SECTION 18

AMPLIFIER C/8 AND OUTGOING BAYS CB/49, OL/49

INTRODUCTION

In control-room installations of post-war design, the outgoing programmes instead of being distributed via trap-valve amplifiers Type TV/20, are routed via a C-amplifier bay CB/49. This is equipped with Type-C/8 amplifiers, each of which consists of two independent amplifying units, mounted together on the same panel. The programme passes through one of these units, and then through a loss-pad on an attenuator panel AT/24 carried by outgoing lines bay OL/49.

The input to the C-amplifier unit is at zero programme volume and the output at + 10 dB, the loss introduced by the pad on the AT/24 being normally 6 dB. The programme sent to line is thus at the usual volume of + 4 dB.

C-AMPLIFIER BAY CB/49

General Description

This bay forms part of the new standard equipment for control rooms and repeater stations. It is designed to carry any required number of C amplifiers up to ten, together with associated jackfields and power supplies, and when fully equipped is capable of feeding a maximum of twenty outgoing lines.

The apparatus is mounted on a 7-ft bay framework, the full installation being as follows:

Front (top to bottom)

5 C/8 Amplifiers (Nos. 5 to 1).
3 Jackfields JF/103.
1 Jackfield JF/101.
3 Mains Units MU/16H (Nos. 3 to 1).

Rear (top to bottom)

5 C/8 Amplifiers (Nos. 10 to 6).
1 Mains Unit Output Distribution Panel MDP/3.
3 Mains Units MU/16H (Nos. 6 to 4).

Jackfields JF/103 and JF/101

The three jackfields JF/103 provide *Listen*, *Apparatus* and *Line* jacks for the input, main output and monitoring output of each of the twenty independent amplifying units comprising the ten C/8 amplifiers for which the bay is designed. The JF/101 incorporates two groups of five parallel-connected jacks and has also provision for ten tie-lines to other bays.

Power Supplies

Mains unit No. 1 supplies amplifiers Nos. 1 and 2, and mains units Nos. 2 to 5 also each supply two amplifiers, in numerical sequence, the connections in each instance being taken via the mains unit output distribution panel MDP/3; this panel is provided with twelve six-pin sockets, of which two are wired to each of the six mains units, the feeds to individual amplifiers being supplied from the sockets through plug-ended flexible cables. The output sockets of mains unit No. 6 on the mains unit output distribution panel are not normally plugged to amplifiers, but provide a reserve supply.

Mains Unit MU/16H

This is in general similar to the MU/16 (Section 16 and Fig. 42), but with the following modifications:

(i) The unit is built on a mild-steel panel instead of on a wooden panel.

(ii) The l.t. a.c. supply is at 6·2–6·8 and 4–4·6 volts instead of at 5 and 4·3 volts. Two 22-ohm resistors are provided which may be connected across the heater terminals and centre-tapped to earth via an additional terminal, 10, where it is necessary to provide a balanced supply.

(iii) An indicator-lamp is provided connected across the 4-volt a.c. supply.

(iv) The rectifying valve may be either a UU4 or a UU5. The mains transformer is an M.168 instead of an M.37 and the smoothing choke is a CH.1A instead of a CH.1.

OUTGOING LINES BAY OL/49

This bay, like the CB/49, is included in the post-war standard control-room design. The apparatus mounted, from top to bottom on the front of the bay, is as follows:

Jackfield JF/103, equipped with 60 jacks S.T. and C. Type 4112B.
Attenuator-mounting Panel AT/24 No. 3.
Jackfield JF/105 (100 jacks).
Attenuator-mounting Panel AT/24 No. 2.
Jackfield JF/105 (100 jacks).
Jackfield JF/103 (60 jacks).
Attenuator-mounting Panel AT/24 No. 1.
Jackfield JF/103 (40 jacks).
Folding Amplifier-bay Desk DBA/1003A.
2 Connection-strip Mountings CSM/1A.

Each of the attenuator-mounting panels AT/24 (Fig. 18.1) carries twentyfour loss pads. Of these pads, twenty, which have usually a loss of 6 dB but may have other values as required, are connected to C-amplifier units on a bay CB/49 through *Listen*, *Apparatus* and *Attenuator In* jacks arranged in three rows immediately above each attenuator mounting, and to the corresponding outgoing lines through *Listen* and *Line* jacks in two rows immediately below the mounting. Four additional pads, two with a loss of 10 dB each and the others with a loss of 2 dB each, are terminated at jacks on the attenuator-mounting panel for use as required.

