BSM #773B

COMPLETION TESTS OF EXCHANGE AREA CABLES

PREPARATIONS

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Caution: Be sure to establish the 1-kc mark on the terminating-end VTVM, and the 60-kc mark also, if necessary, before taking the VTVM's to their assigned points of use. See Part 4.

1. GENERAL

1.01 First, decide which end is to be the measuring end and which the terminating end. In general, the office of higher rank in the general toll switching plan will be the measuring end. For example, a Class-3 office would be the measuring end of a cable terminating in a Class-5 office at the other end. Under certain conditions stated in Par. 10.09, return-loss tests should be made from both ends, in turn.

1.02 Assemble in one place, preferably at the measuring end, all the testing equipment for both the terminating end and the measuring end of the cable. Connect all necessary power sources to the various sets and turn them on.

2. SWITCHBOXES

2.01 Install a fresh 4.5-volt Wheatstone bridge battery in Switchbox M.

2.02 Install fresh 4.5-volt telephone-set batteries in both switchboxes.

3. NOISE-MEASURING SET

3.01 If a noise-measuring set is to be used to measure return loss, be sure its batteries meet the requirements listed in the instructions covering its use.

4. DETECTORS

1-Kc Adjustments

4.01 Connect the 1-kc oscillator to the 1-KC OSCILLATOR jacks of Switchbox T, and the VTVM to be used with that switchbox to the VTVM jacks.

4.02 Set the BUILDING-OUT AND CALIBRATING RESISTORS to an impedance appropriate to the facility, as follows:

Nonloaded,	19	gauge	600 ohms
"	22	"	600 "
"	24	"	900 "
"	26	"	900 "
H88-loaded			900 ohms
D88 "			1200 "
B88 "			1500 "
B135 "			1800 " (Use external resistors: 1800 ohms for terminating and 1200 ohms for building out.)

4.03 Connect the VTVM to be used with Switchbox M to the VTVM jacks.

4.04 Set the 1-KC TERMINATION switch to the same impedance chosen in Par. 4.02.

4.05 Set the FUNCTION and PAIR switches of both switchboxes to 1-KC TRANSMISSION LOSS and 1, respectively.

4.06 Connect the main pickup cables to both switchboxes.

4.07 By means of short insulated wires terminated in clips, connect the contacts for the tip and ring of Pair 1 of one pickup shoe to the corresponding contacts of the other shoe. In effect, you are now set up to measure 1-kc transmission loss on a zero-loss line (the short wires connecting the two shoes).

4.08 Be sure the oscillator is set at 1 kc. Adjust its output carefully to obtain a reading of 0 db on the measuring-end VTVM meter with the latter's dial-switch set at zero.

4.09 Immediately, operate the CAL key of Switchbox T and observe the meter reading of the terminating-end VTVM with its dial-switch set at zero. Record this reading, and also mark it and label it "1 KC" on a paper sticker on the glass cover of the meter. This mark will permit duplicating the correct output of the 1-kc oscillator when it is set up at the terminating end. The sum of the meter and dial readings at the measuring-end VTVM during the regular tests will then be the insertion loss of any cable pair being measured. No correction will be necessary.

60-Kc Adjustments

4.10 Connect the 60-kc oscillator to the 60-KC OSCILLATOR jacks of Switchbox T.

4.11 Set the FUNCTION switches of both switchboxes to 60-KC TRANSMISSION LOSS, and be sure both PAIR switches are set to 1.

4.12 Be sure the oscillator is set at 60 kc. Adjust its output carefully to obtain a reading of 0 db on the measuring-end VTVM with the latter's dial switch set at zero.

4.13 Immediately, operate the CAL key of Switchbox T and observe the meter reading of the terminating-end VTVM with its dial switch set at zero. Record this reading, and also mark it and label it "60 KC" on a paper sticker on the glass cover of the meter. This mark will permit duplicating the correct output of the 60-kc oscillator when it is set up at the terminating end. The sum of the meter and dial readings at the measuring end during the regular tests will then be the insertion loss of any cable pair being measured. No correction will be necessary.

5. PRECISION NETWORKS

5.01 Table 1 lists the types of networks to be used for various uniform facilities.

5.02 Be sure the 54C return-loss set has been connected to 110-120-volt 60-cycle supply and to the central office 48-volt dc supply, and that it has warmed up for 15 minutes.

5.03 Be sure the building-out capacitor built into each network has been removed or disconnected. (Reason: The associated BOC's are not accurate enough for either this check or the completion tests themselves.)

