IMPEDANCE COMPENSATION AND MATCHING TECHNIQUES FOR JUNCTION CABLES BETWEEN ANALOGUE EXCHANGES

1. CANCELLATIONS Nil.

2. GENERAL

2.1 This Instruction covers the need for, and the installation of, impedance compensating and matching devices on trunk and common junction cable circuits.

2.2 The transmission aspects of the junction network are discussed in J 1000.

2.3 The loading scheme for junction cables is covered in GENERAL Planning J 0141.

2.4 The primary constants for paired cable are given in LINES General R 1000.

3. INTRODUCTION

3.1 As discussed in J 1000 and T 1000, whenever a 4-wire trunk is switched to a 2-wire junction, instability and echo caused by imbalance of the 2W/4W hybrid and reflections at points of mismatch, cause significant problems.

3.2 Control of Stability

3.2.1 A major cause of instability in the trunk network is the inability of the balance network (CBJ) in the trunk circuit hybrid to completely match the 2-wire junction, as paired cables have a varying characteristic impedance with cable type and frequency. To improve this match, the impedance which the junction cable presents to the trunk circuit hybrid must be standardised. This is done by compensating the cable impedance.

3.2.2 Little can be done at the local exchange end of a junction cable to improve the stability of the trunk network.

3.3 Control of Echo

3.3.1 The control of echo is important because of the increasing use of the network for data transmission and for long international connections. It is also suspected that echo may be a problem on long national connections, and its control on junctions in the Whangarei and the Dunedin/Invercargill districts should be a prime objective.

3.3.2 The major causes of echo are the reflections from impedance mismatches at:

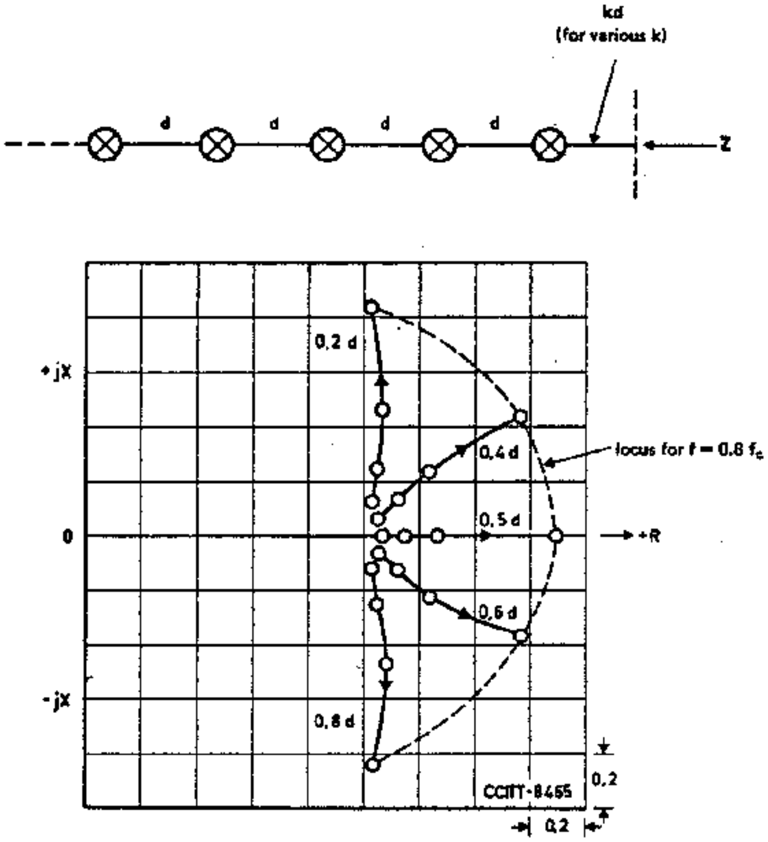
(1) the local exchange between the subscriber-line (600 ohms) the junction cable (1100 ohms);

(2) the trunk exchange between the junction cable (1100 ohms) and the trunk circuit hybrid (900 ohms).

The more significant mismatch is that at the local exchange end of a junction cable but both contribute to the overall echo. Impedance matching techniques must be adopted to overcome these mismatches.

