SECTION 6

TELEVISION EQUALISERS TV/EV/1, TV/EV/2

Introduction

The Equalisers TV/EV/1 and TV/EV/2 form part of the equalising apparatus used with the balanced cable employed for the transmission of television signals. The apparatus is described in general in Section 3 of this Instruction. This section deals with the two Bode equalisers, employed for fine control of the final equalised characteristic. The equaliser TV/EV/1 provides correction graded in steps corresponding to the equalisation required by 0·1-mile lengths of average 1-inch balanced-pair cable. The maximum equalisation obtainable is that required by one mile of cable. The equaliser TV/EV/2 has eight controls, each one governing the action of an equaliser section having a fixed half-loss frequency; adjustment of the control varies the magnitude of the ' step ' introduced.

Both equalisers are mounted on 19-inch panels, suitable for bay mounting. The equaliser TV/EV/2 is mounted on two such panels, designated ' Panel No. 1 ' and ' Panel No. 2 ' respectively. Both equalisers are of the constant-resistance type, and are designed to work between 75-ohm terminations.

The general principles of Bode equalisers are discussed in Appendix B.

Circuit Description

TV/EV/1

A complete circuit diagram of the TV/EV/1 is shown in Fig. 4. From this figure it will be seen that there are two Bode equalisers connected in series. The first provides high-frequency correction whilst the second provides medium- and low-frequency correction. By using the expressions given in the Appendix, it will be seen that the value of the iterative impedance R_0 of both the series added bridged-T networks is 213 ohms, whilst the value of ' a ' is 675/213 = 3·16. The insertion loss of each section in the 'flat' response condition is thus 10 db, and hence the overall loss is 20 db.

In each section the ' added ' network is similar to the type of network employed in the equalisers TV/EQ/7, 8 and 17 to achieve correction in the corresponding frequency ranges. The values of the terminating resistors of the added network at each position of the control switch are chosen to give equi-spaced response curves. The load resistors of the series added network (yR_0) decrease progressively to zero, whilst those of the shunt network ($a^2R_0/(y(a^2-1)^2)$) increase to infinity. The range of values of y greater than 1 which would give a response curve falling with increasing frequency is not used. The values of the components are so chosen that the ten steps available give equalising characteristics corresponding to those required for lengths of average 1-inch cable in 0·1 mile steps from 0 to 1 mile.

The insertion loss at zero frequency varies with setting of the control switch and hence it is necessary to alter the setting of the gain control of the subsequent amplifier, the magnitude of the alteration depending on the degree of equalisation introduced. The z.f. loss varies from 20 db at the 0 mile setting to 8·8 db at the 1 mile setting.

TV/EV/2

A complete circuit diagram of the TV/EV/2 is shown in Fig. 4. From this figure it will be seen that there are eight Bode equalisers connected in series. These sections are closely similar, differing only in the ' half-loss ' frequencies of the added networks. These added networks are of the type having a ' through-transmission ' response rising uniformly with frequency, and were discussed in some detail in Section 5.

By using the expressions given in the Appendix, it will be seen that the value of R_0 is 52·8 ohms, and the value of ' a ' is 74·5/52·8 = 1·41. The insertion loss of each section in the ' flat ' response condition is thus 3 db, and hence the overall loss is 24 db.

The values of the terminating resistors of the added networks are chosen to give the overall correction between zero frequency and 3 Mc/s specified by the control setting. These settings are graduated in steps of 0·25 db up to maximum of 2·5 db. Hence by adjustment of the control with the appropriate half-loss frequency it is possible to achieve fine control over the overall frequency response. The half-loss frequencies employed are at 17·25, 34·5, 69, 138, 250, 420, 650 kc/s and 1 Mc/s.

The insertion loss at zero frequency varies with the setting of the control switches, and hence it is necessary to alter the setting of the gain control of the subsequent amplifier, the magnitude of the alteration depending on the degree of equalisation introduced. The z.f. loss varies from 24 db with no correction to 20 db with maximum correction.

Test Specifications

TV/EV/1

1. With the output terminated in 75 ± 1 ohms, the insertion loss should be measured at 10 kc/s, with the controls set to 0 mile position. The loss should be 20 ± 0·25 db. The insertion loss at all other frequencies in the range 10 kc/s–3 Mc/s should be within 0·15 db of that at 10 kc/s.

2. With the output terminated in 75 ± 1 ohms, the insertion loss should be measured at 10 kc/s at each position of the control switch. This loss should be within 0·2 db of that given in Table 6.1.

