LINE BALANCING NETWORK DATA

CONTENTS — PAGE

1. GENERAL

1.01 This addendum to Section 332-851-102, Issue 1, provides data on line balancing networks for B and H-88-50 loaded cable circuits; 16-gauge B-22 cable circuits; 22-gauge BSA B-135-N cable circuits; 114-mil open-wire circuits, with various wire spacings; and modifications of the 108A, B, and C networks for use on 6-inch spaced open-wire circuits.

1.02 The networks for B and H-88-50 loaded cable circuits are as follows:

NETWORK CODE	TYPE FACILITIES
113P*	19-Gauge H-88 Side
113R*	19-Gauge H-50 Phantom
D-92945	19-Gauge B-88 Side
D-92946	19-Gauge B-50 Phantom

* Replacing the D-92947 and D-92948 networks.

These networks were designed particularly for use with 19-gauge conductors. It appears that H-88-50 loading may be used to a small extent with 16-gauge conductors. Although better return losses at low frequencies could be obtained by the use of networks designed especially for 16-gauge facilities, it is believed that the use of 19-gauge networks for 16-gauge facilities will, in this case, give satisfactory results in the circuit layouts with which these facilities are likely to be used.

1.03 A network for 16-gauge B-22 circuits was developed some time ago for trial purposes but never standardized. No field of use has developed for this type of network but mention of it is being made in this addendum inasmuch as some inquiry has been made of it mainly for completion test purposes. It is coded D-87801. (A schematic diagram and the constants of this network are shown in Fig. 1; and its impedance, in Fig. 2. The same equipment considerations apply to the 102- and 104-types. No further mention is made of this network in the addendum.

1.04 The network for 22-gauge BSA B-135-N circuits is coded 113S and is provided with adjustable elements to compensate for the impedance effects caused by deviation of average loading section capacitance from the normal value. These adjustments are made by strapping terminals provided in the rear of the network.

> *Note:* A network for 19-gauge CNB B-135-N facilities has been designed but not standardized. Arrangements can be made for its manufacture if needed.

1.05 The networks for use with 114-mil, nonloaded, open-wire circuits are coded 114A and 114B for the side and phantom circuits, respectively. These networks are arranged so their impedance may be adjusted to various values in order that a good degree of impedance simulation may be obtained between them and the impedance of 114-mil open-wire circuits having spacings between wires of from 8 to 30 or more inches. The impedance of the network is changed by adjusting the resistance component, the reactance component remaining unchanged. This arrangement does not, of course, give exact impedance simulation for the variously spaced circuits for which these networks may be used. However, the network can be adjusted to give sufficiently close simulation so that a reasonably good balance can be obtained, provided the line facilities are free from serious irregularities.

1.06 Open-wire circuits with 6-inch spacing may be balanced with modified 108-type networks. Networks for the above circuits may be standardized in connection with the possible redesign of all open-wire networks to 113-types. This modification consists of a resistance shunt of 20,000, 15,000, and 12,000 ohms, respectively, across the terminals of the 108A (104-mil), 108B (128-mil), and 108C (165-mil) networks. These are resistances per KS-7843 and can be supported by their own leads connected to the network terminals.

2. DESCRIPTION OF NETWORKS

Networks for B and H-88-50 Facilities

2.01 The electrical configuration of the networks for B-88-50 side and phantom circuits is shown in Fig. 3. The capacitances employed are standard coded condensers. The resistors and coils are mounted in a single unit and are potted as one assembly, all being enclosed under a common can cover and arranged for stud mounting. These networks have been designed to simulate to a high degree the characteristic impedance of B-88-50 side and phantom circuits at half-coil termination over a frequency range from 100 Hz to above 3500 Hz.

2.02 The electrical configuration and constants of the networks for H-88-50 side and phantom circuits are shown in Fig. 4. This figure also shows the proper terminal strapping for various values of average capacitance per load section. These networks, without building-out capacitance, simulate the impedance of H-88-50 side and phantom facilities when terminated at 0.18 load section. The design of the networks has been such, however, that when built out with proper capacitance alone they will simulate the impedance of H-88-50 circuits for any loading section from 0.18 to full load section. Since these facilities normally terminate in 0.5 section, these networks have been designed to give the most accurate simulation when built out to 0.5 loading section. The networks for H-88-50 circuits are of the 113-type, in which form networks for various exchange lines have already been made available. (See Section 332-851-103.)

2.03 The impedances of the B-88-50 side and phantom circuit networks at half-coil termination are given in tabular form in Fig. 3. Table I gives the basic impedance of the H-88-50 networks and also the midsection impedance for various strappings of terminals to simulate cable having nominal and other than nominal capacitance.

Networks for 22-Gauge BSA B-135-N Facilities

2.04 The electrical configuration and constants of the network (also of the 113-type) for 22-gauge BSA B-135-N facilities are shown in Fig. 5. This figure also shows the way in which the terminals should be strapped for various values of loading section capacitance. The basic end section of this network is 0.186. The network impedance for the various strappings is shown in Table J.

Networks For 114-Mil Open-Wire Circuits

2.05 A schematic diagram of the 114A network for use with side or physical circuits, either nonpole pair or pole pair, is shown in Fig. 6, and a similar diagram of the 114B network for use with phantom circuits is shown in Fig. 7. The network configuration in each case consists of two elements in parallel, each element consisting of a capacitor and resistor in series, this combination being in series with another resistor. The variable feature of the network is provided by adjustment of this later resistor, the adjustment being accomplished by strapping certain terminals which are available on the exterior of the network. This permits the absolute impedance and also the resistance component of the network impedance to be changed but does not affect the reactance component. By proper strapping of the available terminals, the resistance component may be varied in 10-ohm steps, the series resistance being adjustable from 0 to 150 ohms.