AMPLIFIER C/8

General Description

The C/8 amplifier is a fixed-gain unit designed to replace the TV/20 for feeding programme to line. It comprises two independent amplifying units, built side-by-side on a steel panel suitable for rack mounting.

The two units, which are identical, are designated respectively A and B. Each unit has a gain of 10 dB. The input impedance of the units has been made 50,000 ohms nominal (minimum 20 kΩ at 8 kc/s) to facilitate bridging, and the output impedance 600 ohms. The input programme volume in normal service use is 0 dB, and the normal output volume therefore + 10 dB. The units are capable of handling a peak output of + 22 dB, with any value of load impedance from 100 ohms to 2,000 ohms, and are thus suitable for feeding any ordinary line.

To facilitate cross-plugging of amplifiers, without risk of change in gain, the usual volume control is omitted, any necessary loss-pads being provided as part of the line-termination equipment.

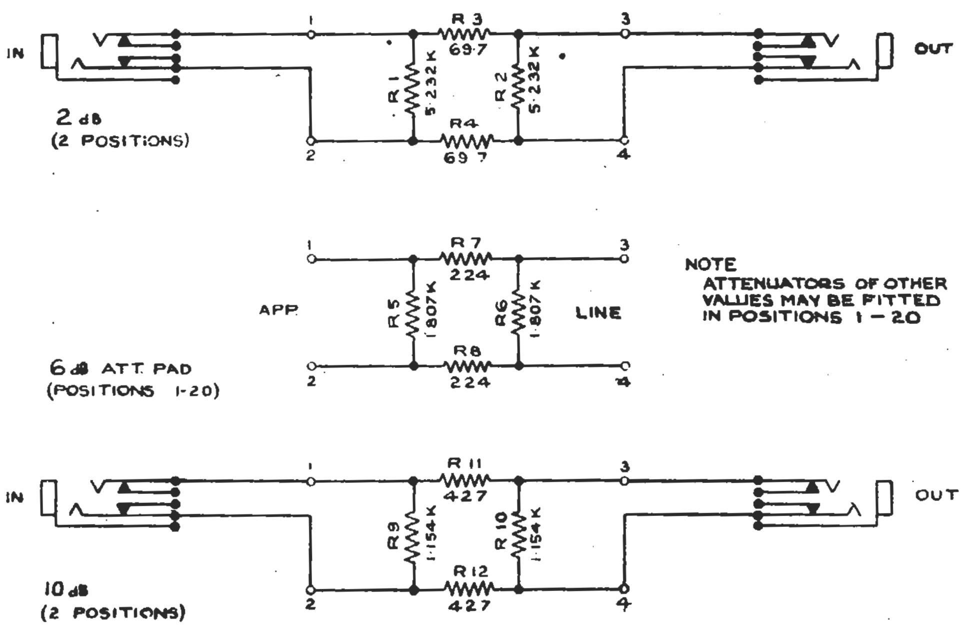

Fig. 18.1. Attenuator Panel AT/24

Since the bay is equipped with three attenuator-mounting panels, it is capable of accommodating the terminations for up to sixty permanently-connected outgoing lines. Panel No. 1 is associated with lines 1-20, panel No. 2 with lines 21-40 and panel No. 3 with lines 41-60.

Also provided on the bay are a parallel jack-strip and *Line* and *Listen* jacks for twenty miscellaneous lines.

A feature of the design is the provision of a monitor output derived from the secondary winding of the output transformer, thus allowing the quality of the programme fed to line to be checked subsequent to the last valve in the chain.

Circuit Description (Fig. 18.2)

Each unit comprises a two-stage resistance-capacitance coupled amplifier with transformer input and output. Voltage negative feedback is applied from a tertiary winding on the output transformer to the cathode circuit of the first valve.

The frequency response and output impedance of the amplifier are sensibly constant over the range 30 c/s to 15 kc/s, this result being achieved by a simple but careful design which includes the use of a large amount of feedback and of resistive and capacitive elements connected across the input and output transformer windings.

