GROUNDED TELEGRAPH SYSTEM
EQUALIZATION

CONTENTS PAGE

1. GENERAL

1.01 This section describes the methods of determining the constants to be used in the equalizers for improving transmission over repeatered telegraph circuits with ground return. The equalizers are adjusted to give the minimum characteristic distortion as determined by transmission tests.

1.02 A discussion of the theory of characteristic distortion and its reduction by equalization is given in Section 312-006-100. For 4-wire metallic equalization, see Section 312-200-500. For neutral telegraph equalization, see Section 312-008-100.

1.03 Equalization is accomplished by adjusting an electrical network at the receiving end of the line section. This alters the overall transmission characteristic and so changes the wave shape of the current which actuates the receiving relay. The objective is to improve this wave shape so that the distortion in the signals repeated by the relay will be a minimum.

1.04 Before proceeding with any equalization test, it should be determined that the circuit to be tested is free from trouble, that the telegraph repeaters used in the tests are correctly wired, relays properly adjusted, and the measuring devices properly calibrated.

1.05 In general, equalization test should be made at a speed of 75 words per minute for 60 and 75 speed operation. For a speed of 100 words per minute equalization should be made at 100 speed operation. For 2-way service, equalization should be made in both directions.

1.06 Cases may arise where the value of the equalizer which produces minimum characteristic distortion on the Letters character biased 20 per cent marking may result in overequalization of the unbiased Letters character, or vice versa. The equalizer setting that will produce the least bias under service conditions for the particular circuit should be used.

2. REQUIREMENTS FOR MAKING TEST

2.01 Equalization tests prescribed in this section should be made and equalizers adjusted when:

(a) The layout is to be operated at a speed of 75 or 100 words per minute.

(b) Layouts containing 60 or more miles of cable.

(c) Layouts containing 150 miles or more of composited open wire without intermediate composites.

(d) Open wire layouts containing one or more intermediate composite sets.

(e) Any layout where the characteristic distortion is greater than 5 per cent.

Note: For layouts containing a combination of open wire and cable, the mileage of the cable circuit should be multiplied by three and added to the open wire circuit mileage to obtain the equivalent circuit length of open wire, then consider the layout as containing only open wire. Disregard entrance cables of 10 miles in length or less.

3. TESTING EQUIPMENT

3.01 The teletypewriter signals which are used for equalization are either the six characters which have only two transitions, namely, Blank, T, O, M, V, and Letters, or miscellaneous teletypewriter signals such as the standard test sentence. Usually equalization can be made more quickly by using the standard test sentence, however, the use of the test characters afford considerable advantage from the standpoint of interpreting the results.

3.02 The bias meter on the 118-type TMS is designed to measure miscellaneous signals that average approximately four transitions per character. When two transition characters are being received, the bias meter indication must be multiplied by two to obtain the correct value of the distortion in the signals. The difference between the indications of the total distortion meter and twice the bias meter is the fortuitous distortion.

3.03 For a list of the testing apparatus suitable for equalization purposes, see Chart A. Any combination that will send and receive the desired signals may be used.

4. TESTING PROCEDURE

4.01 For the operation and calibration of the various types of testing equipment, reference should be made to the practice covering the particular set involved. Likewise, reference should be made to the practice covering the particular type of telegraph repeater or station set for the details of strapping to obtain equalization.

4.02 Cases may arise where a section of line requires equalization and the assigned repeaters or station sets are not equipped with equalizers. In this case, the matter should be referred, via the lines of organization, to the responsible party for a change of assignment of the type repeater or station set.

4.03 The procedure for equalizing repeatered telegraph circuits with ground return is outlined on Chart A.

5. RECORDS AND REPORTS

5.01 A record should be maintained in the test room of all equalization tests for future reference and studies.

5.02 If tests indicate that the characteristic distortion in a section of line can not be reduced within telegraph transmission limits, a report, preferably completed forms similar to Exhibits A and B, should be forwarded, via the lines of organization, to the responsible party as required by local instructions.

CHART A EQUALIZATION GROUNDED TELEGRAPH SYSTEMS

Equalization is accomplished by adjusting an electrical network at the receiving end. The objective is to improve the wave shape so that the distortion in the signals repeated by the relay will be a minimum.

For predominately negative characteristic distortion use the resistance-inductance type of equalizer.

For predominately positive characteristic distortion use the series-resistance type of equalizer.