5.04 Test the 54C set by measuring the return loss of 600 ohms vs. 900 ohms. Insert a 600-ohm plug in the MEAS RL jacks and a 900-ohm plug in the EXT NET jacks. Turn Key S3 of the 54C set to EXT NET. Set the key that controls the sweep-frequency to the range 500-2500 cps. Operate the other key to SEND LEVEL CAL, and adjust the SEND LEVEL ADJ control for the 500-2500-cps range to give a 0-db reading of the meter. Restore the latter key to MEAS, and adjust the return-loss switch so that the meter reads on-scale. The sum of the dial setting and meter reading should be within about 0.2 db of 14 db and the needle should be fairly steady. If those conditions are not met, there is probably trouble in the 54C set.

5.05 Test the balancing and the terminating network to make sure each is in good condition. In situations where the same type of network is used for both balancing and terminating, test the balance of one network against the other. Where different networks are used, test each one against a second network of the same type with the same strapping. Patch the two networks into the MEAS RL and EXT NET jacks of the 54C set, using the 3-ft. patch cords.

5.06 The return loss of one network against the other is equal to the reading of the switch plus that of the meter. This return loss should be at least 40 db. If it is less than 40 db, try other networks until a pair is found having at least 40-db return loss.

5.07 When the facilities are not uniform, that is, not the same gauge or nominal capacitance throughout the entire length, use as a balancing network the type listed for the predominant facility in the first three full loading sections at the measuring end. Naturally, you use the same balancing network in measuring the return loss of artificial cable as an aid in computing expected return loss for a mixed facility. (See Par. 10.06 and 10.07.)

5.08 When the facilities are mixed, use as a terminating network the type listed for the predominant facility in the loading section adjacent to the terminating end section. Use this network also in terminating on any auxiliary mock-ups using artificial lines. (See Par. 10.06 and 10.07.)

6. SETTING UP THE APPARATUS

6.01 Take the test equipment to the points of use.

6.02 Examine the distributing frames at both ends of the cable. If any crossconnections have been placed on the pairs to be tested, be sure they are disconnected, at least temporarily, from the cable pairs while the tests are being made.

6.03 At each point, choose the most convenient location within the flexible cable's reach of the main distributing frame (MDF), and set up on the wagon all the components that must frequently be adjusted or observed. Except for the Wheatstone bridge, connect all the components at each location into the switchboxes, as shown in the 501 section. Establish communication through the telephone sets provided. Connect power where needed and turn on all sets that consume power.

6.04 Be especially careful in inserting the pickup shoes for the reference pair. Any bad contact at either the measuring or the terminating end will cause an error in every reading of resistance. Be sure the contacts are good.

6.05 When preparing for tests of pairs that have been in service, guard against errors that may be introduced by disturbing protectors. For example, if old protectors in 1177-, C50- or C51-type frames are moved slightly when pickup shoes are inserted, they may cause leaks to ground. It is safer to replace the protectors temporarily with dummy protector blocks.

7. SELECTING A REFERENCE WIRE

7.01 Select the first complement of pairs to be tested.

7.02 At the terminating end, connect together all the wires of the five highest-numbered pairs of the complement. Call them A, B, C, D, E, F, G, H, I, J.

7.03 At the measuring end, take the Wheatstone bridge to the distributing frame and set its switches for measuring resistance. Set the "ratio" dial to 1/1. (Instructions for using portable Wheatstone bridges are usually found inside their lids.)

7.04 Make the following ten measurements as rapidly as possible in order to avoid error from temperature changes: A + each of the other nine wires in turn, and B+C.

7.05 Enter the measurements on the PRELIMINARY TESTS form, and complete the computations indicated on the form.

7.06 Note whether or not all the deviations from Line 4 are less than Line 3. If they are, the reference wire may be selected from the ten wires measured. If any deviation exceeds Line 3, discard the corresponding wire, choose another in its place, and repeat as much as necessary of the measurements and calculations to fill out a new form.

7.07 When all deviations are less than Line 3, note which wire looped with A has the smallest deviation from Line 4. This one shall be used as the reference wire. In case two loops deviate equally from Line 4, but one is higher and one lower, choose the reference wire from the lower one. If A+A deviates least from Line 4, choose A as the reference wire.