Referring to Fig. 18.2, the 100-k Ω resistors, R1 and R13, across the 1 : 1 input transformer, T1, are effectively in parallel with the 200-H shunt inductance of the primary winding, and hence prevent any serious relative falling off in the

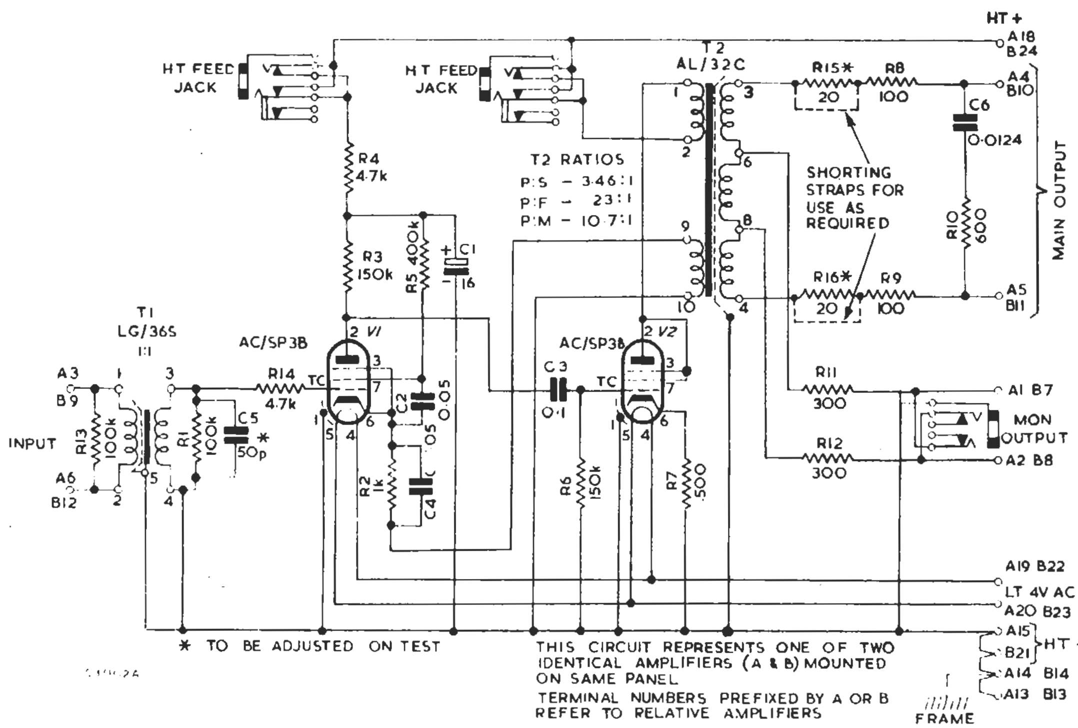

Fig. 18.2 ***Amplifier C/8***

The feedback voltage is injected in series with the cathode-bias resistor, R2, which is shunted by the 0·005-μF capacitor, C4, in order to prevent positive feedback with instability occurring at frequencies above the audible range. As a further precaution, damping is applied to the grid circuit by means of R14 ; the screen-decoupling capacitor, C2, is connected directly to cathode. The output valve, which is strapped as a triode, has a small amount of current feedback, due to the omission of the normal by-pass capacitor across its cathode-bias resistor, R7.

amplifier input impedance and gain at the lower audio frequencies. The response at the higher audio frequencies is controlled by C5, this capacitor also neutralising the effect of leakage inductance in the secondary winding. By a suitable choice of value for C5, and for the resistor R1, in relation to the effective leakage inductance and self-capacitance of the winding, the frequency at which these latter resonate and the shape of the skirts of the resonance curve can be adjusted as required. In practice, the value of R1 is maintained constant at 100 k Ω, but since there may be appreciable variation between the characteristics of different transformers, the value of C5, which is in the neighbourhood of 50 pF, is adjusted for each amplifier to bring the frequency response within the limits prescribed.

The resistors R15, R16, in series with T2 secondary winding are provided to permit adjustment for the variation in resistance between different output transformers, so that the resistive component of the amplifier output impedance may be brought within tolerance; for a satisfactory balance to earth, the values of R15 and R16 must agree to within twenty per cent. The purpose of the network C6, R10, between the output transformer secondary and the main output terminals, is to correct for the leakage reactance of T2, and thus to limit the reactive component of the amplifier output impedance at the higher audio frequencies.

