Melbourne). This test is only carried out at the Melbourne Terminal.

(ii) Apparatus.

30A Transmission Measuring Set.
1 - W2AY Cord equipped with 289A Plug (2W24A).
5 - P3P Cords equipped with 305A Plugs (3P20B).
10 - 600-ohm Plugs.
1 - L2K Cord equipped with 289A Plug (2W2A).
1 - 528 Receiver (connect this to the 2W2A Cord and Plug Assembly).

Not required but may be used if available -

1 - Cathode Ray Oscillograph.
2 - W2BP Cords 6 feet long equipped with 241A Plugs at one end (2W15B).

(iii) Procedure. (See Fig. 3a.)

(1) Lock-in the emergency carrier supply when testing the regular carrier supply. Lock-in the regular carrier supply when testing the emergency carrier supply. See Paragraph 2.1.

(2) Patch from the output of the 4 kc/s reference frequency to the 600-ohm jacks of Coil 1 in the 30A Transmission Measuring Set, and patch from the 135-ohm jacks of Coil 1 to the ATTENUATOR IN jacks.

(3) Operate the test key to ADJUST position, and adjust the attenuator of the 30A set to obtain a meter reading between 3 and 5 db below 1 milliwatt.

(4) Insert 600-ohm plugs in the TST EVEN and TST ODD jacks of the carrier supply under test and in the TST jacks of the carrier supply amplifiers of the carrier supply under test.

(5) Patch from the ATTENUATOR OUT jacks to the MULTIPLE jacks of the 30A set.

(6) Connect the telephone receiver to the second set of MULTIPLE jacks, using the 2W2A cord.

(7) Patch from the 135-ohm jacks of Coil 2 of the 30A set to the MULTIPLE jacks. Using the 2W24A cord patched to the 600-ohm jacks of Coil 2, connect the test clips to the grid terminals of AMP T and AMP R tubes.

(8) Adjust the frequency of the carrier generator by means of the ADJ air condenser and, if necessary, by strapping the M condenser of the generator panel under test until the beats do not exceed one per second.

(9) Remove the receiver from the MULTIPLE jack and patch from the MULTIPLE jack to the 135-ohm TC jacks of the 30A set.

(10) Observe the beats on the 30A set meter, adjusting the attenuator as necessary to give a convenient swing of the needle over the meter scale. A beat is a complete cycle of the swing of the meter needle, and the reference point should be taken at some point other than the extreme ends of the needle swing. The frequency of the generator is changed by adjusting the ADJ condenser and by strapping the M condenser.

Requirements. The beats should have a period longer than one beat in two minutes.

(11) If a cathode ray oscillograph is available, using the 2W15B cords connect from ATTEN OUT jacks to the X AXIS and GROUND terminals and from the 135-ohm jacks of Coil 2 to the Y AXIS and GROUND terminals. Adjust the amplitude for each axis by means of the corresponding GAIN dial until a satisfactory pattern is obtained.

A beat is a complete cycle of the change observed in the pattern. The requirements of Item (10) should be met.

(12) After adjusting the frequency, make the 4 kc/s Carrier Generator Output Test (Paragraph 2.2).

2.5 Synchronisation of Transmitting and Receiving Terminal Carrier Supplies.

(i) Description. This test can be made only when channel terminals are provided at both terminals of the system. It is carried out at all terminals other than Melbourne for synchronising the 4 kc/s carrier generator to that at Melbourne after it has been checked with the reference standard.

The frequency of the carrier generator at each terminal may be adjusted within narrow limits by means of the variable condenser in the oscillator circuit which is employed in connection with the 4 kc/s tuning fork.

Any error in the fundamental frequency generated by the tuning fork will be multiplied in the harmonic generator in direct proportion to the number of the harmonic. Thus, a one-cycle error at 4 kc/s will be a 15-cycle error at 60 kc/s. Advantage may be taken of this characteristic to synchronise the carrier generators at the two ends of a system by sending a single frequency from a common oscillator over the system on Channels 1 and 12, and then observing the difference between the frequencies received on these channels at the far end of the system. On an NA system, for example, a difference between the received frequencies of Channels 1 and 12 of 60 cycles per minute indicates an actual frequency displacement of Channel 1 E-W of about 3 cycles per second. For all other channels, both E-W and W-E, the frequency displacement is less than for Channel 1 E-W. The difference of 60 cycles per minute between Channels 1 and 12 is produced when the 4 kc/s forks at the sending and receiving terminals have a frequency difference of about 5.5 cycles per minute.

In the following procedure, the "transmitting" terminal is assumed to be the one which has already been adjusted against the 4 kc/s reference frequency.

(ii) Apparatus.

At Transmitting Terminal.

1 - 30A Transmission Measuring Set.
2 - P2AA Cords 6 feet long equipped with 241A Plugs at each end (2P13B).

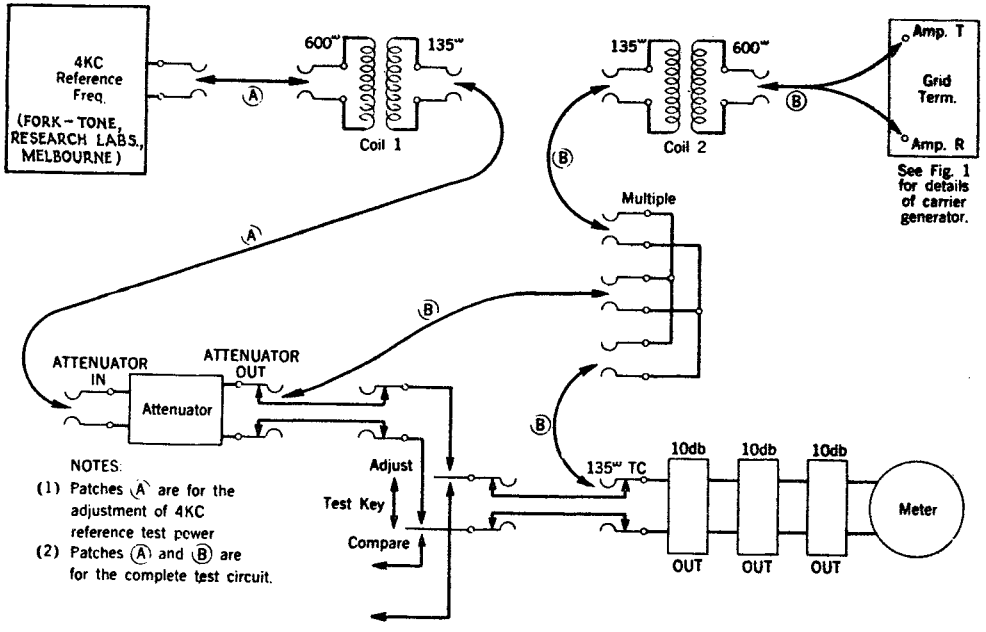
At Receiving Terminal.

1 - 30A Transmission Measuring Set.
1 - Head Receiver equipped with Cord and 241A Plug.
3 - P2AA Cords 6 feet long equipped with 241A Plugs at each end (2P13B).

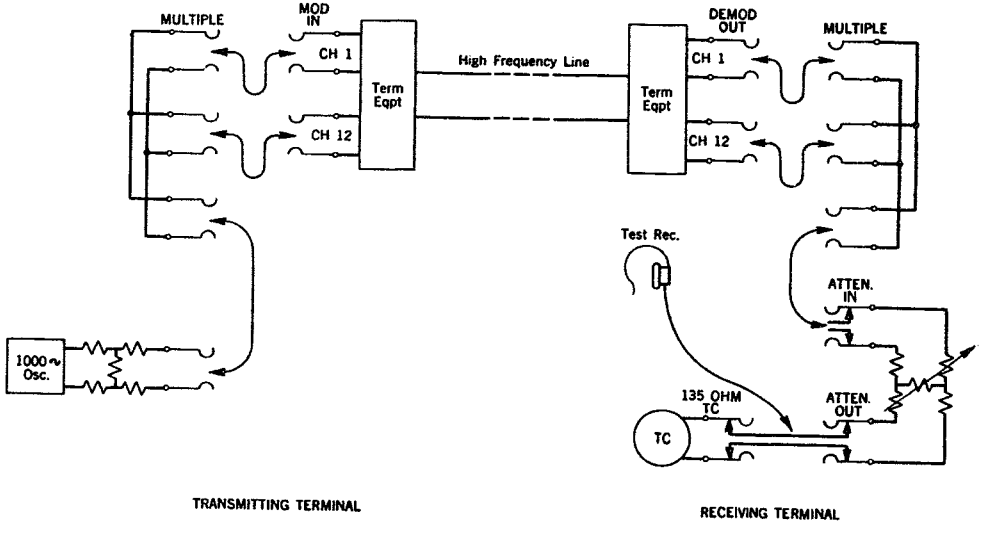
(iii) Procedure. (See Fig. 3b.)

(1) At the four-wire patching bay at the transmitting terminal connect 1,000 c/s testing power at the level established for the office (normally -13 dbm) to the multiple jacks of the 30A Transmission Measuring Set, and patch from the multiple jacks of the 30A set to the MOD IN jacks of Channels 1 and 12.

(2) At the four-wire patching bay at the receiving terminal, patch from the DEM OUT jack of Channels 1 and 12 to the multiple jacks of the 30A set.



(a) Synchronisation of Carrier Supply with 4 kc/s Reference Frequency.



(b) Synchronisation of Carrier Generators - Over-all System Test.

SYNCHRONISATION.

FIG. 3.

Then patch from the multiple jacks to the ATTEN IN jacks and patch the telephone receiver to the ATTEN OUT jacks. Adjust the attenuator until beat notes between the two frequencies can be heard with comfort, and note the beat frequency.

Requirements. Not to exceed one beat per second, counting for a period of at least five seconds.

(3) Where the requirement is not met, remove the cover from the carrier generator panel at the receiving terminal and vary the frequency of the carrier generator by means of the ADJ air condenser, or by strapping the M condenser on the carrier generator panel, until the beating of the two tones is a minimum and not exceeding the above requirement.

(4) Disconnect the receiver from the ATTEN OUT jacks, operate the test key to the ADJUST position and adjust the attenuator to obtain a satisfactory reading on the thermo-couple. Vary the frequency of the carrier generator until the beating of the two frequencies is less than five per minute. A beat is a complete cycle of the swing of the meter needle, and the reference point should be taken at some point other than the extreme ends of the needle swing. When observing the beats on the 30A set meter, the condenser dial of the carrier generator should be locked and the cover should be placed on the generator panel and secured with at least one screw.

(5) If there is not sufficient range in the M and ADJ condensers to permit adjustment to meet the requirements, the frequency of the 4 kc/s fork at the transmitting terminal should be checked against the 4 kc/s reference frequency as outlined in Paragraph 2.4.

(6) After making the above adjustments, the output of the carrier generator at the receiving terminals should be checked.

(7) Repeat the above operations after switching to the emergency carrier supply at the receiving terminal.

2.6 Carrier Supply Output at Test Jacks.

(i) Description. The output of the 4 kc/s generator circuit is delivered to the harmonic producers which generate odd and even harmonics of 4 kc/s. These harmonics are measured at the TST ODD and TST EVEN jacks. In addition, certain frequencies are selected and amplified to provide a carrier supply to the group modulators and demodulators. The output of each frequency is measured at the TST jacks on the amplifier for that frequency.

This test is made on both the regular and emergency carrier supplies. When it is made on either the regular or emergency carrier supply, the other carrier supply must be locked-in so that service will not be interrupted by an accidental operation of the transfer circuit.

(ii) Apparatus.

30A Transmission Measuring Set.
9 - 600-ohm Plugs.
3 - P3P Cords equipped with 305A Plugs (3P20B).
1 - Hybrid Coil Assembly. (See Fig. 4.)

(iii) Procedure.

(a) Procedure - Output at TST ODD and TST EVEN Jacks. (See Fig. 5.)

(1) Lock-in the emergency carrier supply and test the regular carrier supply. (See Paragraph 2.1.)

(2) Terminate the TST EVEN jacks of the generator under test and the TST jacks of the associated carrier supply amplifiers with 600-ohm plugs.

(3) Patch from ATTENUATOR IN jacks to 135-ohm jacks of one of the transformers of the 30A set.

(4) Patch from the 600-ohm jacks of the same transformer to the TST ODD jacks.

(5) Set the attenuator to 27 db and operate the test key to the ADJUST position. Read the thermo-couple meter with the three protection keys operated.

(6) Interchange the patch cord and the 600-ohm plug in the TST ODD and TST EVEN jacks and again read the thermo-couple meter with the three protection keys operated.

Requirements. A reading of not less than -0.5 db should be obtained on the thermo-couple meter of the 30A set for both (5) and (6).

(7) If the requirements are not met, check the OSC, CON, AMP T and AMP R tubes, as described in Paragraph 1.3, and replace tubes if necessary. If the tubes are found to meet requirements, make the 4 kc/s Carrier Generator Output Test (Paragraph 2.2).

(b) Procedure - Output at TST Jacks of Regular and Emergency Carrier Supply Amplifiers. (See Fig. 5.)

(1) Lock-in the emergency carrier supply and test the regular carrier supply. (See Paragraph 2.1.)

(2) Patch from the TST EVEN and TST ODD jacks of the regular carrier generator to HYBRID 1 and 2 jacks of the hybrid coil assembly. (See Fig. 4.) Terminate the TST jacks of the regular carrier supply amplifiers with 600-ohm plugs, except the unit to be tested.

(3) Patch from the TST jacks of the carrier amplifier under test to the ATTEN IN jacks of the 30A set.

(4) With the TEST KEY in the ADJUST position, adjust the attenuator to obtain a reading as close as possible to 0 on the meter with all three protection keys in the OUT position. The attenuator setting corrected for the meter reading is the output of the carrier supply amplifier at the TST jacks.

Requirements. Where 130 volt plate battery is used, the output of the carrier supply amplifiers should be between +16.5 and +19.5 dbm, and the output of the regular and emergency carrier supply amplifiers should not differ by more than 1.0 db.

Where 152 volt plate battery is used, the output of the carrier supply amplifiers should be between +18.0 and +21.0 dbm, and the output of the regular and emergency carrier supply generators should not differ by more than 1.0 db.

(5) If these requirements are not met, check the vacuum tubes of the unit under test, as described in Paragraph 1.3.

(6) In the case of the 484 or 543 kc/s amplifiers, if the requirements are not met and the tubes are found to meet requirements, bridge the 135-ohm TC jacks of the 30A set to terminals 3 and 4 of the CSF1 filter (484 kc/s amplifier) or the CSF2 filter (543 kc/s amplifier). Where both amplifiers are furnished, connect to the CSF2 filter. Insert 600-ohm plugs in all of the TST jacks of the 5 kc/s oscillator and the carrier supply amplifiers under test, and patch from the TST EVEN and TST ODD jacks to HYBRID 1 and 2 jacks of the hybrid coil assembly. (See Fig. 4.)

(7) With the TEST KEY of the 30A set in the ADJUST position and the attenuator set for zero loss, measure the output.

Requirements. The meter reading should not be less than -10 db.

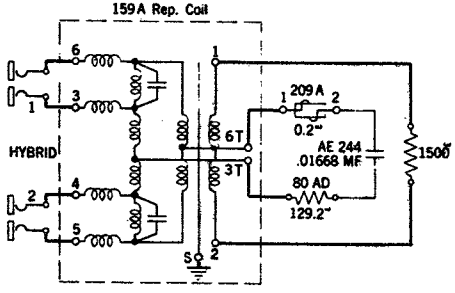
(8) If this requirement is not met, adjust the A and B strappings on the HP varistors and HP condenser on the carrier generator panel to bring the output within limits. If this is done, the channel and group busbar voltage should be

checked (Paragraph 2.7).

(9) Remove all cords and plugs from the regular carrier generator and regular carrier supply amplifiers.

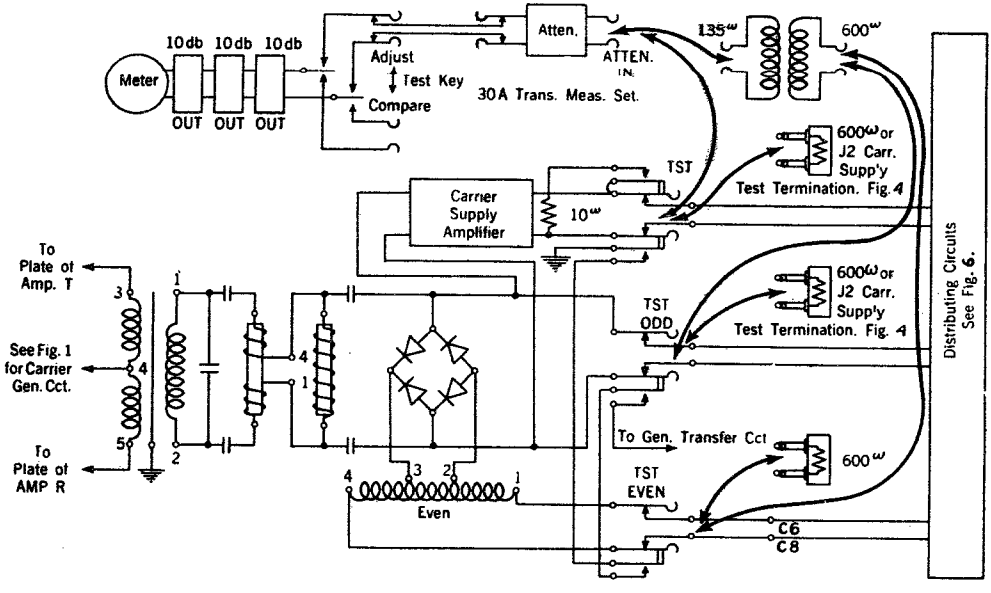
(10) Lock-in the regular carrier supply (see Paragraph 2.1) and test the emergency carrier supply using the procedure of Items (2) through (8).

(11) Remove all cords and plugs from the emergency carrier generator and emergency carrier supply amplifiers. Operate the RLS key to restore the carrier supply to normal operation.



HYBRID COIL ASSEMBLY.

FIG. 4.



CARRIER SUPPLY OUTPUT AT TST ODD AND TST EVEN JACKS.

FIG. 5.

2.7 Carrier Supply Busbar Output.

(i) Description. The output of the harmonic producer and the carrier supply amplifiers, as measured at the TST ODD, TST EVEN and TST jacks, is delivered through suitable filters to the distributing busbars. This test provides a procedure for measuring the busbar output and for adjusting the load on the busbars.

This test is made first with the regular carrier supply locked-in and then with the emergency carrier supply locked-in. When making tests or adjustments on the busbars, extreme caution should be observed to avoid interruption of the carrier supply to working equipment. The busbar itself is covered by a fibre protector which should not be removed for test. The adjusting resistances A, B, C, D and E on the channel busbar are not to be used for measuring carrier output.

(ii) Apparatus.

30A Measuring Set.
1 - W2AY Cord equipped with 289A Plug (2W24A).

(iii) Procedure.

(a) Procedure - Channel Busbar Output - Regular Carrier Supply. (See Fig. 6.)

(1) Lock-in the regular carrier supply and check the regular carrier supply. (See Paragraph 2.1.)

(2) Insert the plug of the 2W24A cord in the 135-ohm TC jacks of the 30A set.

(3) Connect the test clips of the 2W24A cord to the terminals of an unused resistance for Channel 1. If all the resistances are connected to terminal equipment, the connection should be made to the PC terminals, removing the leads if the PC terminals are in use. Since removing the leads from PC terminals will bring in alarms at all W-E repeaters and E terminals, the PC terminals should be used only when all the other resistances are in use.

(4) Read the 30A set meter, which gives a measure of the busbar output.

Requirements. The busbar output as measured should be 1 milliwatt ± 0.5 db.

(5) If requirements are not met, adjust the voltage on the busbar by strapping various combinations of the ADJ resistances designated A, B, C, D, E.

(6) If leads were removed from the PC terminals, reconnect the leads.

(7) Repeat the above procedure for each channel busbar.

