TYPE K1 CARRIER SYSTEMS

DEVIATION REGULATOR

Contents

		Page
1.	GENERAL	2
2.	TESTS AND ADJUSTMENTS - GRID BATTERY AND A-C SUPPLY	4
	(A) Grid Battery for Amplifiers	4
	(B) Grid Battery for Control Circuit	6
	(C) Emergency A-C Supply for Control Circuit	10
3.	VACUUM TUBE TESTS	11
	(A) Heater Circuit Operation	11
	(B) Vacuum Tube Tests	12
4.	TESTS AND ADJUSTMENTS OF DEVIATION REGULATOR	16
	(A) Gain and Equalization Adjustments	16
	(B) Gain Measurement - General	18
	(C) Gain Measurement - Deviation Regulator	22
	(D) Gain Measurement - Test Amplifier	23
	(E) Amplifier Gain - Load Measurement	28
	(F) Measurement for Turnover in Wiring of Deviation Regulator	29
	(G) Thermistor Heater Voltage	33
	(H) Gain Measurement - Auxiliary Switching Amplifier - Key Operated Switching Circuit	36
	(I) Gain Measurement - Line Amplifier	36
	(J) Gain Measurement - Twist Amplifier	38
5.	TESTS AND ADJUSTMENTS OF CONTROL AND LIMITER CIRCUITS	39
	(A) Maximum 60-Cycle Output Voltage	39
	(B) Pilot Filter Characteristics	40

Contents - Continued

	Page
(C) Control Circuit Tuning Adjustment	46
(D) Regulator Sensitivity and Regulation Accuracy	48
(E) Limiter Circuit	56
6. DIRECT CURRENT TESTS	64
(A) Resistance Measurements in Line, Twist, Test and Aux. Switching Amplifiers; in Control Circuit; and in Regulating Networks and Deviation Equalizers	64
(B) Resistance Measurements in Thermistors and Varistors	66

1. GENERAL

1.01 This Section describes the methods of making tests and adjustments on the deviation regulator for Type K1 carrier systems and gives the requirements to be met for each test. The system lineup procedure is contained in an E34 Section covering the overall system.

1.02 This issue replaces Issue 2, dated May, 1941, which was rated Provisional and was given limited distribution. Additions and changes have been made in the procedures and requirements to extend and clarify their application. The more important changes and additions are as follows:

(1) Additional tests have been specified for the grid battery supply and the a-c supply for the control circuit with Figs. 2 and 3 added.

(2) Changes covering corrections and clarifications in gain requirements tables have been made; former Tables II, III, IV and V are replaced by Tables II, III and IV.

(3) Gain requirements for various strappings of the amplifier deviation equalizer have been added; given in Table V.

(4) Gain measurements have been added to cover the auxiliary switching amplifier.

(5) Restrictions are given on the maximum 60 cycle a-c voltage which may be used on the control circuit.

(6) Changes have been made in the procedures and requirements on the pilot filter measurements.

(7) Changes have been made in the procedures and requirements on the regulator sensitivity and regulation accuracy, with the former Fig. 6 replaced by Fig. 8.

(8) Amplifier gain measurements without feedback have been omitted as these tests were not found to have field applications.

(9) Additional requirements are given under d-c resistance measurements including requirements on the regulating networks and deviation equalizers.

1.03 For the purpose of this Section, the term "deviation regulator" is used to designate the assembly of equipment consisting of line amplifier, twist amplifier, equalizers, control circuit, and other apparatus used to provide amplification, equalization, and pilot channel regulation at a repeater point or receiving terminal of a type K1 carrier system.

1.04 In applying the methods it will be necessary to be familiar with the available descriptive information covering the deviation regulator and testing apparatus.

1.05 Certain testing methods are given which although not ordinarily required in connection with service maintenance, may be helpful in conducting trouble investigations.

1.06 When referring to various types of testing equipment and auxiliary equipment such as cords, plugs, meters, etc., the standard name is used and the code of the latest

type is given. Other types of equipment or apparatus may be used if they accomplish the desired results. If substitutions are not permissible this is so stated.

1.07 Testing power above or below 1 milliwatt is stated in dbm, that is, for example, testing power of 10 db above 1 milliwatt is stated as +10 dbm and testing power of 10 db below 1 milliwatt is stated as -10 dbm.

1.08 The oscillator output impedance should be set for 135 ohms for all tests listed herein.

1.09 In making measurements using the attenuator and meter of the 30A Transmission Measuring Set in conjunction, it is not always possible to obtain a zero db reading on the meter. When this occurs, the measured value is the setting of the attenuator corrected for the reading of the meter. Unless otherwise specified, if the reading of the meter is above zero db it should be added to the attenuator setting while, if it is below zero db it should be subtracted from the attenuator setting to give the measured value.

2. TESTS AND ADJUSTMENTS - GRID BATTERY AND A-C SUPPLY

(A) Grid Battery for Amplifiers

2.01 Common grid battery supplies are used to provide grid bias for the 311A output tubes of the following amplifiers:

(1) Line amplifier, operating on equalizer taps 6 or 8.

(2) Twist amplifier

(3) Auxiliary switching amplifier

(4) Test amplifier

(5) Transmitting amplifier (at terminals)

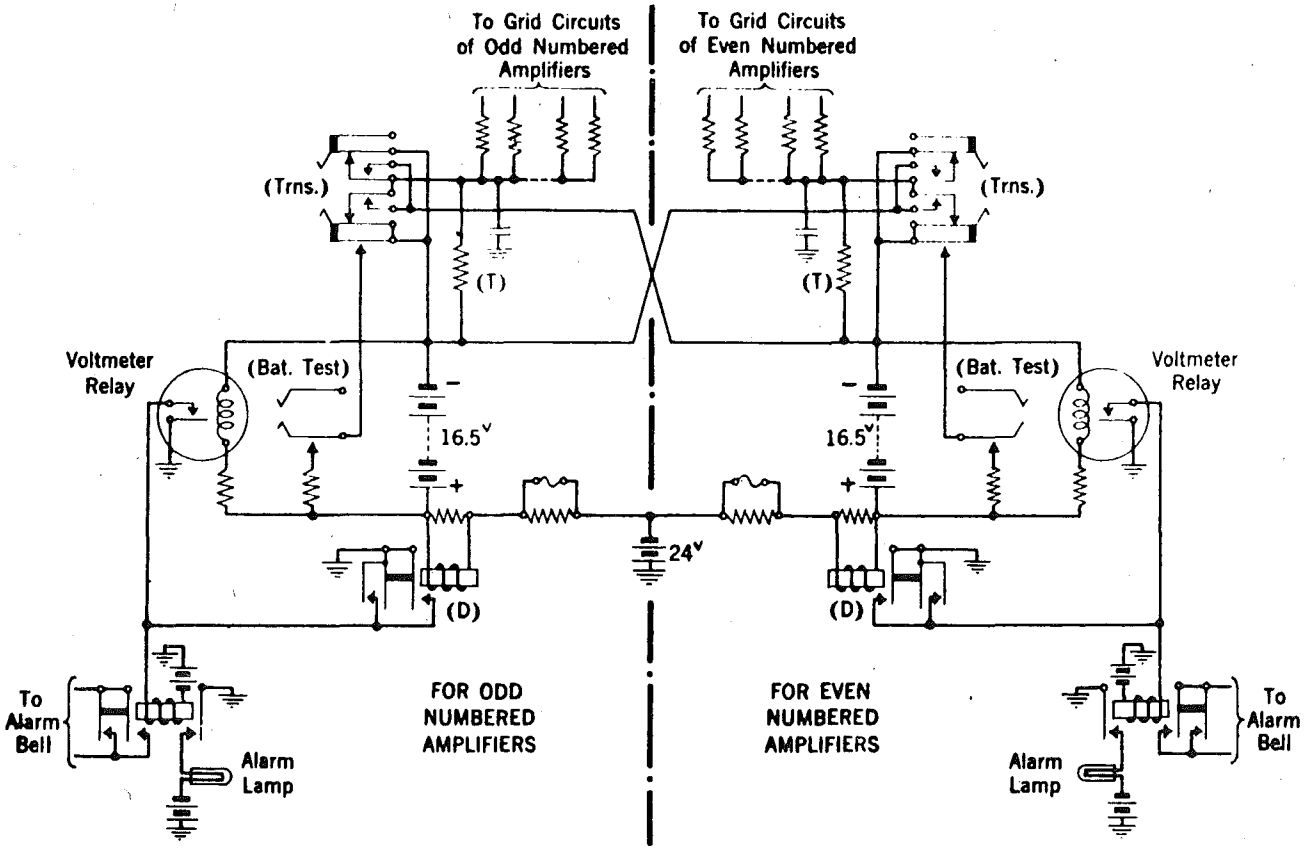


Fig. 1 - Grid Battery Supply Circuit for Amplifiers

2.02 A separate grid battery supply is provided for each 21 or less carrier systems (both directions of transmission). Each battery supply consists of two separate sets of batteries, of which the first provides grid battery for the amplifiers of the odd-numbered systems for both directions of transmission, and the second provides grid battery for the amplifiers of the even-numbered systems for both directions of transmission. A transfer key is provided so that either set of batteries may be used to provide the grid battery for the amplifiers of all 21 two-way systems, thus releasing the other set of batteries for test or replacement purposes. After the

transfer key of the battery to be tested has been operated, the operation of a test key places a resistance load across the battery for test purposes. The circuit is so arranged that the switching of the grid battery supply during the transfer operation will not interfere with the operation of the amplifiers. Each set of grid batteries is equipped with a voltmeter relay (sensitrol indicating type relay) which gives a visual indication of the grid battery voltage and also provides a low voltage alarm.

2.03 Procedure - See Fig. 1

(1) Operate the TRNS key of the battery to be tested to the TRNS position.

(2) To measure the voltage of the battery under a resistance load, operate BAT TEST key, and after 10 seconds read the voltage on the voltmeter relay.

Requirement: Not less than 16 volts.

(3) If the requirement is not met, all 11 cells should be replaced and the voltage again checked as in (2).

(4) Restore the TRNS key to normal, and with all other keys in the normal position note the voltage on the voltmeter relay. This gives the voltage under the operating conditions.

Requirement: Not less than 16 volts.

(5) The alarm adjustment on the voltmeter relay should be set for 15.5 volts.

(B) Grid Battery for Control Circuit

2.04 An 85-volt grid bias is supplied to each control circuit panel from the J86207R regulated tube rectifier. Two of these rectifiers are provided for each station, one to supply the odd-bumbered circuits and the other to supply the even-numbered circuits. Three potentiometers are provided in each control circuit to furnish the required bias adjustment for the three output control tubes. In-

asmuch as any variation in this bias produces a variation in the sensitivity of the control circuit, and consequently, in the gain of the deviation regulator, it is important that a high degree of stability be maintained in the output voltage of the rectifier.

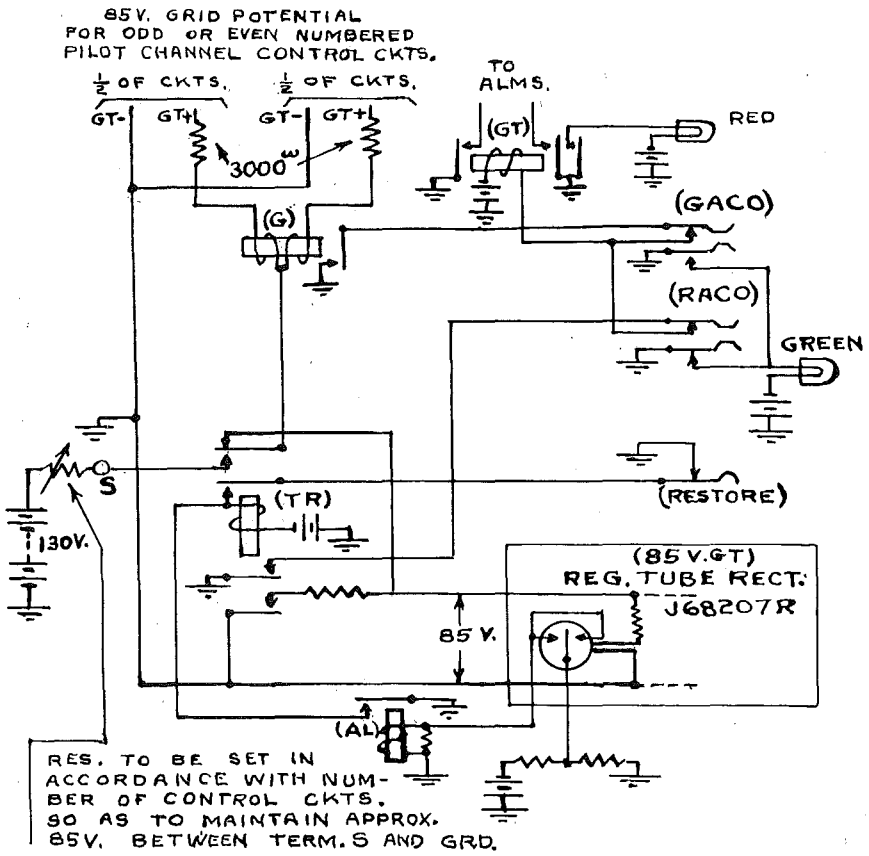


Fig. 2 - 85 Volt Grid Potential Supply for Pilot Channel Control Circuits

2.05 If the output voltage of the rectifier drops to 83 volts or rises to 87 volts an alarm occurs and an automatic switching circuit operates to provide an emergency grid battery supply from the office plate battery. The voltage regulation is then dependent upon the regulation of the plate battery supply, so that greater variations in voltage may be obtained than when the rectifier circuit is used.

2.06 This circuit is also provided with an alarm in case of a short in the grid circuit of a control circuit. A protective grid circuit resistance prevents disturbance to other grid circuits.

2.07 Procedure - Normal Operation Test - See Fig. 2

(1) Read the rectifier output voltage on the VR meter of the J86207R rectifier panel under test.

Requirement: 85 ± 0.5 volts.

(2) If the voltage is outside these limits it should be readjusted by means of the screwdriver adjustment on the panel. If this adjustment will not permit it to be restored to 85.0 volts, the trouble should be investigated within the rectifier panel, the probability being that the reference grid battery in the rectifier circuit requires replacement or that a vacuum tube in the rectifier circuit has become defective.

2.08 Apparatus

1 - KS-8295 Volt-ohmmeter

2.09 Procedure - Emergency Operation Test - See Fig. 2

(1) Disconnect the a-c supply by removing the AC fusetron of the J86207R rectifier under test.

Requirement: The audible alarm should come in and the red alarm lamp on the associated ALM & TRNS panel should operate.

(2) Operate the RACO rectifier alarm cut-off key.

Requirement: The alarm should be silenced, the red lamp extinguished and the green guard lamp operated.

(3) Measure the voltage from terminal S to ground.