PRELIMINARY TESTS

RESISTANCE

	WIRES		OHMS	
	A+B	=	1411	(Measured)
(Add)	A+C	=	1412	(Measured)
(Total)	2A+B+C	=	2823	
(Subtract)	B+C	=	1417	(Measured)
(Remainder)	2A	=	1406	(1)
(Divide by 2)	A	=	703	(2)
1% of 2A		=	14.06	(3)

	WIRES		OHMS	DEVIATION FROM LINE 4
(From Line 1)	A+A	=	1406	4
(Measured)	A+B	=	1411	1
	A+C	=	1412	2
	A+D	=	1408	2
	A+E	=	1420	10
	A+F	=	1408	2
	A+G	=	1405	5
	A+H	=	1411	1
	A+I	=	1410	0
	A+J	=	1411	1

(Add 10 figures)	10A + sum of 10 wires	=	14102	
(Divide by 10)	A + average of 10 wires	=	1410	(4)
	A + reference wire (I)	=	1410	
(Subtract)	A	=	703	
(Remainder)	Reference wire (I)	=	707	

8. CALIBRATING THE WHEATSTONE BRIDGE

8.01 Open the BA (battery) switch of the Wheatstone bridge to disconnect the internal battery.

8.02 Set the ratio dial of the Wheatstone bridge to 1/1, and set each decade dial to zero.

8.03 Connect X1 on Wheatstone bridge to X1 on Switchbox M. Connect X2 on Wheatstone bridge to X2 on Switchbox M. Connect BA− on Wheatstone bridge to V1 on Box M.

8.04 Plug the auxiliary wires terminated on Jones plugs, into the small Jones sockets in Switchboxes M and T.

8.05 Connect to Switchboxes M and T the first 10 pairs to be tested.

8.06 Set the selector switches to "Pair 1" and "Resistance," on both boxes.

8.07 Set the 0-5000-ohm rheostat at approximately midrange.

8.08 Operate the BATTERY key of Switchbox M to NORMAL, unlock the galvanometer needle of the Wheatstone bridge, and set the needle to zero while the BA and GA keys of the bridge remain normal.

8.09 Operate the BA and GA keys, progressing to the most sensitive of the GA keys (if more than one are provided). The galvanometer pointer should deflect. If it does not, change the setting of the 10-ohm rheostat, and try again. In either case, try to bring the pointer back to zero by adjusting the 10-ohm rheostat. You may have to use the decade dial of the bridge as well as the rheostat. In rare cases, there may be insufficient resistance in the rheostat to balance the test wire against the standard. In this case, change the test wire by setting the selector switch to "Pair 2," and try again. When you have obtained a zero reading of the galvanometer, check the zero adjustment by operating the BATTERY key to REVERSE and observing the needle for deflection. If it deflects, touch up the rheostat adjustment until it does not change when the battery is reversed. Finally, leave the BATTERY key on NORMAL.

8.10 Increase the decade setting by 10 ohms. This should cause the pointer to deflect. If it deflects to the right (+), reverse the BATTERY key of Switchbox M so that it deflects to the left.

8.11 Adjust the 5000-ohm rheostat so that the deflection produced in Par. 8.10 is exactly 10 divisions of the scale to the left (−). If the deflection is less than 10 divisions with the rheostat set for least resistance, connect more cable conductors in parallel with the BATTERY lead between the two frames.

8.12 Return the decade dials to zero, and turn the 10-ohm rheostat all the way counterclockwise (zero resistance). The apparatus is now ready for resistance measurements.

9. ESTIMATING THE END SECTION

9.01 In each complement, pick up at the frames at both ends of the cable the ten lowest-numbered pairs.

9.02 If the cable record shows the end section at the measuring end to be less than one-half loading section, set the BON switch to LINE; if more than one-half loading section, to NETWORK. (For loading section lengths see Table 1.)

9.03 Set the BOC in Switchbox M to the values shown in Column I of Table 1. Set the BOC in Switchbox T as follows:

(a) Subtract from the length given in Column G the length of the end section at the terminating end, and express the result in kilofeet.

(b) Multiply this last figure by the nominal capacitance per kilofoot as given in Column E. The result is the capacitance to be set in the BOC.

Example — See sample data sheet headed: COMPLETION TESTS, PREPARATIONS, in the 501 section.

9.04 Set the FUNCTION switch of each switchbox to RETURN LOSS, and the PAIR switch of each to Pair 1.

9.05 Set the 54C return-loss set for 500-2500-cycle sweep.

9.06 Adjust the BON network for maximum return loss of LINE against EXTERNAL NET. To do this, first adjust the capacitors until a maximum return loss is indicated on the meter. Then adjust the resistors until a higher maximum is attained. Continue, alternately adjusting C and R until no further increase can be made.

9.07 If the return loss is still increasing as the capacitance in the BON is reduced to zero, shift the BON to the opposite position and try again.

9.08 See if the adjustment of the ***BOC in Switchbox T*** will increase the return loss, and leave it at the setting that gives the highest return loss.

9.09 If the adjustment of the BOC increased the measured return loss, repeat Par. 9.06.

9.10 Note on the form the final reading of the C and R dials of the BON network for maximum return loss, and also note the position of the BON switch.

9.11 Repeat for Pairs 2 through 10.

9.12 Complete on the PREPARATIONS form the computation for the end section capacitance. See sample form. Note that if the capacitance in the pickup cable is more than 0.0005 uf, a correction is made for it.

