BELL SYSTEM PRACTICES
Outside Plant Construction and Maintenance

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AT&T Co Standard

CABLE TESTING

LOCALIZED BALANCING FOR REDUCTION OF CROSSTALK IN 4-WIRE CABLE CIRCUITS

Contents **Page**

General 1
General Method on New Installations 19-H-44-25 Facilities 2
Types and Location of Cable Splices..... 2
Testing and Splicing Procedure..... 2
Terminal Balancing (4-Wire Quads)..... 6
General Method on New Installations 19-H-88-50 Facilities 12
General Method on Existing Installations..... 13
Localized Crosstalk Balancing Data Sheet..... 14

1. GENERAL

1.01 This section describes methods of localized crosstalk balancing in 4-wire cable circuits.

1.02 The principal changes made in the previous issue are: (1) the use of the 2A or 2B Noise Measuring Set in the balancing tests, (2) revised crosstalk coupling values for 19-H-44-25 facilities and (3) information describing the crosstalk balancing of 19-H-88-50 4-wire facilities.

1.03 The method in its entirety may be used in new cable installations consisting largely of 4-wire cable circuits and in part in the maintenance of existing cable installations.

1.04 In cable installations the use of localized balancing for the reduction of crosstalk in 4-wire circuits involves a modified form of the capacitance unbalance test splicing procedure, together with the use of suitable balancing condensers installed at a terminal of a particular repeater section under consideration.

1.05 In cable installations involving 19-H-88-50 4-wire facilities the usual test splicing procedure is followed. In some cases further crosstalk reduction may be necessary and this is obtained by localized balancing, involving the use of suitable balancing condensers installed at a terminal of a particular repeater section under consideration.

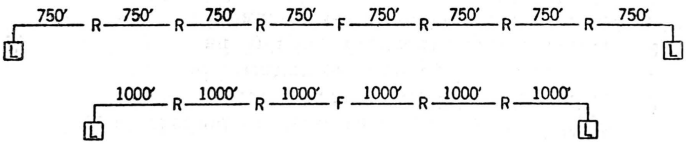
2. GENERAL METHOD ON NEW INSTALLATIONS 19-H-44-25 FACILITIES

Types and Location of Cable Splices

2.01 Since the localized balancing method is only applicable to 4-wire circuits only 6,000-foot loading sections will be involved and further discussion will refer to 6,000-foot loading sections.

2.02 As outlined in Section G72.225, usually three test splices are required in each loading section. Where the localized balancing method is employed on 19-H-44-25 facilities however, a single test splice is used.

2.03 A layout of a loading section of cable showing the type and location of the test points is shown in Fig. 1 for 750-foot and 1,000-foot lengths.



R = Random Splice
F = Final Test Splice
L = Loading Coil

Fig. 1

Testing and Splicing Procedure

2.04 The random splices should be made in the usual manner.

2.05 The phantom-to-side and the side-to-side unbalances in the cable portions at the final test splice should be measured and recorded in the usual manner for the 2-wire quads.

2.06 On the 4-wire quads only the phantom-to-side unbalances should be measured and recorded.

2.07 Next the 2-wire quads should be matched in accordance with the method outlined below. In general, with this method of test splicing, a quad in Direction A should be spliced to a quad in Direction B having unbalances of the same magnitude. In addition, the two quads should be in different classes, that is, one should be a positive and the other a negative quad. The procedure consists in starting with the first quad in Direction A (which may not necessarily be the quad having the highest unbalance value) and selecting a quad in Direction B which will effect the best unbalance neutralization. The quads in Direction A are usually taken in order, that is, 1, 2, 3, etc. If during this process quads in Direction A are found whose unbalances are of such magnitude as to make it impossible to effect satisfactory neutralization with the available quads in Direction B, the Direction A quads should be noted for further investigation. In this way, there will be a few quads having unbalances of such magnitude as to make it impossible to obtain satisfactory neutralization. After all except these few quads have been matched they should be matched with the remaining quads in Direction B in such a way as to obtain the lowest possible resultant unbalances.

2.08 The method of "doping" the unbalance sheets can best be illustrated by examples. Fig. 2 indicates a group of quads spliced in accordance with this method.

