TECHNICAL INSTRUCTION
S.3

Audio-frequency Amplifiers

BRITISH BROADCASTING CORPORATION

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S3

Audio-frequency Amplifiers

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AMENDMENT RECORD

Amendments S3-1 to S3-11 have been incorporated
in the text of this edition of S3.

Amendment Sheet No.	*Initials*	*Date*	*Amendment Sheet No.*	*Initials*	*Date*
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DIAGRAMS AT END

AUDIO-FREQUENCY AMPLIFIERS

SECTION 1

AMPLIFIER A/11

The Amplifier A/11, designed shortly before the outbreak of war was intended to form part of the apparatus included in a general scheme for the modernisation of a.f. equipment. This scheme had to be abandoned owing to war conditions and only a few amplifiers of the A/11 type were produced.

It is of interest to note that the application of feedback utilised in this amplifier has been an essential feature of a number of the more important a.f. amplifiers designed during the past few years. The A/11 is, in fact, a prototype of modern amplifier design.

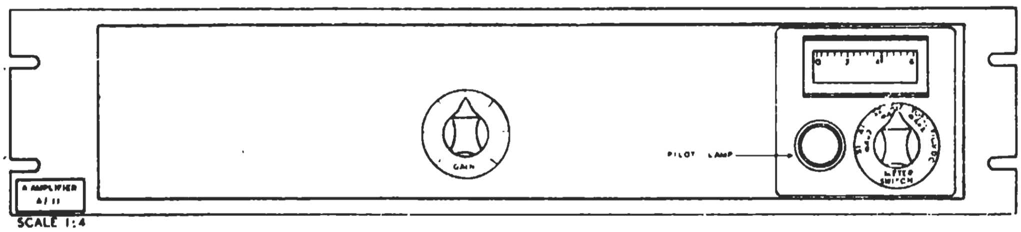


Fig. 1.1. Face Panel A/11

Circuit Description (Fig. 1)

The amplifier employs two pentode stages, resistance-capacitance coupled with transformer input and output. Correction for ribbon-microphone response is provided, the general design of the amplifier being somewhat similar to, but not identical with, that of the OBA/8.

The input transformer has an impedance ratio of 1 : 665. Since its secondary is loaded with an effective resistance of 200,000 ohms, the input impedance is 300 ohms.

Current feedback is applied to the first stage by returning the cathode to h.t. negative through R4, R3 and R19. R3 and R19 are shunted by the potentiometer PF/3A1 and C3, the latter acting as a blocking capacitor for the d.c. component.

The potentiometer provides coarse volume control by varying the feedback in 6 steps of 4 dB per stud. The bias voltage developed across R4, R3, is applied to the grid through R20.

A small amount of high-frequency correction is introduced in the feedback circuit by shunting a small capacitance C4, across R4.

The ribbon-microphone bass correction consists of the capacitors, C2, in series with the input circuit, and C5, in series with the coupling capacitor C6. The response at frequencies above 2,000 c/s is increased by the inclusion of the a.f. choke, L1, in series with the anode circuit of V1. Both bass and treble correction can be shorted if required by closing the strapping at points AA, BB, CC.

Voltage feedback of 19 dB is applied to the output stage by taking the cathode-return circuit through a tertiary winding on the output transformer.

By means of the voltage feedback, and the building out of the secondary winding of the transformers with the resistors R14, R15, an output impedance of 600 ohms is obtained.

Where l.t. supply is a.c., mains hum is kept at a minimum by the application of bias to the heaters, the bias voltage being obtained from the potentiometer, R26, R27, placed across the h.t. supply. The bias is applied by strapping terminals 14, 17 and 18 (Fig. 1). The effect of the bias is to maintain the heater at a high potential with respect to cathode, and so minimise the diode effect produced between heater and cathode. In addition, the buzzing effect associated with an unbiased heater is eliminated, the bias causing the heater to be held against the cathode.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AC/SP3B RH	4·6	1·5	4	1

Total Feed, 7·7 mA.
H.T. Supply, 300 or 250 V.
L.T. Supply, 4 V. a.c. or 6 V. d.c. adjusted to 4 V.

General Data

Volume Control

Type	*Resistance*	*No. of Studs*	*Loss per Stud*
Painton PF/3A1	25670	7	4 dB

Meter. Miniature Edgewise E.D. 1456.
Meter Switch. Yaxley Type B. 2-bank, 9-position.
Impedances
Input $Z = 300\ \Omega$
Output $Z = 600$,,
Normal Load $Z = 600$,,

Normal Working Levels
Input − 75 dB approx.
Output 0 or + 4 dB.

Test Data

600-ohm Test Gain
Test Conditions:
Volume Control set at maximum gain.
Tone Source Sending Level − 70 dB.
Gain at 1,000 c/s, G = 74 dB.
Gain at 50-18,000 c/s relative to gain at 1,000 c/s, ± 0·2 dB.

Maximum Working Voltage Gain
Test Conditions:
Output loaded with 600 Ω.
Output level adjusted to + 4 dB.
Gain at 1,000 c/s, G = 78·5 dB.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< 0·2	< 0·6
1,000 c/s	< 0·2	< 0·3

SECTION 2

MICROPHONE AMPLIFIER AMC/2

General Description

This amplifier is part of the standard Type-A studio equipment. It was designed to raise the output level from the Type-A ribbon microphone previous to mixing. There are three particular advantages in placing the AMC/2 between microphone and mixer:

(i) Potentiometer noise is much lower relative to programme volume.

(ii) Constant-impedance mixing, which inevitably introduces some loss, can be employed, thereby ensuring constant volume from any one microphone, whether other microphones connected to the same mixer are faded up or down.

(iii) Microphone-correction units, which also introduce definite loss, may be inserted between the AMC/2 and the mixer, still leaving the programme volume from the mixer high enough to retain the advantages outlined above.

Mechanically, the AMC/2 differs from normal BBC amplifiers in that it is not designed for rack mounting, but is shaped like a deep drawer.

A modified version of this amplifier, known as the AMC/2A, is used in the Type-D recorder; this amplifier is described in Instruction R1.

Electrical Design Considerations

The maximum gain required from the amplifier is about 50 dB, and simple arrangements are provided to enable the gain to be reduced in 10-dB steps, to permit rough lining up of the output levels from various microphones. A single AC/SP3 valve is used to give the required gain and three values of current negative feedback can be selected, giving a choice of 30, 40 or 50-dB gain.

To make valve hiss and hum as innocuous as possible the input transformer has a large step-up ratio (the turns ratio is approximately 1 : 30) and special switching arrangements are used to ensure that the alterations in the amount of feedback do not upset the loading of the secondary winding. The secondary load should be maintained at 250,000 ohms to obtain the correct frequency characteristic and to keep the input impedance of the amplifier constant at 300 ohms.

The anode of the valve is resistance-capacitance coupled to the output transformer, the component values and transformer ratio being calculated to give an output impedance of 600 ohms.

A low noise and hum level is assured in the amplifier by using generous smoothing, earthing the cathode of the valve by means of a large capacitance (100 μF), and by adequate screening.

Mechanical Design Considerations

As these amplifiers are required in large numbers, simplicity of construction, cheapness and ease of replacement are essential. Accordingly, a drawer type of construction is adopted, an end view of which is shown in Fig. 2.1. The chassis is of folded construction and is turned up at one end to form a front panel which carries the gain control, listen jacks, supply jack and a feed measuring jack. A vertical screen in the centre of the drawer carries the valve holder and serves as a screen between input and output circuits.

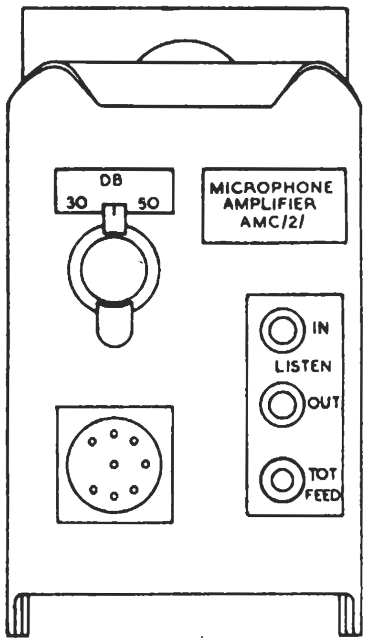


Fig. 2.1. End View of AMC/2 Chassis

In spite of the difference between the input and output levels and the low absolute value of the former, it is practicable to make both connections and also introduce both l.t. and h.t. feeds by means of a single multi-contact plug and socket.

These amplifiers are mounted in threes on trays which are attached to the studio cubicle apparatus cabinet by rubber suspensions. The high mass-to-stiffness ratio thus obtained gives good insulation from mechanical shock.

Circuit Description (Fig. 2)

General

A complete circuit diagram of the amplifier is given in Fig. 2. The anode of the AC/SP3A is fed via two RC smoothing circuits R11, C1 and R8, C4, and its d.c. anode load of 20,000 ohms is made up of two resistors, R9 and R14 in parallel with the preferred values of 22,000 and 220,000 ohms respectively. The anode load of the valve is coupled to the output transformer T2 by the capacitor C5, and is, in effect, the generator resistance for T2. Accordingly the ratio of T2 (5·9 : 1) matches 20,000 ohms to 600 ohms. Parallel-feeding the output transformer has the merit of preserving the correct value of output impedance if the amount of feedback is varied or if the valve fails. The screen h.t. supply is smoothed by the two filters R11, C1 and R7, C3. The automatic bias resistor R6 is shunted by the 100-μF capacitor C2.

The input transformer T1, which has a turns ratio of 1 : 28·8, is shunted on its primary side by the capacitor C7, and on its secondary side by the network R1-R5, which is designed to have an effective value of 250,000 ohms at all three positions of the gain selector switch S1. This loading ensures that the transformer has a substantially level response over the required frequency range.

Feedback Circuit (Fig. 2.2.)

The anode load of the AC/SP3A and the apparent resistance of the primary of T2 are both equal to 20,000 ohms and the a.c. component of the anode current of the valve divides equally between them. As C4 and the primary winding of T2 are both returned to R10, practically the whole of the a.c. component passes through this resistor. The p.d. developed across R10 is introduced into the grid circuit via the switch S1. This is an example of current negative feedback.

The sliders A and B, together with the apparent 250,000-ohms resistance of the input transformer secondary (shown dotted in Fig. 2.2), form a potential divider across R10, which applies a certain fraction of the p.d. developed across R10 to the grid of the valve. As A and B move upwards, this fraction increases, giving increased feedback and, therefore, decreased gain. In practice, as indicated in Fig. 2, A and B are not sliders but a two-pole three-way switch, S1, giving three degrees of negative feedback. A single slider, A,

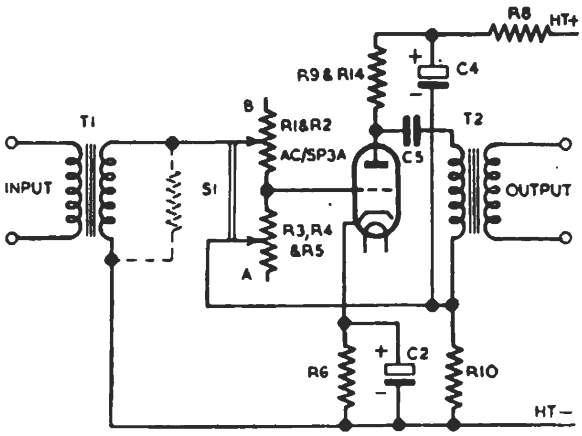


Fig. 2.2. AMC/2 Feedback Circuit Simplified

could be used to give the required degrees of feedback but this would alter the loading on the secondary winding of T1. The slider, B, and the resistors R1 and R2 are therefore necessary in order to keep the secondary loading constant at 250,000 ohms. As A and B move upwards the effective resistance of R3, R4 and R5 becomes progressively less, due to the increasing feedback, but additional padding resistance is inserted into the secondary circuit by the slider B. The way in which the effective value of the grid circuit resistance is decreased by the application of feedback is explained in the instruction on the GPA/1 amplifier, which uses a somewhat similar circuit. (Page 8.1)

The network R17, C8 in parallel with R10 (Fig. 2) reduces the feedback voltage at high audio-frequencies and has the effect of compensating for a slight loss in the output transformer. This correction is common to all gain settings. The capacitor C6 is inserted to correct for high-frequency loss caused by the shunting effect of the secondary winding of T1 by the input capacitance of the valve. This loss is negligible when the gain is set for 30 or 40 dB, due to the large amount of feedback and the "padding-out" effect of R1, R2 at those positions, but in the 50-dB gain position some correction is necessary; accordingly C6 is connected in such a way that it is only effective in the 50-dB position; in other positions one or two resistors totalling more than 1 megohm (R4 and R5) are connected in series with it, so rendering it ineffective. On the 40-dB and 30-dB gain positions, the amplifier will deliver zero volume with distortion on 8-dB peaks of less than 1 per cent at 1,000 c/s and less than 1·5 per cent at 50 c/s. *It will not give this performance with 50-dB gain* owing to the smaller amount of feedback.

Valve Data

Valve	*Anode Potential*	*Anode Current*	*Screen Potential*	*Screen Current*	*Fil. Potential*	*Fil. Current*
AC/SP3A RH	100V.	7·0 mA	115V.	2·1 mA	4V. a.c.	1 A

Total Feed 9 mA.
Total h.t. Supply 300 V.

General Data

Gain Control

Three-position switch giving nominal gains of 30, 40 or 50 dB.

Combined Input, Output and Supply Connector (8-way)

Plug: Films and Equipment, Type EP/C6/8/15 (light pressure).

Socket: Films and Equipment, Type EP/8/14s (light pressure).

Impedances

Normal source 300 Ω (balanced).
Normal input 300 Ω (balanced).
Normal output 600 Ω (balanced).
Normal output load 600 Ω (balanced).

Normal Working Input Level
− 60 dB to − 90 dB
Normal Working Output Level
− 10 dB to − 40 dB
} approximately, depending on programme.

Maximum Gain. 49 dB at 1,000 c/s.

Gain and Feedback Details

Gain Setting	*Normal Voltage Gain*	**Amount of Current Feedback*
50	49 dB	4.7 dB
40	39 dB	11·5 dB
30	28 dB	15·6 dB

*With normal source impedance.

Test Data

600-ohm Test Gain

Gain Setting	*600-ohm Test Gain*
50 dB	45·5 dB
40 dB	35·5 dB
30 dB	24·5 dB

Frequency Response

Within ± 0·1 dB from 100 to 5,000 c/s.
±0·5 dB from 50 to 10,000 c/s.
± 1·5 dB from 30 to 15,000 c/s.

Total Percentage Harmonic Content

Frequency	*At normal input and output levels*	*8 dB above normal input and output levels*
50 c/s	< 0·1	< 0·6
1,000 c/s	< 0·1	< 0·5

Total Percentage Harmonic Content at +8 dB Output Level

Frequency	*30-dB and 40-dB Gain Settings*	*50-dB Gain Setting*
50 c/s	1	2
1000 c/s	1	2

Noise Level

< − 77 dB total with input and output circuits loaded normally.

SECTION 3

AMPLIFIER APM/1

The Amplifier APM/1 is a modification of the Amplifier OBA/8 and was first introduced as a studio output amplifier for use on control-position bays in emergency control rooms.

The physical design was modified for rack mounting as indicated in Fig. 3.1

Circuit Description (Fig. 3)

The circuit employed in the APM/1 is similar to that of the OBA/8 except that the output circuit has been modified to give an output impedance of approximately 300 ohms. The working conditions do not call for frequency correction, the straps at AA, BB, CC being permanently connected.

The circuit comprises two pentodes, resistance-capacitance coupled, with transformer input and output. A peak programme meter amplifier is connected across the output circuit.

The input transformer, T1, has an impedance ratio of 1 : 1,000 and its secondary is loaded with a 300,000-ohms resistor, R1. The input impedance, therefore, is 300 ohms.

The output transformer, T2, has an impedance ratio of 50 : 1. The primary is shunted with a 100,000-ohms resistor, R2, and the secondary with a 400-ohms resistor, R23. The output impedance, therefore, is approximately 300 ohms.

Current feedback is applied to the first stage through the unshunted cathode resistor, R5, in series with R6. R5 also acts as the bias resistor, the bias being applied through R7. R5 and R6 are shunted by the potentiometer, R18, in series with the blocking capacitor, C3. The amount of feedback is, therefore, variable and applied to the grid through C2. The maximum feedback amounts to 16 dB.

Current feedback of 6 dB is applied to the second stage through the unshunted cathode resistor, R13.

Volume control is effected by two ganged potentiometers embodied in a single unit, P/63P. The first potentiometer, R18, controls the feedback to V1 and the second, R19, functions as a normal volume control in the grid circuit of V2.

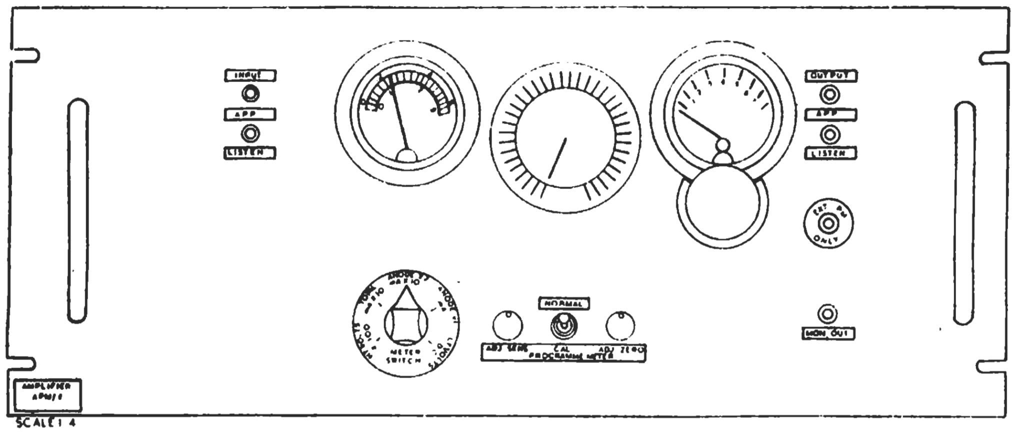


Fig. 3.1. Face Panel APM/1.

Over the first twenty-seven studs of the control the full amount of feedback is applied to V1, the volume being controlled at the input to V2. At stud 0, the loss is infinity and at stop 1, 80 dB. A control of 4 dB operates between studs 1 and 2 ; studs 3 to 12 introduce a further control of 3 dB per stud, and studs 13 to 27, 2 dB per stud ; at stud 27, V3 operates at maximum gain.

Between studs 27 and 35 the feedback to V1 is progressively reduced by 2 dB per stud. At stud 35 the a.c. path between cathode and grid is direct through C2, so that no feedback is applied.

The advantage of this form of volume control is that at high input levels, distortion is avoided by the use of maximum feedback, whereas at low levels, by reducing the feedback, full use is made of the high slope of the pentode.

APM/1 Peak Programme Meter (Fig. 3)

The circuit of the peak programme meter incorporated in the APM/1 is similar to that of the OBA/8 and also employs the principles outlined in the instruction on the PPM/2 (Instruction S4).

The input transformer T3 is connected across the main amplifier output, the primary being shunted with a high-impedance network, one arm of which (R25) is made variable and acts as the sensitivity control.

The secondary winding feeds into a double-diode rectifier, V3, the rectified signal being applied to the capacitor, C13, in the grid circuit of V4.

The circuit is so arranged that with no input signal, the variable-mu valve, V4, passes maximum anode current, causing the right-hand-zero meter to be deflected to the 'no signal' zero mark.

The cathode resistor, R30, of V4 is made variable so that the cathode bias may be adjusted by the *Adj. Law* control to obtain the required characteristic. When a signal is applied to the input of the main amplifier, the rectified output of V3 is applied to the grid of V4 in a negative sense, causing a reduction in anode current logarithmically proportional to the negative voltage applied to the grid. The meter, which is connected in series with the anode circuit of V4, is deflected to the right, the calibrated scale indicating the level of the applied signal.

The correct calibration of the meter is conditioned by the four controls marked *Adjust Zero, Adjust Law, Adjust Sensitivity* and *Zero Balance.*

The *Adjust Zero* control R34 is included in the screen-grid circuit of V4, its function being to adjust the screen volts to obtain 'no signal' zero.

The function of the *Adjust Law* control has already been described, while that of the *Adjust Sensitivity* control is explained under the next heading.

The *Zero Balance* control takes the form of a potentiometer, R42, whose fixed ends are connected across R30 between V4 cathode and earth, while its slider is taken to the earthy side of the neon stabiliser in the screen circuit of V4. When the mains-supply voltage and hence the h.t. voltage varies, the current through the neon changes, and as this current also flows through part of V4 cathode resistance, the valve bias is altered in such a way as to oppose the change in anode current which would otherwise occur. Thus, by suitable adjustment of R42, drifting of the meter zero with mains-voltage variations may be eliminated over a given range.

Calibration

1. Switch on the mains unit about 10 minutes before use.
2. Adjust Meter to read 'no signal' zero by means of *Adjust Zero* control.
3. Set the *Amplifier Gain* control to stop 26 and apply tone to the input at a level of – 70 **dB** approximately. Adjust the *Gain Control* for a reading of 4 on the meter.
4. Adjust the input level by **8 dB** in both directions. Readings of 6 and 2 should be obtained on the meter. If not, proceed as follows :—
5. *To open scale.* (Meter reading above 2 and below 6.) Disconnect tone. Turn *Adjust Law* control until meter reads **above** 'no signal' zero. Re-set to zero by means of *Adj. Zero* control.

   To close scale. (Meter reading below 2 and above 6.) Proceed as for open scale, but turn *Adj. Law* control until meter reads **below** 'no signal' zero.

The above operation should be repeated as necessary until the law error is reduced to a minimum.

Adjust tone source level so that the output level, measured at the amplifier output by means of an amplifier detector, is 0 **dB** into 600 ohms. Adjust *Sensitivity Control* for a meter reading of 4.

Recalibration after Neon and Valve Replacements

Replacement of the rectifier D41 should not affect the calibration in any way, but after replacement of a neon tube or AC/VP1, the zero and law calibration including 'zero balance' must be checked and adjusted. For this purpose it is necessary to provide a means of varying the supply voltage, and a tapped transformer or 'Variac' should be interposed between the mains-supply socket and the mains unit feeding the amplifier APM/1. A variation from the normal working voltage down to about 15 per cent below normal (e.g., from 240 volts down to 200 volts) should be obtainable.

The procedure is as follows :

(i) Adjust the mains-unit input voltage to the nominal value, e.g., 240 volts, and with the *Zero Balance* control fully clockwise (i.e., neon returned to earth), calibrate the programme meter as previously described.

(ii) Set the *Zero Balance* control to its mid position, and restore the meter reading to zero by means of the *Adjust Law* control.

(iii) Reduce the mains-unit input to 200 volts. If the meter reading rises, the *Zero Balance* control has not been rotated far enough. If the reading falls, the control has been turned too far.

(iv) Restore the mains-unit input voltage to normal, rotate the *Zero Balance* control a small amount in the direction as indicated in (iii) above, and re-set the meter zero by means of the *Adjust Law* control.

(v) Reduce the mains-unit input volts once again to 200, and proceed as above, until varying the voltage between 240 and 200 produces no change in the meter zero reading.

(vi) The *Zero Balance* control should be left in the position thus found unless either the neon tube or the AC/VP1 valve has to be replaced.

NOTE :—Each time the a.c. voltage is varied, before proceeding with the next step about 20 seconds should be allowed to elapse for the consequent variation in valve-heater voltage to take effect.

50-c/s Mains Calibration

Provision is made for lining up the PPM, using the 50-c/s mains supply to the heaters of the valves. This calibration is provided as a ready means of checking the sensitivity of the PPM without having to use a tone source.

To apply the calibration, set the programme meter toggle switch to *Cal.* and adjust the sensitivity control until the meter reads 4. Restore the toggle switch to *Normal.* To ensure the accuracy of this check it must first be ascertained that the 50-c/s supply circuit has itself been calibrated against a standard level.

This operation involves the calibration of the PPM as described above. *After this calibration, the Sensitivity Control must not be disturbed.* Then set the toggle switch to *Cal.* and, with the mains transformer adjusted for correct mains voltage, adjust the potentiometer, R24, until the meter reads 4. This potentiometer is situated on the deck below the programme meter and is labelled *Adj. PPM. Cal. Input.*

This latter calibration will normally be carried out on installation, after which R24 should not be adjusted.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·05	0·3	4	1
Stage 2, AC/SP3B RH	12·5	5·0	4	1
Stage 3, D41	—	—	4	0·3
Stage 4, AC/VP1	—	—	4	0·65

Total feed, including neon, 24 mA.
H.T. Supply, 250 V. L.T. Supply, 4 V a.c.

General Data

Volume Control	*No. of Studs*	*Loss per Stud*	
Painton P/63P	35	1-12	3 dB.
		12-35	2 dB.

Feed Meter. Turner model 505 E.D. 1453.
Prog. Meter. Turner E.D. 1415.
Meter Switch. Yaxley Type B, 2-bank, 9-position.

Potentiometers

Adjust P.M. Cal. Input :	Morganite Stackpole LHAR 10250, 1,000Ω.
Adjust Sensitivity :	Morganite Stackpole MNAP 10350, 10,000Ω.
Adjust Zero :	Morganite Stackpole MNAP 50350, 50,000Ω.
Adjust Law :	Morganite Stackpole LHAR 10250, 1,000Ω.
Zero Balance :	Morganite Stackpole LHAP 10250, 5,000Ω.

Impedances
Input Z = 300Ω.
Output Z = 330Ω.
Normal Load Line or T.V. Amplifier.

Normal Working Levels
Input − 70 dB.
Output 0 or + 4 dB.

Test Data

600-ohm Test Gain
Volume Control set at maximum gain.
Tone Source Sending Level − 91 dB approx.
Gain at 1,000 c/s, G = 91·5 dB.
Gain at 50-10,000 c/s, ± 0·5 dB relative to 1 kc/s.

Maximum Working Voltage Gain
Output load 600 Ω and output level + 4 dB.
Gain at 1,000 c/s, G = 95 dB.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< 1	< 2

SECTION 4

B AMPLIFIERS, B/14-B/14C

The B Amplifiers, Series B/14 to B/14C, were designed as part of the programme input equipment at H-group transmitter stations.

Each amplifier in this series comprises an input transformer followed by two stages, resistance-capacitance coupled, the second stage being duplicated to give two separate outputs. Each output stage includes a shunt-fed transformer. The amplifiers have a high gain and are designed to work between 600-ohm terminations.

B/14. Circuit Description (Fig. 4)

The circuit of the amplifier B/14 is straightforward and employs a pentode, AC/SP3A, strapped for triode working in the first stage. Volume control is effected at the paralleled grids of the output stage. Each output stage utilises a triode, type AC/P1, the anode circuit of which is choke-capacitance-coupled to the output transformer.

Valve Data

Valve	*Anode Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	2·8	4	1
Stage 2 (A & B) AC/P1	18	4	1

Total Feed, 39 mA.
H.T. Supply, 250 V.
L.T. Supply, 4 V. a.c.

General Data

Volume Control
Type, Morganite Stackpole MNAP 25450.
Resistance, 250,000 Ω.

Impedances
Input Z = 600 Ω.
Output Z = 185 ,,
Normal Load Z = 600 ,,

Normal Working Levels
Input − 40 dB.
Output + 4 dB.

Test Data

600-ohm Test Gain
Test Conditions:
Volume Control set at maximum gain.
Tone Source Sending Level, − 48 dB.
Gain at 1,000 c/s, G = 52 dB.
Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain
Test Conditions:
Output loaded with 600 Ω and output level adjusted to + 4 dB.
Gain at 1,000 c/s, G = 52 dB.

B/14A. Circuit Description (Fig. 5)

The circuit of the amplifier B/14A is similar to that of the B/14 except that the valve in the first stage is used as a pentode and employs negative feedback. Current feedback is obtained from R5, R13; R5 also provides bias through R12. To compensate for high-frequency losses elsewhere in the circuit, frequency correction is introduced by shunting R5 with a small capacitance, C1, which reduces feedback at the higher frequencies. Below about 8,000 c/s, the total feedback is 19·5 dB, applied through C8.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2 (A & B), AC/P1	18		4	1

Total Feed, 37·5 mA.
H.T. Supply, 250 V.
L.T. Supply, 4V. a.c.

General Data

Volume Control
Type, Morganite Stackpole MNAP 25450.
Resistance, 250,000 Ω.

Impedances

Input	Z = 600 Ω.
Output	Z = 185 ,,
Normal Load	Z = 600 ,,

Normal Working Levels

Input	− 40 dB.
Output	+ 4 dB.

Test Data

600-ohm Test Gain

Test Conditions:
Volume Control set at maximum gain.
Tone Source Sending Level, − 48 dB.
Gain at 1,000 c/s, G = 52 dB.
Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions:
Output loaded with 600 Ω and output level adjusted to + 4 dB.
Gain at 1,000 c/s, G = 52 dB.

B/14B. Circuit Description (Fig. 6)

The circuit of the amplifier B/14B is similar to that of the B/14A except that the output stages employ pentodes, Type AL60, strapped for triode working. In order to maintain approximately the same gain as that of B/14 and B/14A, the anode resistance of V1 is split and the coupling to the output stages taken from the junction of R4, R14. A slight modification to the feedback circuit is introduced, the value of C1 being changed from 0·025 μF to 0·008 μF, and the capacitor shunted across the whole of the feedback resistor R5, R13. Thus, the feedback is reduced at the upper extremity of the audio-frequency range.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AL60 (A & B)	25·5	—	4	2·1

Total Feed, 52·5 mA.
H.T. Supply, 250 V.
L.T. Supply, 4 V. a.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 25450.
Resistance, 250,000 Ω.

Impedances

Input	Z = 600 Ω.
Output	Z = 160 ,,
Normal Load	Z = 600 ,,

Normal Working Levels

Input	− 40 dB.
Output	+ 4 dB.

Test Data

600-ohm Test Gain

Test Conditions:
Volume Control set at maximum gain.
Tone Source Sending Level, = 52 dB.
Gain at 1,000 c/s, G = 56 dB.
Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions:
Output loaded with 600 Ω and output level at + 4 dB.
Gain at 1,000 c/s G = 56 dB.

B/14C. Circuit Description (Fig. 7)

The amplifier B/14C employs a circuit similar to that of the B/14B, the only modification being the change in output transformers and chokes, giving a slight increase in overall gain.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AL60 (A & B)	32·0	—	4	2·1

Total Feed, 65·5 mA.
H.T. Supply, 250 V.
L.T. Supply, 4 V. a.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 25450.
Resistance, 200,000 Ω.

Impedances

Input	Z = 600 Ω.
Output	Z = 245 ,,
Normal Load	Z = 600 ,,

Normal Working Levels

Input	− 40 dB.
Output	+ 4 dB.

Test Data

600-ohm Test Gain

Test Conditions :

Volume Control set at maximum gain.

Tone Source Sending Level, − 55 dB.

Gain at 1,000 c/s, G = 59 dB.

Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions :

Output loaded with 600 Ω and output level adjusted to + 4 dB.

Gain at 1,000 c/s, G = 59 dB.

SECTION 5

AMPLIFIER C/4

The Amplifier C/4 is of modern design and was intended to function as a distribution amplifier in the scheme for new control room equipment. Since war conditions caused the general scheme to be abandoned, the C/4 was not produced on a large scale.

Circuit Description (Fig. 8)

The circuit comprises a single push-pull stage with transformer input and output. High slope pentodes of the AC/SP3B type are used, with balanced cathode-injected voltage feedback.

Volume control is effected in eight steps of 2 dB by means of the ganged potentiometers, P1, P2, which are connected across the two secondary windings of the input transformer. This arrangement ensures a balanced input to the grids of the two push-pull valves, irrespective of input level.

H.T. is applied to the anodes of the valves through the primary windings of the output transformer, in a meter-shunt R16, R17, being included in series with each half of the primary winding so that the anode feed for each valve may be measured independently. A variable resistor, R5, is included in the screen grid circuit of V2 to maintain balanced feeds.

The main secondary winding of the output transformer is built out by R9, R10 to give an output impedance of 600 ohms.

A centre-tapped tertiary winding on this transformer provides voltage feedback to each valve independently, the cathode circuits being completed through this winding. The total feedback amounts to 13 dB.

Power supplies may be taken from either batteries or mains unit. When a.c. is used for heater supply, the resistors, R21, R22, are shunted across the heater circuit and centre-tapped to h.t.. negative in order to reduce mains hum to a minimum. The required connections are given in Note 2, Fig. 8.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
AC/SP3B RH (2)	10	4·5	4	1

Total Feed, 29 mA.

H.T. Supply, 250 or 300 V.

L.T. Supply, 4 V a.c. or 6 V d.c.

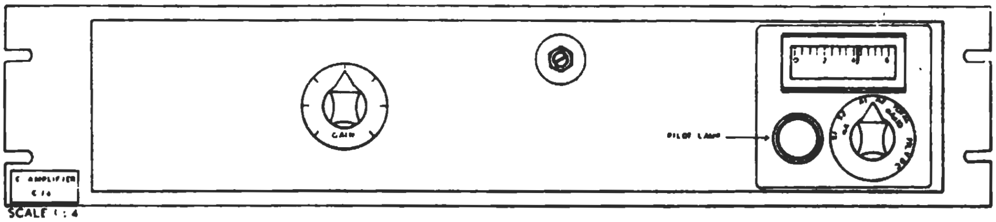


Fig. 5.1. Face Panel C/4

General Data

Volume Control

Type	*Resistance*	*No. of Studs*	*Loss per Stud*
Painton PNN/3B	25,000 Ω	8	2 dB.

Note: PNN/3B comprises two ganged potentiometers, as indicated above.

Impedances

Input	Z = 56,000 Ω.	
Output	Z = 600 ,,	
Normal Load	Z = 600 ,,	(Line)

Normal Working Levels

Input	0 dB.
Output	− 8 to + 8 dB.

Test Data

600-ohm Test Gain

Test Conditions:

Volume Control set at maximum gain.

Tone Source Sending Level, 0 dB.

Gain at 1,000 c/s, G = 14 dB.

Gain at 50-18,000 c/s, ± 0·1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain	*Total Percentage Harmonic Content*		
Test Conditions:		*8 dB above normal level*	*12 dB above normal level*
Output loaded with 600 Ω and output level at + 8 dB.	100 c/s	< 0·6	< 0·7
Gain at 1,000 c/s, G = 8 dB.	1,000 c/s	< 0·25	< 0·3

SECTION 6

D AMPLIFIERS

Introduction

The main function of a D amplifier is to raise the programme level of an incoming Post Office line to that normally obtained from a studio amplifier. At transmitting stations it is used to raise the line level to a value suitable for feeding into the limiter via the main programme controls. At recording centres, D amplifiers are used for reproduction and monitoring purposes.