Requirement: 85 ± 8 volts.

(4) Reconnect the a-c supply by restoring the fusetron to the rectifier panel.

(5) After 20 seconds, read the output voltage on the VR voltmeter relay.

Requiremont: 85 ± 0.5 volts.

(6) Operate the RESTORE key to reconnect the rectifier supply to the grid circuits and then restore the RACO key to its unoperated position.

Requirement: The green lamp should be extinguished and the alarm should not reoccur.

(7) Short to ground, terminal B1 on a control circuit which is connected to this grid potential supply.

Requirement: The alarm should be immediately brought in and the red lamp operated.

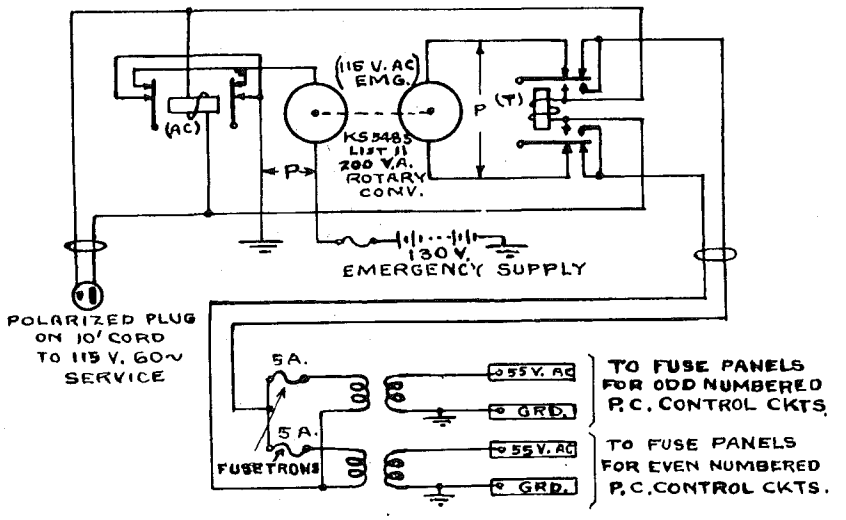
(8) Operate the GACO, grid alarm cutoff key.

Requirement: The alarm should be silenced, the red lamp extinguished and the green lamp operated.

(9) Remove the short to ground on terminal B1 of the control panel and restore the GACO key to its unoperated position.

Requirement: The green lamp should be extinguished and the alarm should not reoccur.

(C) Emergency A-C Supply for Control Circuit



FOR OFFICES HAVING OVER 40 DEVIATION REGULATORS A SLIGHTLY DIFFERENT POWER SUPPLY CIRCUIT IS PROVIDED WITH A 750 V.A. ROTARY CONVERTER.

Fig. 3 - Emergency AC Supply for Pilot Channel Control Circuits

2.10 A failure of the 60-cycle, 115 volt a-c service supply should automatically cause the output of a rotary converter to be supplied in place of the normal a-c supply. In checking this voltage, it is convenient to measure the voltage across the input terminals 1 and 2 of the 60~ transformer on one of the control circuit panels.

2.11 Apparatus

1 - KS-8295 Volt-ohmmeter

2.12 Procedure - See Fig. 3

(1) Measure the a-c voltage across terminals 1-2 of the 60~ transformer on one of the REG CONT panels.

Requirement: 55 ± 5 volts.

(2) Remove the 115 volt a-c service plug on the 115 V AC RECPT panel.

(3) Again measure the voltage as in (1).

Requirement: 55 ± 10 volts.

(4) Reconnect the 115 volt a-c service plug.

3. VACUUM TUBE TESTS

3.01 Heater current adjustments should be made in accordance with the information contained in an A502 Section of Central Office Maintenance Practices and the adjustment values on the SD Drawings. These adjustments should not be made with the 1AC Tube Test Set.

(A) Heater Circuit Operation

3.02 The following precautions should be observed in connection with the insertion or removal of any vacuum tube of the deviation regulator.

(1) The deviation regulator should be out of service whenever tube replacements are made or whenever the heater circuit is opened.

(2) Before inserting or removing a tube of an amplifier circuit, the heater circuit should be opened by means of a 258C plug in the FIL jack. This is necessary in order to prevent the excessive increase in heater current which would occur in one of the 310A tubes if the other 310A tube whose heater is wired in parallel with it should be removed from its socket before the heater circuit is opened.

(3) Any input to the deviation regulator, such as pilot frequencies, carrier leaks, test tones, etc., should be removed from the input of the deviation regulator before the heater circuit of an amplifier is closed. The reason for this is briefly as follows. When the heater circuit is closed, the 310A tubes of the first two stages of the feedback amplifier reach

their normal values of gain more rapidly than does the 311A tube of the third stage of the amplifier. During this period of time, the lack of gain in the third stage of the amplifier prevents the normal feedback action, so that if any signal is present at the input of the amplifier, an excessive value of this signal is applied to the grid of the third tube, thereby injuring the tube. At least three minutes should be allowed for the tubes to heat up after the heater current has been turned on before tests are made or before the amplifier is returned to service.

3.03 Apparatus

1 - 258C Plug
1 - 323A, 135 Ohm Plug

3.04 Procedure

(1) If the amplifier is connected to the amplifier switching circuit, be sure that there is no input applied to the test jacks. If the amplifier is not connected to the switching circuit, insert a 323A plug in the EQ jacks of the input sealed test terminal.

(2) To open the heater circuit, insert a 258C plug in the FIL jack on the amplifier or control circuit panel.

(3) To close the heater circuit, remove the 258C plug from the FIL jack.

(4) After the heater circuit has reached its normal operating temperature, requiring at least three minutes, the 323A plug may be removed from the input EQ jacks and test power may be applied to the input of the amplifier.

(B) Vacuum Tube Tests

3.05 The vacuum tubes are tested by means of the 1AC tube test set without being removed from their sockets and without inter-

ruption to service. This set provides for measurements of heater currents, space currents, grid currents, cathode activity, and grid voltages, as covered in an E40. section. Limits applying to each measurement are given herein.

3.06 When it is necessary to replace vacuum tubes because of failure to meet requirements the procedure given in the E24 Section, covering the operating routines, should be followed in switching the deviation regulator out of service and in making the supplementary test when it is returned to service.

3.07 It is not practicable to make cathode activity tests when the battery voltage is changing rapidly because of the resulting changes in heater current. For these reasons, vacuum tube tests should not be made when the battery voltage is changing rapidly or when it is outside its normal operating range. This situation will probably exist during and shortly after a power or rectifier failure, or during a routine battery overcharge. The procedure outlined in the E24 Section covering operating routines should be followed.

> Caution: When the heater current is changed in making tube tests, time should be allowed for the heater current and space current to become stabilized before making the final reading as discussed in the E40 section covering the 1R and 1AC tube test set.

3.08 The cathode activity test of tubes 2, 3 and 4 of the control circuit can only be made when the control circuit is operating normally. If necessary, pilot frequency may be supplied from a local oscillator. The control circuit must not be operating too close to either end of its operating range. If the space current of the tube under test is not extreme (it should be between 100 and 400 millivolts) the control circuit should be in a satisfactory condition for the measurement. Under these conditions, when a change in

heater current produces a change in the d-c plate current, and in the effective plate impedance to the 60 cycle current, the control circuit operates to produce a sufficient change in grid bias to restore the plate current to approximately its original value. The resulting percentage change in grid voltage is approximately the same as the percentage change in d-c plate current which would have resulted if the control action had not been operative, so that the percentage change in grid voltage resulting from a given change in heater current may be used as a measure of the cathode activity of the tube. The grid voltage measurement is obtained in terms of the space millivolt reading of the vacuum tube incorporated in the 1AC set.

3.09 Apparatus

1 - 1AC Tube Test Set
1 - M12B Cord equipped with 307A and Yaxley 625 pin plugs
1 - M8E Cord equipped with 307A and Yaxley 625 pin plugs
1 - P3Y Cord equipped with 306A and 310 plugs

3.10 Procedure - Line, Twist, Test and Auxiliary Switching Amplifiers

(1) Make heater current, grid current, space current and cathode activity tests in the order shown on Table I. Where grid current readings in excess of 5 microamperes are involved, they should be read on the millivolt scale of the SPACE-GRID meter of the 1AC tube test set. A deflection of 125 millivolts is equivalent to 5 microamperes of current on the grid current scale and similarly 750 millivolts is equivalent to 30 microamperes.

Requirements: Refer to Table I(A).

(2) 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.

(3) Replace vacuum tubes when requirements are not met. See Paragraph 3.06 and Part 3(A).

3.11 Procedure - Control Circuit:

(1) Make heater current and space current tests as indicated on Table I(B). No provision is made for the measurement of grid currents of the tubes of the control circuit.

(2) Measure the cathode activity of tube 1 of the control circuit in the usual manner.

(3) Make the cathode activity test of tubes 2, 3 and 4 of the control circuit in the normal manner by decreasing the heater current by .04 ampere and observing the resulting percentage change in grid voltage as indicated on the space millivolt scale of the 1AC Set. If the space millivolt reading is outside the limits of 100 and 400 millivolts, then the control circuit may be operating near the end of its range, or this may be an indication of a defective tube. The latter possibility may be checked by the insertion of another tube. If the space current is still extreme, then the control circuit is operating near the end of its range. If the system is operating on the regular pilot frequency, it will be necessary to make the test at some other time, when the regulator is not at the extreme end of its range. If a local pilot is being used, the level of this pilot can be readjusted to meet the above requirements.

(4) If the range of the SPACE PER CENT ZERO ADJUSTMENT rheostats of the 1AC tube test set will not permit of adjusting the space current to give a zero reference

for the cathode activity test, 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 percentage on the space millivolts at normal heater current.

Requirements: Refer to Table I(B).

(5) Replace vacuum tubes which do not meet the requirements. See Paragraph 3.06 and Part 3(A).

4. TESTS AND ADJUSTMENTS OF DEVIATION REGULATOR

(A) Gain and Equalization Adjustments

4.01 Before deviation regulator gain measurements are made, it is necessary to make the various adjustments of the line amplifier and to insert the required cable and amplifier deviation equalizers. These adjustments are made in accordance with instructions given in an E34 Section covering the overall system and according to information on the SD drawings. They depend upon the characteristics of the cable and amplifiers. In general, all amplifiers operating in the same direction and over the same cable section will be strapped alike.

4.02 Apparatus

Soldering Equipment.

4.03 Procedure - Line Amplifier:

(1) Make the specified gain strappings on the line amplifier.

(2) When strap Y is open, disconnect the lead from terminal 3 to the battery supply circuit and strap terminals 2 and 3 at the terminal block on the amplifier. Properly tape the lead removed from terminal 3 to protect it from grounding.

Table I

Vacuum Tube Test Requirements

(A) Tubes of Amplifier Circuits

	Line Amplifier				Twist, Test, or Auxiliary Switching Amplifier		
TUBE:	1	2	3	3*	1	2	3
TEST: TYPE:	310A	310A	311A	311A	310A	310A	311A
Heater Current in Amperes)Min.			.58	.58			.58
)Max.			.70	.70			.70
Grid Current:							
Switch on 1AC Set	G1	G2	G3	G3		G2	G3
Max. Grid Current in Microamps.	.5	1.0				1.0	
Max. Grid Current-Read on Millivolt Scale			375	375			375
Space Current:							
Switch on 1AC Set	P1	P2	P3	P3	P1	P2	P3
Space Millivolts - Min.	350	350	350	450	240	240	350
Max.	750	750	#1000	750	420	420	#1000
Cathode Activity:							
Switch on 1AC Set	P1	P2	P3	P3	P1	P2	P3
Decrease Heater Current, Amperes			.04	.04			.04
Cathode Activity, Max. %							
When Grid Current Reading is 0-125 mv	15	15	25	15	15	15	25
When reading is 126-375 mv.			35	20			35

This is read as 100 with the shunt key of the 1AC set in non-operated position.

* Use these values when Z lead is on ter. No. 10.

(B) Tubes of Control Circuit

TEST:		Control Circuit			
	TUBE:	1	2	3	4
	TYPE:	310A	310A	310A	310A
Heater Current in Amperes	Min.		.58		
	Max.		.70		
Space Current:					
Switch on 1AC Set		P1			
Space Millivolts -	Min.	420			
	Max.	900			
Cathode Activity:					
Switch on 1AC Set		P1	P2	P3	P4
Decrease Heater Current Amp.		.04			
Cathode Activity, Max. %		10	15*	15*	15*

*The requirement on the max. % cathode activity only applies if a space millivolt reading made at the time of the measurement is between 100 and 400 millivolts, as explained in 3.08 and 3.11(3).

- -

4.04 Procedure - Regulating Networks and Deviation Equalizers

(1) Refer to drawing SD-64999-01 for the connections for various combinations of SL and BU networks, REP coil, HPF filter, and CDE and ADE equalizers.

(B) Gain Measurement - General

4.05 The general method of measuring gain is described in the following procedure, using the complete deviation regulator as an

example and assuming that the necessary terminations and adjustments have been made on the deviation regulator so that it is ready for measurement.

4.06 In later individual test procedures, the particular input and output jacks, the test frequency, and the amplifier and equalizer terminations are specified but the detailed test procedure is not repeated for each test.

4.07 A measurement of gain over the deviation regulator serves as a check of the equalizer characteristics and of the correctness of the gain strappings on the line amplifier.

4.08 Before making any gain measurements specified in this section, it is necessary to remove the limiter circuits (by inserting 258C plugs into the three B jacks of the control circuit), to apply the required "test resistance" shunts (when required) across the thermistors of the line amplifier and the regulating networks, and to disable the control circuit (by inserting a 258C plug into the FIL jack). The test resistance shunts to be used for establishing average settings for reference are:

250 ohms for flat gain thermistors of line amplifiers

500 ohms for slope or bulge thermistors of regulating networks

These resistance values represent the mean values assumed by the thermistors in their normal operation. The shunting effect of the cold thermistor during the test is negligible. Unless otherwise specified all gain measurements on the deviation regulator will be made with these test resistance shunts.

4.09 Apparatus

1 - 17B Oscillator
1 - 30A Transmission Measuring Set
1 - 250-Ohm ± 1% Resistance (106A Type, or equivalent)
2 - 500-Ohm ± 1% Resistance (106 Type, or equivalent)
3 - 3P20B Cord Assemblies (P3P Cords equipped with 305A Plugs at each end)
4 - 258C Plugs

Note: Each of the 106A type resistances is to be equipped locally with KS-6780 Connecting Clips and 108 Cord Tips or their equivalent.