2.09 In "doping" the data sheet shown in Fig. 2 the first step is to determine which quad in Direction B will neutralize Quad 1 in Direction A in the manner indicated in paragraph 2.07. It is noted that Quad 1, Direction A, is a positive quad and a negative quad having unbalances of approximately the same magnitude should be selected. An inspection of the quads in Direction B indicates that Quad 11 meets these requirements fairly well. As indicated by the data sheet, the quads are spliced reverse, straight, straight.

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FORM E 442

CAPACITANCE UNBALANCE DATA SHEET

WITHIN - QUAD UNBALANCES

LOADING SECTION 2

CABLE Culver - Dorchester "A"

TEST POINT Poles 50 - 51

ESTIMATE NO. 2011 · PRINT NO. 12

TYPE OF TEST Final

DIRECTION A			QUAD NO.	DIRECTION B			SPLICING INSTRUCTIONS				BUILT UP TO BE MET	RESULTANT - UNBALANCES CALCULATED			OBSERVED		
PH. TO SIDE		SIDE TO SIDE		PH. TO SIDE		SIDE TO SIDE	QUAD A	PAIRS WHITE	PAIRS BLACK	QUAD B		PH. TO SIDE		SIDE TO SIDE	PH. TO SIDE		SIDE TO SIDE
WHITE	BLACK			WHITE	BLACK							WHITE	BLACK		WHITE	BLACK	
+110	+20	+10	1	-85	-15	+10	1	X	-	11	1	15	5	5			
-10	-15	+10	2	+65	-5	+10	2	-	-	5		0	10	15			
+70	-50	+25	3	-10	-65	+35	3	-	X	14		10	5	5			
+20	-65	-10	4	-125	+25	-20	4	X	X	9		10	10	15			
+45	+35	+35	5	+110	+5	+5	5	X	X	21		5	10	25			
-10	-20	+5	6	+25	-15	+20	6	X	-	6		5	5	15			
-75	+5	+45	7	-50	+5	-45	7	X	-	3		10	5	10			
-45	-80	-65	8	-5	+85	-6	8	-	X	19		30	85	0			
-160	+5	+100	9	-75	+30	+25	9	-	X	13		15	50	20			
-35	-35	-15	10	+85	+5	-35	10	X	-	4		10	10	5			
-10	-60	0	11	-25	-95	-5	11	X	X	2		5	5	10			
-70	-70	+55	12	-15	-85	+5	12	-	-	17		15	15	15			
-15	-35	-10	13	-145	+45	+80	13	X	-	24		5	0	0			
-175	+15	+15	14	+60	-55	-70	14	-	-	20		30	5	5			
+10	-40	+25	15	-55	+20	+25	15	X	X	7		5	10	20			
+40	+75	-15	16	+10	+25	+15	16	-	-	12		25	10	10			
0	0	+15	17	+55	-55	+40	17	-	X	23		25	0	10			
+15	-65	+5	18	+100	-70	+5	18	X	-	25		15	0	40			
+85	0	0	19	-75	-95	+65	19	X	X	8		0	5	5			
-205	-95	+5	20	+145	+20	+10	20	X	-	15		15	40	30			
-35	-5	-30	21	+25	+45	-50	21	X	-	16		10	5	15			
-70	+115	-5	22	+20	-20	-10	22	X	X	18		0	15	0			
-30	+85	+15	23	+25	0	+5	23	X	X	1		5	0	5			
+15	-100	-45	24	+35	-10	+40	24	X	X	10		10	15	10			
+25	-35	+5	25	-45	-30	+45	25	-	X	21		5	15	5			

SPLICER TESTER CALCULATOR

SET NO. SET ZERO

TEST TO (A) DATE

TEST TO (B)

REMARKS:

GROUP	GAUGE	NO. OF QUADS	OBSERVED RESULTANTS PH. TO SIDE AVE.	PH. TO SIDE MAX.	SIDE TO SIDE AVE.	SIDE TO SIDE MAX.
2-W	19	25				

* These spaces used for checking purposes

Fig. 2

2.10 Next it is determined which quad in Direction B will best neutralize Quad 2 in Direction A. It is noted that Quad 5 in Direction B is a quad having unbalances of the same order of magnitude. However, it is also a positive quad. A further inspection indicates that since the S-S unbalance of Quad 5 is only +5 mmf. it still affords the best neutralization of Quad 2. The connection of the two quads is as indicated, straight, straight, straight.