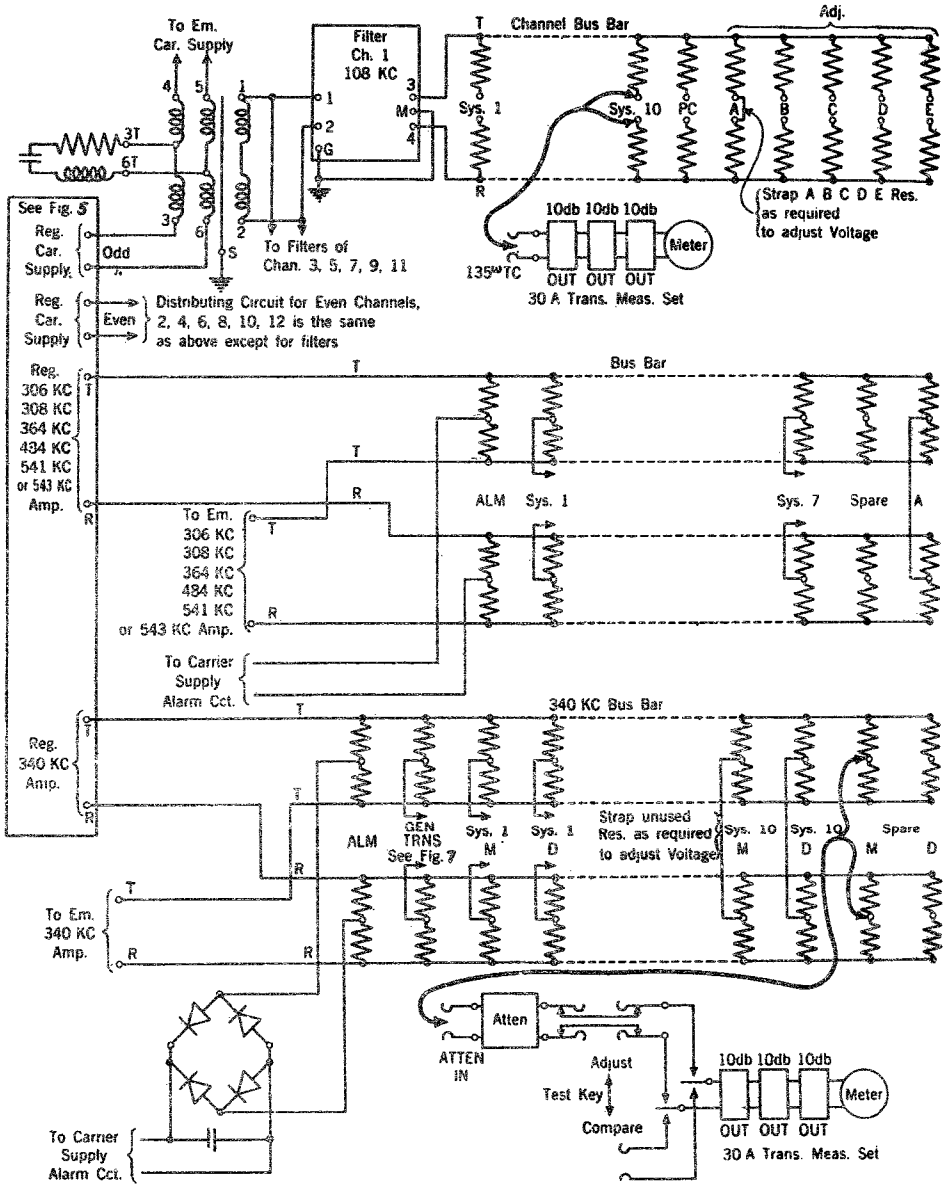
(8) If any changes in strapping of resistances A to E for any channel have been made, remeasure the output of each busbar and readjust if necessary. This procedure should be repeated until all channels meet requirements without the adjustment of other channels. When requirements are met, proceed with (b) below.

(b) Procedure - Group Carrier Supply Busbar Output - Regular Carrier Supply. (See Fig. 6.)

(1) Remove the plug of the 2W24A cord from the 135-ohm TC jacks and insert it in the ATTEN IN jacks of the 30A set.

(2) Connect the test clips of the 2W24A cord to the terminals T and R of unused resistances of the group carrier busbar under test, as shown in Fig. 6.

(3) Set the attenuator to 14 db where 130 volt plate battery is used on the carrier supply amplifiers, or to 16 db where 152 volt plate battery is used on these amplifiers. Operate the TEST KEY of the



CARRIER BUSBAR OUTPUT.

FIG. 6.

30A set to the ADJUST position.

(4) Read the 30A set meter which gives a measure of the busbar output.

Requirements. The meter should read 0 + 1.5 db where 130 volt plate battery is used, or between -2 db and + 1 db where 152 volt plate battery is used. Record the reading for use in (c) below.

(5) If the requirement is not met, strap the resistances T and R of other unused resistances. When requirements are met, restore the carrier supply to normal operation by operating the black RLS key and proceed with (c) below.

(c) Procedure - Channel and Group Carrier Supply Busbar Output - Emergency Carrier Supply. (See Fig. 6.)

(1) Lock-in the emergency carrier supply and read the output for the emergency carrier supply following the procedures outlined in (a) and (b) above.

Requirements. For Emergency Carrier Supply.

When the channel busbar is measured, the meter should read 0 $\pm$ 1.5 db.

When any of the group carrier supply busbar outputs is measured, the meter should read within 1 db of the value obtained in Item (4) of (b) above.

(2) If requirements are not met, repeat the test "Carrier Supply Output at Test Jacks", Paragraph 2.6, and, if necessary, adjust the busbar output to provide a compromise for the two carrier supplies.

2.8 Ionisation of Gas Tubes in Carrier Generator Transfer Circuit.

(i) Description. The carrier generator transfer circuit is operated by failure of any group carrier supply output which causes a gas tube to break down, that is, to ionise and increase the bias on the control tube of the regular carrier generator and decrease the bias on the control tube of the emergency carrier generator. This blocks the regular generator output and releases the output of the emergency generator which is normally blocked. This test provides a procedure for adjusting the ionisation point of the two gas tubes which operate in parallel, and to make the necessary adjustment so that the two tubes will fire at approximately the same voltage. The tubes used in this test should meet the requirements of Paragraph 1.3, Vacuum Tube Tests.

(ii) Apparatus. One 20 $\pm$ 1 ohm resistance connected to test leads 3 inches long terminated with test clips. To be assembled locally.

(iii) Procedure. (See Fig. 7.)

(1) Lock-in the regular carrier supply. (See Paragraph 2.1.)

(2) Remove one of the gas tubes from its socket, or remove both tubes, and insert a new tube in one of the sockets.

(3) Connect the 20-ohm resistance across the GEN TRNS terminals of the 340 kc/s busbar. The connecting lead should not exceed 3 inches in length. This is equivalent to placing the resistance across the input transformer of the carrier transfer circuit as shown in Fig. 7.

(4) Operate the RLS key.

(5) If the tube ionises, that is, shows a bluish glow, operate the REG key and move the resistance tap lead one step towards the AB resistance. Continue this procedure until a point is reached where the tube fails to ionise. When this point is reached, move the resistance tap lead back one step towards the X resistance. If the tube ionises with the tap connected to the cathode end of the AB resistance, consider this to be the operating step for this tube unless the procedure of Item (6) results

in a change in the location of the resistance tap lead. It may take several seconds for the tube to heat up enough to ionise.

(6) If, after operating the RLS key (Item (4)), the tube does not ionise, operate the REG key and move the resistance tap lead one step toward the X resistance. Operate the RLS key again and, if the tube still fails to ionise, operate the REG key and move the resistance tap lead one more step toward the X resistance. Continue this process until a point is reached where the tube ionises, and consider this to be the operating step for this tube.

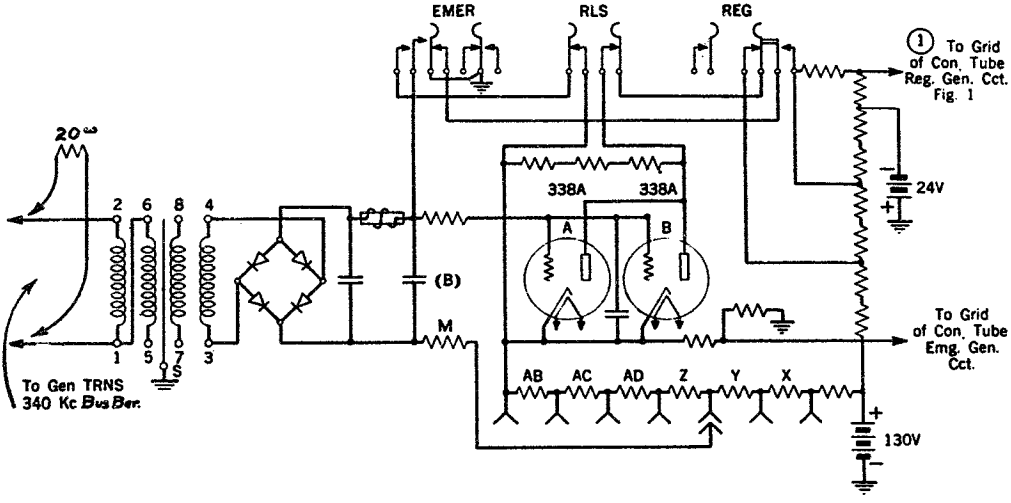
(7) After determining the proper operating step for the tube being tested, operate the REG key and insert another tube in the other socket, removing the tube which has just been tested. Note the resistance tap.

(8) Repeat Items (4) to (7) inclusive to find the proper operating point for the second tube.

Requirements. The adjustment point for the two tubes which are connected in parallel should not differ by more than one resistance step.

(9) If this requirement is not met, repeat the above procedure with other tubes. The resistance tap lead should be connected between the AB and X resistances at one of the critical adjustment points determined above. Connect to the one which is farthest from the cathode (AB resistance).

(10) After the requirements are met, insert the other tube in its socket. Remove the 20-ohm resistance. Restore the carrier supply to normal operating condition and check the operation of the transfer circuit, Paragraph 2.9.



IONISATION TEST OF TUBES IN TRANSFER CIRCUIT.

Note. Alarm features are not shown.

FIG. 7.

2.9 Operation of Carrier Generator Transfer Circuit.

(i) Description. The transfer circuit is operated automatically by failure of any one of the group carrier supplies. The circuit can also be made to function manually by operating keys provided for that purpose, and this test gives a procedure for checking both automatic and manual operation.

(ii) Apparatus. One 600-ohm Plug.

(iii) Procedure.

(a) Procedure - Automatic Operation.

(1) Operate the RLS key on the transfer panel to ensure that the load is on the regular generator.

(2) While watching a CON sensitrol relay on one of the receiving terminals, insert a 600-ohm plug in the TST jacks of any one of the regular carrier supply amplifiers.

Requirements. The reading of the sensitrol relay should not change by more than 0.2 db.

When the transfer is made by inserting the 600-ohm plug in the TST jacks, the green TRNS lamp on the carrier transfer panel should light and an alarm bell should ring until the EMER key is operated. The operation of the EMER key should cause the green lamps to light on the REG carrier supply amplifiers and on the REG carrier generator panel.

(3) If the former requirement is not met, check the regular and emergency supply circuits first, as described in Paragraph 2.7, Carrier Supply Busbar Output, omitting the test of the channel busbar output, and then, if necessary, as described in Paragraph 2.6, Carrier Supply Output at Test Jacks.

(4) If the requirements are met, remove the 600-ohm plug from the TST jacks and operate the RLS key on the transfer panel.

(b) Procedure - Manual Operation.

(1) Operate the RLS key on the transfer panel to ensure that the load is on the regular generator.

(2) While watching a CON sensitrol relay on one of the receiving terminals, operate the red EMER key on the carrier transfer panel.

Requirements. The reading of the sensitrol relay should not change by more than 0.2 db.

When the transfer is made, the green TRNS lamp on the transfer panel and the green lamps on the REG carrier generator and all REG carrier supply amplifier panels should light.

(3) Operate the RLS key, extinguishing the lamps.

(4) Operate the REG key.

Requirements. The green lamps on the EMER carrier generator panel and on all the EMER carrier supply amplifier panels should light.

(5) Operate the RLS key, extinguishing the lamps.

3. TESTS AND ADJUSTMENTS OF GROUP EQUIPMENT AND CHANNEL CIRCUITS.

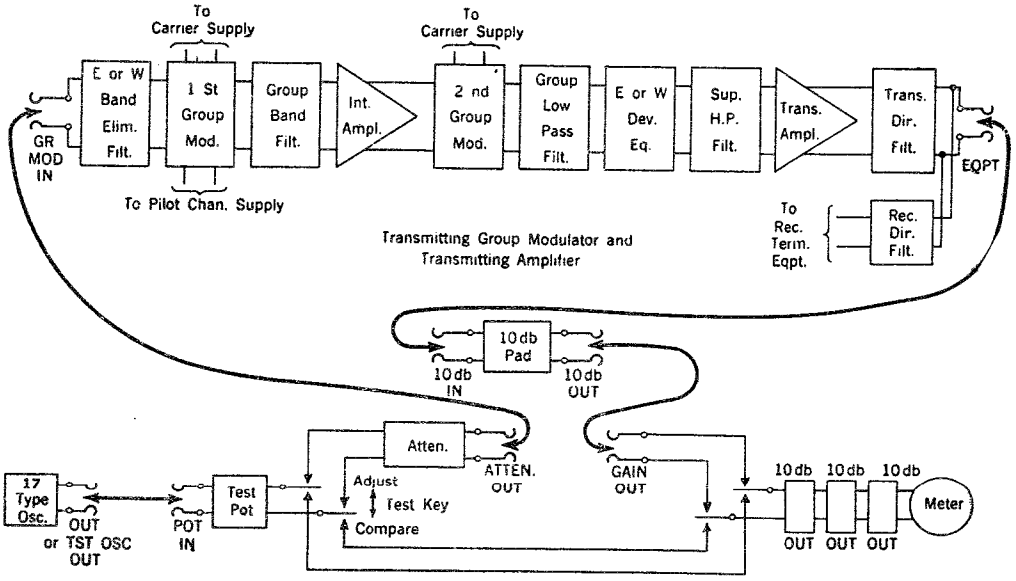
3.1 Transmitting Group Gain.

(i) Description. This test covers the measurement of the gain of the transmitting group circuit. The procedure provides for an output test level of +20 dbm, in order to minimise the effects of the pilot frequencies which are present at the transmitting amplifier output. The system or group terminal should be out of service for this test.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
4 - P3P Cords equipped with 305A Plugs at each end (3P20B).
1 - Screwdriver.

(iii) Procedure. (See Fig. 8.)



TRANSMITTING GROUP GAIN.

FIG. 8.

(1) Patch from the OUT or TST OSC OUT jacks of the 17B oscillator to the POTENTIOMETER IN jacks of the 30A set.

(2) Patch from ATTEN OUT jacks to GR MOD IN jacks.

(3) Patch from EQPT jacks to 10 db IN and from 10 db OUT to GAIN OUT jacks.

(4) Set the 17B oscillator to 83 kc/s and, with the TEST KEY in the COMPARE position, adjust the oscillator output and the test potentiometer to obtain a zero reading on the meter when all three protection keys are in the OUT position.

(5) Set the attenuator for 39 db and operate the TEST KEY to the ADJUST position.

(6) Adjust the attenuator to give a reading as close as possible to zero db on the meter with only two of the 10 db protection keys in the OUT position. The gain of the transmitting group equipment is equal to the attenuator setting corrected for the meter reading plus 20 db.

Requirements. The gain of the transmitting group equipment should be 42 db plus the specified transmitting level ±0.1 db.

(7) If the requirements are not met, adjust the potentiometer on the panel of the intermediate amplifier.

(8) Measure the transmitting group gains at the frequencies given in the following requirements, using the procedure of Items (1) through (6).

Requirements.

Frequency (kc/s).	Gain (db).
63	42 + specified level ± 1.1
67	42 + specified level ± 0.7
103	42 + specified level ± 0.7
107	42 + specified level ± 1.1

(9) If the requirements are not met, the gains or losses of the individual units in the transmitting group equipment should be checked by means of the bridging tests or the values for gains or losses of individual units given later in this Section.

(10) Remove all patch cords.

3.2 Over-all Transmitting Gain Adjustment.

(i) Description. The transmitting terminal equipment of the Type J2 carrier telephone system is designed to have a fixed gain. The intermediate amplifier is provided with a potentiometer for varying its gain, as described in Paragraph 3.1, but, after the potentiometer is once adjusted, only small changes should be required subsequently. Large departures from the specified limits indicate trouble in the transmitting equipment.

Each channel modulator is provided with a pad adjustment, so that the individual channels may be adjusted to give the required output level at the EQPT jacks. After replacement of any varistor in channel modulators, a recheck should be made of the gain of the channels as measured at the EQPT jacks.

This test gives the procedure for adjusting the output level of the individual channels. The system or group terminal should be out of service for this test.

(ii) Apparatus.

30A Transmission Measuring Set.
11 - 600-ohm Plugs.
1 - P3P Cord equipped with 305A Plug at each end (3P20B).
1 - P2AA Cord equipped with 241A Plug at each end (2P13B).

(iii) Procedure. (See Fig. 9.)

(1) Terminate with 600-ohm plugs the MOD IN jacks of all channels except the channel under test.

(2) Patch from the EQPT jacks at the output of the transmitting directional filter to 10 db IN and from 10 db OUT to the ATTEN IN jacks of the 30A set.

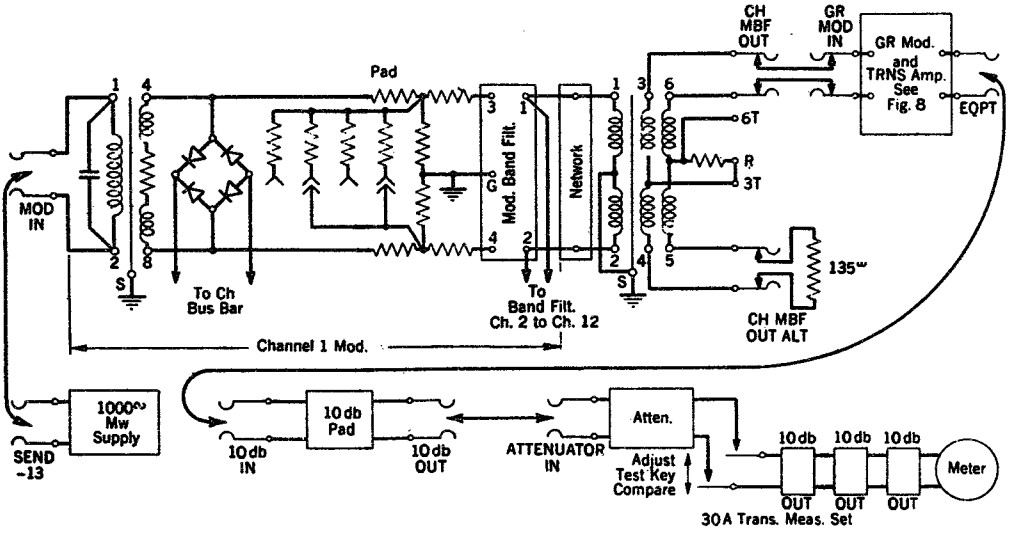
(3) At the voice-frequency patching bay, patch 1,000 c/s testing power at the level established for the office (normally -13 dbm) to the MOD IN jacks of the channel under test.

(4) With the TEST KEY of the 30A set in the ADJUST position, measure the output power. The setting of the attenuator corrected for the reading of the meter plus 10 db indicates the output power.

Requirements. The output level of each channel should be the specified level ±0.3 db.

The output levels of Channels 2, 7 and 11 should be the same as closely as possible.

(5) If the requirements are not met, the equalisation of the transmitting equipment should be adjusted by means of the pad resistances in the channel modulator circuit.



TRANSMITTING GAIN ADJUSTMENT.

FIG. 9.

3.3 Carrier Leak Measurement.

(i) Description. The combined carrier leaks from all channels are measured at the output of the transmitting amplifier. If the total carrier leak meets requirements, the individual channel leaks need not be measured. However, if the requirements are exceeded, each channel should be measured separately in order to determine which varistor or varistors cause the trouble.

Because of the operating difficulties involved in removing the pilot frequencies from the system, the total carrier leak measurements will include power from the pilot channels. Allowance for this is made in the requirements.

(ii) Apparatus.

30A Transmission Measuring Set.
12 - 600-ohm Plugs.

For use only where individual channel leaks are to be measured -

26 - No. 59 or similar type cord tips.

(iii) Procedure.

(1) Terminate each channel by inserting a 600-ohm plug in the MOD IN jacks.

(2) Patch from the EQPT jacks to the ATTEN IN jacks of the 30A set.

(3) With the TEST KEY in the ADJUST position, measure the power delivered to the 30A set. The attenuator setting corrected for the reading of the meter indicates the power in dbm.

Requirements. The output power should not exceed +7.0 dbm for a West terminal or +2.0 dbm for an East terminal.

(4) If the requirements are not met, remove the can covers of all the channel modulator-demodulator circuits and measure the carrier leaks of the individual channels as follows.

(5) Using the cord tips in pairs, connected with flexible wire, short-circuit the carrier supply to all channel modulators by bridging the cord tips across the bottom terminals of the J and K resistances. Remove the pilot channel power from the system by short-circuiting terminals 4 and 5 of the hybrid coil (1MI) on the group modulator panel.