4.10 Procedure - General Method of Gain Measurement. See Fig. 4

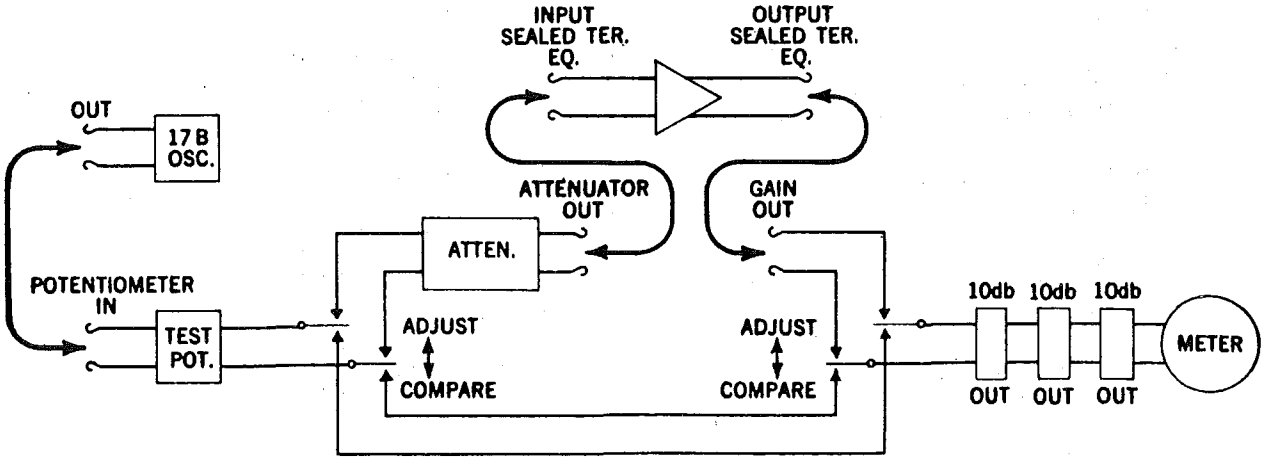


Fig. 4 - Gain Measurement

(1) Insert 258C plugs into the three B jacks of the control circuit to remove the limiter circuits.

(2) Insert a 258C plug into the FIL jack of the control circuit.

(3) Shunt terminals 1 and 2 of the TH thermistor of the line amplifier with the 250 ohm test resistance; shunt terminals 1 and 2 of the SL thermistor of the slope network and terminals 1 and 2 of the BU thermistor of the bulge network with the 500 ohm test resistances or apply other shunts as specified.

Caution: Care should be exercised in connecting the shunt resistances to terminals 1 and 2 of the TH thermistor of the line amplifier as these terminals are 130 volts above ground potential.

(4) Set the attenuator in the 30A Set for maximum loss.

(5) Set the 17B oscillator for the test frequency and adjust for minimum output.

(6) Patch from the oscillator OUT jacks to the POTENTIOMETER IN jacks of the 30A Set.

(7) Patch from ATTENUATOR OUT jacks to the EQ jacks at the input sealed test terminal.

(8) Patch from the EQ jacks at the output sealed test terminal to the GAIN OUT jacks of the 30A Set.

(9) Operate the test key of the 30A Set to COMPARE position and adjust the test power to obtain a reading of 0 db on the 30A Set.

(10) Operate the test key of the 30A Set to ADJUST position and adjust the attenuator to obtain a reading as close as possible to 0 db on the meter.

(11) The amplifier gain is equal to the attenuator setting plus or minus the db reading of the 30A set meter.

(12) After the gain measurement is completed, remove all patches and plugs unless other tests are to be made.

(C) Gain Measurement - Deviation Regulator

4.11 The gain measurements of the Deviation Regulator may be classified broadly as follows:

(1) Gain for average settings of flat gain control and of slope and bulge networks.

(2) Change in gain produced in any regulator (flat, slope or bulge) when the thermistor increases or decreases from its value for the average gain setting.

In order to obtain these conditions, the appropriate test resistance to be shunted across the thermistor is indicated in Table II.

4.12 During actual operation of the regulator the thermistor resistance is, of course, never raised to as high a resistance value as in the unshunted condition of Table II, but this condition is used because of its convenience for test purposes.

4.13 Apparatus

1 - 17B Oscillator
1 - 30A Transmission Measuring Set
3 - 3P20B Cord Assemblies (P3P Cords equipped with 305A Plugs at each end)
1 - 250 Ohm ± 1% Resistance (106A Type, or equivalent)
2 - 500 Ohm ± 1% Resistances (106A Type, or equivalent)
1 - 25 Ohm ± 1% Resistance (106A Type, or equivalent)
1 - Short Circuiting Lead (3 inches of flexible wire)
4 - 258C Plugs

Note: Each of the 106A Type resistances and the short-circuiting lead are to be equipped locally with KS-6780 Connecting Clips and 108 Cord Tips or their equivalent.

4.14 Procedure:

(1) Measure the gain for each test condition of Table II, at frequencies given in table, between the EQ jacks at the input sealed test terminal and the EQ jacks at the output sealed test terminal as covered in Paragraph 4.10. At the terminal office the equivalent jacks are designated EQ and REC AMP OUT.

Requirements: The requirements are given in Tables II, III, IV and V.

(D) Gain Measurement - Test Amplifier (SD-64329-02)

4.15 Apparatus

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

4.16 Procedure

(1) Patch from ATTENUATOR OUT jacks of the 30A set to the 135-ohm jacks of one of the 135:600 ohm repeating coils of the 30A set.

(2) Patch from the 600-ohm jacks of the repeating coil to the TEST AMP IN jacks of the test amplifier.

(3) Measure the gain at 12, 20, 40, 60, and 130 kc between the 135 ohm jacks of the 135:600 ohm transformer and the TEST AMP OUT jacks of the test amplifier. The test procedure is the same as that given in Part 4 (B) except for the above modifications. The gain is the attenuator setting plus the transformer loss plus or minus the meter reading.

Requirements:

Frequency	Gain in db at 12 kc	Change in Gain in db from 12 kc Gain
12 kc	64.0 ± 1.0	
20		-0.1 ± 0.5
40		-0.4 ± 0.5
60		-0.5 ± 0.7
100		-1.2 ± 0.8
130		-2.5 ± 1.0

TABLE II

DEVIATION REGULATOR GAIN REQUIREMENTS

Test Resistances Values given for Average, Maximum and Minimum gains

Test No.	Freq. KC	Type of Regulation Tested	Regulator Gain Adjustments			Test Resistance Required as Shunt Across Thermistor			Gain Requirement - db Compared to Test No. 1
			Flat	Slope	Bulge	Flat	Slope	Bulge	
1	(60,56,28 & 12)	-	Avg.	Avg.	Avg.	250ω	500ω	500ω	See Tables III,IV & V
2	"	Flat	Max.	"	"	25ω	"	"	+15.5 min.
3	"	"	Min.	"	"	No Shunt	"	"	-14.0 max.
4	56	Slope	Avg.	Max.	"	250ω	Short Circuit	"	-4.7 ± 1.0
5	28	"	"	"	"	"	"	"	+2.2 ± 0.5
6	12	"	"	"	"	"	"	"	+5.5 ± 1.0
7	56	"	"	Min.	"	"	No Shunt	"	+5.0 ± 1.0
8	28	"	"	"	"	"	"	"	-1.9 ± 0.5
9	12	"	"	"	"	"	"	"	-5.8 ± 1.0
10	56	Bulge	"	Avg.	Max.	"	500ω	Short Circuit	+2.2 ± 0.5
11	28	"	"	"	"	"	"	"	+9.3 ± 1.0
12	12	"	"	"	"	"	"	"	+1.1 ± 1.0
13	56	"	"	"	Min.	"	"	No Shunt	-1.7 ± 0.5
14	28	"	"	"	"	"	"	"	-9.5 ± 1.0
15	12	"	"	"	"	"	"	"	-1.0 ± 1.0

TABLE III

60 KC GAIN REQUIREMENTS -DB

Thermistors and Control Circuit Inoperative
Average Regulator Gains, using Test Resistances
See Notes 1, 2 and 3

Columns							
1	2	3	4	5	6	7	8
Line Amp EQL	Line Amp Gain Strapping Note 1	Line Amp Alone	Line Amp Twist Amp SL & BU Nets "A" Wiring on EQL Circuit	Line Amp Twist Amp SL & BU Nets 50A EQL	Line Amp Twist Amp SL & BU Nets 50A EQL 34A EQL	Line Amp Twist Amp SL & BU Nets 50A EQL Two 34A EQL	Line Amp Twist Amp SL & BU Nets 50A EQL 34B EQL
30D	6X Y6	74.2±1.6	80.0±2.0	81.2±2.0	80.5±2.0	79.8±2.0	80.2±2.0
"	6 Y8	68.8±1.6	74.6±2.0	75.8±2.0	75.1±2.0	74.4±2.0	74.8±2.0
"	7 Y8 or 6 -10	63.4±1.6	69.2±2.0	70.4±2.0	69.7±2.0	69.0±2.0	69.4±2.0
"	7 -10	57.7±1.6	63.5±2.0	64.7±2.0	64.0±2.0	63.3±2.0	63.7±2.0
30B	6X Y6	71.1±1.6	76.9±2.0	78.1±2.0	77.4±2.0	76.7±2.0	77.1±2.0
"	6 Y8	65.6±1.6	71.4±2.0	72.6±2.0	71.9±2.0	71.2±2.0	71.6±2.0
"	7 Y8 or 6 -10	60.2±1.6	66.0±2.0	67.2±2.0	66.5±2.0	65.8±2.0	66.2±2.0
"	7 -10	54.5±1.6	60.3±2.0	61.5±2.0	60.8±2.0	60.1±2.0	60.5±2.0
30A	6X Y6	69.4±1.6	75.2±2.0	76.4±2.0	75.7±2.0	75.0±2.0	75.4±2.0
"	6 Y8	64.0±1.6	69.8±2.0	71.0±2.0	70.3±2.0	69.6±2.0	70.0±2.0
"	7 Y8 or 6 -10	58.6±1.6	64.4±2.0	65.6±2.0	64.9±2.0	64.2±2.0	64.6±2.0
"	7 -10	52.9±1.6	58.7±2.0	59.9±2.0	59.2±2.0	58.5±2.0	58.9±2.0
30C	6X Y6	67.3±1.6	73.1±2.0	74.3±2.0	73.6±2.0	72.9±2.0	73.3±2.0
"	6 Y8	61.8±1.6	67.6±2.0	68.8±2.0	68.1±2.0	67.4±2.0	67.8±2.0
"	7 Y8 or 6 -10	56.4±1.6	62.2±2.0	63.4±2.0	62.7±2.0	62.0±2.0	62.4±2.0
"	7 -10	50.7±1.6	56.5±2.0	57.7±2.0	57.0±2.0	56.3±2.0	56.7±2.0

Notes:

1. The gain strapping is expressed in terms of the connections to the input transformer tap of the line amplifier, the X, Y and Z strapping in order. The first and last numerals refer respectively to the connection to the input transformer terminal and the Z lead. When X or Y or both X and Y are used these straps should be closed. If either letter is omitted that strap is open. If both letters are omitted, indicated by a dash "-", both straps are open.

2. The use of the HPF high pass filter will make no change in gain at 60 kc.

3. The above limits are for normal-normal strappings of the 50A EQL. For other strappings make corrections as per Table V.

TABLE IV

REQUIRED DECREASE IN GAIN (DB) AT 56, 28, AND 12 KC
FROM GAIN AT 60 KC (GIVEN IN TABLE III)

Thermistors and Control Circuit Inoperative
Average Regulator Gains, using Test Resistances
See Notes 1 and 2

Columns							
1	2	3	4	5	6	7	8
Freq. in kc	Line Amp. EQL	Line Amp Alone	Line Amp Twist Amp SL & BU Nets "A" Wiring on EQL Ckt.	Line Amp Twist Amp SL & BU Nets 50A EQL	Line Amp Twist Amp SL & BU Nets 50A EQL 34A EQL	Line Amp Twist Amp SL & BU Nets 50A EQL Two 34A EQL	Line Amp Twist Amp SL & BU Nets 50A EQL 34B EQL
56	30D	1.6±0.3	1.8±0.4	3.0±0.6	3.2±0.6	3.4±0.6	1.6±0.6
56	30B	1.5±0.3	1.7±0.4	2.9±0.6	3.1±0.6	3.3±0.6	1.5±0.6
56	30A	1.5±0.3	1.7±0.4	2.9±0.6	3.1±0.6	3.3±0.6	1.5±0.6
56	30C	1.2±0.3	1.4±0.4	2.6±0.6	2.8±0.6	3.0±0.6	1.2±0.6
28	30D	15.8±0.6	15.8±0.9	16.7±1.0	17.6±1.2	18.5±1.4	15.8±1.2
28	30B	13.4±0.6	13.4±0.9	14.3±1.0	15.2±1.2	16.1±1.4	13.4±1.2
28	30A	11.9±0.6	11.9±0.9	12.8±1.0	13.7±1.2	14.6±1.4	11.9±1.2
28	30C	10.0±0.6	10.0±0.9	10.9±1.0	11.8±1.2	12.7±1.4	10.0±1.2
12	30D	24.6±0.8	24.5±1.5	24.4±1.5	24.4±1.7	24.4±1.9	24.4±1.7
12	30B	21.5±0.8	21.4±1.5	21.3±1.5	21.3±1.7	21.3±1.9	21.3±1.7
12	30A	18.7±0.8	18.6±1.5	18.5±1.5	18.5±1.7	18.5±1.9	18.5±1.7
12	30C	15.6±0.8	15.5±1.5	15.4±1.5	15.4±1.7	15.4±1.9	15.4±1.7

Notes:

1. When the HPF high pass filter is used, the decrease in gain at 12 kc may be 0.5 more than that specified above. The use of the HPF filter will make no change in gain at 28 and 56 kc.

2. The above limits are for normal-normal strappings of the 50A EQL. For other strappings, where the precision is warranted, make corrections as per Table V. Example: Suppose it is desired to determine corrected gain requirement at 28 KC for 30 D EQL, 6Y8, with 50A EQL on Half-Max. strapping and conditions of Column 8. (Note same conditions for Columns 4 to 8 in both Tables III and IV). From Table III the 60 kc gain requirement (at normal-normal strapping) is 74.8 ± 2.0 db. From Table IV the gain decrease for 28 kc is 15.8 ± 1.2 db, giving (74.8 ± 2.0)-(15.8 ± 1.2) = 59.0 ± 3.2 db. The correction for half-max. strapping, from Table V, is + 0.6 db, giving as the desired requirement (59.0 ± 3.2) + 0.6 = 59.6 ± 3.2 db. The limits on the desired requirement would be reduced to ± 1.2 db if based upon an actual measurement at 60 kc, itself within the ± 2.0 required limits of Table III.