2.06 Typical impedance characteristics are shown in Fig. 6 and 7 for the 114A and 114B networks, respectively. The 1000-Hz value of the resistance component is given for all values of the variable resistance, and the absolute impedance is given for a number of frequencies for certain strappings which frequently occur in practice.

Networks for 6-inch Spaced, Open-Wire Facilities

2.07 Typical impedance characteristics of the 108-type network modified for use with 6-inch spaced facilities are shown in Table K.

3. BALANCE CONSIDERATIONS

Networks for B and H-88-50 Facilities

3.01 Since the B-88-50 facilities terminate in half-coil, only a small building-out capacitor will generally be required, the amount depending only upon the capacitance on the office side of the last loading coil. In the case of the H-88-50 facilities, it will be necessary to build out the network not only for the office cabling capacitance but also for the capacitance of the line facilities where the termination of the line is in excess of 0.18 load section. Figure 8 shows the nominal value of the building-out capacity required corresponding to different cable end sections for H-88-50 facilities. This figure covers both the D-specifications and the 113-type networks, the basic end sections of which are different.

3.02 In certain cases where the average capacitance of the cable for one or more loading sections is slightly lower than the average nominal cable capacitance for which the B-88-50 networks have been designed, somewhat improved return losses will be obtained if the building-out capacitance is supplemented by a series resistance as indicated in the building-out arrangement shown in Fig. 3. Resistances are provided along with the building-out capacitance so that 18, 39, or 57 ohms may be obtained in series with the networks. Where the larger of the first two resistances is required (that is, 39 ohms), it will probably be best to connect it between the building-out capacitor and the network. For the smaller of the two resistances, the position is usually not important. Where the maximum resistance value is required, the building-out capacitance should be connected to the center point of the two resistances. The above also applies to the old D-specifications networks for H-88-50 circuits. The 113-type network for H-88-50 circuits has provisions for adjustments to simulate cable having either higher or lower than the nominal 0.062-μF/mile capacitance. The appropriate strappings for the various conditions are shown in Fig. 4.

3.03 The minimum return losses of the B and H-88-50 networks against theoretical line impedances, half-coil termination for B loaded circuits, and half-section termination for the H loaded circuits are as follows:

FREQUENCY — HZ	MINIMUM RETURN LOSS — DB	
	D-92945 & D-92946	113P & 113R*
100-200	38	38
200-300	40	40
300-2500	44	44
2500-3000	44	44
3000-3500	35	32

* Same values apply to the replaced D-92947 and D-92948.

The minimum return loss of any one network against any other network of the same type should be 38 dB for the frequency range of 300 to 3000 Hz when measured with the 3A return loss measuring set.

Networks for 22-Gauge BSA B-135-N Facilities

3.04 The network for 22-gauge BSA B-135-N facilities likewise includes provisions for simulating loading section capacitance higher or lower than nominal. The strapping arrangements are shown in Fig. 5. With suitable strapping, the return loss between the network and the theoretical cable impedance will be greater than 35 dB from 200 to 3200 Hz and at least 25 dB at 100 and 3600 Hz.

Networks for 114-Mil Open-Wire Circuits

3.05 In Fig. 6 and 7 are shown, in tabular form, the network connections which will give impedances simulating the nominal impedances of 114-mil open-wire circuits for the wire spacing indicated. Various factors such as transpositions, spacing between crossarms, spacing between pairs, etc., may affect the impedance so that some network connection other than the one shown on the table may give better results. The proper connection to be used may be determined by return-loss measurements or by measurements of the line impedance, comparing this with the table of network impedances in order that the best combination may be selected. When such tests are made, it will be desirable to remove all equipment from the line and terminate the distant end in substantially characteristic line impedance.

3.06 The design of these networks is such that when the proper network terminals are used, return losses of 25 dB or more over the frequency range of 200 to 3000 Hz can be obtained for lines which are free from irregularities such as pieces of nonloaded cables, etc., and which are terminated at the distant end in characteristic line impedance.

3.07 Where the open-wire line is brought into the repeater office through nonloaded cable or twisted pair, or where a considerable length of office cabling may be involved, the return loss can usually be improved by the addition of a building-out capacitance connected across the network terminals as is done for other nonloaded open-wire networks.

Networks for 6-Inch Spaced, Open-Wire Facilities

3.08 The return losses of the modified 108-type networks for use with 6-inch spaced circuits against the nominal dry weather impedance of such circuits are as follows (values for wet weather in general are somewhat lower):

FREQ — HZ	RETURN LOSS BETWEEN 6-INCH SPACED CIRCUITS AND NETWORKS		
	(104-MIL) 108A + 20000	(128-MIL) 108B + 15000	(165-MIL) 108C — 12000
300	34	37	36
500	36	35	38
1000	37	37	41
1500	38	39	39
2000	37	40	40
3000	37	40	40

Building-Out Section Adjustments—113-Type Networks

3.09 In general, in connection with the 113-type network, it is preferable to make adjustments of the building-out sections in accordance with capacitance data on the cable in question, or, in absence of such data, by means of return-loss measurements over the important frequency range from about 200 to 300 Hz. The optimum adjustment should be determined at frequencies below about 500 Hz for the building-out resistance, and above 1500 Hz for the building-out capacitance.

3.10 If return-loss measuring apparatus is not available, the adjustment can be made by means of measuring the impedance on a few of the circuits and comparing the average of these measurements with the impedance of a network adjusted in various ways. The adjustments may also be made by means of 21 test singing point measurements but, because of the effect of phase shift, adjustments so made may not always be optimum. One likely source of error is the use of too much building-out resistance and compensating this with adjustment of the building-out capacitor, with the result that the return loss will be high at the singing frequency but lower than might otherwise be obtained at other frequencies.