TABLE 1

(A) Network	(B) Gauge and Loading	(C) Nominal Length of Loading Section	(D) Nominal Capacitance per Mile	(E) Nominal Capacitance per 1000′ of Cable	(F) Equivalent Length of End Section in Network	(G) Length of Loading Section Minus End Section in Network	(H) Build-Out to Half Section Length	(I) Build-Out to Half Section Capacitance	(J) Full-Section Capacitance	(K) Half-Section Capacitance	(B) Gauge and Loading
					HIGH-CAPACITANCE CABLE						
115H(1)	19H88	6000′	0.084UF	0.0159UF	900′	5100′	2100′	0.033UF	0.0955UF	0.048UF	19H88
115P(3)	19D88	4500′	0.084	0.0159	800′	3700′	1450′	0.023	0.072	0.036	19D88
115L	19B88	3000′	0.084	0.0159	540′	2460′	960′	0.015	0.048	0.024	19B88
115J	19B135	3000′	0.084	0.0159	540′	2460′	960′	0.015	0.048	0.024	19B135
115H(2)	22H88	6000′	0.082	0.0155	900′	5100′	2100′	0.033	0.093	0.047	22H88
115P(3)	22D88	4500′	0.082	0.0155	820′	3680′	1430′	0.022	0.070	0.035	22D88
115L	22B88	3000′	0.082	0.0155	515′	2485′	985′	0.015	0.047	0.023	22B88
115J	22B135	3000′	0.082	0.0155	515′	2485′	985′	0.015	0.047	0.023	22B135
115AL(4)	24H88	6000′	0.084	0.0159	1150′	4850′	1850′	0.029	0.0955	0.048	24H88
115CE(6)	26H88	6000′	0.079	0.0150	1260′	4740′	1740′	0.026	0.090	0.045	26H88
					LOW-CAPACITANCE CABLE						
115P(8)	19H88	6000′	0.066UF	0.0125UF	1080′	4920′	1920′	0.024UF	0.075UF	0.0375UF	19H88
115P(3)	19H88(*)	6000′	0.062(*)	0.0117	1080′	4920′	1920′	0.022	0.070+	0.035	19H88(*)
115M	19B88	3000′	0.066	0.0125	540′	2460′	960′	0.012	0.075	0.0375	19B88
115K	19B135	3000′	0.066	0.0125	540′	2460′	960′	0.012	0.075	0.0375	19B135
115AL(5)	24H88	6000′	0.072	0.0136	1250′	4750′	1750′	0.024	0.082	0.041	24H88
115CE(7)	26H88	6000′	0.069	0.0131	1285′	4715′	1715′	0.022	0.078	0.039	26H88

* Toll-type cable

Use Terminals 1 and 2 of networks for external connections.

(1) Strap Terminals 2-3-4.
(2) No straps.
(3) Strap 3-4. If return-loss objective is not met, try 2-3.
(4) Strap 2-4; 3-6. If return-loss objective is not met, try 2-4; 1-6.
(5) Strap 6-8; 3-5. If return-loss objective is not met, try 6-8; 1-5.
(6) Strap 3-4; 5-6; 7-8. If return-loss objective is not met, try 3-4; 5-6; 2-7.
(7) Strap 7-8. If return-loss objective is not met, try 2-7.
(8) Strap 2-3.

10. EXPECTED RESULTS

Resistance

10.01 The expected resistance of a single wire is obtained by multiplying its length by the nominal resistance per unit length. If the wires are not of the same gauge throughout their length, the resistance of the total length of each gauge is computed separately and the results are added together. When the pairs are loaded, half the resistance of all the loading coils in a pair must be added to the resistance of each wire in the cable to obtain the total. The total is the expected resistance of a conductor of exactly the lengths and gauges shown in the cable record, at a temperature of 68°F. Table 2 gives the resistances per kilofoot and per mile at 68°F.

TABLE 2

RESISTANCES OF WIRES AT 68°F.