The use of the D amplifier is not restricted to these specified functions and it may be regarded as a general purpose amplifier of medium or high gain, usually working between 600-ohm terminations.

D/8 (Fig. 9)

Circuit Description

The D/8 is a two-stage amplifier with screened input transformer and resistance-capacitance coupling between the stages. It has two output stages to enable echo to be added to the programme when required. The output stages are choke-capacitance coupled to the output transformers. The main output stage comprises two AC/P1's in parallel. Grid bias is automatic.

Valve Data

Valve	*Anode Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/HL	2·7	4	1
Output Stage 1, 2AC/P1's	36·0	4	2
Output Stage 2, AC/P1	18·5	4	1

Total Feed 57·2 mA.
H.T. Supply, 300 V.
L.T. Supply, 6 V (adjusted to 4 V by series resistor).

General Data

Volume Control

Type	*Resistance*	*No. of Studs*	*Loss per Stud*
P.37	100,000	21	2 dB (Loss on lowest stud infinite.)

Impedances

Input Z = 600 Ω.
Output 1 Z = 180 ,,
Output 2 Z = 180 ,,

Normal Load Impedance

Output 1 (B amplifier input) Z = 600 Ω.
(C amplifier and programme meter amplifier inputs) Z = 8,000-17,000 Ω.
Output 2, Z = 3,000 Ω.

Test Data

600-ohm Test Gain

Test Conditions:
Volume control set at maximum gain.
Tone Source Sending Level, zero.
Gain at 1,000 c/s.
Output 1 G = 34±2 dB.
Output 2 G = 32±2 dB.
Gain at 50-5,000 c/s. (Output 1) G = ± 0·5 dB. relative to gain at 1,000 c/s.
Gain at 5,000-9-000 c/s. (Output 1) G = ± 1 dB. relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions:
Volume control set for maximum gain.
Gain at 1,000 c/s.
Output 1. (Loaded with 600 Ω and output level at 0 dB) G = 34 ± 2 dB.
Output 1. (Loaded with 8,000 Ω and output level at + 10 dB) G = 36 ± 2 dB.
Output 2. (Loaded with 5,000 Ω and output level at 0 dB) G = 34 ± 2 dB.

D/8A—D/8G

The amplifiers in the series designated D/8A to D/8G are, in general, modifications of earlier types of amplifiers introduced to meet emergency requirements.

Each of these amplifiers comprises two stages, resistance-capacitance coupled, and with the exception of D/8A, which uses a triode in the first stage, employ pentodes throughout the series.

The amplifiers are used in all cases as medium-gain level raisers and operate between 600-ohm source and load impedances.

D/8A. Circuit Description (Fig. 10)

The D/8A is a modified form of the original D/8 and is of straightforward design. The input transformer feeds into the grid of a triode, AC/HL. Gain control is effected by means of a stud potentiometer connected across the secondary winding.

The first stage is resistance-capacitance coupled to the output stage, which employs an AL60 with anode, screen grid and suppressor grid strapped for triode working. H.T. supply is taken either from batteries or a rectifier. L.T. supply is taken from 6-volt batteries. The amplifier is not designed for a.c. filament supply.

Valve Data

Valve	*Anode Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/HL	2·8	4	1
Stage 2, AL60	35·0	4	2·1

H.T. Supply, 300 V.
L.T. Supply, 6 V. d.c. adjusted to 4 V.

General Data

Volume Control

Type	*Resistance*	*No. of Studs*	*Loss per Stud*
P/37	100,000 Ω	21	2 dB

Impedances

Input Z = 600 Ω.
Output Z = 230 ,,
Normal Load Z = 600 ,,

Normal Working Levels

Input − 40 dB.
Output + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions :
Volume control set at maximum gain.
Tone Source Sending Level, − 46 dB.
Gain at 1,000 c/s, G = 50 db.
Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions :
Output loaded with 600 Ω and output level at + 4 dB.
Gain at 1,000 c/s, G = 50 dB.

Total Percentage Harmonic Content

	Normal level	8 dB *above normal level*
100 c/s	—	< 0·7
1,000 c/s	—	< 0·9

D/8B. Circuit Description (Fig. 11)

The input transformer feeds into the grid of the first stage through a continuously-variable volume control.

The first stage, which employs a pentode AC/SP3, is resistance-capacitance coupled to an AL60 strapped for triode working.

The cathode of V1 is biased by the resistor, R8, which is shunted by C2, the bias being applied to the grid through R10. Current feedback of 17·5 dB is obtained from the resistors, R8 and R9. As the by-pass capacitor, C2, has low capacitance, the feedback will be reduced progressively at the higher frequencies. The voltage developed across R9 will be applied in full at all frequencies. This arrangement results in a limited amount of frequency correction at the higher frequencies.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AL60	32	—	4	2·1

H.T. Supply, 300 V
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 50350.
Resistance, 50,000 Ω.

Impedances

Input Z = 600 Ω.
Output Z = 245 ,,
Normal Load Z = 600 ,,

Normal Working Levels

Input − 40 dB.
Output + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions :
Volume control set at maximum gain.
Tone Source Sending Level − 43 dB.
Gain at 1,000 c/s, G = 47 dB.
Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions :
Output loaded with 600 Ω and output level at + 4 dB.
Gain at 1,000 c/s, G = 47 dB.

D/8C. Circuit Description (Fig. 12)

The circuit of the D/8C is similar to that of the D/8B except for some slight differences in component values.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AL60	35	—	4	2·1

H.T. Supply, 300 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type	*Resistance*	*No. of Studs*	*Loss per Stud*
P/37	10,000 Ω.	21	2 dB

Impedances

Input Z = 600 Ω.
Output Z = 230 ,,
Normal Load Z = 600 ,,

Normal Working Levels

Input − 40 dB.
Output + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions:
Volume control set at maximum gain.
Tone Source Sending Level − 45 dB.
Gain at 1,000 c/s, G = 49·5 dB.
Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions:
Output loaded with 600 Ω and output level at + 4 dB.
Gain at 1,000 c/s, G = 49·5 dB.

D/8D. Circuit Description (Fig. 13)

The circuit of the amplifier D/8D is similar to that of the D/8B except that the by-pass capacitor, C2, is connected across both R8 and R9, thus reducing the feedback as frequency rises.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AL60	35	—	4	2·1

H.T. Supply, 300 V.
L.T. Supply, 4 V. a.c. or 6 V. d.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 10450.
Resistance, 100,000 Ω.

Impedances

Input Z = 600 Ω.
Output Z = 230 ,,
Normal Load Z = 600 ,,

Normal Working Levels

Input − 40 dB.
Output + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions:
Volume control set at maximum gain.
Tone Source Sending Level, − 45 dB.
Gain at 1,000 c/s, G = 49·5 dB.
Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions:
Output loaded with 600 Ω and output level at + 4 dB.
Gain at 1,000 c/s, G = 49·5 dB.

D/8E. Circuit Description (Fig. 14)

The circuit of the amplifier D/8E is similar to that of D/8D except for some slight changes in component values.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AL60	35	—	4	2·1

H.T. Supply, 300 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 10450.
Resistance, 100,000 Ω.

Impedances

Input Z = 600 Ω.
Output Z = 160 ,,
Normal Load Z = 600 ,,

Normal Working Levels

Input − 40 dB.
Output + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions :

Volume control set at maximum gain.

Tone Source Sending Level, – 43 dB.

Gain at 1,000 c/s, G = 47 dB.

Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions :

Output loaded with 600 Ω and output level at + 4 dB.

Gain at 1,000 c/s, G = 47 dB.

D/8F. Circuit Description (Fig. 15)

The circuit of the amplifier D/8F is similar to that of the D/8D except for some slight changes in component values.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AL60	35	—	4	2·1

H.T Supply, 300 V.

L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 10450.

Resistance, 100,000 Ω.

Impedances

Input Z = 600 Ω.

Output Z = 245 ,,

Normal Load Z = 600 ,,

Normal Working Levels

Input – 40 dB.

Output + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions :

Volume control set at maximum gain.

Tone Source Sending Level – 51 dB.

Gain at 1,000 c/s, G = 55 dB.

Gain at 50-10,000 c/s, ± 1 dB. relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions :

Output loaded with 600 Ω and output level at + 4 dB.

Gain at 1,000 c/s, G = 55 dB.

D/8G. Circuit Description (Fig. 16)

The circuit of the amplifier D/8G is similar to that of the D/8D, except for some slight changes in component values.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AL60	32	—	4	2·1

H.T. Supply, 300 V.

L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 10450.

Resistance, 50,000 Ω.

Impedances

Input Z = 600 Ω.

Output Z = 245 ,,

Normal Load Z = 600 ,,

Normal Working Levels

Input – 40 dB.

Output + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions :

Volume control set at maximum gain.

Tone Source Sending Level, – 47 dB.

Gain at 1,000 c/s, G = 51 dB.

Gain at 50-10,000 c/s, ± 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions :

Output loaded with 600 Ω and output level at + 4 dB.

Gain at 1,000 c/s, G = 51 dB.

D/9, D/9A, D/9B

The amplifiers D/9 and D/9A are designed as general purpose level raisers and operate between 600-ohm source and load impedances. The D/9B is of similar design but has an input impedance of 300 ohms and a much greater gain. Each of the amplifiers in this series comprises two stages, resistance-capacitance coupled and employing pentodes, Type AC/SP3, feedback being applied to both stages.

D/9. Circuit Description (Fig. 17)

The input transformer secondary winding is shunted by four resistors in series, R28 to R31, which are tapped so that the gain of the amplifier may be set to close limits on installation.

Current feedback of 13 dB is applied to the first stage and is obtained from the resistors R3, R4, R19, which are included in the cathode return circuit. The volume control, PF/4A1, and blocking capacitor, C3, are shunted across R3 and R19. Volume control is therefore effected by varying the amount of feedback in this stage, the control being limited to 10 dB in steps of 1 dB. A small amount of high-frequency correction is introduced by shunting C4 across R4.

Voltage feedback of 19 dB is applied to the second stage by means of a feedback winding on the output transformer, the cathode return circuit being completed through this winding and the bias resistor, R18. This enables maximum undistorted output to be obtained and compensates for the distortion due to the output transformer.

In order to minimise mains hum when using a.c. filament supply, bias is applied to the heaters from the potential divider, R26, R27, connected across the h.t. supply, the bias being applied via R24, R25, thereby maintaining the two ends of the heater at the same potential with respect to the cathode. Under these conditions, terminals 14, 17 and 18 must be strapped to complete the circuit.

Where two amplifiers are supplied from a single mains unit, the strapping should only be done on one amplifier.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AC/SP3B RH	4·6	1·5	4	1

Total feed, 7·7 mA.
H.T. Supply, 300 or 250 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type	*Resistance*	*No. of Studs*	*Loss per Stud*
PF/4A1	6,119 Ω	10	1 dB.

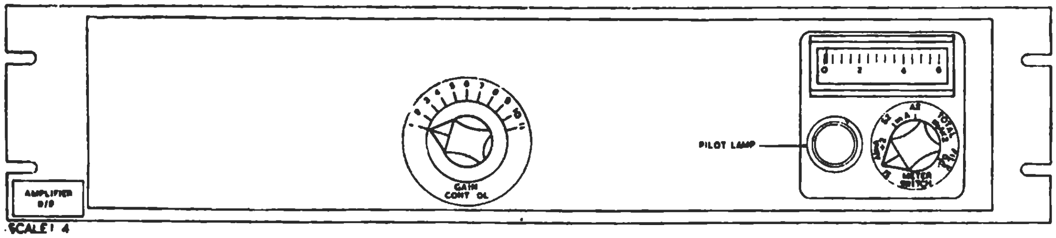


Fig. 6.1. Face Panel D/9

Meter, Miniature Edgewise No. 1456.

Meter Switch, Yaxley Type B, No. 2123.

Impedances
Input Z = 600 Ω.
Output Z = 600 ,,
Normal Load Z = 600 ,,

Normal Working Levels
Input – 50 dB.
Output 0 or + 4 dB.

Test Data

600-ohm Test Gain
Test Conditions :
Volume control set at maximum gain.
Tone Source Sending Level, – 46 dB.
Gain at 1,000 c/s, G = 50 dB.
Gain at 50-10,000 c/s, ± 0·1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions:

Output loaded with 600 Ω and output level at + 4 dB.

Gain at 1,000 c/s, G = 50 dB.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< ·1	< ·5
1,000 c/s	< ·1	< ·2

D/9A. Circuit Description (Fig. 18)

The input transformer feeds the grid of the first stage via a continuously-variable volume control, R32.

Current feedback of 13 dB is applied to the first stage from the combination of resistors R3, R4, R19, R33 and is applied through the blocking capacitor, C2. The amount of feedback is predetermined by shunting R33 across R3, R19. Correction at the higher frequencies is obtained by shunting C4 across R4.

General Data

Volume Control

Type, Morganite Stackpole MNAP 20350.-

Resistance, 20,000 Ω.

Meter, Miniature Edgewise No. 1456.

Meter Switch, Yaxley Type B, No. 2123.

Impedances

Input	Z = 600 Ω.
Output	Z = 600 „
Normal Load	Z = 600 „

Normal Working Levels

Input	– 50 dB.
Output	0 or + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions:

Volume control set at maximum gain.

Tone Source Sending Level, – 49 dB.

Gain at 1,000 c/s, G = 53 dB

Gain at 50-10,000 c/s, ± 0·1 db relative to gain at 1,000 c/s.

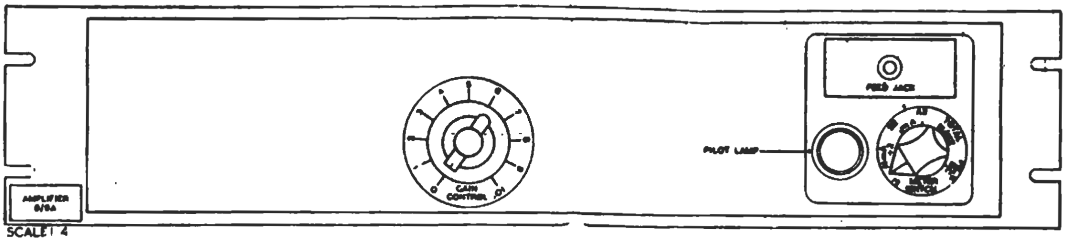


Fig. 6.2 Face Panel D/9A

Voltage feedback of 19 dB is applied to the second stage by means of a feedback winding on the output transformers, the cathode return circuit being completed through this winding and the bias resistor R18.

Similar arrangements for minimising mains hum are provided as those previously described under the heading D/9.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1,				
AC/SP3A RH	1·2	0·4	4	1
Stage 2,				
AC/SP3B RH	4·6	1·5	4	1

Total feed, 7·7 mA.

H.T. Supply, 300 or 250 V.

L.T. Supply, 4 V a.c. or 6 V d.c.

Maximum Working Voltage Gain

Test Conditions:

Output loaded with 600 Ω and output level at + 4 dB.

Gain at 1,000 c/s, G = 53 dB.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< 0·1	< 0·5
1,000 c/s	< 0·1	< 0·2

D/9B. Circuit Description (Fig. 18)

The circuit of the D/9B is similar to that of the D/9A but employs a high step-up ratio input transformer which increases the overall gain to 71 dB and reduces the input impedance to 300 ohms. The D/9B can therefore be used as an "A" amplifier when required.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1,				
AC/SP3A RH	1·2	0·4	4	1
Stage 2,				
AC/SP3B RH	4·6	1·5	4	1

Total feed, 7·7 mA.
H.T. Supply, 300 or 250 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control
Type, Morganite Stackpole MNAP 20450.
Resistance, 200,000 Ω.
Meter, Miniature Edgewise No. 1456.
Meter Switch, Yaxley Type B, No. 2123.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< 0·1	< 0·5
1,000 c/s	< 0·1	< 0·2

D/10, D/10A, D/10B

The amplifiers D/10, D/10A and D/10B are single-stage medium-gain units designed as general purpose level raisers. Except for minor details, the same circuit is used in each of these amplifiers.

Circuit Description (Figs. 19, 20, 21)

The input transformer, the secondary of which is shunted by a volume control, feeds into a pentode, Type AC/SP3B. H.T. is fed to the anode of the valve through the primary winding of the output transformer, the secondary of the trans-

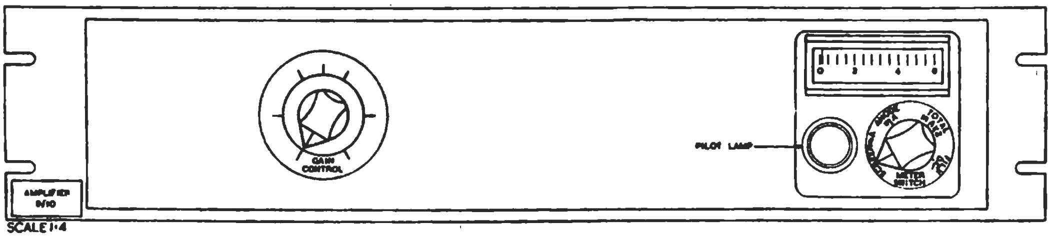


Fig. 6.3 Face Panel D/10

former being built out to an impedance of 600 ohms by the resistors R6, R7.

The cathode-return circuit is taken through a third winding on the output transformer, which provides 19 dB voltage feedback, the effect of which is to assist in obtaining correct output impedance and to reduce distortion due both to the valve and to the transformer.

Power supplies are normally taken from a mains unit of the MU/16 type, but provision is made for 6-V. d.c. l.t.. supply.

Metering facilities are available for the measurements of anode and screen currents.

Impedances
Input Z = 300 Ω.
Output Z = 600 ,,
Normal Load Z = 600 ,,

Normal Working Levels
Input – 70 dB.
Output 0 or + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions :
Volume control set at maximum gain.
Tone Source Sending Level, – 64 dB.
Gain at 1,000 c/s, G = 67·5 dB.
Gain at 50-10,000 c/s, ± 0·1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain
Test Conditions :
Output loaded with 600 Ω and output level at + 4 dB.
Gain at 1,000 c/s, G = 71 dB.

D/10 (Fig. 19)

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1,				
AC/SP3A RH	4·6	1·5	4	1

Total feed, 6·1 mA.
H.T. Supply, 300 or 250 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 25450.

Resistance, 250,000 Ω.

Meter, Miniature Edgewise No. ED 1456.

Meter Switch, Yaxley Type B ; 2-bank, 9-position.

Impedances

Input	Z = 600 Ω.
Output	Z = 600 ,,
Normal Load	Z = 600 ,,

Normal Working Levels

Input	– 40 dB.
Output	– 10 dB.

Test Data

600-ohm Test Gain

Test Conditions :
Volume control set at maximum gain.
Tone Source Sending Level, – 29 dB.
Gain at 1,000 c/s, G = 33 dB.
Gain at 50-10,000 c/s, ± 0·1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions :
Output loaded with 600 Ω and output level at – 10 dB.
Gain at 1,000 c/s, G = 33 dB.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< 0·1	< 1·0
1,000 c/s	< 0·1	< 1·0

D/10A (Fig. 20)

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	4·6	1·5	4	1

Total feed, 6·1 mA.

H.T. Supply, 300 or 250 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type	*Resistance*	*No. of Studs*	*Loss per Stud*
PN/5A1	8,900 Ω	19	2 dB.

Meter, Miniature Edgewise No. ED 1456.

Meter Switch, Yaxley Type B, 2-bank, 9-position.

Impedances

Input	Z = 600 Ω.
Output	Z = 600 ,,
Normal Load	Z = 600 ,,

Normal Working Levels

Input	– 39 dB.
Output	– 10 dB.

Test Data

600-ohm Test Gain

Test Conditions :
Volume control set at maximum gain.
Tone Source Sending Level, – 25 dB.
Gain at 1,000 c/s, G = 29 dB.
Gain at 50-10,000 c/s, ± 0·1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions :
Output loaded with 600 Ω and output level at – 10 dB.
Gain at 1,000 c/s, G = 29 dB.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< 0·1	< 0·5
1,000 c/s	< 0·1	< 0·2

D/10B (Fig. 21)

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	4·6	1·5	4	1

Total feed, 6·1 mA.
H.T. Supply, 300 or 250 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 25450.
Resistance, 250,000 Ω.

Meter, Miniature Edgewise No. ED 1456.

Meter Switch, Yaxley Type B, 2-bank, 9-position.

Impedances

Input	Z = 600 Ω.
Output	Z = 150 ,,
Normal Load	Z = 150 ,,

Normal Working Levels

Input	– 30 db.
Output	– 6 dB.

Test Data

600-ohm Test Gain

Test Conditions:

Volume control set at maximum gain.

Tone Source Sending Level, -- 37 dB.

Gain at 1,000 c/s, G = 31 dB.

Gain at 50-10,000 c/s, ± 0·1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions:

Output loaded with 150 Ω and output level at – 6 dB.

Gain at 1,000 c/s, G = 27 dB.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< 0·1	< 0·5
1,000 c/s	< 0·1	< 0·2

AMPLIFIER D/11

Considerable attention was paid to the design of the D/11 Amplifier, and it was produced on a large scale as a high-grade general purpose amplifier. It comprises two stages, resistance-capacitance coupled, with transformer input and output. The amplifier can be used under three conditions of maximum gain, 70 dB, 50 dB or 30 dB.

Circuit Description (Fig. 22)

The input transformer is connected to the grid of the first stage via a continuously-variable volume control.

Current feedback is applied to the first valve via C1 by means of the resistors R5, R6, R7 in series with the cathode return. Control over the maximum gain is obtained by local arrangement of these resistors.

For maximum gain of 30 dB, the whole of the feedback chain is in circuit, the feedback being applied through C1. For maximum gain of 50 dB, R7 is short-circuited, thus reducing the effective feedback.

For maximum gain of 70 dB, no feedback is applied, since R6 and R7 are short-circuited and the grid return path is direct to cathode via C1.

In the second stage, both voltage and current feedback are employed, balanced to obtain an output impedance of 600 ohms.

Voltage feedback is obtained from the potentiometer comprising R16, R17 and current feedback from the resistor R13 in conjunction with R22.

The grid circuit of V2 is returned, via the high-value resistor R11, to the junction of R13 and R22, so that the grid bias potential is obtained from R13 only.

Output Impedance Considerations

The output stage of this amplifier has been designed to give an output impedance of 600 ohms, which is obtained by use of negative feedback. For the amplifier to give the required output power with low harmonic content, considerable feedback is necessary. This can take the form of voltage or current feedback or both. As voltage feedback decreases and current feedback increases the effective generator impedance of a valve, considerable control of this impedance is possible by varying the ratio of voltage to current feedback, whilst keeping the total feedback factor the same. As the generator impedance of V2 without feedback is too high, some voltage feedback is necessary. The rather unusual arrangement of the feedback circuits in the output stage can best be explained by means of a theoretical circuit.

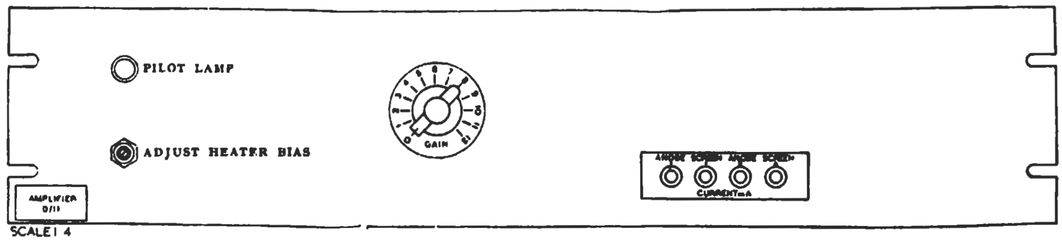


Fig. 6.4 Face Panel D/11

From Fig. F.5, it will be seen that the two resistors R16 and R17 together form a potential divider connected across the output circuit of V2, and in parallel with the primary winding of the output transformer. The decoupling capacitor C6 has such a large capacitance (16 μ F) that its reactance at audio frequencies is negligible compared with the values of the resistors R16 and R17 ; it therefore plays no part in the feedback circuit.

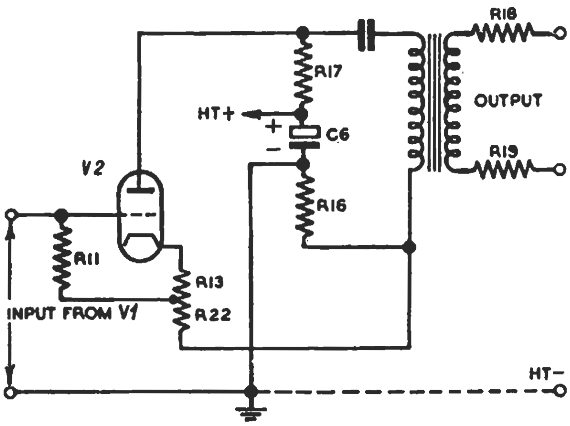


Fig. 6.5 Feedback Circuit D/11 (Theoretical)

The resistors R13, R22 and R16 are connected in series between the cathode of V2 and negative h.t. ; neglecting R13 and R22 for the moment, it will be seen that any alternating potentials developed across R16 will cause the cathode potential to fluctuate. The input voltage to V2 (the potential between grid and cathode), is the algebraic sum of the output voltage of V1 (between the grid of V2 and h.t. negative) and that across R16 (between cathode of V2 and h.t. negative), the latter being in phase opposition to the output voltage of V1.

If all the feedback required had been made proportional to output voltage, then the effective generator impedance of V2 would have been too low. It was therefore necessary to introduce some current feedback. This is applied by means of resistors R13 and R22, and their values, together with those of R16 and R17, are chosen to give the required degree of total feedback.

It is customary in negative voltage-feedback circuits to make the values of the resistors forming the potential divider very large compared with that of the anode load so that they take a negligible share of the output current. In the D/11 it should be noted that R17 carries the d.c. anode current and R16 the total d.c. cathode current of V2. In order to give the valve a suitable anode-to-cathode potential the permissible drop across R16 and R17 is limited, that is to say, the values of R16 and R17 must be kept reasonably low. In fact the total resistance of the potential divider is approximately equal to the resistance reflected across the primary winding of the output transformer so that approximately half of the a.c. anode current of V2 passes through the potential divider. Thus the output impedance of the amplifier depends not only on the effective generator impedance of V2, as modified by the voltage and current feedback, but also on the value of R16 + R17 which is effectively in parallel with it. In addition the step-down ratio of the output transformer has to be taken into account, and an output impedance of 600 ohms is obtained by inserting the padding resistors R18, R19 in series with the secondary winding (Fig. 22).

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	1·2	0·4	4	1
Stage 2, AC/SP3B RH	10	3·5	4	1

Total feed, 15 mA.
H.T. Supply, 320 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Volume Control

Type, Morganite Stackpole MNAP 10450 (linear) or 10410 (logarithmic). 10410 preferred

Resistance, 100,000 Ω.

Impedances

Input Z = 600 Ω.
Output Z = 600 ,,
Normal Load Z = 600 ,,

Normal Working Levels

Input − 70 dB.
Output 0 or + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions :
Volume control set at maximum gain.
Tone Source Sending Level, − 66, − 46 or − 26 dB.
Gain at 1,000 c/s, G = 70, 50 or 30 dB.
Gain at 50-10,000 c/s, ± 0·1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions:

Output loaded with 600 Ω and output level at + 4 dB.

Gain at 1,000 c/s, G = 70, 50 or 30 dB.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< 0·5	< 1·0
1,000 c/s	< 0·5	< 1·0

D/11A

This amplifier is similar to D/11, the only modification being to the volume control, R2. On the D/11, this is a continuously variable resistor; on the D/11A it is a 10-stud potentiometer.

SECTION 7

AMPLIFIER ECA/2

The ECA/2 is an echo-room amplifier used in conjunction with the dramatic control unit DC/7.

Circuit Description (Fig. 23)

The ECA/2 is a two-stage amplifier with two input stages, one associated with each of the two groups of d.c. input channels in the output of the echo group mixer. A stabilising resistor is included in series with the grid in each of the input stages and grid bias for both valves is obtained from a resistor in the common h.t. return lead. Resistance-capacitance coupling is used between the stages, the anodes of the two input stages being connected in parallel, via individual 25,000-ohm decoupling resistors and a common coupling capacitor, to a fixed potentiometer in the input to the second stage, which is choke-capacitance coupled to the output transformer.

Valve Data

Valve	*Anode Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1 (each stage)			
AC/HL	2·5	4	1
Stage 2			
AC/P	13·0	4	1

Total Feed, 18 mA.

H.T. Supply, 300 V.

L.T. Supply, 6 V (adjusted to 4 V by series resistor).

General Data

Impedances

Input (either stage) Z = 15,000 Ω.
Output Z = 600 „
Normal Load Z = 2,400 „

Test Data

600-ohm Test Gain

Test Conditions:
Tone Source Sending Level, – 20 dB.
Gain at 1,000 c/s, G = 27 ± 2 dB.
Gain at 50-5,000 c/s, G = ± 0·5 dB relative to gain at 1,000 c/s.
Gain at 5,000-8,000 c/s, G = ± 1·0 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions:
Output loaded with 2,400 Ω and output level at – 5 dB.
Gain at 1,000 c/s, G = 25 ± 2 dB.

SECTION 8

GENERAL PURPOSE AMPLIFIER, GPA/1

General Description

The General Purpose Amplifier, GPA/1, has been designed to function as a high-grade amplifier having a maximum gain of 80, 65, 50 or 35 dB and operating between 600-ohm terminations.

For 35-dBmaximum gain, the amplifier employs a single stage ; in all other conditions two stages resistance-capacitance coupled are used. Selection of maximum gain is effected by two range switches, one of which switches the first stage out of circuit when the 35-dB range is required ; the other varies the amount of feedback applied to the first stage.

A fine gain-control, calibrated from 0 to − 18 dB in 2-dB steps, is provided in the grid circuit of the second stage, thus permitting variable gain over an extensive range. The minimum gain obtainable from the amplifier is approximately 17 dB. The amplifier is rack-mounted and takes its supplies from a standard mains unit, such as the MU/16.

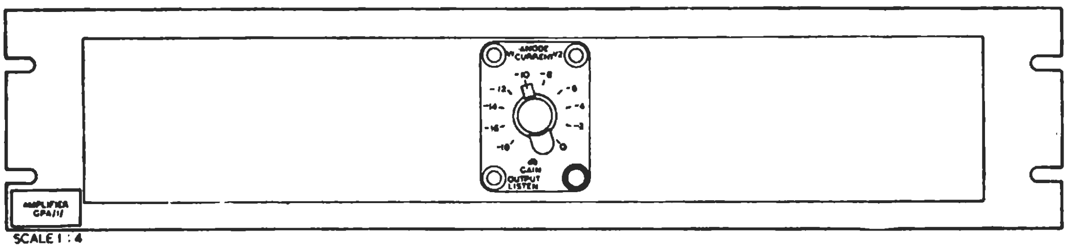


Fig. 8.1. Face Panel GPA/1

Design Considerations

In the pre-war period, audio-frequency amplifiers were designed on a single-purpose basis, which resulted in a large number of different types of amplifiers being included in the programme chain. War conditions made it necessary to reduce very considerably the number of different types of amplifier, and the D/11 was designed to meet this need. Experience has shown that this principle of a general purpose amplifier has many advantages over the pre-war system and the GPA/1 has been designed to retain these advantages and at the same time to remove the deficiencies inherent in the amplifier D/11, which resulted from austerity restrictions obtaining at the time of its design.

This applies in particular to noise level and valve " ponging," both of which have been materially reduced in the GPA/1, particularly in the lower ranges of maximum gain.

Mechanical Design

The mechanical design of the GPA/1 has taken into consideration possible modifications in the design of future apparatus bays, the layout being such that the unit can be accommodated, without redesign, on a 19-inch bay and, in order to economise in bay space, two units may be mounted back to back, with the cable form running down the bay channel.

The components are mounted on both sides of the panel, so arranged that most of the wiring is accommodated at the back and is therefore screened by the panel itself. The first valve, together with the input transformer and associated components, is mounted on a sub-panel which is attached to the main panel through a very flexible mounting. This arrangment, which has been used on previous high-grade amplifiers, minimises microphonic noises.

The front of the amplifier unit is shown in Fig. 8.1. It will be seen that the only control accessible with the dust cover in position is the fine gain-control. The range switches, which determine the maximum operating gain, are deliberately concealed, since in all normal circumstances they are pre-set on installation. In order to economise in meters and switches, anode feeds are measured by means of a portable meter, via appropriate feed-jacks. An output listen jack and a pilot lamp are the only other items appearing on the front of the unit with the dust cover in position.

Electrical Design

The GPA/1 is designed to provide voltage gain which may be varied, according to requirement, between the limits of 17 and 80 dB and thus, in general, can be used at any point in the programme chain where the required minimum gain is not less than about 20 dB. Arrangements are included which, by varying the amount of feedback, permit the pre-setting of maximum gain at 80, 65 or 50 dB, and cut out the first stage for maximum gain of 35 dB. A fine gain-control calibrated in 2-dB steps, caters for intermediate values.

It should be noted here that some overlap between the maximum ranges is obtainable by suitable adjustment of the fine gain-control. For instance, in the 50-dB maximum-gain position, the amplifier will operate at a gain of 32 dB if the fine gain-control is set to − 18.

Frequency Response

The frequency response of the amplifier is almost level between 50 c/s and 10,000 c/s for all conditions of working, the tolerance being ± 0·5 dB. There is a slight fall in the response below 50 c/s and above 10,000 c/s due to the input transformer, but the losses do not exceed 1 dB at 30 c/s and 15,000 c/s. It is anticipated that the low-frequency response will improve when better materials become available.

Distortion Factor

The amount of harmonic distortion naturally varies with the maximum gain working conditions, but since feedback is applied under all conditions the total percentage distortion is very low and, except under 80-dB maximum-gain conditions, does not exceed 0·5 per cent at peak volume of + 8 dB, which is the normal working condition. Under the same output conditions, but with the range switch set for 80-dB maximum gain, the total distortion does not exceed 1 per cent, provided that the variable gain-control is not set to − 18 dB.

If in the 80-dB position the switch is set at − 18 dB, the feedback at the first stage is insufficient to prevent distortion exceeding 1 per cent. For this reason, this position of the switch is engraved in red.

