EXCHANGE LINE BALANCING NETWORK DATA

CONTENTS PAGE

1. GENERAL

1.01 This section provides data on balancing networks for simulating the impedances of the following exchange area facilities and apparatus:

(1) Loaded cable circuits

(2) Nonloaded cable circuits

(3) Subscriber sets

(4) Battery supply repeating coils.

1.02 The more common use for these networks, especially the latter three types, is expected to be on special service lines, the design of which is discussed in Exchange Area Transmission Practices, Section AB22.326. However, there may also be a number of applications on tandem and toll board trunks as discussed in Exchange Area Transmission Practices AB22.127 and AB22.128, respectively.

1.03 Figure 1 shows the general assembly of the 113-type networks.

1.04 The networks require 1-3/4 inches by 7 inches of panel mounting space and extend 4-13/32 inches from the panel. They are arranged to mount on a 600A mounting plate (drilled as specified) or on mounting bars per ED-90185-01, Fig. 1 for 23-inch racks or Fig. 2 for 19-inch racks.

2. LOADED CABLE NETWORKS

2.01 Table D gives the types of exchange area loaded cable circuits for which balancing networks are now available. Each network includes a basic network unit and a multiunit building-out capacitor with which to adjust the network to correspond to the termination of the loaded cable circuit. The multiunit capacitor used is the electrical equivalent of the 187B condenser and has the same terminal designations. The 113G and 113H networks as indicated on the table are each intended for use on two types of facility, the terminal connections for which are noted in Fig. 2. This, of course, by limiting the types of networks, effects economies and increases flexibility whereas the impairment in balance is not usually important in the situations where these networks are used.

2.03 Table E shows the minimum return losses of the 113-type networks against the characteristic impedance of perfect lines.

2.04 Table F notes the types of facility for which no 113-type networks have been specifically designed but for which the available 113-type networks give fair balances. Table G shows the impedances of the networks.

3. NONLOADED CABLE NETWORKS

3.01 The nonloaded cable circuit balancing network which is coded as the 113D balancing network provides a convenient means for balancing lengths of nonloaded cable adjacent to repeaters. It consists of a rectangular sheet metal can containing a number of capacitors and resistors which can be connected to simulate various lengths of nonloaded cable as in Table A.

TABLE A

NONLOADED CABLE CIRCUITS SIMULATED BY 113D BALANCING NETWORK

TYPE	RANGE	PRECISION
16 TH	0 to 6 miles	±1/4 mile
19 DNB	0 to 6 miles	±1/4 mile
19 CNB	0 to 5-1/2 miles	±1/4 mile
22 BSA	0 to 3 miles	±1/4 mile
24 ASM	0 to 1-3/4 miles	±1/8 mile

Further circuit details regarding the 113D balancing network are given in Fig. 3. This figure shows the resistors and capacitors which the network contains, the relation of the network terminals to these elements, and the methods of connecting the terminals to obtain "T" or "multiple T" networks to simulate particular lengths and types of nonloaded cable circuits. The electrical configurations of the resulting "T" or "multiple T" networks are also shown. As noted in Table E, the networks provide for limiting the unbalance of nonloaded sections to 25 dB when used in this manner.

3.02 Although the connections in Fig. 3 apply only for nonloaded cable circuits which are uniform throughout their length, the 113D network can also be used to simulate lengths of nonloaded cable of mixed gauges. The terminal connections required can, in some cases, be determined by combining the connections given for the individual sections of the cable. For example, suppose it is desired to balance 1-1/2 miles of 19 DNB cable and 1 mile of 22 BSA cable. The connections of the adjustment terminals should be 1-2, 3-20, 8-16, and 9-11. This combination of the connections for the individual sections will not always be possible and it may be necessary to determine the connections required from the information given in Fig. 3 and the characteristics of the nonloaded cable circuit to be balanced. The total series resistance of the network should be made equal to the total dc resistance of the cable circuit and the network shunt capacitance equal to the total mutual capacitance of the cable circuit. The best simulation will be obtained when the network capacitors used are distributed with respect to the series resistance as illustrated by the configurations shown in Fig. 3.

3.03 If it is required to simulate a length of nonloaded cable with a greater precision than can be obtained with the 113D network, a 187-type multiunit condenser can be associated with the network to allow finer capacitance adjustment. It will not be necessary to make a correspondingly fine adjustment of the resistance.