4. EQUIPMENT CONSIDERATIONS

Networks for B and H-88-50 Facilities

4.01 The networks for B-88-50 (also the old D-specifications networks for H-88-50) facilities are each 3-3/8 inches wide by 5-1/8 inches long and 3-11/15 inches high. Five networks may be mounted in a horizontal row on a 19-1/24 inch relay rack. The mounting arrangements of the networks and associated building-out units are shown on drawings ED-63666-02 and ED-63666-03. The first mentioned drawing applies to the earlier installations, which employed 80-type building-out resistances, and the second drawing covers the arrangements now standard, employing 18- or 19-type building-out resistors.

4.02 The 113-type networks for H-88-50 circuits are similar to the other networks of the 113-type. The structure consists of a bracket assembly having a formed channel into which are assembled the various resistance, capacitance, and inductance elements of the networks. In this same channel are assembled the building-out capacitor and resistors used to build out these networks to the end section corresponding to the loading end section of the cable and for simulating other than nominal capacitance conditions. The network dimensions are:

Overall length	6-15/16 inches
Depth (projection from panel)	4-13/32 inches
Width	1-19/32 inches

These networks are arranged for stud mounting on 1-3/4 inch by 7-inch centers. They can be mounted on 600A mounting plates drilled as specified, one or two networks per plate, or mounting bars per ED-90185-01, Fig. 2, for 19-inch relay racks, each bar accommodating ten networks per 7 inches of vertical space. The terminals for strapping the building-out resistor appear in the rear of the networks; those for the building-out capacitor may be reached from the front by removing the front cover.

Network for 22-Gauge BSA B-135-N Facilities

4.03 The network for 22-gauge BSA B-135-N facilities is also of the 113-type and the same dimensions and mounting details given in 4.02 are applicable.

Networks for 114-Mil Open-Wire Circuits

4.04 The networks for 114-mil open-wire circuits are 4-9/32 inches long, 1-11/16-inches wide, and 4-3/4 inches high. The terminals for the network appear on the top side and two tapped holes spaced 1-3/4 inches apart, for use in mounting the network, are located on the bottom side. These networks may be obtained assembled on 3-5/32 inch by 8-11/16 inch plates and may then be mounted on mounting bars on relay racks in the same manner as 102-, 104-, and similar-type networks.

Network for 6-Inch Spaced, Open-Wire Circuits

4.05 As already indicated, the only additional equipment consideration involved in the modification of 108-type networks for 6-inch spaced circuits is the bridging resistance across the terminals of the 108-type network. The resistance can be supported by its own leads connected to the network terminal.

5. ATTACHMENTS

List of Tables Attached

List of Figures Attached

REVISION OF TABLES A, D, E, F, AND G
OF SECTION 332-851-102, ISSUE 1, AND
NEW TABLE B.1

Table A - Standard Precision Type Balancing Networks - Relay Rack Mounting Designed for Nonloaded Open-Wire Impedance

Add:

Gauge	Circuit	Spacing	Code No.	Replacing
114	(Pole or Nonpole Pair (Side or Physical	Variable	114A	-
114	Phantom	Variable	114B	-
104	Nonpole Pair Physical	6 inches	108A+20000W*	-
128	Nonpole Pair Physical	6 inches	108B+15000W*	-
165	Nonpole Pair Physical	6 inches	108C+12000W*	-

* Resistance per KS-7643 bridged across terminals of the 108-type network.

Add New Table B.1 as follows:

Table B.1 - Standard Precision Cable Networks of 113-type - Stud-Mounting

Gauge	Nominal Cap./Mile	Loading	Circuit	Code	Network End Section	Replacing
19 AWG	0.062	H-88-S	Side	113-P	0.18	D-92947
19 AWG	0.100	H-50-P	Phantom	113-R	0.18	D-92948
22 AWG	0.078	B-135-N	Physical	113-S	0.186	-

Table D - Specifications Networks Obtainable on Order

Add:

Facility	Gauge	Loading	Circuit	Type of Network	Specification Number	Former Designation
Cable	19	B-88-50	Side	(Precision)	D-92945	-
Cable	19	B-88-50	Phantom	(Balancing)	D-92945	-
				(Relay Rack)		-
				(Stud-mounting)		-
Cable	16	B-22	Physical		D-87801	-

Table E - Basic Networks Rated A. and M. Only - Coil Rack Mounting Designed for Nonloaded Open-Wire Circuits

Delete Networks 17-A, B, C, D, E, F and G; 18-A; 11-A, B, C, and D; 12-A, B, D, E, F, G, H, J, K and L; and 20-A.

Table F - Networks and Low-Frequency Correctors Rated A. and M. Only - Designed for Cable Circuits

Delete Networks 13-R, and 21-A.