Apparatus:

Sending	Type Signal
100A TTY Test Dist.	Test Characters (biased or unbiased)
1A TTY Test Set	Test Characters or Miscellaneous Sigs. (biased or unbiased)
14-Type TD (Tape Type)	Test Characters or Miscellaneous Sigs. (unbiased)
110-Type Mult. Sender	Miscellaneous Sigs. (unbiased)

Receiving	Type Signal
161A Teleg. Station Set	Test Characters
164C1 TMS	Test Characters or Miscellaneous Sigs.
118-Type TMS	Test Characters or Miscellaneous Sigs.
Teletypewriter	Miscellaneous Signals

STEP	PROCEDURE
	To Determine Type Characteristic Distortion
1	Disconnect equalizers from line and artificial line windings of receiving relay at the receiving terminal and from neutralizing wire winding of receiving relay, if used.
2	Transmit each of the test characters Blank, Blank biased 20 per cent spacing, T, O, M, V, Letters, and Letters biased 20 per cent marking.
3	Measure bias of each character at sending end.
4	Record transmitted bias on line A of Exhibit A.
5	Measure bias at receiving end.
6	Record received bias on "unequalized" line 1 of Exhibit A.
7	Complete "unequalized" lines 2 and 3 of Exhibit A. (a) Line 2 = Line 1 minus Line A (algebraically). (b) Line 3 = Line 2 minus O character of Line 2 (algebraically). Note: Change sign of results in columns with asterisk after subtracting algebraically. Character O represents approximate bias in the circuit.

STEP	PROCEDURE
8	Transmit miscellaneous signals.
9	Measure the miscellaneous signals at receiving end and record in space provided on Exhibit A. Note: For analytical purposes it may be desirable to show the results of the measurements of line 3, Exhibit A in graph form on Exhibit B.
	Predominately Negative Characteristic Distortion
10	Connect the resistance-inductance type equalizer across the line and artificial line windings of the receiving relay and across the neutralizing wire winding, if used, using a trial setting of the equalizer.
11	Repeat Steps 2 through 9, recording the results on "equalizer" line and complete lines 2 and 3 of Exhibit A.
12	Continue Step 11 until minimum distortion is obtained.
	Predominately Positive Characteristic Distortion
13	Add or remove a trial value of series line resistance.
14	Rebalance repeaters, readjust line and bias currents.
15	Repeat Steps 2 through 9 and record on Exhibit A.
16	Continue Steps 13 through 15 until minimum distortion is obtained. Note: Do not add series resistance greater than that permitted by instructions covering the repeater or station set being used.
	Equalization Using Miscellaneous Signals
17	Connect equalizer per Step 10.
18	Arrange for distant end to send miscellaneous signals.
19	Measure distortion at receiving end with 118 or 164C1 TMS and adjust equalizer for minimum distortion. Subtract algebraically any bias in the signals at the sending end.
20	If equalization can not be obtained with resistance-inductance type equalizer the series-resistance type should be tried, rebalancing the repeaters, and adjusting the line and bias currents for each resistance setting.