2.11 Quad 3 in Direction A is next investigated and the process is repeated with 4, 5, 6 and 7. Next Quad 8 is considered. However, an inspection of the remaining quads available for use in Direction B indicates that it is impossible to effect satisfactory reduction with any one quad. For the time being it is best not to consider Quad 8, making note of it and passing on to Quad 9. It will be noted that Quad 9 represents a case similar to Quad 8, and this quad is also set aside and Quad 10 is next considered. Satisfactory reduction of Quad 10 is obtained by using Quad 4 in Direction B.

2.12 The process indicated in the preceding paragraphs is repeated until all of the quads in Direction A have been investigated. Next the procedure is to take the quads which have been set aside for the reason that proper unbalance neutralization cannot be obtained. These quads in Direction A are 8, 9 and 20. The remaining quads in Direction B to be used for neutralizing these are Quads 13, 15 and 19. An inspection shows that Quad 8 can be best neutralized by Quad 19, Quad 9 by 13 and Quad 20 by 15. The connections are indicated on the data sheet.

2.13 The usual capacitance unbalance limits given should be observed in matching the 2-wire quads and, if the resultant unbalances are in excess of these limits, loading section balancing units should be employed as described in other current information to bring the unbalances within the allowable limits. The usual check tests should, of course, be made to determine whether the necessary neutralization of unbalances has been obtained.

2.14 The 4-wire quads should next be matched and spliced having in mind the reduction of only the phantom-to-side unbalances and with a view of obtaining the minimum average unbalance per group. This matching process should be carried out in the usual manner except that no consideration need be given to the side-to-side unbalances. The neutralization is accomplished by first matching a quad having the highest unbalances in one direction to one having the highest unbalances in the other direction and then proceeding to the next highest, etc. The elimination of the consideration

of the side-to-side unbalances should result in great simplification in the matching process, since no attention need be given to positive or negative quads. No loading section balancing units should be employed on the 4-wire quads, and with such a procedure it will not be possible to adhere to any specific capacitance unbalance limits.

2.15 Phantom-to-side and also side-to-side check tests should be made on the 4-wire quads. The side-to-side check tests are made only for the purpose of detecting any splits and, therefore, it will not be necessary to record the side-to-side unbalances.

Terminal Balancing (4-Wire Quads)

2.16 After the 4-wire quads have been loaded, Ph-S_1, S_1-Ph, Ph-S_2, S_2-Ph, and S-S far-end crosstalk coupling measurements should be made on these quads over the repeater section of outside cable from main frame to main frame. The method of making these measurements is covered in other current information. Care should be taken in the course of these tests to make the necessary wire turnovers between the oscillator and testing apparatus and the cable pairs, in order to make sure that the testing apparatus and wiring is not a source of crosstalk. Record the crosstalk coupling measurements in the first, third, fourth and fifth columns of a form similar to that of Fig. 5 described in Part 4.

2.17 Using the chart of Fig. 3, determine and record in Column 6 of Fig. 5, the crosstalk units corresponding to the db values given in Column 5.

RELATION BETWEEN
CROSSTALK UNITS AND DECIBELS

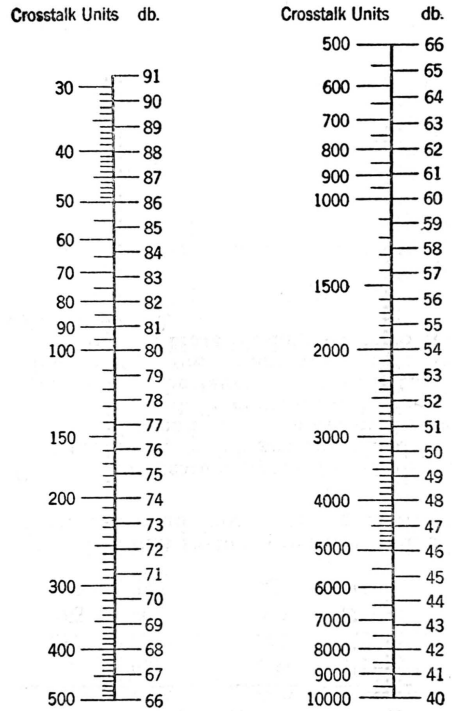

Fig. 3

2.18 Determine the average crosstalk coupling in crosstalk units for all phantom-to-side combinations, side-to-phantom combinations, and side-to-side combinations, respectively. Determine the maximum phantom-to-side, side-to-phantom and side-to-side crosstalk coupling values in crosstalk units, respectively.