(6) Read the meter of the 30A set.

Requirements. There should be no deflection of the meter.

(7) If the requirements are met, remove the clip from the modulator of Channel 1 and measure the power delivered to the 30A set.

(8) Replace the clip on the modulator of Channel 1, remove the clip from Channel 2 and again measure the power delivered to the 30A set.

(9) Repeat this procedure for all 12 channels, making each measurement with only one clip removed.

(10) Replace the varistors of the channel giving the highest output.

(11) Remove all test clips and connections and measure the total carrier leak again, following the procedure of Items (1) through (3).

(12) After any varistor is replaced, the over-all transmitting gain should be checked using the procedure of Paragraph 3.2.

3.4 Receiving Group Gain.

(i) Description. This measurement covers the gain of the regulator and the group demodulator, together with the associated equalisers and filters and the auxiliary amplifier.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
3 - P3P Cords equipped with 305A Plugs at each end (3P20B).
1 - Open Plug.

(iii) Procedure. (See Fig. 10.)

(1) Insert an open plug in the BCO jack on the pilot control panel.

(2) Set the oscillator to the desired frequency and patch from the OUT or TST OSC OUT jacks to the POT IN jacks on the 30A set.

(3) Patch from the ATTEN OUT jacks to the EQPT jacks and from the GR DEM OUT jacks to the GAIN OUT jacks.

(4) With the TEST KEY in the COMPARE position, adjust the test potentiometer and the output of the oscillator to give a reading of 0 db on the meter with all three protection keys in the OUT position.

(5) Operate the TEST KEY to the ADJUST position, and adjust the attenuator to obtain as closely as possible a 0 reading on the meter with all three protection keys in the OUT position.

(6) The receiving group gain is equal to the setting of the attenuator corrected for the meter reading.

3.5 Measurement of Receiving Group Characteristics.

(i) Description. The terminal is set for specified gain conditions, so that the over-all gain may be measured and compared with requirements.

(ii) Apparatus.

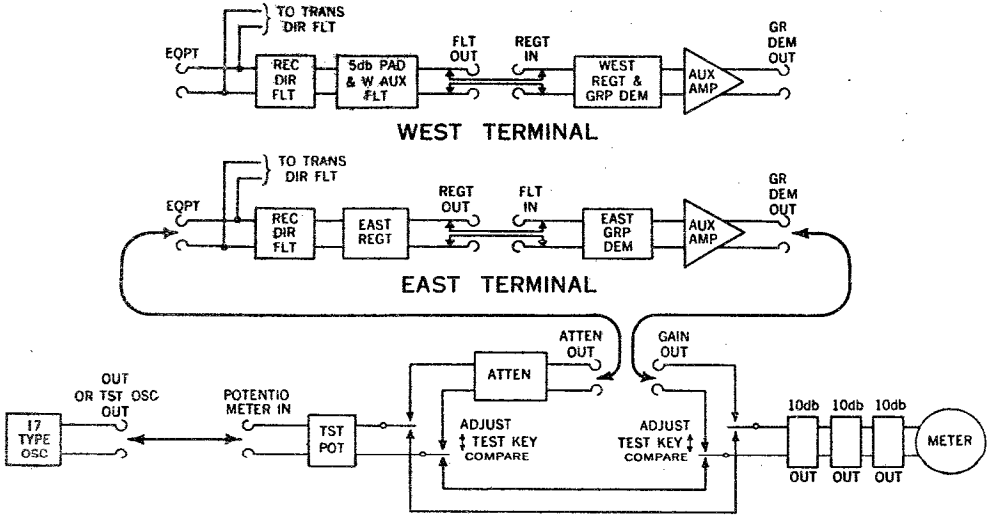
17B Oscillator.
30A Transmission Measuring Set.
3 - P3P Cords equipped with 305A Plugs at each end (3P20B).
1 - Open Plug.

(iii) Procedure.

(a) Preliminary Procedure. (See Fig. 10.)

(1) Insert open plugs in the BCO jacks to prevent operation of office alarms and pulsing of the Sensitrol relays. Remove the 55 volt A.C. fuses from the regulating amplifier under test.

(2) The Slope dial reading at the high end of the scale is normally 100 at west terminals and 86 at east terminals. If, at the point of maximum travel, the reading is less than 100 or 86, the Slope dial should be set at this reading instead of 100 or 86 specified for the setting of the Slope dial in the following paragraphs.



RECEIVING GROUP GAIN AND CHARACTERISTICS.

FIG. 10.

(b) Procedure - East Terminal.

(1) Make receiving group gain measurements at the frequencies and for the regulating condenser settings shown in Table 5, using the method given in Paragraph 3.4, Receiving Group Gain. When an output of 1 mW cannot be attained with the attenuator set at 0, a loss measurement should be made.

Requirements. The requirements to be met for each measurement are given in Table 5.

(c) Procedure - West Terminal.

(1) Make receiving group gain measurements at the frequencies and for the regulating condenser settings shown in Table 6, using the method given in Paragraph 3.4, Receiving Group Gain. When an output of 1 mW cannot be attained with the attenuator set at 0, a loss measurement should be made.

Requirements. The requirements to be met for each measurement are given in Table 6.

GROUP CIRCUIT RECEIVE MEASUREMENTS - EAST TERMINAL.

Measurement.	Conditions.			Requirements (db).	Tolerance (db).	
	Input kc/s	Slope Cond. Dial	Flat Cond. Dial	Note. Letters in ( ) indicate actual measured value of test so lettered.	Initial Test	Maintenance Test
(a)	60	86	100	23.5	± 2.0	± 2.4
(b)	36	86	100	(a)	± 1.0	± 1.2
(c)	84	86	100	(a)	± 1.0	± 1.2
(d)	84	86	50	(c) - 21.3	± 1.5	± 1.8
(e)	84	86	10	(c) - 40.5	± 2.0	± 2.4
(f)	84	86	100	(c) + 0.3	± 0.8	± 1.0
(g)	84	71	100	(c)	± 0.8	± 1.0
(h)	84	57	100	(c) - 0.3	± 0.8	± 1.0
(i)	84	43	100	(c) - 0.5	± 0.8	± 1.0
(j)	84	29	100	(c) - 1.2	± 0.8	± 1.0
(k)	84	14	100	(c) - 2.1	± 1.0	± 1.2
(l)	36	86	100	(f) + (b) - (c)	± 0.6	± 0.7
(m)	36	71	100	(g) + (b) - (c) - 4.1	± 0.6	± 0.7
(n)	36	57	100	(h) + (b) - (c) - 8.1	± 0.6	± 0.7
(o)	36	43	100	(i) + (b) - (c) - 12.2	± 0.6	± 0.7
(p)	36	29	100	(j) + (b) - (c) - 17.7	± 0.6	± 0.7
(q)	36	14	100	(k) + (b) - (c) - 23.5	± 0.8	± 1.0

TABLE 5.

GROUP CIRCUIT RECEIVE MEASUREMENTS - WEST TERMINAL.

Measurement.	Conditions.			Requirements (db).	Tolerance (db).	
	Input kc/s	Slope Cond. Dial	Flat Cond. Dial	Note. Letters in ( ) indicate actual measured value of test so lettered.	Initial Test	Maintenance Test
(a)	116	14	100	23.5	± 2.0	± 2.4
(b)	92	14	100	(a)	± 1.0	± 1.2
(c)	143	14	100	(a)	± 1.0	± 1.2
(d)	92	14	50	(b) - 20.7	± 2.0	± 2.4
(e)	92	14	10	(b) - 39.5	± 2.0	± 2.4
(f)	92	100	100	(b)	± 1.0	± 1.2
(g)	92	86	100	(b)	± 1.0	± 1.2
(h)	92	71	100	(b)	± 1.0	± 1.2
(i)	92	57	100	(b)	± 1.0	± 1.2
(j)	92	43	100	(b)	± 1.0	± 1.2
(k)	92	29	100	(b)	± 1.0	± 1.2
(l)	92	5	100	(b)	± 1.0	± 1.2
(m)	143	100	100	(f) + (c) - (b) + 34.7	± 0.8	± 1.0
(n)	143	86	100	(g) + (c) - (b) + 24.8	± 0.8	± 1.0
(o)	143	71	100	(h) + (c) - (b) + 16.7	± 0.6	± 0.7
(p)	143	57	100	(i) + (c) - (b) + 10.0	± 0.6	± 0.7
(q)	143	43	100	(j) + (c) - (b) + 7.0	± 0.6	± 0.7
(r)	143	29	100	(k) + (c) - (b) + 3.4	± 0.6	± 0.7
(s)	143	5	100	(l) + (c) - (b) - 0.3	± 0.8	± 1.0

TABLE 6.

3.6 Measurement of Supplementary Amplifier and Equaliser.

(i) Description. This test checks the performance of the supplementary amplifier and equaliser.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
4 - P3P Cords equipped with 305A Plugs at each end (3P20B).

(iii) Procedure.

(a) West Terminal. Procedure - Amplifier Only.

(1) Set the oscillator for a frequency of 92 kc/s.

(2) Patch from OUT or TST OSC OUT jacks to POT IN jacks of the 30A set.

(3) Patch from ATTEN OUT jacks to SUPL IN jacks of the supplementary amplifier and from SUPL OUT jacks to GAIN OUT jacks of the 30A set.

(4) With the TEST KEY in the COMPARE position, adjust the test potentiometer and the oscillator output to obtain a reading of 0 on the meter with all three protection keys in the OUT position.

(5) Operate the TEST KEY to the ADJUST position and adjust the attenuator until a meter reading as close as possible to 0 is obtained with all three protection keys in the OUT position. The attenuator setting corrected for the reading of the meter is the gain of the amplifier.

(6) Repeat the steps of Item (2) through (5) for a frequency setting of 143 kc/s.

Requirements.

Gain at 92 kc/s.	Increase in Gain at 143 kc/s.
36.3 ± 0.5 db	0.2 ± 0.5 db

Procedure - Amplifier Plus Equaliser.

(1) Patch from ATTEN OUT jacks to EQL IN and from EQL OUT to SUPL IN jacks. Patch from SUPL OUT jacks to GAIN OUT jacks of the 30A set.

(2) Using the procedure of Item (4) through (6) above, measure the gain of the equaliser and the supplementary amplifier in tandem at frequencies of 92 kc/s and 143 kc/s.

Requirements. The 92 kc/s gain should be 3.3 ± 0.6 db less than that measured at 92 kc/s and the 143 kc/s gain should be 35.3 ± 0.6 db less than that measured at 143 kc/s in "Procedure - Amplifier Only" above.

(b) East Terminal. Procedure - Amplifier Only.

(1) Using the procedure of Items (2) through (6) of (a) above, measure the gain of the supplementary amplifier at 36 kc/s and 84 kc/s with the GAIN key (mounted to the right of the SUPL IN jacks on the supplementary amplifier) set first at 24 and then at 36.

Requirements.

Gain Key at	Gain in db	
	36 kc/s	84 kc/s
24	25.4 ± 0.5	-
36	36.4 ± 0.5	36 kc/s gain ± 0.5

Procedure - Amplifier Plus Equalisers.

(1) Before measuring the supplementary amplifier or supplementary amplifier and equaliser in tandem, determine the loss at 36 kc/s and at 84 kc/s in the two repeating coils of the 30A set when the two 600-ohm sets are connected together.

(2) Patch from the 600-ohm jacks of Coil 1 to the 600-ohm jacks of Coil 2. Then patch from the LOSS IN jacks to the 135-ohm jacks of Coil 2 to the LOSS OUT jacks.

(3) Remove any patches from ATTEN OUT jacks and GAIN OUT jacks.

(4) Set the oscillator for the desired test frequency, and adjust the oscillator output and the test potentiometer to give a reading of 0 on the meter with all three protection keys in the OUT position.

(5) Operate the TEST KEY to the ADJUST position, and adjust the attenuator to give a reading as close as possible to 0 on the meter with all three protection keys in the OUT position.

(6) The attenuator setting corrected for the reading of the meter is the loss of the two repeating coils.

(7) Remove the patches from the LOSS IN and LOSS OUT jacks, and patch from ATTEN OUT jacks to 135-ohm jacks of Coil 1 and from 135-ohm jacks of Coil 2 to EQL IN jacks. Patch from EQL OUT jacks to SUPL IN jacks and from SUPL OUT jacks to GAIN OUT jacks.

(8) Using the procedure of Items (4) through (6) of (a) above, measure the gain at 36 and 84 kc/s between the 135-ohm jacks of Coil 1 and the SUPL OUT jacks. Correct these measurements for loss in the repeating coils by adding the values obtained in Item (6) above to the measured gain.

Requirements. At 36 kc/s the gain should be 24.4 ± 0.5 db less, and at 84 kc/s it should be 3.0 ± 0.5 db less than that measured in "Procedure - Amplifier Only" above for corresponding settings of the GAIN key.

3.7 Channel Receiving Gain.

(i) Description. This test covers the measurement of the channel receiving gain, including only the channel demodulator circuit, and also provides for measuring the range of the channel demodulator potentiometer.

(ii) Apparatus.

600-ohm Transmission Measuring System.
17B Oscillator.
30A Transmission Measuring Set.
1 - 125-ohm Plug.
2 - P3P Cords equipped with 305A Plugs (3P20B).
1 - P2AA Cord equipped with 241A Plugs (2P13B).

(iii) Procedure. (See Fig. 11.)

(1) Patch from the OUT or TST OSC OUT jacks of the 17B oscillator to the POTENTIOMETER IN jacks of 30A set.

(2) Patch from the ATTENUATOR OUT to the CH DBF IN jacks. Place the 125-ohm plug in the GRP DEM OUT jacks.

(3) Set the 17B oscillator to the frequency corresponding to the 1,000-cycle point of the channel under test as indicated below.

Channel.	Frequency (kc/s).	Channel.	Frequency (kc/s).
1	107	7	83
2	103	8	79
3	99	9	75
4	95	10	71
5	91	11	67
6	87	12	63

(4) Operate the test key to the COMPARE position and adjust the oscillator output to give a 0 db reading on the 30A set meter.

(5) At the voice frequency patching bay, patch from the DEM OUT jacks of the channel under test to the input jacks of a 600-ohm transmission measuring system.

(6) Set the demodulator potentiometer of all channels for maximum gain, that is, extreme clockwise position.

(7) Operate the test key of the 30A set to the ADJUST position, and adjust the attenuator to give as closely as possible a reading of 0 db on the meter of the 600-ohm transmission measuring system.

(8) The channel gain is the attenuator setting corrected for the reading of the 600-ohm transmission measuring system.

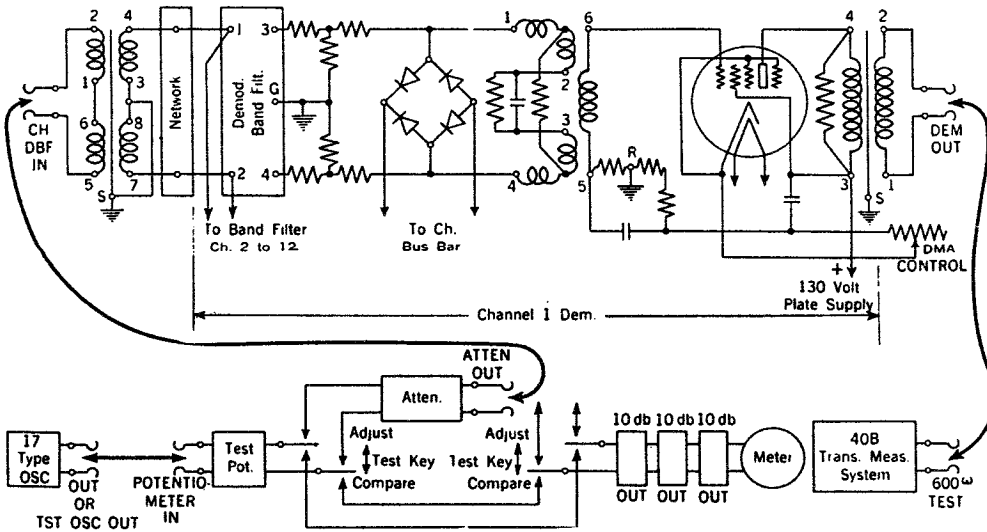
Requirements. Gain should be between 12 and 18.5 db.

(9) If the requirements are not met, change the vacuum tube in the amplifier as set out in Paragraph 7.6.

(10) To check the range of the demodulator potentiometer, set the potentiometer for minimum gain, that is, extreme counter-clockwise position, and repeat the above procedure.

Requirements. The gain should be at least 8 db below that measured for maximum position, Items (6) and (7).

(11) Reset the demodulator potentiometers. Remove all patch cords and plugs.



CHANNEL RECEIVING GAIN.

FIG. 11.

3.8 Check of Two-Wire Termination. The loss between the four-wire patch bay and the switchboard termination is checked at a frequency of 800 or 1,000 c/s on the 12 channels at each terminal. In addition, the return loss of the hybrid network is checked.

(i) Apparatus.

Variable Oscillator suitable from 300-3,400 c/s.
A.P.O. Transmission Measuring Set.
Patch Cords, and Terminating Plugs.

(ii) Details of Test.

(a) Send test current at 0 dbm from SWBD jack of channel, and measure the current received at EQUIP IN jack on four-wire V.F. test bay. The loss should be 13 db.

(b) Send test current at 0 dbm at EQUIP IN jacks on four-wire V.F. test bay, and measure the current received at SWBD jacks. The loss should be 4 db.

(c) Terminate channel on SWBD jacks with 600 ohms. Send test current at 0 dbm at EQUIP IN jacks and measure EQUIP OUT jacks. Check the loss over the frequency range 300-3,400 c/s. The loss should be at least 40 db over the frequency range.

4. TESTS AND ADJUSTMENTS OF PILOT CHANNEL CIRCUITS.

4.1 Measurement and Adjustment of Pilot Output Levels.

(i) Description. This test gives a procedure for measuring and adjusting the pilot output level and for adjusting the IND 1 and IND 2 relays, which give an alarm in case the pilot level departs from the required value by more than 0.5 db.

The pilot supplies for controlling the automatic regulation system are introduced in the transmitting terminal equipment just ahead of the first group modulator, the frequencies introduced being -

Frequency Allocation.	Pilot Supply Frequency (kc/s).			
	EAST Terminal.		WEST Terminal.	
	Slope.	Flat.	Slope.	Flat.
NA	111	60	104	64
NB	58	109	104	64
SA	60	111	64	104
SB	109	58	64	104

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
1 - 125-ohm Plug.
2 - P3P Cords equipped with 305A Plugs at each end (3P20B).
3 - P3P Cords, 6 feet long, equipped with 305A Plug at one end and Test Clips at the other. Assemble locally.
Telephone Receiver with Leads having Test Clips at one end.

(iii) Procedure.

(a) Procedure - Pilot Output.

(1) Remove the system from service unless a spare group terminal is available, in which case this test can be made on the spare equipment.

(2) Measure and, if necessary, adjust the transmitting group gain as described in Paragraph 3.1.

(3) Insert the 125-ohm plug in the GR MOD IN jacks.

(4) Patch from the EQPT jacks of the terminal under test to the 135-ohm TC jacks in the 30A set, and measure the power delivered to the thermo-couple.

Requirements. The total output should be within 0.5 db of 17 db below the specified level at the EQPT jacks.

(5) If this requirement is not met, check the SLOPE pilot separately as described in the following items.

(6) In order that only one pilot at a time will be measured, the grid on the oscillator tube of the pilot supply circuit not being measured should be grounded.

Caution. This procedure will remove pilot from all systems in the office that are supplied from the panel under test.

(7) Measure the output at the EQPT jacks by noting the reading of the meter.

Requirements. The output should be within 0.2 db of 20 db below the specified level at the EQPT jacks.

(8) If this requirement is not met, adjust the OUTPUT condenser of the SLOPE pilot being measured until the pilot level is as close as possible to 20 db below the specified level at the EQPT jacks.

(9) Repeat Items (6) through (8) for the FLAT pilot. Replace any grid clip that has been removed.

(10) It should be borne in mind that adjustment of the OUTPUT condensers raises or lowers the amount of pilot current being supplied to all carrier systems using this pilot supply.

(b) Procedure - Adjustment of IND 1 and IND 2 Relays.

(1) With the SLOPE and FLAT pilots each set as closely as possible to 20 db below the specified level at the EQPT jacks, observe the reading of the IND 1 and IND 2 sensitrol relays on the pilot supply panel.

Requirements. Each relay should have a reading of approximately 0.

(2) If the relay reads within 0.1 db of 0, adjust it to read 0 as closely as possible by means of the pointer adjusting screw on the sensitrol relay.