Noise Level

Under high-gain conditions, the greater part of the background noise is associated with the first stage. Since the fine gain-control is interposed between the two stages, it follows that the noise applied to the grid of the second stage is reduced as the gain-control is brought down. In this way, the signal-to-noise ratio is maintained at its optimum value at all times. Further, the reduction of maximum gain from 80 dB to 65 dB and from 65 dB to 59 dB is achieved by varying the amount of feedback on the first stage. This again reduces the noise level approximately, but not exactly, in the same ratio as the reduction in gain.

Two other points are worth mentioning with regard to noise level. Firstly, the input transformer is designed with the highest possible voltage step-up, ensuring maximum signal-to-noise ratio at the grid of the input valve. Secondly, the heater circuits have been designed to keep the hum down to a lower value than that obtaining in earlier amplifiers. In previous amplifiers, hum voltage has been injected into the cathode circuit by virtue of imperfect insulation between cathode and heater and, where the cathode is maintained at a high impedance with respect to earth, the hum may be considerable.

This condition is avoided in the GPA/1 by maintaining the cathode virtually at earth potential.

Circuit Description (Fig. 24)

The input transformer T1 has an impedance ratio of 1 : 416 and therefore to maintain an input impedance of 600 ohms across its primary terminals, it must be loaded by 0·25 megohms across the secondary winding.

Under 80-dB maximum-gain conditions, the load is obtained artificially. The 2-megohm resistor R4 (Fig. 8.2), instead of being connected between the grid of V1 and earth, is connected between grid and a point on a potentiometer across the anode circuit, comprising the variable gain control in series with R20, R21. This point on the potentiometer is at a potential of 7 volts negative when the instantaneous potential on the grid is 1 volt positive. Thus, for example, if the grid of V1 is given a potential of + 1 volt with respect to earth, R4 will have a potential of 8 volts across it. A little consideration will show that the value of the current through R4 will be the same as that which would obtain if a resistor equal to $\frac{R4}{8}$ were connected between grid and earth and a potential of 1 volt applied across it. Since this current must be supplied by the transformer, the apparent load on the transformer is 0·25 megohms. It should be noted that, because R4 is connected to the junction of the resistors R20, R21, which are included in the anode circuit, a certain amount of feedback (5 dB) is applied to the first stage even in this condition of maximum gain.

This is in itself an improvement on previous amplifiers such as the D/11, where, at the highest maximum gain, feedback is eliminated in the first stage. The capacitor C6 shunted across R21 slightly reduces the feedback at high frequencies to compensate for slight losses in other parts of the circuit.

Under 65-dB maximum-gain conditions (Fig. 8.3) the feedback applied to the first stage is increased to 19 dB by connecting the lower end of R4 to a point on the potentiometer which is at a higher potential than that used in the case of 80-dB maximum gain. This has the effect of making the apparent load on the transformer much less than 0·25 megohms for reasons previously discussed and, in order to compensate for the reduced load, R2 is switched in series with R4 and the secondary of T1.

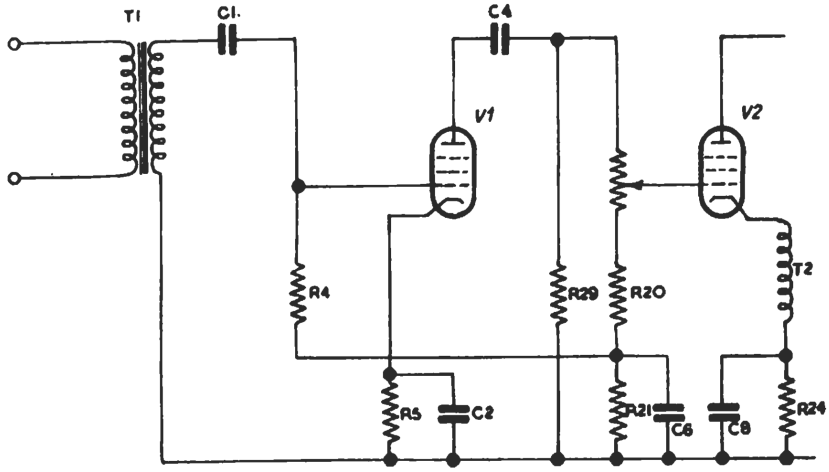


Fig. 8.2. Circuit for 80-dB gain

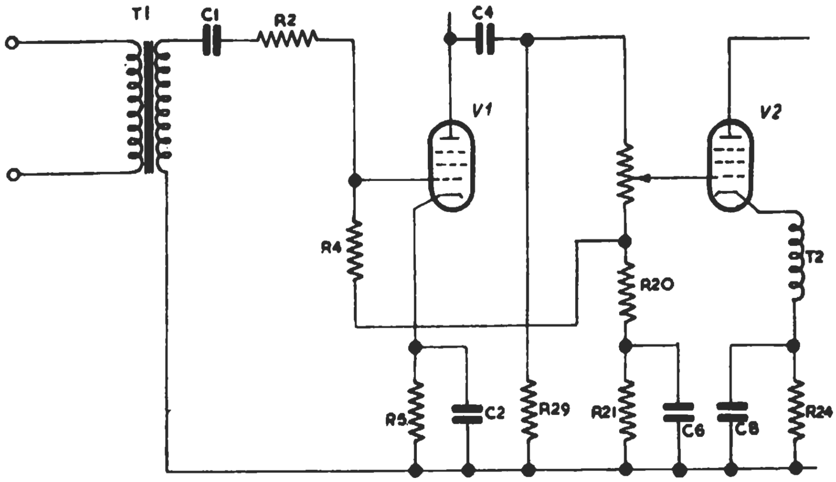


Fig. 8.3. Circuit for 65-dB gain

Under 50-db maximum-gain conditions (Fig. 8.4), the feedback is increased to 33 dB by switching the lower end of R4 to the high-potential side of the anode circuit potentiometer, so that virtually

R4 is connected between anode and grid of V1. This reduces the impedance of R4 still further, to compensate for which R1 is connected in series with R2, etc., thus still maintaining the correct load on the transformer T1.

end of R4 is connected to earth via the high resistance R29 (Fig. 24).

The output circuit is of a type developed by the BBC before the war, and which has since become standard. It employs a form of voltage feedback

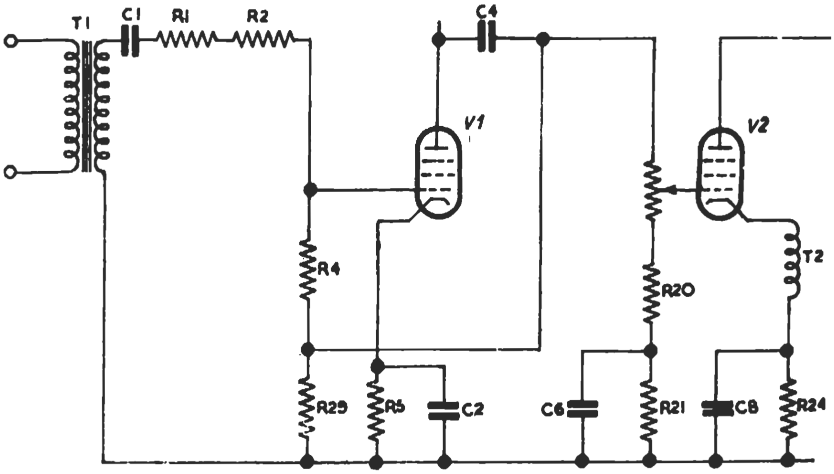


Fig. 8.4. Circuit for 50-dB gain

Under 35-dB maximum-gain conditions (Fig. 8.5), the secondary of T1 is disconnected from the grid of V1 and connected to the top end of the gain-control, thus cutting V1 out of circuit. The load

usually referred to as cathode-injected feedback, in which a third winding of the output transformer is used to inject the feedback voltage into the cathode circuit of the valve. This method of

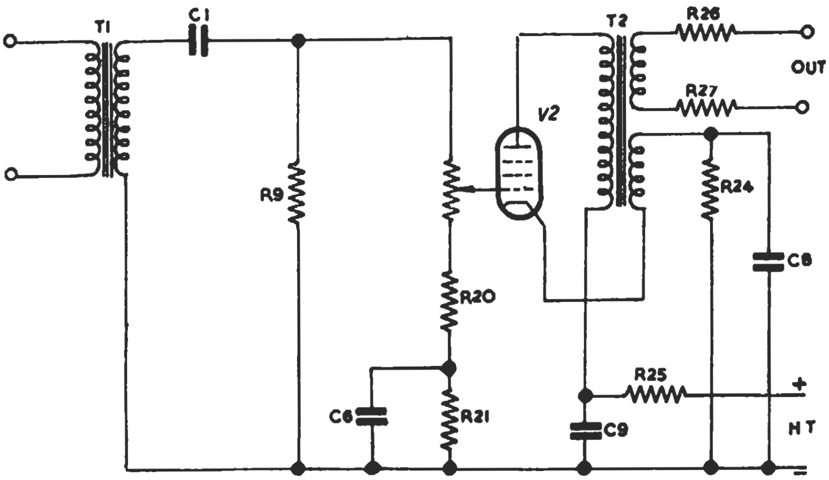


Fig. 8.5. Circuit for 35-dB gain

on T1 is maintained at 0·25 megohms by shunting R9 across the gain-control and R20, R21.

In order to prevent the grid of V1 being left open-circuited under these conditions, the lower

feedback has the merit of allowing the grid circuit of the valve to operate under normal conditions, its input impedance remaining at a high value.

Dealing with the circuit in detail (Fig. 8.5), when the normal 600-ohm load is connected to the output terminals, the two resistors R26 and R27 (the function of which is described later) increase the load impedance to 960 ohms. The impedance ratio of T2 is 65 : 1, and, by taking into account the resistance of the primary winding, the total anode load applied to the valve is 71,000 ohms.

Now, where the anode load of a pentode is low compared with its internal impedance, the gain operating between the grid and anode is approximately equal to the product of the anode load in thousands of ohms and the mutual conductance in mA/V.

In this case, the mutual conductance is 5·2, hence the gain of the valve is 370 times, i.e. 51 **dB.**

The third winding of T2 is connected in series with the cathode circuit, the feedback voltage thus introduced reducing the gain to 32 **dB.** The transformer introduces a further loss making the overall gain of the stage approximately 8 **dB.**

It is explained in E.T.S.3, that the application of voltage feedback has the effect of reducing the output impedance of the amplifier and in this case the value of the output impedance at the terminals of the transformer secondary winding is 240 ohms. An output impedance of 600 ohms is obtained by padding out the secondary winding with the two 180-ohm resistors R26 and R27.

Valve Data

Valve	*Anode Volts*	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/SP3A RH	80	1·7	0·6	4	1·0
Stage 2, AC/SP3B RH	260	5·0	1·75	4	1·0

Total Feed, 9·5 mA.
H.T. Supply, 300 V.
L.T. Supply, 4 V a.c.

General Data

Gain-control	*No. of Studs*	*Loss per Stud*	*Loss on lowest Stud*
	10	2 dB	18 dB.

Range-switch S1 S2 Yaxley, 2-bank, 4-position, Type A, N.S.
Range-switch S3 British N.S.F. single-pole, 2-position, Oak, Type 23.
Gain-control switch, Yaxley, 1-bank, 10-position, Type A., C.C.
Potentiometer R28, Painton, 25 Ω, Type CV2/25P.
Pilot Lamp, P.O. No. 2, 4 V.

Impedances
Input $Z = 600$ Ω.
Output $Z = 600$,,
Normal Load $Z = 600$,, (balanced).

Normal Working Levels
Input – 15 to – 80 dB.
Output Zero. (Max. + 4 dB.)

Test Data

Maximum Working Voltage and 600-ohm Test Gain
Test Conditions :
Fine gain-control at zero attenuation.
Tone Source Sending Level, – 80 dB, – 65 dB, – 50 dB, – 35 dB.
Maximum gain at 1,000 c/s :
80 dB, ± 2 dB.
65, 50 or 35 dB, ± 1 dB.
Frequency Characteristics; 50-10,000 c/s ± 0·5 dB, 30-15,000 c/s ± 1·0 dB.

Total Percentage Harmonic Content (Max.)

	Normal level	*8 dB above normal level*	*12 dB above normal level*
100 c/s	0·5 %	1·0 %	1·5 %
1,000 c/s	0·2 %	0·5 %	0·8 %

Noise Level
– 45 dB at 80-dB gain.
– 55 dB at 65-dB gain.

AMPLIFIER GPA/1A

See Notes 5 and 6 on Fig. 24.

SECTION 9

LIMITER LIM/2

Function

The function of the Limiter LIM/2 is to prevent the accidental overloading of a transmitter or recording apparatus. The chief advantage gained from the use of the limiter is the ability to maintain the mean programme level at a higher value than is possible with manual control. In other words, transmitters can be modulated to a greater mean percentage and recordings made with a higher signal-to-noise ratio without the risk of distortion on peak levels. Maximum permissible peak volume is normally 8 dB above programme line-up level. Under working conditions, the controls of the limiter are so adjusted that this maximum peak volume cannot be exceeded. In the case of transmitters—which are normally lined up so that normal programme volume produces 40 per cent, modulation—the effect of limitation is to prevent maximum modulation from exceeding 100 per cent. (See Engineering Training Manual, p. 212.)

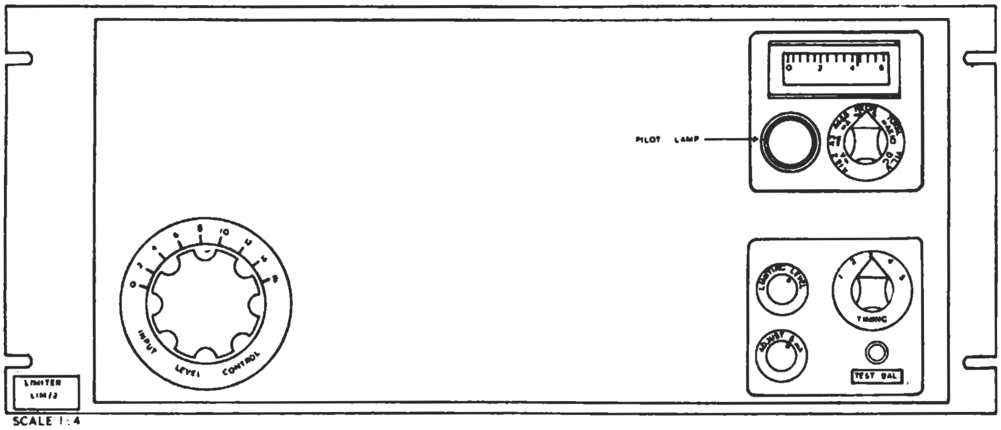


Fig. 9.1. Face Panel LIM/2

General Description

The LIM/2 was the first limiter to be put into general service and was developed from the experimental limiter, LIM/1.

It consists of a straightforward variable gain push-pull amplifier, preceded by a variable attenuator, and an associated side chain to provide the bias voltage for reducing the gain of the amplifier at excessive peak volume. When the variable attenuator is set at maximum loss, i.e., at zero position, the amplifier has zero gain. Variable-mu pentodes are used in the amplifier because the mutual conductance of this type of valve decreases smoothly (approximately exponentially) with increased bias and vice versa. The gain of the stage can be controlled by means of a d.c. bias potential. This potential is provided by the side-chain amplifier and is arranged to be proportional to the amount by which the output volume of the amplifier exceeds a predetermined maximum.

The action of the limiter may be described as follows :—

Referring to Fig. 9.2., when a signal e_s is applied to the input of the amplifier, a voltage V/n proportional to the input voltage, is developed across a tertiary winding on the output transformer T2. This voltage is applied to the side chain comprising an amplifier, control stage and rectifying stage. The control stage is normally biased back beyond cut-off point. If the signal e_s does not produce an output voltage greater than the permissible maximum value, the voltage V/n will not be great enough to counteract the cut-off bias of the control stage, and there will be no output from the side chain. If, however, the input signal causes the output voltage to rise above the permissible maximum, the value of V/n will be sufficiently high to operate the control stage, and a voltage proportional to the excess voltage will be passed through to the rectifier. This rectified voltage − e,

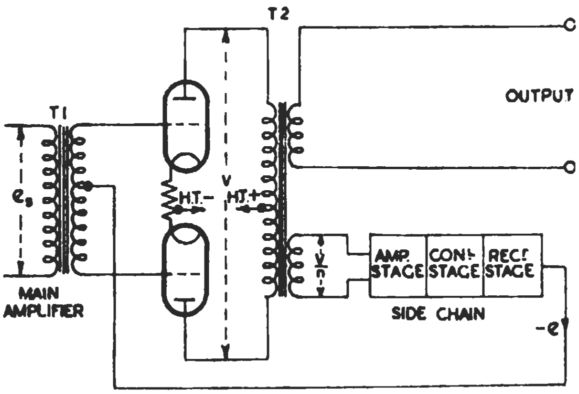


Fig. 9.2. Theoretical Circuit

will then be applied to the grids of the main amplifier valves in the form of negative bias, and the gain of that amplifier will be reduced, until the output falls below the maximum predetermined level.

adjustable by means of a timing switch, and it is upon the adjustment of this control that the behaviour of the limiter chiefly depends.

If the restoration time is very slow, the effect is that of an automatic maximum-level-setting device. If, however, the restoration time is comparatively quick, the effect is that of a compressor, cutting back the peak levels, and restoring the gain rapidly for the low-level intervals between the peaks. In certain circumstances, particularly when used on transmission channels subject to fading, the limiter is in fact used for compression. The degree of compression may be increased after line-up by adjusting the calibrated *Input Level Control* to a higher setting. This explains why in the earlier models of the LIM/2, this control is labelled *Compression Decibels.*

Unlike other types of compressor, the limiter does not introduce any noticeable harmonic distortion, except perhaps during the very short periods whilst the gain is being cut back. It should however, be understood that the rapidity with which the gain is cut back has been deliberately curtailed in the design, so that very sharp peaks in the programme will be passed on by the limiter at a level exceeding the predetermined maximum. These peaks will be of such a transient nature that the distortion produced will not be detected

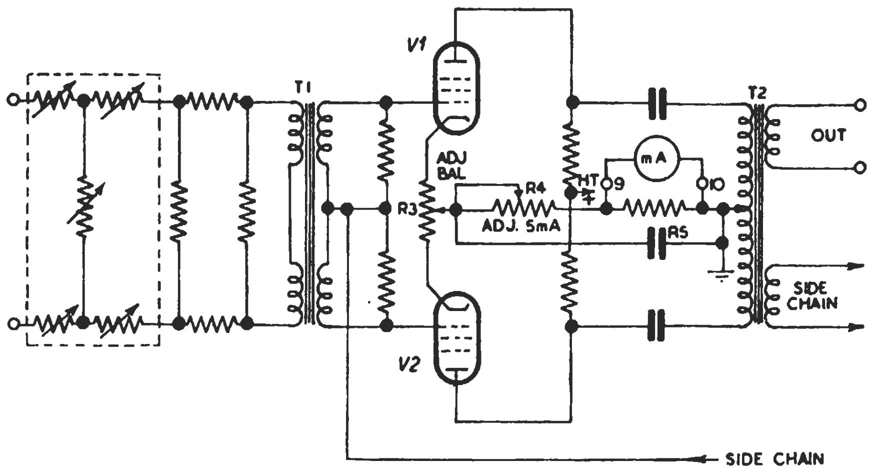


Fig. 9.3. Main Channel

If the output then remains below maximum for a considerable time (i.e., if no other excess voltage is applied to the input), the gain of the main amplifier is arranged to return slowly to normal. The speed at which the gain is restored after cut-back is

aurally, and by allowing this condition, mean modulation can be maintained at a higher level than if the cut-back were instantaneous. In the case of certain transmitters, where it is highly undesirable that modulation should ever exceed the permissible maximum percentage, some form of peak limiter or chopper is included in the transmitter circuit.

Circuit Description (Fig. 25)

The circuit of the LIM/2 comprises two sections, viz. the amplifier proper, or *main channel*, and the *side chain*. These will be dealt with under separate headings.

(a) Main Channel (Fig. 9.3)

The main channel is designed to work between 600-ohm terminations and consists essentially of a balanced input attenuator, an input transformer, T1, two variable-mu pentodes, V1, V2, of the AC/VP2 type, connected in push-pull, and an output transformer, T2, having two secondary windings.

The bias is controlled by the side chain, as shown in Fig. 9.2, and it is important to realise that the bias control voltage may be many times greater than the input signal voltage. When a sudden application of control voltage is fed to the grids of V1, V2, a sudden change of anode current is produced and, unless the anode currents of the two push-pull valves are properly balanced, the sudden changes will give rise to considerable " plops " in the output. The setting of the adjust balance potentiometer R3 is therefore critical. The method of adjusting this balance is described under the heading Operating Instructions.

The two terminals, 9 and 10, shown in the circuit diagram are the limiter meter terminations on the main terminal block. In some cases a high speed limiter extension meter is inserted at this point, in series with the normal meter. It is important to remember that the normal limiter meter also functions as the feed meter for other stages. When the limiter is in use, therefore, the meter switch must always be set at position 1 (or A1, A2) so that the meter will give an indication of the operation of the limiter.

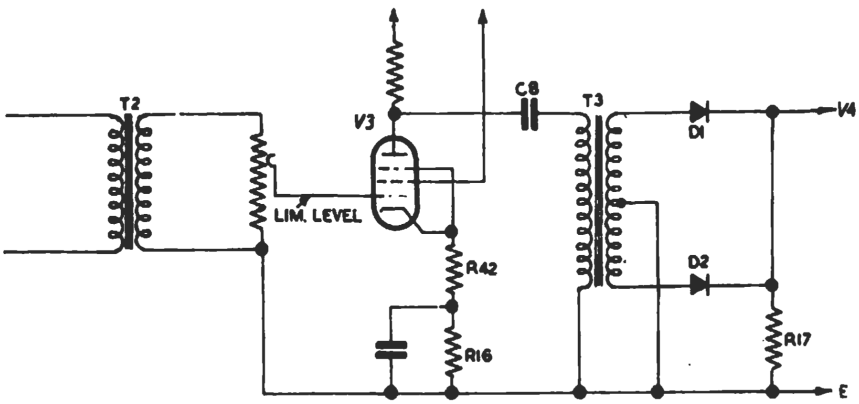


Fig. 9.4. Side Chain. Amplifier Stage

The input attenuator is divided into two sections, the first of which is the *Input Level* control and takes the form of a variable H-network. The second section is in the form of a fixed square-network and is included because the normal gain of the amplifier is greater than that required for working conditions. With the input level control set at zero (maximum loss) and no limiting taking place, the amplifier as a whole has zero gain.

Steady bias for V1, V2 is obtained from the resistor R3, the tapping point on which is made variable to obtain accurate balance, and also from the common cathode resistors, R4, R5 in series. Total cathode current is controlled by the adjustment of R4 and measured across R5.

(b) The Side Chain (Figs. 9.4, 9.5, 9.6)

The first part of the side chain consists of a single-stage amplifier, V3 (Fig. 9.4), the gain of which is controlled by the potentiometer labelled *Limiting Level.*

A small amount of current feedback is obtained from R42. This stage is followed by a full-wave rectifier, D1, D2, comprising two copper-oxide rectifiers Type WX6. The rectified output produces a ripple voltage across R17, which is applied unsmoothed and in a positive sense to the grid of V4 (Fig. 9.5).

This valve is already biased beyond cut-off point by the voltage (approximately 20 volts) developed across R18, through which is passed the cathode current of V5. V4 passes no anode current until the bias on its grid is approximately − 3 volts. It therefore remains inoperative until the rectified signal exceeds about 17 volts peak value.

The reason for the inclusion of V5 in the circuit can be explained as follows :—

It has been stated that limiting does not take place until the signal voltage applied to V4 is sufficiently high to counteract the cut-off voltage developed across R18. If the limiting level is to remain constant for a given setting of the *Limiting Level* control, the voltage across R18 must not vary.

In the absence of some form of stabiliser, the pulsating d.c. voltages applied to V4 would, under operating conditions, cause variations in the cathode current and hence in the biasing voltage. V5, therefore, acts in the same way as a neon stabiliser and is used in preference to a neon because of its greater reliability. The circuit is so arranged that V5 passes maximum cathode current when V4 is inoperative. When V4 operates, the cathode current of V5 falls as that in V4 rises, so that the mean cathode current and hence the cut-off bias voltage remains constant.

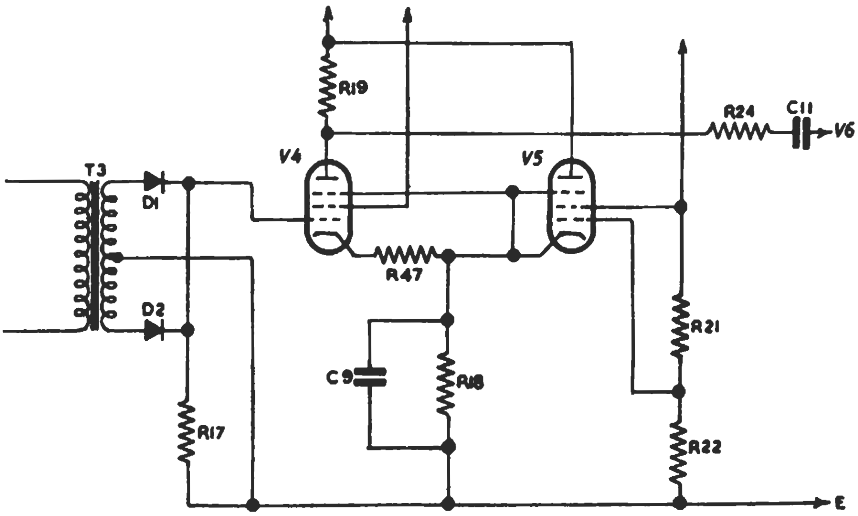


Fig. 9.5. Side Chain. Control Stage

When V4 operates, the amplified ripple voltage developed across R17 is passed through R24, C11 to V6 and charges up the 0·2-μF capacitor, C12 (Fig. 9.6).

It should be pointed out here that R24 increases the time taken for C12 to charge fully. This delay permits the passage of transient peaks through the main amplifier as previously explained.

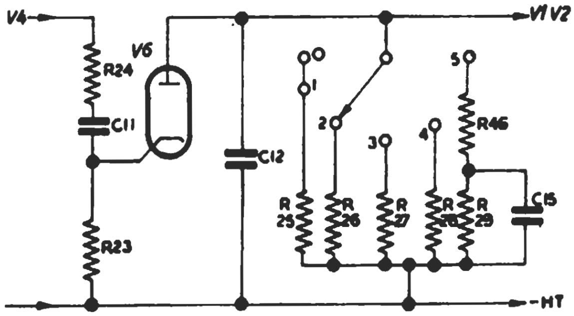


Fig. 9.6. Side Chain. Rectifier Stage

The resulting d.c. voltage obtained from C12 provides additional negative bias in the main amplifier valves V1 and V2, thereby reducing their gain. The capacitor discharges slowly through any one of the five resistors, R25 to R29, selected by the timing switch. Except in cases where compression is required, the timing switch is normally set to position 5. This position introduces a special discharge circuit designed to avoid the disastrous effect of, for example, a heavy drum beat occurring in the middle of a pianissimo orchestral passage. The effect of such a peak is to charge C12, which momentarily reduces the limiter gain but rapidly discharges via R46 into the large reservoir capacitor, C15. If a number of peaks occur in succession, C15, ultimately becomes charged and the limiter gain is therefore held down until this charge on C15 slowly leaks away through R29.

Stabilising Screen Grid Volts

A neon stabilising lamp is provided to maintain constant screen voltages of all valves irrespective of screen currents taken by V1, V2, V4 and V5. Difficulty may be experienced with the striking of the neon lamp, especially when the limiter is supplied from a mains unit and, to cover this, a special *Strike Neon* key is fitted. The operation of this key will cause the lamp to glow slightly, the lamp striking on the release of the key ; lamps which fail to strike should be rejected. When once struck, lamps will remain alight, provided their working voltage is sufficiently low, and will be practically unaffected by programme peaks.

Depression of the *Test Balance* key will reduce the lamp current and may extinguish a lamp whose working voltage is unduly high ; any lamps which behave in this way should be changed, as balancing cannot be carried out properly unless the lamps stays alight during the operation. In order to see whether the neon lamp remains alight, two view holes are provided through the main panel and one through the lower sub-panel. Provided the back cover is in position it is easy to see the lamp glow.

The type of neon originally fitted in the LIM/2 is being replaced by an alternative type (Cossor S130) which should overcome the troubles outlined above.

Operating Instructions

1. *Adjusting Amplifier Feed*

Switch on mains unit and allow one or two minutes for working conditions to become stabilised. Set the meter switch to position 1 and adjust the total cathode current for valves V1 and V2 to read 5 mA. Make this adjustment with no incoming signal and the *Timing* switch at the setting it is intended to use for the programme.

2. *Balancing*

This operation should only be necessary when (*a*) the equipment is first installed, (*b*) either V1 or V2 is changed, or (*c*) it is suspected that the characteristics of the valves have changed through ageing or other causes.

To obtain correct balance conditions, proceed as follows :—

(*a*) Adjust for *5 mA* as indicated under 1, and remove front cover.

(*b*) Set the *Limiting Level* control fully anti-clockwise. (In this position the side chain is at maximum gain and full limiting action obtains.)

(*c*) Set the *Timing* switch to 1. (Minimum recovery time.)

(*d*) Plug headphones into *Check Balance* jack.

(*e*) Depress and release the *Test Balance* key repeatedly, at the same time adjusting the *Adj. Balance* potentiometer, R3, until the ‘ plops ’ produced by the operation of the *Test Balance* key are reduced to minimum loudness. The correct condition will only be obtained by a process of elimination. Between successive depressions of the *Test Balance* key sufficient time should elapse for the feed-meter to be restored to 5 mA. When carrying out this operation, attention should be concentrated on the low-frequency component of the ‘ plop,’ the residual high-frequency ‘ click ’ being relatively unimportant.

3. *Lining Up*

Although the limiter can be arranged to operate over wide limits of programme level, the optimum level for operation is −23 dB. This condition is obtained, in the case of transmitting stations by the insertion of attenuators and a listener correction unit between the D-amplifier output and the limiter input. In the case of recording channels, the limiter is preceded by a fixed attenuator, the value of which is conditioned by the incoming programme level.

Since the circuits with which the limiter is associated vary considerably at different centres, it is not desirable that a standard line-up instruction should be given here. Detailed information is issued in the Station Instructions at those centres where limiters are employed.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/VP2	2·0	0·5	4	1
Side Chain				
V 3, AC/SP3B RH	4·5	1·6	4	1
V 4, AC/SP3B RH	—	—	4	1
V 5, AC/SP3B RH	3·4	0·9	4	1
V 6, D/42	—	—	4	0·6

Total Feed, 26 mA, including neon.
H.T. Supply, 250 or 300 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Input Level Control

Type	*No. of Studs*	*Loss per Stud*
Painton PH/2G1	8	2 dB.

Meter. Elliott Miniature Edgewise. No. ED 1456.
Meter Switch. Yaxley Type A. 2-bank, 9-position.
Timing Switch. Yaxley Type B12. No. 5168.

Potentiometers

Adjust Balance.
Type : Morganite Stackpole MNAP 40150.
Resistance : 400 Ω.
Adjust 5 mA.
Type : Morganite Stackpole MNAP 10250.
Resistance : 1,000 Ω.
Limiting Level.
Type : Morganite Stackpole MNAP 10410.
Resistance : 100,000 Ω.

Pilot Lamp. P.O. No. 2, 4 V.

Impedances

Input Z = 600 Ω.
Output Z = 600 ,,
Normal Load Z = 600 ,,

Normal Working Levels

Input − 23 dB.
Output − 23 dB.
Normal Limiting Output, − 15 dB.

Test Data

Maximum Working Voltage Gain and 600-ohm Test Gain

Test Conditions :
V1, V2 feeds tested for Balance.
Feeds for V1, V2 adjusted to 5 mA.
Input Level Control set to Stop 16.
Limiting Level Control fully clockwise (non-limiting).
Tone Source Sending Level, − 23 dB.
Gain at 1,000 c/s, G = 16 dB.

Frequency-response Test

Test Conditions :
V1, V2 feeds tested for Balance.
Feeds for V1, V2 adjusted to 5 mA.

(*a*) Input Level Control set at minimum gain.
Tone Source Level adjusted so that no limiting takes place.
Gain at 50-10,000 c/s, ±0·5 dB relative to gain at 1,000 c/s.

(*b*) Input Level Control set for 14-dB limitation.
Timing Switch set to 1.
Gain at 50-10,000 c/s, ± 0·5 dB relative to gain at 1,000 c/s.

Total Percentage Harmonic Content

8 dB above normal working input and output levels.

	Without limitation	*15-dB limitation*	*20-dB limitation*
1,000 c/s	0·26	< ·25	< ·2

SECTION 10

LOUDSPEAKER AMPLIFIERS

LSM/1

The LSM/1 is an a.c. mains-operated loudspeaker amplifier used for quality checking and talk-back purposes.

Circuit Description (Fig. 27)

The amplifier comprises two stages, the second employing two AC/P1's in push-pull. The volume control is connected in the grid circuit of the first stage across the loaded secondary winding of the input transformer and the valve is resistance-capacitance coupled to the inter-stage transformer. The supplies are obtained from a mains unit of conventional design, a.c. being used for filament heating. Rectified a.c. is applied to the anodes via a smoothing filter followed, in the case of the first stage, by a decoupling circuit. The current applied to the loadspeaker for polarising purposes is a.c. since the loudspeaker incorporates its own rectifier and smoothing circuit.

Valve Data

Valve	*Anode Current mA*	*Fil. Volts*	*Fil. Amps.*	*Grid Bias Volts*
Stage 1, AC/P	6·3	4	1	7·5
Stage 2, 2 AC/P1 s	16·5 (each valve)	4	1 (each valve)	31·0
Rectifier UU60/250 or UU/4		4	2	

Total Feed, 39·3 mA.

H.T. Supply, 200-240 V. (The transformer primary should be tapped according to the voltage of the supply.)

Current drawn from a.c. mains

Amplifier, 0·25 A.

Loudspeaker, 0·15 A.

General Data

Volume Control:

Continuously-variable potentiometer.

Resistance, 100,000 Ω.

Impedances

Input	Z = 2,400 Ω.
Output	Z = 11 ,,
Normal Load	Z = 12 ,,

(Loudspeaker input.)

Test Data

Maximum Working Voltage Gain

Test Conditions:

Volume Control set for maximum gain.