The design specification provides that with the monitor output terminated in 600 ohms the ratio of *output reactance/output resistance*, measured at the main output, shall over the range 60c/s to 8 kc/s be less than 0·1, and in case it should ever become necessary for the output transformer to be replaced, it may be worth mentioning that the value of 0·0124 μF, shown for C6 in Fig.18.2, is related to an effective leakage reactance under normal working conditions of 4·4 mH; if the leakage reactance of the transformer fitted differs from this figure by more than ± 15 per cent, the value of C6 may have to be altered in order to meet the tolerance on net output reactance. Design details for the correction network are given in the appendix to this Section

Mechanical Construction

The two amplifying units, A and B, are mounted side-by-side on a standard panel of folded construction, measuring 22⅛ inches by 4½ inches. The arrangement of the rear components is such that two panels can be mounted back-to-back. The separate input, output and power-supply connections for each unit are terminated in a common 24-pin plug and socket at the left-hand side of the panel facing the front. The feed and monitor jacks for the two units are mounted together on a single sub-panel; this is situated centrally on the main panel, and is accessible through a cut-out in the front cover of the amplifier.

Valve Data

Valve	*H.T. Feed Current*	*Heater Volts*	*Heater Amps.*
Stage 1			
AC/SP3B	2 mA ± 10%	4	1
Stage 2			
AC/SP3B	13 mA ± 10%	4	1

Supplies

H.T. supply (at supply plug), 300 V, d.c. ± 5%.
L.T. supply (at valve pins), 4 V, a.c. ± 5%.
Note.—All measurements taken with avometer Model 40.

General Data

Impedances

Normal source	Z = 300 Ω.
Input (1 kc/s)	Z > 40 kΩ.
Input (8 kc/s)	Z > 20 kΩ.
Output (60 c/s to 8 kc/s)	R = 600 Ω ± 5%; X/R < 0·1.
Normal load	Z = 100 Ω to 2 kΩ.

Normal Working Input Volume

0 db from 300-Ω source.

Normal Working Output Volume

Main output, + 10dB into 600 Ω.
Monitor output, 0 dB into 600 Ω.

Test Data

Test Gain

Test Conditions:

Source impedance 300 Ω; frequency 1 kc/s; input level 0 db; test output terminated in 600 Ω.

(a) Gain at main output, with monitor output terminated in 600 Ω, G_1 = 10dB ± 0·1 dB.
(b) Gain at monitor output, with main output terminated in any impedance from 100 Ω to infinity, G_2 = 0dB, + 0 − 1 dB.

Frequency Response

Input level 0 dB, feeding from 300-Ω balanced source. Tolerances with respect to level at 1 kc/s.

(a) Measured at ***main output***, loading 100 Ω or 600 Ω.
Response from 30 c/s to 10 kc/s, + 0 − 0·2 dB.
Response from 30 c/s to 15 kc/s, + 0 − 1·0 dB.
A change of loading on monitor output from 600 Ω to infinity must not affect response between 30 c/s and 10 kc/s by more than 0·1 dB.

(b) Measured at *monitor output*, loading 600 Ω.

Freq. Range	*Main Output Loading* 600 Ω	100 Ω
30 c/s- 8 kc/s	± 0·2 dB	+ 0·1 – 0·5 dB
30 c/s-10 kc/s	+ 0·2 – 0·5 dB	+ 0·1 – 0·8 dB

Total Percentage Harmonic Content

Value (r.m.s.) at main output.

Level at Main Output	*Loading on Main Output*	*Maximum Total Harmonic Distortion %* 100 c/s	1 kc/s
+ 18 dB into 600 Ω	600 Ω	0·3	0·3
	100 Ω	0·3	0·3
+ 22 dB into 600 Ω	600 Ω	0·3	0·3
	100 Ω	0·5	0·5

Noise Volume

The unweighted noise volume, measured by means of a P.P.M.-type instrument, with the input and output terminals of the amplifier connected to 600 ohms, is not to exceed – 60 dB.

Crosstalk

With one amplifier of a pair fed at + 10 dB from a 300- Ω source, the separation between the output levels of the two amplifiers at all frequencies over the range 60 c/s to 8 kc/s must be greater than 65 dB.