(3) If the IND 1 or IND 2 sensitrol relay reads more than 0.1 db from 0, or if there is any indication that the 64 kc/s or 104 kc/s pilot supply has changed in frequency, the corresponding pilot channel supply output should be checked and adjusted as described below.

(c) 58-109 kc/s and 60-111 kc/s Pilot.

(1) These pilot supply circuits are equipped with a crystal in the feedback circuit, so that the output frequency is normally held constant. The output level may, however, be subject to change in case the tuning adjustment has been altered or a change has occurred in the balance of the bridge circuit.

(2) Retune the TUNE IN and TUNE OUT condensers for the particular frequency to obtain maximum deflection on the sensitrol relay. After one condenser has been adjusted, the setting of the other condenser should be rechecked and so on until maximum deflection has been obtained.

(3) The sensitrol relay should then be adjusted to read zero as closely as possible by means of its pointer adjusting screw.

(4) If the relay is off scale, the output of the oscillator should be checked by bridging from the ATTEN IN jacks to the panel ground and Terminal 1 of the A varistor when using the TUNE IN 1 and TUNE OUT 1 condensers, or to panel ground and Terminal 4 of the A varistor when using the TUNE IN 2 and TUNE OUT 2 condensers. Operate the TEST key to the ADJUST position. Tune the condensers as above to obtain maximum output. The output is equal to the attenuator setting corrected for the meter reading.

Requirements. The output should be +5.0 $\pm$ 1.5 dbm.

(5) If the requirement is met, remove the bridged connection and adjust the relay to read zero. If the requirement is not met, proceed as outlined below.

(6) During the adjustment, the pointer of the relay may be restored when desired by pressing the RST key, which also silences the audible alarm if the pilot supply has become normal. If the pilot supply is not normal, the audible alarm may

be silenced by pressing the CO key.

(7) If the bridge balance has been affected in any way, the output requirements of Item (4) above may not be met.

(8) Readjust the output. If the output is too low, change the oscillator bridge arms to use XX wiring and remove ZZ wiring. If the output is too high, change the oscillator output bridge arms to use YY wiring and remove ZZ wiring. If the output is brought within limits by changing the oscillator output bridge arm wiring, retune the TUNE IN and TUNE OUT condensers to obtain maximum output. After this has been done, the output should meet the requirements stated in Item (4) above.

(9) If the relay reads low and cannot be readjusted with the range of adjustment available, the sensitrol relay alarm circuit should be disabled. The pilot output at the EQPT jacks should be adjusted following the procedure of (a) above. The failure to meet the requirements of Item (4) above, and the fact that the alarm circuit has been disabled, should be reported.

(10) If the relay reads high and cannot be readjusted with the range of adjustment available, a shunt should be placed across Terminals 2 and 3 of the sensitrol relay to bring it within the range of adjustment. The use of a decade resistance box may be found convenient in determining the value of resistance to be used in the shunt. The relay should then be adjusted to read zero by means of its pointer adjusting screw. The pilot output at the EQPT jacks should be adjusted following the procedure in (a) above. The failure to meet the requirements of Item (4) should be reported.

(d) 64-104 kc/s Pilots - Using Cathode Ray Oscillograph.

(1) The 64 kc/s and 104 kc/s pilot supply circuits are connected to the 64 kc/s and 104 kc/s channel supply circuits, respectively, and are arranged with a feedback connection so that they are forced to oscillate at the channel supply frequency. However, if the pilot supply circuit is not tuned correctly, it may also oscillate at some other frequency, thus causing noise in one or more channels of the system. The pilot supply circuit cannot be tuned correctly by adjusting the TUNE IN and TUNE OUT condensers to give maximum output. It is necessary to make sure that it is tuned accurately to the corresponding channel supply frequency by following the procedure given below.

(2) To adjust the 64 kc/s or 104 kc/s pilot supply circuit, disconnect the leads connected to the PC resistance at the corresponding channel distributing busbar.

(3) Set the TUNE IN and TUNE OUT condensers of the pilot supply circuit under test for maximum capacity (plates fully meshed). The TUNE IN and TUNE OUT condensers of the other pilot supply circuit should be left in the position in which they were found.

(4) Bridge from the ATTEN IN jacks to panel ground and Terminal 1 of the A varistor when testing a 64 kc/s pilot, or to panel ground and Terminal 4 of the A varistor when testing a 104 kc/s pilot.

(5) Make sure that the GROUND terminal of the oscillograph is connected to panel ground. Then bridge X AXIS and GROUND terminals of the cathode ray oscillograph between Terminal 1 of the A varistor and panel ground for the 64 kc/s pilot supply, or between Terminal 4 of the A varistor and panel ground for the 104 kc/s pilot supply.

(6) Bridge from the 135-ohm jacks of Coil 1 across the PC resistance of the 64 kc/s busbar or 104 kc/s busbar from which the leads were removed in Item (2) above, and connect from 600-ohm jacks of Coil 1 to Y AXIS and GROUND terminals of the oscillograph.

(7) With the TEST KEY in the ADJUST position, note the output of the pilot channel supply, first with the TUNE IN and TUNE OUT condensers both fully meshed and then both fully unmeshed.

Requirements. In each case, the output should be +5 ± 1.5 dbm.

(8) If the bridge balance has been affected in any way, these requirements may not be met and the procedure below should be followed.

(9) Readjust the output. If the output is too low, change the oscillator bridge arms to use XX wiring and remove ZZ wiring. If the output is too high, change the oscillator output bridge arms to use YY wiring and remove ZZ wiring.

(10) If the relay reads low and cannot be readjusted with the range of adjustment available, the sensitrol relay alarm circuit should be disabled. The pilot output at the EQPT jacks should be adjusted following the procedure of (a) above. The failure to meet the requirements of Item (7) above, and the fact that the alarm circuit has been disabled, should be reported.

(11) If the relay reads high and cannot be readjusted with the range of adjustment available, a shunt should be placed across Terminals 2 and 3 of the sensitrol relay to bring it within the range of adjustment.

The use of a decade resistance box may be found convenient in determining the value of resistance to be used in the shunt. The relay should then be adjusted to read zero by means of its pointer adjusting screw. The pilot output at the EQPT jacks should be adjusted following the procedure in (a) above. The failure to meet the requirements of Item (7) should be reported.

(12) Increase the capacity of the TUNE IN and TUNE OUT condensers for the pilot supply circuit under test, first one and then the other by small amounts, observing the oscillograph until a straight line pattern or an ellipse results. If the phase relation between the applied potentials is 0° or 180°, an inclined straight line will be obtained. At other phase relations, an ellipse will result, the slope of the axis of this ellipse depending on the phase relation. The pattern need not remain absolutely stationary. In the final position, both condensers should be meshed by approximately the same extent.

(13) Reconnect the bridged connection to the ATTEN IN jacks and note the output.

Requirements. The output should be +5.0 ± 1.5 dbm and, unless the bridge balance has been readjusted since making the measurement called for in Item (7), the output should be within 0.1 db of the value measured in Item (7).

(14) Reconnect the leads (which were removed in Item (2)) to the PC resistance. With the Y AXIS and GROUND terminals of the oscillograph bridged across this resistance through Coil 1 as in Item (6) and the X AXIS and GROUND terminals connected as in Item (5), observe that the pattern on the oscillograph screen is a stationary single line figure and that the output as measured by the 30A set is increased slightly (about 0.1 db) from the final output measured in Item (13).

(15) Remove all test connections.

(16) Operate the RST key and adjust the sensitrol relay for the pilot channel supply under test to read zero by means of the pointer adjusting screw. If the range of adjustment is not sufficient to permit this, the alarm circuit should be disabled or the sensitrol relay shunted as outlined in Items (10) and (11).

(e) 64-104 kc/s Pilots - Cathode Ray Oscillograph Not Available.

(1) The conditions of Item (1) under (d) above also apply here.

(2) In tuning the 64 kc/s or 104 kc/s pilot supply circuits by means of a telephone receiver and the thermo-couple meter in the 30A set, the pilot supply circuit is first tuned to the frequency of the corresponding channel frequency supply while operating almost entirely free from the control of the channel frequency supply. This tuning adjustment is first made approximately using a telephone receiver, and then more accurately using the meter of the 30A set and the test oscillator which is adjusted accurately to the channel supply frequency. After

tuning to within ±50 c/s of the channel frequency supply, the pilot supply circuit is reconnected to operate under the control of the channel frequency supply. Since tuning which is correct within this amount is satisfactory, carrying the procedure further to obtain greater refinement of the tuning adjustment is not necessary.

(3) To adjust the 64 kc/s or 104 kc/s pilot supply circuit, disconnect the leads connected to the PC resistance at the corresponding channel distributing busbar.

(4) Set the TUNE IN and TUNE OUT condensers of the pilot supply circuit under test for maximum capacity (plates fully meshed). The TUNE IN and TUNE OUT condensers of the other pilot supply circuit should be left in the position in which they were found.

(5) Bridge from the 135-ohm TC jacks to panel ground and Terminal 1 of the A varistor when testing a 64 kc/s pilot supply circuit, or to panel ground and Terminal 4 of the A varistor when testing a 104 kc/s pilot supply circuit.

(6) Note the output of the pilot channel supply, first with the TUNE IN and TUNE OUT condensers fully meshed and then with both condensers fully unmeshed. The measurement should be made with two of the protection keys in the OUT position.

Requirements. The output in each case should be +5 ± 1.5 dbm.

(7) If the bridge balance has been affected in any way, these requirements may not be met and the procedure below should be followed.

(8) Readjust the output. If the output is too low, change the oscillator bridge arms to use XX wiring and remove ZZ wiring. If the output is too high, change the oscillator bridge arms to use YY wiring and remove ZZ wiring.

(9) If the relay reads low and cannot be readjusted with the range of adjustment available, the sensitrol relay alarm circuit should be disabled. The pilot output at the EQPT jacks should be adjusted following the procedure of (a) above. The failure to meet the requirements of Item (6) above, and the fact that the alarm circuit has been disabled, should be reported.

(10) If the relay reads high and cannot be readjusted with the range of adjustment available, a shunt should be placed across Terminals 2 and 3 of the sensitrol relay to bring it within the range of adjustment. The use of a decade resistance box may be found convenient in determining the value of resistance to be used in the shunt. The relay should then be adjusted to read zero by means of its pointer adjusting screw, and the pilot output at the EQPT jacks should be adjusted following the procedure under (a) above. The failure to meet the requirement of Item (6) should be reported.

(11) Remove the patch from 135-ohm TC jacks to panel ground and Terminal 1 of the A varistor for the 64 kc/s pilot supply circuit, or to panel ground and Terminal 4 of the A varistor for the 104 kc/s pilot supply circuit. Connect a telephone receiver to Terminal 2 of the A varistor and panel ground for the 64 kc/s pilot supply, or to Terminal 5 of the A varistor and panel ground for the 104 kc/s pilot supply.

(12) Set the attenuator for a loss of 50 db and connect ATTEN IN jacks across the PC resistance. Connect ATTEN OUT jacks to the leads removed from the PC resistance. With these connections, the frequency of the 64 kc/s or 104 kc/s busbar is beating against the frequency from the pilot channel supply circuit which is oscillating at its independent frequency.

(13) Starting with the TUNE IN 1 and TUNE OUT 1 condensers fully unmeshed and listening to the beat tone in the receiver, increase the capacity of first one condenser and then the other by small equal amounts to find the null region. (No sound in the receiver.) Mark on the panel with a pencil the limits of the condenser settings at each side of the null region, using the screwdriver slot as a reference. Then set each condenser midway between the two pencil marks on the panel. Remove the connections to ATTEN IN and ATTEN OUT jacks, but do not reconnect the leads to the PC resistances which were removed in (3). Disconnect the receiver.

(14) Check the frequency calibration of the 17B oscillator and set the frequency at the nominal frequency of the pilot channel supply under test (64 kc/s or 104 kc/s). Patch from OUT or TST OSC OUT jacks to GAIN OUT jacks of the 30A set, and, with

all three protection keys in the OUT position and the TEST key in the ADJUST position, adjust the oscillator output until a reading of zero is obtained on the meter.

(15) Change the patch from GAIN OUT jacks to one set of the MULTIPLE jacks. Patch from OUT or TST OSC OUT jacks to a second set of MULTIPLE jacks. Connect from the third set of MULTIPLE jacks to the PC resistance from which the leads were removed.

(16) Adjust the frequency of the 17B oscillator to obtain zero beat on the meter with the CYCLES dial set approximately at zero. The oscillator is now tuned to the frequency of the channel frequency supply.

(17) Remove all patches from the MULTIPLE jacks, but do not reconnect the leads (which were removed in Item (3)) to the PC resistance.

(18) When testing the 64 kc/s pilot supply circuit, connect the grid of Tube 2 to panel ground. When testing the 104 kc/s pilot supply circuit, connect the grid of Tube 1 to panel ground. Patch from OUT or TST OSC OUT jacks to ATTEN IN jacks. Set the attenuator for a loss of 60 db. Connect ATTEN OUT jacks across the system resistance of the pilot channel supply busbar of the system under test. Place a 125-ohm plug in the GR MOD IN jacks of the system under test.

(19) Patch from 135-ohm TC jacks to EQPT jacks. A beat should be observed on the meter. If the beat is not observed, change the CYCLES dial of the oscillator slowly over its entire range to obtain a slow beat on the meter. If this does not produce a beat, set the CYCLES dial at approximately zero and retune the TUNE IN 1 and TUNE OUT 1 condensers slowly, and by equal amounts, in the same direction within the two pencil reference marks on the panel to obtain a slow beat on the meter, changing the CYCLES dial within its range. Remove the connection to the 17B oscillator and from the EQPT jacks. Remove the connection to the ATTEN OUT jacks.

(20) After tuning, connect the 135-ohm TC jacks to panel ground and Terminal 1 of the A varistor when testing the 64 kc/s pilot channel supply, or to panel ground and Terminal 4 of the A varistor when testing the 104 kc/s pilot channel supply. With two of the protection keys in the OUT position, note the output.

Requirements. The output should be +5 ± 1.5 dbm, and, unless the bridge balance has been readjusted since making the measurement called for in Item (6), the output should be within 0.1 db of the output measured in Item (6).

(21) Reconnect to the PC resistance the leads which were disconnected from it in Item (3).

(22) Remeasure the output.

Requirements. It should be slightly greater (about 0.1 db) than the output measured in Item (20).

(23) Remove all test connections. Remove the connection between the grid of the pilot oscillator tube and panel ground which was made in Item (18).

(24) Operating the RST key as necessary to obtain a reading, adjust the IND relay for the pilot supply circuit under test to read zero by means of its pointer adjusting screw. If the range of adjustment is not sufficient to permit this, the alarm circuit should be disabled or the relay shunted as outlined in Items (9) and (10).

4.2 Pilot Amplifier-Rectifier Circuit Sensitivity Measurement.

(i) Description. This test, when made immediately after the over-all system line-up, is for the purpose of determining the pilot control circuit sensitivity for use in connection with future maintenance tests. The procedure also covers the readjustment of the pilot sensitivity subsequent to the line-up. The terminal need not be removed from service for this test.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
1R Tube Test Set.
1- M4T Cord equipped with 306A and 307A Plugs.
2 - P3P Cords equipped with 305A Plugs at each end (3P20B).
1 - Screwdriver.
2 - Open Plugs.

(iii) Procedure.

(a) Procedure - Sensitivity Measurement. (See Fig. 12.)

(1) Unless this has already been done, insert an open plug in the BCO jack and remove the 55-volt fuses associated with the regulating amplifier under test.

(2) Set the oscillator to the frequency corresponding to the amplifier-rectifier to be tested as indicated in the table below.

Frequency Allocation.	Pilot Amplifier-Rectifier Frequency (kc/s).			
	EAST Terminal.		WEST Terminal.	
	Slope.	Flat.	Slope.	Flat.
NA	104 (PC1)	64 (PC2)	111 (PC1)	60 (PC2)
NB	104 (PC1)	64 (PC2)	58 (PC1)	109 (PC2)
SA	64 (PC2)	104 (PC2)	60 (PC2)	111 (PC1)
SB	64 (PC2)	104 (PC1)	109 (PC2)	58 (PC1)

(3) Patch from OUT or TST OSC OUT jacks to POT IN jacks of the 30A set and set the attenuator for a loss of 25 db.

(4) With the TEST key in the COMPARE position, adjust the oscillator output and the test potentiometer to obtain a reading of 0 db on the meter with all three protection keys in the OUT position.

(5) Operate the TEST key to the ADJUST position and patch from ATTEN OUT jacks to the PC IN jacks.

(6) Connect the 1R tube test set to the TUNE jacks of the circuit under test, and adjust the rotary switch on the 1R set to P1 or P2 for the amplifier-rectifier under test as indicated in the table in Item (2) above. Turn the TUBE 1 and TUBE 2 potentiometers to about the centre of the range.

(7) With all keys of the 1R set normal except the SHUNT key which should be in the OFF position, adjust the main frequency dial of the oscillator to obtain a maximum deflection on the millivolt scale of the 1R set. Increase the deflection thus obtained to about 700 millivolts by means of the potentiometer on the 1R set corresponding to the position of the rotary switch, or, if this does not provide sufficient adjustment, decrease the loss in the attenuator. Then set the CYCLES dial alternately back and forth to +50 and -50 while adjusting the main frequency dial until successive settings of the CYCLES dial give equal readings within 5 millivolts on the millivolt

scale. After making this adjustment, set the CYCLES dial to 0 and disconnect the 1R set from the TUNE jacks.

(8) After adjusting the oscillator to the mid-band pilot frequency as described in Item (7), remove the plug from the BCO jack and adjust the input power to the PC IN jacks by means of the 30A set attenuator and test potentiometer until the CON sensitrol relay of the pilot channel under test reads 0. The sensitrol relay may be made to pulse, when desired, by operating the TST key momentarily.

(9) Operate the TEST key to the COMPARE position and note the attenuator setting and the meter reading. The setting of the attenuator corrected for the meter reading in the manner noted below gives the input level of the test current in db below 1 milliwatt.

Note. The input level is the algebraic sum of the attenuator setting and the meter reading, the attenuator setting being regarded as a negative quantity. For example, if the attenuator reads 27 db and the meter -0.6 db, the input level is -

$$-27.0 + (-0.6) = -27.0 - 0.6 = -27.6.$$

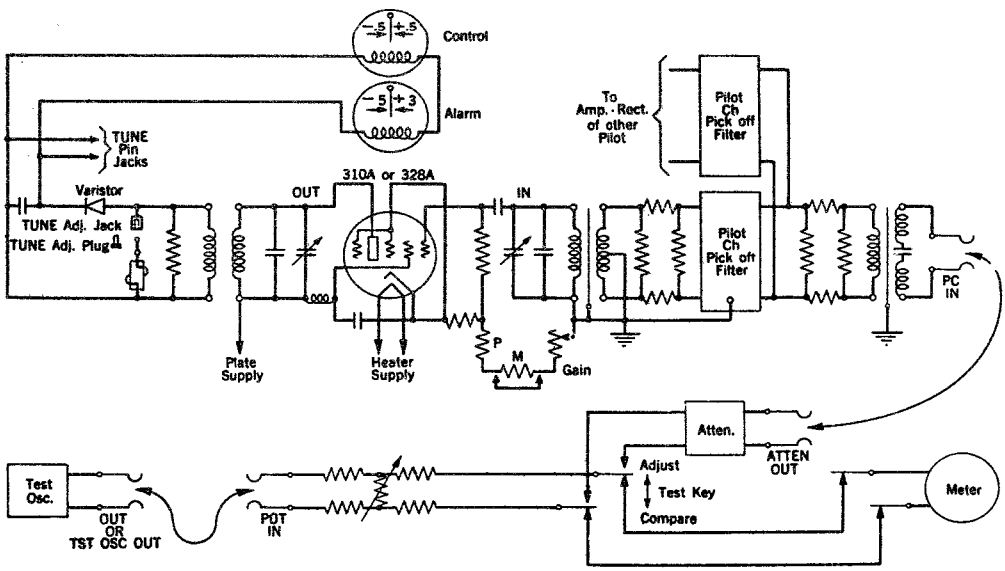
(10) When this test is made as a part of the system line-up, record the sensitivity for reference when making subsequent routine or trouble tests.

(11) When this test is made as a routine or trouble test subsequent to the system line-up, the following requirements should be met.

Requirements. The measured sensitivity should be within 1.5 db of the sensitivity obtained at the time of the system line-up.

(12) If this requirement is not met and the change from the value at the time of system line-up is less than 2 db, the pilot amplifier-rectifier sensitivity should be readjusted as outlined in (b) below.