Table G - Basic Networks Rated Manufacture Discontinued - Coil and Relay Rack Mounting

Add Networks deleted from Tables E and F as above. Also Add:

Cable	19 Ga	H-88-S	Side	(Precision, Relay)	D-92947	- 113P
Cable	19 Ga	H-30-P	Phantom	(Rack, Stud-Mounting)	D-92948	- 113R

TABLE I

NOMINAL IMPEDANCE OF 113P BALANCING NETWORKS FOR BALANCING 19-GAUGE H-88-50 LOADED QUADDED TOLL CABLE

NETWORKS AS PER FIG. 4

Midsection Impedance
(Impedance Between Terminals 1 and 2)

BOR - Ohms	0	20	40	60	Basic Net.
Terminals Strapped	2-3	3-4	2-4	None	2-3
BOC - UF	0.0226	0.0226	0.0216	0.0216	None
Freq (Hz)					
100	1389 - j809	1389 - j809	1409 - j809	1429 - j809	1400 - j791
140	1272 - j621	1292 - j621	1313 - j621	1333 - j621	1303 - j595
200	1204 - j459	1224 - j459	1245 - j460	1265 - j460	1235 - j422
300	1161 - j317	1181 - j317	1201 - j319	1221 - j319	1190 - j262
500	1139 - j195	1159 - j195	1179 - j197	1199 - j197	1164 - j103
700	1138 - j139	1158 - j139	1178 - j144	1198 - j144	1156 - j10
1000	1150 - j99	1170 - j99	1189 - j104	1209 - j104	1152 + j90
1500	1193 - j66	1213 - j66	1230 - j72	1250 - j72	1152 + j231
2000	1271 - j47	1291 - j47	1307 - j54	1327 - j54	1153 + j375
2500	1412 - j41	1432 - j41	1443 - j48	1463 - j48	1157 + j549
2800	1550 - j55	1570 - j55	1578 - j59	1596 - j59	1162 + j678
3000	1677 - j83	1697 - j83	1699 - j84	1719 - j84	1166 + j780
3200	1842 - j143	1862 - j143	1861 - j136	1881 - j136	1171 + j900
3500	2181 - j366	2201 - j366	2198 - j334	2218 - j334	1183 + j1188

NOMINAL IMPEDANCE OF 113R BALANCING NETWORKS FOR BALANCING 19-GAUGE H-88-50 LOADED QUADDED TOLL CABLE

Midsection Impedance
(Impedance Between Terminals 1 and 2)

BOR - Ohms	0	15	30	45	Basic Net.
Terminals Strapped	2-3	3-4	2-4	None	2-3
BOC - UF	0.0372	0.0372	0.0355	0.0355	None
Freq (Hz)					
100	786 - j436	801 - j436	816 - j436	831 - j436	802 - j426
140	730 - j327	745 - j327	760 - j328	775 - j328	746 - j318
200	696 - j237	711 - j237	726 - j238	741 - j238	711 - j216
300	676 - j161	691 - j161	706 - j163	721 - j163	691 - j130
500	668 - j98	683 - j98	698 - j100	713 - j100	679 - j46
700	669 - j71	684 - j71	698 - j74	713 - j74	677 + j3
1000	675 - j50	690 - j50	705 - j55	720 - j55	675 + j57
1500	699 - j34	714 - j34	727 - j40	742 - j40	675 + j134
2000	740 - j24	755 - j24	766 - j33	781 - j33	676 + j212
2500	812 - j21	827 - j21	835 - j31	850 - j31	678 + j303
2800	880 - j27	895 - j27	900 - j37	915 - j37	680 + j372
3000	940 - j38	955 - j38	958 - j47	973 - j47	681 + j424
3200	1019 - j60	1034 - j60	1034 - j67	1049 - j67	684 + j483
3500	1181 - j141	1196 - j141	1190 - j139	1205 - j139	689 + j596

TABLE J

NOMINAL IMPEDANCE OF 113S BALANCING NETWORK FOR

BALANCING 22-GAUGE BSA B-135 LOADED CABLE CIRCUITS

	Midsection Impedance (Impedance Between Terminals 1 and 2)			
BOR - Ohms	0	37	102	Basic Net.
Terminals Strapped	2-4	2-3	None	None
BOC - UF	0.01462	0.01391	0.01302	None
Freq (Hz)				
100	1727 - j975	1765 - j975	1830 - j976	1860 - j956
250	1726 - j393	1764 - j393	1830 - j393	1858 - j327
300	1728 - j329	1765 - j328	1831 - j329	1858 - j248
500	1733 - j202	1771 - j201	1836 - j202	1857 - j63
1000	1765 - j109	1802 - j106	1866 - j107	1857 + j178
1500	1828 - j76	1864 - j71	1926 - j72	1858 + j351
2000	1943 - j55	1976 - j46	2035 - j45	1859 + j579
2400	2099 - j43	2129 - j29	2183 - j23	1861 + j780
2600	2212 - j44	2241 - j24	2290 - j14	1863 + j899
2800	2361 - j54	2387 - j27	2432 - j10	1866 + j1035
3000	2560 - j86	2583 - j47	2621 - j18	1869 + j1194
3200	2828 - j162	2849 - j105	2881 - j56	1874 + j1383
3600	3649 - j716	3698 - j575	3737 - j426	1891 + j1906