TABLE V

Gain Corrections for 50A EQL, with respect to normal-normal strapping, for all possible strappings

Strapping of 50A EQL	Gain Correction for Tables III and IV for following Frequencies			
	60 KC	56 KC	28 KC	12 KC
Normal-normal	0	0	0	0
" -max.	-0.2	-0.5	0	0
" -min.	+0.3	+0.7	0	0
Half-max.	-0.2	-0.6	+0.6	+0.1
" -normal	0	0	+0.6	+0.1
" -min.	+0.2	+0.6	+0.6	+0.1

(E) Amplifier Gain - Load Measurement

4.17 The load carrying ability of carrier amplifiers is extremely important for satisfactory carrier system operation. The feedback type of amplifier drops its gain very suddenly when overloaded, with the result that modulation noise is produced over the entire carrier band by even momentary overloads. If the load carrying capacity of one amplifier in a long circuit is impaired, operation of the entire system may become unsatisfactory due to momentary load peaks.

4.18 The twist and line amplifier are designed to carry a load which will very rarely be exceeded when the system is lined up for normal operating levels. If the cause of the trouble is not readily apparent from a check of operating level, a load measurement made on the deviation regulator or on the individual amplifiers may be necessary to identify the particular amplifier which is overloading. This test can be made at an output of +30 dbm by using the three 10 db protective keys as a load pad at the output of the amplifier. At this increased level do not allow the oscillator frequency to become adjusted to a pilot frequency to avoid possible damage to the pilot filter. In measuring the line or twist amplifier alone it is necessary to open the wiring and insert shielded pair jumpers from the amplifier under test to the pairs of wires from the input and output sealed test terminals, as instructed in the procedures for such gain measurements.

4.19 Apparatus

1 - 17B Oscillator
1 - 30A Transmission Measuring Set
4 - 3P20B Cord Assemblies (P3P Cords with 305A Plugs at each end)
1 - 250 Ohm ± 1% Resistance (106A Type, or equivalent)
2 - 500 Ohm ± 1% Resistances (106A Type, or equivalent)

Note: Each of the 106A Type resistances is to be equipped locally with KS-6780 Connecting Clips and 108 Cord Tips, or their equivalent.

4.20 Procedure: - Gain-Load Measurements of Deviation Regulator, and Line, Twist, Auxiliary Switching and Test Amplifiers

(1) Prepare circuit conditions and arrange apparatus to measure the gain of the deviation regulator or amplifier in accordance with the procedure in Paragraph 4.10 for the general method of gain measurement and as further instructed under the procedure for the particular amplifier gain measurement.

(2) Measure the gain at 60 kc for an output of 1 milliwatt and note carefully the reading of the 30A set meter.

(3) With the test key in the ADJUST position and the attenuator reading equal to the amplifier gain, allow the three 10 db protection keys to remain non-operated.

(4) Remove 30 db from the attenuator in the 30A set with the 10 db protection keys non-operated and again read the meter.

Requirements: Except as noted below, the reading on the meter with 10 db protection keys non-operated should be within ± .2 db of the reading obtained in (2) above. For Line Amplifier operating with lead 'Z' on terminal 10 the reading should be within ± 0.3 db of that noted in (2) above.

(F) Measurement for Turnover in Wiring of Deviation Regulator

4.21 When transferring a deviation regulator from one carrier pair to another, it is important that there be no turnovers in the wiring of the equipment. A gain measurement made with two deviation regulators bridged together should not show a large change in gain

compared to the gain of each deviation regulator measured separately; a large change in gain would indicate turnover in the wiring of one deviation regulator with respect to the other, if the individual gains are approximately the same.

Caution: Care must be exercised to insure that there are no turnovers in the patches for the various test conditions.

4.22 In testing for wiring turnover, it is desirable to include, in the one set of measurements, as many as possible of the deviation regulators which operate in the same direction of transmission. After measuring the gain of each deviation regulator, select one as a "reference." The reference should preferably have approximately an average value of gain. Each of the other deviation regulators may then be tested in conjunction with this reference. The following procedure gives the details of each of these tests.

4.23 It is recommended that test resistance shunts on the thermistors be provided to secure gain measurements for the different deviation regulators with conditions more uniformly alike.

4.24 In order to insure that no turnover exists in the wiring of a deviation regulator with respect to the wiring of the reference deviation regulator, the gain of the parallel combination is compared with the gain of the reference alone. If the individual gains are the same, the gain of the parallel combination will be 1 db less than that of each one alone. In the test herein specified, each deviation regulator may deviate by ± 2 db from its nominal value of gain so that an allowance for this variation is made in the requirement for the gain of the parallel combination.

4.25 Apparatus

1 - 17B Oscillator
1 - 30A Transmission Measuring Set
6 - 3P20B Cord Assemblies (P3P Cords equipped with 305A Plugs at each end)
1 - W3R Cord equipped with 308A Plug at one end and 305A Plug at the other end
1 - 250 Ohm ± 1% Resistance (106A Type, or equivalent)
2 - 500 Ohm ± 1% Resistances (106A Type, or equivalent)
8 - 258C Plugs

Note: Each of the 106A Type resistances is to be equipped locally with KS-6780 Connecting Clips and 108 Cord Tips or equivalent.

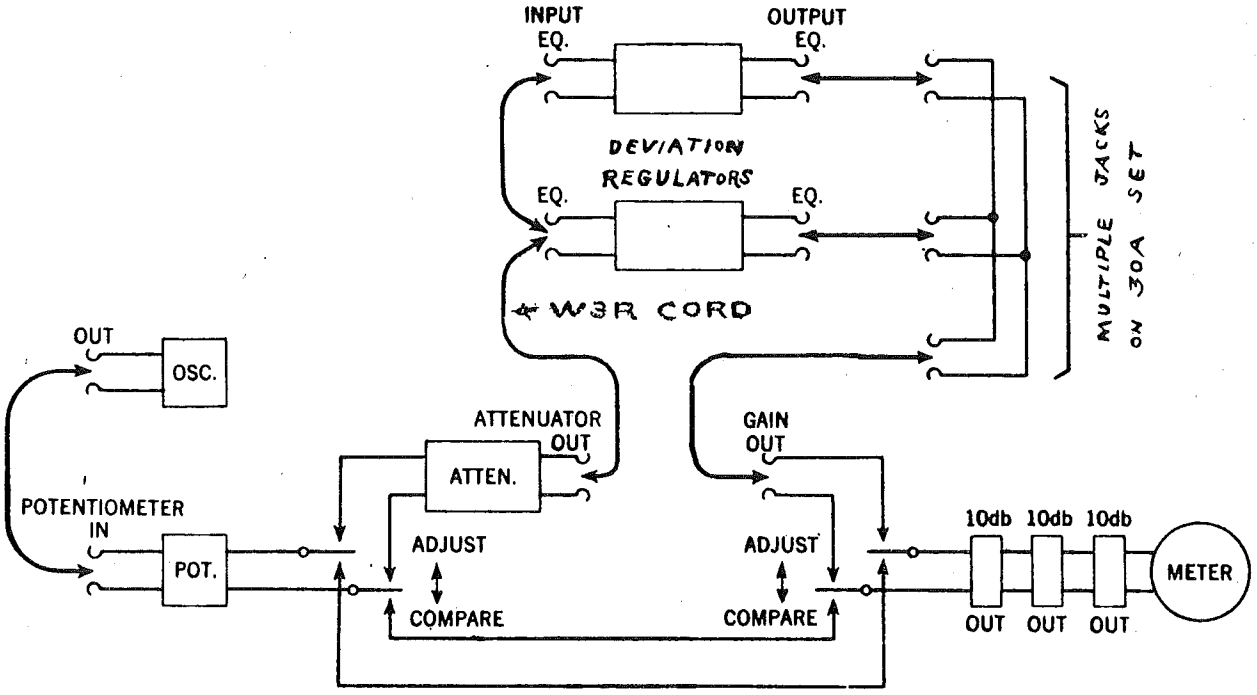


Fig. 5 - Test for Wiring Turnover

4.26 Procedure - See Fig. 5

(1) Prepare circuit conditions and arrange apparatus to measure the gain of each deviation regulator to be tested for wiring turnover, in accordance with the procedure in Paragraph 4.10.

(2) Make gain measurements at a frequency of 29 kc on each deviation regulator to be tested for wiring turnover.

Requirement: The maximum and minimum values of gain shall not differ by more than 4 db.

(3) Remove the patch cords between the 30A set and the deviation regulator last tested.

(4) Select a deviation regulator having approximately average gain for use as the reference. Set up the circuit for measuring each of the other deviation regulators in parallel with this reference, according to the following procedure:

(a) Patch the inputs of the two deviation regulators together at the EQ jacks in the input sealed test terminal.

(b) Insert the 308A Plug, at one end of the W3R cord, into one of the 305A plugs on the cord strapping the EQ jacks in the input sealed test terminal. Connect the plug at the other end of the W3R cord to the ATTENUATOR OUT jacks.

(c) Patch the output of each deviation regulator at the EQ jacks in the output sealed test terminal (or REC AMP OUT jacks at a terminal office) to the multiple jacks on the 30A set.

(d) Patch the remaining one of the multiple jacks to the GAIN OUT jacks of the 30A set.

(5) Measure the gain at 29 kc of this parallel combination of deviation regulators.

Requirement: The gain should be within -4 db and +2 db of the gain of the deviation regulator which was chosen as a reference.

Caution: Do not leave the deviation regulators bridged together longer than is necessary to make the measurement.

(6) If the requirement is not met because of low gain, turn over the patch cord from the output of one of the deviation regulators to see if the limit is met when a deliberate turnover is introduced. If the requirement is then met, a wiring turnover exists in the deviation regulator which has been added in parallel with the reference deviation regulator; this turnover should be located and corrected.

(7) Check each of the deviation regulators, for a given direction of transmission, in combination with the reference. This will indicate a minimum number which should be checked for errors in wiring which cause turnover. Make corrections in wiring errors so that all deviation regulators will be uniform and meet the above requirement.

(G) Thermistor Heater Voltage

4.27 The thermistor resistance which determines the amount of equalization and deviation regulator gain is a function of the a-c voltage across the heater of the thermistor. The heater voltage is therefore a useful indication of the performance of the system and of the amount of range still available in the deviation regulator. If the cable temperature is known at the time when the heater voltage is measured, the amount of regulator range which will probably be required to care

for extreme temperature variations can be estimated, but because of the difficulty of determining the cable temperature throughout the cable section for which regulation is provided, no test is practicable for the determination of this range.

4.28 Useful information may be obtained regarding the performance of a particular carrier system from a pair to pair comparison of the heater voltages even though the cable temperature is not known. Any large variation of the heater voltage of a thermistor of a given regulator from the average voltage of other similar thermistors may be taken as an indication of possible trouble in this pair. inasmuch as a high degree of similarity is normally exhibited among corresponding pairs of a cable.

4.29 For purpose of information, the percentage of the operating range inserted by each regulating network is given as a function of the heater voltage in TABLE VI; the table also gives the db change in gain inserted and the value of the corresponding thermistor resistance.

4.30 Apparatus

1 - 2P1D Cord Assembly (P2A Cord with 347A Plugs at each end)

4.31 Procedure:

(1) With the 2P1D cord connecting the 0-5 volt voltmeter at the V jack on the limiter circuit to each of the three A jacks in turn on the control circuit, measure and record the voltage for each case.

Requirement: No one voltage should differ from the average voltage by more than ± 1.0 volt.

(2) To make a very rough estimate of the range still available in the regulator refer to TABLE VI.

TABLE VI

Thermistor Heater Voltage as an Indication of the Portion of Regulator Range Inserted

Flat Gain Regulation

Voltage Across Heater of Thermistor (Volts)	% of Operating Range Inserted	Change in Flat Gain from Average Gain Setting	Thermistor Resistance
3.1 ± 0.6	100% of available increase in gain	+11.0 db	60 Ohms
2.6 ± 0.5	50% of available increase in gain	+ 5.5 db	125
2.2 ± 0.5	0	0	250
1.7 ± 0.5	50% of available decrease in gain	- 5.5 db	540
1.2 ± 0.5	100% of available decrease in gain	-11.0 db	2000

Slope Regulation

Voltage Across Heater of Thermistor (Volts)	% of Operating Range Inserted	Amount Slope Inserted (12 KC Gain-60KC Gain)	Thermistor Resistance
3.3 ± 0.7	100% of (+) Slope	+10 db	50 Ohms
2.3 ± 0.6	50% "	+ 5 db	200
1.8 ± 0.5	0	0	500
1.4 ± 0.5	50% of (-) Slope	- 5 db	1200
0.8 ± 0.5	100% "	-10 db	5000

Bulge Regulation

Voltage Across Heater of Thermistor (Volts)	% of Operating Range Inserted	Amount of Bulge Inserted (28 KC Gain-12 KC Gain) (= Approx. 0.9 x Change in 28 KC Gain)	Thermistor Resistance
3.3 ± 0.7	100% of (+) Bulge	+ 7.5 db	50 Ohms
2.3 ± 0.6	50% "	+ 3.7 db	200
1.8 ± 0.5	0	0	500
1.4 ± 0.5	50% of (-) Bulge	- 3.5 db	1200
0.8 ± 0.5	100% "	- 7.0 db	5000

(H) Gain Measurement - Auxiliary Switching Amplifier - Key Operated Switching Circuit

4.32 Apparatus

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

4.33 Procedure

(1) For circuit preparation follow the general procedure of gain measurements as given in Paragraph 4.10 except that no deviation regulator circuit preparation is required.

(2) Patch from the ATTENUATOR OUT jacks of the 30A set to the SW AMP IN jacks of the auxiliary switching amplifier.

(3) Patch from the SW AMP OUT jacks of the auxiliary switching amplifier to the GAIN OUT jacks of the 30A set.

(4) Measure the gain at 12, 28 and 60 KC.

Requirements:

Frequency in KC	db Gain	db Change in Gain from 12 KC Gain
12	40.3±1.0	
28		+0.3±0.5
60		+1.0±0.7

(I) Gain Measurement - Line Amplifier

4.34 Apparatus

1 - 17B Oscillator
1 - 30A Transmission Measurement Set
1 - 250 Ohm ± 1% Resistance (106A Type, or equivalent)

3 - 3P20B Cord Assemblies (P3P Cords equipped with 305A Plugs at each end)
4 - 258C Plugs
Shielded Pair Wire to serve as a jumper
Soldering Equipment

Note: The 106A Type resistance is to be equipped locally with KS-6780 Connecting Clips and 108 Cord Tips, or their equivalent.

4.35 Procedure

(1) For circuit preparation follow the general procedure for gain measurements as given in Paragraph 4.10 except that no test resistance shunts are required on the SL and BU thermistors.

(2) Disconnect wires from the line and twist amplifiers as follows:

(a) At the line amplifier OUT output transformer, disconnect wires from terminals 1 and 4.

(b) At the twist amplifier OUT output transformer, disconnect wires from terminals 1 and 4 and to these leads connect a shielded pair jumper wire the other end of which is then connected to terminals 1 and 4 of the line amplifier OUT output transformer.