(13) If the requirement in Item (11) is not met and the change from the value at the time of line-up is greater than 2 db, the possibility of trouble in the pilot pick-off filter or in the pilot control circuit should be considered. A test of the pilot pick-off filter may be made as described in Paragraph 4.6. In addition, the tuning of the pilot amplifier-rectifier circuit to the line pilot frequency should be checked following the procedure for tuning this circuit given in Section 7 on operating and testing methods covering the Over-all Line-up of a system using J2 terminals and J2 repeaters.



PILOT AMPLIFIER-RECTIFIER CIRCUIT SENSITIVITY MEASUREMENT.

FIG. 12.

(b) Procedure - Sensitivity Readjustment.

(1) Adjust the oscillator to the pilot frequency as outlined in (a) above, Items (1) through (8).

(2) Remove the patch from the ATTEN OUT jacks to the PC IN jacks.

(3) Set the attenuator at the setting nearest to the required sensitivity and, with the TEST KEY in the ADJUST position and all three protection keys in the OUT position, adjust the oscillator output or the test potentiometer until the attenuator setting corrected for the meter reading in the usual way is equal to the required sensitivity.

(4) Patch from ATTEN OUT jacks to PC IN jacks, thus sending testing power to the PC IN jacks at a value equal to the required sensitivity.

(5) Adjust the GAIN or SLOPE potentiometer in the amplifier-rectifier panel under test until a deflection of zero is observed on the corresponding CON sensitrol relay.

(6) After the test is completed, replace the 55-volt fuses in the regulating amplifier under test.

4.3 Check of Pilot Level Alarm and End Alarm.

(i) Description. The alarm features incorporated in the J2 terminal are provided by the automatic control circuit. These include -

(a) An alarm after the pilot level has departed more than 3 db above or 5 db below the normal level for more than about 25 seconds, and

(b) Alarms indicating that the regulator is at either end of its range.

Since this test involves changing the terminal receiving gain, the group equipment must be out of service.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
2 - P3P Cords equipped with 305A Plugs at each end (3P20B).
1 - 125-ohm Plug.
2 - Open Plugs.

(iii) Procedure.

(1) Terminate the GR DEM OUT jacks by means of a 125-ohm plug. When testing a SLOPE pilot alarm, block the L2 and H2 relays non-operated, and, when testing a FLAT pilot alarm, block the L1 and H1 relays non-operated.

(2) Follow the procedure for a pilot level sensitivity measurement and adjust the input power to the PC IN jacks, as described in Paragraph 4.2 (iii) (a), Items (1) through (8).

(3) Remove the plug from the BCO jack and increase the setting of the attenuator on the 30A set by 8 db.

Requirements. The ALM sensitrol relay should deflect to the left, causing the ALM lamp to light immediately, and the audible alarm should ring between 20 and 30 seconds later.

(4) Decrease the attenuation setting by 8 db to restore to normal level and remove alarm.

(5) Decrease the attenuator setting by 4 db.

Requirements. The ALM relay should deflect to the right and bring in alarm as before.

(6) Increase the attenuator setting by 4 db to restore to normal level and remove alarm.

(7) Note the setting of each regulating condenser dial, and then turn them, one at a time, to the high numbered end of the scale.

Requirements. The ALM lamp should light immediately, and, where connected, the audible alarm should ring between 20 and 30 seconds later.

(8) Reduce the setting of the 30A attenuator until the ALM relay no longer makes contact.

Requirements. The ALM lamp and the audible alarm should remain operated, which will be due to operation of the end alarm contacts of the regulator condenser dials.

(9) Turn the dial of each of the regulating condensers away from its maximum reading by three divisions. Readjust the attenuator, if necessary, to keep the pointer of the ALM sensitrol off contact.

Requirements. The ALM lamp should be extinguished and the audible alarm should cease.

Note. The end contacts on the slope regulating condenser dial may be disconnected at the particular station, in order to prevent frequent high end position alarms when working over a repeater section having relatively low attenuation during dry cold weather. The end alarms will, however, come in from operation of the end contacts on the flat regulating condenser dial.

(10) Repeat Items (7) to (9) but with the regulating condenser dials turned to the low numbered end of the scale, noting similar end alarms to those occurring when at the high numbered end of the scale. Note the removal of the alarms with the dials advanced from the minimum positions by three divisions.

(11) Remove all plugs and patch cords and restore the regulating condensers to their operating positions. Remove the relay blocking tools from the L1 and H1 (or L2 and H2) relays and from the EB and WB relays.

4.4 Zero Adjustment of Pilot Channel Control Circuit Sensitrol Relays. (Also applies at Repeaters.)

(i) Description. The sensitrol relays on the pilot control panel should indicate 0 db when a current of 30 microamperes is flowing through their windings. Each sensitrol is provided with a zero adjusting screw for correcting for small deviations from the normal condition. In the following test, the meter of the 1R tube test set is connected in series with the sensitrol relays.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
1R Tube Test Set.
2 - P3P Cords equipped with 305A Plugs at each end (3P20B).
2 - 893 Cords equipped with 360A Tools on each end (1W13B).
2 - 411A Tools (Test Picks).
2 - 365 Tools (Test Clips).
1 - M4T Cord equipped with 306A and 307A Plugs.

(iii) Procedure. (See Fig. 13.)

(1) Remove the 24-volt fuses and the 55-volt fuses associated with the regulating amplifier under test.

(2) Follow the procedure of Paragraph 4.2 (iii) (a), Items (2) through (7).

(3) Open the wiring at the C1 or C3 terminals in the pilot control panel to test the Slope or Flat sensitrol relays, respectively.

(4) Connect the test clip of one of the test cords to the wire which was removed from the terminal block, and insert the test pick on the other end of the cord in the top left pin jack of the 18A connecting block on the 1R set. (See Fig. 13.)

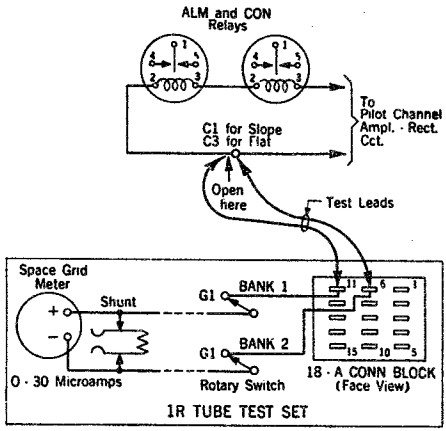
(5) Connect the test clip of the other test cord to the punching from which the wire was removed, and insert the test pick of this cord in the top centre pin jack of the 18A connecting block.

(6) Operate the rotary switch on the 1R set to G1. Then, with all keys on the 1R set normal, note the deflection of the SPACE GRID meter. If the meter reads in the wrong direction, operate the GRID key to the REVERSE position. Operate the SHUNT key to the OFF position if the meter reading is less than 3 microamperes.

(7) Adjust the input to the PC IN jacks by means of the attenuator of the 30A set and the test potentiometer to obtain a full scale deflection (750 millivolts) on the 1R set meter. Full scale is 30 microamperes.

(8) Observe the deflection of the CON and ALM sensitrol relays for the Slope or Flat pilot. If they do not indicate 0 db, they should be adjusted to that point by means of their zero adjusting screw.

(9) Remove all testing equipment and solder the disconnected wires to the C1 or C3 terminals. After this has been done, replace the 24 and 55-volt fuses.



ZERO ADJUSTMENT OF SENSITROL RELAYS.

FIG. 13.

4.5 Pilot Pick-Off Filter Characteristic.

(i) Description. This test serves as an indication of the condition of the pilot pick-off filter and its termination. The test oscillator is first tuned to the frequency of the pilot channel control circuit, and measurements are made at closely spaced frequencies on each side of the centre of the filter band. A comparison of the results obtained with typical characteristic curves shown in Fig. 14 should indicate whether the filter is performing satisfactorily or may be in trouble.

(ii) Apparatus. See Paragraph 4.2 (ii).

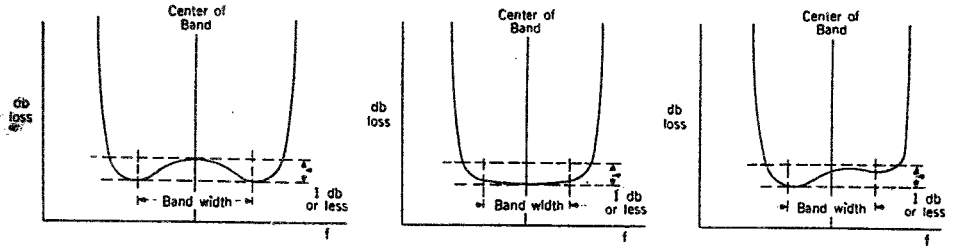
(iii) Procedure.

(1) Follow the procedure for making a measurement of pilot sensitivity, and tune the oscillator to the frequency of the pilot channel control circuit as outlined in Paragraph 4.2 (iii) (a), Items (1) through (8).

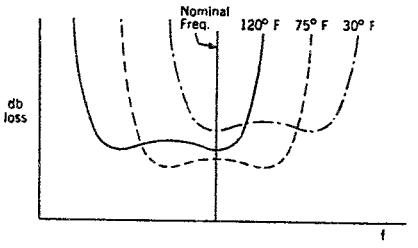
(2) After the test oscillator is tuned to the centre of the filter band with its CYCLES dial set on zero, measure the sensitivity of the pilot channel control circuit at this frequency and at the successive 5-cycle points on each side of this frequency within the band-width of the filter as shown below. (See Fig. 14.)

Filter	Nominal Frequency	Nominal Band-width	Nominal Impedance
107A	58 kc/s	30 c/s	25,000 ohms
107B	60 kc/s	30 c/s	25,000 ohms
107C	64 kc/s	16 c/s	25,000 ohms
107F	104 kc/s	24 c/s	25,000 ohms
107G	109 kc/s	30 c/s	25,000 ohms
107H	111 kc/s	30 c/s	25,000 ohms

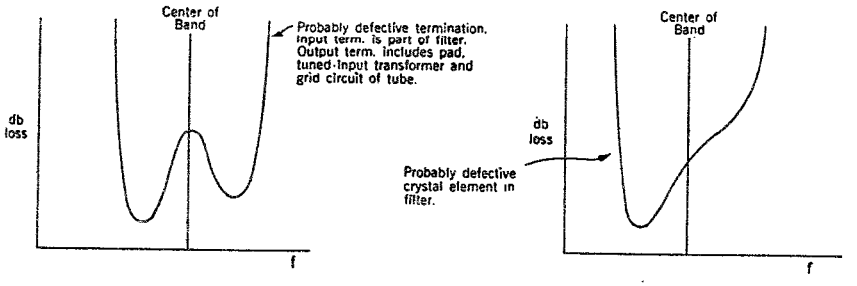
Requirements. The measured sensitivities within the band-width should not differ by more than 1 db.



A. NORMAL BAND SHAPES.



B. NORMAL TEMPERATURE EFFECT.



C. BAND SHAPES INDICATING TROUBLE IN PICK-OFF FILTER OR ITS TERMINATIONS.

BAND SHAPES OF PILOT PICK-OFF FILTERS.

FIG. 14.

(3) If the requirements are not met, the possibility of trouble in the filter or its termination should be considered. If the band shape indicates that the termination may be in trouble (see (c), Fig. 14), the filter should, if practicable, be replaced by a similar filter and the test repeated. The termination of the filter should be investigated if the band shape obtained is similar to that for the first filter.

REPEATERS.

5. TESTS AND ADJUSTMENTS OF VACUUM TUBES AND GRID BATTERIES.

5.1 Vacuum Tube Heater Circuit Operation.

(i) Description. It is necessary, in order to avoid damage to tubes, to open the heater circuit before removing a tube from, or placing a tube in, its socket, changing a ballast lamp or changing a grid battery tap.

A repeater must be taken out of service before the heater circuits of the line or regulating amplifiers are opened. The heater circuit of the pilot channel amplifier rectifiers may be opened at any time without affecting service. The regulating equipment will lock up during this period, but this will not affect operation of the system unless there is a large change in line attenuation before the repeater is restored to normal.

In order to prevent possible damage to the tubes in feedback amplifiers, whenever practicable the input to the amplifier (carrier leak, pilot channel energy or test tone) should be removed before the heater circuit is opened, and no input should be applied to the amplifier until after all tubes have been energised for at least three minutes.

(ii) Apparatus.

Open Plugs.
125-ohm Plugs.

(iii) Procedure.

(1) Unless the repeater is switched out of service, insert a 125-ohm plug in the input EQPT jacks before opening the heater circuit of the tubes in the line amplifier or regulating amplifier.

(2) To open the heater circuit of the tubes in the amplifiers, insert open plugs in the jacks listed below.

Amplifier	Jack Designation	Tubes
Line	A	1, 2
Line	B	3, 4
Line	C	5, 6
W-E Reg.	FIL	1, 2
E-W Reg.	F FIL	F1, F2
E-W Reg.	S FIL	S1, S2
Pilot Amp. Rect.	FIL	1, 2

(3) To close the heater circuit, remove the open plug from the jacks listed in Item (2) above. If only one tube of a series heater circuit is replaced, wait at least three minutes before closing the heater circuit to prevent damage to the tubes.

(4) After the heater circuit has been energised for at least three minutes, the 125-ohm plug may be removed from the input EQPT jacks and test power may be applied to the input of the amplifier, or the amplifier may be returned to service.

5.2 Grid Battery Voltage Measurement and Adjustment.

(i) Description. The grid voltage for the output stage of a line amplifier is provided by a KS-7105 dry battery. In addition, one other KS-7105 and one KS-6569 battery are provided for each E-W line amplifier for biasing a varistor in the grid circuit of the output tubes. The batteries are located on a grid battery panel below the directional filter at the bottom of the bay in which the amplifier is mounted.

Dry battery voltage measurements may be made on systems in service without service reaction due to level changes, provided proper care is taken. The meters employed should have a resistance of 1,000 ohms per volt, and the test picks should be held at all times so that the hands are in contact with only the insulated handles of the picks and metallic contact is made only with the battery terminals of the battery to be tested.

(ii) Apparatus.

1 - Weston Volt-Ohmmeter per KS-8295, Ranges 0-15 volts, 0-30 volts, 0-150 volts, 0-300 volts.

Note. If another type of voltmeter is used, it must have a resistance of at least 1,000 ohms per volt.

(iii) Procedure.

(1) On the grid battery panel, connect the voltmeter across punchings +GT and -GT for a W-E line amplifier, or across +GT and -GT1 for an E-W line amplifier, and observe the voltage reading. The battery voltage should be between 17 and 19 volts for a W-E amplifier or between 15.5 and 17.5 volts for an E-W amplifier.

(2) For an E-W line amplifier, connect the voltmeter across punchings +GT and -GT2 on the grid battery panel and observe the voltage reading. The battery voltage should be between 42 and 48 volts.

(3) If the requirements of Items (1) and (2) are not met, the repeater must be taken out of service and heaters of the tubes 3, 4, 5 and 6 for both E-W and W-E amplifiers turned off (Paragraph 5.1). After waiting about three minutes for the tubes to cool somewhat, adjust the grid battery voltage to bring it within limits or, if this is not possible, replace the grid batteries.

Caution. In order to avoid damaging the tubes while the grid battery is disconnected, the heater circuits of the output tubes must be opened during the entire time the grid circuit is being adjusted.

(4) After the adjustment is made and requirements met, close the heater circuit (Paragraph 5.1) and put the repeater back into service.

5.3 Vacuum Tube Tests.

(i) Description. The vacuum tubes are tested by means of the 1R tube test set, which makes it possible to test the tubes without removing them from their sockets and without interrupting service. The circuit arrangements provide for the measurement of the heater and space currents and per cent. cathode activity.

In auxiliary stations and in main repeater offices having regulated battery, heater current adjustment should be made in accordance with the information shown on the circuit drawings. A meter having an accuracy of ±1/2 of one per cent. should be used.

Where ballast lamps are provided in the heater circuits, no maintenance adjustments are required. The limits for the tests described below are based on heater battery voltages between 21 and 27 volts. If the voltage is outside this range, vacuum tubes may not meet the requirements given below.

Vacuum tube tests should not be made when the battery voltage is changing rapidly or when it is outside its normal operating range.

Caution. When the heater current is changed in making tube tests, time should be allowed for the heater current and space current to become stabilised before making the final reading as discussed in the information covering the 1R tube test set.

When it is necessary to replace vacuum tubes or ballast lamps because of failure to meet requirements, the procedure outlined in Paragraph 7.6 should be followed.

(ii) Apparatus.

1 - 1R Tube Test Set.
1 - M4T Cord equipped with 306A and 307A Plugs.
1 - M11D Cord equipped with 307A Plug and Yaxley 625 Pin Plug.

(iii) Procedure.

(1) Make heater and space current measurements and cathode activity tests on the line amplifiers and regulating amplifiers. Measure only the heater current and cathode activity of tubes in the pilot amplifier rectifiers.

Requirements. Refer to Table 7.

(2) The space current measurements for the pilot channel amplifier-rectifier are for trouble location purposes, and should be made with the potentiometer set for maximum gain (extreme clockwise position) and with the M1 and M2 resistances strapped out. The requirements for these trouble tests are indicated by an asterisk in Table 1. After completing the trouble tests, the gain should be readjusted to the proper operating level by means of the GAIN potentiometer and the M resistances.

(3) 310A and 311A tubes should normally fall within a heater current range of 0.300 to 0.335 ampere or 0.600 to 0.670 ampere respectively for normal battery conditions. If a large group of tubes in an office falls outside this range, the adjustment of the heater current should be checked.

(4) If heater currents are found to be out of limits in offices having non-regulated batteries, the battery voltage should be checked, and, if the voltage is inside the 21-27 volt range, the ballast lamp in the circuit under test should be replaced. If the ballast lamp change does not bring the heater current within limits, replace the vacuum tubes one at a time.

(5) For all cases except as noted in (4) above, replace the vacuum tubes when requirements are not met.

6. TESTS AND ADJUSTMENTS OF REPEATER AND PILOT CHANNEL CIRCUITS.

6.1 Repeater Output Level, Gain and Gain Characteristics.

(i) Repeater Output Level Measurement. (See Fig. 15)

(a) Description. Repeater output level measurements can be made whenever testing power is transmitted from any preceding office. These measurements require terminating the repeater output in the measuring equipment, and, consequently, should be made only when the system is removed from service.

(b) Apparatus.

30A Transmission Measuring Set.
2 - P3P Cords equipped with 305A Plugs at each end (3P20B).
1 - Open Plug.

(c) Procedure.

(1) Place an open plug in the BCO jack on the pilot channel relay control circuit panel.

(2) Set the attenuator on the 30A set for 7 db loss and operate the test key to ADJUST.

(3) Patch from the WEST EQPT jacks for an E-W measurement, or the EAST EQPT jacks for a W-E measurement, to the 10 db IN jacks on the 30A set and from the 10 db OUT jacks to the ATTEN IN jacks.

(4) With the TEST KEY in the ADJUST position, adjust the attenuator as necessary to obtain a meter reading as close as possible to 0 db when all three protection keys are operated. The output is 10 db plus the attenuator setting corrected for the meter reading.

(5) Remove all patches and remove the open plug from the BCO jack unless other tests are to be made.

TUBE TEST REQUIREMENTS.

		Line Amplifier			E-W Regulating Amplifier		W-E Reg. Amp.	Pilot Amplifier-Rectifier
REGULATED BATTERY SUPPLY.								
TUBE DESIGNATION		1, 2	3, 4	5, 6	F1,F2	S1,S2	1, 2	1 (Slope) 2 (Flat)
TYPE OF TUBE TESTED		310A	311A	311A	310A	310A	310A	310A
FILAMENT JACK		A	B	C	F	S	Fil	Fil
Heater Current (In Amperes) (See Paragraph 1.3(i))	Min.	0.290	0.580	0.580	0.290	0.290	0.290	0.290
	Max.	0.350	0.700	0.700	0.350	0.350	0.350	0.350
Space Current Switch on 1R Set		P1-P2	P3-P4	P5-P6	P1-P2	P1-P2	P1-P2	P1-P2
Main Station Space-Millivolts	Min.	410	300	300	280	280	280	350*
	Max.	670	850	850	500	500	500	650*
Auxiliary Station Space-Millivolts	Min.	450	300	300	340	340	340	450*
	Max.	850	850	850	600	600	600	750*
ϕ Cathode Activity Switch on 1R Set		P1-P2	P3-P4	P5-P6	P1-P2	P1-P2	P1-P2	P1-P2
Decrease Heater Current (Amperes)		0.02	0.04	0.04	0.02	0.02	0.02	0.02
Max. % Activity		15	25	25	15	15	15	8
NON-REGULATED BATTERY SUPPLY - BALLAST LAMP OPERATION.								
TYPE OF TUBE TESTED		328A	329A	329A	328A	328A	328A	328A
Heater Current (In Amperes)	Min.	0.385	0.77	0.77	0.385	0.385	0.385	0.385
	Max.	0.465	0.93	0.93	0.465	0.465	0.465	0.465
Space Current Switch on 1R Set		P1-P2	P3-P4	P5-P6	P1-P2	P1-P2	P1-P2	P1-P2
Space-Millivolts	Min.	410	300	300	280	280	280	350*
	Max.	670	850	850	500	500	500	650*
ϕ Cathode Activity Switch on 1R Set		P1-P2	P3-P4	P5-P6	P1-P2	P1-P2	P1-P2	P1-P2
Decrease Heater Current (Amperes)		0.025	0.05	0.05	0.025	0.025	0.025	0.025
Max. % Activity		15	25	25	15	15	15	8

* These space current measurements are for trouble location purposes, and should be made with the GAIN potentiometers set for maximum gain (extreme clockwise position) and with the M1 and M2 resistances strapped out. Resistances P1 and P2 should not be strapped out.