Output loaded with 12 Ω and output level at + 4 dB.

Gain at 1,000 c/s, G = 20 ± 2 dB.

LSM/2

The LSM/2 is an a.c. mains-operated loudspeaker amplifier employed in loudspeaker units used in listening halls.

Circuit Description (Fig. 28)

The amplifier comprises two stages, the second stage employing two PX/25's in push-pull. The volume control is connected in the grid circuit of the first stage across the loaded secondary of the input transformer and the valve is choke-capacitance coupled to the screened inter-stage transformer.

Supplies are obtained from the mains unit, a.c. being used for heating the valves. Rectified a.c. is applied to the anodes via a smoothing filter, the choke having two windings on a common core, one winding being connected in each leg of the circuit. The supply to the first stage is further decoupled. Milliammeter shunts are provided in the anode lead to each valve and, by means of the 3-position key, the milliammeter can be connected across any of the shunts so that the anode current taken by each valve can be measured individually.

The first stage uses an indirectly-heated valve and the bias is obtained from a resistor connected in the h.t. return circuit. The valves in the second stage have directly-heated filaments and automatic bias is obtained by returning h.t. negative to the centre point of the filament. This is provided by two 600-ohm resistors which are effectively paralleled in the common h.t. return circuit. The current supply to the loudspeaker for polarising purposes is a.c. since the loudspeaker incorporates its own rectifier and smoothing circuit.

A red lamp provided on the front panel is lit from the l.t. winding of the power transformer as soon as the amplifier is switched on.

Valve Data

Valve	*Anode Current mA*	*Fil. Volts*	*Fil. Amps.*	*Automatic Grid Bias Volts Negative*
Stage 1, AC/HL	9	4	1	3·1
Stage 2, 2PX/25's	50 (each valve)	4	2 (each valve)	30
Rectifier UU 120/500 or UU/5		4	2·5	

Total Feed, 109 mA.
H.T. Supply, 400 V.

Current drawn from Mains
Amplifier, 0·4 A.
Loudspeaker, 0·15 A.

General Data

Volume Control
Continuously variable potentiometer.
Resistance, 100,000 Ω.

Impedances

Input	Z =	4,400 Ω.
Output	Z =	0·5 ,,
Normal Load	Z =	12 ,,

(Loudspeaker input.)

Test Data

Maximum Working Voltage Gain
Test Conditions :
Volume Control set at maximum gain.
Output loaded with 12 Ω and output level at + 12 dB.
Gain at 1,000 c/s, G = 30 ± 2 dB.

LSM/3

The LSM/3 is a d.c. mains-operated loudspeaker amplifier used for quality checking and talk-back purposes. It is normally connected either in the output of the programme trap-valve amplifier or in that of the CPL unit.

Circuit Description (Fig. 29)

The amplifier has two stages, the first consisting of a DC/2P valve, resistance-transformer coupled to two P/650's in push-pull. The amplifier is transformer coupled on its input side to the line and on its output side to the loudspeaker.

All supplies are taken from 220-volt d.c. mains. The filament supply is taken, via a smoothing system consisting of series chokes, one in each lead, and parallel 8-μF capacitors which, in conjunction with the 4-μF capacitor between the negative lead and earth, also serves to suppress any mains-borne interference. Additional smoothing is provided in the h.t. supply lead, by the D/14 choke and 8-μF capacitor. The smoothing arrangements are such that either the positive or negative lead of the mains may be neutral (earthy) without affecting the performance of the amplifier but care must be taken to ensure that the supply is connected to the amplifier in the correct polarity, otherwise the electrolytic smoothing capacitors will be damaged. The mains plug is clearly marked with polarity symbols.

The heater of V1 takes 100 mA at 35 volts, and a suitable dropping resistor is included in the positive lead. This stage is biased by the anode current passing through the 1,000-ohm resistor connected in the cathode lead. The filaments of the P/60's take 0·5 A at 6 volts, and are connected in series. The voltage-dropping resistance for these valves is included partly in the positive lead and partly in the negative lead. A tapped resistor mounted on the back of the unit is shunted across the 72-ohm resistor in the negative lead. This serves as a potential divider and provides the grid bias to the output stage. Since one of the filaments is at a higher potential than the other, separate leads are provided for each valve, tapping the potential divider at points differing in potential by the voltage drop across one of the filaments, in order that both valves may receive the same bias. This arrangement necessitates the secondary winding of the inter-stage transformer being split into two halves, each connected to the filament via a capacitor, in order to complete the grid circuits as regards a.c. The feeds to the two stages may be read by plugging a PTM/1 into the jacks provided.

A neon lamp is connected across the mains supply to take the inductive discharge from the loudspeaker polarising winding when the amplifier is switched off.

Valve Data

Valve	*Anode Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, DC/2P	7-8	35	0·1
Stage 2, 2 P/650's	38-40	6 (each valve)	0·5

Total Feed, 45-48 mA.
H T. Supply, 220 V d.c.
Current drawn from Mains
Amplifier, 700 mA.
Loudspeaker, 50 mA.

General Data
Volume Control
Continuously-variable potentiometer.
Resistance, 50,000 Ω.
Impedances
Input Z = 2,000 Ω.
Output Z = 10 ,,

Test Data
Maximum Working Voltage Gain
Test Conditions :
Output loaded with 12 Ω and output level at 0 dB.
Gain at 1,000 c/s, G = 17 ± 2 dB.

LSM/6

The LSM/6 forms part of the loudspeaker unit LSU/4.

Circuit Description (Fig. 30)

This is a single-stage amplifier employing a pentode Type AL60 and transformer input and output. The amplifier was designed to operate with an input level of + 4 dB and an output level of + 8 dB, but in order to obtain the correct output impedance for the speech coil, 8-dB voltage feedback was required which reduced the effective stage gain to −6 dB. The required overall gain of + 4 dB is achieved by using an input transformer having a voltage step-up of 1 to 3·16, which is equivalent to a voltage gain of + 10 dB.

The requisite amount of feedback is obtained by applying the whole of the voltage developed across the secondary winding of the output transformer back to the grid in a negative sense.

The input transformer is balanced, and because of its high impedance, may be connected across any line without introducing noticeable loss. The output transformer is unbalanced (one side being connected to negative h.t.) so that the amplifier as a unit is unsuitable for any purpose other than that for which it has been designed.

Valve Data

Valve	*Anode Volts*	*Anode Current mA*	*Screen Volts*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AL60	262	60	235	6·7	4	2·1

Total Feed 66·7 mA.
H.T. Supply, 310 V.
L.T. Supply, 4·5 V a.c.

General Data
Gain Control
Type, Morganite Stackpole MNAP 10450.
Resistance, 100,000 Ω.

Impedances
Input Z = 10,000 Ω.
Output Z = 2·2 ,,
Normal Load Z = 2·4 ,,

Normal Working Levels
Input + 4 or 0 dB.
Output + 8 or + 4 dB.

Test Data

600-ohm Test Gain

Test Conditions:

Gain Control set for maximum gain

Tone Source Sending Level, zero dB.

Gain at 1,000 c/s G = + 13·3 dB.

Maximum Working Voltage Gain

Test Conditions.

Gain Control set for maximum gain.

Tone Source Sending Level, zero dB.

Measuring Instrument at high impedance.

Gain at 1,000 c/s G = + 4 dB.

Frequency Response

With reference to 1,000 c/s.

50 c/s	– 0·4 dB.
10,000 c/s	– 0·2 dB.
14,000 c/s	– 0·1 dB.

Total Percentage Harmonic Content

	Normal Level (*Input*+4 *Output*+8)	*4dB above normal level*	*8dB above normal level*
100 c/s	2·0%	4%	9%
1,000 c/s	1·2%	1·6%	2·7%

Mains Unit MUE/1

There are several variations of this mains unit, but the circuit is essentially the same for all (Fig. 30). The following are the chief modifications:

MUE/1A Larger mains transformer than MUE/1.

MUE/1B Fitted with metal cover.

MUE/1K 2-amp fuses; commercial transformer and choke; choke not tapped for series or parallel connection; fitted with metal cover.

LOUDSPEAKER AMPLIFIER AM8/1

General Description

Loudspeaker Amplifier AM8/1 forms part of O.B. Loudspeaker LS3/1 (Instruction S.1) but for ease of transport is kept as a separate self-contained unit instead of being mounted in the loudspeaker cabinet.

Its performance and certain other features are specified by the BBC but otherwise its design and construction are left to the manufacturer. Models supplied at different times by the same or different manufacturers are interchangeable but may differ slightly in design and construction.

It is approximately 14 in. long, 7 in. wide and 7 in. high and weighs under 22 lb. A protective cover, secured to the chassis by screws, is fitted.

The amplifier is mains-operated and gives an output of approximately 15 watts into 25 ohms for an input of less than 0·5 volt r.m.s. It has very low distortion at this output over the frequency range of 30 c/s to 15 kc/s.

A gain control is fitted, and plugs and sockets are provided for mains input and loudspeaker output connections. A signal input jack is fitted to take P.O. plug No. 316.

AM8/1: SERIAL NOS. 101 TO 150

Circuit Description (Fig. 56)

The circuit of amplifiers with serial numbers 101 to 150 inclusive is shown in Fig. 56. It is basically the same circuit as that used in Loudspeaker Amplifiers LSM/8 and LSM/10 and described in Instruction S.1 Section 2, but differs somewhat in certain respects. The biasing arrangements for the cathode-coupled phase-splitting stage (V2) are different as the valve is direct coupled to the first stage and the two grids are maintained at the same d.c. potential as the anode of V1; the value of the common cathode resistor R10 is arranged to maintain the potential of the two cathodes at the correct value relative to the grid potential.

In the LSM/8 and LSM/10 the pentode valves in the push-pull output stage are operated as triodes by connecting the screen grid to the anode. In the AM8/1, however, the output stage is of the so-called *ultra linear* or distributed load type in which the screen grid of each valve is connected to a tapping on the corresponding half of the primary winding of the output transformer. This gives negative feedback in the output stage itself and the operating characteristic of each valve lies between those of the valve when used as a pentode and as a triode. If the tapping is taken to the anode end of the half-winding the valve operates as a triode, and if it is taken to the mid-point of the whole primary winding it operates as a pentode. By suitable choice of a tapping point between these two extremes a useful compromise can be obtained between the greater power-handling capacity and efficiency of a pentode and the lower distortion of a triode; in addition the output impedance approaches the lower value obtained from a triode.

The output stage of the AM8/1 is suitable for only one load impedance, viz. 25 ohms, instead of two as in the LSM/8 and LSM/10. Another difference is the omission of a smoothing choke.

General Data

Mains Power Supply

Voltage: 200 to 250 V a.c.
Frequency: 45 to 55 c/s.

Impedances

Specified input impedance:	At least 10 kΩ over the range 50 c/s to 15 kc/s at any input level below 0·5 V r.m.s.
Measured input impedance:	30 kΩ at 1 kc/s
Specified output impedance:	Not greater than 2·5 Ω over the range 50 c/s to 6 kc/s Not greater than 5 Ω over the range 6 kc/s to 15 kc/s
Measured output inpedance:	0·5 Ω at 50 c/s to 6 kc/s 1 Ω at 6 kc/s to 15 kc/s

Load impedance: 25 Ω nominal

Stability

No observable self-oscillation when either an impulsive or a steady signal from zero to maximum input is applied to the input under any conditions of source impedance and setting of gain control, and with open-circuit output, 25-Ω resistive load, load of 0 to 1,000 pF, either of the two push-pull output valves removed from its socket.

Sensitivity and Power Output

At least 15 watts output power into a resistive load of 25 Ω with a sinusoidal input of 0·5 V r.m.s. at 1 kc/s.

Harmonic Distortion

(a) Without Input Transformer

Percentage harmonic distortion for an output of 12 watts into 25 Ω does not exceed the following:

	60 c/s	*1 kc/s*	*4 kc/s*
2nd harmonic	0·5	0·5	0·5
3rd harmonic	0·3	0·15	0·15
r.m.s. sum of all higher harmonics up to 16 kc/s	0·1	0·1	0·1

(b) With Input Transformer

With a sinusoidal input of 3 V r.m.s. at 60 c/s upwards from a 600-Ω source, the output up to 15 watts into 25 Ω does not have a total harmonic content which exceeds by 0·5% the amount present for the same output level with the input signal applied directly without the transformer.

Typical measured values of total harmonics for an output of 15 watts into 25 Ω are:

60 c/s	<1%
1 kc/s	<0·8%
4 kc/s	<1%

Frequency Response

With a 600-Ω source and a 25-Ω resistive load, and any setting of the gain control, the response relative to that at 1 kc/s is within the following limits:

50 c/s to 10 kc/s: +0·2 dB to —0·5 dB
30 c/s to 15 kc/s: +0·2 dB to —0·1 dB

Noise

With the input terminated by a 600-Ω resistor, the total noise output level across a load resistor of 25 Ω with the gain control at maximum gain, does not exceed —50 dB (reference 0·775 V r.m.s.).

Valve Data

Stage	*Type*	*Bias Resistor*	*Volts Across Bias Resistor*	*Heater Volts*	*Heater Amps*
V1	CV2901	R3	1·6	6·3	0·2
V2	CV492	R10	75	6·3	0·3
V3	EL34	R17	27	6·3	1·5
V4	EL34	R16	27	6·3	1·5
V5	GZ34			5	1·9

Voltages measured with Avometer Model 8.

AM8/1: SERIAL NOS. 151 TO 156

Amplifiers with serial numbers 151 to 156 are a small batch of a different make from those with earlier serial numbers and were supplied to Specialist Departments.

AM8/1: SERIAL NOS. 157 TO 186

Circuit Description (Fig. 56A)

The circuit of amplifiers with serial numbers 157 to 186 is shown in Fig. 56A. It is basically the same as that shown in Fig. 56, but a.c. coupling instead of d.c. coupling is employed between the first two stages and the biasing and decoupling arrangements are somewhat different. The amplifiers have a similar performance to those with serial numbers 101 to 150.

Valve Data

Stage	*Type*	*Bias Resistors*	*Volts Across Bias Resistors*	*Heater Volts*	*Heater Amps*
V1	EF86	R1 + R2	0·75	6·3	0·2
V2	ECC81	R6 + R8	30	6·3	0·3
V3	EL34	R18/R19	25	6·3	1·5
V4	EL34			6·3	1·5
V5	GZ34			5	1·9

Voltages measured with Avometer Model 8.

LOUDSPEAKER AMPLIFIER AM8/2

General Description

Loudspeaker Amplifier AM8/2 forms part of the General Purpose Loudspeaker LS1/1 described in Instruction S.1, and is mounted in the amplifier compartment at the bottom of the loudspeaker cabinet.

Its performance and certain other features are specified by the BBC but otherwise its design and construction are left to the manufacturer. Models supplied at different times by the same or different manufacturers are interchangeable but may differ in design and construction.

It is approximately 11 in. long by 5½ in. wide by 5½ in. high and weighs under 10 lb.

The amplifier is mains-operated and gives an output of at least 3 watts into a resistive load of 3 ohms for an input of 0·1 volt r.m.s. at a frequency of 1 kc/s. It has low distortion over the frequency range of 60 c/s to 10 kc/s.

No gain control is fitted, as a separate 50-kilohm volume control is provided as part of Loudspeaker LS1/1; mains fuses and a mains switch also are provided as part of the LS1/1 and are omitted from the amplifier.

Tag blocks are fitted for external connections.

Circuit Description (Fig. 57)

The circuit of AM8/2 amplifiers so far supplied is shown in Fig. 57. Only two stages are used and the amplifying stage V1 is d.c.-coupled to the single-valve output stage V2. The specified requirements, which are not so severe as those for the AM8/1, have been met without employing a push-pull output stage. Negative feedback, however, is employed in the single-valve output stage itself by coupling the anode to the screen grid via the 47-kilohm resistor R9 to give an arrangement which has advantages similar to the *ultra linear* or distributed load type of circuit used in the AM8/1. This arrangement causes the valve to operate more like a triode and less like a pentode, and so reduces its output impedance and distortion while retaining to the necessary extent the greater efficiency and power-handling capacity of the valve used as a pentode.

Further negative feedback is obtained by connecting the 5·6-kilohm resistor R13 between the cathode circuit of V1 and the output of the amplifier.

Since d.c. coupling is employed between V1 and V2, the control grid of V2 is at the same d.c. potential as the anode of V1; consequently, the cathode potential of V2 must be raised correspondingly, and is in fact about 36 volts above earth as measured across the bias resistors R10 and R11 in series. This is a suitable value for the screen-grid potential of V1, so the screen of V1 is connected via R4 to the cathode of V2.

H.T. current for both stages is supplied by the rectifying valve V3.

Valve Data

Valve	*Anode Volts*	*Anode Current (μA)*	*Bias Volts across R10 + R11*	*Heater Volts*	*Heater Amps*
V1: EF86	—	70	—	6·3	0·2
V2: EL84	280	—	36	6·3	0·76
V3: U709	—	—	—	6·3	0·95

Voltage across reservoir capacitor C8: 325 V.

General Data

Mains Power Supply

Voltage: 200 to 250 V a.c.
Frequency: 45 to 55 c/s

Impedances

Specified input capacitance:	Not greater than 150 pF
Specified output impedance:	Not greater than 1 Ω over the range 100 c/s to 10 kc/s.
Load impedance:	3 Ω nominal.

Stability

No observable self-oscillation at the output terminals when either an impulsive or a steady signal of any kind from zero to maximum input (0·1 V r.m.s.) is applied to the input terminals from any source impedance ahead of the external 50-kilohm control; this applies with any setting of the volume control and with the amplifier output (a) open-circuit and (b) loaded with a 3-ohm resistor in series with any value of inductance.

Sensitivity and Power Output

At least 3 watts output into a resistive load of 3 ohms with a sinusoidal input of 0·1 volt r.m.s. at a frequency of 1 kc/s.

Noise

With the input terminated by a resistor of 50 kilohms, the total noise output does not exceed 2·5 mV r.m.s. across a load resistor of 3 ohms in the frequency band 0 c/s to 10 kc/s.

Harmonic Distortion

Not greater than 1·5 per cent total for an output into a 3-ohm resistive load of 2 watts at 1 kc/s and 0·5 watt at 60 c/s.

Frequency Response

With a constant input voltage and a 3-ohm resistive load the response with respect to that at 1 kc/s is within ±1 dB from 60 c/s to 10 kc/s.

W.G. 8/60

LOUDSPEAKER AMPLIFIERS AM8/4, AM8/4A SERIAL NOS. 101 TO 205

General Description

Amplifier AM8/4

Loudspeaker Amplifier AM8/4 forms part of Studio Loudspeaker LS5/1 (Instruction S.8) and is mounted in the pedestal compartment of the loudspeaker cabinet. It is fitted with a protective cover and lifting handle so that it can be used as a separate unit for other purposes if desired.

Its performance and certain other features are specified by the BBC but otherwise its design and construction are left to the manufacturer. Models supplied at different times by the same or different manufacturers are interchangeable but may differ slightly in design and construction.

It is approximately 12 in. long by 7 in. wide and 7 in. high and weighs 16 lb.

The amplifier is mains operated and gives an output of approximately 15 watts into a resistive load of 25 ohms for an input of less than 0·15 volt r.m.s. It has very low distortion at this output over the frequency range of 30 c/s to 15 kc/s.

The amplifier has a sensibly flat response over the above-mentioned frequency range, but an equaliser giving a slightly rising characteristic is provided for use when the AM8/4 forms part of an LS5/1.

A gain control, mains switch and fuses are fitted, and plugs and sockets are provided for mains supply and for input and output connections. A signal input jack to take a P.O. plug No. 316 is fitted and wired in parallel with the input socket.

Amplifier AM8/4A

Loudspeaker Amplifier AM8/4A forms part of General Purpose Loudspeaker LS1/2. The AM8/4A is the same as the AM8/4 but has a different equaliser, for use with the LS1/2. This equaliser, shown inset in Fig. 62, can be taken out of circuit by physical reorientation, as can that of the AM8/4.

Circuit Description (Fig. 62)

The circuit (Fig. 62) is almost identical with that of the later version of Loudspeaker Amplifier AM8/1 with serial numbers 157 to 186 (Fig. 56A), the main difference being the inclusion of the equaliser in the input circuit to the first valve. The equaliser gives a rise in response of about 4 dB at 10 kc/s to compensate for the falling characteristic of the high-frequency loudspeaker system used in the LS5/1. When the amplifier is used for other purposes where this correction is not required a flat frequency characteristic is obtained by removing the four screws which hold the equaliser in position, turning the equaliser round and refixing it in this position.

Decoupling capacitors are connected across the signal input and output of the amplifier and across the mains input to reduce radio-frequency pick-up.

General Data

The data below apply in general to the amplifier with the equaliser out of circuit.

Mains Power Supply

Voltage: 200 to 250 V a.c.
Frequency: 45 to 55 c/s.

Impedances

Specified input impedance:	Resistive component of at least 20 kΩ from 200 c/s to 15 kc/s and at least 15 kΩ from 50 c/s to 200 c/s, in parallel with reactive component of not less than 2·5 kΩ from 50 c/s to 15 kc/s, at any input level below 0·5 V r.m.s.
Measured input impedance:	15 kΩ at 50 c/s 30 kΩ at 1 kc/s 10 kΩ at 10 kc/s
Specified output impedance:	Not greater than 2·5 Ω over the range 50 c/s to 6 kc/s. Not greater than 5 Ω over the range 6 kc/s to 15 kc/s.
Measured output impedance:	1 Ω approx. from 50 c/s to 15 kc/s.
Load impedance:	25 Ω nominal.

Stability

No observable self-oscillation when either an impulsive or a steady signal from zero to maximum input is applied to the input terminals under any conditions of source impedance and setting of gain control, and with open-circuit output, 25-Ω resistive load, load of 0 to 1,000 pF, either of the two push-pull output valves removed from its socket.

Sensitivity and Power Output

At least 15 watts output power into a resistive load of 25 Ω with a sinusoidal input of 0·15V r.m.s. at 1 kc/s.

Harmonic Distortion

(a) Without Input Transformer

Percentage harmonic distortion for an output of 15 watts into 25 Ω does not exceed the following:

	60 c/s	*1 kc/s*	*4 kc/s*
2nd harmonic	0·5	0·5	0·5
3rd harmonic	0·3	0·15	0·15
r.m.s. sum of all higher harmonics up to 16 kc/s .	0·1	0·1	0·1

(b) With Input Transformer

With a sinusoidal input of 3 V r.m.s. at 60 c/s upwards from a 600-Ω source, the output up to 15 watts into 25 Ω does not have a total harmonic content which exceeds by 0·5% the amount present for the same output level with the input signal applied directly without the transformer. The total harmonic content measured as above is not increased if the gain control is set to 6 dB below maximum gain, and the amplifier input re-adjusted to give the same output as before.

Typical measured values of total harmonics for an output of 15 watts into 25 Ω are:

60 c/s	0·8%
1 kc/s	0·3%
4 kc/s	0·3%

Frequency Response

(a) Amplifier (without equaliser)

With a 600-Ω source and a 25-Ω resistive load, and any setting of the gain control, the response relative to that at 1 kc/s is within the following limits:

50 c/s to 10 kc/s: +0·2 dB to −0·5 dB
30 c/s to 15 kc/s: +0·2 dB to −1·0 dB

(b) Equaliser

When the equaliser is connected in circuit the frequency response of the amplifier under the same conditions as for (a) is changed as follows:

50 c/s to 2 kc/s	0 dB
5 kc/s	+1·5 dB ±0·25 dB
10 kc/s	+4 dB ±0·25 dB
14 kc/s	+3 dB ±0·25 dB

Noise

With the input terminated by a 600-Ω resistor the total noise output level across a load resistance of 25 Ω with the gain control at maximum gain does not exceed −50 dB (reference 0·775 V r.m.s.) with the mains earth connected.

Valve Data

Valve	*Bias Resistor*	*Volts Across Bias Resistor*	*Heater Volts*	*Heater Amps*
V1 EF86	1,000 Ω	0·85	6·3	0·2
V2 ECC81	1·5 kΩ	3·2*	6·3	0·3
V3 EL34	560 Ω	27	6·3	1·5
V4 EL34	560 Ω	27	6·3	1·5
V5 GZ34	—	—	5	1·9

*Cathode to earth 23 V
Voltages measured with Avometer Model 8

Maintenance

It should be noted that if crackles are experienced when operating the gain control they are often caused by a faulty first valve and not by a faulty gain control.

Access to the valves is obtained by removing the valve shield, which is done by removing the rear fixing screw only and slackening the front screw, the front fixing hole being slotted.

AM8/4, AM8/4A: SERIAL NOS. 206 ON

General Description

These closely resemble the amplifiers serial-numbered 101 to 205, with the addition of an external means of adjustment to accept different mains-supply voltages.

Circuit Description (Fig. 62A)

The circuit differs in detail from that already described, and also in the type of phase-splitting arrangement employed to feed the push-pull output stage.

V4 is driven by one of the two sections of V2, which in turn is driven by V1 in a conventional manner. V3 is driven by the remaining section of V2, to which is applied the signal potential developed across R17, a resistor shared by the grid circuits of V3 and V4. The presence of any signal potential across R17 implies that the signal potentials at the grids of V3 and V4 are unequal; thus the push-pull portion of the circuit is not truly balanced in operation. The circuit is self-stabilising to a condition in which the outputs from the two sections of V2 differ from one another just sufficiently to provide the input signal to the second section appropriate to maintain this condition. Because the circuit of each section of V2 has a fairly high gain (of the order of 50), the unbalance is acceptably small.

General Data

The specified performance is the same as for the earlier series of amplifiers; data of measured performance are as follows:

Input impedance: 15 kilohms at 50 Hz
20 kilohms at 1 kHz

Output impedance: about 2 ohms from 1 kHz to 10 kHz

Total harmonic content of output
(15 watts in 25 ohms)
0·5 per cent at 60 Hz
0·3 per cent at 1 kHz
0·5 per cent at 4 kHz

Valve Data

Voltages measured with Avometer Model 8 on lowest practicable range.

Valve	*Bias Resistor*	*Volts Across Bias Resistor*	*Heater Volts*	*Heater Amps*
V1 EF86	1,000 Ω	1·7*	6·3	0·2
V2 ECC83	470 Ω	1·7	6·3	0·3
V3 EL34	470 Ω	28	6·3	1·5
V4 EL34	470 Ω	28	6·3	1·5
V5 GZ34	—	—	5	1·9

*Cathode to chassis, 1·8 volts.

Maintenance: Removal of Valve Shield

The valve shield is secured by four screws tapped into the ends of the chassis/case of the amplifier through slots pierced in the end edges of the shield. Thus the shield can be removed by withdrawing the pair of screws at one end and slackening those at the other.

W.G. 1/62
D.E.H. 11/66

LOUDSPEAKER AMPLIFIERS AM8/6, AM8/6A

General Description

The AM8/6 and AM8/6A are mains operated loudspeaker amplifiers giving an output of 30 watts for a voltage input level of −18 dB. The AM8/6 has been designed primarily for use with the suspended loudspeaker LS5/2 in conditions where the 15-watt output of the AM8/4 is inadequate. The AM8/6 normally contains an equaliser suitable for use with the LS5/2, but different equalisers can be fitted if the amplifier is used to feed other types of 25-ohm loudspeakers.

The AM8/6A is identical with the AM8/6, except that the equaliser is omitted and different strappings are used on the secondary winding of the output transformer to give a 30-watt output at 110 volts for feeding a public-address system.

Precautions have been taken in the design to keep both non-linearity and amplitude/frequency distortion as low as possible and to avoid instability and radio-frequency interference under all likely working conditions.

Printed wiring boards are used for the pre-amplifier and the main amplifier, and these, with the valve-holders attached, can be readily released for access to the components. The output valves are considerably under-run to ensure a long valve life.

The sides of the steel chassis are cut away and a perforated base guard ensures good air circulation over the components provided the amplifier is not installed in a confined space where air cannot circulate freely.

The input, output and mains transformers and sockets are mounted on the top of the chassis with the sockets at one end. On the end-face of the same end are the gain control, the fuses and the input listen jack.

Each amplifier weighs approximately 25 lb and is 15½ in. long by 8 in. wide by 8¾ in. high.

Circuit Description (Fig. 69)

The circuit of both amplifiers is shown in Fig. 69.

The input transformer, which gives a balanced input of high impedance, is coupled via a continuous uncalibrated gain control to a double-triode pre-amplifier V1 with the second half working as a direct-coupled cathode-follower. This stage is followed by an equaliser unit in the AM8/6 to give the correction required for use with the suspended LS5/2 loudspeaker. The correction provided gives a rise of +4 dB at 11—12 kc/s, together with alternative bass correction of +3 dB or +5 dB at 34 c/s as required.

In the AM8/6A, which is used to feed a public-address system, the equaliser unit is replaced by a 15-kilohm resistor.

The main amplifier consists of a pentode valve V2, direct-coupled to a double-triode phase-changer valve V3, which drives a pair of output valves V4 and V5 working in class AB1 with ultra linear anode/screen connection on the output transformer. (The advantages of this type of connection are given in the description of loudspeaker amplifier AM8/1.) Approximately 20 dB of negative feedback, derived from the secondary winding of the output transformer, is applied to the cathode circuit of V2.

The four sections of the secondary winding of the output transformer are connected in parallel in the AM8/6 and in series in the AM8/6A.

Radio-frequency by-pass capacitors are fitted at the input and output terminals of the amplifier and the mains input to avoid r.f. interference received either by direct pick-up or injected along the leads.

The h.t. supply is obtained from a bridge-rectifier circuit using silicon rectifiers. The h.t. fuse has been placed on the load side of the circuit to prevent it from being blown by the charging surge of the reservoir capacitor, and the value of 250 mA has been selected to protect the rectifiers from faults on the equipment. Protection of the mains transformer is obtained by using anti-surge mains fuses.

The general earthing arrangements, and the wiring of the output transformer in particular, have been chosen to ensure minimum hum level and maximum stability.

General Data

Mains Power Supply

Voltage: 200 to 250 V a.c.
Frequency: 45 to 55 c/s.

Impedances

Input impedance: 18 kΩ approx. at 1 kc/s (measured by simple substitution).
Output impedance (AM8/6):

60 c/s	1·3 Ω	(measured by simple substitution)
1 kc/s	1·2 Ω	
10 kc/s	2·2 Ω	

D.C. Conditions

Typical voltage measurements using an Avometer Model 8 are shown on Fig. 69.

Stability

No tendency to self-oscillation should be evident with any combination of resistive and capacitive load in the range $R = 25\ \Omega$ to infinity and $C = 0{\cdot}1\ \mu F$ to 0, and also with either output valve removed.

Sensitivity and Power Output

With a sinusoidal voltage input of -18 ± 1 dB at a frequency of 1 kc/s, the output power should be 30 watts at 27·4 volts into 25 ohms for the AM8/6, and 30 watts at 109·6 volts into 400 ohms for the AM8/6A.

Frequency Response

With a source impedance of 600 ohms, and a load of 25 ohms for the AM8/6 and of 400 ohms for the AM8/6A, the frequency response with respect to that at 1 kc/s should be within the following limits for any setting of the gain control:

(*a*) *AM8/6A, and AM8/6 with equaliser replaced by 15 kΩ*
+0·2 dB and −0·5 dB at all frequencies between 30 c/s and 15 kc/s.

(*b*) *AM8/6 with h.f. equalisation*
As (*a*) from 30 c/s to 1 kc/s.
+2 dB ±0·2 dB at 5·9 kc/s relative to (*a*).
+4 dB ±0·2 dB at 11·5 kc/s relative to (*a*).

(*c*) *AM8/6 with medium l.f. equalisation (C-D strapped)*
+1·5 dB ±0·2 dB at 68 c/s relative to (*b*).
+3 dB ±0·2 dB at 34 c/s relative to (*b*).

(*d*) *AM8/6 with maximum l.f. equalisation (A-B strapped)*
+2·75 dB ±0·2 dB at 68 c/s relative to (*b*).
+5·5 dB ±0·2 dB at 34 c/s relative to (*b*).

Harmonic Distortion

Typical figures for percentage harmonic distortion at 30 watts power output into the appropriate resistive loads are:

Condition	*Harmonic*	*Percentage Distortion*		
		60 c/s	*1 kc/s*	*5 kc/s*
Unequalised	2nd	0·24	0·12	0·31
	3rd	0·15	0·03	0·03
H.F. equalisation only	2nd	0·2	0·15	0·37
	3rd	0·14	0·07	0·25
H.F. and medium l.f. equalisation	2nd	0·25	0·15	0·37
	3rd	0·17	0·07	0·25
H.F. and maximum l.f. equalisation	2nd	0·26	0·15	0·37
	3rd	0·18	0·07	0·25

Noise

With the input terminated with a 600-ohm resistor the total noise volume read on a T.P.M. peaking to 6 should not be greater than the following:

AM8/6 −45 dB across 25-Ω load
AM8/6A −33 dB across 400-Ω load

Installation

Considerable care has been taken to ensure that maximum air can flow through the amplifier chassis and across the components. It is absolutely essential that this air flow is fully maintained and the amplifier must not be installed in a confined space, cupboard or cavity where this is prevented.

Maintenance

For access to components the printed wiring board assemblies, complete with valveholders on their mounting pillars, can be released and swung through 180 degrees by removing the screws which fix the valveholder mounting plates. These screws are on top of the chassis and are ten in number, two for the pre-amplifier and eight for the main amplifier.

Test points for checking d.c. voltages are indicated on the circuit diagram (Fig. 69). The voltages shown are those of a typical amplifier measured on the appropriate range of an Avometer Model 8.

W.G. 3/64

SECTION 11

AMPLIFIER MNA/1

General Description

This amplifier is used in the new Type-A studio equipment to provide facilities for simultaneous visual and aural monitoring across a high-level programme circuit. Strictly speaking, the MNA/1 is an interim design, and consists essentially of a PPM/2 amplifier modified to give an audio output circuit. The design is such that existing PPM/2 amplifiers can be modified to the new circuit arrangement if required.

Electrical Design Considerations

The amplifier comprises a stage of voltage amplification with feedback, feeding two output circuits, one giving a signal at zero level and having 600-ohms impedance for aural monitoring purposes, and the other feeding a peak programme meter amplifier circuit, for visual monitoring. The latter is very similar to the circuit of the PPM/2, and has controls for adjusting the sensitivity, zero reading, zero balance and law of the programme meter. As in the PPM/2, a switch precedes the first valve and is used when the peak programme meter is calibrated in conjunction with a CAL/1 unit. The amplifier has a high input impedance so that it may be connected across 300-ohm or 600-ohm programme sources without appreciably affecting the level.