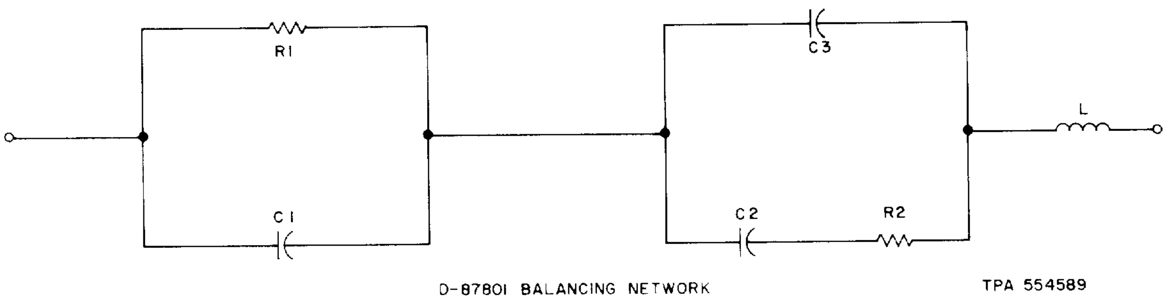
TABLE K

NOMINAL IMPEDANCE VALUES OF 108-TYPE

BALANCING NETWORKS MODIFIED FOR BALANCING 6-in. SPACED

OPEN-WIRE CONDUCTORS

Line Conductors	104-Mil		128-Mil		165-Mil	
Balancing Network	108-A		108-B		108-C	
Shunt Resistance	20,000 Ohms		15,000 Ohms		12,000 Ohms	
Frequency (Hz)	R	-jx	P	-jx	R	-jx
100	1030	767	853	573	691	400
200	804	503	684	362	590	232
300	718	375	634	262	583	167
500	649	249	595	168	544	103
1000	611	132	575	86	537	56
1500	600	90	570	61	535	34
2000	599	68	567	45	535	26
2500	598	54	567	38	535	21
3000	598	44	567	30	534	18



COMPONENT	CODE NO.	NOMINAL VALUE
R1	D-87865	795.8 Ohms
R2	D-87866	1662.0 Ohms
C1	76-FH	0.01349 UF
C2	57-M	2.60 UF
C3	2-57-BH	2.36 UF
L	D-87826	0.00818 Henry

This network is designed to balance 16-gauge B-22 cable pairs with midcoil termination.

Fig. 1—2-Wire Circuits Employing 16-GA B-22 Cable Pairs—Schematic of Balancing Network

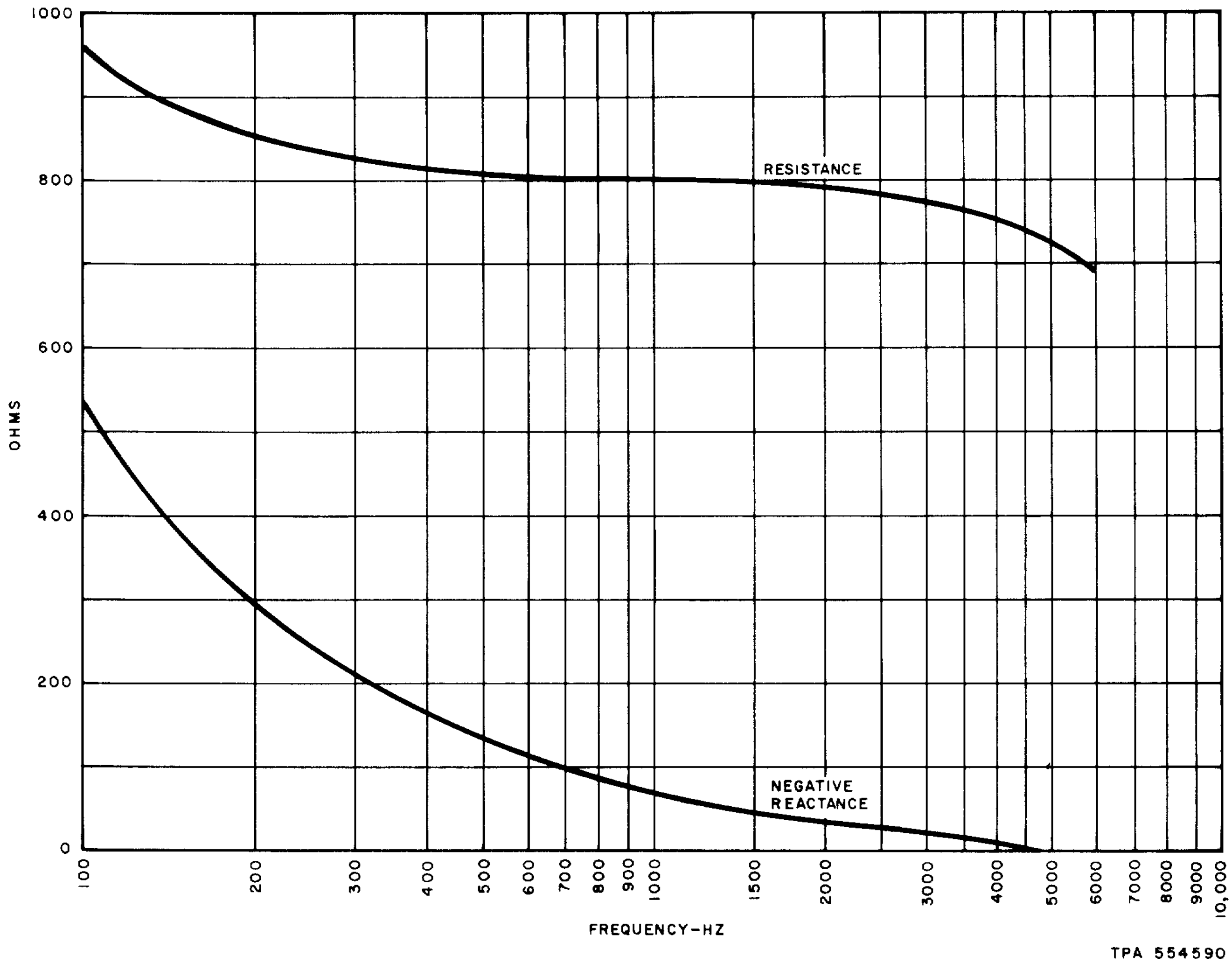
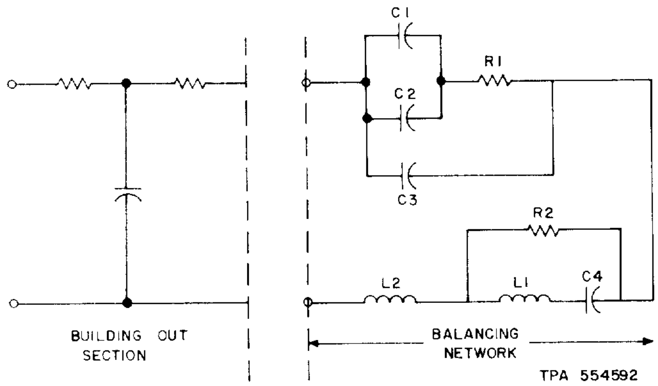