3. Using the insertion losses measured in 2 above as reference level, the frequency response at each setting of the control switch should be measured. The gain at any frequency relative to that at 10 kc/s should be within 0·15 db of the figures given in Table 6.2.

TV/EV/2

1. With the output terminated in 75 ± 1 ohms, and all controls set to '0 db', the insertion loss of each panel should be 12 ± 0·25 db. The loss at any other frequency in the range 10 kc/s–3 Mc/s should be within 0·15 db of that at 10 kc/s.

2. The overall insertion loss of each panel should be measured at each of the half-loss frequencies; at each such frequency this loss should be measured at each setting of the associated control. The remaining controls should be set to '0 db'. The measured values should be within 0·2 db of the values given in Table 6.3.

3. Using the appropriate insertion loss at 2·5 db measured in (2) above as reference level, the frequency response at the '2·5 db' setting of each control switch should be measured. The gain (loss) at any frequency should be within 0·15 db of the figures given in Table 6.4.

Control Switch Position	0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1·0
Insertion Loss	19·97	18·85	17·85	16·85	15·84	14·8	13·74	12·64	11·57	10·43	9·25

Table 6.1

	Control Switch Position										
	0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1·0
Frequency	*Gain (db) Relative to that at 10 kc/s*										
100 kc/s	0	0·01	0·09	0·1	0·19	0·23	0·31	0·28	0·37	0·37	0·45
500 kc/s	0	0·15	0·37	0·51	0·62	0·91	1·12	1·31	1·52	1·83	2·04
1·0 Mc/s	0	0·25	0·53	0·85	1·22	1·49	1·85	2·2	2·6	3·0	3·33
2·0 Mc/s	0	0·47	1·0	1·55	2·18	2·67	3·31	3·92	4·52	5·21	5·84
2·5 Mc/s	0	0·63	1·21	1·85	2·56	3·2	3·89	4·62	5·41	6·23	7·02
3·0 Mc/s	0	0·75	1·44	2·09	2·84	3·6	4·5	5·23	6·11	7·03	7·94

Table 6.2

Control Setting db	0	0·25	0·5	0·75	1·0	1·25	1·5	1·75	2·0	2·25	2·5
Insertion Loss db	11·95	11·75	11·6	11·4	11·2	11·1	10·9	10·7	10·6	10·4	10·2

Table 6.3

Half-loss frequency 250 *kc/s*

Frequency	10 kc/s	116 kc/s	250 kc/s	536 kc/s	1·0 Mc/s	3·0 Mc/s
Relative Gain db	—1·2	—0·9	0	0·8	1·2	1·3

Half-loss frequency 420 *kc/s*

Frequency	10 kc/s	195 kc/s	420 kc/s	900 kc/s	1·7 Mc/s	3·0 Mc/s
Relative Gain db	—1·2	—1·1	0	0·8	1·2	1·3

Half-loss frequency 650 *kc/s*

Frequency	10 kc/s	100 kc/s	300 kc/s	650 kc/s	1·4 Mc/s	2·6 Mc/s
Relative Gain db	—1·2	—1·2	—1·1	0	0·8	1·2

Half-loss frequency 1 *Mc/s*

Frequency	10 kc/s	100 kc/s	465 kc/s	1·0 Mc/s	2·15 Mc/s	3·0 Mc/s
Relative Gain db	—1·2	—1·2	—1·1	0	0·8	1·2

Half-loss frequency 17·25 *kc/s*

Frequency	8 kc/s	17·25 kc/s	37 kc/s	69 kc/s	1·0 Mc/s	3·0 Mc/s
Relative Gain db	—0·9	0	0·8	1·2	1·2	1·2

Half-loss frequency 34·5 *kc/s*

Frequency	16 kc/s	34·5 kc/s	74 kc/s	138 kc/s	1·0 Mc/s	3·0 Mc/s
Relative Gain db	—0·9	0	0·8	1·2	1·2	1·2

Half-loss frequency 69 *kc/s*

Frequency	10 kc/s	32 kc/s	69 kc/s	148 kc/s	276 kc/s	3·0 Mc/s
Relative Gain db	—1·2	—0·9	0	0·8	1·2	1·2

Half-loss frequency 138 *kc/s*

Frequency	10 kc/s	64 kc/s	138 kc/s	296 kc/s	552 kc/s	3·0 Mc/s
Relative Gain db	—1·2	—1·1	0	0·8	1·2	1·2