Mechanical Design Considerations

The amplifier is built on a standard 4½-in. panel and when mounted on a bay the following controls are accessible at the front with the cover in position :—Calibration Switch ; Zero Control ; Feed Meter Jack ; Feed Meter Switch ; Programme Meter Jack. The law, sensitivity and zero balance controls are only accessible when the cover is removed. A drawing of the front of the amplifier is given in Fig. 11.1.

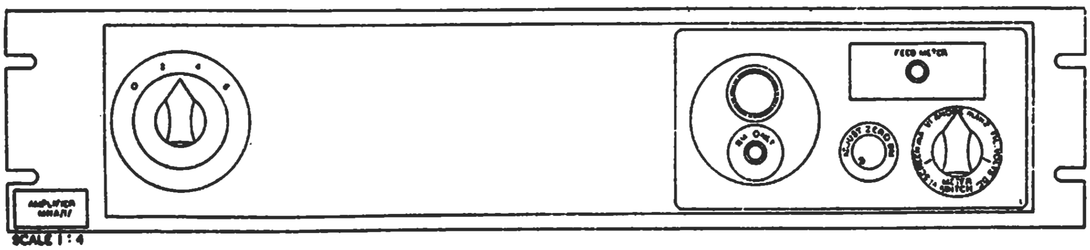


Fig. 11.1 MNA/1. Face Panel

Circuit Description (Fig. 31)

The full circuit diagram of the MNA/1 is given in Fig. 31. It is very similar to that of the PPM/2 and reference should be made to Instruction S4, for full details of the method of operation. But the MNA/1 differs from the PPM/2 in the following respects :—

(a) It uses current and not voltage feedback. The feedback is applied to V1 by means of the resistors R14, R37 and R33. The p.d. developed across R14 and R33 by the a.c. component of the anode current of V1 is applied to the grid circuit via C1, R12 and R13 giving a feedback voltage of 10 dB. The d.c. component of the anode current in flowing through R14 provides automatic grid bias via R37, R12 and R13.

(b) The anode load of V1 consists of R17 and R19 in parallel and R18 as shown in the simplified circuit diagram, Fig. 11.2. The p.d. developed across the parallel network is used to feed the programme meter amplifier via C4 and T2, and the amplitude of the signal thus obtained can be adjusted by varying R17, this being the *Adjust Sensitivity* control. The particular arrangement adopted for the connections of this *Adjust Sensitivity* control is designed to maintain the source impedance feeding the diode circuit as nearly constant as possible. The p.d. developed across R18 provides the output for aural monitoring, connections to the output tags being made via C7 and the step-down matching transformer T3, which makes the output impedance effectively equal to 600 ohms.

Operation of the MNA/1

Input Volume

The MNA/1 can be used with an input volume of 0, + 4 or + 10 dB. Adjustment for the volume

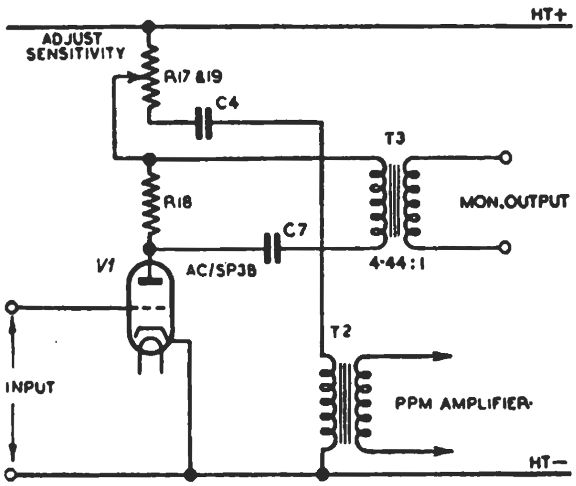


Fig. 11.2. MNA/1. Simplified Circuit of V1

normally required is made by soldering the two flexible leads on the input attenuator to the appropriate tags, which are accessible when the front cover is removed. The meter is adjusted so that it reads 4 at normal volume and 6 at maximum permissible peaks.

Calibration

This is carried out with the aid of a calibration unit CAL/1. The amplifier should be switched on at least ten minutes before calibration in order to ensure stability.

(1) Note the reading of the meter with no input to the amplifier. If this is not zero, turn the *Adjust Zero* control until zero reading is obtained.

(2) Connect the output of the CAL/1 to the input of the amplifier and set the calibration switch on the amplifier to 4. The meter should now read 4. If it does not, remove cover and adjust the *Sensitivity* control until a reading of 4 is obtained.

(3) Set the calibrating switch to 2 and 6 in turn. The meter should read 2 and 6 respectively.

If it does not, proceed as follows :—

(a) If the scale is too cramped, i.e., if the meter reads above 2 and below 6.
   (i) Remove the input plug.
   (ii) Turn the *Adjust Law* control until the meter reads between 0 and 1
   (iii) Bring the pointer back to zero by means of the *Adjust Zero* control.
   (iv) Replace the input plug and repeat (2) and (3).

(b) If the scale is too ' open,' i.e., if the meter reads below 2 and above 6, proceed as in (a) except that in test (ii) set the meter to read below zero in no-signal conditions by means of the *Adjust Law* control.

The process must be repeated until the error is reduced to a minimum.

Recalibration after Neon and Valve Replacements

Replacement of the rectifier D41 should not affect the calibration in any way, but after replacement of a neon tube or AC/VP1, the zero and law calibration including ' zero balance ' must be checked and adjusted. For this purpose it is necessary to provide a means of varying the supply voltage, and a tapped transformer or ' Variac ' should be interposed between the mains-supply socket and the mains unit feeding the amplifier MNA/1. A variation from the normal working voltage down to about 15 per cent below normal (e.g., from 240 volts down to 200 volts) should be obtainable.

The procedure is as follows :

(i) Adjust the mains-unit input voltage to the nominal value, e.g., 240 volts, and with the *Zero Balance* control fully clockwise (i.e., neon returned to earth), line up the programme meter in the usual way.

(ii) Set the *Zero Balance* control to its mid position, and restore the meter reading to zero by means of the *Adjust Law* control.

(iii) Reduce the mains-unit input to 200 volts. If the meter reading rises, the *Zero Balance* control has not been rotated far enough. If the reading falls, the control has been turned too far.

(iv) Restore the mains-unit input voltage to normal, rotate the *Zero Balance* control a small amount in the direction as indicated in (iii) above, and re-set the meter zero by means of the *Adjust Law* control.

(v) Reduce the mains unit input volts once again to 200, and proceed as above, until varying the voltage between 240 and 200 produces no change in the meter zero reading.

(vi) The *Zero Balance* control should be left in the position thus found unless either the neon tube or the AC/VP1 valve has to be replaced.

Each time the a.c. voltage is varied, before proceeding with the next step about 20 seconds should be allowed to elapse for the consequent variation in valve-heater voltage to take effect.

Valve Data

Valve	*Anode Potential*	*Anode Current*	*Screen Potential*	*Screen Current*	*Fil. Potential*	*Fil. Current*
Stage 1 AC/SP3B	80V	10mA	285V	3·5mA	a.c. 4V	1A
Stage 2 D41	—	rectifier	—		4V	0·3A
Stage 3 AC/VP1	150V*	1·5mA*	†	0·6mA*	4V	0·65A

† Adjusted for law. *With no input.

Total Feed

L.T. Supply, 4 V a.c. 2·3 A or 6 V d.c.
H.T. Supply, 300 V 17 mA.

General Data

Neon Stabiliser
BBC Type S1

Pilot Lamp
P.O. No. 2, 4 V

Potentiometers
Adjust Sensitivity : Reliance TW, 5,000 Ω.
Adjust Zero : Morganite Stackpole, Type MNAP 50350, 50,000 Ω.
Adjust Law : Morganite Stackpole, Type MNAP 10250, 1,000 Ω.
Zero Balance : Morganite Stackpole, Type LHAP 50250, 5,000 Ω.

Switches
Calibration : Plessey Yaxley, Type B, s.p., 4-position.
Metering : Plessey Yaxley, Type A, 2-bank, 9-position.

Impedances
Normal Source Z = 300 Ω (balanced).
Normal Input Z = 10,000 Ω.
Output Z = 600 Ω.
Normal Load Z = 600 Ω (balanced).

Normal Working Input Volume
0 dB, + 4 dB or + 10 dB. (Apparatus adjusted to read 4 on steady tone.)

Normal Working Output Volume
0 dB approximately when programme meter is peaking 6.

Normal Voltage Gain (audio)
Zero.

600-ohm Test Gain (audio-circuit)
15 dB with calibration switch on 6

Test Input Level
Zero (to give meter reading 4, with calibration switch at 4, and zero level on audio circuit).

Frequency Characteristic
±0·5 dB from 50 c/s to 10,000 c/s both audio and visual.

Total Percentage Harmonic Content

Frequency	*Normal working input and output levels*	*8 dB above normal input and output levels*
50 c/s	< 0·5	< 2
1,000 c/s	< 0·35	< 1·6

SECTION 12

AMPLIFIER MPA/1

General Description

The amplifier MPA/1 was designed to meet the need for a loudspeaker amplifier having a better performance than existing types. It is suitable for monitoring purposes in Control Rooms and Recording Rooms and may also be used for feeding ring mains.

A stage of voltage amplification with current feedback precedes a push-pull output stage, with voltage feedback, which delivers 10 watts to the output load. An input level of – 5 dB is required for maximum power output. The amplifier incorporates its own mains-supply equipment. The mechanical construction is such that the amplifier may be rack-mounted or used in conjunction with an R.K. loudspeaker in a Howe-type box baffle.

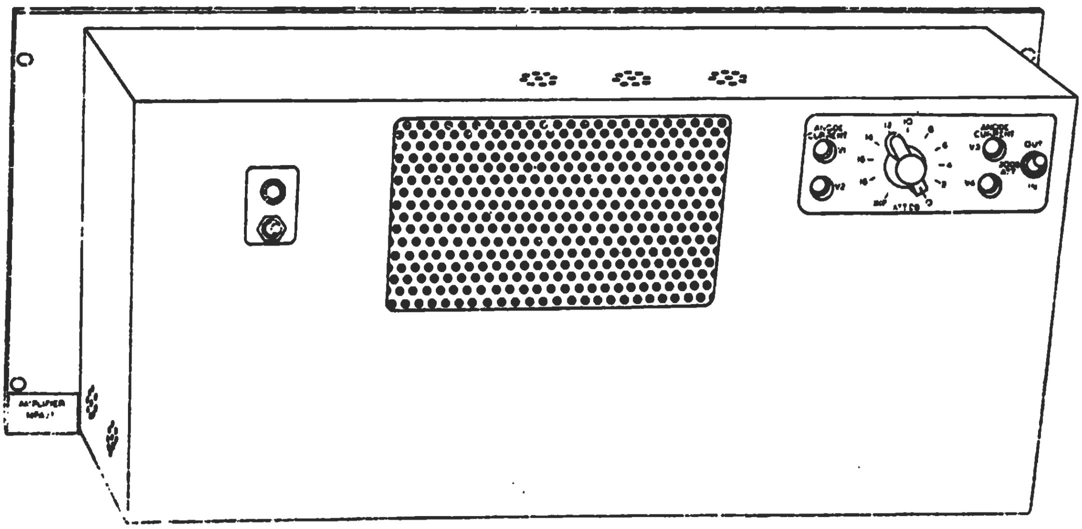


Fig. 12.1. MPA/1. Front View

Electrical Design Considerations

The required power output of 10 watts is obtained from two Type AL60 pentodes operating in push-pull. To avoid running these valves continuously at their maximum rated anode dissipation, they are biased near to the point of anode current cut-off. The input signal to the output stage is not allowed to produce grid current so that these valves operate under Class AB1 conditions. As the anode current varies during operation, grid bias cannot be obtained by means of the usual cathode resistor. Grid bias voltage is obtained from a separate winding on the mains transformer and rectified by a metal rectifier. Very good voltage regulation is necessary in the h.t. supply unit as distortion would be caused if the h.t. voltage fluctuated with the current drawn from it; a choke input filter is therefore used.

A very low impedance is required to provide adequate damping of the loudspeaker, and a value of rather less than 2 ohms at the secondary of the output transformer is obtained by using about 25 dB voltage feedback. This involves the use of a stage of high voltage amplification previous to the output valves. Phase-splitting is achieved by means of an AC/SP3B, used as a triode.

Mechanical Design Considerations

In common with other post-war designs, the amplifier is constructed on a standard panel of folded construction, measuring 22⅛ inches by 9 inches. All the bulky components are mounted on the face of this panel. The space occupied by the small components at the rear of the panel is less than 1½ inches deep, so that two of these amplifiers can be mounted back to back on the same bay. If necessary, and without alteration in component layout, the amplifier can be constructed on a panel measuring 19 inches by 8½ inches for use on 19-inch bays.

The following controls are mounted on two sub-panels and appear at the front of the amplifier when it is used on a bay :—Mains on-off switch ; Indicator lamp ; Gain control ; Feed jacks. A perspective drawing of the front of the amplifier is given in Fig. 12.1.

When the amplifier is used in a box baffle it is necessary that the controls should be accessible from the front of the baffle and that the dust cover should be removable from the rear. Accordingly, a duplicate mains on-off switch and indicator lamp are provided at the back of the amplifier, and the gain control is mounted so that it can easily be reversed on its bracket without disconnecting any wires. A perspective drawing of the back of the amplifier is given in Fig. 12.2.

The input and output circuits and the a.c. mains supply are connected to the amplifier by a single multi-point plug and socket. This plug may be inserted or withdrawn from the front of the amplifier, the plug and cables passing through an opening in the panel from the rear.

Circuit Description (Fig. 32)

General

A simplified circuit diagram of the amplifier is given in Fig. 12.3, and the complete circuit in Fig. 32. The input signal is fed to the primary of the screened input transformer T1 via two resistors R1 and R2. By operating the switch S3 it is possible to connect the resistor R22 in parallel with the primary of T1, where it becomes part of a fixed balanced potential divider with an attenuation of 20 db. T1 has a turns ratio of 1 : 5 and the total resistance on the secondary side is roughly 250,000 ohms, so that the input impedance of the amplifier is approximately 10,000 ohms. This value is maintained in both positions of the switch S3. The input impedance has been made high in order that the amplifier may be connected across 300-ohm or 600-ohm circuits without appreciably reducing the level thereon.

The gain control consists of the resistors R28-R37 selected by a Yaxley-type switch with 11 positions, giving attenuations of between 1 and 19 dB in 2-dB steps. Position 11 gives infinite attenuation, while the maximum position gives an overall amplifier voltage gain of 28 dB. The scale of the gain control is calibrated in 2-dB steps from 0 to −18 dB, the zero indication corresponding to the position of the Yaxley switch which gives 1-dB attenuation and brings the overall gain of the amplifier to an even number of dB.

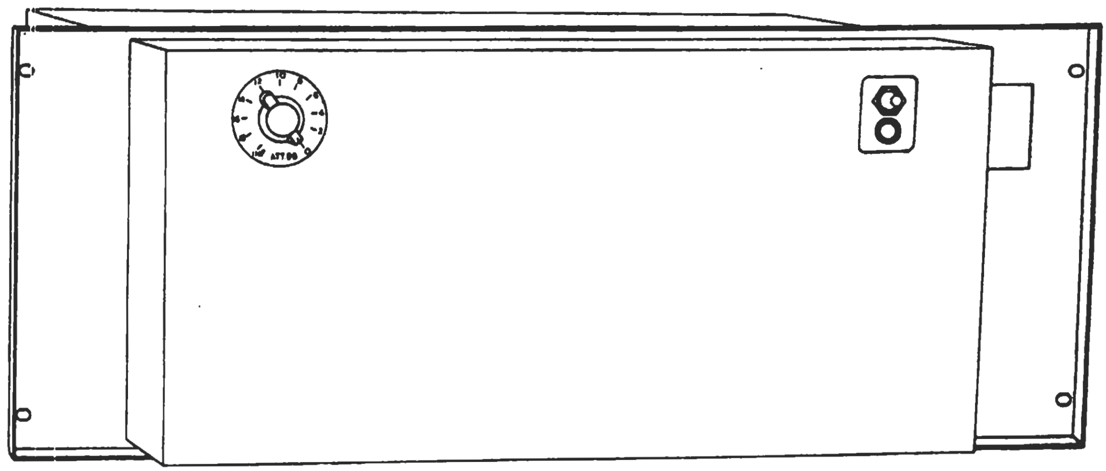


Fig. 12.2. MPA/1. Back View

In conjunction with the fixed 20-dB attenuator S3 it is thus possible to vary the output volume in 2-dB steps over a total range of 38 dB.

The first stage of amplification consists of an AC/SP3B valve, V1, which gives considerable voltage gain. R3 not only provides automatic bias but also 12-dB current feedback, as the capacitor C1 is too small to have any effect at audio frequencies. (The reason for its inclusion in the circuit will be given later.) V1 is RC coupled to the phase-splitting valve, V2. This is an full-wave copper-oxide rectifier. The smoothing circuit for the grid-bias supply includes two 250-μF capacitors C13 and C8 and a 1,200-ohm resistor R26. R21 is a pre-set potentiometer, which provides a differential control of the grid bias applied to the two output valves. It is adjusted to obtain equality in the anode currents of the two AL60's under static conditions, and is only accessible from the inside of the unit.

The mains unit includes a full-wave rectifying valve V5, Type UU4, with a smoothing circuit

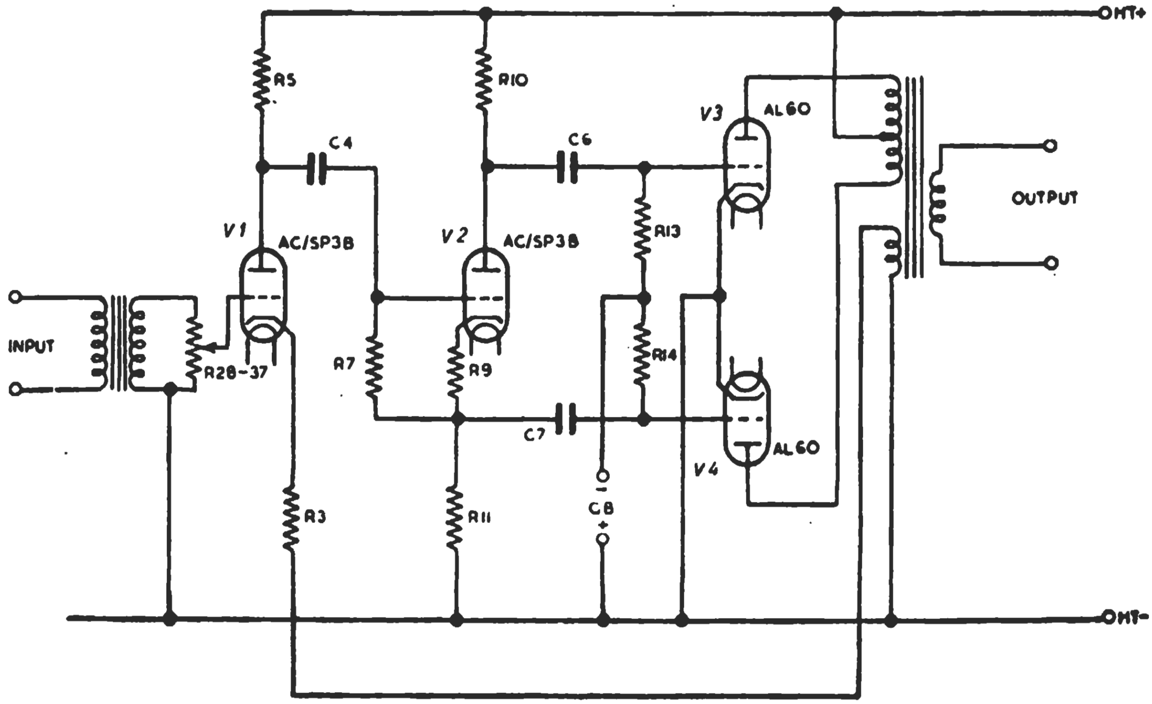


Fig. 12.3. MPA/1. Simplified Circuit

AC/SP3B connected as a triode, and having equal anode and cathode loads of 56,000 ohms (R10 and R11 respectively). The anti-phase outputs developed across these loads are applied to the output pentodes by means of the capacitors C6 and C7. The two secondary windings of T2 may be connected in parallel when the amplifier is required to work into a load of 3 ohms. When the secondaries are connected in series as in Fig. 30, the correct load is 12 ohms, approximately the impedance of an R.K. Senior loudspeaker. The cathodes of the AL60's are earthed and grid bias is introduced by means of the network R21, R38 and R39, the necessary d.c. being obtained from a special winding on the mains transformer T3, and a which includes a choke input to give good voltage regulation. The two double-pole on-off switches S1 and S2 in the primary circuit of the mains transformer are provided so that the amplifier can be switched on or off either from the front or the rear of the unit.

Feedback Circuit

The amplifier incorporates both current and voltage feedback. Current feedback is applied to V1 by making the reactance of C1 very great at audio frequencies compared with the value of R3.

A special winding on the output transformer T2 is used to provide voltage feedback, which is injected into the cathode circuit of V1. In an amplifier where a considerable amount of feedback is applied, acting over several stages of amplification, instability frequently results due to the feedback voltage becoming positive at a very low or supersonic frequency while the overall gain of the loop is still greater than unity. To prevent this instability, it is necessary to make the response of the amplifier, without feedback, fall off in a controlled manner at very low and very high frequencies. The frequency response of the MPA/1 is controlled from 1 c/s to 100 kc/s. Control of bass attenuation is obtained chiefly by suitable choice of inductance in the output transformer primaries, by the use of a small decoupling capacitor for the screen, of V1 and by the network R7, R8, C10. The required high-frequency response is obtained by the use of the 0·003-μF capacitors C15 and C16 which resonate with the primaries of T2 at about 15 kc/s and by the use of the circuit C1, R3, which limits the sharpness of cut-off above 15 kc/s. This frequency correction ensures that the application of feedback will not cause instability and that the amplifier will have a level frequency response over the required range.

Valve Data

Valve	*Anode Potential*	*Anode Current*	*Screen Potential*	*Screen Current*	*Fil. Potential*	*Fil. Current*
Stage 1, AC/SP3B	90V.	1·5mA	80V.	0·5mA	4V.	1A
Stage 2, AC/SP3B	60V.*	1·7mA	(connected as triode)		4V.	1A
Stage 3, AL.60	285V.	13mA†	260V.	1·6mA†	4V.	2·1A
Stage 4, AL.60	285V.	13mA†	260V.	1·6mA†	4V.	2·1A
Stage 5, UU4					4V.	2·2A

* Anode to cathode potential.
† Measured under static conditions.

General Data

	No. of Studs	*Loss per Stud*	*Loss on Lowest stud*
Variable Gain Control	11	2	Infinity

Yaxley type switch, Type A, 1-pole, 11-position, 1-bank.

Fixed Gain Control S3 20-dB attenuation Arrow Type No. 20905.

Mains On-off Switches S1, S2 Arrow type No. 20905.

Balance Control R21 1,000 Ω. Reliance Type TW.

Indicator Lamps. P.O No. 2. 4 V.

Combined Input, Output and Mains Socket:— Films and Equipment Ltd. Type EP-8-14S (light pressure).

Impedances
Normal source Z = 300 Ω.
Input Z = 10,000 Ω (balanced).
Output Z = 1·1 to 3·0 Ω over most of the audio-frequency range.
Normal load Z = 12 Ω (or 3 Ω balanced).

Normal Working Volume
Input zero (minimum line-up level for peak volume output = − 13 dB).
Output zero, + 4 dB or + 10 dB (voltage level on 12-Ω load).

Maximum Gain at 1,000 c/s
G = 28 dB.

Frequency Characteristic
± 0·25 dB from 50 c/s to 8,000 c/s.
± 1 dB from 30 c/s to 15,000 c/s.

Total Percentage Harmonic Content

Frequency	+ 15-*dB Output Voltage Level*	+ 23-*dB Output Voltage Level*
50 c/s	< 1	< 2
1,000 c/s	< 0·5	< 1

Noise Level
Less than −70 dB compared with normal output level

Modifications

The following modifications have been made to MPA/1 amplifiers with serial numbers S162-271 inclusive.

(*a*) The 27,000-ohm resistor R27 connected between the input transformer secondary and the variable potentiometer is omitted.

(*b*) Two 500-ohm resistors are inserted, one in each of the input leads to terminals 1 and 2 of the primary of the input transformer.

These changes have no effect upon the overall performance of the amplifier but compensate for certain variations in the input transformer.

SECTION 13

AMPLIFIER OBA/8

General Description

The OBA/8 amplifier is designed as a unit incorporating a control potentiometer, peak programme meter, and all the necessary line-switching facilities. It can be used with either BBC-Marconi ribbon or S.T. & C. moving-coil microphones for sending programme to line at a maximum volume of + 4 dB. An attenuator is provided in the output circuit for adjusting the volume sent to line to either + 4 dB, zero or − 4 dB. By a special arrangement of the circuit the programme volume indicated by the programme meter is a measure of the approximate power (instead of the voltage) sent to line, and consequently no adjustment is necessary in respect of the impedance of the line into which the amplifier works. The amplifier is arranged to operate either from a.c. mains or from batteries.

The OBA/8 amplifier, in conjunction with its associated apparatus, provides a complete set of equipment for an O.B. point. Each set of apparatus comprises the following :—

2 or 4 microphones, as required, in a carrying case

2 amplifiers, OBA/8, each in a separate carrying case

2 mains units, MU/3, each in a separate carrying case

1 microphone mixer (4-channel), MX/18, in a carrying case which also accommodates the communication units and their connecting cable

1 communication unit, CMU/6

1 communication unit, CMU/7

1 loudspeaker unit, LSU/1, constructed in the form of a folding baffle and incorporating an amplifier, LSM/4, mains unit, MU/7, and a loudspeaker, and also housing the associated mains lead

1 set of inter-unit connectors, cords, mains and battery connectors, five-way mains turret connector, including spares, and a set of spare valves, in a common carrying case

2 portable telephone sets with batteries

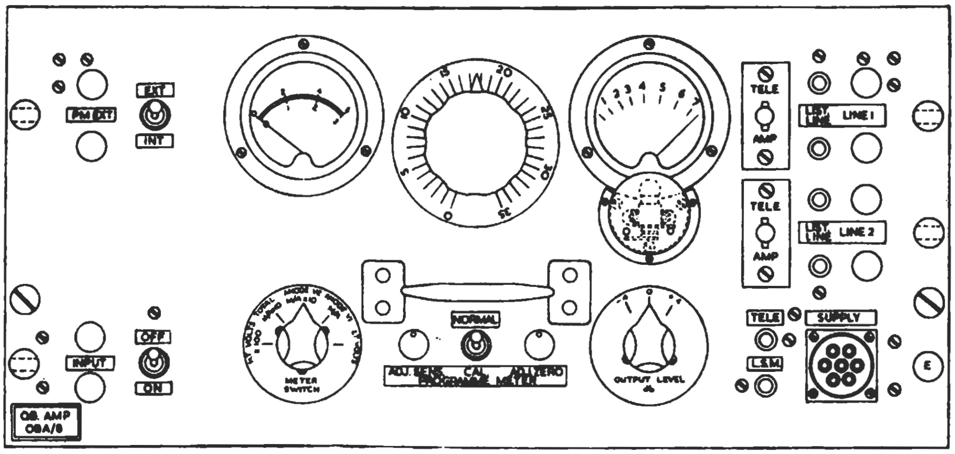


Fig. 13.1. Face Panel OBA/8

The general arrangement of the apparatus, showing the normal connections, is given in Fig. 44. The earth connection is made to the amplifier as shown, and is extended to the other units via the cable screens, special spring earthing clips being provided on each unit for making the connection. As an additional precaution, the LSU/1 and MU/3 are fitted with earth terminals which must be connected to a direct earth. The plugs and sockets used for making the connections to the various units are all keyed to prevent improper connection, but for convenience in aligning the plugs before insertion, dots are inscribed on the plugs and socket mountings in positions which correspond.

Each O.B. amplifier consumes approximately 25 mA at 250 V and 3·5 A at 4 V, and each loudspeaker amplifier approximately 30 mA at 300 V and 2 A at 4 V. The supplies, as stated, are normally obtained from the respective mains units but batteries must be provided for emergency use in the event of failure of the mains. No provision is made for connecting batteries on the loudspeaker unit but battery terminals are provided on the mains units MU/3 associated with the O.B. amplifiers. Separate batteries are required for each O.B. amplifier. For the l.t. supply, 6-V, 40-Ah batteries must be provided, a suitable resistance being included in the mains unit to drop the voltage to 4V at the valve terminals. For the h.t. , dry batteries of suitable voltage and capacity suffice.

Where a.c. mains are not available the amplifiers will be battery operated and the battery equipment mentioned above must be duplicated.

The arrangement of the front panel of the amplifier is shown in Fig.13.1 and the circuit in Fig. 45.

Referring to the circuit drawing, the amplifier itself comprises two resistance-capacitance coupled high-slope pentode stages, using AC/SP3 valves, with a high-ratio screened input transformer and choke-capacitance transformer-coupled output circuit.

Due to the action of the leakage inductance of the transformer, in conjunction with the grid-to-cathode capacitance of the valve, the capacitance between the wiring, and the capacitor C1 connected across the primary, the input circuit of the valve V1 constitutes a low-pass filter cutting off at approximately 10,000 c/s. On the other hand, the output circuit of the valve V2 constitutes a high-pass filter, the choke R/1A virtually shunting the load as regards the lower frequencies. Its effect is, however, restricted to frequencies below 30 c/s by the resistor R15 which can be considered as shunting the choke. (C10 is merely a blocking capacitor to prevent the d.c. component from reaching the output circuit.) The complete amplifier thus acts as a band-pass filter with a pass band extending from 30 to 10,000 c/s.

A rising characteristic above 2,000 c/s, required for ribbon microphones, is provided by connecting the choke S/1A in series with the anode resistance of the valve V1 so as to increase the gain of this stage at the higher frequencies. The response at the lower frequencies is reduced by suitably adjusting the values of the inter-stage and output coupling capacitors.

It will be seen from Fig. 45 that frequency correction can be removed by inserting straps at the points AA, BB and CC. The use of frequency correction is dependent upon conditions obtaining in other parts of the programme chain and the omission or inclusion of the straps is subject to specific instructions governing local requirements.

With a turns ratio of 1/31·6 in the input transformer and a step-up impedance ratio, therefore, of 1/1,000, and since the secondary is loaded with 300,000 ohms, the input impedance of the amplifier is 300 ohms. The primary of the output transformer is loaded by R15 and R16 parallel, equivalent to 33,000 ohms, and since the output transformer has a turns ratio of 1/20 the output impedance is approximately 75 ohms.

Gain control is provided by the potentiometers R18 and R19, which consist of two ganged elements operated by a single control. The potentiometer R18 operates by the progressive application of negative feedback to the valve V1, reducing the gain in 8 steps of 2 dB (total 16-dB) and operating over the first 9 studs (Nos. 35-27) of the switch. The potentiometer R19 in the grid circuit of the output stage operates over the remaining studs (Nos. 26-0), providing an attenuation of 2 dB per stud over the greater part of the range and then larger steps to give a complete fade out. Studs 35 to 27 of R19 are connected together so that this potentiometer remains at full gain until stud 26 is reached, while stud 27 and all the remaining studs of R18 are connected together so that this potentiometer remains on minimum below stud 27.

Negative feedback consists of providing coupling between the anode and grid circuits of a resistance-coupled valve via a resistance in the cathode lead so as to apply to the grid a portion of the output which will be 180° out of phase with the signal voltages applied to the grid. The effect of negative feedback, as applied to a high-slope pentode valve, though reducing the effective gain, enables the valve to handle without distortion a signal that would normally cause serious overloading. In the case of V1 the arrangement is such that the full gain of the pentode is available if the applied signal is very weak, but that as the strength of the input signal increases, the effective " grid-base " of the valve is extended at the same time as the gain is reduced, to enable the valve to handle the increased voltage swing applied to its grid without overloading.

The negative feedback is provided by the resistors R5 and R6 connected between cathode and — h.t., R5 also providing grid bias to the valve. The potentiometer R18 is connected across R5 and R6 in series with C3, and its slider is returned to the grid via the coupling capacitor C2; to prevent frequency discrimination in the feedback voltage, R7 is large compared with the reactance of C2 over the pass band of the amplifier. When the slider is at the earthy end of R18 (stud 27) the whole of the negative feedback potential is applied to the grid and when it is at the other end of R18 (stud 35) the cathode is short-circuited to the grid, as regards a.c., via C2.

Provision is thus made for applying attenuation in 24 steps of 2 dB between studs 35 and 11 and then in 10 steps of 3 dB between studs 11 and 1 with a complete fade-out on stud 0. Under normal working conditions the amplifier must not be operated with a gain less than that given by stud 10.

Negative feedback amounting to 6 dB is also applied to V2 to enable this valve to handle the output delivered to line without overloading, and is obtained from the resistor R13 which also provides the negative bias to the valve. The correction circuit C8, R14 shunting this resistor is introduced to modify the frequency characteristic of the feedback to compensate for certain small losses in the neighbourhood of 8,000 c/s.

Decoupling for the screen supply to V2 is provided by C9 and for the h.t. supply and screen supply to V1 by C7 and C4, respectively.

Meter shunts are included which, in conjunction with the metering switch and meter provided on the panel, enable the h.t. voltage, the total h.t. current and the individual anode currents taken by V1 and V2 to be read. When batteries are being used the l.t. voltage also can be read.

The anode current taken by valve V1 is 1 mA ± 0·2 and that taken by valve V2 is 12·5 mA ± 2·0.

The outers of the loudspeaker jack to which the input of the LSM/4 can be plugged are connected across R17, which is permanently included in the anode return circuit of V2. In the original circuit, R17 was connected across the inners of the jack and was replaced by the 2,000-ohm input of the LSM/4 when this was plugged up.

The revised circuit makes the anode circuit of V2 independent of the jack contacts and the potential for feeding the input of the PPM circuit is obtained from an additional series resistor R41. With this rearranged circuit the output voltage of the amplifier remains sensibly constant, whether the LSM/4 is plugged up or not.

Where the LSM/4 input leads are very long, a capacitance effect may be introduced, which will affect the high-frequency response of the PPM. If, therefore, the PPM be used for frequency tests, the LSM/4 should be unplugged.