2.19 In case the average values or the maximum values or both are in excess of the recommended tolerable values of Table 1, crosstalk reduction will be necessary as outlined in succeeding paragraphs.

TABLE 1

19-H-44-25—4-Wire Facilities

Length of Rep. Section Miles	Crosstalk Coupling in Crosstalk Units					
	P-S		S-P		S-S	
	Ave.	Max.	Ave.	Max.	Ave.	Max.
30	225	850	300	1150	150	1000
40	250	825	365	1200	170	1000
50	265	800	425	1250	190	1000
60	280	750	485	1350	210	1000

2.20 Assuming that further crosstalk reduction is desired, select the quad having the greatest crosstalk coupling.

2.21 Connect the testing apparatus shown on Fig. 4, details regarding which are contained in other current information, to this quad. Either a 3A or 4A capacitance unbalance set may be used. In connecting in the capacity unbalance set, care should be taken to connect the White and its Mate binding posts to the tip and ring respectively of Side 1, and the Black and its Mate binding posts to the tip and ring respectively of Side 2.

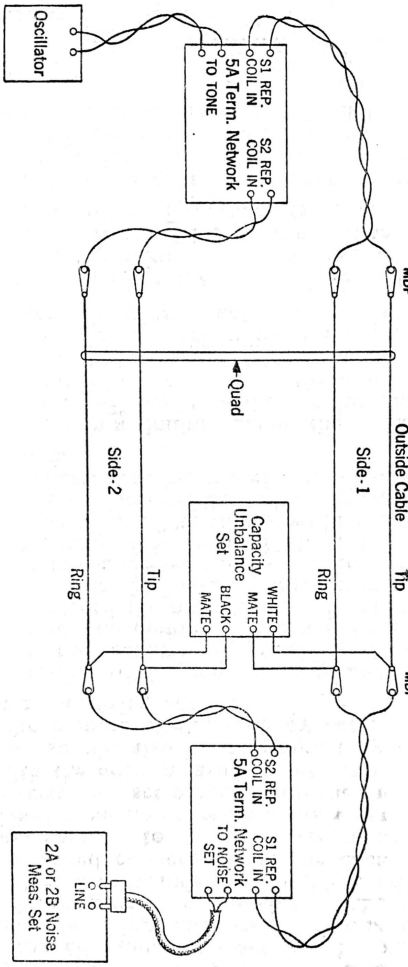
Oscillator
S1 REP. COIL IN
TO TONE
5A Term. Network
S2 REP. COIL IN
MDF
Quad
Outside Cable
Side-1
Side-2
Ring
Tip
Ring
Tip
Capacity Unbalance Set
WHITE MATE
BLACK MATE
MDF
S2 REP. COIL IN
5A Term. Network
TO NOISE SET
S1 REP. COIL IN
2A or 2B Noise Meas. Set
LINE

Fig. 4

2.22 Assume that the Ph-S_2 crosstalk coupling for the quad being tested is of the highest magnitude. With the oscillator at the sending end operating on the phantom circuit and the noise measuring set connected to S_2, set the keys of the capacity unbalance set for the particular combination which is being measured (in this case Ph-S_2). Next adjust the measuring set condensers (the measuring set condensers referred to include the variable condenser as well as the key operated condensers) of the capacity unbalance set in a manner similar to that employed in ordinary capacitance unbalance measurements until the volume of the tone heard in the telephone set plugged into the monitoring jacks associated with the noise measuring set reaches a minimum. This minimum should also be determined by following the changes in the volume of the tone by actual measurement with the noise measuring set.