4. SUBSCRIBER SET NETWORKS

4.01 The network which simulates subscriber sets is coded as the 113F balancing network. It is intended to balance subscriber sets adjacent to a repeater or separated from the repeater by a nonloaded cable circuit. It consists of a rectangular sheet metal container in which are enclosed an induction coil, a receiver, two capacitors, and a variable resistor. These elements may be connected to make the network simulate (with respect to impedance) standard, sidetone reduction, and antisidetone subscriber sets of the handset type. The available data indicate that balances of 15 dB should generally be obtained with standard and antisidetone sets and about 10 dB with sidetone reduction sets.

4.02 The circuit details of the 113F networks are shown in Fig. 4. The receiver element has its diaphragm cemented to the pole pieces with a suitable spacer to prevent mechanical resonance. If such resonance were allowed and the resonant frequency did not correspond to that of the receiver of the line subscriber set, impedance differences caused by receiver resonance would be spread over a wider frequency range or might be considerably increased. Clamping the diaphragm in this manner also prevents the network from "talking." The variable resistance of the 113F network represents the subscriber set transmitter. It may be varied from 0 to 200 ohms in steps of about 20 ohms. Except in cases where special refinement is necessary, a value of 60 ohms will probably be found satisfactory.

4.03 The equipment features of the 113F network are shown in Fig. 1. It will generally be found that the best balances can be obtained with subscriber sets of the antisidetone type. Standard connected sets produce lower impedance irregularities due to receiver resonance than sidetone reduction sets, but introduce greater irregularities with equal variations of transmitter resistance.

4.04 It will be noted that the 113F network cannot be connected to simulate the desk-stand type of subscriber instrument. Such an adjustment has not been provided because of the considerable increase in the size of the network which would be necessary if a No. 144 receiver were enclosed. The terminal arrangements do, however, allow an external No. 144 receiver to be connected in place of the receiver of the network. A No. 144 receiver used for this purpose should have its diaphragm clamped in some manner. If the 113F network is used to balance a deskstand subscriber set and an external No. 144 receiver is not used between the subscriber set and the 113F network, return losses due to the differences in receiver impedances will be approximately as given in Table B. These values assume perfect simulation to otherwise exist.

TABLE B

FREQUENCY Hz	RETURN LOSS (dB)	
	STANDARD CONNECTION	SIDETONE REDUCTION CONNECTION
300	26	18
1000	14	9
2200	17	15

5. BATTERY SUPPLY REPEATING COIL NETWORK

5.01 The battery supply repeating coil balancing network is coded as the 113N network. It simulates the impedance-modifying effects of an average 94E repeating coil and can be used in a balancing network circuit to simulate a 94E battery supply repeating coil in the line. An actual 94E repeating coil can, of course, be used for such balancing purposes. However, relatively large manufacturing deviations are allowed in the characteristics of 94-type coils and the fact that the 113N network represents an average coil ensures a somewhat better balance than may be obtained with a coil chosen at random. Table C gives approximate values of return losses which may be obtained if a 94E repeating coil in the line is not simulated in the network circuit and the return losses which may be obtained if a 94E repeating coil or a 113N network is used for balancing purposes. In the computation of these values it was assumed that the line 94E repeating coil was terminated by a subscriber loop the impedance of which was exactly balanced in the network.

TABLE C

POSSIBLE RETURN LOSSES RESULTING FROM THE PRESENCE OF A 94E REPEATING COIL IN A LINE CIRCUIT (dB)

FREQUENCY Hz	CORRESPONDING BALANCING ELEMENT IN NETWORK CIRCUIT				
	NONE	94E REPEATING COIL		113N NETWORK	
		MIN	AVG	MIN	AVG
300	11	15	19	20	25
1000	16	16	22	22	29
2200	10	16	22	22	29

The equipment features of a 113N network are the same as those shown in Fig. 1. The network has four terminals, 1 and 2 being one set of the tip and ring terminals and 3 and 4, the other set.