ϕ See Sections 4.4 and 4.41, Page 11, in 1R Tube Test Set Handbook.

TABLE 7.

(ii) Repeater Gain Measurement. (See Fig. 16.)

(a) Description. This method of measurement may be used for all W-E repeater gains and for normal E-W repeater gains. Because of interaction and longitudinal effects which occur when gains of over 60 db are involved, E-W repeater gains over 60 db should be measured using the method given in (iii) below.

(b) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
4 - P3P Patch Cords equipped with 305A Plugs at each end (3P20B).
2 - Open Plugs.

(c) Procedure.

(1) Insert open plugs in the BCO jacks to prevent operation of office alarms and pulsing of the sensitrol relays. Remove the 55-volt fuses from the regulating amplifier under test.

(2) Set the oscillator to the frequency at which the repeater gain is to be measured, and patch from the OUT or TST OSC OUT jacks to the POTENTIOMETER IN jacks on the 30A set.

(3) If the repeater has not been switched out of service, patch from the ATTEN OUT jacks to the WEST EQPT jacks for a W-E measurement, or to the EAST EQPT jacks for an E-W measurement. Patch from the 10 db IN jacks to the EAST EQPT jacks for a W-E measurement, or to the WEST EQPT jacks for an E-W measurement. Patch from the 10 db OUT jacks to the GAIN OUT jacks of the 30A set.

(4) If the repeater has been switched out of service, the patches should be made to the TST 1 and TST 2 jacks instead of to the WEST EQPT and EAST EQPT jacks.

(5) With the TEST KEY in the COMPARE position, adjust the oscillator output and the test potentiometer to obtain a 0 db reading on the meter with all three protection keys in the OUT position.

(6) Operate the TEST KEY to the ADJUST position and adjust the attenuator to obtain a reading as close as possible to 0 db on the meter with all three protection keys in the OUT position.

(7) The gain of the repeater is equal to the setting of the attenuator plus the 10 db pad corrected for the meter reading.

(8) The line-up gain of a repeater can be measured by setting the SLOPE and FLAT regulating condenser dials to the positions determined at the time of line-up, and measuring the repeater gain at the line-up frequencies.

(9) Remove all patches and remove the open plugs from the BCO jacks unless other tests are to be made. Replace the 55-volt fuses.

(iii) Measurement of Repeater Gain Characteristics.

(a) Description. The repeater is set for specified gain conditions, so that the over-all gain may be measured and compared with requirements.

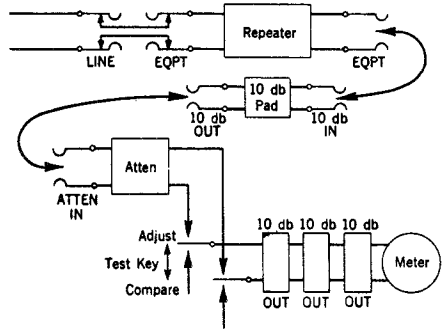
(b) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
5 - P3P Cords equipped with 305A Plugs at each end (3P20B).
2 - Open Plugs.

(c) Preliminary Procedure.

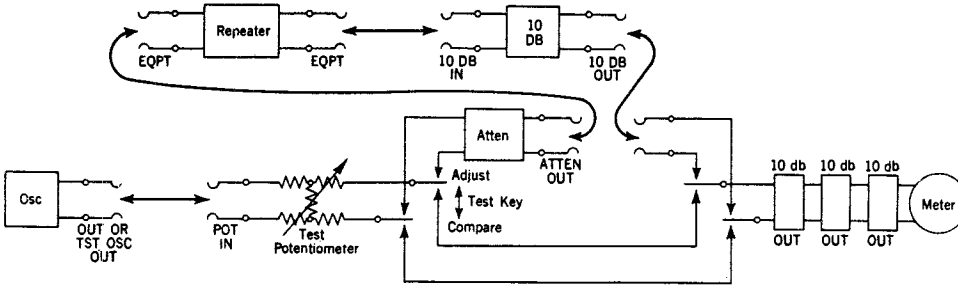
(1) Insert open plugs in the BCO jacks to prevent operation of office alarms and pulsing of the sensitrol relays. Remove the 55-volt fuses from the regulating amplifier under test.

(2) The SLOPE dial reading at the high end of the scales is normally 100 for E-W and 86 for W-E. If, at the point of maximum travel, the reading is slightly less, the dial should be left at this reading instead of the



REPEATER OUTPUT LEVEL MEASUREMENT.

FIG. 15.



REPEATER GAIN MEASUREMENT. (ALL W-E GAINS AND E-W GAINS LESS THAN 60 db.)

FIG. 16.

maximum which is specified for the SLOPE dial in the following paragraphs.

(3) Before making E-W repeater gain measurements, determine the loss in the repeating coils of the 30A set when connected back to back by patching the 600-ohm jacks of Coils 1 and 2 together. Patch from the LOSS IN jacks to 135-ohm jacks of Coil 1 and from the LOSS OUT jacks to the 135-ohm jacks of Coil 2.

(4) With the TEST KEY in the COMPARE position, adjust the oscillator output and the test potentiometer to give a 0 db reading on the meter with all three protection keys in the OUT position. Operate the TEST KEY to the ADJUST position and adjust the attenuator until a reading as close as possible to 0 db is obtained on the meter. The setting of the attenuator corrected for the reading of the meter is the loss of the two repeating coils.

(d) Procedure - W-E Measurements.

(1) Make W-E repeater gain measurements for the frequencies and conditions shown in Table 8, using the method given in (ii) above - Repeater Gain Measurement.

Requirements. The requirements to be met for each measurement are given in Table 8.

(2) If the requirements are not met, the possibility of trouble in the regulating amplifier or other parts of the repeater circuit should be considered.

(3) Unless E-W measurements are to be made, remove all patches, and remove the open plugs from the BCO jacks unless other tests are to be made. Replace the 55-volt fuses.

(e) Procedure - E-W Measurements.

(1) Patch from OUT or TST OSC OUT jacks to POTENTIOMETER IN jacks on the 30A set. Patch from the ATTEN OUT jacks to 135-ohm jacks of Coil 1, from 600 ohm jacks of Coil 1 to 600-ohm jacks of Coil 2 and from 135-ohm jacks of Coil 2 to the EAST EQPT jacks of the repeater to be tested, where the repeater has not been switched out of service. If the repeater has been switched out of service, patch from 135-ohm jacks of Coil 2 to TST 1 jacks.

(2) Adjust the attenuator for maximum loss by operating the 30 db key to the IN position and setting the two dial switches on 50 db and 10 db respectively.

(3) If the repeater has not been switched out of service, patch from WEST EQPT jacks of the repeater to be tested to GAIN OUT jacks of the 30A set. If the repeater has been switched out of service, patch from TST 2 jacks to GAIN OUT jacks.

(4) With the TEST KEY operated to the COMPARE position, adjust the oscillator output and the test potentiometer to obtain a reading of 0 db on the meter with all three protection keys in the OUT position.

(5) Operate the TEST KEY to the ADJUST position and, with only one of the protection keys operated, adjust the attenuator to obtain a meter reading as close as possible to 0 db. The E-W repeater gain is equal to the attenuator setting (including the 30 db IN) plus the coil loss plus 20 db corrected for the reading of the meter.

(6) Make E-W repeater gain measurements for the frequencies and conditions shown in Table 9.

Requirements. The requirements to be met for each measurement are given in Table 9.

(7) If the requirements are not met, the possibility of trouble in the regulating amplifier or other parts of the repeater circuit should be considered.

(8) Remove all patches and remove the open plugs from the BCO jacks unless other tests are to be made. Replace the 55-volt fuses.

WEST-EAST GAIN MEASUREMENT.

Measurement.	Test Freq. kc/s.	Slope Cond.	Flat Cond.	Gain Requirements (db). Note. Letters in ( ) indicate actual measured gain of measurements so denoted.		Tolerance (db).	
				With 111A Filter*	With 112A Filter*	Initial Test.	Maintenance Test.
(a)	60	86	100	46.1	46.1	±1.5	±1.8
(b)	36	86	100	(a) + 0.7	(a) + 0.8	±0.5	±1.0
(c)	84	86	100	(a)	(a)	±0.5	±1.0
				Gain Requirements (db).			
(d)	84	86	50	(c) - 21.3		±1.5	±1.8
(e)	84	86	10	(c) - 40.5		±2.0	±2.4
(f)	84	86	100	(c) - 0.3		±0.8	±1.0
(g)	84	71	100	(c)		±0.8	±1.0
(h)	84	57	100	(c) - 0.3		±0.8	±1.0
(i)	84	43	100	(c) - 0.5		±0.8	±1.0
(j)	84	29	100	(c) - 1.2		±0.8	±1.0
(k)	84	14	100	(c) - 2.1		±1.0	±1.2
(l)	84	5	100	Less than (c) - 9.0			
(m)	36	86	100	(f) + (b) - (c)		±0.6	±0.7
(n)	36	71	100	(g) + (b) - (c) - 4.1		±0.6	±0.7
(o)	36	57	100	(h) + (b) - (c) - 8.1		±0.6	±0.7
(p)	36	43	100	(i) + (b) - (c) - 12.2		±0.6	±0.7
(q)	36	29	100	(j) + (b) - (c) - 17.7		±0.6	±0.7
(r)	36	14	100	(k) + (b) - (c) - 23.5		±0.8	±1.0
(s)	36	5	100	(l) + (b) - (c) - 24.0		±0.8	±1.0

* 111A Filter used at Main Repeater Stations. 112A Filter used at Auxiliary Stations.

TABLE 8.

EXPLANATION OF TABLE 8.

(Similar Examples Apply to Table 9.)

INITIAL TEST.

Assume measurement (a) is being made. The test frequency used is 60 kc/s. The slope condenser setting should be 86 and the flat condenser setting 100. Then, at either Main or Auxiliary Repeater Stations, the measured gain should be within 46.1 ± 1.5 db, that is, between 44.6 and 47.6 db.

Assume the gain measured is 47.0 db, then for measurement (b) (for which the test frequency is 36 kc/s) the gain at a Main Station should be within 47.0 + 0.7 ± 0.5 db, that is, between 48.2 and 47.2 db. For measurement (o) with a test frequency of 36 kc/s and slope and flat condenser settings at 57 and 100, respectively, the gain should be within (h) + (b) - (c) - 8.1 ± 0.6 db. If measurement (h) gave 46.8, (b) 47.8 and (c) 47.0 db, the (o) measurement should lie within -

46.8 + 47.8 - 47.0 - 8.1 ± 0.6 db or between 40.1 and 38.9 db.

EAST-WEST GAIN MEASUREMENTS.

Measure-ment.	Test Freq. kc/s.	Slope Cond.	Flat Cond.	Gain Requirements (db). Note 1. Letters in ( ) indicate actual measured gain of measurements so denoted.	Tolerance (db). Initial Test	Tolerance (db). Maintenance Test
(a)	116	100	100	60.0	±3.0	±3.5
(b)	92	100	100	(a) - 15.7	±1.2	±1.5
(c)	143	100	100	(a) + 19.0	±1.2	±1.5
(d)	92	100	50	(b) - 20.7	±2.0	±2.4
(e)	92	100	10	(b) - 39.5	±2.0	±2.4
(f)	92	20	100	(b)	±2.0	±2.4
(g)	92	5	100	Less than (b) - 16.0		
(h)	92	43	100	45.5	±2.0	±2.4
(i)	92	14	100	(h) - 3.4	±2.0	±2.4
*(j)	92	100	100	(h) - 1.5	±1.0	±1.2
(k)	92	86	100	(h) - 0.4	±1.0	±1.2
(l)	92	71	100	(h)	±1.0	±1.2
(m)	92	57	100	(h)	±1.0	±1.2
(n)	92	29	100	(h)	±1.0	±1.2
ø(o)	92	5	100	(h) - 24.4	±3.0	±3.5
(p)	143	14	100	(i)	±1.8	±2.2
(q)	143	43	100	(h) + (p) - (i) + 7.0	±0.6	±0.7
(r)	143	100	100	(j) + (p) - (i) + 34.7	±0.8	±1.0
(s)	143	86	100	(k) + (p) - (i) + 24.8	±0.8	±1.0
(t)	143	71	100	(l) + (p) - (i) + 16.7	±0.6	±0.7
(u)	143	57	100	(m) + (p) - (i) + 10.0	±0.6	±0.7
(v)	143	29	100	(n) + (p) - (i) + 3.4	±0.6	±0.7
(w)	143	5	100	(o) + (p) - (i) - 0.3	±0.8	±1.0

Note 2. The values given above do not include the loss in Coil 1 and Coil 2.

* Same measurement as (b). Restated to show additional requirement.

ø Same measurement as (g). Restated to show additional requirement.

For Table explanation, see "Explanation of Table 8".

TABLE 9.

6.2 Tests on Pilot Amplifier-Rectifier and Pick-off Filters.

(i) Description. This test, when made immediately after the over-all system line-up, is for the purpose of determining the pilot control circuit sensitivity for use in connection with future maintenance tests. The procedure also covers the readjustment of the pilot sensitivity subsequent to the line-up. The repeater need not be taken out of service for this test.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
1R Tube Test Set.
1 - M4T Cord equipped with 306A and 307A Plugs.
2 - P3P Cords equipped with 305A Plugs at each end (3P20B).
1 - Screwdriver.
2 - Open Plugs.

(iii) Procedure.

(a) Procedure - Sensitivity Measurement. (See Fig. 17.)

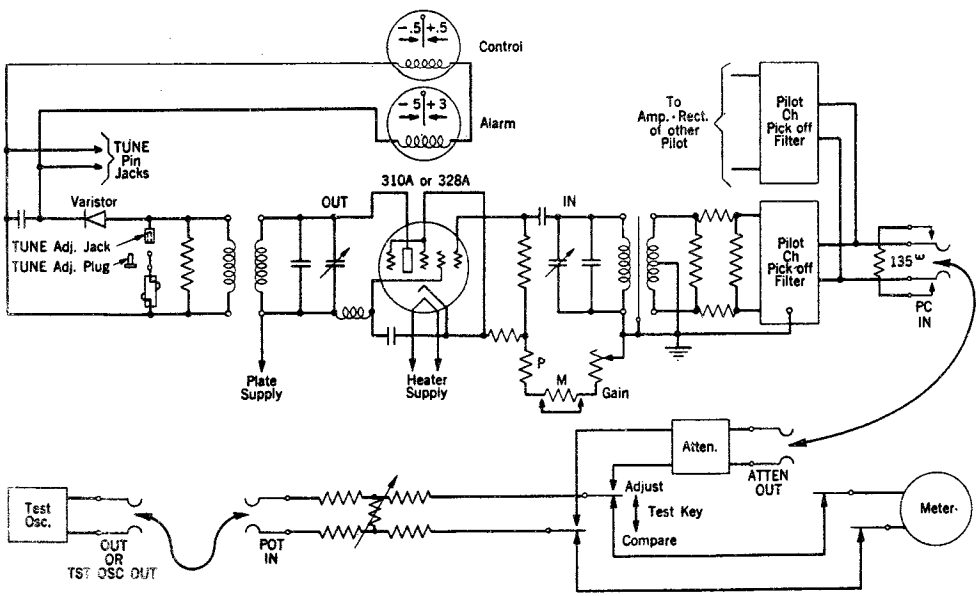
(1) Insert an open plug in the BCO jack and, unless the 55-volt fuses have already been removed, remove them from the regulating amplifier circuit under test.

(2) Set the oscillator to the frequency corresponding to the amplifier-rectifier to be tested as indicated in the following table.

	E-W	W-E
SLOPE	143 kc/s	40 kc/s
FLAT	92 kc/s	80 kc/s

(3) Patch from OUT or TST OSC OUT jacks to POTENTIOMETER IN jacks of the 30A set and set the attenuator for a loss of 3 db.

(4) With the TEST KEY in the COMPARE position, adjust the oscillator output and the test potentiometer to obtain a reading of 0 db on the meter with all three protection keys in the OUT position.



PILOT AMPLIFIER-RECTIFIER CIRCUIT SENSITIVITY MEASUREMENT.

FIG. 17.

(5) Operate the TEST KEY to the ADJUST position and patch from ATTEN OUT jacks to the PC IN jacks.

(6) Connect the 1R tube test set to the TUNE jacks of the circuit under test, and adjust the rotary switch on the 1R set to P1 for the SLOPE pilot or to P2 for the FLAT pilot. Turn the TUBE 1 and TUBE 2 potentiometers to about the centre of the range.

(7) With all the keys of the 1R set normal except the SHUNT key which should be in the OFF position, adjust the main frequency dial of the oscillator to obtain a maximum deflection on the millivolt scale of the 1R set. Increase the deflection thus obtained to about 700 millivolts by means of the potentiometer on the 1R set corresponding to the position of the rotary switch, or, if this does not provide sufficient adjustment, decrease the loss in the attenuator. Then set the CYCLES dial alternately back and forth to +50 and -50 while adjusting the main frequency dial, until successive settings of the CYCLES dial give equal readings within 5 millivolts on the millivolts scale. After making this adjustment, set the CYCLES dial to 0 and disconnect the 1R set from the TUNE jacks.

(8) After adjusting the oscillator to the pilot frequency as described in Item (7), remove the plug from the BCO jack and adjust the input power to the PC IN jacks by means of the 30A set attenuator and test potentiometer until the CON sensitrol relay of the pilot channel under test reads 0. The sensitrol relay may be made to pulse, when desired, by operating the TST key momentarily.

(9) Operate the TEST KEY to the COMPARE position and note the attenuator setting and the meter reading. The pilot amplifier-rectifier circuit sensitivity in dbm is equal to the algebraic sum of the attenuator setting (considered as a negative quantity) and the meter reading (considered as positive if above the 0 mark or negative if below the 0 mark).

(Example. If the attenuator setting is 3 db and the meter reading is +0.5 db, the sensitivity is -3.0 + 0.5 = - 2.5 dbm. If the attenuator setting is 3 db and the meter reading is -0.5 db, the sensitivity is -3.0 - 0.5 = -3.5 dbm.)

(10) When this test is made as a part of the system line-up, record the sensitivity for reference when making subsequent routine or trouble tests.

(11) When this test is made as a routine or trouble test subsequent to the system line-up, the following requirements should be met.

Requirements. The measured sensitivity should be within 0.5 db of the sensitivity obtained at the time of the system line-up.

(12) If this requirement is not met and the change from the value at the time of system line-up is less than 2 db, the pilot amplifier-rectifier circuit sensitivity should be readjusted as outlined in (b) below.

(13) If the requirement in Item (11) is not met and the change from the value at the time of system line-up is greater than 2 db, the possibility of trouble in the pilot pick-off filter or in the pilot control circuit should be considered. A test of the pilot pick-off filter may be made as described in (iv) below. In addition, the tuning of the pilot amplifier-rectifier circuit to the line pilot frequency should be checked following the procedure for tuning this circuit given later in the over-all line-up of a system using J2 terminals and J2 repeaters.

(b) Procedure - Sensitivity Readjustment.

(1) Adjust the oscillator to the pilot frequency as outlined in (a) above, Items (1) through (7).

(2) Remove the patch from the ATTEN OUT jacks to the PC IN jacks.

(3) Set the attenuator at the setting nearest to the required sensitivity and, with the TEST KEY in the ADJUST position and all three protection keys in the OUT position, adjust the oscillator output of the test potentiometer until the attenuator setting corrected for the meter reading in the usual way is equal to the required sensitivity.

(4) Patch from ATTEN OUT jacks to PC IN jacks, thus sending testing power into the PC IN jacks at a value equal to the required sensitivity. Remove the plug from the BCO jack.