(3) Measure the gain at 12, 28, 56, and 60 kc between the EQ jacks at the input sealed test terminal and the EQ jacks at the output sealed test terminal. At a terminal office, the corresponding jacks are designated EQ and REC AMP OUT.

Requirements: The gain at 60 kc should meet the requirements of Table III. The gain at 12, 28 and 56 should be less than the gain measured at 60 kc by the amounts given in Table IV.

(4) Remove the shielded jumper wire and restore the normal connections to the output transformers of the line and twist amplifiers.

(J) Gain Measurement - Twist Amplifier

4.36 Apparatus

1 - 17B Oscillator
1 - 30A Transmission Measuring Set
4 - 3P20B Cord Assemblies (P3P Cords equipped with 305A Plugs at each end)
Shielded Pair Wire to Serve as a jumper
Soldering Equipment

4.37 Procedure

(1) For circuit preparation follow the general procedure for gain measurements as given in Paragraph 4.10 except that no test resistance shunts are required on the thermistors.

(2) Disconnect wires from the line and twist amplifiers as follows:

(a) At the twist amplifier IN input transformer disconnect wires from terminals 1 and 1T.

(b) At the line amplifier IN input transformer, disconnect wires from terminals 1 and 4 and to these leads connect a shielded pair jumper wire the other end of which is then connected to terminals 1 and 1T of the twist amplifier input transformer.

(3) Patch from the ATTENUATOR OUT jacks of the 30A set to 135-ohm jacks of one of the 135:600-ohm repeating coils of the 30A set.

(4) Patch from the 600-ohm jacks of the repeating coil to the EQ jacks at the input sealed test terminal.

(5) Measure the gain at 12, 20, 40 and 60 kc between the 135-ohm jacks of the 135:600-ohm repeating coil and the EQ jacks at the output sealed test terminal. At a terminal office, the corresponding jacks are designated REC AMP OUT. The gain is the attenuator setting plus the repeating coil loss plus or minus the meter reading.

Requirements:

Frequency in kc	Gain in db at 12 kc	Change in Gain in db from 12 kc Gain
12	66.0 ± 1.0	
28		-0.2 ± 0.5
56		-0.3 ± 0.5
60		-0.3 ± 0.5

(6) Remove the shielded jumper wire and restore the normal connections to the input transformers of the line and twist amplifiers.

5. TESTS AND ADJUSTMENTS OF CONTROL AND LIMITER CIRCUITS

(A) Maximum 60-Cycle Output Voltage

5.01 The maximum 60-cycle a-c output voltage, measured at the A jacks, is obtained for a condition of no pilot input. Normally the 60~ transformer in the control circuit shall operate with connection to tap 4 on the secondary winding. In special cases (as when the preceding deviation line section is longer than usual, or the voltage supply below 55 volts) tap 5 may be used. Taps 6, 7 and 8 should never be used due to risk of burning-out the thermistors.

5.02 Apparatus

1 - 2P1D Cord Assembly (P2A Cord equipped with 347 Plugs at each end)
4 - 258C Plugs
1 - 323A, 135 Ohm Plug
Soldering Equipment

5.03 Procedure

(1) Insert 258C plugs into the three B jacks on the control circuit.

(2) Insert a 323A plug into the EQ jacks at the input sealed test terminal.

(3) With the 2P1D cord patch from the 0-5 volt voltmeter at the V jack on the limiter circuit to each of the three A jacks in turn on the control circuit.

(4) Measure and record the voltage at each A jack, the transformer tap 4 or 5 being used as specified.

Requirements:

Voltage of 55 Volt AC Supply	A-C Output Voltage Tap 4		Tap 5	
50	3.0 ± 0.5		3.5 ± 0.5	
51	3.1	"	3.6	"
52	3.2	"	3.7	"
53	3.3	"	3.8	"
54	3.4	"	3.9	"
55	3.5	"	4.0	"
56	3.6	")		
57	3.7	") Not		
58	3.8	") recommended		
59	3.9	") with Tap 5		
60	4.0	")		

(B) Pilot Filter Characteristics

5.04 If the pilot filter of the control circuit has normal band width and normal discrimination (the filter discrimination is

the difference between its loss outside the pass band and its loss within the pass band), it is very probable that the loss in the pass band, the tuning adjustment, and the other characteristics of the filter are satisfactory. Therefore this paragraph gives only measurements of band width and discrimination. Fig. 7 shows typical filter characteristics.

5.05 Details of this instruction are given using the 56 kc pilot frequency (flat gain control) as an example. A similar procedure is followed for each of the other two pilot frequencies with appropriate changes made in the procedure to correspond to the pilot frequency under test.

5.06 Apparatus

1 - 17B Oscillator
1 - 30A Transmission Measuring Set
1 - 250 Ohm ± 1% Resistance (106A type, or equivalent)
2 - 500 Ohm ± 1% Resistance (106A type, or equivalent)
1 - 200 Ohm ± 1% Resistance (106A type, or equivalent)
3 - 3P20B Cord Assemblies (P3P Cords equipped with 305A Plugs at each end)
1 - 2P1D Cord Assemblies (P2A Cords with 347 Plugs at each end)
4 - 258C Plugs
2 - 113A, 31.2 Ohm Resistances Soldering Equipment

Note: Each of the 106A Type resistances is to be equipped locally with KS-6780 Connecting Clips and 108 Cord Tips, or their equivalent.

5.07 Procedure - Pilot Filter Band Width: See Fig. 6 and Fig. 7

(1) Remove the control circuit from the limiter circuit by inserting the 258C plugs into the three B jacks of the control circuit.

(2) Shunt the flat gain control TH thermistor of the line amplifier by the 250 ohm test resistance and the BU and SL thermistors of the slope and bulge networks by the 500 ohm test resistances.

(3) Insert 113A resistances in the two tube positions not used, in this case tube positions 3 and 4.

(4) Lift off leads from terminals 3 and 4 of the TH thermistor (on the line amplifier panel) and connect to the removed leads the 200 ohm test resistance.

(5) Set the oscillator to the pilot frequency and adjust its output to a minimum.

(6) Patch from the oscillator OUT jacks to the POTENTIOMETER IN jacks of the 30A set. Set attenuator at maximum.

(7) Patch from the ATTENUATOR OUT to the EQ jacks of the deviation regulator under test at the input sealed test terminal.

(8) Patch the 0-5 volt voltmeter at the V jack on the limiter circuit to the A-56 kc jack on the control circuit.

(9) With at least 34 db in the attenuator of the 30A set operate the test key of the 30A set to ADJUST position and adjust the output of the test oscillator to give a reading of about 2 volts on the voltmeter.

(10) Adjust the frequency of the oscillator to give a minimum voltmeter reading, leaving the "cycles" dial of the oscillator on "0". Note that two minima may be obtained with a normal filter, as indicated in Fig. 7. Either minimum point may be used for this test inasmuch as the primary objective is to obtain a frequency within the pass band.

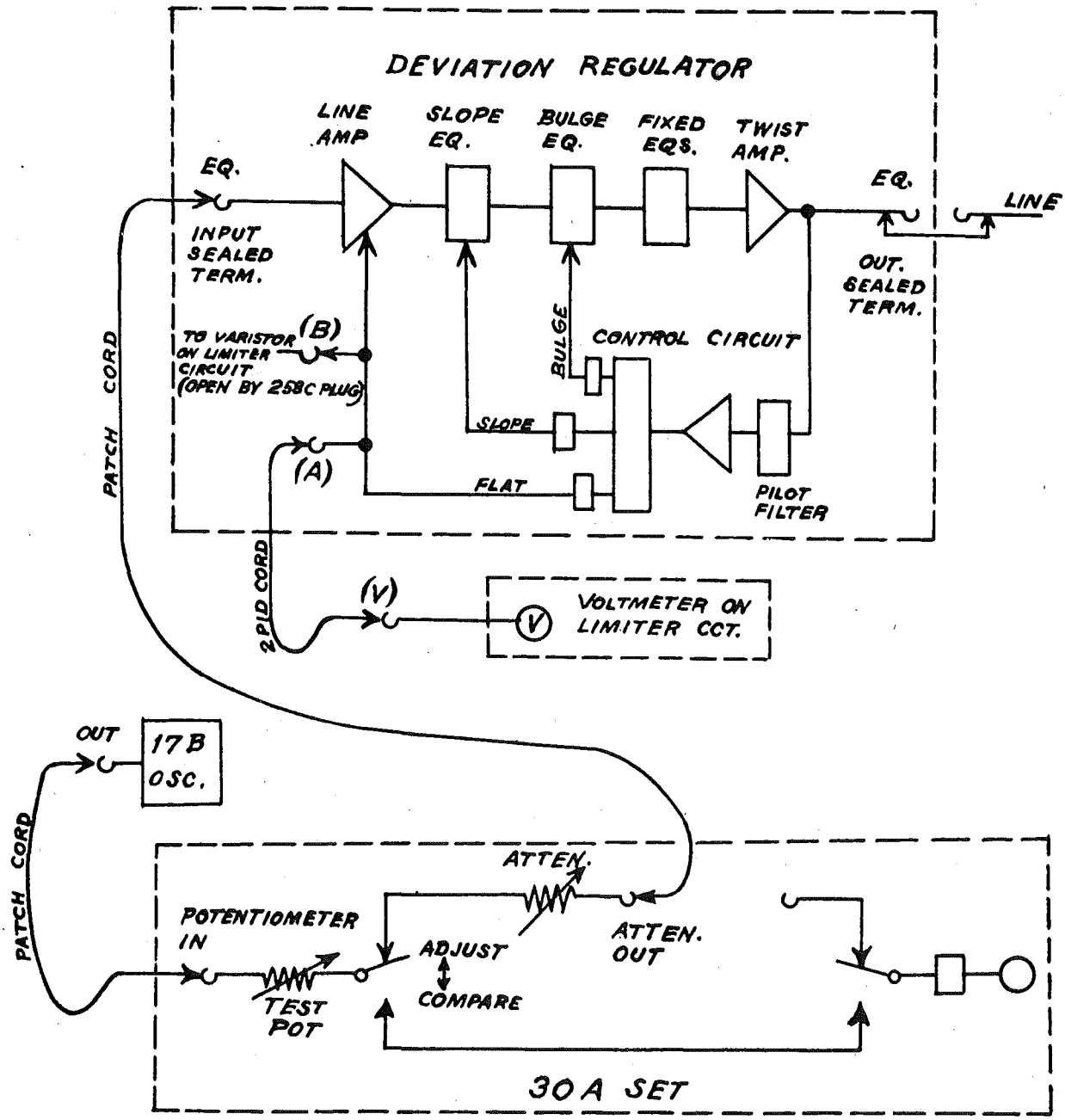
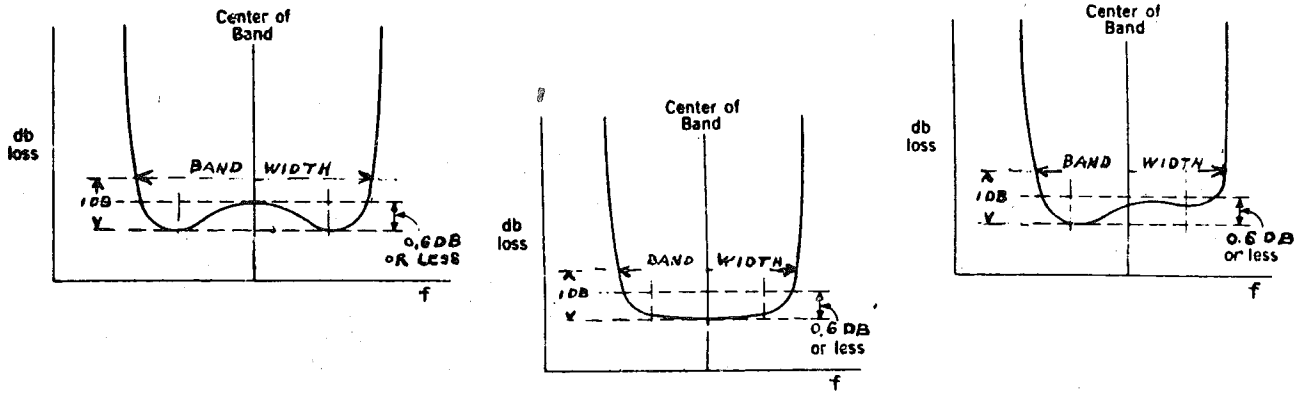
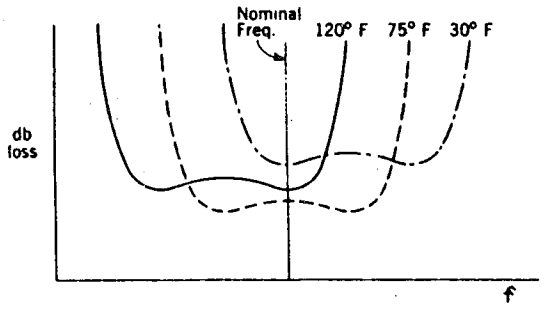


Fig. 6 - Pilot Filter Band Width Measurement

(A) NORMAL BAND SHAPES



(B) NORMAL TEMPERATURE EFFECT



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

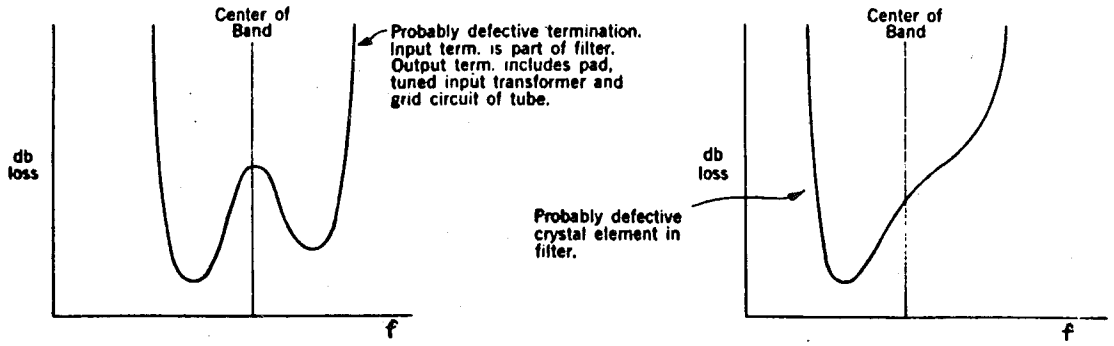


Fig. 7 - Typical Pilot Filter Characteristics

(11) Readjust, if necessary, the output of the test oscillator until a reading of 2.0 volts is again obtained on the voltmeter.

(12) Decrease the loss in the attenuator by 1.0 db. This will cause the voltmeter reading to decrease to a very low value.

(13) Using the "cycles" dial of the oscillator, increase the frequency of the oscillator until a reading of 2.0 volts is again obtained on the voltmeter. This indicates that at this frequency the loss of the filter has increased by 1.0 db relative to its loss at the tuning point. Record this reading of the "cycles" dial.