GAUGE	RESISTANCE PER WIRE KILOFOOT — OHMS	RESISTANCE PER WIRE MILE — OHMS
19	8.14	43.0
22	16.4	86.5
24	25.9	137
26	41.7	220

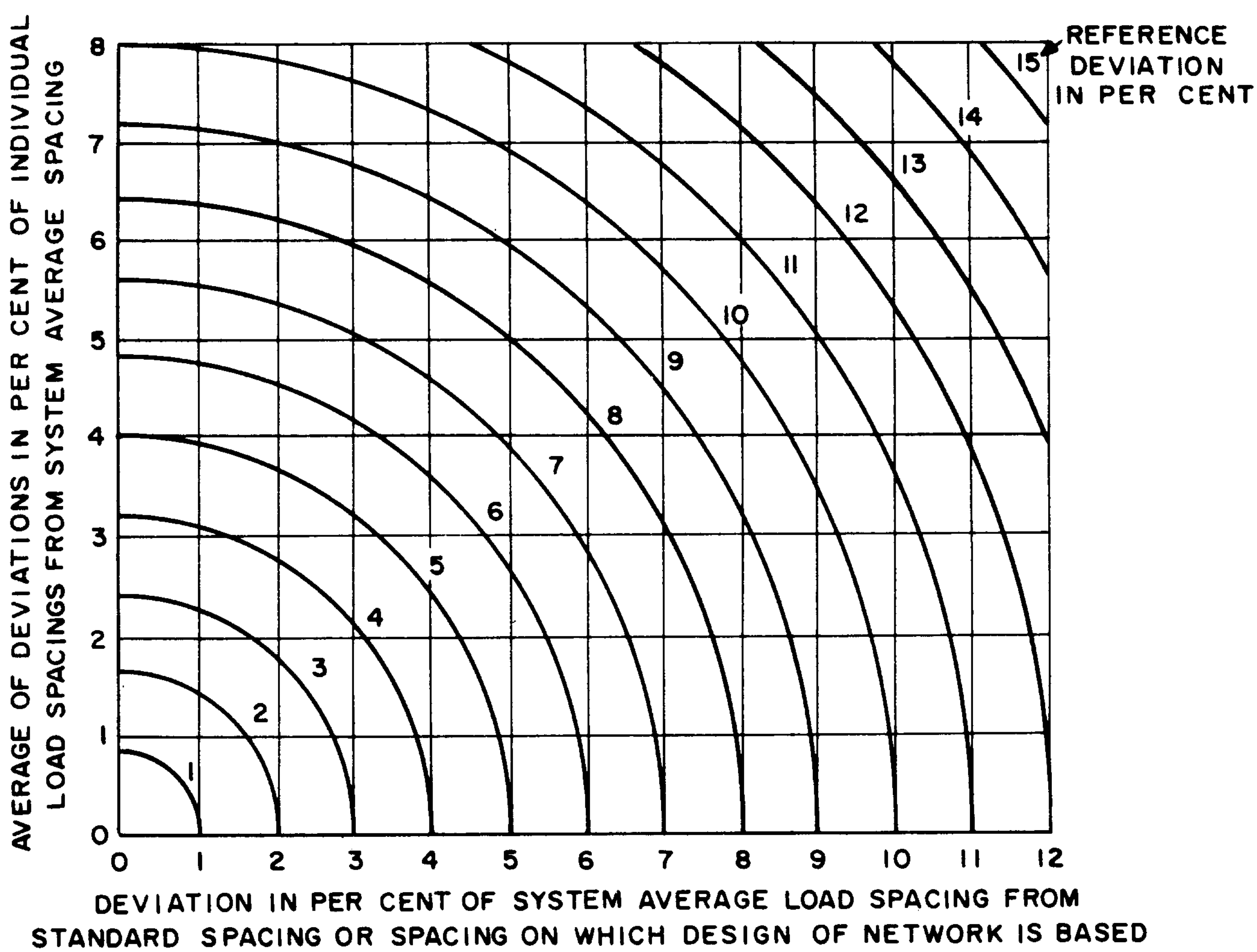

Fig. 1 – Chart for Obtaining Reference Deviation of a Loading System

10.02 In reality, the wires are not exactly the lengths or gauges specified, and their temperature is generally not 68°F. It is usually possible to make a rough estimate of cable temperature (perhaps within 20° or so) but there is no way of knowing how much, or in which direction, the length and diameter of a wire depart from the nominal values. It is usual to make a rough correction for temperature and then allow a certain tolerance to take care of the uncertainties. The tolerance tentatively chosen is from 7% below to 10% above the resistance corrected for temperature (−7% to +10%).

Example

(a)	Computed resistance per wire	649 ohms
(b)	½ resistance of 7 loading coils,* ½ x 7 x 8.4	29 "
(c)	Estimated average cable temperature at time reference wire was measured	85°F
(d)	Temperature corrections** 0.0022 x (85−68) x (649+29)	25 ohms
(e)	Computed resistance corrected for loading coils and temperature (a) + (b) + (d)	703 "
(f)	7% of (e)	49 "
(g)	10% of (e)	70 "
(h)	Acceptable range: (e) − (f) to (e) + (g)	654-773 "
(i)	Resistance of reference wire	707 "
(j)	Average tip wire referred to reference	−.14 "
(k)	" ring " " " "	+.48 "
(l)	" of all wires " " " $\frac{(j)+(k)}{2}$	+.17 "
(m)	Average of all wires (i) + (e) This is within the acceptable range (h)	707 "

* Use the correct resistance for the type of coils shown on the cable record.