5.02 When a subscriber loop is balanced by a simulating loop in a repeater network, there will be some unbalance introduced if no direct current flows in the network loop corresponding to the transmitter supply direct current. This is a low-frequency effect and may introduce return losses in the order of 15 dB in the frequency range around 300 Hz or below. In general, such imbalances in this frequency range will not be controlling. If, however, in any particular case this factor should be found important, an improvement can be obtained by introducing direct current in the balancing network circuit of about the same value as that flowing in the line circuit at the average battery voltage. The ballast lamps and relays of the line battery supply circuit need not be reproduced in the network circuit but only a resistor will be required to limit the direct current to the proper value. Capacitors at the midpoints of battery supply repeating coils should be simulated in the network circuit.

5.03 To avoid the waste of battery power, the network direct current may be cut off when the repeater is not in use. This can be arranged, if the current is obtained from the 24-volt battery, by connecting the + battery lead for the network current supply to lower contact No. 3 of the L1 relay of the associated long line or long trunk circuit. This relay contact controls the filament current of the associated repeater.

TABLE D

BALANCING NETWORKS FOR EXCHANGE AREA LOADED CABLE CIRCUITS

TYPE OF CIRCUIT	CODE NO. OF BALANCING NETWORK	BASIC END SECTION LENGTH (FEET)	BO CAPACITY (μF PER 1000 FEET IN EXCESS OF BASIC END SECTION)
19 CNB H-135	113A	900	0.0159
19 DNB H-135	113B	780	0.0125
19 DNB H-175	113E	840	0.0125
22 BSA H-135	113C	900	0.0155
19 CNB M-88)	113G (Note 2)	1350	0.0159
22 BSA M-88)		1260	0.0155
19 CNB H-88)	113H (Note 2)	900	0.0159
22 BSA H-88)		900	0.0155
19 CNB B-135	113J	540	0.0159
19 DNB B-135	113K	540	0.0125
19 CNB B-88	113L	540	0.0159
19 DNB B-88	113M	540	0.0125

Note 1: For the equipment features of the 113-type networks, see Fig. 1.
Note 2: Terminal connections for each facility are shown in Fig. 2.

TABLE E

MINIMUM RETURN LOSSES (dB) OF 113-TYPE BALANCING NETWORKS AGAINST CHARACTERISTIC IMPEDANCE OF PERFECT LINES FOR MIDSECTION TERMINATION

BALANCING NETWORK	FREQUENCY IN Hz											
	200	300	500	2200	2500	2700	2800	2900	3000	3100	3200	3600
113A	32	34	35	35	26	17	–	–	–	–	–	–
113B	32	34	35	35	35	26	26	17	17	–	–	–
113C	32	34	35	35	26	17	–	–	–	–	–	–
113D*	25	25	25	25	25	25	–	–	–	–	–	–
113E	32	34	35	35	26	17	–	–	–	–	–	–
113G	25	27	28	28	25	–	–	–	–	–	–	–
113H	25	27	28	28	28	28	28	20	20	20	–	–
113J	32	34	35	35	35	35	35	25	25	25	25	20
113K	32	34	35	35	35	35	35	25	20	20	20	20
113L	32	34	35	35	35	35	35	35	35	25	25	15
113M	32	34	35	35	35	35	35	35	35	25	25	25

* Return losses given are for nonloaded sections.

TABLE F

NETWORKS FOR MISCELLANEOUS FACILITIES*

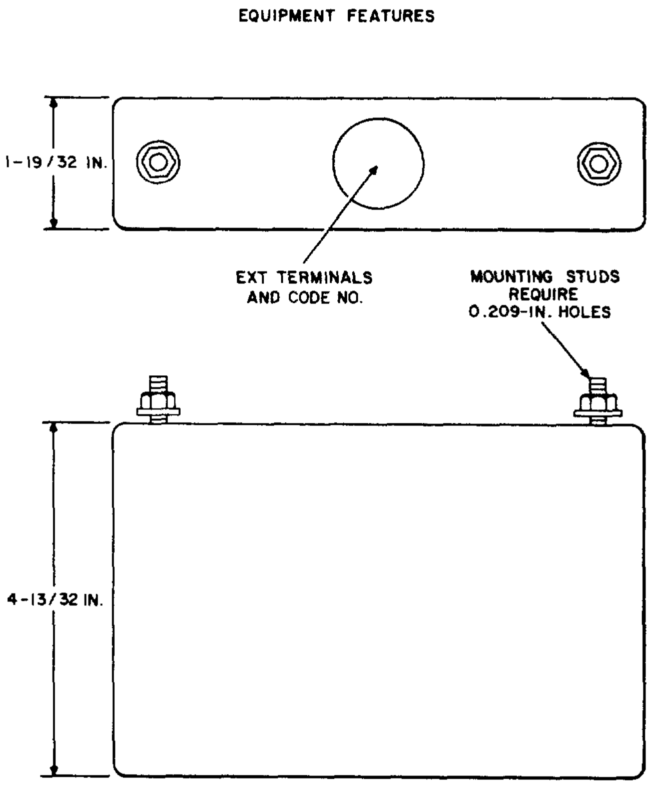
FACILITY*	NETWORK	BASIC END SECTION LENGTH (FEET)	BO CAPACITY (μF PER 1000 FEET IN EXCESS OF BASIC END SECTION)
16 TH H-135	113B	780	0.0125
16 TH H-88	113H	330	0.0125
19 DNB H-88	113H	330	0.0125
22 BSA B-135	113J	515	0.0155
16 TH B-135	113K	540	0.0125
16 TH B-175	113K	540	0.0125
19 DNB B-175	113K	540	0.0125
22 BSA B-88	113L	515	0.0155
16 TH B-88	113M	540	0.0125