APPENDIX TO SECTION 18

AMPLIFIER C/8 OUTPUT CIRCUIT: DESIGN OF COMPENSATING NETWORK

General

As the type of compensating network employed in the output circuit of the C/8 amplifier has a number of applications, it is worth considering the principles underlying its design.

The first requirement is the establishment of an equivalent circuit. Referring to Fig. 18.2 the generator resistance measured across tags 3 and 4 of transformer T2 looking back into the secondary winding is approximately 400 ohms, this being due almost entirely to the resistance of the secondary winding itself, since the impedance transferred from the primary circuit is reduced to negligible proportions by the step-down ratio of the transformer, and by the effect of voltage negative feed-back on the primary winding resistance and the already-low anode impedance of the triode-connected AC/SP3. The 400-ohm source resistance is built out to 600 ohms by means of resistors R8, R9. (Where the source impedance is less than 400 ohms the straps across R15 and R16 may be removed.) In series with this 600-ohm resistance is the secondary leakage inductance, amounting to about 4·4 mH, and in parallel with the combination across the main output terminals is a further 600-ohm resistor, R10 in series with a 0·0124-μF capacitor C6. Across the secondary winding resistance and leakage inductance is the effective self-capacitance C_w of the winding.

The equivalent circuit of T2 secondary winding and the compensating network are shown in Fig. 18.3 (a) and in simplified form, omitting C_w, in Fig. 18.3 (b). It will be seen that the values of the added resistors and the capacitor C6 have been chosen so that $R = \sqrt{(L/C)}$. For this condition, neglecting C_w, the output impedance of the amplifier at all frequencies is equal to R; i.e., it is a pure resistance of value 600 ohms.

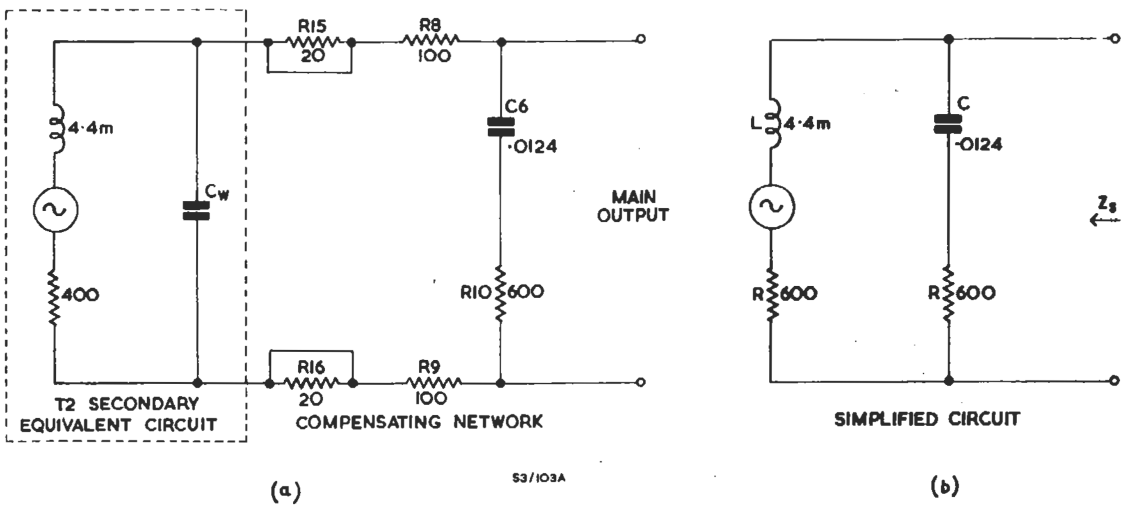

Fig. 18.3 *Amplifier C/8 : Equivalent Output Circuit*

Although the above statement is strictly true only provided that C_w can be ignored, it does, however, represent a very close approximation to the truth over the working frequency-range. The value of C_w is minimised by suitable design of the transformer; this has the relatively low primary-to-secondary turns ratio of 3·46 : 1, and is wound in thirteen sections incorporating four metallised-tissue screens.

Analysis of Simplified Equivalent Circuit (Fig. 18.4)

In order to define the symbols required for use in the analysis, the simplified equivalent circuit, which is a two-branch parallel network, has been re-drawn in Fig. 18.4.