4. IMPEDANCE COMPENSATION

4.1 The physical length of the first loading section adjacent to the trunk exchange (i.e., the end section) should be 0.45 to 0.55 of a standard loading section. Under these conditions, the impedance of the cable is almost purely resistive and increases with frequency particularly as the cutoff frequency (fc) is approached. The relationship between impedance, frequency, and end section length is shown in Figure 1.



The complex values of the normalized impedance are shown i.e.:

the values of $Z = \frac{R}{R_0} + j\frac{X}{R_0}$, with $R_0 = \sqrt{\frac{L}{cd}}$ for the non-dissipative case

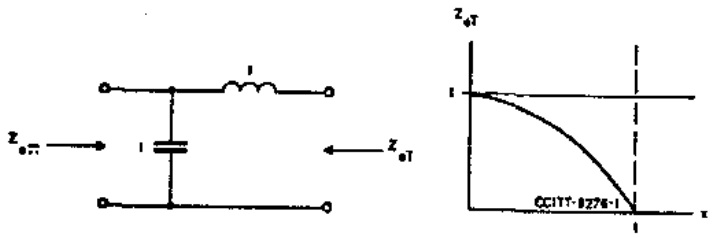
(The frequency markers are at $0.2 f_c$, $0.4 f_c$, $0.6 f_c$ and $0.8 f_c$.)

Figure 1: Impedance/Frequency Diagram for Loaded Cable End Section

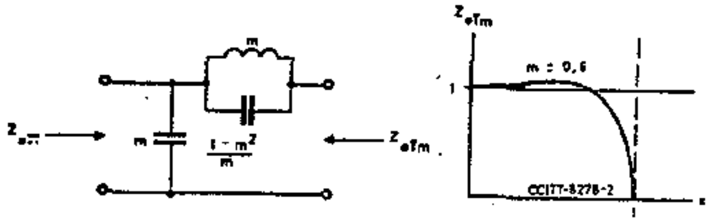
4.2 If the length of the end section is varied about the nominal 0.5, the reactive component of the complex impedance will increase. At a 0.8 end section, the impedance has a relatively constant resistive component, and a capacitive reactive component which increases with frequency. Therefore, if the 0.5 end section is electrically built out to a 0.8 end section, and an inductive reactance introduced in series with the line, the total reactive component can be minimised leaving the impedance of the cable almost purely resistive and independent of frequency.

4.3 This simple filter comprising a shunt capacitor and a series inductor compensates the cable impedance so that it is constant up to about 0.7 fc. This is sufficient to reduce echo as echo return loss is averaged over the passband. However, stability return loss occurs at one specific frequency in the passband, and can only be improved if the cable impedance is compensated over the entire band.

4.4 If a capacitor is added to the simple filter, in parallel with the series inductor so that the resulting resonant circuit is tuned to about 1.1 fc, the total reactive component can be minimised over a wider frequency range and the cable impedance compensated up to about 0.9 fc. This filter is called a shunt m-derived half section or Hoyt-section (ref. Fig. 2).



(a) Basic half-section (normalized)



(b) Shunt *m*-derived half-section (normalized)

Figure 2: Impedance Compensation afforded by an m-derived Half Section

5. IMPEDANCE MATCHING

5.1 Matching can be achieved by interfacing the trunk and junction networks or the junction and subscriber networks with a matching device. Because the difference in the nominal impedances of the trunk and junction networks is small, the matching required can be included in the compensating filter described above. Matching of the junction and subscriber networks, however, requires an auto-transformer.

6. THE IMPEDANCE COMPENSATING UNIT (Figure 3)

6.1 The impedance compensating unit is introduced between the trunk switch and the junction cable and comprises a shunt m-derived half section together with a pad, variable up to 1.5 dB.

6.2 This unit is used to:

(1) enhance trunk network stability by standardising the impedance which all cables present to the trunk circuit hybrid;

(2) improve the match between the trunk and junction networks;

and (3) build-out physically short trunk-junctions to the nominal 3 dB loss objective.

7. IMPEDANCE MATCHING UNIT (Fig. 4)

7.1 The impedance matching unit is introduced between the local switch and the junction cable and comprises a matching transformer and buildout network. If a NIR is required on the junction, the buildout network should be eliminated and the NIR installed between the matching transformer and the junction cable.

7.2 This unit is used to match the junction and subscriber networks, the buildout network providing a junction cable impedance which is constant over most of the passband and sufficient for echo control. As little can be done at this point to improve trunk network stability, the use of an m-derived half section cannot be justified.