(5) Adjust the GAIN 1 (SLOPE) or GAIN 2 (FLAT) potentiometer on the amplifier-rectifier panel under test until a deflection of 0 is observed on the corresponding CON sensitrol relay.

(6) After the test is completed, replace the 55-volt fuses in the regulating amplifier under test.

(iv) Pilot Pick-Off Filter Characteristic. Refer to Paragraph 4.5, except that in (iii), Item (2), substitute the following filter details -

Filter	Nominal Frequency	Nominal Band-width	Nominal Impedance
107D	80 kc/s	26 c/s	25,000 ohms
107E	92 kc/s	30 c/s	25,000 ohms
107J	143 kc/s	50 c/s	25,000 ohms
107K	40 kc/s	30 c/s	60,000 ohms

6.3 Singing Tests.

(i) Singing Test of Directional Filters.

(a) Description. The test is made by noting if any singing current appears in the repeater loop when the gain of the repeater is increased to maximum.

(b) Apparatus.

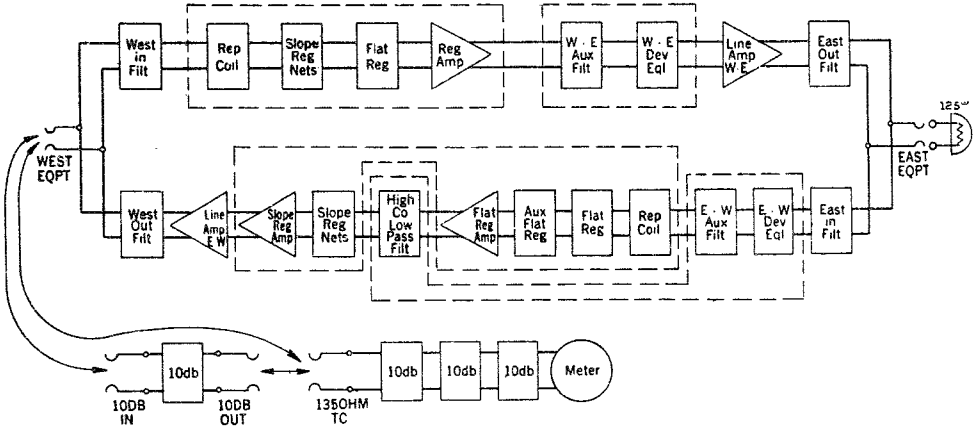
30A Transmission Measuring Set.
1 - 125-ohm Plug.
2 - P3P Cords equipped with 305A Plugs at each end (3P20B).

(c) Procedure. (See Fig. 18.)

(1) Adjust all four regulating condensers on the repeater to 15 divisions.

(2) Insert the 125-ohm plug in the EAST EQPT jacks. Then patch from the WEST EQPT jacks to the 10 db IN jacks on the 30A set and from the 10 db OUT jacks to the 135-ohm TC jacks.

(3) In succession, increase the setting of the E-W SLOPE and FLAT and W-E SLOPE and FLAT condenser dials until all dials are at maximum reading, or until singing occurs, as indicated by a deflection of the 30A set meter when any or none of the protection keys are operated. A singing condition is indicated by a sudden large deflection of the meter. A gradual change in meter reading as the dial settings are changed may be due to noise.



SINGING TEST OF DIRECTIONAL FILTERS.

FIG. 18.

(4) If no deflection is observed during these gain changes, remove the 10 db pad by patching from the WEST EQPT jacks to the 135-ohm TC jacks. Then operate the 10 db protection keys, one at a time, to see if there is a meter deflection.

Requirements. With the 10 db pad removed from the circuit and all three 10 db keys operated, the meter deflection should not be above -10 db except where the presence of noise is clearly indicated.

(ii) Singing Test of High Frequency Line.

(a) Description. The test is made by using the total gain of the repeater in both directions and noting if any singing current appears in the singing path. It should be made starting with the repeater in the normal operating condition. The procedure requires the co-operation of the adjacent offices for terminating the line section under test.

All telephone and telegraph repeaters at the testing office which are normally in service should be arranged for normal operation during the test. These precautions should be taken because the gains of the repeaters on other facilities are involved in the singing paths.

(b) Apparatus.

1R Tube Test Set.
1 - M11D Cord equipped with 307A Plug and Yaxley 625 Pin Plug.
2 - 125-ohm Plugs.
2 - 125-ohm Plugs at each of the Adjacent Offices.

(c) Procedure.

(1) At the two adjacent offices, terminate the LINE and EQPT jacks on the sides of these offices toward the testing office with the 125-ohm plugs.

(2) Connect the 1R tube test set to the FIL ACT TST jack on the E-W line amplifier. Set the rotary switch of the 1R set to the P4 position and measure the space current of vacuum tube No. 4.

(3) Note the regulating condenser settings of the E-W and W-E regulating condensers, so that they may be subsequently returned to their working condition, and adjust all four condenser dials to read 15 divisions.

(4) While watching the millivolt reading on the 1R set, rotate in succession the E-W SLOPE and FLAT and W-E SLOPE and FLAT condenser dials until maximum gain is reached, or until a singing condition is observed as indicated by a sudden change of the millivolt reading of the 1R set.

(5) A sudden change of millivolt reading of 10 or more millivolts while increasing the gain is usually an indication of a singing condition. If a change occurs in the millivolt reading, the test should be repeated in order to make sure that battery voltage variations did not cause the change. Defective terminations will also give false indications.

Requirements. The repeater should not sing when all four regulating condensers are on maximum reading.

(6) If the requirements are not met, the Singing Test of Directional Filters, (i) above, should be made, and, if the directional filters meet requirements, investigate the wiring and line for crosstalk coupling. This can be done by using the procedure of the Singing Test of High Frequency Line detailed above, with the 600-ohm termination placed on the line side of the line filters at the office at which the test is made.

6.4 Check of Pilot Level Alarm and End Alarm.

(i) Description. The alarm features incorporated in the J2 repeater are provided by the automatic control circuit. These include -

(a) An alarm after the pilot level has departed more than 3 db above or 5 db below the normal level for more than about 25 seconds, and

(b) Alarms indicating that the regulator is at either end of its range.

At an auxiliary repeater station, it will be necessary to operate the key controlling the alarm lamps in order to obtain an indication of the alarm.

This test checks the operation of the visual alarms and, where provided, the audible alarms which are associated with large changes in the pilot level and with the extreme positions of the regulating condenser, that is, the end alarm. The repeater must be out of service for this test, since making it involves changing the repeater gain.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
2 - P3P Cords equipped with 305A Plugs at each end (3P20B).
2 - 125 ohm Plugs.
1R Tube Test Set.
1 - M4T Cord equipped with 306A and 307A Plugs.
2 - 136B Relay Blocking Tools.

(iii) Procedure.

(a) Procedure - Main Station. (See Fig. 17.)

(1) Terminate the EAST and WEST EQPT jacks with 125-ohm plugs if the repeater has not been switched out of service.

(2) Insert an open plug in the BCO jack. Remove the can cover from the pilot channel relay control panel. When testing the SLOPE pilot, block the L2 and H2 relays non-operated, and, when testing the FLAT pilot, block the L1 and H1 relays non-operated, in order to prevent an alarm being given by the pilot channel not under test.

Block the EB and WB relays to prevent intermittent pulsing during testing of the alarms.

(3) Set the oscillator to the frequency corresponding to the amplifier-rectifier to be tested as indicated in the following table.

	E-W	W-E
SLOPE	143 kc/s	40 kc/s
FLAT	92 kc/s	80 kc/s

(4) Patch from OUT or TST OSC OUT jacks to POTENTIOMETER IN jacks of the 30A set and set the attenuator for a loss of at least 4 db.

(5) With the TEST KEY in the COMPARE position, adjust the oscillator output and the test potentiometer to obtain a reading of 0 db on the meter.

(6) Operate the TEST KEY to the ADJUST position and patch from ATTEN OUT jacks to the PC IN jacks.

(7) Connect the 1R tube test set to the TUNE jacks of the circuit under test, and adjust the rotary switch on the 1R set to P1 for the SLOPE pilot or to P2 for the FLAT pilot. Turn the TUBE 1 and TUBE 2 potentiometers to about the middle of their range.

(8) With all keys of the 1R set normal except the SHUNT key which should be in the OFF position, adjust the main frequency dial of the oscillator to obtain a maximum deflection on the millivolt scale of the 1R set. Increase the deflection thus obtained to about 700 millivolts by means of the potentiometer on the 1R set corresponding to the position of the rotary switch, or, if this does not provide sufficient adjustment, adjust the oscillator output of the test potentiometer until this deflection is reached. Then set the CYCLES dial alternately back and

forth to +50 and -50 while adjusting the main frequency dial, until successive settings of the CYCLES dial give equal readings within 5 millivolts on the millivolt scale. After making this adjustment, set the CYCLES dial to 0 and disconnect the 1R set from the TUNE jack.

(9) After adjusting the oscillator to the pilot frequency as described in Item (8), remove the plug from the BCO jack and adjust the input power to the PC IN jacks by means of the oscillator output control and test potentiometer until the CON relay of the circuit under test reads 0.

(10) Increase the setting of the attenuator on the 30A set by 8 db.

Requirements. The ALM sensitrol relay should deflect to the left, causing the ALM lamp to light immediately, and, where connected, the audible alarm should ring between 20 and 30 seconds later.

(11) Decrease the attenuation setting by 8 db to restore to normal level and remove alarm.

(12) Decrease the attenuator setting by 4 db.

Requirements. The ALM relay should deflect to the right and bring in alarms as before.

(13) Increase the attenuator setting by 4 db to restore to normal level and remove alarm.

(14) Note the setting of each regulating condenser dial and then turn them one at a time to the high numbered end of the scale.

Requirements. The ALM lamp should light immediately and, where connected, the audible alarm should ring between 20 and 30 seconds later.

(15) Reduce the setting of the 30A attenuator until the ALM relay no longer makes contact.

Requirements. The ALM lamp and the audible alarm should remain operated, which will be due to operation of the end alarm contacts of the regulator condenser dials.

(16) Turn the dial of each of the regulating condensers away from its maximum reading by three divisions. Readjust the attenuator, if necessary, to keep the pointer of the ALM sensitrol off contact.

Requirements. The ALM lamp should be extinguished and the audible alarm should cease.

Note. The end contacts on the slope regulating condenser dial may be disconnected at the particular station, in order to prevent frequent high end position alarms when working over a repeater section having relatively low attenuation during dry cold weather. The end alarms will, however, come in from operation of the end contacts on the flat regulating condenser dial.

(17) Repeat Items (14) to (16) but with the regulating condenser dials turned to the low numbered end of the scale, noting similar end alarms to those occurring when at the high numbered end of the scale. Note the removal of the alarms with the dials advanced from the minimum positions by three divisions.

(18) Remove all plugs and patch cords and restore the regulating condensers to their operating positions. Remove the relay blocking tools from the L1 and H1 (or L2 and H2) relays and from the EB and WB relays.

(b) Procedure - Auxiliary Station. (See Fig. 17.)

(1) Set the test oscillator for the mid-band frequency of the pilot amplifier-rectifier under test by following the procedure of (a) above, Item (1) through (8).

(2) After adjusting the oscillator to the mid-band pilot frequency, remove the plug from the BCO jack and adjust the input power to the PC IN jacks by means of the oscillator output control and test potentiometer until the CON relay of the circuit under test reads 0.

(3) Increase the setting of the attenuator of the 30A set by 8 db and operate the L key on the key and lamp panel.

Requirements. The ALM sensitrol relay should deflect to the left and, from 20 to 30 seconds later, either the PILOT CH W-E or the PILOT CH E-W (depending upon which circuit is being tested) should light.

(4) Decrease the setting of the attenuator by 8 db to restore to normal level and remove alarm.

(5) Decrease the attenuator setting by 4 db.

Requirements. The ALM relay should deflect to the right and bring in alarms as before.

(6) Increase the attenuator setting by 4 db to restore to normal level and remove alarm.

(7) Note the setting of each regulating condenser dial and then turn them, one at a time, to the high numbered end of the scale. Increase the attenuator setting as required, so that the ALM relay pointer no longer makes contact.

(8) Operate the L key on the key and lamp panel.

Requirements. As soon as the L key is operated, the PILOT CH END lamp should light.

(9) Repeat (7) and (8) but with the regulating condenser dials turned to the low numbered end of the scale, noting similar end alarms to those occurring when at the high numbered end of the scale. Note the removal of alarms with the dials advanced from the minimum positions by three divisions.

(10) Remove all plugs and patch cords and restore the regulating condensers to their operating positions. Remove the relay blocking tools from the L1 and H1 (or L2 and H2) relays and from the EB and WB relays.

OVER-ALL TESTS.

7. TRANSMISSION TESTS AND ADJUSTMENTS.

7.1 Line-Up using Channel Terminals.

(i) Description. After the line-up is completed at one station, it will be necessary to retain an attendant at that station to regulate manually the output of the repeater during line attenuation changes, thus ensuring that the repeater output is kept closely at the proper level. While the succeeding section is being lined up, the attendant at the last station which has been lined up should keep the output level constant by adjusting the regulating condenser dial or dials, so that the pointers of the SLOPE and FLAT CON sensitrol relays are kept as closely as possible on zero.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
2 - P3P Cords equipped with 305A Plugs at each end (3P20B).
1 - Screwdriver.
2 - Open Plugs.

(iii) Procedure.

(a) Preliminary Procedure - Transmitting Terminal.

(1) With the regular carrier generator in operation if practicable, check and, if necessary, adjust the transmitting levels and pilot output levels.

(2) Make sure that there are no plugs or test patches in any of the jacks of the carrier supply circuits before proceeding with the line-up.

(b) Preliminary Procedure - Each Successive J2 Repeater and J2 Receiving Terminal.

(1) Insert an open plug in the BCO jack on the pilot control panel and remove the 55-volt A.C. fuses for the system under test, in order to stop the pulsing of the control circuit and prevent operation of the office alarms or creeping of the telechron motors.

(c) Procedure - At J2 Repeater Stations and Receiving Terminal.

(1) This procedure assumes that, prior to the system line-up, the pilot channel equipment at each repeater station and the receiving terminals has been given the preliminary tuning and sensitivity adjustment previously described.

(2) At the transmitting terminal, patch 1,000 c/s testing power at the level established for the office (normally -13 dbm) to the MOD IN jacks of Channel 2 at the four-wire patching bay.

(3) At the station being lined up, adjust the SLOPE and FLAT regulation condensers to give a zero reading on the sensitrol relays.

(4) At the station being lined up, measure the output level of Channel 2 using the EQPT jacks at a repeater station and the GRP DEM OUT jacks at a terminal.

(5) In order to check the equalisation more accurately at a receiving terminal by using a more easily read portion of the meter scale, adjust the output level by means of the FLAT condenser dial to read approximately 0 db.

(6) At the transmitting terminal, send on Channel 11 by changing the patch from the MOD IN jacks of Channel 2 to the MOD IN jacks of Channel 11.

(7) At the station being lined up, measure the output level of Channel 11. Subtract the figure obtained for the level of Channel 11 from that obtained for the level of Channel 2, using algebraic subtraction. Note whether this difference is positive or negative.

Requirements - Repeater Station or Receiving Terminal. The difference between the levels of Channels 2 and 11 should be 0 ± 0.2 db.

(8) If the requirements are not met, adjust the SLOPE regulating condenser dial by the amount, and in the direction, indicated in Tables 10 and 11, and repeat Items (2) through (7) until the requirements are met. While this is being done, the FLAT regulating condenser dial should be adjusted as necessary to keep the measured output at approximately the specified level at a repeater or 0 db at a receiving terminal.

Difference in Level Between Channels 2 and 11.	Approximate Dial Divisions Change in Setting of Slope Regulating Condenser.
0.25	1
0.50	2
0.75	3
1.0	4
2.0	8
3.0	12
4.0	16

TABLE 10.

Frequency Allocation.	Direction of Slope Condenser Dial Change.			
	E-W Level Difference.		W-E Level Difference.	
	Positive	Negative	Positive	Negative
NA	toward 0	toward 100	toward 0	toward 86
NB	toward 100	toward 0	toward 0	toward 86
SA	toward 100	toward 0	toward 86	toward 0
SB	toward 0	toward 100	toward 86	toward 0
Note. To turn the dial toward 100 or 86, rotate the adjusting knob in a clockwise direction.				

TABLE 11.

(9) Fig. 19 shows schematically the repeater characteristic for settings of the SLOPE and FLAT condensers at the extreme ends of the scale for a J2 repeater. Because the slope characteristic of the repeater pivots about 92 kc/s, it will be found that a change in the setting of the W-E SLOPE dial requires a compensating change in the setting of the W-E FLAT dial.

(10) After completing the SLOPE adjustment and while sending on either Channel 2 or 11 at the transmitting terminal, adjust the FLAT receiving condenser dial at the receiving office to obtain an output level as close as possible to the specified level at repeaters or 0 db at a receiving terminal.

(11) With the SLOPE and FLAT dial settings obtained above, measure and record the output levels of Channels 2, 7 and 11 at repeaters. At the receiving terminal, measure Channels 2 to 11 inclusive.

Requirements. The measured channels should be as close as possible to the specified level at repeaters and 0 db at a receiving terminal.

(12) If these requirements are not met, change the setting of the FLAT regulating condenser dial until the measurements are within limits.

(13) At a receiving terminal, measure and record the levels of Channels 1 and 12.

(14) After the requirements of Item (11) are met at a receiving terminal, adjust the level of the channel which was closest to 0 db in the procedure of Item (10) to be as close as possible to -5 db, using the FLAT regulating condenser dial.

(15) Record the final dial settings at either a repeater station or the receiving terminal.

(16) Remove the plug from the BCO jack on the pilot control panel. At a repeater, remove the patch cord from the EQPT jacks thus terminating the repeater in the line.

(17) Remove the can cover from the amplifier-rectifier and insert the TUNE ADJ plugs in the tune adjust jacks. This position of the plug uncovers the ends of the shafts of the OUT condensers, so that they may be adjusted as described below.

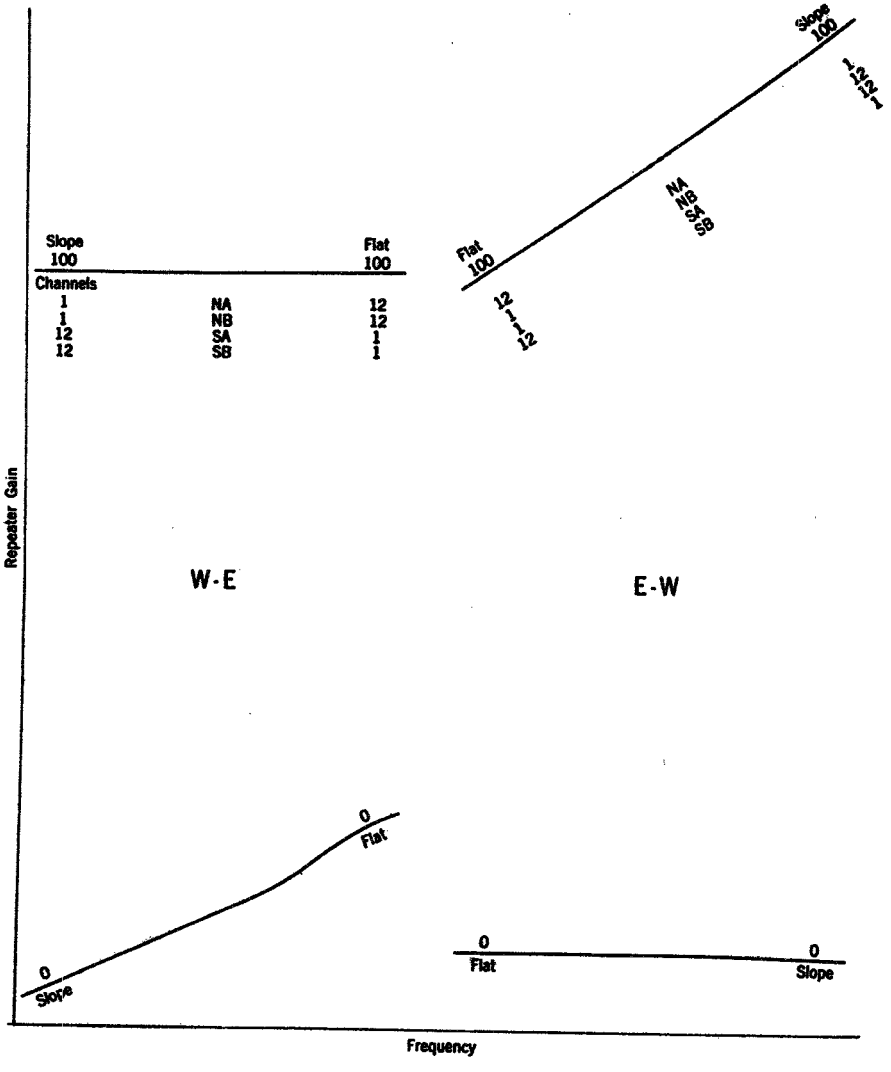
(18) At a repeater, with the regular pilot currents being received from the transmitting terminal, adjust the GAIN 1 potentiometer on the amplifier-rectifier to obtain approximately a midscale deflection of the SLOPE CON sensitrol relay, and adjust the GAIN 2 potentiometer to obtain approximately a midscale deflection of the FLAT CON sensitrol relay. If the pointers cannot be brought to midscale, the M1 resistance (SLOPE) or the M2 resistance (FLAT) should be strapped to bring the pilot sensitivities within the range of the GAIN 1 or GAIN 2 potentiometers.