(14) Decrease the frequency of the oscillator below the tuning point, by means of the "cycles" dial, until the voltmeter reading again increases to 2.0 volts. The number of cycles by which the frequency is decreased may be either greater or less than the number of cycles by which it was increased in the test above; this is to be expected in view of the typical filter characteristics, as indicated in Fig. 7. Also note that, if two minimum points occur in the filter characteristic, an increase of 0.6 db or less may be obtained in the filter loss between these two frequencies; since this increase in loss is less than 1.0 db in a normal filter, it will not affect this test.

(15) Determine the total change in frequency between the 1 db points of the filter characteristic from the two above tests. This is taken as the filter band width.

Requirements:

Pilot Frequency	Minimum Band Width
56 kc	35 cycles
28 kc	35 cycles
12 kc	10 cycles

5.08 Procedure - Pilot Filter Discrimination:

(1) After the procedure for the band width test is completed, change the frequency of the oscillator successively on each side of the pilot frequency by the amount indicated in the following table. After this is done change the loss in the attenuator by the amount indicated:

Pilot Frequency	Decrease Loss in Attenuator by	Change Oscillator Frequency by
56 kc	34 db	± 500 cycles
28 kc	34 db	± 500 cycles
12 kc	34 db	± 500 cycles

(2) Note the voltmeter reading.

Requirements: The voltage in each case should be not less than 2.0 volts, indicating a discrimination of at least 34 db at frequencies 500 cycles above and below each pilot. Satisfactory discrimination at other frequencies outside the band is then reasonably assured.

Caution: Do not return oscillator to pilot frequency before reducing output, to avoid damage to pilot filter.

(3) Restore circuits to normal.

(C) Control Circuit Tuning Adjustment

5.09 The OUT output transformer of the control circuit is tuned, by means of a screwdriver capacity adjustment, to each pilot frequency. This adjustment is made at the factory and no readjustment should normally be required unless a different varistor unit is later installed in the control circuit.

5.10 The procedure outlined in this paragraph is based upon the fact that the thermistor resistance changes slowly in response to a change in its heater voltage, and that its heater voltage may be readily observed as a function of loss inserted or removed in the pilot frequency path of the control circuit. A change in the tuning capacity of the transformer changes the pilot frequency voltage appearing across the secondary winding, giving maximum voltage when correct tuning is obtained. An increase in the pilot level delivered to the varistor increases the negative grid bias on the control tube which in turn reduces the amount of 60 cycle voltage delivered to the heater of the thermistor. Accordingly, if this 60 cycle heater voltage is observed as an indication of tuning, the tuning adjustment may be made for a minimum voltage on the heater of the thermistor. In order that the test may be made without waiting for the thermistor to change its resistance in response to the change in tuning adjustment, and in order that advantage may be taken of the expandor action of the control circuit whereby a large change in voltage is produced across the thermistor heater as the result of a small change in transmission loss of the pilot frequency, it is recommended that the tuning adjustment be made rapidly. This procedure should be carried out when the deviation regulator is operating normally on its pilot frequencies.

5.11 Apparatus

1 - 2P1D Cord Assembly (P2A Cord with 347 Plugs at each end)
1 - 258C Plug
1 - Screwdriver with insulated shaft to reduce capacity effects at 56 kc

5.12 Procedure

(1) Note that pilot frequencies are being normally received.

(2) Insert the 258C Plug into the B jack of the pilot frequency under test, to remove the limiter circuit.

(3) Patch the 0-5 volt voltmeter, at the V jack on the limiter circuit, to the A jack corresponding to the pilot frequency under test.

(4) Make the screwdriver adjustment of the proper tuning capacity of the OUT transformer with sufficient speed so that the minimum reading can be quickly obtained on the voltmeter corresponding to the position of correct tuning. When the transient response on the voltmeter resulting from a change in the screwdriver adjustment is toward a lower voltage on the voltmeter, the adjustment is being made in the proper direction. At the point of correct tuning, a change in either direction will cause an increase in the voltmeter reading.

Requirement: The screwdriver adjustment shall be left in the position for correct transformer tuning, as indicated by a minimum voltmeter reading.

(D) Regulator Sensitivity and Regulation Accuracy

5.13 The regulator sensitivity, at a given pilot frequency, is the pilot frequency power in milliwatts (expressed in dbm) required into a 135 ohm termination at the deviation regulator output (EQ jacks at the output sealed test terminal) to produce an average value of deviation regulator gain at the pilot frequency in question. Average values of deviation regulator gain are obtained when the thermistor resistances are 500 ohms in the slope and bulge networks and 250 ohms in the flat gain regulator. The heater voltages corresponding to these values of thermistor resistances are given in Table VI.

5.14 The regulation accuracy is determined by the departure, in db, of the pilot level at the output of the deviation regulator from its desired value, which is nominally -11.0 dbm. As a measure of the performance of the regulating system, the regulation accuracy is specified for a given change in pilot frequency input level.

5.15 Normal regulator operation requires that the regulator sensitivity should be correctly adjusted and that the regulation accuracy should be within specified limits for a given change in pilot frequency level at the input of the deviation regulator.

5.16 When the type K1system is operated at its normal +9 db output level with respect to the transmitting toll switchboard, the pilot frequency is supplied to the line at the output of the transmitting amplifier at the nominal value of -11 dbm. The +9 db level is normally maintained at the output of successive repeaters by the action of the regulating system. For this normal operating range, "X" wiring should be used on the F resistance of the control circuit as specified on SD-64395-01 and as indicated in the table in the following paragraph.

5.17 When a different operating level is desired, as in the case of special system operating conditions, the desired level may be obtained by the following strapping.

REGULATOR SENSITIVITY ADJUSTMENT
CONTROL CIRCUIT STRAPPING REQUIREMENTS

Specified Output Level	Strapping on "F" Resistance	Wiring on Potentiometers H, J and K
+13 db	Omit "X","Y" and "Z" Wiring	"S" Wiring
+11 db	Omit "X","Y" and "Z" Wiring	"R" Wiring
+ 9 db	"X" Wiring	"R" Wiring
+ 7 db	"Y" Wiring	"R" Wiring
+ 5 db	"Z" Wiring	"R" Wiring

5.18 Intermediate values are obtained by making the adjustment to the nearest nominal value of column 1 and then adjusting the grid bias potentiometers H, J, and K to give the desired output level.

5.19 The regulator sensitivity for each pilot frequency is determined primarily by the relative values of the grid bias supplied to tube 2, 3 or 4 thru potentiometer K, J or H, and the rectified pilot voltage across resistance M, N or P supplied by the varistor. This rectified voltage is affected by transmission variations of the pilot filter, the input transformer, tube 1, the OUT transformer, and the varistor. Compensation for these variations is obtained in the adjustment of the grid bias supplied by potentiometers H, J and K.

5.20 The adjustment of the regulator sensitivity should constitute the last adjustment of the control circuit. It is assumed that the tuning adjustment as has been made at the factory on the OUT output transformer is satisfactory, that the voltage adjustment has been made on the 60~ transformer, and that the pilot filter is normal with respect to band width and discrimination.

5.21 The discussion and procedure following is given with regard to a regulator sensitivity of -11.0 dbm. In systems operating at different sensitivity the appropriate changes must be made.

5.22 The adjustments required in the control circuit, which determine the regulator sensitivity are such that when the pilot level is -11.0 dbm at the output of the deviation regulator, the average losses should be inserted in the flat, slope and bulge networks.

5.23 In actual operation with correct equalization over the system this would give a flat overall characteristic at an average cable temperature of 55° F.

5.24 The average flat loss characteristic of the flat network is obtained with a thermistor resistance of 250 ohms; of the slope and bulge networks, thermistor resistances for each of 500 ohms.

5.25 With test resistances of these values shunted about the cold thermistors and pilot frequency supplied by a local oscillator the input can then be adjusted to give an output of -11.0 dbm at each pilot frequency in turn. Each shunt resistance is removed when the input of the corresponding pilot frequency has been adjusted to give the -11.0 dbm output after which the corresponding control circuit potentiometer is adjusted, with input unchanged, to reobtain the same output.

5.26 Apparatus:

1 - 30A Transmission Measuring Set
1 - 42A Transmission Measuring System
1 - Portable a-c Voltage Test Set per J68602AH, if available
1 - 250-Ohm ± 1% Resistance (106A Type or equivalent)
2 - 500-Ohm ± 1% Resistances (106A Type or equivalent)
2 - 113A 31.2-Ohm Resistances
1 - 312A Plug
4 - 258C Plugs
4 - 3P20B Cord Assemblies (P3P Cords with 305A Plugs at each end.)
1 - 2P1D Cord Assembly (P2A Cord with 347A Plugs at each end)
1 - W3R Cord equipped with 308A and 305A Plugs

Note: Each of the 106A Type resistances is to be equipped locally with KS-6780 Connecting Clips and 108 Cord Tips or their equivalent.

5.27 Procedure - Regulator Sensitivity Adjustment See Fig. 8

(1) Make a preliminary measurement of the gain of the auxiliary switching amplifier at the pilot frequency of test, as per Part 4(H).

(2) Insert 258C plugs into the three B jacks of the control circuit, after which insert a 258C plug into the FIL jack of the control circuit.

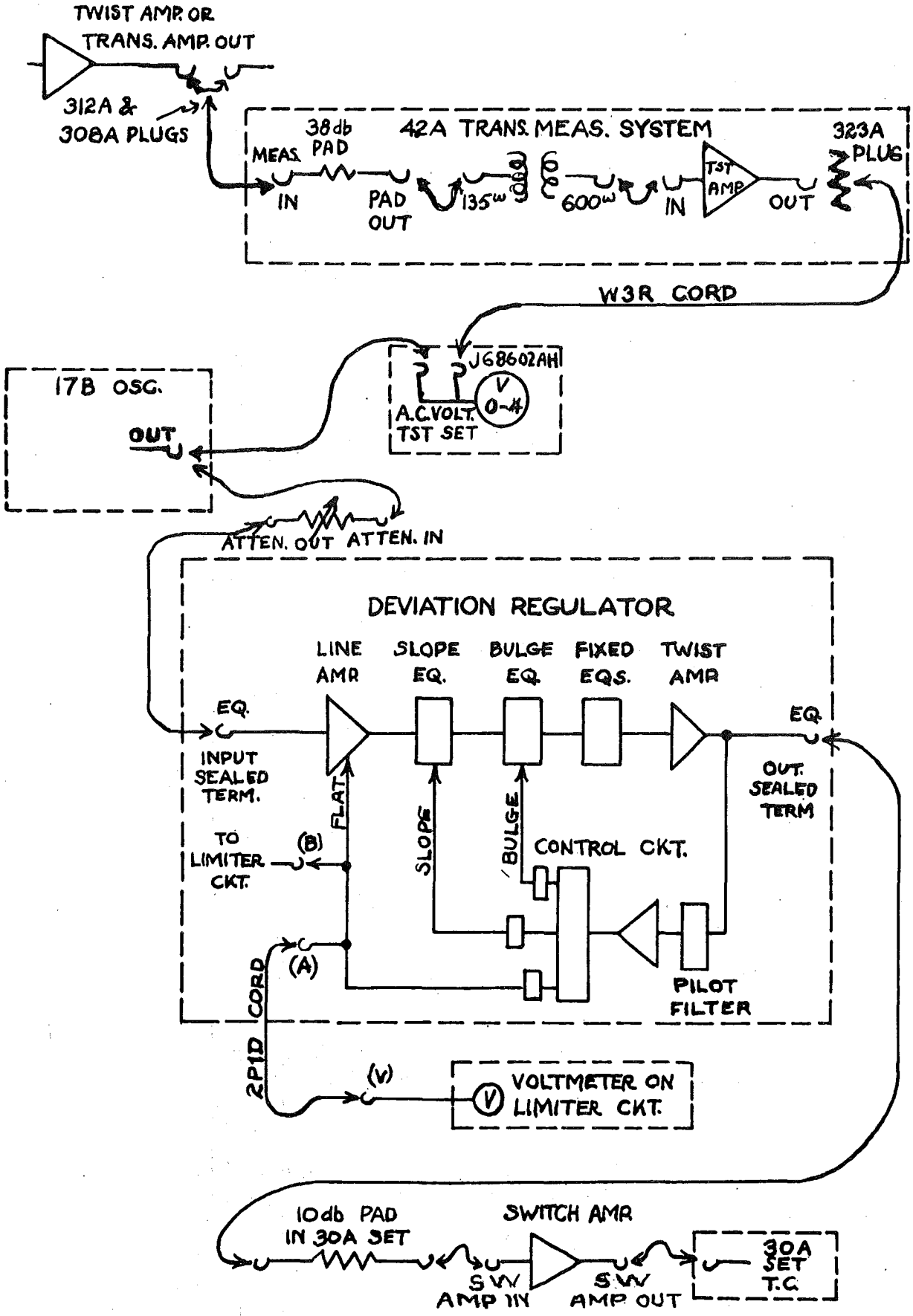


Fig. 8 - Regulator Sensitivity Adjustment and Regulator Accuracy Measurement

(3) Shunt terminals 1 and 2 of the TH thermistor with the 250 ohm test resistance and terminals 1 and 2 of the SL and BU thermistors with the 500 ohm test resistances.

(4) Calibrate the frequency of the 17B oscillator to the pilot frequency - 56, 28 or 12 kc, using as standard the pilot frequency from another system, which may be safely bridged off into the high impedance input pad of the 42A transmission measuring system, proceeding as follows:

(a) Insert the four prong adapter plug, 312A, into the EQ-LINE jacks at the output sealed test terminal on the other system. At a terminal office insertion would be made into the REC AMP OUT - GR DEM IN jacks.

(b) Insert into the 312A plug the 308A plug on the LEV MEAS cord of the 42A transmission measuring system.

(c) At the PAD OUT or MEAS TRK OUT jacks, as provided, on the 42A measuring system patch to the 135-ohm jacks of one of the 135: 600-ohm repeating coils in the 30A set.

(d) Patch the 600-ohm jacks from the repeating coil to the TST AMP IN jacks at the test amplifier in the 42A measuring system.

(e) Terminate the TST AMP OUT jacks of the test amplifier by the 323A, 135-ohm plug.

(f) Insert into the 323A plug the 308A plug at one end of a W3R cord and connect the 305A plug at the other end of the cord to one set of T and R jacks on the portable a-c voltage test set J68602AH (0-4 volt scale).

(g) Patch from the other (multiple) T and R jacks on the voltage test set to the OUT jacks of the 17B oscillator. If the J68602AH test set is not available the 0-5 volt a-c voltmeter on the limiter circuit may be used with suitable long cords being provided.

(h) Slowly adjust the frequency setting on the 17B oscillator until a beat of less than 2 per second is obtained on the voltmeter for the particular pilot frequency of test.