8. BASIS OF PROVISION

8.1 Impedance Compensating Units should be provided at the trunk exchange end of all trunk and common junctions which terminate at a 2-wire GCX or SCX and which do not exhibit a minimum stability return loss of 2 dB. If their provision does not achieve the stability return loss limit, the variable pad should be used to introduce additional loss into the junction circuit (i.e., a termination penalty PT). All trunk-junctions which comply with the constant mutual capacitance loading scheme specified in GENERAL Planning J 0141 should not require an impedance compensating unit.

8.2 Impedance Matching Units should be provided at the local exchange end of all trunk and common junctions which do not exhibit a minimum echo return loss of 11 dB.

9. INSTALLATION PROCEDURES

9.1 Both the compensating and matching units are to be mounted on a miscellaneous apparatus rack and cabled to and from the ~~line~~ equipment side of the exchange MDF.

9.2 Both units have switchable or strappable options which are chosen at installation to optimise the transmission performance of the cable junction.

9.3 In the following paragraphs end section capacitance includes that of the terminating cable, MDF jumpers and exchange wiring.

9.4 <u>NZPO Impedance Compensating Unit</u> (CD stocklist) (Phillips Manufacture) (Fig. 6)

(1) ~~Strap~~ Switch A and B so that the trunk exchange end section capacitance (i.e., the capacitance to the first loading coil plus C4 and any combination of C5 and C6) equals 0.75 to 0.8 of the capacitance in the mean loading section.

(2) ~~Strap~~ Switch C and D as follows:

Mean loading section capacitance	C	D
less than 75 nF	OUT	OUT
75-83 nF	IN	OUT
83-89 nF	OUT	IN
greater than 89 nF	IN	IN

(3) ~~Strap~~ Switch E, F, G and H as follows:

Junction Cable Loss	Buildout Loss	E	F	G	H
3 dB	0 dB	IN	OUT	OUT	IN
2.5 dB	0.5 dB	IN	IN	OUT	IN
2 dB	1.0 dB	OUT	IN	OUT	OUT
1.5 dB	1.5 dB	OUT	IN	IN	OUT

9.5 <u>NEC Impedance Compensating Unit</u> (N1-IMPCU-A) (Fig. 5)

(1) Strap 1 and 2 so that the trunk exchange end section capacitance equals 0.75 to 0.8 of the capacitance in the mean loading section.

(2) Strap 3 to 6 as follows:

Mean loading section capacitance	3 and 6	4 and 5
less than 75 nF	OUT	OUT
75-83 nF	IN	OUT
83-89 nF	OUT	IN
greater than 89 nF	IN	IN

9.6 NZPO Impedance Matching Unit (CD stocklist) (Fig. 4)

(1) If amplification is not required, connect the junction cable to terminals 1 and 2 and strap any combination of A to G so that the local exchange end section capacitance equals 0.8 of the capacitance in the mean loading section.

(2) If an Anritsu type NIR is to be provided, the exchange side of this device should be connected to terminals 3 and 4 (1100 ohms).

(3) If a Philips PE6 type NIR is to be provided, the exchange side of this device should be connected to terminals 5 and 6 (900 ohms).

(4) The exchange relay set is connected to terminals 7 and 8 (600 ohms).

9.7 NEC Impedance Matching Unit (N2-VDREPCU-A) (Fig. 5)

(1) If amplification is not required connect the junction cable to terminals 1-5 and 1-8 (1100 ohms).

(2) If an Anritsu type NIR is to be provided, the exchange side of this device should be connected to terminals 1-5 and 1-8 (1100 ohms).

(3) If a Philips PE6 type NIR is to be provided, the exchange side of this device should be connected to terminals 1-1 and 1-4 (900 ohms).

(4) The exchange relay set is connected to terminals 1-2 and 1-3 (600 ohms).

10. MECHANICAL ASPECTS

10.1 Both the NZPO compensating and matching units are mounted on 63.6 x 135 mm printed circuit boards and are to be accommodated in a NZPO mounting bin on a miscellaneous apparatus rack.

10.2 The mounting bin (CD stocklist) is shown in NZPO 40131. The overall length of the bin is 1100 mm and this dimension should be modified to suit the miscellaneous apparatus rack by shortening the mounting bars and the cover.