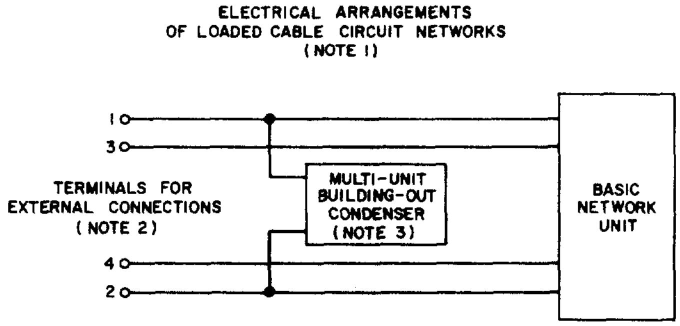
* Facilities for which networks have not been specifically designed but for which available 113-type networks can be used with minimum balances of between 20 and 25 dB against characteristic impedance (perfect line).

TABLE G

113-TYPE NETWORK DATA
MIDSECTION IMPEDANCES

NETWORK TYPE OF FACILITY BASIC SECTION MIDSECTION BOC	113A 19CNB-H-135 0.15 0.0334 μF	113B 19DNB-H-135 0.13 0.0277 μF	113C 22BSA-H-135 0.15 0.0326 μF	113E 19DNB-H-175 0.14 0.0270 μF	113G 19CNB-M-88 0.15 0.0501 μF	113G 22BSA-M-88 0.14 0.0501 μF	113H 19CNB-H-88 0.15 0.0334 μF	113H 22BSA-H-88 0.15 0.0326 μF	113J 19CNB-B-135 0.18 0.0153 μF	113K 19DNB-B-135 0.18 0.0120 μF
FREQUENCY (Hz)										
200	1194—j357	1356—j367	1374—j634	1542—j360	838—j433	1103—j701	998—j435	1237—j724	1695—j246	1910—j273
300	1200—j235	1360—j244	1298—j455	1548—j237	837—j298	994—j552	998—j297	1130—j549	1697—j163	1912—j183
500	1214—j133	1371—j146	1259—j283	1566—j138	837—j196	893—j385	999—j192	1046—j364	1704—j100	1918—j111
700	1237—j87	1309—j107	1263—j202	1595—j92	842—j152	864—j292	1004—j147	1025—j270	1716—j73	1928—j81
1000	1288—j51	1425—j77	1300—j140	1659—j59	857—j118	866—j218	1013—j116	1029—j196	1741—j52	1950—j57
1400	1400—j31	1507—j59	1397—j100	1800—j44	906—j92	915—j173				
1500							1060—j87	1081—j139	1814—j32	2010—j38
1800	1588—j36	1644—j55	1574—j92	2040—j57	1016—j76	1020—j162				
2000	1729—j38	1743—j58	1712—j99	2225—j73	1108—j76	1103—j171	1166—j69	1190—j121	1945—j19	2112—j25
2200	1923—j40	1876—j67	1916—j120	2501—j90	1248—j86	1225—j195				
2400	2292—j44	2058—j82	2233—j173	2995—j116	1484—j122	1422—j250				
2500	2603—j79	2185—j92	2538—j232	3518—j149	1681—j172	1580—j309	1381—j75	1395—j139	2186—j19	2281—j19
2600	3173—j148	2344—j105	2974—j392	4437—j422						
2700	4358—j738	2560—j125	3045—j893	5891—j1929						
2800		2857—j166					1620—j95	1613—j171	2427—j50	2435—j25
2900		3312—j278								
3000							1925—j99	1884—j186	2656—j106	2570—j39
3100							2217—j100	2139—j192		
3200									2961—j234	
3300										2842—j94
3400										
3600										3239—j243