(5) With the 17B oscillator now calibrated for the 56, 28 or 12 kc frequency, as desired, disconnect the calibrating cord from the 17B oscillator OUT jacks and patch these jacks to the ATTENUATOR IN jacks on the 30A set. Set the oscillator to a minimum output and the attenuator to a maximum setting.

(6) Patch from the ATTENUATOR OUT jacks on the 30A set to the EQ jacks at the input sealed test terminal for the deviation regulator to be tested.

(7) Patch from the EQ jacks at the output sealed test terminal, or REC AMP OUT jacks at a terminal office, to the 10 db pad IN of the 30A set.

(8) Patch from the 10 db pad OUT jacks to the SW AMP IN jacks on the auxiliary switching amplifier.

(9) Patch from the SW AMP OUT jacks of this switching amplifier to the thermocouple jacks on the 30A set.

(10) With a 2P1D cord patch from the V jack of the 0-5 volt a-c voltmeter in the limiter circuit to the A jack, corresponding to the pilot frequency of test, in the control circuit.

(11) Place a 113A resistance in each of the tube positions in the control circuit of the two pilot frequencies not under test.

(12) Operate one 10 db meter protection key on the 30A set thermocouple and decrease the attenuator setting in the 30A set to obtain a reading on the meter of (G-41) db, where G is the gain of the auxiliary switching amplifier as determined in Item (1). The output from the deviation regulator will then be -11.0 dbm.

(13) Remove the 258C plug from the FIL jack of the control circuit.

(14) Remove the resistance shunt from terminals 1 and 2 of the thermistor corresponding to the pilot frequency of test.

(15) Adjust the appropriate one of the gain bias potentiometers H, J or K; H for the 12 kc pilot, J for the 28 kc pilot and K for the 56 kc pilot to again obtain the reading of (G-41) db on the thermocouple meter with one 10 db protection key operated. The sensitivity is then adjusted to the normal -11.0 dbm at the output of the deviation regulator.

(16) Record the thermistor heater voltage. This is the heater voltage which gives a thermistor resistance equal to the test resistance of 250 or 500 ohms as used in this test.

(17) Proceed with the regulation accuracy measurement of Paragraph 5.28 for the particular frequency just adjusted for sensitivity, before changing to another pilot frequency.

5.28 Procedure - Regulator Accuracy Measurement - See Fig. 8

(1) Increase and decrease the attenuation, from the value found to give -11.0 dbm output, by the amount shown in the requirements table below.

Requirements: The changes in output level produced by the indicated changes in input level are not to exceed the values given in the following table.

Regulation Accuracy Requirements

(60~) Transformer Tap	Change in Input Levels at 56 kc	28 kc	12 kc	Max. Change In Output Level
4	± 5.0 db	± 5.0 db	± 3.0 db	± 0.3 db
5	± 8.0 db	± 6.0 db	± 4.0 db	± 0.4 db

(2) Make similar sensitivity and regulation accuracy measurements for each of the other two pilot frequencies.

(3) Restore all circuits to normal.

(E) Limiter Circuit

(1) Connections From Control Circuit to Varistors of Limiter Circuit

5.29 It is the purpose of the gain deviation limiter circuit to prevent an excessive increase in gain as a result of failure of the pilot frequency or of the regulating equipment. This is accomplished by means of the shunting effect of the A varistor together with the distribution bus and its associated varistors, across the heater of each regulating thermistor. This becomes effective when the voltage across the thermistor heater becomes abnormal. Optional connections are provided to the limiter circuit so that it will not limit the heater voltage to such an extent as to impair compensation for normal variations of the individual circuits.

5.30 The limiter circuit is not specified when the number of circuits which would connect to a common limiter distribution bus is less than five.

5.31 In general, the connections from the control circuit to the A varistors of the limiter circuit should be made in accordance with the instructions of this paragraph. The deviation regulators on all pairs should be working normally and all systems should be in normal working condition at all previous repeater points at least as far back as the previous deviation regulator and preferably as far back as the transmitting terminal.

5.32 It will be assumed in this instruction that the system is available for test purposes and has been properly lined up at all points between the transmitting terminal and the repeater or receiving terminal under test. If this is not the case, the equivalent condition for the adjustment of the limiter circuit can be obtained by transmitting in turn each pilot frequency to the line at the previous deviation regulator point at the nominal level of -11 dbm.

5.33 Apparatus

1 - 2PID Cord Assembly (P2A Cord with 347A Plugs at each end)
258C Plugs, one per system connected to limiter circuit.
Soldering Equipment

5.34 The procedure is given using the 12 kc pilot frequency as an example. The procedure for each of the other pilot frequencies is similar when appropriate changes are made according to the frequency under test.

5.35 Procedure:

(1) Plug off the gain deviation limiter circuit by inserting 258C plugs into the B jacks of the control circuits associated with the particular limiter circuit.

(2) With a 2PID cord patch from the V jack of the 0-5 volt voltmeter to the A jack of the thermistor heater associated with the 12 kc pilot frequency.

(3) Measure and make a record of the a-c voltage.

(4) Make similar measurements and records of the a-c voltages across the heaters of the 12 kc pilot frequency thermistors of each of the other deviation regulators in the office.

(5) Compute the average of all the voltages measured on the 12 kc pilot frequency thermistors. Compute the difference in voltage of the deviation regulator in question from the average of all of the voltages. Determine the per cent difference, that is, the per cent change in voltage from the average voltage, by taking the difference in voltage between the average and the individual voltage divided by the average voltage, this ratio being multiplied by 100. Make connections to the deviation limiter according to Table VII.

(6) Make measurements, computations and connections for each of the other two pilot frequencies in a similar manner.

TABLE VII

Choice of Limiter Circuit Connections

% Change in Voltage from Avg. Voltage $\left(=\frac{\text{Avg. Volt.} - \text{Individual Volt.}}{\text{Avg. Volt}} \times 100\right)$	Connection to Varistor of Limiter Circuit
Less than 20%	1T
20 to 50%	2T
Greater than 50%	3T

(7) Remove all 258C plugs and restore all connections.

(2) Effect of Limiter Circuit on Amplifier Gain When Pilot Has Not Failed

5.36 If the connections are properly made to the limiter circuit and if normal transmission is occurring over a given pair, the addition or removal of the limiter circuit from this pair should not produce an excessive change in gain of the amplifier (See Table VIII). This may be checked conveniently by

measurements of the pilot level at the output of the amplifier. The measurements should be made at a time when all other circuits are in normal operation and are normally connected to the limiter circuit, preferably at a time when the cable temperature is very high or very low.

5.37 Apparatus:

1 - 42A Transmission Measuring System
1 - 312A Plug
1 - 258C Plug

5.38 Procedure:

(1) Remove the limiter circuit from the appropriate thermistor of the pilot frequency under test by inserting the 258C plug into jack B.

(2) Measure the pilot level by means of the 42A transmission measuring system at the output of the deviation regulator.

(3) Restore the connection to the limiter circuit by removing the 258C Plug.

(4) Again measure the pilot level at the output of the amplifier by means of the 42A set.

Requirements: The change in pilot level produced by the addition of the limiter circuit should not exceed 0.6 db when all pairs are operating normally.

(3) Deviation Regulator Gain Resulting From a Pilot Frequency Failure

5.39 In any trouble condition which causes a failure of the pilot frequency the limiter circuit will limit the resulting increase in amplifier gain. The amount of limiting obtained may be checked by artificially producing a failure of the pilot frequency and observing the change in gain which results in the amplifier.

5.40 Apparatus

1 - 42A Transmission Measuring System
1 - 312A Plug

5.41 Procedure

(1) Measure the pilot level at the output of the deviation regulator with the control circuit working normally.

(2) Produce a failure in the control circuit by removing the grid clip from the grid of the appropriate one of tubes 2, 3 or 4 depending upon the pilot frequency under test.

(3) Measure the pilot output level at the pilot frequency under test of all normally working deviation regulators connected to the particular limiter.

Requirements: The increase in gain should not exceed that given in Table VIII.

(4) If the above requirements are not met either the pair-to-pair transmission variations are excessive or the varistors are defective and resistance measurements should be made of the varistor units as specified in Part 6. If these resistance values are satisfactory and if the above requirements are not met, then it is probable that the trouble is not with the limiter circuit but is due to some defect in the transmission characteristics of this pair.

TABLE VIII

Effect of Limiter Circuit on Amplifier Gain
- Change in Gain Resulting From a Pilot Failure

Pilot Frequency	Cable Temperature At Time of Failure	Connection to Varistor	Increase in Gain - db Due to Pilot Failure (A) In Amplifier Whose Pilot Has Failed	(B) In Other 4 Amplifiers Connected to Same Bus
12 KC (Slope) (Control)	Ave.	1T	2.5	0.4
		2T	3.8	0.3
		3T	4.5	0.2
	Max.	1T	3.5	0.4
		2T	6.4	0.3
		3T	8.0	0.2
28 KC (Bulge) (Control)	Ave.	1T	4.4	0.4
		2T	6.2	0.3
		3T	7.6	0.2
	Min.	1T	5.2	0.4
		2T	9.7	0.3
		3T	12.0	0.2
56 KC (Flat Gain) (Control)	Ave.	1T	5.0	0.6
		2T	10.3	0.4
		3T	12.5	0.2
	Min.	1T	6.0	0.6
		2T	12.5	0.4
		3T	19.0	0.2

(4) Manual Control of a System

5.42 If a failure occurs in a deviation regulator, or if a change in gain is desired for testing purposes, or if for any reason, the a-c voltage on a thermistor heater increases abnormally the gain may be restored to its normal value or adjusted as desired, by connecting the TC1, TC2 or TC3 potentiometer, across the heater of the thermistor. If this heater is still connected to the limiter circuit, then the potentiometer will also reduce the errors in gain produced in other amplifiers connected to the same limiter circuit.

5.43 When jack R1 of the potentiometer is used for connection of the potentiometer to a thermistor heater, the a-c voltage may still be measured by making the voltmeter connection to jack R2 of the potentiometer instead of to the A jack of the thermistor heater.

5.44 Two methods of adjustment of the potentiometer are given:

(1) On the basis of equal thermistor heater voltages. With this adjustment, the heater voltage is made equal to the average of the heater voltages of the other pairs. It is then possible to maintain the connection to the limiter circuit This adjustment is usually preferable if the line and amplifier are normal but some trouble exists in the control circuit.

(2) On the basis of equal pilot level at the amplifier output. With this adjustment, the amplifier is made to operate at the correct output level, although its gain may differ from the gains of the other amplifiers, because of a different line loss. The limiter should generally be disconnected in this case.

5.45 Apparatus

1 - 42A Transmission Measuring System
2 - 2PID Cord Assemblies (P2A Cords with 347A Plugs at each end)
1 - 3P20B Cord Assembly (P3P Cord with 305A Plugs at each end)
1 - 312A Plug
3 - 258C Plugs

5.46 Procedure: Adjustment on Basis of Equal Thermistor Heater Voltages.

(1) Disconnect the regulator control circuit of the system under test by inserting 258C plugs into the three B jacks.

(2) With the 2PID cord, patch from an R1 jack on the limiter panel to the A jack of the regulator control circuit whose voltage is excessive.

(3) Measure the thermistor heater voltages of the corresponding thermistors of each of the other working systems. This may be done in each case as follows:

(a) With the 2PID cord patch from the V jack of the 0-5 volt voltmeter to the A jack of the corresponding control circuits of other systems associated with the limiter circuit.

(b) Note the heater voltage readings.

(c) Remove the patch from the V jack to the A jack.

(4) Determine the average voltage of all the readings of the thermistor heater voltages excluding the reading of the regulator control circuit which is to be manually adjusted.

(5) Patch the 2PID cord from the R2 jack to the V jack on the limiter panel.

(6) Adjust the TC1, TC2 or TC3 potentiometer so that the voltmeter reads the average voltage determined in Item (4) above.

(7) Leave the 2PID cord patched from the R1 jack to the A jack of the regulator control circuit.

(8) Remove the patch from the V jack to the R2 jack.

5.47 Procedure - Adjustment On Basis of Equal Pilot Levels at Amplifier Outputs

(1) Disconnect the control circuit of the system under test by inserting 258C Plugs into the three B jacks.

(2) With a 2PID cord patch from an R1 jack to the A jack of the regulator control circuit whose voltage is excessive.

(3) Connect a 312A 4-prong adapter plug in the EQ - LINE jacks at the output sealed test terminal for a repeater; at the REC AMP OUT - GR DEM IN jacks at a terminal.

(4) Insert the 308A plug on the LEV MEAS cord of the 42A transmission measuring system into the 312A plug.

(5) Adjust the TC1, TC2 or TC3 potentiometer to give a reading of zero on the meter of the 30A set in the 42A measuring system for a required output of -11 dbm. Adjustment could likewise be made for any other required output.

6. DIRECT CURRENT TESTS

(A) Resistance Measurements in Line, Twist, Test and Aux. Switching Amplifiers; in Control Circuit; and in Regulating Networks and Deviation Equalizers.

6.01 Circuit troubles in carrier amplifiers will ordinarily be discovered as a result of routine level checks and vacuum tube tests. From a knowledge of the nature of the trouble, reference to the circuit drawing will indicate the desirability of making certain measurements. In locating specified circuit elements which may be in trouble, d-c resistance measurements in addition to the vacuum tube tests may be found useful. For convenient reference, limits are given here for a number of resistance measurements to be made with an ohmmeter.

6.02 Apparatus

1 - KS-8295 Volt-ohmmeter
6 - 258C Plugs

6.03 Procedure

(1) Insert 258C plugs into the three B jacks of the control circuit.

(2) Insert 258C plugs into the FIL jacks of all tube circuits associated with the deviation regulator under test.

(3) Remove filament and plate battery fuses from all tube circuits under test.

Note: This procedure unbalances the load in the battery at auxiliary stations and the time during which power is off should not exceed 2 hours unless the battery is readjusted.

(4) Measure the resistance of the various circuit elements with the volt-ohmmeter. The ohmmeter scale giving the greatest sensitivity should be used for each measurement, except where otherwise specified.

Caution: In order to avoid damage due to magnetization of the coils, the volt-ohmmeter should be used for all resistance tests as this limits the d-c testing voltage to less than 5 volts.

(5) Where requirements of 0-1 ohm are given continuity tests may replace the ohmmeter tests.

Requirements: Resistance limits are given in appended Tables as follows:

	Table
Line Amplifier	IX
Twist, Test and Aux. Switching Amplifiers	X
Control Circuit	XI
Regulating Networks and Deviation Equalizers	XII

(B) Resistance Measurements In Thermistors and Varistors

6.04 Since the resistance of a thermistor or varistor is a function of the applied voltage and of the ambient temperature, it is rather difficult to obtain accurate information concerning the characteristics of the unit except under controlled laboratory test conditions. However, if a particular unit is neither open-circuited nor short-circuited and if its resistance value is of the same order of magnitude as the resistance of other similar units, it is very probable that it is in satisfactory working condition. The ohmmeter tests specified in this section should be satisfactory for this purpose.