Fig. 2—Impedance Characteristic of D-87801 Balancing Network—This Network is Designed to Balance 16-GA B-22 Cable With Midcoil Termination



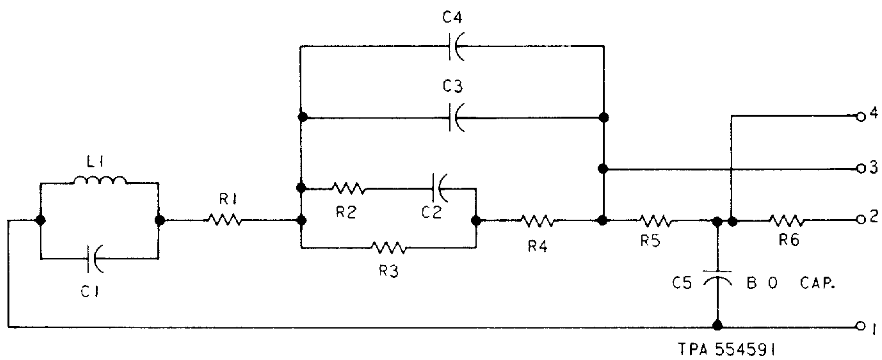
BALANCING NETWORK CONSTANTS		
	D-92945 SIDE CKT NETWORK	D-92946 PHANTOM CKT NETWORK
	VALUE	VALUE
C1	4.32 UF	2.16 UF
C2	2.16 UF	0.54 UF
C3	2.16 UF	4.32 UF
C4	0.0132 UF	0.02035 UF
R1	3287 Ohms	1634 Ohms
R2	1548 Ohms	927 Ohms
L1	24.61 mH	16.17 mH
L2	28.46 mH	17.0 mH

Note: Network end-section termination is half coil.

NETWORK IMPEDANCE

FREQ (Hz)	D-92945 SIDE			D-92946 PHANTOM		
	RESISTANCE (OHMS)	REACTANCE (OHMS)	IMPEDANCE AND ANGLE (OHMS/DEGREES)	RESISTANCE (OHMS)	REACTANCE (OHMS)	IMPEDANCE AND ANGLE (OHMS/DEGREES)
100	1714	- j694	1849 /22	997	- j342	1054 /18.9
140	1643	- j512	1721 /17.3	975	- j248	1008 /14.3
200	1602	- j366	1644 /12.9	954	- j179	971 /10.6
300	1578	- j250	1598 /9.0	943	- j122	951 /7.4
400	1569	- j191	1581 /6.9	939	- j92	944 /5.6
500	1553	- j157	1571 /5.7	936	- j74	939 /4.5
700	1553	- j119	1557 /4.4	931	- j54	933 /3.3
1000	1539	- j93	1542 /3.5	924	- j40	925 /2.5
1500	1505	- j76	1507 /2.9	906	- j30	907 /1.9
2000	1458	- j69	1460 /2.7	882	- j23	882 /1.5
2500	1395	- j63	1397 /2.6	849	- j18	849 /1.2
3000	1317	- j53	1318 /2.3	807	- j12	807 /0.9
3500	1222	- j35	1222 /1.6	755	- j4	755 /0.3

Fig. 3—Balancing Networks for B-88-50 Circuits

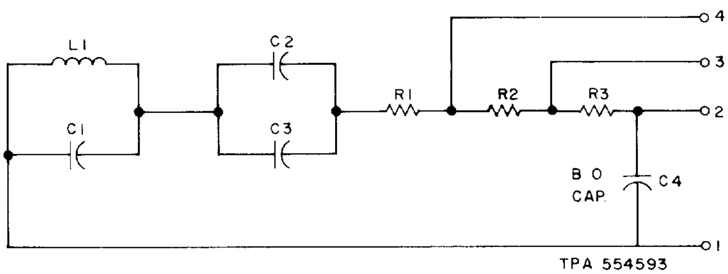


COMPONENT	VALUE	
	113P NET. FOR 19-GA H-88-SIDE	113R NET. FOR 19-GA H-50-PH
L1	0.0288 H	0.0163 H
R1	1135 Ohms	666 Ohms
R2	1226 Ohms	1750 Ohms
R3	4150 Ohms	1175 Ohms
R4	1450 Ohms	800 Ohms
R5	40 Ohms	30 Ohms
R6	20 Ohms	15 Ohms
C1	0.0325 UF	0.0524 UF
C2	1.08 UF	1.08 UF
C3	0.54 UF	1.08 UF
C4	1.08 UF	2.16 UF
C5	0.001 to 0.085 UF	0.001 to 0.085 UF
Basic End Section	0.18	0.18
Midsection BOC	0.0226 UF	0.0372 UF

C_S		STRAP TERMINALS
H-88-S CIRCUITS 113P NET.	H-50-PH CIRCUITS 113R NET.	
Normal	Normal	3-4
2% to 5% below normal	2% to 6% below normal	2-4
More than 2% above normal	More than 2% above normal	2-3
More than 5% below normal	More than 6% below normal	None

* C_S = Average capacitance per loading section.