NOTES:

1. THE ELECTRICAL ARRANGEMENTS OF NONLOADED CABLE BALANCING NETWORK 113D AND THE SUBSCRIBER SET BALANCING NETWORK 113F ARE GIVEN IN FIG. 3 AND 4.
2. TERMINALS 3 AND 4 APPEAR ON THE 113G AND 113H NETWORKS. WHEN THE GAUGE OF THE CABLE CIRCUIT TO BE SIMULATED BY THESE NETWORKS IS 22, CONNECTIONS ARE MADE ONLY TO TERMINALS 1 AND 2. WHEN THE GAUGE IS 19, TERMINALS 3 AND 4 ARE CONNECTED AS FOLLOWS:

NETWORK	CONNECT
113G	3-1, 4-2
113H	3-4-2

3. THE MULTI-UNIT BUILDING-OUT CONDENSER USED IN THE LOADED CABLE CIRCUIT NETWORKS IS THE ELECTRICAL EQUIVALENT OF THE 187B CONDENSER. ITS CAPACITANCE-ADJUSTING TERMINALS ARE LOCATED UNDER THE REMOVABLE COVER OF THE NETWORK.

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Fig. 1—113-Type Balancing Networks

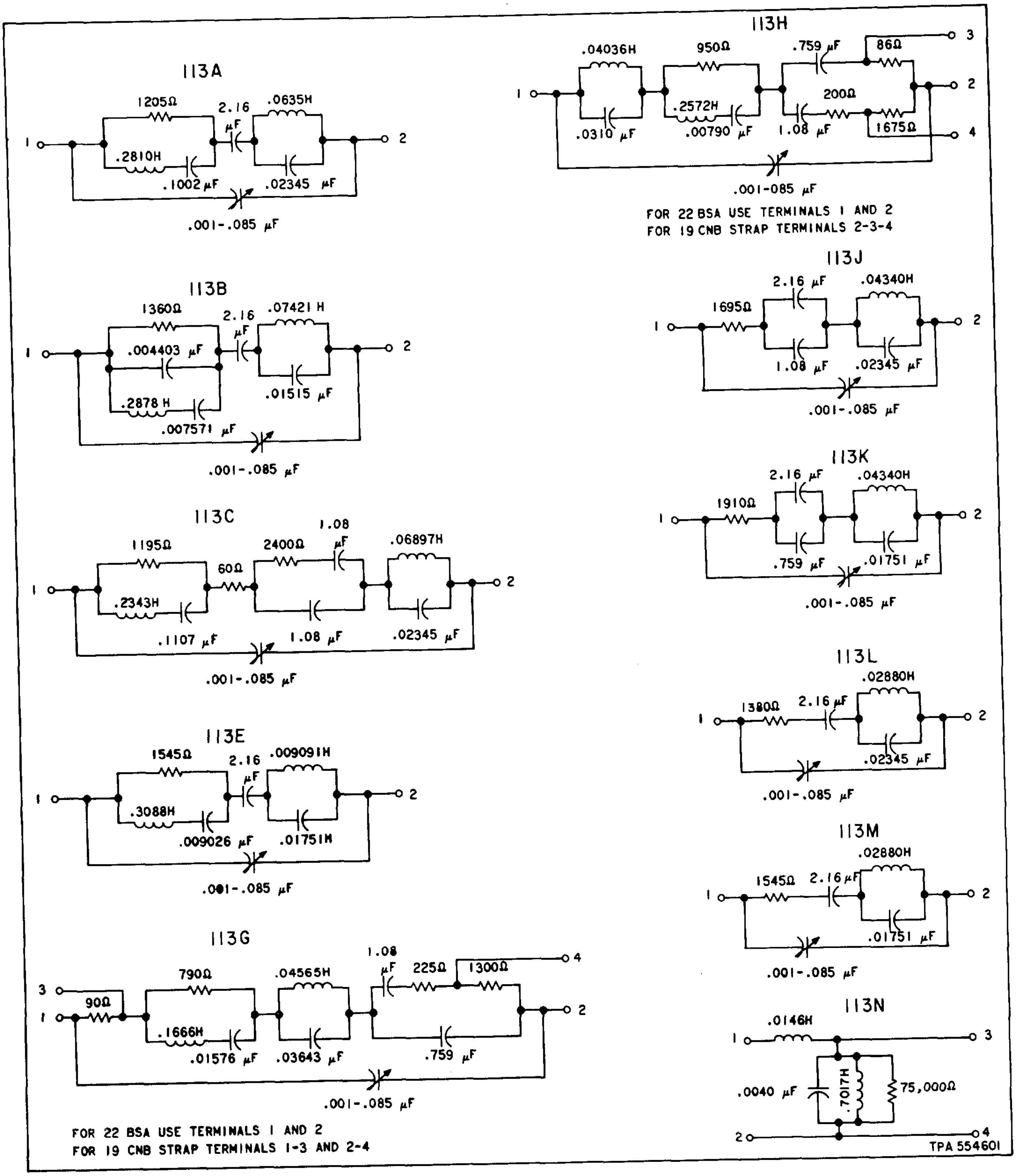
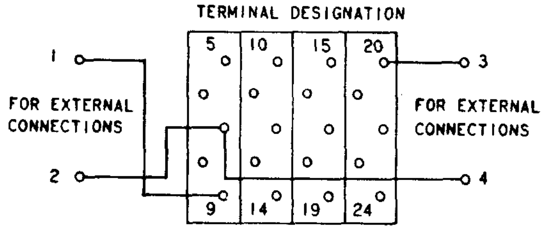