The maximum voltage gain at 1,000 c/s, working into a 600-ohm load, is 91 dB. The gain at 9,000 c/s is approximately + 4 dB, and that at 50 c/s, — 5 dB, with respect to that at 1,000 c/s when the correction circuit for ribbon microphones is in use.

The output is connected via an attenuator controlled by a three-position switch. Position 1 with the attenuator out of circuit corresponds to the switch position designated +4, position 2 with attenuation of 4 dB in circuit corresponds to the switch position designated 0 and position 3 with the full attenuation of 8 dB in circuit, to the switch position designated — 4.

The attenuator output is wired to one pair of make contacts of both the line change-over keys and the outers of the telephone jack to the other pair of make contacts in each case. Terminals and line and listen jacks, wired in parallel in each case, are provided for two lines which are wired each to the travellers of one of the change-over keys. By suitable operation of the keys, therefore, either line can be connected either to the amplifier output or to the telephone set.

The Peak Programme Meter

The peak programme meter is incorporated in the amplifier and its circuit is shown in Fig. 45.

The signal is applied via an input transformer and is then rectified by a full-wave rectifier, the output of which charges up C13, connected across the grid circuit of a variable-mu pentode valve, with the programme meter connected in its anode circuit. The meter is of the right-hand zero, quick-acting type, but is calibrated like a normal programme meter from left to right, 1 to 7. By suitable adjustment of the screen and grid-bias voltages the valve is arranged to operate over the particular part of the curved portion of its characteristic which gives the required logarithmic law, and to deflect the meter to zero when the standing feed has its correct value. The output of the rectifier is applied to the grid in a negative sense so that the stronger the signal the more negative the grid and the smaller the feed.

The time constant of the circuit is such that if a transient pulse is applied the voltage attained by the capacitor will rise to within 2 dB of the value of the applied voltage within 4 milliseconds. The indications of the programme meter will, therefore, correspond very nearly to the peak levels actually present in the programme. The return time from full deflection to 1 is of the order of 3 seconds.

A switch and a pair of terminals are provided to enable an extension programme meter to be connected in series with that included in the amplifier unit. A neon stabiliser is fitted for maintaining the screen voltage applied to the variable-mu valve.

The impedance of the lines with which the O.B. amplifier will be used may vary between 75 and 600 ohms. Consequently if the programme meter amplifier input were connected across the amplifier output so as to regulate the voltage sent to line, the power actually sent to line for a given programme meter reading might vary for different lines by as much as 9 dB. This is a greater variation than, from considerations of cross talk and overloading of repeaters, Lines Department is prepared to allow. In this equipment the programme meter input is connected across a 2,000-ohm resistance included in the amplifier output circuit in series with the output loading network. The voltage across this resistance, and, therefore, the total current in the output loading network is maintained constant whatever the impedance of the line may be. With this arrangement for a particular reading of the programme meter, the maximum variation in the level sent to line (measured in terms of power and ignoring the voltage) will always lie, in practical cases, as is shown below, between limits of $\pm$ 2 dB.

If we denote the value of the line impedance by $75x$ ohms (the output impedance of the amplifier being 75 ohms), x will have a value lying between say 1·0 and 8·0 in all cases met with in practice (since, as stated above, the line impedance can vary between values of 75 and 600 ohms). If n is the turns ratio of the output transformer, the line impedance referred to its primary circuit can be represented by a resistance equal to $n^2.75x$ ohms, or $30{,}000x$ ohms, connected in parallel with the (equivalent) 30,000-ohm resistance already connected across the primary of the transformer. The complete output circuit of the amplifier may therefore be represented as shown in Fig. 13.2.

If i is the total current, the current in the line will be proportional to

$$\frac{30{,}000}{30{,}000 + 30{,}000x} \cdot i$$

i.e., to

$$\frac{1}{1 + x} \cdot i$$

and the power (I^2R) in the line will be proportional to

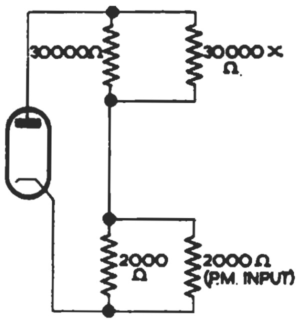


Fig. 13.2. Output Circuit (Theoretical)

$$\frac{1}{(1 + x)^2} \cdot i^2 \cdot 30{,}000x$$

i.e., to

$$\frac{x}{(1 + x)^2} \cdot 30{,}000 i^2$$

whence if i is maintained constant the power in the line will vary in proportion to

$$\frac{x}{(1 + x)^2}$$

Now, as stated, x can vary between 8·0 and 1·0, i.e., in the ratio of 8 : 1 or 9 dB ; but $\frac{x}{(1 + x)^2}$ will only vary between 0·25 and 0·10, i.e., in the ratio of 2·5 or 4 dB.

The programme meter circuit is designed so that when the meter reads 4, a power level of approximately + 4 dB (referred to 1 milliwatt) is sent to line, no matter what the line impedance may be.

It so happens that if a load of 239 ohms is placed across the output of the OBA/8, a voltage level of 0 dB indicated on the meter corresponds exactly to a power level of + 4 dB. Therefore, if the meter is lined up to read 4 when the output of the amplifier is loaded with a 240-ohm resistance, it is safe to assume that the level to line will be + 4 dB $\pm$ 2 dB, irrespective of line impedance. The setting of the output switch to the position marked +4 dB ensures these conditions.

Calibration at O.B. Point. This should be carried out only after the equipment has been switched on for about 10 minutes.

(1) Adjust the programme meter to read zero by means of the control marked *Adj. Zero.*
(2) Unplug the LSM/4, and throw the calibration switch to the *Cal.* position.
(3) Bring the programme meter reading to 4 by means of the *Adj. Sens.* control.
(4) Restore the calibration switch to *Normal.*

The programme should now be controlled so that during loud passages the meter deflects to 6 on peaks. Under these conditions a power volume of approximately +4 dB is delivered to line when the output-level switch is in the normal position, which is designated +4.

Complete Calibration. If the neon tube or AC/VP1 valve has to be replaced, an accurate calibration cannot be made at the O.B. point.

When a complete calibration is to be carried out, a tapped transformer or 'Variac' should first be inserted between the mains-supply socket and the mains input to the MU/3. The equipment should be switched on with the mains-unit input voltage adjusted to the nominal value of the supply, e.g., 240 volts, the mains voltage tap-selector switch on the MU/3 being also set to this value. Allow 10 minutes for warming up, then proceed as follows :—

(1) Set the amplifier gain control on 26 stud and terminate the amplifier in 240 ohms.
(2) Rotate the *Zero Balance* control fully clockwise. Restore the meter reading to zero using the *Adj. Zero* control.
(3) Apply 1,000-c/s tone at a level of approximately −70 dB to the amplifier input and adjust the level of the tone so that zero voltage level is obtained at the amplifier output (measured with the high-impedance amplifier detector connected across the 240-ohm terminating resistance) the output-level switch being in the position marked +4.
(4) Bring the meter reading to 4 by means of the *Adj. Sens.* control.
(5) Check whether the programme meter needle follows the scale divisions over the range from 6 to 2 when the input level is altered in 4-dB steps, two above and two below the level which causes the meter to read 4.
(6) If the calibration is incorrect :
   (i) Switch off the tone.
   (ii) *To open the scale*, i.e., if in (5) the meter reads above 2 and below 6, adjust the programme meter to read between 0 and 1 by means of the *Adj. Law* control.

   To close the scale, i.e., if in (5) the meter reads below 2 and above 6, set it to read below zero by means of the *Adj. Law* control.
   (iii) Restore zero, using *Adj. Zero* control.
   (iv) Repeat (5) and (6) as necessary.
(7) Set the *Zero Balance* control to its mid position, and restore the meter reading to zero by means of the *Adjust Law* control.
(8) Reduce the mains-unit input to 200 volts. If the meter reading rises, the *Zero Balance* control has not been rotated far enough. If the reading falls, the control has been turned too far.
(9) Restore the mains-unit voltage to normal, rotate the *Zero Balance* control a small amount in the direction as indicated in (8) above, and re-set the meter zero by means of the *Adjust Law* control.
(10) Reduce the mains-unit input volts once again to 200, and proceed as above, until varying the voltage between 240 and 200 produces no change in the zero.

At each stage, allow 20 seconds for changes in valve-heater voltage to take effect.

The programme meter amplifier itself will now be fully calibrated as regards both its law and its sensitivity. It therefore only remains to calibrate the 50-c/s supply used for calibrating it at an O.B. point and obtained from the heater supply. This is carried out as follows :—

(11) Switch off the tone and throw the programme meter calibration switch to the *Cal.* position. Then, having first ascertained that the correct mains tapping on the mains supply unit, MU/3, is being used, adjust the programme meter to read 4 by means of the *Adjust P.M. Cal. Input* control.

Mains Unit MU/3

This is a conventional circuit for obtaining an h.t. supply at 250 V d.c., 25 mA, and an l.t. supply at 4 V, 50 c/s, 3·5 A, from 50-c/s a.c. mains at any voltage between 200 and 250. An indirectly-heated double-diode valve UU/4 is used in the h.t. supply circuit.

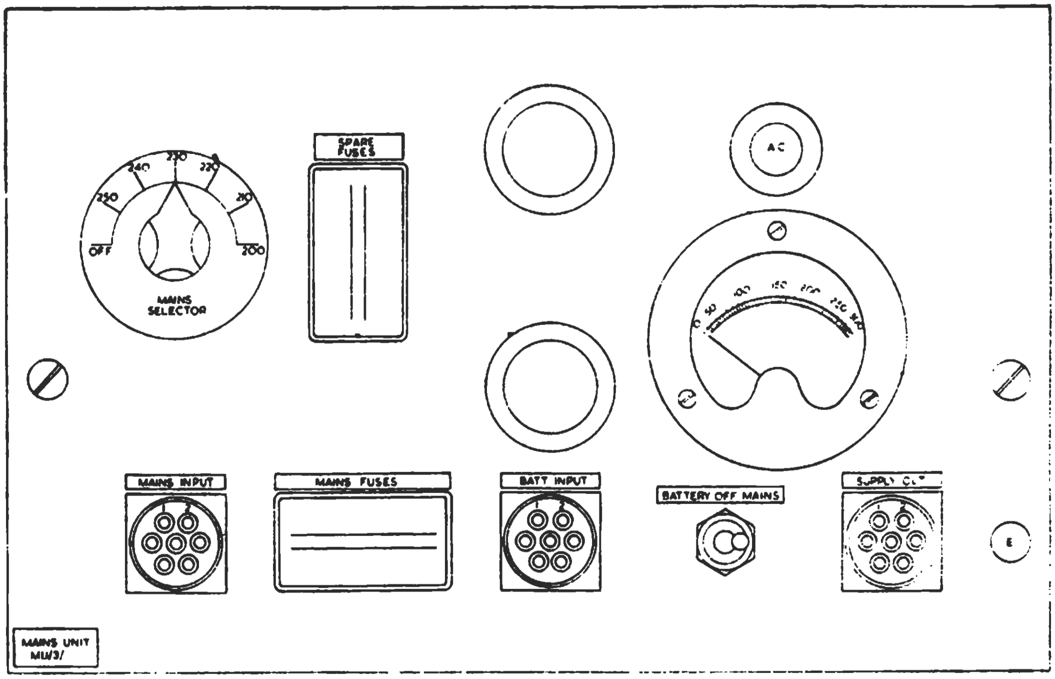


Fig. 13.3. Face Panel MU/3 and MU/3A

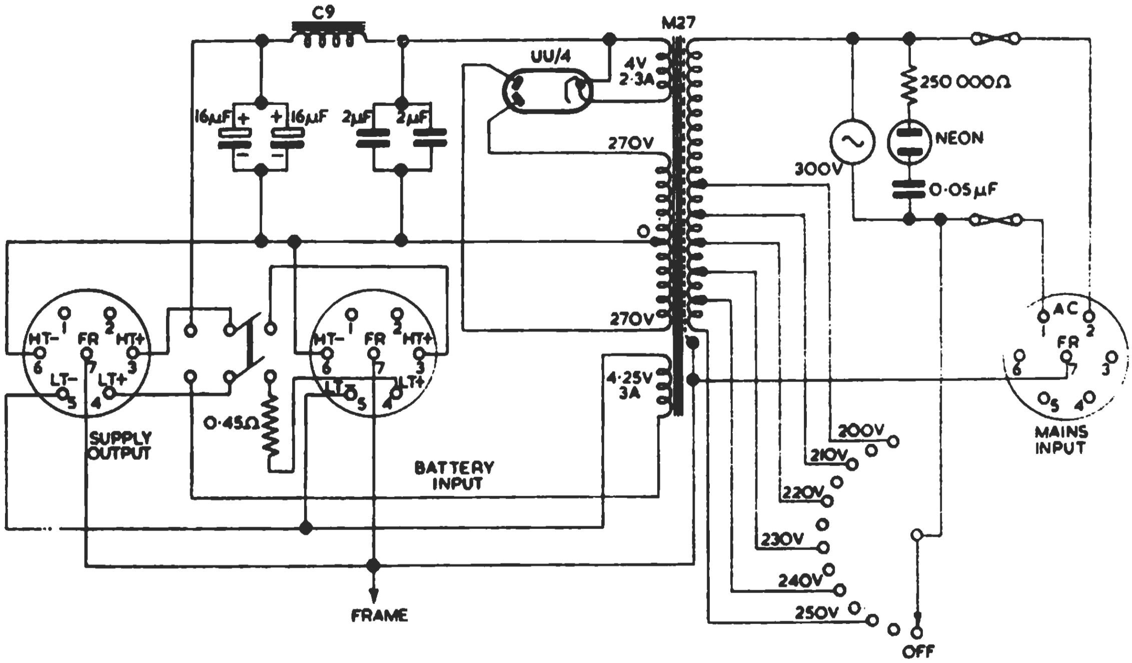


Fig. 13.4. Circuit of Mains Unit MU/3

A voltmeter is provided for reading the mains voltage and a switch for selecting the appropriate primary tapping. The selector switch has an 'off' position and is used for the mains switching on the unit. A neon indicator is connected in series with a capacitor across the mains terminals and therefore glows as soon as the unit is plugged up to the mains. The presence of the capacitor ensures that the lamp will not light if connection is made to d.c. mains, and thus serves as a warning against moving the selector switch from the " off " position which in these circumstances would result in the fuses being blown.

The stand-by battery connections are also made to the mains unit and a change-over switch is provided for connecting the output sockets either to the supplies obtained from the mains or to those obtained from the batteries. The 0·45-ohm resistance inserted in the positive battery lead is provided for dropping the voltage so as to obtain 4 V at the valve terminals of the amplifier. The main fuses, one in each leg, are carried in a plug-in type holder on the front panel, and a spare holder equipped with fuses is provided in a spare holder ready for change-over in the event of failure.

The mains unit MU/3A is similar to MU/3, but the mains transformer gives an l.t. supply of 4 V, 5 A and is designated M27c. Most OBA/8 amplifiers have MU/3A mains units.

Mixer Unit MX/18

This is a four-channel balanced series fade unit. On one leg of each potentiometer between the end of the resistor and the off stop, a high-resistance or static leak, is provided in order to preserve continuity and so prevent any difference of potential developing between the microphone line and the output circuit which might give rise to clicks when the microphone is faded up.

The arrangement of the front panel is shown in Fig. 13.5, and the circuit in Fig. 13.6. At the back of the carrying case, compartments are provided for the storage of the communication units and their connecting cable.

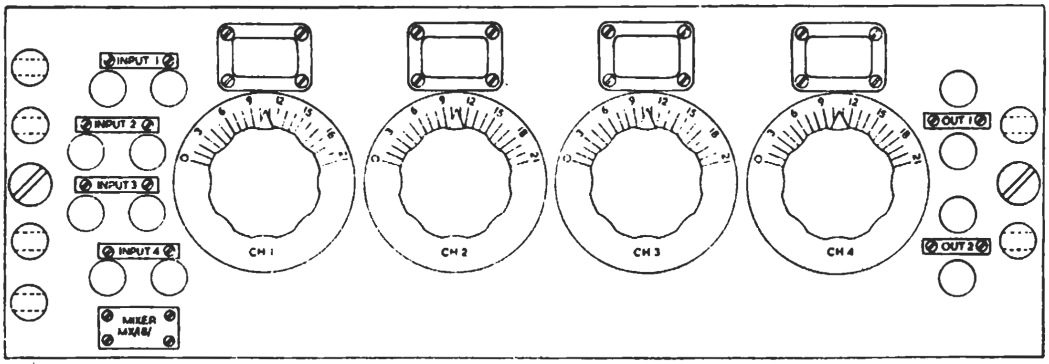


Fig. 13.5. Face Panel MX/18

Loudspeaker Unit LSU/1

The loudspeaker unit LSU/1 comprises an amplifier LSM/4, with the associated mains unit MU/7, and a loudspeaker. A block schematic of the circuit arrangement is given in Fig. 13.7. The unit is constructed as a wooden box with the loudspeaker grille in the front panel and with the back hinged about the middle of the top so that it can be raised to align with the front panel and form a large baffle. For transport purposes the loudspeaker grille is covered with an aluminium plate. The amplifier and mains units are inserted from the back and holes are provided in the front panel to give access to the volume control and the input jack on the front panel of the amplifier unit, and to enable the lamp provided on the front of the mains unit to be seen.

Loudspeaker Amplifier LSM/4 (Fig. 13.8)

For the amplifier LSM/4, a paraphase push-pull circuit is used employing two AC/SP3 valves with negative feedback and giving a power output

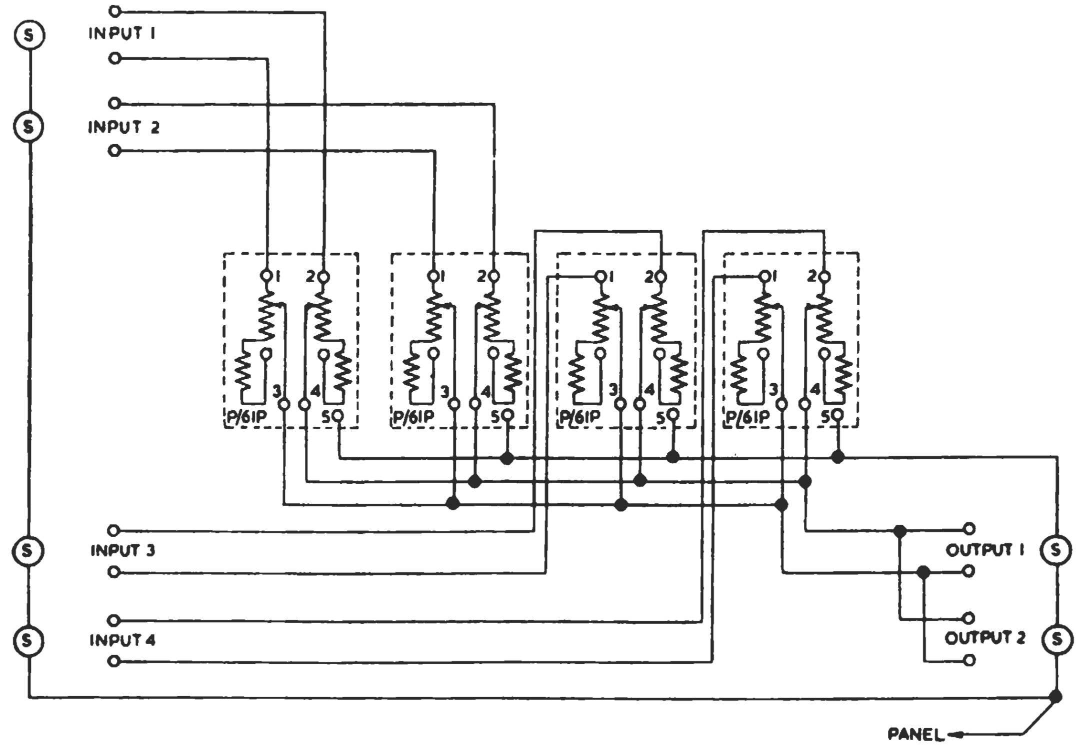


Fig. 13.6. Circuit MX/18

Fig. 13.7. LSU/1 Block Schematic

of 1·5 watts. The reason for adopting this circuit was to make possible a design of loudspeaker amplifier satisfying exacting requirements as regards gain, power output, frequency characteristic and freedom from harmonic distortion, using the same type of valves as those used in the O.B. amplifier. It should be noted, however, that an AC/SP3A is used in the first stage of the OBA/8 and an AC/SP3B in the second stage. The LSM/4 valves, which are AC/SP3A's, may be used in either stage of the OBA/8.

The input transformer has a turns ratio of 1 : 12·25 and, since the secondary is loaded with 300,000 ohms, the input impedance is 2,000 ohms. The leakage inductance in conjunction with the primary and secondary capacitances forms a low-pass filter cutting off at approximately 10,000 c/s. The input circuit is connected in parallel with that of the programme meter amplifier and the level is therefore independent of the line impedance and sending level. The input voltage corresponding to a steady tone at a power level of + 4 dB to line is approximately 0·7 V giving 8·5 V across the secondary of the transformer. But the input circuit of the valve to which this input is applied is connected to earth via the output circuit in such a way that the voltage developed across the load is fed back to the input in inverse phase.

The loudspeaker is a Wharfedale model of the permanent-magnet type with an impedance of 2 ohms. The output voltage corresponding to 1·5 watts is therefore 1·73. The output transformer has a turns ratio of 115 : 1 so that the load impedance referred to the primary side of the transformer is about 25,000 ohms, across which is developed an a.c. voltage of approximately 200 giving an a.c. current of about 7·5 mA.

The voltage actually applied to the grid of the valve is the difference between the applied input signal and the feedback voltage and, since the valve has a mutual conductance of approximately 7·5 mA per volt, the net input voltage required to

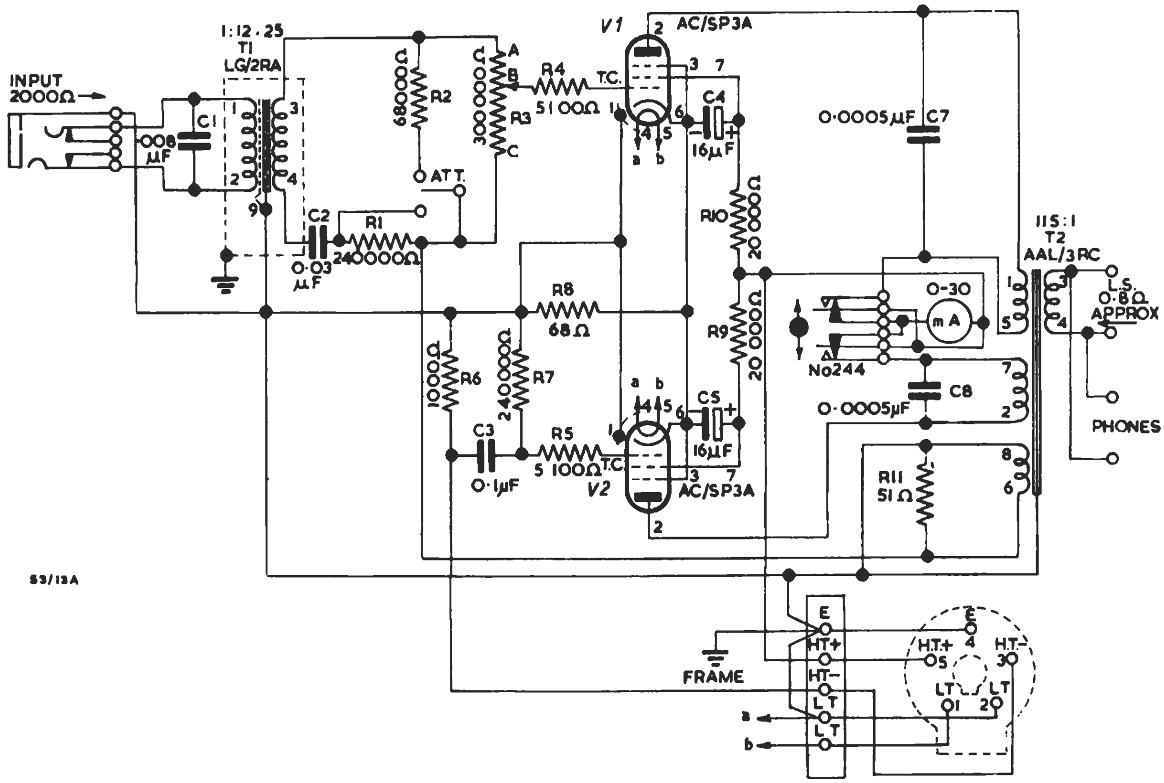


Fig. 13.8. Circuit LSM/4

give the full output is approximately 1. The output is returned to h.t. — via the common return lead which includes a 68-ohm biasing resistor and a 1,000-ohm resistor, across which is connected the grid circuit of the second valve. If the first valve were acting alone, therefore, the voltage developed across the 1,000-ohm resistance and applied to the grid of the second valve would be approximately 7·5 V in inverse phase to the input voltage applied to the first valve. This push-pull stage to the centre point of the primary of the output transformer, and a meter and key are provided, the meter at the back and the key at the side, of the amplifier, for reading either the total anode current (key normal) or the current taken by each valve. The supplies to the screen grids of the two valves are separate and are decoupled from the anodes in the usual way, but a common bias resistance is used. The result is that if for any reason the emission of one of the

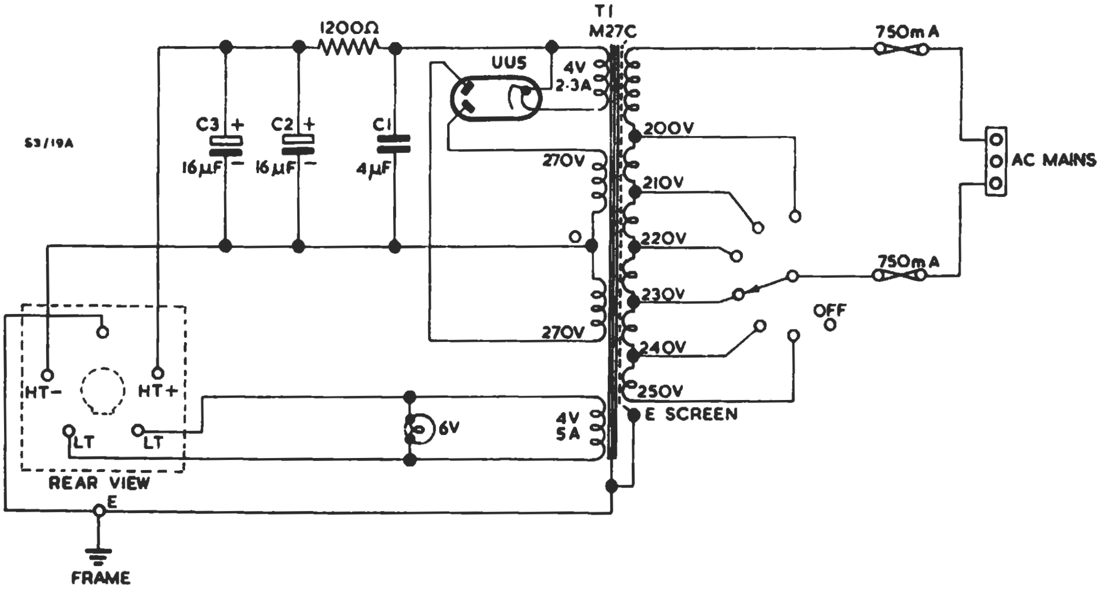


Fig. 13.9. Circuit Mains Unit MU/7

is obviously much more than is required to operate the second valve; but since the output of the latter is returned to h.t. — via the same lead, it will generate a voltage in the 1,000-ohm resistance which will oppose that due to the output of the first valve and will thus reduce its own input voltage. A condition of equilibrium will be reached in which the net voltage applied to the second valve will be slightly less than, but opposite in phase to, that applied to the input of the first valve. The two valves thus operate, in practice, as the two halves of a push-pull circuit each carrying approximately half the load.

The h.t. is applied in the normal manner for a valves should fall, the bias volts will fall and the anode current of the other valve will tend to rise. For this reason the tolerance allowed on the value of the total anode current is actually less than that allowed for the valves individually. The individual anode currents should lie between limits of 8 and 15 mA and the total anode current between limits of 20 and 26 mA.

The maximum voltage gain at 1,000 c/s available with a 2-ohm load connected to the output is approximately 13 dB, while at no frequency between 30 and 10,000 c/s does the gain differ from that at 1,000 c/s by more than ± 1·5 dB. The full gain is not, however, required for normal monitoring but is provided to facilitate checking line noise. A 15-dB attenuator comprising the resistors R1 and R2 is connected in the input circuit and is controlled by a switch designated *Att. In—Att. Out* mounted on the side of the amplifier unit. For normal monitoring the attenuator should be in circuit.

It should be observed that the arrangement adopted in the O.B. amplifier output circuit for supplying the loudspeaker and programme meter amplifier inputs (discussed on pages 13.3 and 13.4) besides ensuring that the power to line will be practically independent of the line impedance also ensures that the quality in the loudspeaker will equally be unaffected by variations of the line impedance in any particular case over the frequency range reproduced.

Mains Unit MU/7 (Fig.13.9)

The mains unit MU/7 is of conventional design and provides an h.t. supply at 300 V d.c., 30 mA and an l.t. supply at 4V, 50 c/s, 2A, from 50 c/s a.c. mains at any voltage between 200 and 250. The rectifier valve is an indirectly heated double-diode, Type UU/4 or UU/5 operating as a full-wave rectifier.

The primary of the mains transformer is provided with tappings for mains of various voltages In use, the selector switch, which is available at the back of the unit when the baffle is raised, should be *set to the corresponding tapping to that used for the O.B. amplifier.* The switch has an " off " position and is used for the mains switching on the unit. A lamp supplied from the l.t. circuit is provided on the front panel to indicate when the amplifier is switched on.

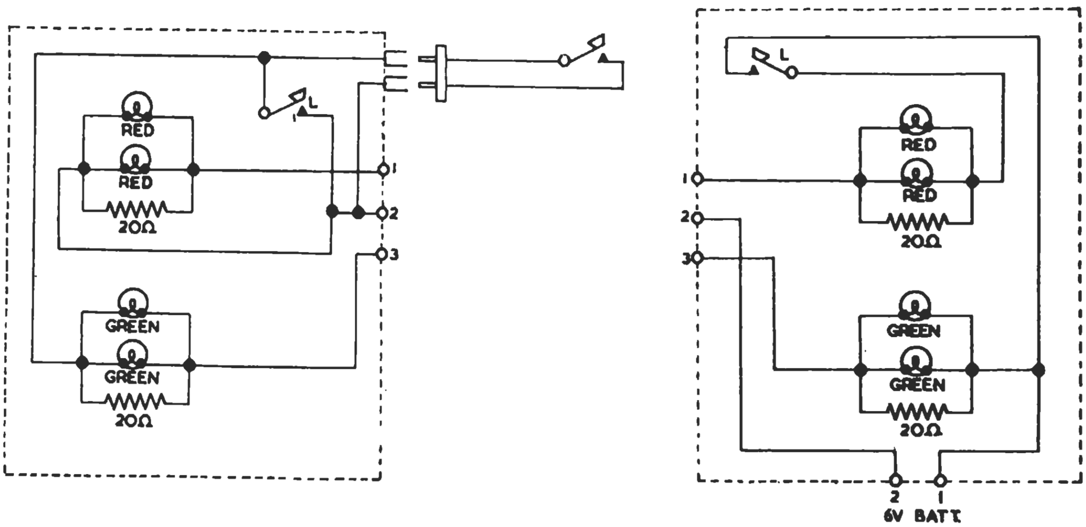


Fig. 13.10. Circuits of CMU/6 and CMU/7

Communication Units CMU/6 and CMU/7

These units are provided to enable cue-light signals to be exchanged between the mixing point and the amplifier. The unit is equipped with two red and two green lights and a push-button switch with provision for locking. The CMU/7 unit which is used at the mixing point is similar in construction except that the 6-V battery terminals are omitted and provision is made for plugging into the unit the leads of a pendant type switch as an alternative to the push-button switch to enable the unit to be operated from a distance.

The arrangement of the circuits of the two units is shown in Fig. 13.10. When the correspondingly numbered terminals of the two units are interconnected it will be seen that the red lamps of both units can be connected in series with the 6-V battery by closing the contact of the press-switch of the CMU/6 unit, while the green lamps of both units can be connected in series with the battery by operating the switch of the CMU/7 unit. Thus the red lights are used for signalling from the amplifier to the mixer and the green lights for signalling in the reverse direction. The lamps are duplicated in each case and continuity in the event of the failure of both lamps of a kind in one of the units is secured by shunting them with a resistance.

Valve Data

Stage	*Valve*	*Anode Potential*	*Anode Current*	*Screen Potential*	*Screen Current*	*Fil. Potential*	*Fil. Current*
V1	AC/SP3A	92V	1·05mA	100V	0·3mA	4·0V	1·0A
V2	AC/SP3B	210V	12·5mA	150V	5·0mA	4·0V	1·0A
V3	D41					4·0V	0·3A
V4	AC/VP1					4·0V	0·65A

Total Feed, 24 mA.

L.T. supply 4 V, a.c., 3 A. or 6 V, d.c.
H.T. supply, 250 V.
} Mains, or Battery through MU/3

General Data

Programme Meter Lamp
Osram Flashlight Lamp, focusing type, 6·5 V 0·3 A, 12-mm round bulb.

Neon Stabiliser
BBC Type S1.

Potentiometers

Adjust Sensitivity : Morganite Stackpole LHAP 50250, 5,000Ω.
Adjust Zero : Morganite Stackpole MNAP 50350, 50,000Ω.
Adjust Law : Morganite Stackpole LHAR 10250, 1,000Ω.
Zero Balance : Morganite Stackpole LHAP 50250, 5,000Ω.
Adjust P.M. Cal. Input : Morganite Stackpole LHAR 10250, 1,000Ω.
Gain Control : Painton P/63P.

Switches
Meter Switch : Yaxley Type A, 2-bank, 9-position
Output Level : Yaxley Type B12, 3-pole, 3-position.

Impedances
Normal Source : 300Ω (balanced).
Normal Input : 300Ω ± 10%.
Output : 75Ω ± 10%.
Normal Output Load : Line (100Ω – 2,000Ω) (balanced).

Normal Working Input Volume
Ribbon – 80 to – 50 dB M.C. – 70 to – 40 dB.

Normal Working Output Volume
0·5 V into 75-Ω load.

Test Input Level. (Max. Gain.)
– 90 dB.

Normal Voltage Gain
+ 86 dB when loaded with 75 Ω.