Fig. 4—113-Type Balancing Networks for Balancing 19-GA H-88-50 Quadded Toll Cable Circuits—Nominal Side Circuit Capacitance is 0.062 μF per Mile



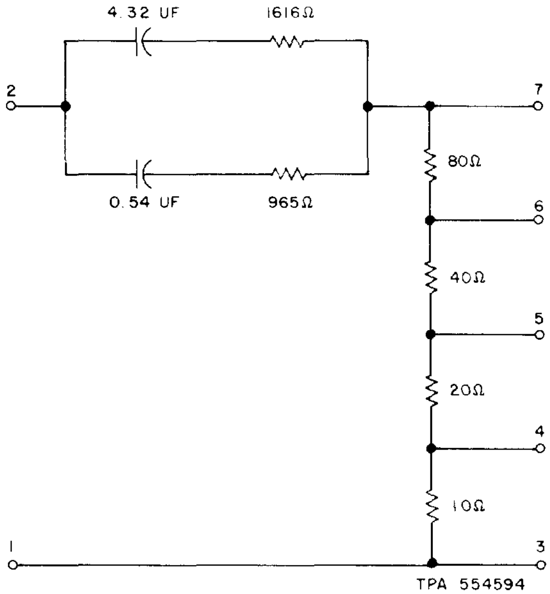
COMPONENT	NOMINAL VALUE
L1	0.0418 H
C1	0.02345 UF
C2	1.08 UF
C3	0.54 UF
C4	0.001 to 0.085 UF
R1	1750 Ohms
R2	37 Ohms
R3	65 Ohms

	NOMINAL CABLE CAPACITANCE PER MILE		
BASIC END SECTION = 0.186	0.073 UF	0.078 UF	0.082 UF
MIDSECTION BUILDING-OUT CAPACITANCE	0.01302 UF	0.01391 UF	0.01462 UF

TABLE SHOWING CONNECTIONS TO BE USED FOR VARIOUS AVERAGE LOAD SECTION CAPACITANCES

AVERAGE LOAD SECTION CAPACITANCE (UF)	TERMINALS	
	CONNECT TO	STRAP
0.042 or Less	1-2	NONE
0.042 to 0.044	1-2	3-4
0.044 to 0.046	1-2	2-3
0.046 or Greater	1-2	2-4

Fig. 5—113-Type Balancing Network for Balancing 22-GA BSA, B-135-N Cable Circuits



RESISTANCE ADJUSTMENTS		
TERMINALS STRAPPED	AMOUNT OF RESISTANCE ADDED TO NETWORK (OHMS)	RESISTANCE COMPONENT OF NETWORK IMPEDANCE AT 1000 Hz
3-7	0	614
4-7	10	624
3-4 and 5-7	20	634
5-7	30	644
3-5 and 6-7	40	654
4-5 and 6-7	50	664
3-4 and 6-7	60	674
6-7	70	684
3-8	80	694
4-6	90	704
3-4 and 5-6	100	714
5-6	110	724
3-5	120	734
4-5	130	744
3-4	140	754
None	150	764

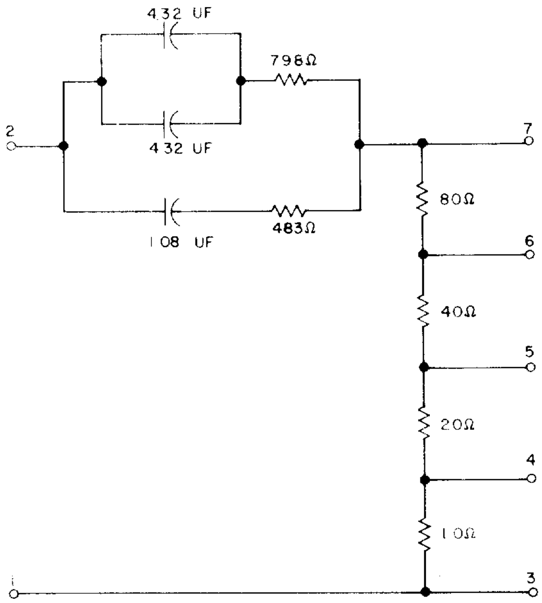
NETWORK IMPEDANCE									
FREQ (Hz)	REACT-ANCE (OHMS) *	TERMINALS STRAPPED							
		3-7		4-5 and 6-7		3-6		NONE	
		RES	Z/θ	RES	Z/θ	RES	Z/θ	RES	Z/θ
100	- j676	1052	1250/32.7	1102	1293/31.5	1132	1320/30.8	1202	1382/29.3
200	- j474	799	928/30.7	849	971/29.2	879	995/28.4	949	1039/28.6
300	- j366	710	795/25.7	760	845/25.7	790	869/24.9	860	935/23.0
500	- j230	644	685/19.6	694	730/18.4	724	760/17.6	794	825/18.2
800	- j148	617	635/13.4	667	633/12.5	697	715/12.0	767	781/10.9
1000	- j119	614	625/11.0	664	674/10.2	694	703/9.7	764	772/8.9
1500	- j80	608	613/7.5	658	681/6.9	688	691/6.6	758	761/6.0
2000	- j60	606	610/5.7	656	659/5.2	686	690/5.0	756	759/4.5
2500	- j48	605	607/4.5	655	657/4.2	685	688/4.0	755	756/3.6
3000	- j40	605	606/3.8	655	656/3.5	685	686/3.3	755	756/3.0

* Reactance is the same for all network combinations.