Fig. 2—113-Type Networks for Exchange Facilities



ADJUSTMENT TERMINALS (NOTE 2)

CONNECTION OF ADJUSTMENT TERMINALS

LENGTH - MILES 16, 19 AND 22	24 GA	16 TH CONNECT	16 TH RESULTING NETWORK	19 DNB CONNECT	19 DNB RESULTING NETWORK
1/2	1/2	5-8-20	21Ω; .033 µF	5-8, 10-20	21Ω, 21Ω; .033 µF
1	3/'	5-12, 10-20	21Ω, 21Ω; .066 µF	10-12, 16-20	42Ω, 42Ω; .066 µF
1-1/2	1	5-9, 8-10 12-16-20	21Ω, 42Ω; .033 µF, .066 µF	5-8, 12-16 14-20	21Ω, 63Ω, 42Ω; .033 µF, .066 µF
2	1-1/4	6-10, 16-20	42Ω, 42Ω; .132 µF	9-19, 17-24	84Ω, 84Ω; .132 µF
2-1/2	1-1/2	5-9, 6-16 8-10, 14-20	21Ω, 42Ω, 42Ω; .033 µF, .132 µF	5-8, 10-19 17-24	21Ω, 105Ω, 84Ω; .033 µF, .132 µF
3	1-3/4	5-12, 6-16 14-20	21Ω, 63Ω, 42Ω; .066 µF, .132 µF	10-12, 16-19 17-24	42Ω, 126Ω, 84Ω; .066 µF, .132 µF
3-1/2		5-9, 6-14 8-10, 12-16 15-20	21Ω, 42Ω, 42Ω, 42Ω; .033 µF, .066 µF, .132 µF	5-8, 12-16 14-19, 17-24	21Ω, 63Ω, 126Ω, 84Ω; .033 µF, .066 µF, .132 µF
4		6-10, 14-17 15-20	42Ω, 84Ω, 42Ω; .132 µF, .132 µF	6-18, 9-15 17-24	84Ω, 168Ω, 84Ω; .132 µF, .132 µF
4-1/2		5-9, 6-14-15 8-16, 16-17 18-20	21Ω, 42Ω, 42Ω, 84Ω; .033 µF, .132 µF, .132 µF	5-8, 6-18 10-15, 17-24	21Ω, 105Ω, 168Ω, 84Ω; .033 µF, .132 µF, .132 µF
5		6-4, 9-10 12-16, 15-17 18-20	42Ω, 42Ω, 42Ω, 84Ω; .066 µF, .132 µF, .132 µF	6-18, 9-16 12-14, 17-24	42Ω, 126Ω, 168Ω, 84Ω; .066 µF, .132 µF, .132 µF
5-1/2		5-9, 6-14 8-10, 12-16 15-17, 18-20	21Ω, 42Ω, 42Ω, 42Ω, 84Ω; .033 µF, .066 µF, .132 µF, .132 µF	5-8, 6-18 12-16, 14-15 17-24	21Ω, 63Ω, 126Ω, 168Ω, 84Ω; .033 µF, .066 µF, .132 µF, .132 µF
6		5-8-23, 6-14 12-16, 13-21 15-17, 18-20	21Ω, 63Ω, 42Ω, 42Ω, 84Ω; .067 µF, .066 µF, .132 µF, .132 µF	6-18, 8-10-23 12-14, 13-21 17-24	42Ω, 84Ω, 126Ω, 168Ω, 84Ω; .067 µF, .066 µF, .132 µF, .132 µF