** Temperature correction = 0.0022 x (T-68) x R
If T is greater than 68°, correction is positive.
" " " less " " , " " negative.

10.03 The following table shows tallies of actual resistance measurements made of both PIC cable and pulp-insulated cable.

MEASURE-MENT	PIC REFERENCE WIRE – 410 OHMS						PULP REFERENCE WIRE – 700 OHMS					
	TIP			RING			TIP			RING		
+6	/											
+5	/									////		
+4	~~////~~	~~////~~	//	/			//			///		
+3	~~////~~	///		///						~~////~~	//	
+2	~~////~~	~~////~~		////			~~////~~			~~////~~	///	
+1	~~////~~	/		~~////~~	////		~~////~~	//		~~////~~	~~////~~	///
0	~~////~~	///		~~////~~	~~////~~	///	~~////~~	/		~~////~~	/	
-1	/			~~////~~	~~////~~	////	~~////~~	//		///		
-2	//			////			~~////~~	~~////~~	/	///		
-3							~~////~~	//		/		
-4							/			/		
-5							////					

Return Loss

10.04 If the pairs are of a single gauge and a single capacitance per mile throughout their length, the expected return loss is shown in Table 3. Note that better performance is expected from PIC cable than from paper- or pulp-insulated cable.

10.05 It is necessary to know the reference deviation of the loading spacing in order to use Table 3. This deviation is calculated as follows:

a. Add the lengths of all the loading sections. This gives the distance from the first to the last loading coil.

b. Divide this total by the number of full loading sections. The result is the average length of loading section.

c. Subtract the standard loading-section length from the result of Step b. The remainder is the deviation of the average spacing from the standard spacing.

d. Divide the deviation found in Step c by the standard spacing and multiply by 100. This gives the percentage deviation from the standard spacing.

e. Find the difference between the average spacing found in Step b and the length of each individual loading section.

f. Add the results of Step e without regard to sign. (For this calcuiation, it makes no difference whether the section is longer or shorter than the average.)

g. Divide the result of Step f by the number of loading sections. This gives the average absolute (without regard to sign) deviation per loading section from the average of all loading-section lengths.

h. Divide the result of Step g by the average section length and multiply by 100. This gives the average absolute deviation from the average section as a percentage of the average section.

i. Enter the chart of Fig. 1 with the result of Step d horizontally and the result of Step h vertically. The point thus fixed on the chart determines the reference deviation. In Example A, this point lies about eight tenths of the way from 1% to 2%, so the reference deviation is 1.8%.

Example A

	LOADING SECTION LENGTHS		ABSOLUTE DEVIATIONS FROM AVERAGE	
	6100 ft.		72 ft.	(e)
	5930		98	(e)
	5870		158	(e)
	6100		72	(e)
	6140		112	(e)
	6030		2	(e)
	6)36170 ft.	(a)	6)514 ft.	(f)
Average	=6028 ft.	(b)	86 ft.	(g)
	−6000			
	28 ft.	(c)		

$$\frac{100 \times 28}{6000} = 0.5\% \quad (d) \qquad \frac{100 \times 86}{6028} = 1.4\% \quad (h)$$

10.06 If along the cable, there are changes in gauge or in capacitance per unit length, the performance will not be as good. In general, it is hard to predict the performance under these conditions. If artificial sections of cable are available, however, a mock-up of the actual layout can be set up and measured. Because artificial cable sections are nearly perfect, however, these measured return losses will be too good, but they may be modified as described below.

10.07 Look up in Table 3 the return loss for a long length of the predominant facility in the first three full loading sections at the measuring end. Combine this figure with the one measured on the artificial line, by means of Table 5. The result gives the expected return loss. (See Par. 5.07 and 5.08.)

Example

Facility: Mixed 19H88LC and 22H88HC

Deviation of loading spacing: 1.8%

Predominant facility in first three full loading sections: 19H88LC

From Table 3, expected return loss for 19H88LC: 32.5 − 0.8 (32.5 − 30.9)	= 31.2 db
Measured return loss of artificial cable layout:	28.7 db
Difference:	2.5 db

From Table 5, we find that the lower value (28.7 db) must be decreased by 1.9 db. The expected return loss, therefore, is 28.7 − 1.9, or 26.8 db

10.08 If the facility loss is less than 8 db, the expected return loss is greater than that shown in Table 3 by the amount shown in Table 4. Do not apply this correction to mixed facilities.