2.23 The reading of the capacity unbalance set which is made in the usual manner should be recorded both in sign and magnitude in Column 7 of a data sheet similar to that of Fig. 5. Also record the noise on the disturbed circuit for this value of unbalance in Column 9. Next turn over the leads of the capacity unbalance set, that is connect the White post of the set to the ring of S_1 and its Mate to the tip of S_1 and repeat the measurements. The values read should be approximately the same as formerly but with opposite sign and if not, it would indicate that the capacity unbalance set was not properly adjusted.

2.24 Determine in a similar manner the minimum volume of tone for S_2-Ph and record the capacitance unbalance reading both in magnitude and sign in Column 7. In this case the capacity unbalance set should be adjusted for a Ph-S_2 measurement. Also record the minimum noise on the disturbed circuit for this value of unbalance in Column 9.

2.25 Determine the average of the Ph-S_2 reading and the S_2-Ph reading, taking into account the signs as well as the magnitudes. Record this average value both in sign and magnitude in Column 8 of the data sheet.

2.26 Adjust the capacity unbalance set to the average or mean value just determined and measure the resultant Ph-S_2 and S_2-Ph crosstalk coupling. Record the results of the measurements in Columns 10, 11 and 12 of the data sheet.

2.27 Inasmuch as the Ph-S_1 and S_1-Ph and the S-S crosstalk can probably be improved by balancing with little additional work which should result in a lower average crosstalk coupling, determine the best balancing capacitance

for Ph-S_1 and S_1-Ph as outlined in paragraphs 2.22 to 2.26, inclusive. Also do the same for S-S. It will, of course, be necessary in these cases to set up the apparatus respectively for a Ph-S_2, S_1-Ph and S-S crosstalk coupling measurement. The capacity unbalance set, however, should be connected in the circuits in the manner indicated in Fig. 4 with the keys of the set properly adjusted. For the S-S measurement only one setting of the capacity unbalance set need be made since the S_1-S_2 crosstalk coupling should be practically identical with the S_2-S_1 crosstalk coupling.

2.28 Select the quad having the next highest crosstalk coupling and proceed in a similar manner as outlined in paragraphs 2.21 to 2.27, inclusive. Continue this procedure until the correcting capacitances for enough quads have been determined that after such correction is applied it is probable that the average and maximum values of the crosstalk coupling for the entire group of quads will fall within the tolerable values given in paragraph 2.19. In this connection it will expedite matters to keep a running check of the average and maximum values as the crosstalk for the different quads is reduced by the mean balancer.

2.29 After the proper balancing capacitances for the various quads requiring reduction have been determined, the size and connections of the balancing condensers should be determined in the same manner as outlined in other current sections of Bell System Practices relating to the loading section balancing units.

2.30 In view of the relatively large balancing capacitances which will ordinarily be required, the spool type adjustable balancing condensers described in other current sections should in general be used for this localized crosstalk balancing.

2.31 These condensers should be prepared for installation and adjusted to the desired capacitance values as described in other current information.

2.32 Next the condensers should be connected temporarily to the proper wires of each quad on which balancing is required.

2.33 After the connections are made far-end Ph-S_1, Ph-S_2, S_1-Ph, S_2-Ph and S-S crosstalk coupling measurements should be made (with the capacity unbalance set removed from the circuit), in order to determine if the proper reduction is obtained. The results of the measurements should be recorded in Columns 13, 14 and 15 of the data sheet.

2.34 Using the chart of Fig. 3, determine and record in Column 16 of the data sheet the crosstalk units corresponding to the db values given in Column 15.

2.35 In case the crosstalk reduction obtained is not approximately the same as calculated, the calculations and connections should be checked for errors.

2.36 After the units have been permanently installed and the splice wrapped up preparatory to wiping on the sleeve, the far-end crosstalk coupling measurements discussed in paragraph 2.33 should be repeated in order to make sure that the balancing capacitances have been installed properly. The results of the measurements need not be recorded but merely checked against those recorded in Columns 13, 14, 15 and 16.

3. GENERAL METHOD ON NEW INSTALLATIONS 19-H-88-50 FACILITIES

3.01 As indicated in paragraph 1.05 it is assumed that the usual test splicing procedure will have been carried out on the 19-H-88-50 4-wire facilities.