TELEGRAPH TRANSMISSION
DISTORTION AND EQUALIZATION MEASUREMENTS

OFFICE ALPHA, N.Y.
DATE ______ PAGE NO. ______

CIRCUIT NO. 0000 TESTED FROM ALPHA N.Y. TO OMEGA N.Y. TYPE OPERATION PBN SPEED 75

TYPE REPEATER OR STATION TERMINATION — PS OR PR
SENDING TERMINAL 16B1 — PS
RECEIVING TERMINAL 128B2 — PR

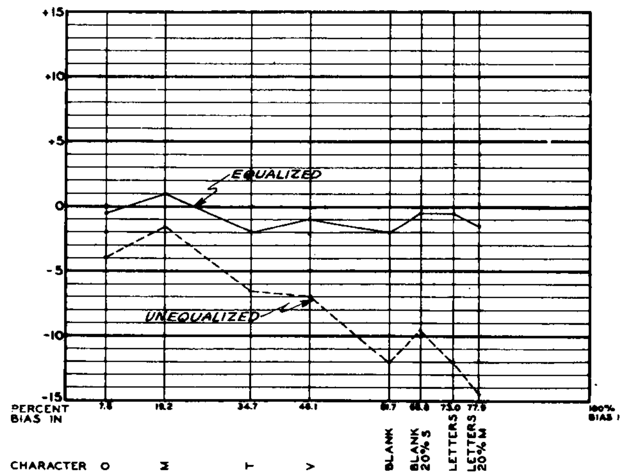
		TEST CHARACTERS								TTY OR TMS READING
						BLANK		LETTERS		
		O	M	T	V	NB	20%S	NB	20%M	MISC. SIGNALS
	A. MEASURED BIAS IN SENT SIGNAL	-1.0	+0.5	+1.0	+1.0	+0.5	-21.0	+1.0	+19.0	
UNEQUALIZED	1. RECEIVED MEASUREMENT	-5.0	-2.0	-9.5	+4.0	-15.5	-34.5	+9.0	+29.5	
	2. REC'D MEAS. LESS BIAS IN SENT SIGNAL (LINE 1-LINE A)	-4.0	-2.5	-10.5	+3.0	-16.0	-13.5	+8.0	+10.5	
	3. CHAR. DIST. (LINE 2 - O CHARACTER OF LINE 2)		*-1.5	-6.5	*-7.0	-12.0	-9.5	*-12.0	*-14.5	
EQUALIZER	1. RECEIVED MEASUREMENT	-0.5	-1.0	-1.5	+1.5	-2.0	-22.0	+1.0	+20.0	
	2. REC'D MEAS. LESS BIAS IN SENT SIGNAL (LINE 1-LINE A)	-0.5	-1.5	-2.5	+0.5	-2.5	-1.0	0.0	+1.0	
	3. CHAR. DIST. (LINE 2 - O CHARACTER OF LINE 2)		*1.0	-2.0	*-1.0	-2.0	-0.5	*-0.5	*-1.5	
EQUALIZER	1. RECEIVED MEASUREMENT									
	2. REC'D MEAS. LESS BIAS IN SENT SIGNAL (LINE 1-LINE A)									
	3. CHAR. DIST. (LINE 2 - O CHARACTER OF LINE 2)		*		*			*	*	
EQUALIZER	1. RECEIVED MEASUREMENT									
	2. REC'D MEAS. LESS BIAS IN SENT SIGNAL (LINE 1-LINE A)									
	3. CHAR. DIST. (LINE 2 - O CHARACTER OF LINE 2)		*		*			*	*	
EQUALIZER	1. RECEIVED MEASUREMENT									
	2. REC'D MEAS. LESS BIAS IN SENT SIGNAL (LINE 1-LINE A)									
	3. CHAR. DIST. (LINE 2 - O CHARACTER OF LINE 2)		*		*			*	*	
EQUALIZER	1. RECEIVED MEASUREMENT									
	2. REC'D MEAS. LESS BIAS IN SENT SIGNAL (LINE 1-LINE A)									
	3. CHAR. DIST. (LINE 2 - O CHARTER OF LINE 2)		*		*			*	*	
EQUALIZER	1. RECEIVED MEASUREMENT									
	2. REC'D MEAS. LESS BIAS IN SENT SIGNAL (LINE 1-LINE A)									
	3. CHAR. DIST. (LINE 2 - O CHARACTER OF LINE 2)		*		*			*	*	

* REVERSE SIGN BEFORE ENTERING RESULTS OF SUBTRACTION IN THESE BLOCKS

TESTING APPARATUS SENDING END BIAS RUN 100A TD RECEIVING END BIAS RUN 161A1 TMS
MISC SIGNALS 110C MULTIPLE SENDER MISC SIGNALS 15 SR

NOTE 1. RECORD SIGN ON ALL MEASUREMENTS -(SPACING)+(MARKING). PERFORM ALL SUBTRACTIONS ALGEBRAICALLY.
NOTE 2. IF 118 TYPE TMS IS USED TO MEASURE TEST CHARACTERS MULTIPLY READING OF BIAS METER BY TWO.
NOTE 3. INDICATE FINAL EQUALIZER ADJUSTMENT

EXHIBIT A



NOTE:- USE •••••, – – – –, — - —, ——— LINES AND LABEL.

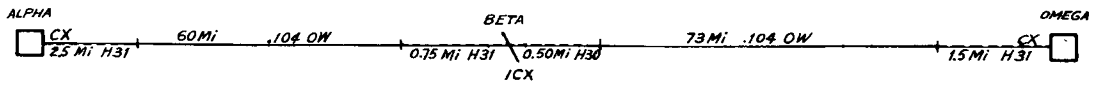
RECEIVED LINE CURRENT
MARK 30 MILS SPACE 30 MILS

WEATHER CONDITIONS
SENDING END CLEAR
RECEIVING END CLOUDY

LINE INSULATION & GROUND POTENTIAL
TEST VOLTAGE ______ VM RES. ______
SHUNT ON — SHUNT OFF
READING TO OPEN ______ ______
READING TO GRD. ______ ______
GROUND POTENTIAL READING ± 1 VOLT

NEUTRALIZING WIRE ☑
60 CYCLE FILTER ☑
OTHER NEUTRALIZING ARRANGEMENT ☐

DRAW A STRAIGHT LINE SKETCH OF THE LINE LAYOUT SHOWING MAKEUP, INCLUDING FOR EACH SECTION THE LENGTH, TYPE FACILITY (PX.SX.ETC.) GAUGE, LOCATION AND TYPE (CX OR ICX) OF ANY COMPOSITE EQUIPMENT.



REMARKS ______

TESTER X.Y.Z

EXHIBIT B