Table 6.4

APPENDIX B

BODE EQUALISERS. BASIC PRINCIPLES

A Bode equaliser is the name given to a class of equalisers designed in accordance with the principles laid down by H. W. Bode in an article in the *Bell System Technical Journal*, for April 1938. This article has been re-printed in BBC Lines Department Engineering Instructions (Sound)

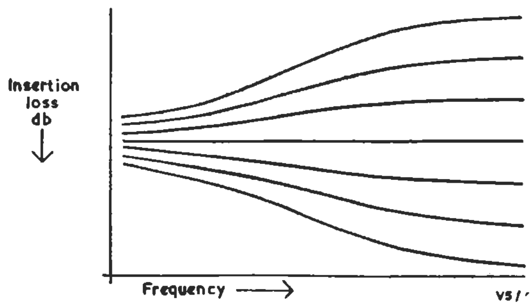


Fig. B.1. Family of Response Curves for various Settings of Controls of a Typical Bode Equaliser

No. 9, together with a discussion of the design of constant-resistance Bode equalisers for BBC use. Bode equalisers are also discussed in Technical Instruction V1, Section G.

Briefly, a Bode equaliser is one in which the magnitude of an equalising characteristic can be changed without change of shape by means of a

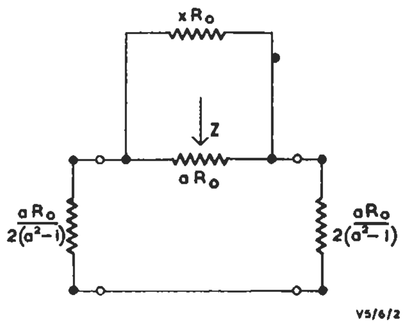


Fig. B.2. Network satisfying Bode Conditions

single control. The response of such an equaliser is shown in Fig. B.1 for various settings of the control.

The particular form of Bode equaliser employed in the equalisers under consideration uses a bridged-T network, and the actual circuit may be built up from basic considerations as follows:

Consider the network of Fig. B.2; in practice the impedances $aR_0/2(a^2 - 1)$ would be the source and load impedances. In this network, the impedance, Z presented to the variable resistance xR_0 is given by R_0/a where a is a constant determined by design requirements. This is the essential condition postulated by Bode for the achievement of the required variable characteristic. The overall loss from input to output is then given by

$$\text{Loss (db)} = 20 \,.\, \log a + 20 \,.\, \frac{x-1}{x+1} \,.\, \log a$$

This expression is a close approximation to the true loss, and is valid only because the conditions

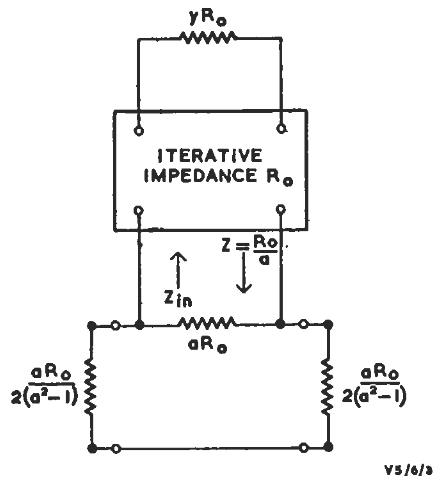


Fig. B.3. Bode Equaliser

governing the magnitude of the impedance Z are fulfilled. There are no restrictions of the value of x, so that the impedance xR_0 can, in fact be made complex. It will be seen from the expression, that as x varies from 0 to infinity, the loss varies from zero to 40 log a db. In this form the network constitutes a rather elaborate gain control; however, it can be modified by making x complex, as suggested above. In the equalisers under consideration this is done by replacing the resistance xR_0 by the input impedance of a four-terminal frequency discriminating network. The added network has an iterative impedance R_0, and is terminated by a variable resistor yR_0. The circuit is as shown in Fig. B.3. It is shown in the standard textbooks on filter theory that the input impedance of such a network is given by

$$Z_{in} = R_0 \,.\, (yR_0 + R_0 \tanh\theta)/(R_0 + yR_0 \tanh\theta)$$
$$= R_0(y + \tanh\theta)/(1 + y\tanh\theta)$$

where θ is the transfer constant of the added network. With a symmetrical network, the transfer constant is equal to the natural logarithm of the ratio of the input voltage to output voltage of the added network when terminated in its iterative impedance. Hence we may write $e^{-\theta} = \beta = E_{out}/E_{in}$ where E_{in} and E_{out} refer to the added network varies with β^2. Further the magnitude of this loss can be varied with y, without change of shape of the frequency response. At $y = 1$, the main network gives a flat loss of 20 log a db. This is to be expected, since at this value of y the input impedance of the added network is constant and equal to R_0. It should be noted that the loss at any frequency is not directly proportional to that of the added network when used directly in a transmission path; the loss of the added network in this condition is given by $-20 \log \beta$ db.