NETWORK TERMINALS TO BE STRAPPED FOR VARIOUS PIN SPACINGS OF 114-MIL OPEN-WIRE CIRCUITS

SPACING BETWEEN WIRES IN INCHES	TERMINALS TO BE STRAPPED
8-in. NONPOLE PAIR	3-7
10-in. NONPOLE PAIR	5-7
12-in. NONPOLE PAIR	4-5 and 6-7
14- to 18-in. POLE PAIR	6-7
20-in POLE PAIR	3-6
22-in. POLE PAIR	4-6
33-in. POLE PAIR	NONE

Fig. 6—114A Balancing Network for 114-Mil Nonloaded Side or Physical Circuit



TPA 554595

RESISTANCE ADJUSTMENTS		
TERMINALS STRAPPED	AMOUNT OF RESISTANCE ADDED TO NETWORK (OHMS)	RESISTANCE COMPONENT OF NETWORK IMPEDANCE OF 1000 Hz
3-7	0	305
4-7	10	315
3-4 and 5-7	20	325
5-7	30	335
3-5 and 6-7	40	345
4-5 and 6-7	50	355
3-4 and 6-7	60	365
6-7	70	375
3-6	80	385
4-6	90	395
3-4 and 5-6	100	405
5-6	110	415
3-5	120	425
4-5	130	435
3-4	140	445
NONE	150	455

NETWORK IMPEDANCE									
FREQ (Hz)	REACT-ANCE (OHMS) *	TERMINALS STRAPPED							
		3-6		4-6		3-4 and 5-6		5-6	
		RES	Z/θ	RES	Z/θ	RES	Z/θ	RES	Z/θ
100	- j325.3	590	676/28.8	600	683/28.4	610	690/28.1	620	700/27.7
200	- j233.5	480	535/25.9	490	545/25.4	500	551/25.0	510	560/24.6
300	- j177	423	458/22.8	433	466/22.3	443	476/21.8	453	485/21.4
500	- j111.4	395	410/15.8	405	420/15.4	415	430/15.0	425	440/14.7
800	- j72.8	387	394/10.7	397	405/10.4	407	415/10.1	417	424/9.9
1000	- j59	385	390/8.7	395	400/8.5	405	409/8.2	415	420/8.1
1500	- j39.5	383	385/5.9	393	396/5.7	403	405/5.6	413	415/5.5
2000	- j29.7	382	384/4.4	392	394/4.3	402	405/4.2	412	414/4.1
2500	- j23.8	381	382/3.6	391	392/3.5	401	402/3.4	411	412/3.3
3000	- j19.8	381	381/3.0	391	392/2.9	401	401/2.8	411	411/2.8

* Reactance is the same for all network combinations.

NETWORK TERMINALS TO BE STRAPPED FOR VARIOUS PIN SPACINGS OF 114-MIL OPEN-WIRE CIRCUITS

SPACING BETWEEN WIRES IN INCHES	TERMINALS TO BE STRAPPED
8-in. NONPOLE PAIR	3-5
10-in. NONPOLE PAIR	3-6
12-in. NONPOLE PAIR	3-4 and 5-6
14- to 18-in. POLE PAIR	4-6
20-in. POLE PAIR	4-6
22-in. POLE PAIR	3-6
33-in. POLE PAIR	6-7

Fig. 7—114B Balancing Network for 114-Mil Nonloaded Phantom Circuit

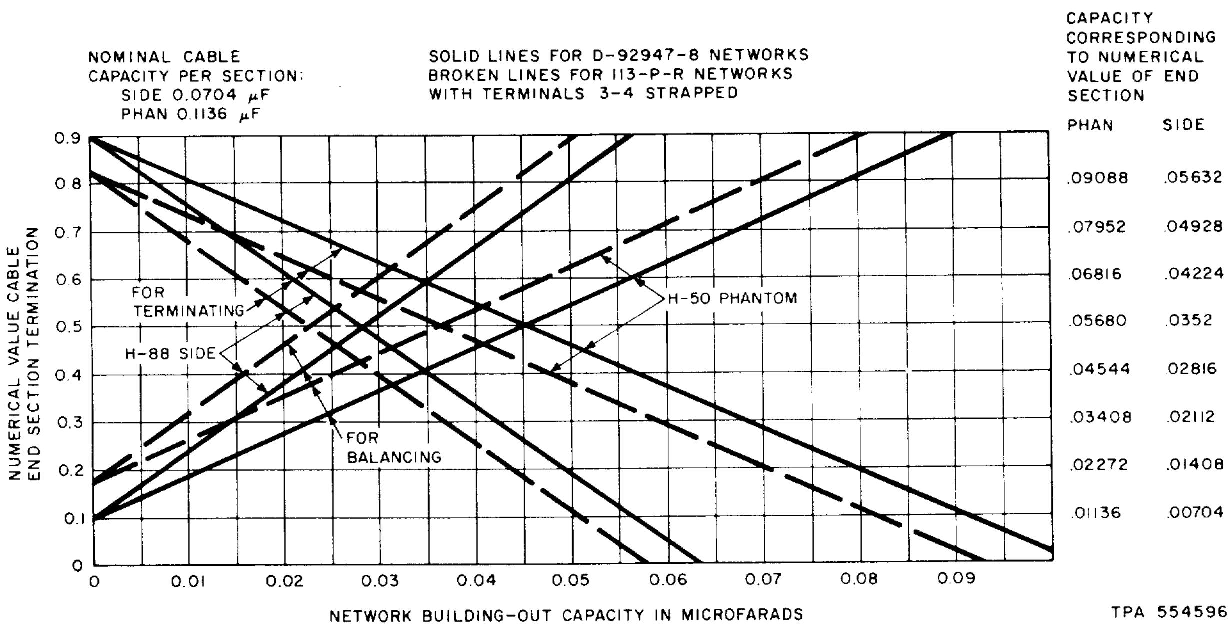


Fig. 8—Network Building-Out Capacity vs Cable End-Section for H-88-50 Balancing Networks