3.02 In order to determine the necessity of further crosstalk reduction make Ph-S_1, S_1-Ph, Ph-S_2, S_2-Ph and S-S far-end crosstalk coupling measurements from main frame to main frame as outlined in other current information. Care should be taken in the course of these tests to make the necessary wire turnovers in order to make sure that the testing apparatus or wiring is not a source of crosstalk. Record the results of the measurements in the first, third, fourth and fifth columns of a form similar to that of Fig. 5.

3.03 Using the chart of Fig. 3 determine and record in Column 6 the crosstalk units corresponding to the db values given in Column 5.

3.04 Determine the average crosstalk coupling in crosstalk units for all phantom-to-side combinations, side-to-phantom combinations and side-to-side combinations, respectively. Determine the maximum phantom-to-side, side-to-phantom and side-to-side crosstalk coupling values in crosstalk units, respectively.

3.05 In case the average values or the maximum values or both are in excess of the recommended tolerable values given in Table 2, crosstalk reduction will be necessary as outlined in paragraphs 2.20 to 2.34, inclusive.

TABLE 2

19-H-88-50—4-Wire Facilities

Length of Rep. Section Miles	Crosstalk Coupling in Crosstalk Units					
	P-S		S-P		S-S	
	Ave.	Max.	Ave.	Max.	Ave.	Max.
30	250	950	310	1125	150	1000
40	280	925	350	1175	170	1000
50	300	900	400	1200	190	1000
60	310	875	450	1225	210	1000
70	320	850	500	1275	225	1000

4. GENERAL METHOD ON EXISTING INSTALLATIONS

4.01 Because of road changes, cable failures, etc., it is sometimes necessary to reroute or replace sections of cable containing 4-wire circuits. Where such reroutes or replacements are made the initial capacitance unbalance conditions may be upset and serious crosstalk may result. In such cases, localized balancing may be employed on the 4-wire circuits for reducing the crosstalk.

4.02 In order to determine the necessity of crosstalk improvement, make Ph-S_1, S_1-Ph, Ph-S_2, S_2-Ph and S-S far-end crosstalk coupling measurements on the 4-wire quads from main frame to main frame as outlined in other current information. Care should be taken in the course of these tests to make the necessary wire turnovers in order to make sure that the testing apparatus or wiring is not a source of crosstalk. Record the results of the measurements in the first, third, fourth and fifth columns of a form similar to that of Fig. 5.

4.03 Using the chart of Fig. 3, determine and record in Column 6 the crosstalk units corresponding to the db values given in Column 5.

4.04 Determine the average crosstalk coupling in crosstalk units for all phantom-to-side combinations, side-to-phantom combinations and side-to-side combinations, respectively. Determine the maximum phantom-to-side, side-to-phantom and side-to-side crosstalk coupling values in crosstalk units, respectively.

4.05 In case the average values or the maximum values or both are noticeably in excess of the values given in Tables 1 and 2, crosstalk reduction will be necessary, as outlined in paragraphs 2.20 to 2.34, inclusive.

5. LOCALIZED CROSSTALK BALANCING DATA SHEET

5.01 Reference has already been made to a data sheet for recording the results of measurements made in connection with localized crosstalk balancing. A copy of a suggested data sheet is given in Fig. 5. Some actual test data have also been recorded in order to indicate how to use such a form.