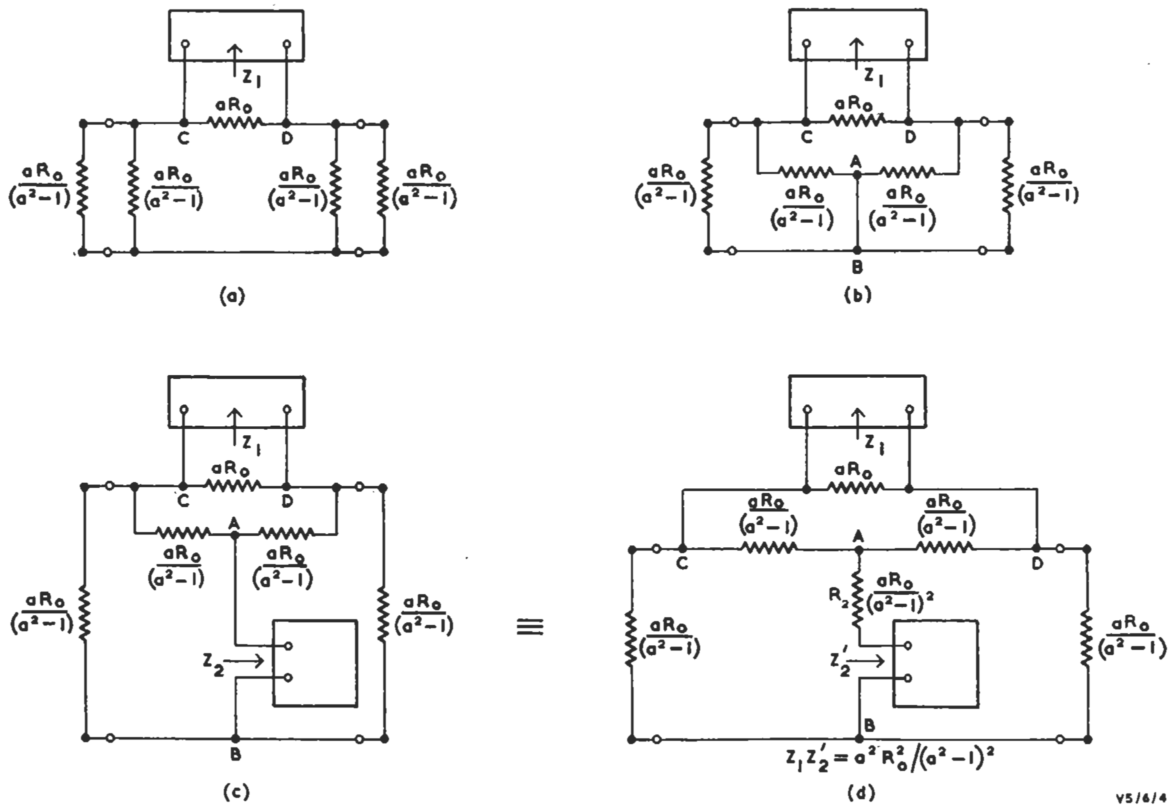


Fig. B.4. Conversion of Network of Fig. B.3 to Constant-impedance Network

when used as a matched network directly in a transmission path. Substitution and manipulation then leads to the following expression for the main network

$$\text{Loss (db)} = 20 \,.\, (\log a) + 20 \,.\, \frac{y-1}{y+1} \,.\, (\log a) \,.\, \beta^2$$

This response is of the desired form, in that it is frequency discriminating, i.e. the frequency response