Feedback Details
P/63P 1st 8 steps 2 dB each. Cathode f.b. in stage 2 to give straight response, i.e., compensating for various circuit treble losses.

Total Percentage Harmonic Content

Frequency	*Normal working input and output levels.*	*8 dB above normal output and input levels.*
50 c/s.	< 1% total.	< 1% total.

Noise Level with Maximum Gain
– 36 dB (measured by VV).
– 42 dB (measured with 100 c/s l.p. filter).

SECTION 14

AMPLIFIERS PFL/4, 4A AND 4B

General Description

The PFL/4 is a pre-fade listening amplifier installed in TD/7A disk reproducing desks at certain stations. It comprises two separate amplifiers with their inputs connected to the output of two gramophones fitted on the desk. Provision is made for connecting headphones via key switching across the output of either amplifier. The PFL/4A and 4B are similar in construction but the 4A has a wooden baseboard and the 4B an input transformer on the secondary side of which is a loading resistance of 100,000 ohms.

Circuit Description (Figs. 33, 34)

The amplifier consists of two independent single-stage amplifiers which, with the exception previously mentioned, have neither input nor output transformers. Grid bias is automatic and jacks are provided for measuring the individual anode currents. No volume control is provided. Rectified h.t. and a.c. l.t. supplies are taken from a mains unit MU/1, common to the six amplifier units incorporated in the standard triple desk (six turntables) provided for gramophone reproduction.

Valve Data

Valve	*Anode Current mA*	*Fil. Volts*	*Fil. Amps.*	*Automatic Grid Bias Volts Neg.*
Each stage, AC/2HL	2	4	1	1

Total Feed, 4 mA.

H.T. Supply, 300 V rectified a.c.

L.T. Supply, 6 V a.c. (adjusted to 4V by series resistor).

General Data

Impedances

Input Z = infinity (PFL/4 and 4A).
Z = 10,000 Ω (PFL/4B).

Output Z = 15,000 Ω.

Normal load Z = 18,000 Ω.
(1 pair Ericsson headphones at 1,000 c/s.)

Maximum Working Voltage Gain

Test conditions:

Output loaded with 18,000 Ω and output level at zero. Frequency 1,000 c/s.

Gain of PFL/4 and 4A: 30 dB.

Gain of PFL/4B: 40 dB.

SECTION 15

TRAP VALVE AMPLIFIERS

Introduction

The function of a trap valve amplifier is to enable a given programme to be distributed to a number of selected points in such a way that a fault occurring on one distribution circuit will not affect the programme on the remaining circuits. In many cases a trap valve amplifier comprises two or more trap valves having a common input and independent outputs.

The input impedance of a trap valve amplifier is conditioned by the source impedance to which it is connected and the number of such amplifiers likely to be connected to that source. Similarly, the output impedance is conditioned by the maximum variation in load likely to be placed across it. Thus for feeding a number of Post Office lines with a given programme, a separate output is required for each line, hence a large number of trap valves may be used, each having a high input impedance and a 600-ohm output impedance. For distribution of programme to house-phone circuits, which involves the feeding of a given programme to a large and varying number of high impedance circuits, the input impedance is usually matched to the source impedance, while the output impedance is made very low to accommodate the maximum required load without affecting level conditions.

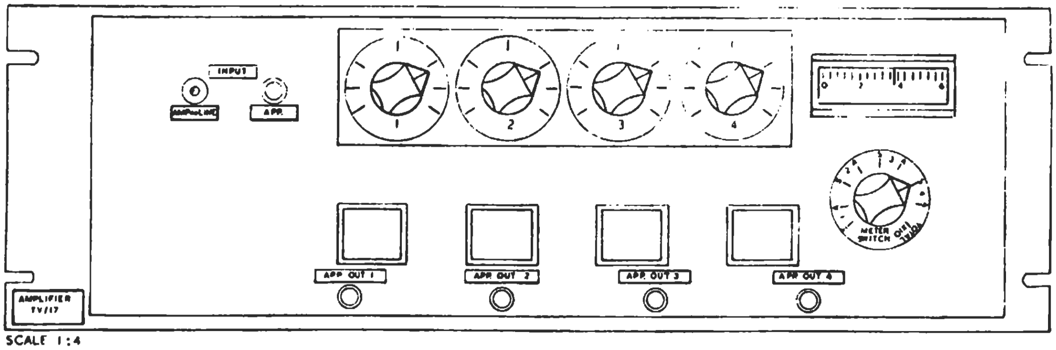


Fig. 15.1 Face Panel TV/17

Trap Valve Amplifier TV/17

The Trap Valve Amplifier TV/17 was designed as a dual-purpose amplifier for use in emergency control rooms.

Its normal function is that of a low-gain amplifier for feeding a number of Post Office lines, but it can also be used as a medium-gain level-raising or D amplifier. The condition under which it works is determined by the setting of a two-way input switch controlling an attenuator network. With the input switch in the *Amplifier* position, the unit functions as a distribution or C amplifier having an input impedance of 3,300 ohms and a gain of 6 dB. With the switch in the *Line* position, it functions as a level raiser having an input impedance of 530 ohms and a gain of 28·5 dB.

The unit comprises four trap valves having a common input, each valve feeding a separate output transformer, designed for an output impedance of 600 ohms. The TV/17 is therefore capable of performing the same function as four C amplifiers.

The programme input and output circuits are connected through a 12-pin plug and socket, the details of which are shown on the circuit diagram.

Circuit Description (Fig. 35)

The circuit comprises an input transformer feeding into the paralleled grids of four pentodes, Type AC/SP3B, the output of each pentode being fed to a separate output transformer. The input transformer is preceded by a resistance network which can be connected in two ways according to the position of the input switch. With the switch in the *Amplifier* position, a 1,500-ohm resistor is inserted in each leg of the transformer primary, the latter being shunted by a 600-ohm resistor, R2. The input impedance under these conditions is 3,300 ohms.

In the *Line* position of the input switch, the primary is shunted by the whole of the resistance network in series. The secondary winding is shunted by a 300,000-ohm resistor, R4, and four gain controls each of 300,000 ohms. The transformer impedance ratio is 1 : 100. The input impedance is therefore equal to $\frac{60,000}{100}$ ohms in parallel with 3,300 ohms, that is 530 ohms approximately. **A gain-control switch is connected in the** grid circuit of each valve which, when the amplifier is used as a trap valve for programme distribution, is normally adjusted so that the output level is + 4 dB. The primary of each output transformer is connected in the anode circuit of the valve, the secondary winding being built out to an impedance of 600 ohms by the insertion of a 200-ohm resistor, R18, R19, in each leg.

The cathode return circuit is taken through an additional winding on the output transformer by means of which 20·2 dB negative voltage feedback is applied in series with the grid-cathode circuit.

An edgewise-type feed-meter is provided with each unit, together with a multi-point rotary switch by means of which anode and screen grid currents for each stage can be obtained.

Power Supplies

Power supplies are taken from a mains unit, type MU/8A or type MU/16. Where the type MU/8A is used, two TV/17 amplifiers are fed from each mains unit.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
AC/SP3B RH	4·5	1·7	4	1

Total feed for four stages, 24·8 mA.
H.T. Supply, 250 or 300 V.
L.T. Supply, 4 V a.c.

General Data

Volume Control (4)
Type, Morganite Stackpole MNAP 30450.
Resistance, 300,000 Ω.
Meter. Elliott Edgewise. Specification No. ED 1456.
Meter Switch. Yaxley Type A, 2-bank, 9-position.
Impedances

Input Amp. Position	Z =	3,300 Ω
,, Line ,,	Z =	530 Ω
Output	Z =	600 Ω
Normal Load Line		100-2,000 Ω

Normal Working Levels

	Amplifier	*Line*
Input	+ 4 dB	− 24 to +4 dB.
Output	+ 4 dB	+ 4 dB.

Test Data

600-Ω Test Gain
Test Conditions :
Volume control set at maximum gain.
Tone Source Sending Level.
Amplifier − 1·5 dB.
Line − 24·5 dB.
Gain at 1,000 c/s.

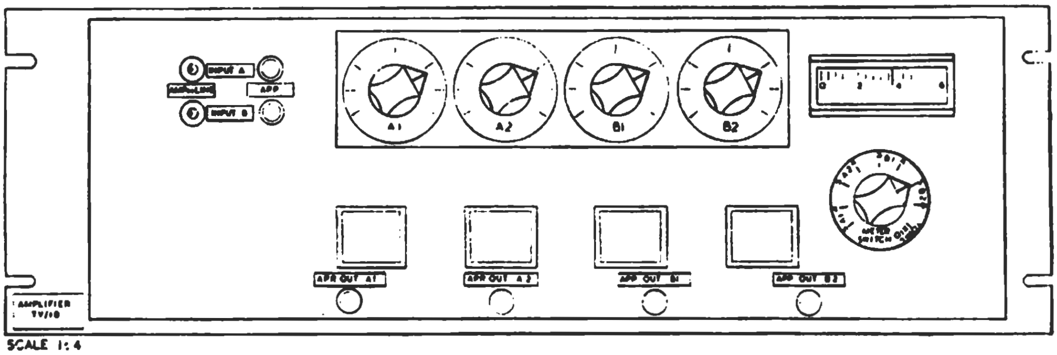


Fig. 15.2 Face Panel TV/18

Amplifier G = 10·5 dB.
Line G = 26·5 dB.
Gain at 50-10,000 c/s G = + 1 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain
Test Conditions :
Output loaded with 600 Ω and output level at + 4 dB.

		Amplifier	*Line*
Gain at 1,000 c/s	G =	6 dB	26·5 dB

Total Percentage Harmonic Content

	8 dB above normal level
100 c/s	< 1·0
1,000 c/s	< 1·0

Trap Valve Amplifier TV/18 (Fig. 36)

This unit is similar to the TV/17, except that it is provided with two inputs each of which is coupled to two output stages. The TV/18, therefore, comprises two separate amplifiers, mounted on a single chassis.

The two inputs are referred to as Input A and Input B, and the outputs as A1, A2 ; B1, B2. The secondary of the input transformer in this case is loaded with two volume controls only, hence to obtain an input impedance similar to that of the TV/17, the shunt resistance (R4) is 100,000 ohms.

In all other respects the electrical design is similar to and the unit functions in the same way as a TV/17 amplifier, but, because of its two inputs, it can be used for two programmes simultaneously, each programme being distributed to two lines or other destinations.

house-phone circuits and is used for this purpose at Broadcasting House, London.

It comprises a single push-pull stage using pentodes Type AC/SP3B. The gain of the amplifier is pre-set at zero, + 2 or + 4 dB, according to the conditions under which it is required to work.

Circuit Description (Fig. 37)

The input transformer secondary winding is fed in push-pull to the grids of the two pentodes. The winding is centre-tapped, each half being shunted by three resistors in series, from which tappings are taken to provide the pre-set gain adjustment.

The anodes of V1, V2 are connected to the h.t. supply through the split primary of the output transformer, T2. An additional centre-tapped winding on T2 provides 14-dB voltage feedback in series with the cathode circuits of the two valves. A variable resistor (R5) is included in the screen-grid circuit of V2, the purpose of which is to balance the anode feeds.

Meter Circuits

An edgewise meter mounted on the face panel can be switched across shunts to obtain individual anode and screen currents, total feed, or filament volts (d.c.).

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
AC/SP3B RH	10·0	4·5	4	1

Total feed, 29 mA.

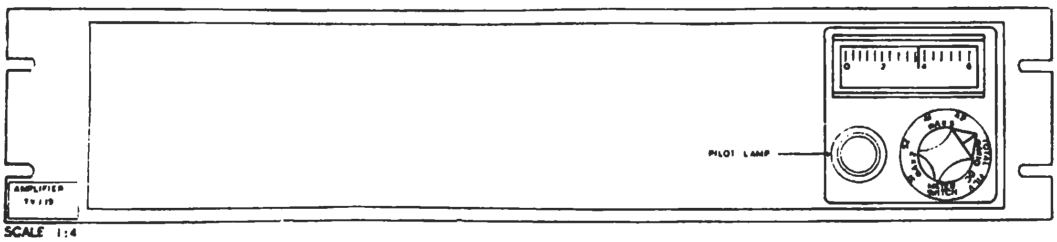


Fig. 15.3 Face Panel TV/19

The amplifier is used extensively at Broadcasting House, London. The Valve, General and Test Data are identical to the Data given for TV/17.

Trap Valve Amplifier TV/19

The Trap Valve Amplifier TV/19 was designed for the distribution of programme to multipled

H.T. Supply, 300 or 250 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Adjust Feed Control
Type, Morganite Stackpole MNAP 10350.
Resistance, 10,000 Ω.

Meter. Elliott Edgewise. Specification No. E.D. 1456.
Meter Switch. Yaxley Type A, 2-bank, 9-position.
Impedances

Input	$Z = 50{,}000\ \Omega$
Output	$Z = 5\ \Omega$
Normal Load	$Z = 12\ \Omega$

Normal Working Levels

Input	0 dB.
Output	0 to + 4 dB.

Test Data
600-Ω *Test Gain*
Test Conditions:
Volume control set at maximum gain.
Tone Source Sending Level, − 9 dB.
Gain at 1,000 c/s, G = 13 dB.
Gain at 50-10,000 c/s, G = ± 0·3 dB relative to gain at 1,000 c/s.

each having two separate outputs, so that each half of the unit is capable of feeding one programme to two Post Office lines. Each output is normally adjusted to deliver a level to line of + 4 dB by means of a variable gain control.

Circuit Description (Fig. 38)
The two sections of the TV/20 unit are referred to as A and B, the outputs being designated A1, A2; B1, B2. Since the two sections are identical, only one will be described.

The secondary of the input transformer is coupled to the grids of two single amplifying valves, AC/SP3, a volume control being included in the grid circuit of each valve. 18-dB negative current feedback is obtained from the voltage developed across R6, R7, and is applied through C2. The amount of feedback is designed to give the amplifier an overall gain of 10 dB with the volume control in the maximum position.

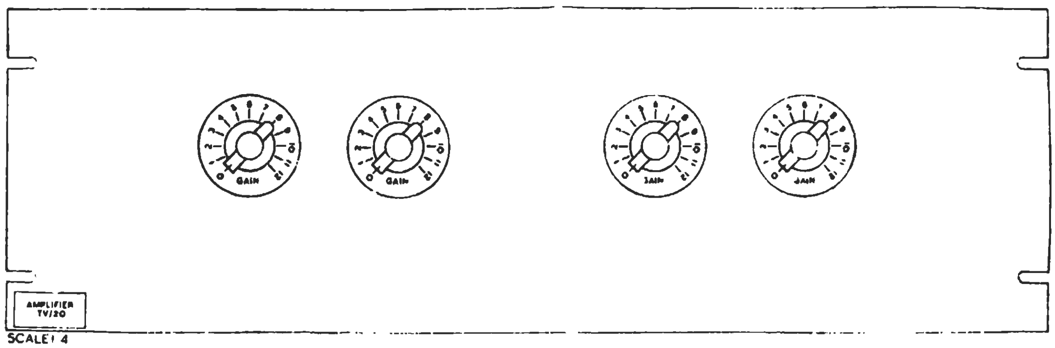


Fig. 15.4 Face Panel TV/20

Maximum Working Voltage Gain
Test Conditions:
Output loaded with 12 Ω and output level at + 4 dB.
Gain at 1,000 c/s G = 4 dB.

Total Percentage Harmonic Content

	Normal level	*8 dB above normal level*
100 c/s	< 0·7	< 1·3
1,000 c/s	< 0·4	< 1·0

Trap Valve-Amplifier TV/20
The Trap Valve Amplifier TV/20 was designed as a programme distribution amplifier and comprises two separate amplifiers on one mounting,

The TV/20 is not equipped with a feed meter and switch, but a jack is provided in each section of the amplifier for measuring total cathode current.

Where a special portable feed-meter is not available, an Avometer should be used. It should be remembered that the reading obtained will represent anode and screen currents for two valves in each case. This test is carried out by means of a single-ended cord, the blue lead (ring) of which should be connected to common negative and the white lead (tip) to the + connection on the meter. In the case of an Avominor, the white lead should be connected to the 25-mA socket, the reading being taken from the centre scale and divided by 2.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
AC/SP3B RH	9	3·5	4	1
Total per Section	18	7·0		

H.T. Supply 300 V.
L.T. Supply 4 V a.c. or 6 V d.c.

General Data

Volume Control
Type, Morganite Stackpole MNAP 20450.
Resistance, 200,000 Ω.

Impedances
Input Z = 8,500 Ω
Output Z = 580 Ω
Normal Load Z = 600 Ω

Normal Working Levels
Input 0 or + 4 dB.
Output + 4 dB or + 10 dB.

for feeding ring-main systems, comprising house-phone, loudspeaker and recording-room circuits. It normally works from zero level and delivers nominal output level of zero or + 4 dB, the gain being pre-set according to which output level is required. The input impedance is 1,200 ohms, hence, in order to maintain a terminating impedance of 600 ohms, two TV/21 amplifiers are normally tied to a 600-ohm source. In the event of an amplifier being connected independently to a 600-ohm source, the input should be loaded with a resistance of 1,200 ohms.

Circuit Description (Fig. 39)

The circuit comprises a single push-pull stage using pentode valves, Type AC/SP3B. The input transformer has an impedance ratio of 1 : 100, each half of the split secondary winding being loaded with 50,000-ohms resistance (R2, R3) which gives a theoretical input impedance of 1,000 ohms. This is increased to 1,200 ohms by the total

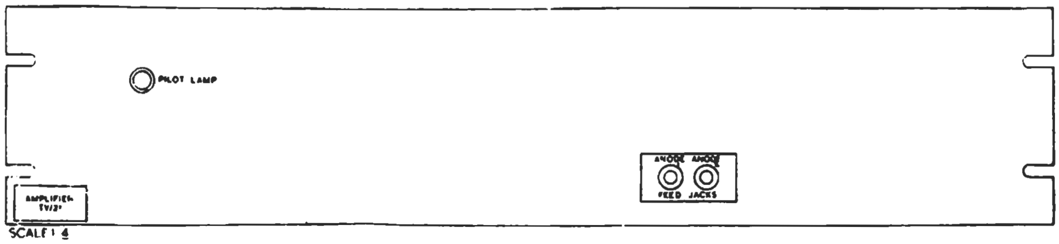


Fig. 15.5 Face Panel TV/21

Test Data

600-Ω Test Gain
Test Conditions :
Volume control set at maximum gain,
Tone Source Sending Level − 8 dB.
Gain at 1,000 c/s, G = 17·5 dB.
Gain at 50-10,000 c/s, G = ± 0·5 dB relative to gain at 1,000 c/s.

Maximum Working Voltage Gain
Test Conditions :
Output loaded with 600 Ω and output level at + 4 dB.
Gain at 1,000 c/s, G = 12 dB.

Total Percentage Harmonic Content

	Normal level (+ 10dB)	*8 dB above normal level*
100 c/s	< 1·26	< 2·4
1,000 c/s	< 0·5	< 1·3

Trap Valve Amplifier TV/21

The Trap Valve Amplifier TV/21 was designed

a.c. resistance of the two secondary windings. Grid stoppers, R17, R18, are fitted in each grid lead, the resistor being mounted inside the grid cap. The two valves are independently biased by resistors R5 and R8, the bias being applied through R7 and R10.

Negative feedback is applied as follows :—

Voltage feedback is tapped off from the potentiometers comprising R11, R12 and R13, R14, and fed to the respective grids through C2, C3. Current feedback, derived from the unde-coupled cathode resistors R5, R6 and R8, R9, is fed to the grids through the same path as the voltage feedback via C1. The total feedback obtained is either 22 dB or 26 dB according to the values of R12 and R14. These values are determined on installation according to whether a nominal gain of zero or + 4 dB is required. For zero level the value is 13,000 ohms and for + 4 dB 6,000 ohms.

The anodes of the valves are connected direct to a split-primary output transformer, T2, which has a very low output impedance. The amplifier has no permanent metering facilities. A feed jack has, however, been inserted in the positive h.t. supply lead to each anode. In the absence of a special feed-meter, feeds should be taken by means of an Avometer, as indicated in the instruction on TV/20.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
AB/SP3B RH (2)	13	4·5	4	1

H.T. Supply, 300 V.
L.T. Supply, 4 V a.c.

General Data

Impedances

Input	Z =	1,200 Ω
Output	Z =	5·3 Ω
Normal Load	Z =	10 Ω

Normal Working Levels

Input	0 dB.
Output	+ 4 dB into 10 ohms.

Test Data

600-Ω Test Gain

Test Conditions :
Tone Source Sending Level, – 2·5 dB.
Gain at 1,000 c/s, G = 10 dB.
Gain at 50-10,000 c/s, G = ± 0·2 relative to gain at 1,000 c/s.

Maximum Working Voltage Gain

Test Conditions :
Output loaded with 10 Ω and output level at + 4 dB.
Gain at 1,000 c/s, G = 4 dB.

Total Percentage Harmonic Content

	Normal level (+ 4 dB)	*8 dB above normal level*
100 c/s	< 0·2	< 1·0
1,000 c/s	< 0·2	< 0·5
1,000 c/s at 12 dB above normal level		10

SECTION 16

MAINS UNITS

Mains Unit MU/1

This mains unit is used in conjunction with TD/7 desks to supply the PFL/4 amplifier. It has a valve rectifier. (See Fig. 33.)

Mains Unit MU/3

This mains unit is used with the OBA/8 equipment and is described in Section 13.

Mains Unit MU/5

This mains unit is used with TD/3702 desks. It has a metal rectifier. (See Fig. 33.)

Mains Unit MU/7

This mains unit forms part of the loudspeaker unit LSU/1. (See Section 13.)

Mains Unit MU/8

The Mains Unit MU/8 was originally designed for use in emergency control rooms. The unit comprises two separate supply units which are identical, each providing h.t. supply of 300 V 40 mA, or 250 V 25 mA (according to the connections made on the smoothing choke C9A), and l.t. supply of 4 V 4 A.

The unit is adequately screened, and may be placed in close proximity to a high-gain amplifier without causing excessive mains hum.

Circuit Description (Fig. 40)

The mains supply is fed to the transformer primary through a double-pole switch and a pair of 750-mA fuses mounted on the front panel. The transformer primary is tapped for supply voltages between 200 and 250 volts, in steps of 10 volts. A neon indicator is connected across the mains unit side of the mains switch.

The l.t. secondary winding is tapped for voltages of 4·25 or 4·6, the latter tapping being used where the filament consumption is heavy, or where the supply leads are sufficiently long to cause excessive voltage drop.

H.T. supply is obtained from a full-wave valve rectifier of the UU/4 type.

Control over the output voltage is effected by the tapped smoothing choke. For an output of 250 volts at 25 mA the two sections of the choke are connected in series, and for 300 volts at 40 mA the two sections are used in parallel.

The arrangement of the smoothing choke tappings to meet the required conditions is shown on the circuit diagram, Fig. 40.

The mains input connector takes the form of a five-pin plug and socket, and is located at the back of the unit. The output connectors from each half of the unit are also terminated on plugs and sockets.

The back of the unit is fitted with a dust cover which cannot be removed until the mains and output plugs have been disconnected.

Facilities are provided at the back of the unit for emergency battery supplies. These consist of two l.t. and two h.t. terminals to which the batteries can be connected, and a three-pole, double-throw switch for quick change-over from mains to battery supply, the arrangement being duplicated to cater for each half-section.

Mains Unit MU/8A. (Fig. 41)

This unit is similar to the Mains Unit MU/8 but has no provision for changing over to battery supply.

In some cases, where the unit is used to feed two amplifiers, the supply to each amplifier is taken from subsidiary plugs and sockets, so that either amplifier can be isolated from the mains unit.

Mains Unit MU/16

The Mains Unit MU/16 is designed to provide rectified h.t. and a.c. l.t. supplies for amplifiers having total feeds of 80 mA or less, and filament consumption of 6 A or less. The no-load h.t. voltage is 385.

This unit is not screened and may not therefore be installed close to an amplifier.

Circuit Description (Fig. 42)

The a.c. mains supply is fed to the transformer primary through a pair of 500-mA fuses and a single-pole switch. The transformer primary is tapped for mains supplies of 200-240 volts in steps of 20 volts. Alternative tappings giving either 4·3 or 5 volts are provided on the l.t. secondary winding, the 5 volt tapping being used where a heavy l.t. load is required, or where the supply lead to the amplifier is sufficiently long to cause excessive voltage drop.

H.T. supply is obtained from a full-wave valve rectifier of the UU/4 type. The smoothing choke is tapped so that the two sections may be used in series for an h.t. load not exceeding 40 mA, or in parallel for loads between 40 and 80 mA. The connections for these adjustments are clearly shown on the circuit diagram, Fig. 42.

In cases where the total feed required is small, a suitable voltage-dropping resistor should be inserted in place of the strap connecting the positive terminals of the 16-μF electrolytic smoothing capacitors.

Mains Unit MU/20

This mains unit is used in conjunction with the Type D recorder and supplies h.t. and l.t. to the LSM/7, two AMC/2A amplifiers and two LFA/1 amplifiers. The unit is constructed on a chassis and is not intended for rack-mounting. Full details of the circuit, etc., are given in Instruction R.1.

Mains Unit MU/21

This mains unit is used in conjunction with the Type D Recorder and supplies h.t. and g.b. for the DRA/4 amplifier. The unit is constructed on a chassis and is not intended for rack-mounting. Full details of the circuit, etc., are given in Instruction R.1.

Mains Unit MU/29

The mains unit MU/29 is designed to supply the following alternative d.c. outputs:

(*a*) 30 volts at 50 mA with minimum ripple for wiping and biasing in Marconi-Stille recorders.

(*b*) 24 volts at 250 mA for operation of 24-volt relays.

(*c*) 30 volts at 250 mA.

(*d*) 48 volts at 250 mA for operation of 48-volt relays.

Output (*c*) has been found useful for continuous charging of a 30-volt clock battery.

The unit is constructed on a 4½-inch panel and the fuses, on/off switch and indicator lamp are mounted on the front. The lamp is connected in series with a variable resistor which is accessible on removing the cover.

Circuit Description (Fig. 43)

The mains input is connected to the appropriate tapping points on the primary of the mains transformer by flexible leads, and a two-pole switch and a pair of 750-mA fuses are included in the circuit. The secondary of the mains transformer is also tapped and the appropriate voltage is applied to the full-wave copper-oxide bridge-type rectifier by flexible leads. To give good voltage regulation, the pulsating d.c. output of the rectifier is smoothed by a choke-input filter and this part of the circuit includes a 500-mA fuse for protection. The smoothing choke includes two identical windings which are connected in parallel to give outputs (*b*) (*c*) and (*d*), and in series (to give better smoothing) for output (*a*) The 24-volt indicator lamp is connected across the smoothed d.c. output and the variable series resistor is included to reduce the voltage applied to the lamp when the d.c. output of the unit exceeds 24 volts.

Test Data

The performance of the unit is illustrated in the following table, which applies when the lamp resistor is adjusted to give 24 volts across the lamp for all tests.

Nominal				Test Values					
Test	Volts	Maximum output mA	Ripple	Transformer output tap	Choke connections	Load, mA	Output volts Min.	Output volts Max.	Ripple dB.
(a)	24	250	normal	36	parallel	0		29	− 6
				36	parallel	250	23		
(b)	30	50	low	36+5	series	0		32	−20
				36+5	series	50	29		
(c)	30	250	normal	36+5	parallel	0		33	− 6
				36+5	parallel	250	28		
(d)	48	250	normal	60	parallel	0		52	− 4
				60	parallel	250	45		

Mains Unit, MU/31

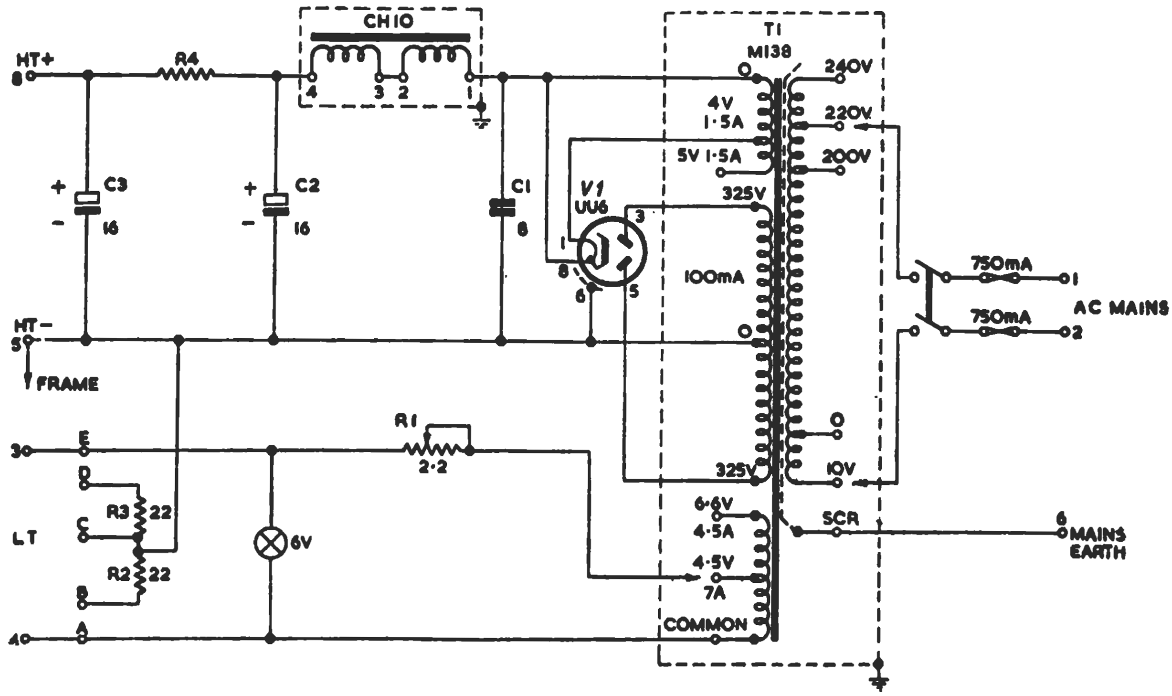
General

The MU/31 is a twin power-supply unit of panel construction designed for general use with post-war amplifiers. For each half of the unit the maximum h.t. output is 100 mA at 300 volts and maximum l.t. output 7 amps at 4·1 volts or 4·5 amps at 6·3 volts. The total output, however, should not exceed 50 watts for each half unit.

Circuit Description

The MU/31 contains two identical power packs the circuit of which is shown in the diagram. The a.c. mains input includes a two-pole on/off switch and two 750-mA fuses and the primary winding of the mains transformer is tapped for supplies between 200 and 250 volts. The h.t. secondary winding supplies 325 volts to the anodes of the full-wave rectifier V1 (type UU6) and the series arms of the π-section smoothing circuit contains a choke L1 and a resistor R4. The choke has two similar windings which are connected in series when an output current of 60 mA or less is required and in parallel for greater outputs. The value of the resistor R4 is adjusted on installation, dependent on the current required, to maintain the h.t. voltage at about 300 volts. Typical values and dissipation ratings are given in the table overleaf.

The l.t. secondary is tapped to give 6·6 or 4·5 volts and a variable series resistor R1 is adjusted to give the required 6·3 or 4·0 volts for heater supplies. The resistors R2 and R3 provide an earthed artificial centre tap of the l.t. supply by strapping A to B and D to E.



Notes 1. When LT centre tap required strap A to B & D to E
2. When parallel operation of choke is required strap choke tags 1 to 3 & 2 to 4

Fig. 16.1 Mains Unit MU/31, Circuit Drawing

Test Specification

Output Current (mA)	*R4*		*Choke Connections*	*D.C Output, volts*		*Ripple dB below 0·775 volts*
	Resistance	*Watts*		*Min.*	*Max.*	
8	15k Ω	2	Series	297	357	60
16	6·8k Ω	2	,,	293	359	58
24	3·9k Ω	3	,,	291	352	52
32	2·2k Ω	3	,,	298	353	50
40	1·5k Ω	3	,,	295	345	49
50	680 Ω	2	,,	306	330	43
60	390 Ω	2	,,	305	344	38
80	270 Ω	2	Parallel	314	355	27
100	0	—	,,	314	346	13

SECTION 17

MICROPHONE AMPLIFIER AMC/3

General Description

The AMC/3 is a unit incorporating a microphone amplifier, a peak programme meter and its associated amplifier. It was designed specially for use with the O.B. mobile f.m. transmitter Type 808 and is housed in a container measuring approximately 12½ by 11½ by 7 inches; the amplifier, together with the transmitter and receiver, constitute the three main units of the O.B. equipment. The AMC/3 is supplied with 300 volts h.t. and 12 volts l.t. (both d.c.) from the transmitter power unit and is normally intended for use with a commentator's lip-ribbon microphone.

Electrical Design (Fig.17.2)

A single pentode V1 provides all the gain necessary between microphone output and transmitter input. Normally this valve operates with about 10-dB current negative feedback but the feedback can be removed if maximum gain is required. V1 is followed by a gain control which feeds the output circuit and the P.P.M. amplifier.

The P.P.M. amplifier follows the basic circuit of the PPM/2 and PPM/6, the first valve V2 acting as a voltage amplifier and feeding a double-diode rectifier V3 via a potentiometer acting as *sensitivity* control. The output of V3 is applied to the grid of a variable-mu pentode V4, the anode current of which operates the programme meter. The bias of V4 is adjusted by a variable resistor (*zero* control) and the screen potential by a potentiometer (*law* control).

Mechanical Design

The four valves and most of the components, including the P.P.M. *adjust law* control, are mounted on a horizontal steel plate which is carried on flexible rubber supports attached to a four-sided steel chassis. A recessed vertical panel (Fig. 17.1) at one end of the chassis carries the peak programme meter, the P.P.M. *zero* and *sensitivity* controls (the latter being provided with a locking device), a variable gain-control, gain switch and the input terminals. The electrical connections between the components on the vertical panel and the amplifier are made with flexible wire so that the amplifier may move freely on the rubber supports. The valves are thus fully floating and are reasonably protected against the mechanical shocks which mobile equipment is likely to receive; the rubber mountings also reduce the chances of superimposing ringing noise on the programme if the equipment is subject to knocks or vibration during transmission. The AMC/3 is normally fitted with a cover secured to the chassis and to the vertical panel by screws, which must be removed to change a valve or adjust the law of the programme meter; access to the underside of the amplifier can be obtained by sliding a cover plate from the bottom of the chassis.