LOCALIZED CROSSTALK BALANCING ON 4-WIRE CIRCUITS
MEASUREMENT OF BALANCERS REQUIRED

Cable *Elizabethtown - Plattsburg* Measuring End *Plattsburg*

DETERMINATION OF BALANCING CAPACITANCES												CROSSTALK COUPLING WITH BALANCING CONDENSERS INSTALLED			
QUAD	COMBINATION	NOISE ON D'ING. CCT. db*	NOISE ON D'ED. CCT db*	INITIAL CROSSTALK COUPLING		MMF. FOR MIN. CROSSTALK COUPLING	MEAN — PH-S & S-PH VALUES	NOISE ON D'ED CCT. WITH BAL'R db*	NOISE ON D'ING. CCT WITH MEAN BAL'R db*	NOISE ON D'ED. CCT. WITH MEAN BAL'R db*	CROSSTALK COUPL WITH MEAN BAL'R db	NOISE ON D'ING. CCT. db*	NOISE ON D'ED. CCT. db*	FINAL CROSSTALK COUPLING •	
				db	CU									db	CU
191/2	PH - S1	*126.8*	*50.0*	*76.8*	*150*	*-90*		*48.9*	*127.8*	*48.8*	*79.0*	*127.8*	*48.8*	*79.0*	*110*
	S1 - PH	*124.2*	*51.3*	*72.9*	*230*	*-160*	*-125*	*42.5*	*125.9*	*41.3*	*84.6*	*125.9*	*41.3*	*84.6*	*60*
	PH - S2	*126.8*	*46.9*	*79.9*	*100*	*-40*		*45.4*	*127.8*	*44.0*	*83.8*	*127.8*	*44.0*	*83.8*	*65*
	S2 - PH	*124.2*	*41.9*	*82.3*	*80*	*-30*	*-35*	*40.6*	*125.9*	*37.6*	*88.3*	*125.9*	*37.6*	*88.3*	*39*
	S1 - S2	*125.0*	*56.0*	*69.0*	*350*	*+380*	*+380*	*40.9*	*125.9*	*41.1*	*84.8*	*125.9*	*41.1*	*84.8*	*60*
195/6	PH - S1	*129.3*	*59.5*	*69.8*	*320*	*-25*		*59.3*	*127.8*	*56.6*	*71.2*	*127.8*	*56.6*	*71.2*	*280*
	S1 - PH	*128.2*	*57.4*	*70.8*	*290*	*-155*	*-90*	*51.9*	*125.9*	*48.3*	*77.6*	*125.9*	*48.3*	*77.6*	*130*
	PH - S2	*129.3*	*51.2*	*78.1*	*125*	*-50*		*43.3*	*127.8*	*44.9*	*82.9*	*127.8*	*44.9*	*82.9*	*70*
	S2 - PH	*128.2*	*53.5*	*74.7*	*180*	*-100*	*-75*	*45.4*	*125.9*	*38.6*	*87.3*	*125.9*	*38.6*	*87.3*	*43*
	S1 - S2	*127.9*	*65.0*	*67.9*	*700*	*+215*	*+215*	*45.0*	*125.9*	*39.9*	*86.0*	*125.9*	*39.9*	*86.0*	*50*
	PH - S1														
	S1 - PH														
	PH - S2														
	S2 - PH														
	S1 - S2														
	PH - S1														
	S1 - PH														
	PH - S2														
	S2 - PH														
	S1 - S2														
	PH - S1														
	S1 - PH														
	PH - S2														
	S2 - PH														
	S1 - S2														
	PH - S1														
	S1 - PH														
	PH - S2														
	S2 - PH														
	S1 - S2														

Note:- D'ING - Disturbing Circuit
D'ED - Disturbed Circuit
BAL'R - Balancer
CU - Crosstalk Units
* db above reference noise (Message Weighting)

Fig. 5

5.02 In view of the expected relatively small demand in the near future it is suggested that forms similar to that of Fig. 5 be made up locally.

5.03 At the top of the data sheet are spaces for recording the particular section and the location of the measuring end. The number of the quad being tested should be recorded in Column 1 of the form. The results of the initial crosstalk coupling measurements should be recorded in Columns 3, 4 and 5. The noise in db above reference noise on the disturbing circuit is recorded in Column 3 and the noise on the disturbed circuit in Column 4. The crosstalk coupling in db which is the difference between Columns 3 and 4 is recorded in Column 5, the corresponding values in crosstalk units being recorded in Column 6.

5.04 The amount of capacitance introduced by the capacity unbalance set for the minimum crosstalk coupling should be recorded in Column 7. Also the noise on the disturbed circuit with this value of capacitance should be recorded in Column 9. The average of the Ph-S and S-Ph mmf. values is recorded in Column 8. The noise on the disturbing and disturbed circuits with the capacity unbalance set adjusted to a value equal to the mean or average balancing capacitance is recorded in Columns 10 and 11, respectively, and the crosstalk coupling which is the difference between these two values is recorded in Column 12.

5.05 The noise on the disturbing and the disturbed circuits with the adjustable balancing condensers actually connected to the proper wires of the quad is recorded in Columns 13 and 14. The final crosstalk coupling which is the difference between the values recorded in Columns 13 and 14 is recorded in Column 15 and the corresponding values in crosstalk units are recorded in Column 16.