In the form in which it is shown in Fig. B.3, the network is not of constant-resistance type. The conversion of this network to a constant-resistance form is achieved by the steps shown in Fig. B.4. The terminating resistors of the main network, $aR_0/(2(a^2 - 1))$ are each replaced by two equal parallel resistors $aR_0/(a^2 - 1)$. This does not affect the Bode condition. The four resistors form a balanced bridge viewed from the points C and D and an impedance Z_2 may be connected between the points A and B as shown in Fig. 6.4(c) *without affecting the Bode condition.* The network is then of the conventional bridged-T form discussed in earlier section of this Instruction, and has a constant resistance input provided that the input impedances of the series and shunt added networks are conjugate and their product equal to $a^2R_0^2/(a^2 - 1)^2$. The series arm comprises Z_1 and aR_0 in parallel, and it is therefore usual to split Z_2 into two components in series, a resistance R_2 and an impedance Z_2' as shown in Fig. 6.4(d). These components have values given by $R_2 = aR_0/(a^2 - 1)^2$ and $Z_2' = a^2R_0^2/(a^2 - 1)^2Z_1$. But Z_1 is the input impedance of a four-terminal network loaded by yR_0, and Z_1 is given by

$$Z_1 = R_0 \,.\, (y + \tanh\theta)/(1 + y\tanh\theta)$$

hence $$Z_2' = \frac{a^2R_0^2}{(a^2 - 1)^2} \cdot \frac{1 + y\tanh\theta}{R_0(y + \tanh\theta)}$$

$$= \frac{a^2R_0}{(a^2 - 1)^2} \cdot \frac{(1/y) + \tanh\theta}{1 + (1/y)\tanh\theta}$$

Hence Z_2 is the input impedance of a network of the same configuration as that of Z_1 except that its iterative impedance is $a^2R_0/(a^2 - 1)^2$ and the terminating resistance has to be $a^2R_0/((a^2 - 1)^2y)$.

FIG. 4. COMPONENT DETAILS FOR TV/EV/2

PANEL 1

Section A	C1	·00748	C2	·00371	L1	20·9μ (0·8Ω)	L2	42·1μ (1·2Ω)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
Section B	C3	·0115	C4	·00571	L3	32·1μ (1·0Ω)	L4	64·7μ (1·4Ω)	R33	R34	R35	R36	R37	R38	R39	R40	R41	R42	R43	R44	R45
Section C	C5	·0179	C6	·00887	L5	49·9μ (1·3Ω)	L6	100μ (1·9Ω)	R65	R66	R67	R68	R69	R70	R71	R72	R73	R74	R75	R76	R77
Section D	C7	·03	C8	·0149	L7	83·7μ (1·7Ω)	L8	169μ (2·3Ω)	R97	R98	R99	R100	R101	R102	R103	R104	R105	R106	R107	R108	R109

Section A	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30	R31	R32	SWA
Section B	R46	R47	R48	R49	R50	R51	R52	R53	R54	R55	R56	R57	R58	R59	R60	R61	R62	R63	R64	SWB
Section C	R78	R79	R80	R81	R82	R83	R84	R85	R86	R87	R88	R89	R90	R91	R92	R93	R94	R95	R96	SWC
Section D	R110	R111	R112	R113	R114	R115	R116	R117	R188	R119	R120	R121	R122	R123	R124	R125	R126	R127	R128	SWD