6.05 Apparatus

1 - KS-8295 Volt-ohmmeter.
Soldering Equipment.

6.06 Procedure - for Thermistors:

(1) Disconnect all leads from the thermistor terminals.

(2) Measure the resistance between terminals 1 and 2 of the thermistor bead.

(3) Measure the resistance between terminals 3 and 4 of the heater.

Requirements:

(1) Thermistor bead resistance = 5,000 ohms to 50,000 ohms.

(2) Heater resistance = 200 ohms ± 15%.

6.07 Procedure - For Varistors in Gain Deviation Limiter Circuit

(1) Disconnect all leads from the terminals of the A varistor.

(2) Measure the resistance (on the low resistance scale of the ohmmeter) between terminals 3B and 1T, between 1T and 2T, and between 2T and 3T.

Requirements: The resistance in each case should be between 4 ohms and 10 ohms, when measured on the low resistance scale (the ohmmeter battery voltage being 4.5 volts).

TABLE IX
OHMMETER TESTS ON LINE AMPLIFIER (SD-64337-02)

(A) Transformers, Networks, Equalizers and Thermistor not Included

Measure From Apparatus	Term.	To Apparatus	Term.	Limits - Ohms Min.	Max.
FIL ACT TST Jack	2	FIL ACT TST Jack	1	90	110
" " " "	6	" " " "	5	900	1100
" " " "	2	" " " "	3	900	1100
" " " "	10	" " " "	11	13	17
" " " "	4	" " " "	5	90	110
" " " "	4	Socket 2	C	550	660
" " " "	9	Terminal Strip	3	900	1100
IN Input Trans.	5	K1 Network	3	630	770
INST 1 Network	1	Socket 3	G	450	550
INST 2 Network	3	FIL ACT TST Jack	8	900	1100
" "	1	Terminal Strip	8	45	55
Socket 1	SC	Socket 2	SC	225	275
EQL Equalizer(Y wiring not used)	5	Socket 3	K	350	450
EQL Equalizer(Y wiring used)	5	Socket 3	K	0	1
EQL Equalizer	7	IN Input Trans.	5	Open	Open
PLT Retard	1	PLT Retard	2	55	85
IN Input Trans.	5	Panel		400000	600000
Terminal Strip	1	IN Input Trans.	2	4500	5500
" "	1	" " "	3	4500	5500
EQL Equalizer	7	TH Thermistor	1	1800	2200
" "	7	" "	2	3500	4500
TH Thermistor	1	" "	3	800000	1200000
Terminal Strip	1	R1 Condenser	Bottom	0	1
" "	1	T1 Condenser	Bottom	0	1
" "	1	FIL ACT TST Jack	2	0	1
" "	1	" " " "	5	0	1
" "	1	" " " "	12	0	1
" "	1	IN Input Trans.	S	0	1
" "	1	C1-C2 Condenser	Middle	0	1
" "	1	C3-C4 Condenser	Middle	0	1
" "	1	C7-C8 Condenser	Middle	0	1
" "	1	Socket 1	SP	0	1
" "	1	Socket 2	SP	0	1
" "	1	Shield for Tube 1	Base	0	1
" "	1	Shield for Tube 2	Base	0	1
" "	1	Shield for Tube 3	Base	0	1
" "	1	OUT Output Trans.	S	0	1
" "	2	FIL ACT TST Jack	10	0	1
FIL ACT TST Jack	11	EQL Equalizer	5	0	1
" " " "	11	C7 Condenser	Top	0	1
IN Input Trans.	2	T1 Condenser	Top	0	1
" " "	3	R1 Condenser	Top	0	1
" " "	5	C10 Condenser	Left	0	1
" " "	1	Connecting Ckt.	Tip	0	1
" " "	4	" "	Ring	0	1
OUT Output Trans.	1	" "	Tip	0	1
" " "	4	" "	Ring	0	1
EQL Equalizer	4	C6 Condenser	Bottom	0	1

(B) Transformers, Networks and Equalizers

K1 Network	3	Socket 1	C	10	20
" "	4	K1 Network	1	640	790
IN Input Trans. (See Note 1)	1	IN Input Trans.	2	0.5	1.5
" " " (" " 1)	3	" " "	4	0.5	1.5

TABLE IX (Continued)

Measure From Apparatus	Term.	To Apparatus	Term.	Limits - Ohms Min.	Max.
IN Input Trans. (See Note 2)	2	Panel		Open	Open
" " " " " "	3	Panel		Open	Open
" " Tap 6 " " 3	7	Tube 1 Grid Cap		7000	8000
" " Tap 7 " " "	5	" " "		7000	8000
" " " " " 4	5	IN Input Trans.	6	250	500
INST 1 or INST 2	1	INST 1 or INST 2 (Resp)	2	2700	3600
" " "	3	" " "	4	38000	46000
" " "	2	" " "	4	Open	Open
EQL Equalizer All Types	1	EQL Equalizer All Types	2	90	160
" " " "	3	" " " "	5	Open	Open
" " " "	4	" " " "	6	650	770
" " " "	6	" " " "	8	780	950
" " " "	8	" " " "	10	1700	2200
" " 30A	1	" " 30A	9	500	750
" " "	2	" " "	9	550	830
" " "	2	" " "	3	105	125
" " 30B	1	" " 30B	9	325	500
" " "	2	" " "	9	400	600
" " "	2	" " "	3	120	150
" " 30C	1	" " 30C	9	525	825
" " "	2	" " "	9	600	900
" " "	2	" " "	3	120	150
" " 30D	1	" " 30D	9	350	550
" " "	2	" " "	9	430	650
" " "	2	" " "	3	90	110
OUT Output Trans. (See Note 1)	1	OUT Output Trans.	2	1	2.5
" " " (" " 1)	3	" " "	4	1	2.5
" " " (" " 5)	1	Panel		Open	Open
" " " (" " 5)	4	"		Open	Open

Notes: (1) Measure with the ohmmeter set at RX10 to avoid excessive current.

(2) Disconnect leads 1 and 4 of IN Input Transformer.

(3) Connect to terminal of IN Input Coil first, then to grid cap of tube and maintain continuous connection until reading is made.

(4) This test should never be made preceding the test of terminals 5 or 7 of the IN Input Coil. Measure with ohmmeter set at RX10.

(5) Disconnect leads to 1 and 4 of OUT Output Transformer.

TABLE X
OHMMETER TESTS ON TWIST AMPLIFIER (SD-64329-03) AND ON TEST AMPLIFIER AND AUXILIARY SWITCHING AMPLIFIERS (SD-64329-02)

(A) Transformers and Networks not Included

Measure From Apparatus	Term.	To Apparatus	Term.	Limits - Ohms Min.	Max.
FIL ACT TST Jack	1	FIL ACT TST Jack	2	90	110
" " " "	11	Socket 1	C	630	770
" " " "	11	IN Input Trans.	5	37	45
" " " "	11	FIL ACT TST Jack	10	12	18
" " " "	6	" " " "	5	900	1100
" " " "	5	" " " "	4	90	110
" " " "	9	Terminal Strip	3	900	1100
C2 Condenser	Lower	INST 2 Network	1	1150	1430
Terminal Strip	8	Socket 2	SC	45000	56000
PLT Retard Coil	1	Socket 3	G	470	570
" " "	1	PLT Retard Coil	2	105	160
FIL ACT TST Jack	10	Terminal Strip	2	7	18
" " " "	8	INST 2 Network	3	900	1100
C7 Condenser	Left	FIL ACT TST Jack	5	540	660
"	Left	Socket 2	C	180	220
Terminal Strip	1	IN Input Trans.	1T	0	1
" "	1	" " "	S	0	1
" "	1	" " "	Grd.Lug	0	1
" "	1	FB Network	6	0	1
" "	1	" "	S	0	1
" "	1	" "	Grd.Lug	0	1
" "	1	C1-C2 Condenser	Middle	0	1
" "	1	Socket 2	SP	0	1
" "	1	C5-C6 Condenser	Middle	0	1
" "	1	C7-C8 Condenser	Middle	0	1
" "	1	" "	Grd.Lug	0	1
Terminal Strip	1	C3-C4 Condenser	Right	0	1
" "	1	D Resistance	Left	0	1
" "	1	C "	Left	0	1
" "	1	FIL ACT TST Jack	5	0	1
" "	1	" " " "	12	0	1
" "	1	OUT Output Trans.	S	0	1
" "	1	Shield for Tube 1	Base	0	1
" "	1	" " " 2	Base	0	1
" "	1	" " " 3	Base	0	1
" "	1	Ground (Panel)		0	1
Terminal Strip	8	"		Open	Open
FIL ACT TST Jack	2	C9 Condenser	Left	0	1
" " " "	2	Socket 1	SP	0	1
IN Input Trans.	2	FB Network	5	0	1
OUT Output Trans.	6	Socket 3	P	0	1
IN Input Trans.	4	Connecting Ckt.	Tip	0	1
" " "	1T	" "	Ring	0	1
OUT Output Trans.	1	" "	Tip	0	1
" " "	4	" "	Ring	0	1

(B) Transformers and Networks

IN Input Trans. (See Note 1)	3	IN Input Trans.	1T	160	200
" " " (See Notes 1&2)	3	" " "	2	0	1.5
" " " (See Notes 1&2)	4	" " "	3	1.5	3.5
" " "	5	" " "	6	15000	25000
INST 1 Network	1	INST 1 Network	3	90000	110000
" "	1	" "	2	35000	45000
" "	5	" "	4	0.4 Meg.	0.6 Meg.
" "	5	" "	2	Open	Open

TABLE X (Continued)

Measure							
From			To			Limits - Ohms	
Apparatus		Term.	Apparatus		Term.	Min.	Max.
INST 2 Network		1	INST 2 Network		2	19000	23000
" "		3	" "		4	70000	90000
" "		2	" "		4	Open	Open
OUT BR Network		1	OUT BR Network		2	14	20
OUT Output Trans.	(See Note 2)	5	OUT Output Trans.		6	11	23
" " "	(See Note 2)	1	" " "		2	3	8
" " "	(See Note 2)	3	" " "		4	8	8
" " "	(See Note 2)	1T	" " "		3T	3.5	6.5
" " "	(See Note 2)	2	" " "		1T	0	0.5
" " "	(See Note 2)	3	" " "		3T	0	0.5
FB Network		1	FB Network		G	2.5	5
" "		2	" "		G	2.5	5
" "	(See Note 3)	5	" "		6	260	320
" "	(See Note 3)	4	" "		6	260	320
" "	(See Note 3)	4	" "		5	85	105

Notes: (1) Disconnect leads to 4 and 2 of the Input Transformer.

(2) Measure with the ohmmeter set at RX10 to avoid excessive current.

(3) Disconnect leads to 4 and 5 of FB network of Test Amplifier

TABLE XI

OHMMETER TESTS ON PILOT CHANNEL CONTROL CIRCUIT
(SD-64395-01)

Measure From Apparatus	Term.	To Apparatus	Term.	Limits - Ohms Min.	Max.
Terminal Strip (See Note 1)	A4	Tube 1	Grid Lead	750	950
FIL ACT TST Jack	1	Terminal Strip	A5	90	110
C1-C2 Condenser	Middle	F Retard	1	450	550
F Retard	1	F Retard	2	95	125
Terminal Strip	A2	Socket 1	SC	225	275
Socket 1	SC	Socket 1	P	60	100
56KC Varistor	2	56KC Varistor	1	30	60
28KC Varistor	2	28KC Varistor	1	150	210
12KC Varistor	2	12KC Varistor	1	170	230
Terminal Strip	B8	Terminal Punching	K4	15000	19500
Terminal Strip	B1	Terminal Punching	K4	14500	19000
Tube 2 (See Note 2)	Grid Lead	FIL ACT TST Jack	7	700000	1500000
Tube 3 (See Note 3)	Grid Lead	FIL ACT TST Jack	8	900000	1800000
Tube 4 (See Note 4)	Grid Lead	FIL ACT TST Jack	9	700000	1500000
56KC OUT Trans.	4	Socket 2	P	600	770
28 KC OUT Trans.	4	Socket 3	P	600	770
12KC OUT Trans.	4	Socket 4	P	600	770
Terminal Strip	B7	Terminal Strip	B4	6	14
Terminal Strip	B6	Terminal Strip	B3	6	14
Terminal Strip	B5	Terminal Strip	B2	6	14
60-Cycle Trans.	1	60-Cycle Trans.	2	20	40
60-Cycle Trans.	Grd.Lug	60-Cycle Trans.	4	20	40
C1-C2 Condenser	Bottom	Socket 1	SC	0	1
C1-C2 Condenser	Grd.Lug	Terminal Strip	A8	0	1
FIL ACT TST Jack	12	Panel		0	1
Terminal Strip	B8	C3 Condenser	Bottom	0	1
" "	B8	C4 "	Bottom	0	1
" "	B8	C5 "	Bottom	0	1
K Pot.	3	C5 "	Top	0	1
J Pot.	3	C4 "	Top	0	1
H Pot.	3	C3 "	Top	0	1

Notes: 1. Measure with the ohmmeter set at RX10 to avoid excessive current.

2. Connect terminal 3 of K potentiometer to terminal 7 of FIL ACT TST Jack.

3. Connect terminal 3 of J potentiometer to terminal 8 of FIL ACT TST Jack.

4. Connect terminal 3 of H potentiometer to terminal 9 of FIL ACT TST Jack.

TABLE XII

OHMMETER TESTS ON REGULATING NETWORKS AND DEVIATION EQUALIZERS

Measure Between Terminals	Limits - Ohms Min.	Max.
(A) 173A SL Network		
1-2	125	170
2-4	165	220
6-8	110	1300
3-6	-	5
5-8	-	6
(B) 174A BU Network		
1-2	115	150
2-4	100	135
6-7	740	950
6-8	450	600
6-9	85	110
6-10	90	120
5-6	750	950
4-6	340	430
(C) 50A ADE Equalizer		
1-8	1030	1250
1-11	300	370
2-8	-	8
2-12	0	1
3-4	440	550
4-6	600	740
5-6	1380	1680
4-11	0	1
7-8	280	350
8-9	330	410
9-10	145	180
8-11	1030	1250
(D) 34C (AMP DEV) (EQL C) Equalizer. MFR. DISC.		
1-3	250	310
1-5	330	410
3-5	330	410
(E) 34D (AMP DEV) (EQL D) Equalizer. MFR. DISC.		
2-4	0	1
2-6	900	1100
(F) 34A (CDE) Equalizer		
1-3	0	2
(G) 34B (CDE) Equalizer		
1-2	110	130
1-3	2700	3300