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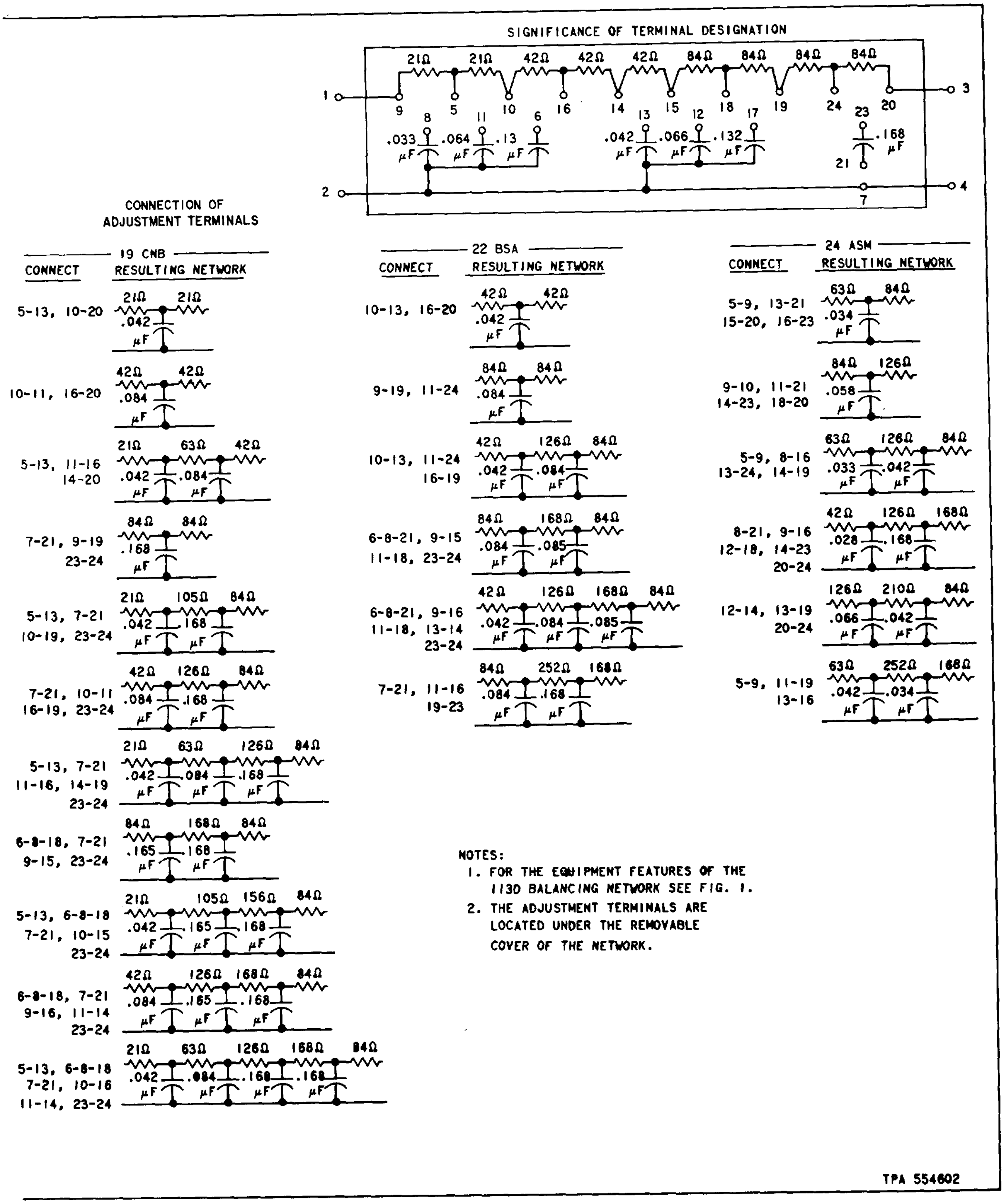
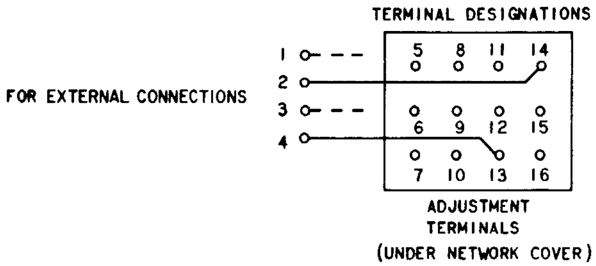