PANEL 2

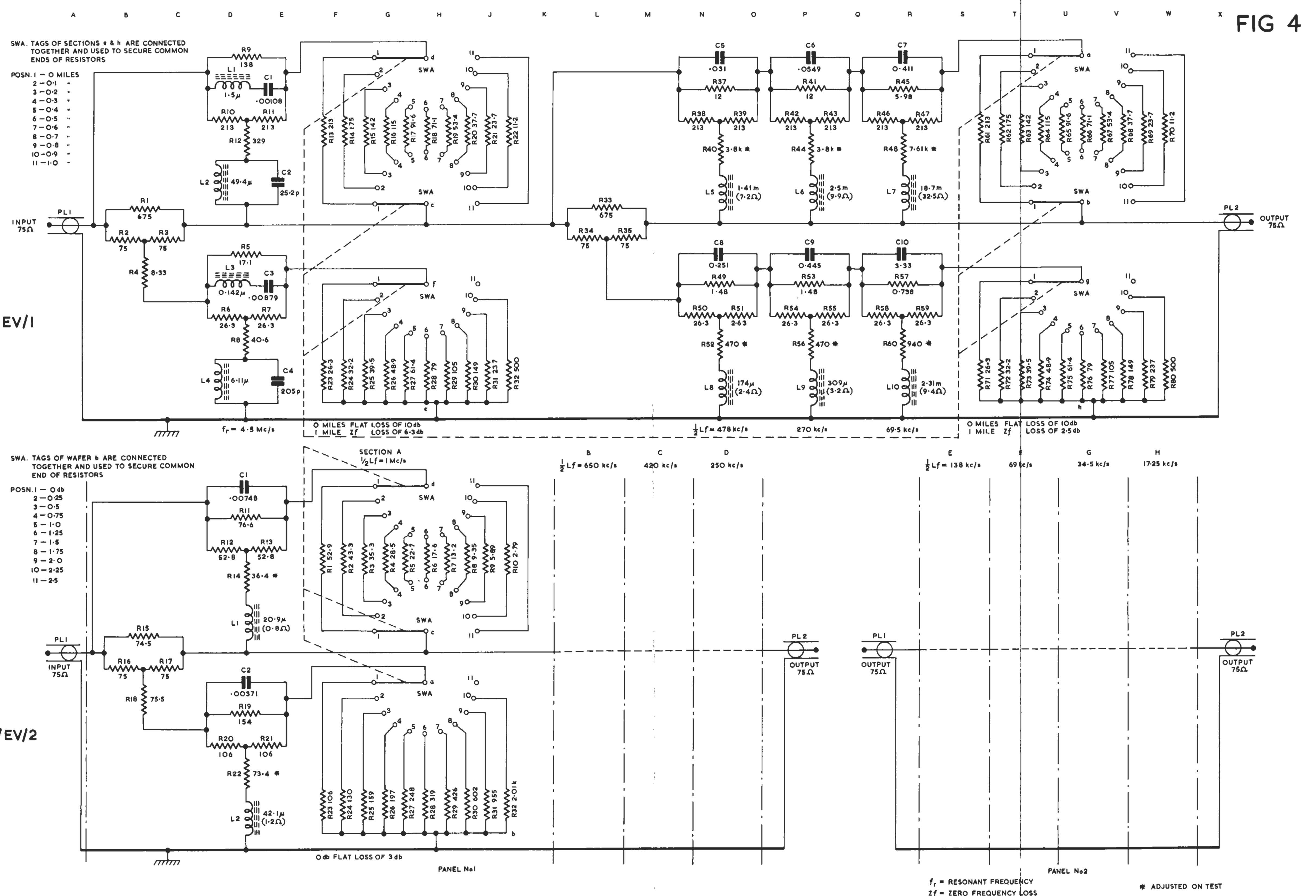
Section E	C1	·0542	C2	·0269	L1	151μ (2·1Ω)	L2	305μ (2·9Ω)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
Section F	C3	0·108	C4	·0537	L3	302μ (2·9Ω)	L4	610μ (4·2Ω)	R33	R34	R35	R36	R37	R38	R39	R40	R41	R42	R43	R44	R45
Section G	C5	0·217	C6	0·107	L5	605μ (4·2Ω)	L6	1·22m (6·1Ω)	R65	R66	R67	R68	R69	R70	R71	R72	R73	R74	R75	R76	R77
Section H	C7	0·434	C8	0·215	L7	1·21m (6·1Ω)	L8	2·44m (9·1Ω)	R97	R98	R99	R100	R101	R102	R103	R014	R105	R106	R107	R108	R109

Section E	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30	R31	R32	SWA
Section F	R46	R47	R48	R49	R50	R51	R52	R53	R54	R55	R56	R57	R58	R59	R60	R61	R62	R63	R64	SWB
Section G	R78	R79	R80	R81	R82	R83	R84	R85	R86	R87	R88	R89	R90	R91	R92	R93	R94	R95	R96	SWC
Section H	R110	R111	R112	R113	R114	R115	R116	R117	R118	R119	R120	R121	R122	R123	R124	R125	R126	R127	R128	SWD

Components occupying similar positions, in circuits of the various sections, are in same column of table

56/GGJ/010/DJE
DC1140
DC1143
ISS4

FIG 4



TELEVISION EQUALISERS TV/EV/1 TV/EV/2 CIRCUITS

f_r = RESONANT FREQUENCY
Zf = ZERO FREQUENCY LOSS
½Lf = HALF LOSS FREQUENCY

* ADJUSTED ON TEST

NOTE 1 CIRCUITS OF SECTIONS NOT SHOWN ARE SIMILAR TO THAT OF SECTION A
NOTE 2 SEE TABLE FACING FOR VALUES OF COMPONENTS AND REF. Nos
NOTE 3 RESISTORS IN ALL SECTIONS HAVE SAME VALUES AS THOSE IN SECTION A