At any frequency $\omega/2\pi$

$$Z_1 = R_1 + j\omega L, \text{ and}$$

$$Z_2 = R_2 - j/\omega C.$$

$$Y_1 = \frac{1}{Z_1} = \frac{1}{R_1 + j\omega L}$$

$$= \frac{R_1}{R_1^2 + \omega^2 L^2} - \frac{j\omega L}{R_1^2 + \omega^2 L^2}$$

$$= G_1 + jB_1.$$

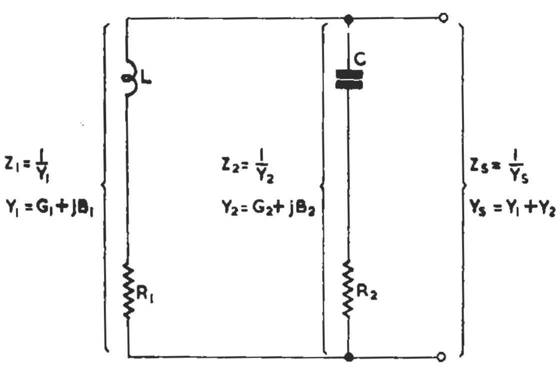

Fig. 18.4 Two-branch Parallel Circuit

Similarly,

$$Y_2 = \frac{1}{Z_2} = \frac{1}{R_2 - j/\omega C}$$

$$= \frac{R_2}{R_2^2 + 1/\omega^2 C^2} + \frac{j/\omega C}{R_2^2 + 1/\omega^2 C^2}$$

$$= G_2 + jB_2.$$

In a parallel circuit, resonance is said to occur when the impedance seen at the terminals is a pure resistance having no reactive component, the sum of the branch susceptances B_1 and B_2 being then zero. Thus

$$-B_1 = B_2, \text{ i.e.,}$$

$$\frac{\omega_0 L}{R_1^2 + \omega_0^2 L^2} = \frac{1/\omega_0 C}{R_2^2 + 1/\omega_0^2 C^2}$$

where the frequency at which the resonance occurs is $\omega_0/2\pi$.

Clearing of fractions, we get

$$\omega_0^2 LC^2 R_2^2 + L = CR_1^2 + \omega_0^2 L^2 C.$$

Hence,

$$\omega_0 = \frac{1}{\sqrt{(LC)}} \cdot \sqrt{\left(\frac{L - CR_1^2}{L - CR_2^2}\right)}$$

Clearly, the parallel resonance can be suppressed by making either CR_1^2 or CR_2^2 equal to L, ω_0 then assuming the value 0 or infinity. At all finite frequencies the terminal impedance, Z_s, behaves in the former case as though the network contained resistance in parallel with capacitance only, and in the latter as though it contained resistance in parallel with inductance. A similar result can be obtained by making either CR_1^2 or CR_2^2 greater than L.

If, however, the values of R_1 and R_2 are made equal, and such that $R_1 = R_2 = \sqrt{(L/C)}$, then both the numerator and the denominator of the fraction within the root sign vanish, with the result that the value of ω_0 becomes indeterminate, and resonance, in the sense previously defined, occurs at all frequencies.

The value of the sending impedance to line, Z_s, under the conditions stated is obtained as follows.

From Fig. 18.4

$$Z_s = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

$$= \frac{(R_1 + j\omega L)(R_2 - j/\omega C)}{R_1 + R_2 + j\omega L - j/\omega C}$$

Putting $R_1 = R_2 = R$ (say) $= \sqrt{(L/C)}$, we get

$$Z_s = \frac{R^2 + j\omega LR - jR/\omega C + L/C}{2R + j\omega L(1 - 1/\omega^2 LC)}$$

$$= \frac{2R^2 + j\omega LR(1 - 1/\omega^2 LC)}{2R + j\omega L(1 - 1/\omega^2 LC)}$$

$$= R \left\{ \frac{2R + j\omega L\,(1 - 1/\omega^2 LC)}{2R + j\omega L\,(1 - 1/\omega^2 LC)} \right\}$$

$$= R.$$

It follows that, over the frequency-range within which the amplifier output circuit can be adequately represented by the network shown in Fig. 18.4 the output impedance is purely resistive, and has the value R, in this instance 600 ohms.