Fig. 3—113D Balancing Network for Nonloaded Cable Circuits



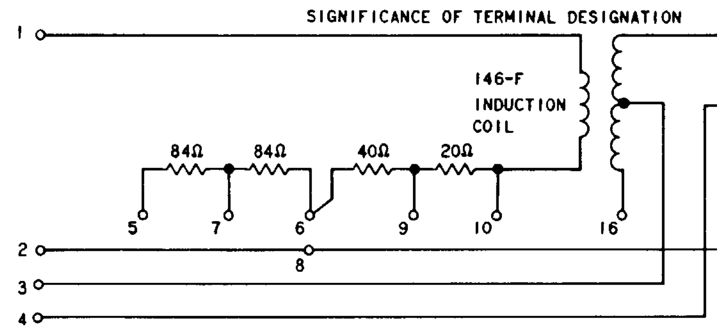


TABLE A
CONNECTION OF ADJUSTMENT TERMINALS

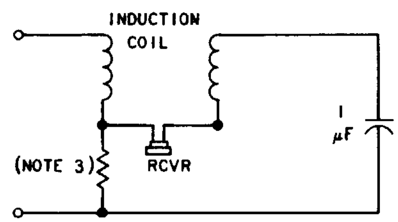
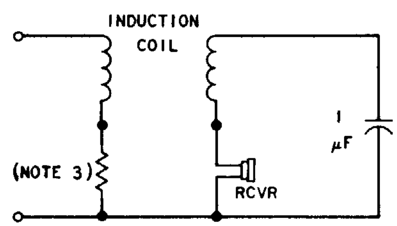
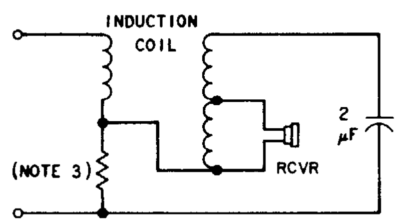
SUBSCRIBER SET		CONNECT	RESULTING NETWORK
STANDARD CONNECTION 46 INDUCTION COIL (NOTE 2)	HANDSET	10-12	
	DESKSTAND	10-13	
SIDETONE REDUCTION CONNECTION 46 INDUCTION COIL (NOTE 2)	HANDSET	11-12	
	DESKSTAND	11-13	
ANTI-SIDETONE HANDSET (NOTE 2) 146 INDUCTION COIL		10-12-16,14-15	

TABLE B

TRANSMITTER RESISTANCE OHMS	TERMIN STRAPP
0	8-10
20	8-9
40	6-8,9-
60	6-8
84	5-8,7-
104	5-8,7-
124	5-8,6-
144	5-8,6-
168	5-8,6-
188	5-8,6-
208	5-8,9-
228	5-8

NOTES:
1. FOR THE EQUIPMENT FEATURES OF NETWORK SEE FIG. 1.
2. FOR A DESKSTAND SUBSCRIBER SE IS CONNECTED TO EXTERNAL TERMI HANDSET THESE TERMINALS SHOULD
3. THIS RESISTANCE REPRESENTS THE RESISTANCE. IT MAY BE ADJUSTED WITH TABLE B.

Fig. 4—113F Balancing Network for Subscriber Sets