10.3 The bin is 88.4 ±0.4 mm or two modular units in height. Should this dimension exceed two units (i.e., 90 mm) the two mounting bars should be redrilled in accordance with NZPO 40131 Fig. 1, using the other face.

10.4 Edge connectors should be provided as follows:

~~Compensating~~ Matching unit - at 37.5 mm centres or every third hole in the mounting bar

~~Matching~~ Compensating unit - at 25 mm centres or every second hole in the mounting bar.

The approximate number of compensating or matching units which can be mounted in a bin on a miscellaneous apparatus rack are as follows:

MAR width	~~Compensating~~ Matching Units	~~Matching~~ Compensating Units
2'9" (SxS)	20	30
4'6" (SxS)	34	51
520 mm (transmission rack)	11	16
951 mm (NC100/230)	23	34
761 mm (NC460/400)	18	26

11. REFERENCES J 1000 T 1000
GENERAL Planning J 0141
LINES General R 1000
Drawing NZPO 40131

(Figures 3, 4, ~~and~~ 5, ~~follow)~~ and 6 follow)

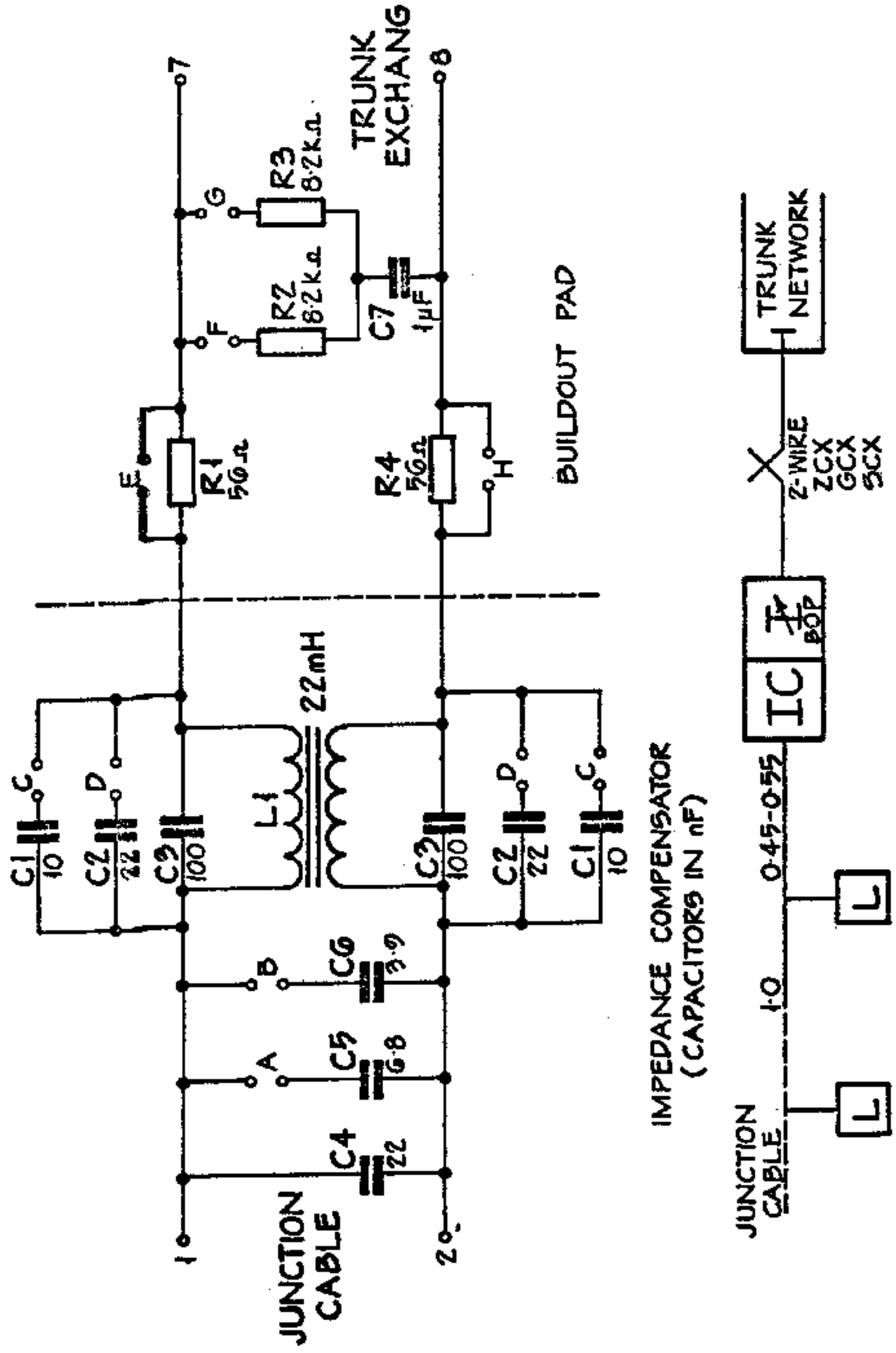


FIG.3. NZPO IMPEDANCE COMPENSATING UNIT

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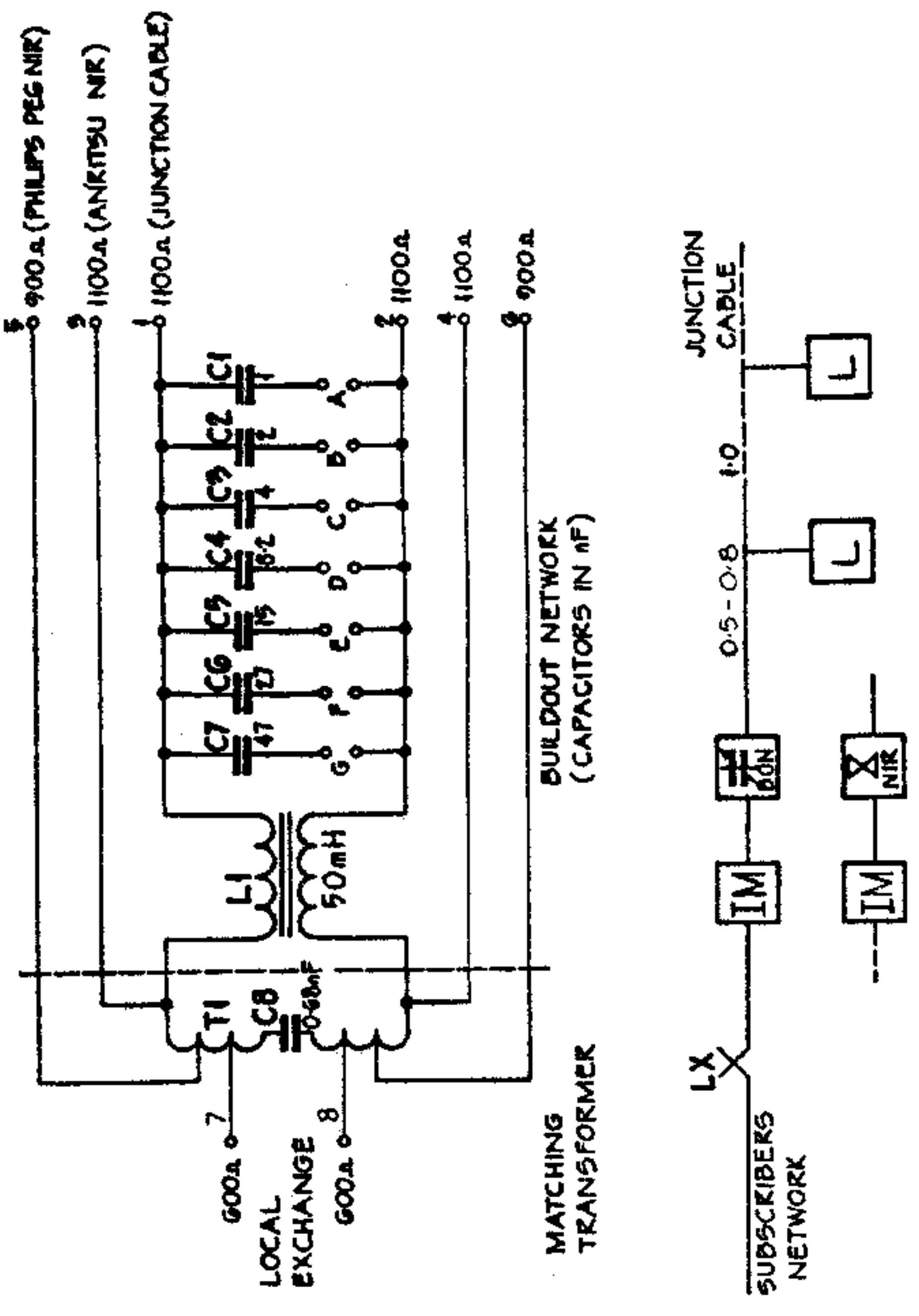
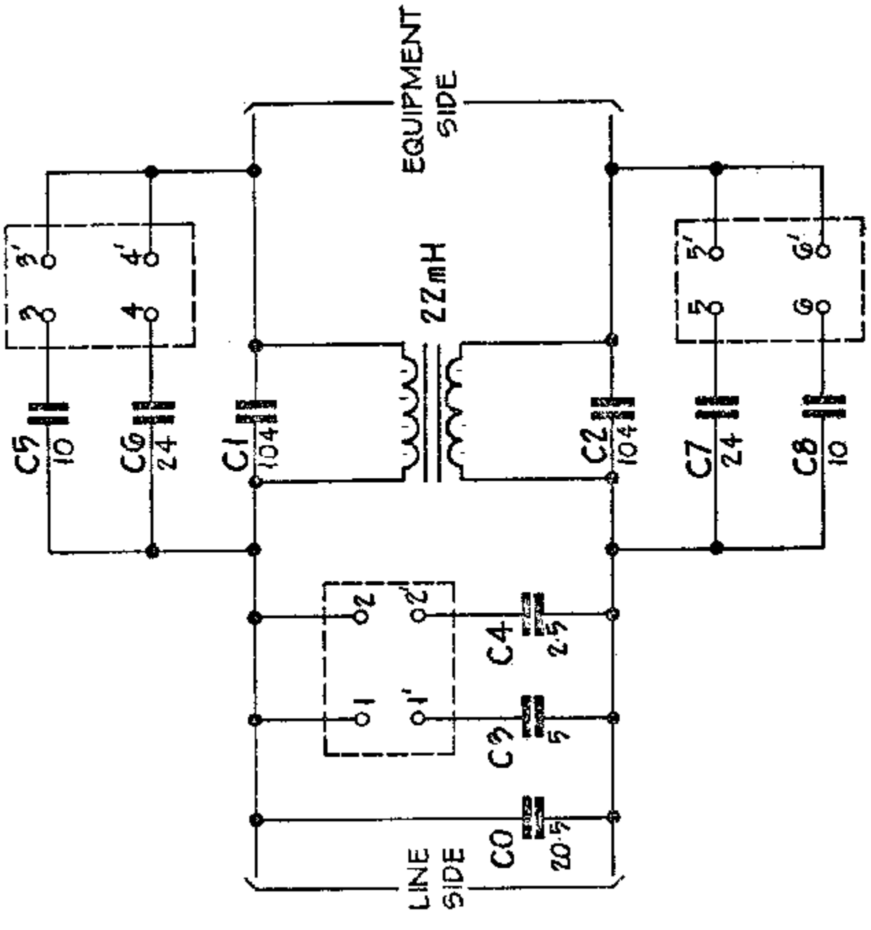
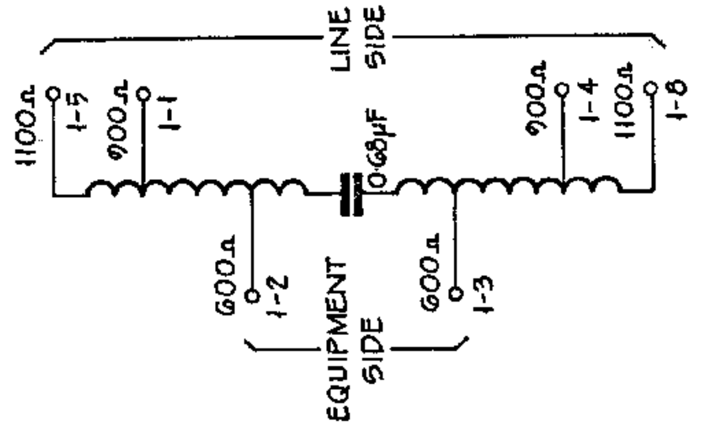