(19) At a repeater, adjust the IN 1 and then the OUT 1 condenser on the amplifier-rectifier panel with a screwdriver to obtain a maximum deflection toward the right on the SLOPE CON sensitrol relay. If necessary, adjust the GAIN 1 potentiometer to keep the pointer on the scale. Next adjust the IN 2 and then the OUT 2 condenser to obtain a maximum deflection toward the right on the FLAT CON sensitrol relay, using the GAIN 2 potentiometer, if necessary, to keep the pointer on scale.

(20) At a terminal follow the procedure of Items (18) and (19), using the SLOPE and FLAT potentiometers to obtain a midscale deflection of the sensitrol relays. If it is necessary to strap the M1 resistance (associated with PC1) or the M2 resistance (associated with PC2), refer to Table 7 which indicates the amplifier-rectifier used for the SLOPE or FLAT pilot channel for any frequency allocation. It should be noted that the IN 1 and OUT 1 condensers are associated with PC1, while the IN 2 and OUT 2 condensers are associated with PC2.

(21) Replace the TUNE ADJ plugs in the positions where the OUT condenser tuning shafts are covered. Replace the can cover.

(22) With the SLOPE and FLAT regulating condenser dials set to the final line-up positions as determined above in Item (9), at a repeater adjust the GAIN 1 and GAIN 2 potentiometers until the pointers of the SLOPE and FLAT CON sensitrol relays are respectively at 0 db as closely as possible.



SCHEMATIC SHOWING OPERATION OF SLOPE AND FLAT PILOT CONTROLS AT A J2 REPEATER FOR THE VARIOUS FREQUENCY ALLOCATIONS.

FIG. 19.

At a terminal with the SLOPE and FLAT regulating condenser dials set to the final line-up positions as determined above in Items (10) and (14), adjust the SLOPE and FLAT potentiometers until the pointers of the SLOPE and FLAT CON sensitrol relays are respectively at 0 db as closely as possible.

(23) At repeater stations, if the pointers cannot be brought to midscale, the M1 resistance (SLOPE) or the M2 resistance (FLAT) should be strapped to bring the pilot sensitivities within the range of the GAIN 1 or GAIN 2 potentiometers respectively.

(24) The same procedure should be followed at a receiving terminal, referring to Table 7 to determine which resistances are associated with the SLOPE and FLAT potentiometers for the various allocations. The M1 resistance is associated with PC1 and the M2 resistance is associated with PC2.

(25) Line up succeeding repeater sections as described above in Items (2) through (23). The repeater station preceding the one which is being lined up should observe the SLOPE and FLAT sensitrol relays for changes in line attenuation. If these relays drift from the 0 point, they should be reset to that point by adjusting the SLOPE and FLAT regulating condensers manually.

(26) Replace the 55-volt A.C. fuses associated with the system under test.

(27) Measure and record the SLOPE and FLAT pilot amplifier-rectifier circuit sensitivities.

7.2 Line-Up not using Channel Terminals.

(i) Description. This method is required in connection with lining up from a system terminal which is not equipped with channel terminals. It may also be used, if desired, in lining up from a system terminal which is equipped with channel terminals, or for lining up the repeater section between any two adjacent repeater stations. Testing power for adjusting the receiving equipment to correct for the line characteristic is obtained by transmitting high frequency power from an oscillator over the line at several frequencies.

(ii) Apparatus.

17B Oscillator.
30A Transmission Measuring Set.
1R Tube Test Set.
3 - P3P Cords equipped with 305A Plugs at each end (3P20B).
2 - Open Plugs.
1 - Screwdriver.
1 - 125-ohm Plug.

(iii) Procedure - J2 Repeaters and Receiving Terminal.

(1) This procedure assumes that, prior to the system line-up, the pilot channel equipment at each repeater station and the receiving terminals has been given the preliminary tuning and sensitivity adjustment previously described.

(2) Insert an open plug in the BCO jack and remove the 55-volt A.C. fuses for the system under test, in order to stop the pulsing of the control circuit and prevent operation of the office alarms.

(3) At the transmitting station, adjust the oscillator for one of the following frequencies -

W-E	42 kc/s or 78 kc/s
E-W	100 kc/s or 135 kc/s.

Adjust the oscillator for an output of the specified level and patch it to the LINE jacks on the line toward the station being lined up.

(4) At the station being lined up, determine the output level as measured at the EQPT jacks at a repeater station and at the GRP DEM OUT jacks at a terminal.

(5) At a receiving terminal, in order to check the equalisation more accurately by using a more easily read portion of the meter scale, adjust the output level by means of the FLAT condenser dial to read approximately 0 db.

(6) At the transmitting station, adjust the oscillator to the other of the pair of testing frequencies in Item (3) and send to the LINE jacks at the specified level.

(7) At the receiving station, note the new output level. Subtract algebraically the value obtained for the output level at the lower testing frequency from the value obtained for the output level at the higher testing frequency. Note whether the difference is positive or negative.

Requirements. The difference between the output levels as measured in Items (5) and (7) should be 0 ± 0.2 db.

(8) If the requirements are not met, adjust the SLOPE regulating condenser dial by the amount and in the direction indicated in Tables 10 and 11, using the SB frequency allocation in Table 11. Reference may also be made to Fig. 19. While this is being done, the FLAT regulating condenser dial should be adjusted as necessary to keep the measured output at approximately the specified level at a repeater or 0 db at a receiving terminal.

(9) Repeat Items (2) through (8) until the requirements are met. Because the slope characteristic of the repeater pivots about 92 kc/s, it will be found that a change in the setting of the W-E SLOPE dial requires a compensating change in the setting of the W-E FLAT dial.

(10) After completing the SLOPE adjustment and while sending with either test frequency at the transmitting office at the specified level, adjust the FLAT regulating condenser dial at the station being lined up to obtain an output level as close as possible to the specified level at repeaters or 0 db at a receiving terminal.

(11) With the SLOPE and FLAT dial settings obtained above, at a repeater measure and record the output level at the test frequencies listed in Item (3) and also at the intermediate frequencies of 60 kc/s W-E or 117 kc/s E-W. At a receiving terminal, measure and record the output level at the line frequencies of the 1,000-cycle points of Channel 1 to 12 inclusive (see Table 10).

Requirements. At a repeater, the output level for each frequency should be as close as possible to the specified level.

At a receiving terminal, the output level for the frequencies of the 1,000-cycle points of Channels 2 to 11 inclusive should be as close as possible to 0 db.

(12) If these requirements are not met, change the setting of the FLAT regulating condenser dial until the measurements are within limits.

(13) After the requirements of Item (12) are met at a receiving terminal, adjust the level of the frequency at which the output level was closest to 0 db in the procedure of Item (11) to be as close as possible to -5db, using the FLAT regulating condenser dial.

(14) Record the final dial settings at either a repeater or the receiving terminal.

(15) If an individual repeater section is being lined up and regular pilot channel current cannot be made available, the sensitrol relays will pulse periodically. Leave the plug in the BCO jack on the pilot control panel and do not replace the 55-volt fuses until final line-up is to be made or the repeater or terminal is about to be placed in service.

(16) If the system is being lined up by successive repeater stations from the transmitting terminal, proceed as outlined in Items (15) through (27) of Paragraph 7.1 (iii) (c).

7.3 Over-all Channel Equivalent Adjustment.

(i) Description. The channel net loss adjustment is made between the four-wire voice frequency terminals. The transmitting level into the carrier system at the four-wire terminal is normally -13 db and the receiving level is normally +4 db, giving an over-all gain of 17 db between the two ends of the system. The gain of any channel can be adjusted by varying the gain adjusting rheostat of the demodulator amplifier at the receiving terminal.

(ii) Apparatus - Each Terminal.

1 - P2AA Cord, 6 feet long, equipped with 241A Plugs at each end (2P13B).
1 - P2AF Cord equipped with 313A Plugs at each end, or one cord equipped with a 313A Plug at one end and the proper plug for connection to the talking and monitoring set at the other end.

(iii) Procedure.

(1) At the four-wire V.F. patch bay, use the P2AF cord or its equivalent to patch from the jacks in the talking and monitoring set to the MON jacks of a channel and establish communication over the system.

(2) At the transmitting terminal, patch from the SEND -13 jacks to the MOD IN jacks of the channel under test. If this channel is used also for talking between terminals, set up the monitoring condition.

(3) With the talking and monitoring set in the monitoring condition at the receiving terminal, patch from the DEM OUT jacks of the channel under test to the 600-ohm test jacks of the transmission measuring system. Obtain a reading on the db meter. The output from each channel should be +4 ± 0.1 db.

(4) If the requirement is not met, adjust the demodulator rheostat associated with the channel under test to bring the measurement as close as possible to +4 db.

(5) Repeat the above procedure for each channel to be tested.

7.4 Over-all Channel Quality Measurement.

(i) Description. The channel net loss frequency response is measured between the four-wire patch bays at the carrier terminals at the following frequencies -

★ 150, 200, 300, 500, 800, 1,500
2,000, 2,500, 3,000 and 3,400 cycles per second.

(ii) Apparatus.

Variable Oscillator suitable from 0-3,400 c/s.
A.P.O. Transmission Measuring Set.
Patch Cords and Terminating Plugs, etc.

(iii) Details of Test.

Send test power of -13 dbm at the MOD IN jacks of the channel under test for each of the frequencies listed above. Measure the loss at the DEM OUT jacks at the other terminal for each frequency. Repeat the measurement for the other direction of transmission. The losses measured should be recorded on Form T.R.M. 57.

★ Requirements. The losses should lie within the limits set out on Form T.R.M. 57. The 800 c/s measurement should be made twice on each channel and at the commencement of the run and once at the completion. If the two measurements do not check within 0.5 db, the measurements at all frequencies should be repeated until a check is obtained. The SLOPE and FLAT CON sensitrol relays should be observed at the terminal during the frequency run to see if line changes occur.

7.5 Gain, Overload Capacity and Intermodulation Check.

(i) Purpose. The following series of direct performance tests has been designed to facilitate routine checking of J and K carrier systems.

(ii) Nature of Tests. The over-all transmission path, from Group Modulator Input of one terminal to Group Modulator Output of the other, is checked as follows -

(a) Gain at various frequencies.
(b) Overload capacity.
(c) Intermodulation level.

(iii) Apparatus - Each Terminal.

17B Oscillator (or equivalent).
30A Transmission Measuring Set.
A.P.O. Transmission Measuring Set.

(iv) Details of Tests.

(a) Gain.

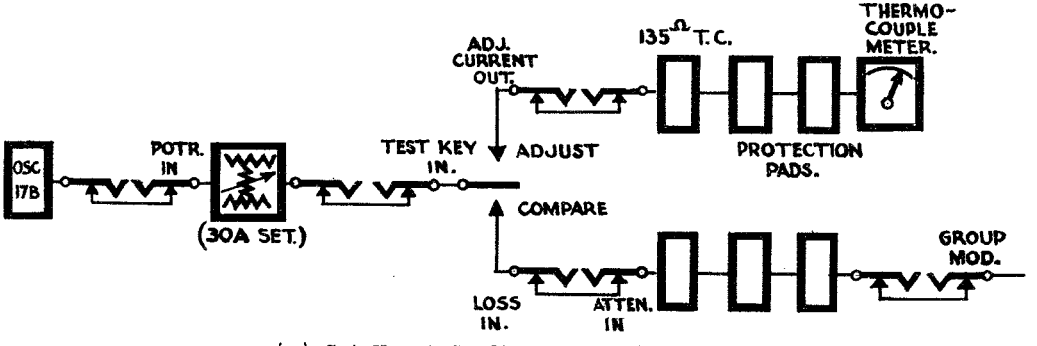
At Sending Terminal. (See Fig. 20a.)

Set 17B Oscillator at 66 kc/s.
Throw test key to ADJUST position and adjust the output of oscillator and test current potentiometer to obtain a reading of 0 dbm on the thermo-couple meter.
Set attenuator to 37 db and throw key to COMPARE position.

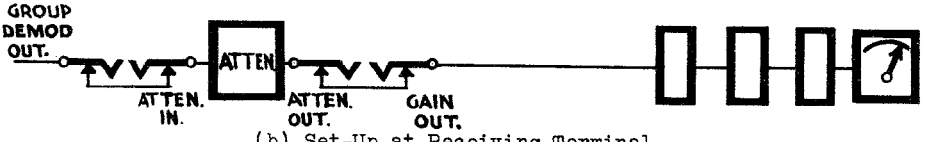
At Receiving Terminal.

The output of the group demodulator at the receiving terminal is then measured by means of the test-circuit of Fig. 20b with the attenuator set at zero.
Repeat the above tests at 84 kc/s and 102 kc/s. The group modulator outputs should be within the following limits -

66 kc/s	0 dbm	±	2 db
84 kc/s	0 dbm	±	3 db
102 kc/s	0 dbm	±	2 db



(a) Set-Up at Sending Terminal.



(b) Set-Up at Receiving Terminal.

GAIN TEST.

FIG. 20.

(b) Overload Test (at 84 kc/s). With test circuits unchanged, set the attenuator at the receiving terminal to 10 db and reduce the attenuator setting at the sending terminal to 27 db. Check the thermo-couple meter reading at the sending terminal (key thrown to ADJUST) and readjust to 0 dbm if necessary; then throw key to COMPARE. The reading of the thermo-couple meter at the receive terminal should be within 0.5 db of the 84 kc/s reading obtained in the Gain test.

(c) Intermodulation (again using Channel Bank).

At Sending Terminal. Connect 1 kc/s input to MOD IN jacks of two channels, in accordance with Column 3 of the table given below. The input levels should be -5 dbm (8 db above normal test level). The MOD IN jacks of the channel indicated in Column 6 should be terminated in 600 ohms.

At Receiving Terminal. Measure at DEMOD OUT jacks of the channel indicated in Column 6. The level should not exceed -35 dbm.

System	Direction	1 kc/s Input to Chennels	Resultant Line Frequencies (kc/s)	Intermodulation Product in Working Range (kc/s)	Disturbed Channel No.	Interference Tone (c/s)
J2 (NA)	W-E (B-A)	1 and 2	37 and 41	78	11	2,000
J2 (SA)	(B-A)	11 and 12	45 and 39	82	1	2,000
J2 (NB)	(B-A)	1 and 2	37 and 41	78	11	2,000
J2 (SB)	(B-A)	11 and 12	43 and 39	82	1	2,000
J2 (NA)	E-W (A-B)	1 and 3	139 and 131	123 (2 x 131) - 139	5	1,000
J2 (SA)	(A-B)	1 and 3	96 and 104	112 (2 x 104) - 96	5	1,000
J2 (NB)	(A-B)	1 and 3	94 and 102	110 (2 x 102) - 94	5	1,000
J2 (SB)	(A-B)	1 and 3	141 and 133	125 (2 x 133) - 141	5	1,000
K	(A-B)	1 and 3	13 and 21	34	6	2,000
K	(B-A)	1 and 3	13 and 21	34	6	2,000

7.6 Vacuum Tube and Ballast Lamp Replacement.

(i) Description. The vacuum tubes of the carrier system are tested without being removed from their sockets and without removing the equipment from service. When tube replacements are required, the action to be taken depends upon the type of circuit and is outlined below.

Vacuum tube tests should not be made when the battery voltage is changing rapidly, since, under this condition, the heater current will be constantly changing.

At auxiliary stations having commercial power, the vacuum tube tests should be made when the battery voltage is between 150 and 154 volts. Therefore, the tubes should not be tested when the battery is on equalising or boost charge, or during a power failure when the voltage cannot be maintained within this requirement.

At auxiliary stations having engine driven generators in place of commercial power, the tubes should be tested when the battery voltage is between 150 and 154 volts. In order that this requirement can be met, the engine driven generator should be started by remote control from the main station about two hours before the test is to be made if such control has been provided. The voltage at the auxiliary station can be kept within 150 and 154 volts by manual regulation while the tube tests are made.

Before removing any tube from its socket, turn off the heater current and allow time for the tube to cool off. After cold tubes are in place, allow sufficient time for the tube to become stabilised before testing the tube. All replacing tubes should be tested before the circuit is returned to service. The details and cautions to be observed when turning off or on the heater circuits are given in the Handbook covering the testing methods for the type of equipment involved.

(ii) Repeaters and Terminal Group Circuits. When tubes or ballast lamps are to be replaced in any of the circuits listed below, the regular equipment should be switched or

patched out of service. If alternate equipment is not available for temporarily replacing the regular equipment, the system must be released from service while the tubes or ballast lamps are changed.

(a) Terminal Group Circuits.
Transmitting Amplifier.
Intermediate Amplifier,
Auxiliary Amplifier.
Regulating Amplifier.

(b) Repeater Circuits.
Line Amplifier.
Regulating Amplifier.

(iii) Pilot Channel Amplifier-Rectifier. Tubes or ballast lamps in the pilot channel amplifier-rectifier at terminals or repeaters may be replaced without removing the group terminal or repeater equipment from service. The regulating equipment will lock up during the few minutes required for the change, but this will not affect the operation of the system. After replacing the tube in the amplifier-rectifier, the following test should be made -

Pilot Amplifier-Rectifier Circuit Sensitivity Measurement.

(iv) Channel Demodulator Amplifier. Temporarily release from service, by channel patching or otherwise, the two channels on the heater circuit in which the defective tube is located. The tubes of an odd and succeeding even channel are connected in series. Replace the tube, and measure and adjust the demodulator output level before restoring the channels to service.

(v) Carrier Supply. When tubes or ballast lamps are to be replaced in any of the circuits listed below, the carrier supply circuits should be switched accordingly to prevent any interruption to systems. If the carrier systems are operating on the emergency supply as a result of an automatic transfer, it indicates a possible trouble in the regular carrier supply, and this should be cleared and the systems transferred to the regular supply before proceeding with tube or ballast lamp changes in the emergency supply or in the transfer circuit.

(a) Regular Carrier Generator and Carrier Supply Amplifiers.
Switch to the emergency carrier supply.
Replace the tube or ballast lamp and test the tubes in the heater circuit affected.
Check the carrier supply output at test jacks.
Transfer the systems to regular carrier supply.

(b) Emergency Carrier Generator and Carrier Supply Amplifiers.
Lock in the regular carrier supply to prevent an automatic transfer to the emergency supply.
Replace the tube or ballast lamp and test the tubes in the heater circuit affected.
Check the carrier supply output at test jacks.
Restore the regular supply to normal so that an automatic transfer can take place.

(c) Carrier Generator Transfer Circuit.
Lock in the regular carrier supply to prevent an automatic transfer to the emergency carrier supply.
Replace the tube or ballast lamp.
Make the tests "Ionisation of Gas Tubes in Transfer Circuit" and "Operation of Carrier Generator Transfer Circuit".
Restore the regular supply to normal so that an automatic transfer can take place.

(vi) Pilot Channel Supply - J2 Terminals. Tubes or ballast lamps may be replaced on an "in service" basis. The regulating equipment at all stations will lock up during the few minutes required for the change, but this will not affect the operation of the systems. Unless the audible alarm feature of the High-Low Pilot Channel Circuit Alarm has been made inoperative, audible alarms will be received at the main repeater stations. Those offices which have the audible alarm feature and terminal stations in operation should be notified by the control terminal.

Replace the tube or ballast lamp.

Read the pilot level on the IND 1 or IND 2 sensitrol relay of the pilot channel supply and adjust the output if required.

7.7 Noise Level Measurement. The noise level is measured in each direction of transmission for every channel at the conclusion of the annual tests.

(i) Apparatus.

2B Noise Measuring Set.
Terminating Plugs, Cords, etc.

(ii) Details of Test. Connect the 2B noise measuring set to hybrid line of channel at one terminal and terminate hybrid line at other terminal in 600 ohms. Measure the weighted noise which should be 54 dbm or lower. Reverse the procedure for the other direction of transmission.

END.