Example

Facility: 4.5 db of 22H88HC

Deviation of loading spacing: 2%

From Table 3, expected return loss = 32.2 db.

From Table 4, correction for 4.5-db loss is 0.5 db.

32.2 db + 0.5 db = 32.7 db, the expected return loss.

10.09 As soon as the expected return loss is known, make a computation to find out whether return loss must be measured at the terminating end as well as the measuring end:

a. Subtract 8 db from the expected return loss.

b. Divide the result by 2.

c. If the answer is less than the expected transmission loss at 1 kc, measure the return loss at both ends.

Example

Expected return loss	30.2 db
Subtract 8 db	−8.0 db
Divide by 2	2)22.2
	11.1 db

Conclusion — Make return-loss measurements at both ends if the expected 1-kc transmission loss is more than 11.1 db.

Transmission Loss

10.10 The expected transmission loss is predicted in about the same way as the expected resistance. Simply multiply the length of each type of cable by the loss per unit length, and add the results. See Table 6 for losses. To take account of reflection losses, temperature effects, etc., allow a margin of 10% of the computed loss in db. For example, if the computed loss is 28.5 db, allow a margin of ± 2.9 db.

Examples

Layout

TYPE OF FACILITY	LENGTH	LOSS PER UNIT LENGTH	TOTAL LOSS
		(1 KC)	
22H88HC	5.42 kft.	0.150	0.81
19H88HC	52.20 kft.	0.080	4.18
			5.0 db ± 0.5 db
		(60 KC)	
24 NL HC	3.68 kft.	2.19	8.06
22 NL HC	12.16 kft.	1.51	18.37
			26.4 db ± 2.6 db

11. SUMMARY OF PREPARATIONS

Part No.

1. Decide which is to be the measuring end; assemble the equipment; connect and turn on the power.
2. Install fresh batteries (3) in the switchboxes.
3. Be sure batteries in the noise measuring set meet requirements.
4. Find reading of terminating-end detector that causes measuring-end detector to read 0 db for zero-loss line. (Two frequencies for nonloaded facilities.)
5. Test the precision networks for accuracy.
6. Take the terminating-end equipment to the terminating end and set it up. If the measuring-end equipment is not at the point of use, take it there and set it up.
7. Select a reference wire.
8. Calibrate the Wheatstone bridge for direct reading of the difference in resistance between unknown wires and the reference wire.
9. Estimate the end section by comparison with a precision net, using the BON and BOC.
10. Compute the expected results.

TABLE 3

COMPUTED STRUCTURAL RETURN LOSSES IN THE ECHO RANGE (500-2500 CPS) EXCHANGE-AREA FACILITIES

For long lengths made up of 750-foot reels of paper- or pulp-insulated cable. See corrections at end for other reel lengths and insulation.

	REFERENCE DEVIATION OF LOAD SPACING (PER CENT)				
FACILITY TYPE	1	2	3	4	5
16 H88	30.2	28.6	26.7	25.1	23.5
19LC "	32.5	30.9	29.0	27.4	25.8
19HC "	31.4	29.8	27.9	26.3	24.7
22 "	33.8	32.2	30.3	28.7	27.1
24 "	34.8	33.2	31.3	29.7	28.1
26 "	36.5	34.9	33.0	31.4	29.8
16 H44	34.7	33.1	31.2	29.6	28.0
19LC "	37.1	35.5	33.6	32.0	30.4
19HC "	36.4	34.8	32.9	31.3	29.7
22 "	38.6	37.0	35.1	33.5	31.9
24 "	39.6	38.0	36.1	34.5	32.9
26 "	41.0	39.4	37.5	35.9	34.3
16 B88	28.3	27.4	26.1	24.8	23.5
19LC "	30.9	30.0	28.7	27.4	26.1
19HC "	29.9	29.0	27.7	26.4	25.1
22 "	31.7	30.8	29.5	28.2	26.9
24 "	32.9	32.0	20.7	29.4	28.1
26 "	34.9	34.0	32.7	31.4	30.1
16 B135	26.4	25.5	24.2	22.9	21.6
19LC "	27.5	26.6	25.3	24.0	22.7
19HC "	26.6	25.7	24.4	23.1	21.8
22 "	28.7	27.8	26.5	25.2	23.9
19LC D88	31.3	29.8	28.3	26.8	25.4
19HC "	30.4	28.9	27.4	25.9	24.5
22 "	33.1	31.6	30.1	28.6	27.2
24 "	34.2	32.7	31.2	29.7	28.3
26 "	35.8	34.3	32.8	31.3	29.9