FIG.4. NZPO IMPEDANCE MATCHING UNIT



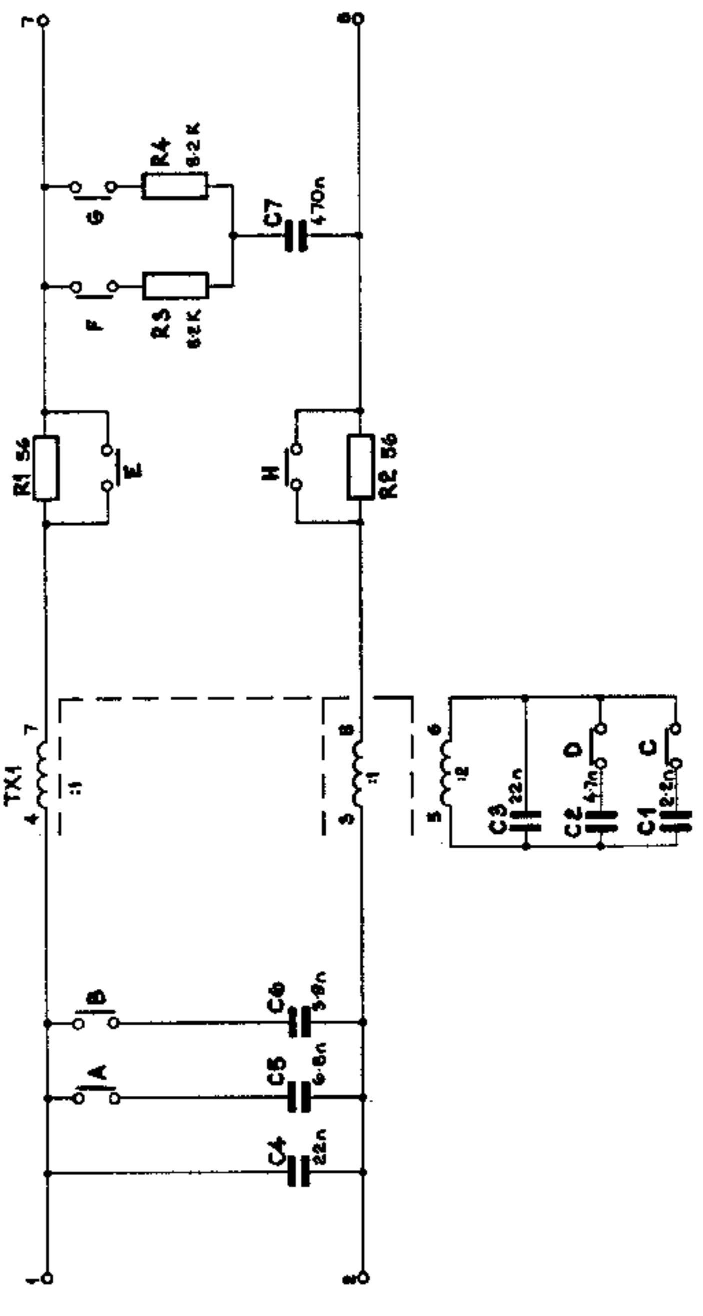
A. NEC IMPEDANCE COMPENSATING UNIT (N1-IMPCU-A)



B. NEC IMPEDANCE MATCHING UNIT (N2-VDREPCU-A)

FIG. 5.

IMPEDANCE COMPENSATION AND MATCHING TECHNIQUES FOR JUNCTION CABLES BETWEEN ANALOGUE EXCHANGES



NOTES.

1. STRAPPING INSTRUCTIONS.
STRAP A AND B SO THAT CABLE END (LENGTH TO FIRST COIL) PLUS C4, C5 AND C6 EQUALS 0·75 TO 0·80 OF A CABLE SECTION.

2. STRAP C AND D AS FOLLOWS

CABLE CAPACITANCE PER SECTION (nF)	C	D
< 75	OUT	OUT
75-83	IN	OUT
83-89	OUT	IN
> 89	IN	IN

3. STRAP E,F,G & H AS FOLLOWS

BUILDING OUT LOSS (dB)	E	F	G	H
0	IN	OUT	OUT	IN
0·5	IN	IN	OUT	IN
1·0	OUT	IN	OUT	OUT
1·5	OUT	IN	IN	OUT

FIGURE 6. Loaded Cable Impedance Compensator and Building Out Pad (Philips Manufacture)

END