Notes

1. The designation HC indicates cable with a capacitance of 0.075 uf per mile or greater and LC indicates cable with a capacitance less than 0.075 uf per mile.
2. The figures in the table are for long lengths of facilities. For lengths less than about 8 db, apply the corrections given in Table 4.
3. The table is based on average reel lengths of 750 feet and on paper- or pulp-insulated cable. For PIC cable and other reel lengths, apply corrections as follows:

CORRECTIONS TO BE ADDED TO RETURN LOSSES SHOWN IN TABLE

REEL LENGTHS — FT.	PAPER-INSULATED OR PULP-INSULATED CONDUCTORS	POLYETHYLENE INSULATED CONDUCTORS (PIC)
350	+2 db	+3 db
500	+1	
750	0	+2
1000	−1	
1500	−2	+1
2100	−3	
3000	−4	0

TABLE 4

STRUCTURAL RETURN LOSS ADJUSTMENTS FOR SHORT LENGTHS OF LOADED FACILITY

FACILITY LOSS — DB	CORRECTION TO BE ADDED TO STRUCTURAL RETURN LOSS — DB
0.5	6.8
0.6	6.2
0.7	5.6
0.8	5.1
0.9	4.7
1.0	4.3
1.1-1.2	3.7
1.3-1.4	3.2
1.5-1.6	2.8
1.7-1.8	2.5
1.9-2.0	2.2
2.1-2.2	1.9
2.3-2.4	1.7
2.5-2.7	1.5
2.8-3.0	1.3
3.1-3.3	1.1
3.4-3.5	1.0
3.6-3.7	0.9
3.8-3.9	0.8
4.0-4.1	0.7
4.2-4.4	0.6
4.5-4.8	0.5
4.9-5.3	0.4
5.4-5.9	0.3
6.0-6.8	0.2
6.9-8.1	0.1
8.2 or more	0.0

TABLE 5

COMBINATION OF TWO RETURN LOSSES ON POWER-RATIO BASIS

DIFFERENCE BETWEEN TWO RETURN LOSSES (DB)	AMOUNT TO BE SUBTRACTED FROM THE SMALLER LOSS (DB)	DIFFERENCE BETWEEN TWO RETURN LOSSES (DB)	AMOUNT TO BE SUBTRACTED FROM THE SMALLER LOSS (DB)
0.0-0.1	3.0	3.7-4.0	1.5
0.2-0.3	2.9	4.1-4.3	1.4
0.4-0.5	2.8	4.4-4.7	1.3
0.6-0.7	2.7	4.8-5.1	1.2
0.8-0.9	2.6	5.2-5.6	1.1
1.0-1.2	2.5	5.7-6.1	1.0
1.3-1.4	2.4	6.2-6.6	0.9
1.5-1.6	2.3	6.7-7.2	0.8
1.7-1.9	2.2	7.3-7.9	0.7
2.0-2.1	2.1	8.0-8.6	0.6
2.2-2.4	2.0	8.7-9.6	0.5
2.5-2.7	1.9	9.7-10.7	0.4
2.8-3.0	1.8	10.8-12.2	0.3
3.1-3.3	1.7	12.3-14.5	0.2
3.4-3.6	1.6	14.6-19.3	0.1
		19.4 up	0

TABLE 6

TRANSMISSION LOSSES AT 68°F

GAUGE	CAPACITANCE µf/mile	LOADING	LOSS AT 1 KC db/kft.	LOSS AT 1 KC db/mi.	LOSS AT 60 KC db/kft.	LOSS AT 60 KC db/mi.
19	0.066	NL	0.212	1.12	0.807	4.26
		H44	.095	.50		
		H88	.071	.375		
		B88	.055	.29		
19	0.083 (PIC)	NL	0.241	1.27	0.858	4.53
		H44	.106	.56		
		H88	.080	.42		
		D88	.072	.38		
		B88	.063	.33		
		B135	.051	.27		
19	0.084 (Pulp)	NL	0.241	1.27	1.005	5.31
		H44	.106	.56		
		H88	.080	.42		
		D88	.072	.38		
		B88	.063	.33		
		B135	.051	.27		
22	0.082	NL	~~0.543~~ 0.343	1.81	1.51	8.00
		H44	.199	1.05		
		H88	.150	.79		
		D88	.133	.70		
		B88	.114	.60		
		B135	.093	.49		
24	0.072	NL	0.405	2.14	1.94	10.22
		H44	.276	1.46		
		H88	.216	1.14		
		D88	.191	1.01		
		B88	.165	.87		
		B135	.131	.69		
24	0.084	NL	0.438	2.31	2.19	11.54
		H44	.297	1.57		
		H88	.229	1.21		
		D88	.205	1.08		
		B88	.174	.92		
26	0.079	NL	0.540	2.85		
		H44	.419	2.21		
		H88	.339	1.79		
		B88	.261	1.38		