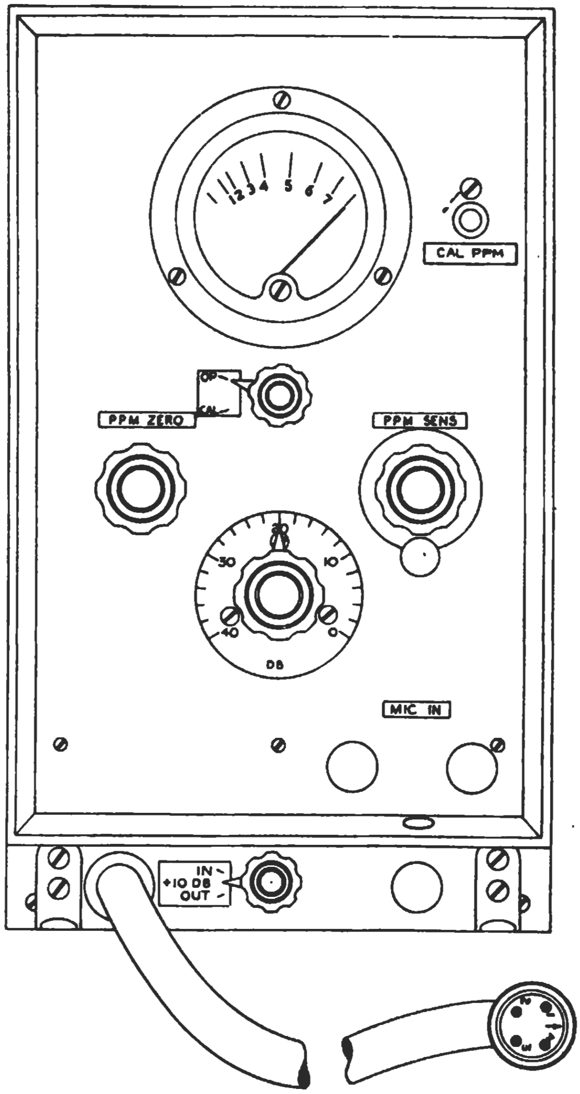


Fig. 17.1 Amplifier AMC/3: Face Panel

The output circuit of the microphone amplifier together with the h.t. and l.t. supplies are carried by a cable which passes through the front panel of the unit and terminates in a 4-pin plug which is inserted in a socket on the transmitter unit.

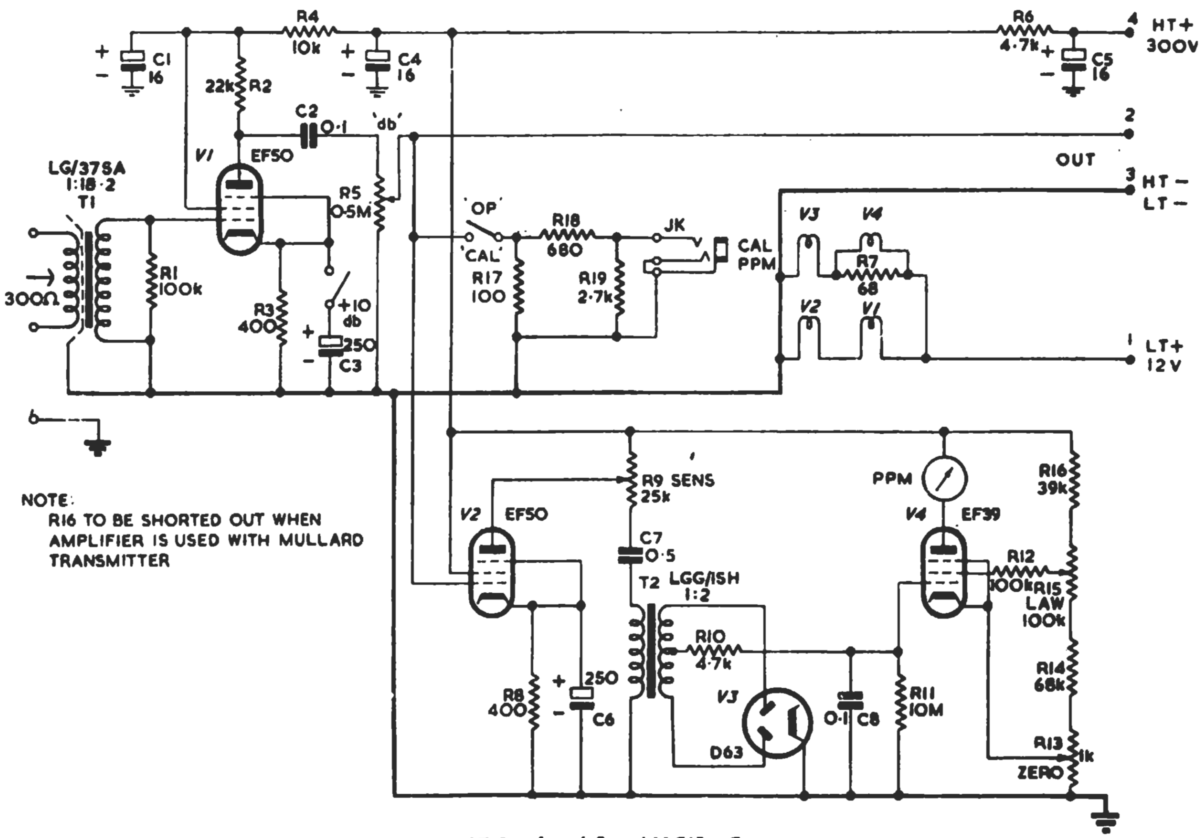


Fig. 17.2 Amplifier AMC/3: Circuit

obtained when required by operating the switch marked +10 *dB* which removes the feedback by connecting a 250-μF capacitor C3 across R3. The h.t. supply for V1 is smoothed and decoupled by the components C5, R6, C4, R4, C1 and the

Circuit Description (Fig.17.2)

The microphone amplifier section consists of a single pentode, type EF50, with a transformer input and an **RC-coupled** output circuit. The turns ratio of the input transformer T1 and its secondary load R1, are chosen to give the unit a 300-ohm balanced input impedance so that the amplifier may be used with any of the standard BBC microphones. The input to the transmitter and the P.P.M. amplifier are both taken from the slider of the stud-type gain-control potentiometer, labelled *dB*; this introduces a loss of 0–38 **dB** as indicated on the engraved scale (Fig. 17.1), with infinite attenuation on the bottom stud (marked 40). V1 normally operates with about **10-dB** current negative feedback provided by the 400-ohm cathode resistor R3 but maximum gain can be

heaters of V1 and V2 are connected in series and fed from a 12-volt d.c. supply in the transmitter.

The first stage of the P.P.M. amplifier is a pentode, type EF50 (V2), which amplifies the signal received from the output circuit of V1. The cathode circuit of V2 includes a bias resistor R8, decoupled by C6, and the screen is fed directly from the h.t. supply. The output of V2 is coupled to the next stage by a parallel-fed transformer T2, the anode circuit of V2 being connected to the slider of the potentiometer R9 which acts as anode resistor. Thus the anode load and the gain of V2 can be controlled by adjustment of R9. The magnitude of the signal fed to the next stage depends on the setting of R9, which is therefore the *sensitivity* control. This circuit enables the gain of V2 to be varied without appreciably altering the effective source impedance to which the primary winding of T2 is connected.

The second stage is a double-diode rectifier, type D63 (V3), the anodes of which are connected to the secondary winding of T2. When V3 conducts, the centre tap of the secondary winding goes negative and the negative potential is applied to the grid of V4 via the series resistor R10 and the two shunt components C8, R11. The time constant of C8, R11 is one second, a value suitable for operation of the P.P.M. V4 is a variable-mu pentode, type EF39, the anode current of which passes directly through the programme meter. A series bleed circuit composed of R13 to R16 is connected across the h.t. supply and the cathode of V4 is returned to the slider of R13 and the screen to the slider of R15. The setting of R13 controls the grid bias and hence the anode current of V4; the anode current, in turn, affects the reading of the P.P.M. R13 is adjusted with no signal input to give zero reading on the P.P.M. and is therefore labelled *zero*. The setting of R15 controls the screen potential and the g_m of V4. R15 thus decides the change in anode current for a given increment in grid potential and is adjusted so that a 4-dB change in grid potential gives a movement of 1 scale division on the P.P.M. R15 is thus known as the *law* control but it affects the anode current in addition to the g_m and when it is adjusted the *zero* control requires adjustment as well.

The heaters of V3 and V4 are connected in series and fed from the 12-volt d.c. supply in the transmitter. The heater of V3 consumes 0·3 amp and that of V4 consumes 0·2 amp; a 68-ohm resistor R7 is therefore connected across the heater of V4 to bring the current for both valves up to 0·3 amp.

P.P.M. Calibration

(1) Throw the *Op./Cal.* switch to *Cal.*

(2) Set the *dB* control anywhere between 0 and 30 on the scale. (If the setting of the control is not within these limits, the P.P.M. input circuit is shunted by an unsuitably low value of R5.)

(3) Adjust the P.P.M. reading to zero by means of the *zero* control.

(4) Apply 1-kc/s tone at zero level to the *Cal. P.P.M.* jack. (The 600-ohm loss-pad R17–R19 attenuates the tone level at V2 grid and across output terminals 2 and 3 by 18 dB, thus simulating to within 2 dB the normal test output level to the transmitter of −20 dB.)

(5) Adjust the P.P.M. reading to 4 on the scale by means of the *sensitivity* control.

(6) Check that the meter law is correct by applying tone at levels of −8, 0 and +8 dB. The corresponding meter readings should be 2, 4 and 6 on the scale.

(7) If the law is incorrect, proceed as follows:
  (*a*) If the scale is too cramped, i.e., if the meter reads above 2 and below 6:
    (i) Remove the tone-input plug.
    (ii) Rotate the *zero* control until the meter reads between 0 and 1.
    (iii) Bring the pointer back to zero by means of the *law* control.
    (iv) Repeat operation (6) and continue with the adjustments until the law error is reduced to a minimum.
  (*b*) If the scale is too open, i.e., if the meter reads below 2 and above 6, proceed as in (*a*), except that in test (ii) the meter should be set to read **below** zero in the no-signal condition when adjusting the *zero* control.

(8) Return the *Op./Cal.* switch to *Op.*

General Data

Total Feeds
H.T.—15mA at 300 volts
L.T.—0·6A at 12 volts (d.c.)

Impedances
Normal Source—300Ω (balanced)
Input—300Ω (balanced)
Output—250 kΩ approximately (unbalanced) variable depending on gain setting
Output Load—0·5 MΩ (unbalanced)

Test Data

Gain, 61 dB with +10 *dB key* in and 51 dB with +10 *dB key* out

Normal Test Output Level, −20 dB

Total Percentage Harmonic Content
1% at 16 dB above normal test level

Frequency Characteristic
Within ±0·5 dB from 60 to 8,000 c/s.

SECTION 18

AMPLIFIER C/8 AND OUTGOING BAYS

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.

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.

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.

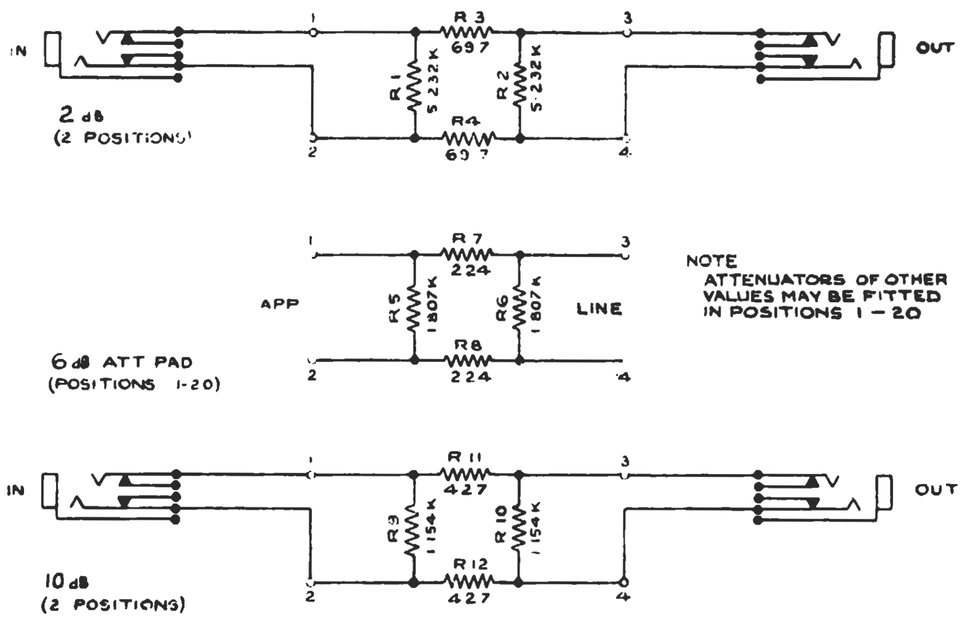


Fig. 18.1. Attenuator Panel AT/24

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

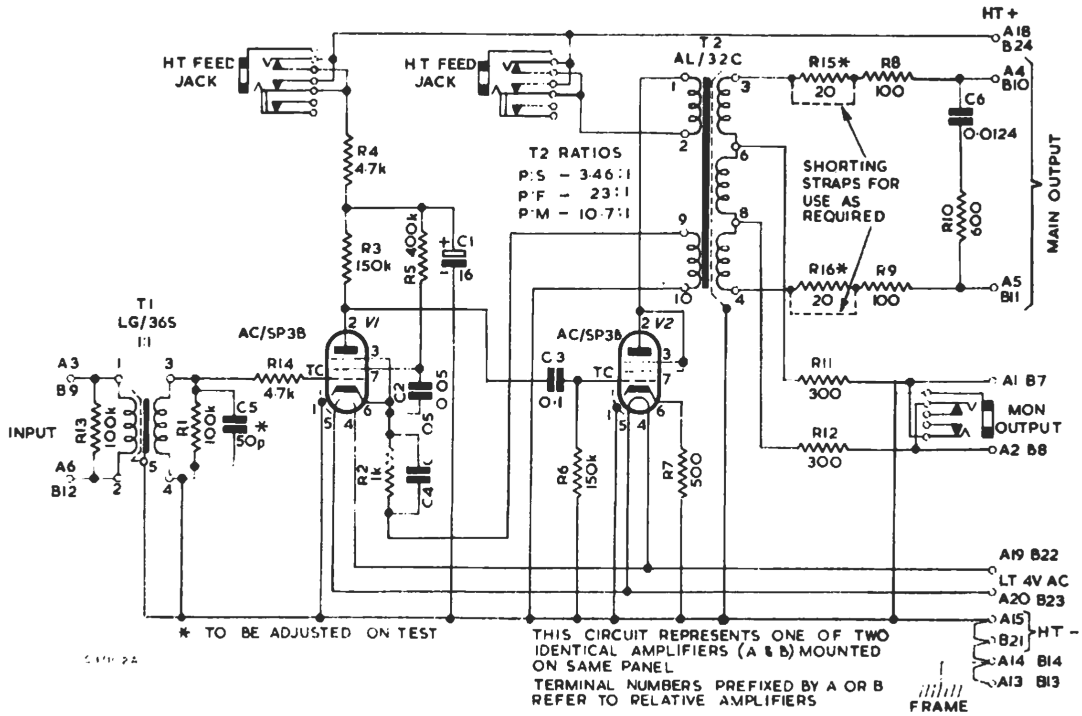


Fig. 18.2 ***Amplifier C/8***

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

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.

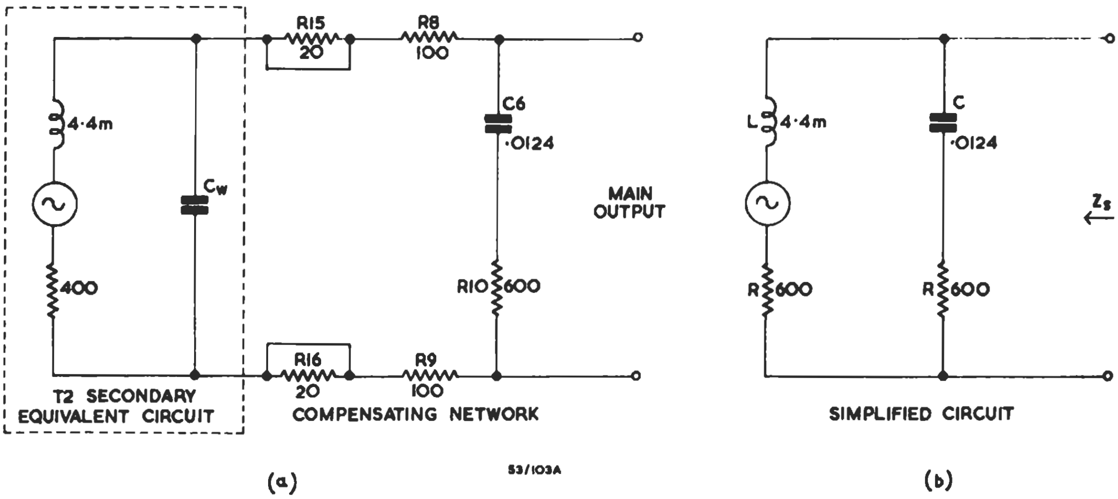


Fig. 18.3 Amplifier C/8 : Equivalent Output Circuit

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 $\omega/2\pi$

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

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

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

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

$$= G_1 + jB_1.$$

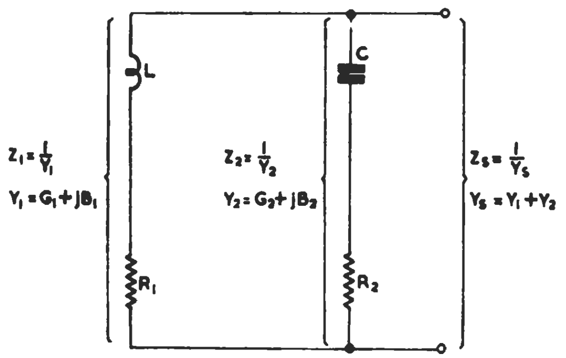


Fig. 18.4 Two-branch Parallel Circuit

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

$$- B_1 = B_2, \ i.e.,$$

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

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.

SECTION 19

LIMITING AMPLIFIERS LIM/5 AND LIM/5A

Introduction

The Limiting Amplifier LIM/5 has been developed to supersede the Limiting amplifier LIM/2, certain components of which are now obsolescent. The design of the LIM/5 follows closely that of the LIM/2, the chief difference being that the LIM/5 is designed to work with zero volume input, and to deliver zero volume output; the LIM/2 works with an input volume of −23 dB and delivers an output volume of −23dB, necessitating a separate amplifier to raise this volume to zero. The use of miniature valves and components has led to a considerable reduction of size in the LIM/5, which is constructed on a 4½-inch panel, for double-sided bay mounting. The incorporation of an amplifier to provide zero volume output eliminates the necessity for the separate output amplifier mentioned above.

The LIM/5 itself is intended for use on 22⅛ in. bays, the LIM/5A being used with 19-in. bays. Other differences between the two amplifiers are very slight, and are indicated in the footnotes to Fig. 46.

General Description

The LIM/5 comprises a variable-gain push-pull amplifier preceded by a variable attenuator, together with a side chain providing the bias voltage for reducing the amplifier gain at excessive peak volume, and an output amplifier.

Variable-mu pentodes are used in the variable-gain amplifier, because the mutual conductance of this type of valve decreases smoothly with increased bias, and vice versa; the gain of the stage can thus be controlled by means of a d.c. potential. This potential is provided by the side chain, which is fed from the output of the variable-gain amplifier. No bias is applied until the peak output signal from the variable-gain amplifier exceeds the pre-determined value; when however, this value is exceeded, control bias is applied to reduce the amplifier gain. The control bias increases very rapidly with increased amplifier output, so that, in practice, the output signal can only exceed the pre-determined value by a very small amount. The side chain is fed from the output of the amplifier to prevent any possibility of over-control (i.e. decreased output with increased input) which might occur if the side chain were fed from the input to the variable-gain amplifier.

The time constants associated with the control-bias supply circuits have been chosen with some care. The charge time constant is relatively short, and the discharge time constant (which can be varied to suit particular applications) is relatively long. Thus when the input signal peak amplitude exceeds the pre-determined value, the gain of the amplifier is reduced rapidly; when the signal amplitude falls back below the limiting value, the gain of the amplifier returns slowly to its normal value. The charge time constant is, however, sufficiently long for very sharp peaks to be passed without the amplifier gain being appreciably reduced. These peaks will be of such a transient nature that the distortion produced will not be detected aurally, and by allowing this condition, mean modulation can be maintained at a higher level than if the charge time constant were very short.

The discharge time constant can be varied by means of the timing switch. If a very long discharge time is selected, the limiter will tend to behave as an automatic maximum-level-setting device. If, however, the discharge time constant is short, the limiter behaves as a compressor, cutting back peak levels, and restoring gain rapidly in the intervals between peaks. If it is required to use the limiter deliberately as a compressor the attenuator control at the input is adjusted to a higher setting; the input signal amplitude at the input of the variable-gain amplifier is consequently increased, so that limiting commences at a lower volume of input signal, although maximum output volume remains substantially unaltered. The effect is to reduce the over-all dynamic range.

To facilitate removal and replacement of the unit, the power supply and programme connections are made through a single multi-way socket at the rear of the panel.

Circuit Description

The circuit of the LIM/5 comprises three sections, the variable-gain amplifier, the side chain and the output amplifier. A circuit diagram of the complete unit is shown in Fig. 46.

Variable-gain Amplifier (*Fig.*19.1)

This section of the LIM/5 comprises the push-pull valves V1 and V2, and their associated components. The input signal is applied to the primary winding of the transformer TR1 through the

12-db attenuator pad formed by R1-R4. The input impedance of the amplifier at the primary side of the transformer is approximately 600 ohms, and the attenuator has a transfer impedance of this value so that the same impedance is presented

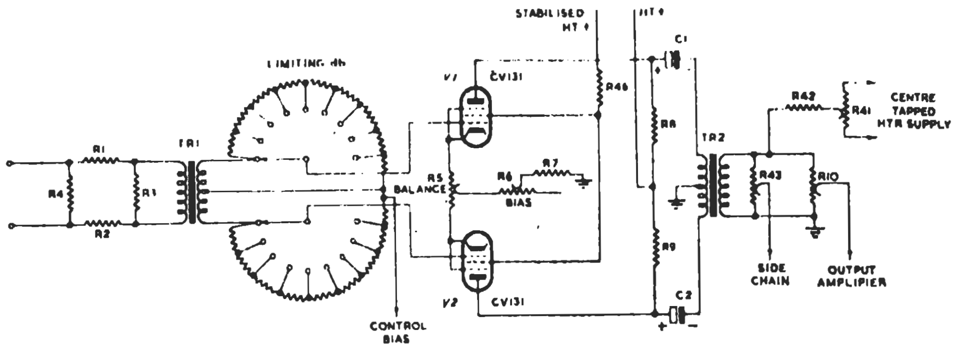


Fig. 19.1 Variable-gain Amplifier

at the input of the attenuator. The centre-tapped transformer has an over-all ratio of 1 : 1, and its secondary winding feeds the variable stepped attenuator controlling the inputs to the grids of V1 and V2. The centre point of the attenuator is connected to the mid-point of the transformer secondary winding, and this point is connected to the control-bias source. The attenuator is variable in eight 2-dB steps, and is designated *Limiting dB*. Its total resistance is 528 ohms, which together with the resistance of the transformer secondary winding presents the required value of 600 ohms. In its position of maximum attenuation, the input at each valve grid is approximately 34 dB below input level. This figure comprises 28 dB from the fixed and variable attenuators, and 6 dB from the step-down ratio of the transformer.

In addition to reducing greatly the magnitude of even-harmonic components of distortion, the use of a push-pull stage also lessens the magnitude of the plop which occurs in the output when the control bias is applied; with a single valve, this plop would be audible. Resistor R5 is included in the cathode circuits of V1 and V2 to compensate for slight differences between the individual valves V1 and V2. By means of it, the grid bias applied to the valves may be varied differentially within narrow limits. The position of the slider is adjusted so that the mutual conductances of the two valves are equal; the changes in the anode current in the two valves arising from the application of control bias will then be equal and, since they are applied to the output transformer TR2 in opposite phase, no output will appear across the secondary winding from this cause. In practice, perfect balance is not obtainable, but the degree of unbalance can be reduced to negligible proportions.

Common bias for the two valves is provided by the variable resistor R6; R7 is a meter shunt by means of which the total feed for the two valves can be measured.

The output from V1 and V2 is fed to the primary winding of the shunt-fed transformer TR2, which has a primary/secondary impedance ratio of 1 : 8 overall. The gain controls R10 (output amplifier, labelled *Output Level*) and R43 (side chain, labelled *Limiting Level*) are connected across the secondary winding of the transformer. The non-earthy end of the transformer secondary is connected via R42 to the slider of the potentiometer R41 (*Hum Bal*) connected across the centre-tapped heater supply. The purpose of this is to reduce the hum produced by the heaters of V1 and V2 which appears in the output. By adjustment of R41 a hum voltage of anti-phase polarity and equal magnitude can be injected in parallel with the output from the amplifier, to reduce the hum level to negligible proportions. This arrangement has been adopted as the normal potentiometer technique is not satisfactory, since in general, the setting of the control for minimum hum from one valve would not be the same as that required for the other.

Side Chain (*Fig.*19.2)

The input signal to the side chain is derived from the pre-set potentiometer R43, connected across the output of the variable-gain amplifier. The signal is applied to the grid of the amplifying stage V3b, the output of which is fed to the primary winding of the shunt-fed transformer TR4. The transformer has an impedance ratio of 1 : 8 overall, and its secondary winding feeds the full-wave rectifier unit comprising MR1, MR2 and R24. No capacitance is connected across R24, so that the signal applied to the grid of V5a is a copy of the input signal, with the negative-going portions of the signal reversed in polarity.

The additional resister R26 in the anode circuit of V5a and the associated capacitor C14 are used to correct a tendancy to instability in certain unbalanced conditions.

From the anode circuit of V5a, the negative-going pulses are fed via R34 and C8 to R35. In parallel with R35 is connected the diode V7 and the capacitor C9; C9 is charged negatively when the cathode of V7 is negative with respect to its

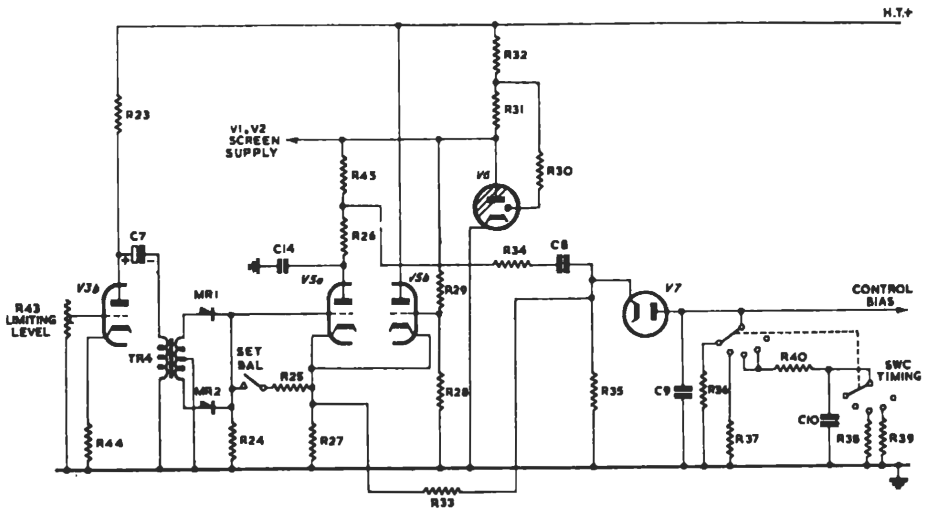


Fig. 19.2 Side Chain

Valve V5a is normally held non-conducting by the positive bias applied to its cathode by current flowing through R27. This current is supplied by valve V5b, the grid of which is held at a positive potential relative to earth by the voltage drop across R28, which forms part of a potential divider R29, R28, connected across a source of stabilised voltage, V6. The grid bias applied to V5a in this manner is about —20 volts, approximately 15 volts beyond cut-off.

When a signal is applied to the input of the side chain, positive-going signals will be applied to the grid of V5a, and if the signal amplitude is sufficiently great, the valve will conduct. The resultant current flowing through the anode load resistor R45 will produce negative-going pulses, which are utilised to provide the control bias for valves V1 and V2 of the variable-gain amplifier as described later.

anode. The charging time constant is determined by the values of R34, R35, C8 and C9 and the forward resistance of V7; it is such that on transient pulses C9 does not charge appreciably, and the gain of V1 and V2 is thus not materially reduced when isolated transient peaks are applied to the input.

The cathode of V7 is returned via R33 to the common cathode circuit of V5a and V5b, and by the potentiometer action of R33 and R35, the cathode of V7 has a positive bias applied. The purpose of this bias is twofold. Firstly, if no bias were applied, a voltage would appear across V7 in the absence of a signal due to the random arrival of electrons at the anode. This voltage, which would make the anode of V7 negative with respect to its cathode, would be shared between R35 and the resistor in parallel with C9, selected by the *Timing* switch, and there would consequently be a control bias applied to V1 and V2 in the absence of an input signal. Further, this voltage, of the order of 1 volt, would be liable to wide changes with variations of filament voltage. The application of positive bias to the cathode of V7 (about 2 volts) eliminates this standing bias, since random electrons will no longer arrive at the anode.

Secondly, the cut-off voltage of V5a varies with individual valves, and the commencement of limiting action, if determined by the voltage at which V5a begins to conduct, would be subject to variation. Since, however, V7 does not begin to conduct until the voltage applied to its cathode exceeds 1 volt approximately, the commencement of limiting action is not so dependent upon the exact value of grid bias at which V5a begins to conduct.

The recovery time constant of the control bias is determined by the magnitude of C9 and the discharge resistor selected by means of the *Timing* switch. The switch has four positions. In the first position, where R36 is selected, the recovery time constant is approximately 0·5 seconds. In this position recovery after overload is rapid, and is suitable therefore where the limiter is used for compression. In the second position, where R37 is selected, the recovery time constant is 2·5 seconds.

In the third position, the first of two more complex discharge circuits is introduced. If an overload of short duration occurs, C9 charges, but C10 does not, since its charge time constant is about 2 seconds. At the end of the overload period, the charge on C9 is shared with C10, and since C10 is much larger than C9, the control bias falls fairly rapidly as C10 charges, to a value of approximately 1/9th of its initial value. The time constant of this charge is approximately 0·1 seconds, determined to a first degree of approximation by the magnitude of C9, C10 and R40. The control bias then returns slowly to zero value as C9 and C10 discharge through R38, the time constant being approximately 40 seconds. If, however, a sustained overload, or a series of short duration overloads in quick succession, occurs, C9 will charge rapidly as before, and C10 will also be charged, but more slowly. When the overload period ends, C9 and C10 will be at approximately the same potential, and consequently C9 will not discharge into C10. The control bias will then die away slowly, the recovery time constant being approximately 40 seconds. In this position, therefore, the limiter differentiates between short isolated overload periods, and sustained overload periods. In both instances, gain is reduced during the overload period, but in the first instance recovery is rapid, whilst in the second, recovery is prolonged.

In the fourth position, the behaviour of the circuit is similar to that in position 3, except that the recovery time constant is nominally 16 minutes; in this condition the limiter behaves as an automatic maximum-level-setting amplifier.

To assist in the operation of equalising the mutual conductances of V1 and V2, a "set-balance" key is fitted in the grid circuit of V5a. When the key is pressed, the grid of V5a is connected to cathode, so that the valve condition changes rapidly from non-conducting to fully conducting, simulating the application of a severe transient overload. The control bias then changes rapidly from zero to maximum value, producing an audible "plop" at the output. This "plop" can then be reduced to a minimum value by adjustment of R5.

Output Amplifier (Fig. 19.3)

The output amplifier comprises V3a driving valves V4a and V4b, a cathode-coupled push-pull output pair. The overall gain is 18 dB; negative voltage feedback (15 dB) is applied from a tertiary winding of the output transformer TR3 to the cathode of V3a; capacitor C4 is included in parallel with the anode load of V3a to ensure that the amplifier remains stable at high frequencies. Resistor R21 is connected in series with the secondary winding of the transformer TR3, so that together with the secondary winding resistance and amplifier output impedance, the output impedance is equal to 600 ohms.

The push-pull stage is noteworthy for the cathode coupling arrangement adopted. The two cathode-load resistors are connected by means of the capacitor C5, and by virtue of the low impedance of the capacitor at all frequencies in the working range, the circuit behaves as if V4a and V4b shared a common cathode-load resistor, equal to the value of R17 and R15 in parallel. The grid of V4b is decoupled to earth by C6, and the stage therefore functions as a normal cathode-coupled pair to applied a.f. signals.

The grid leak of each valve is not, however, returned to a tapping point on its own cathode load, but to the corresponding point on the cathode load of the other. The purpose of this is to ensure that the currents through both valves are as nearly equal as possible, so that polarisation of the core of the output transformer is reduced to a minimum.

The action of the circuit is as follows. If the current through valve V4a increases for any reason, the cathode potential of V4a increases, and the grid potential of V4b also increases. Consequently the cathode potential of V4b will also rise by cathode-follower action, and as its cathode load is very large, the rise in potential will be almost equal to the rise in grid potential. To produce this increased potential, the V4b anode current must therefore have increased by a value almost equal to the rise in V4a. The rise in potential of the cathode of V4b will also be communicated to the

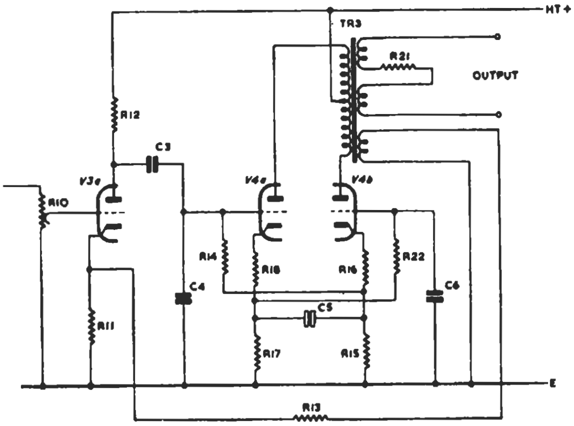


Fig. 19.3 Output Amplifier

grid of V4a, and since this rise is less than the rise in cathode potential of V4a, the grid-cathode voltage of V4a will have increased negatively, tending to reduce the anode current of V4a. The system therefore also stabilises both valves against individual anode-current changes, as well as ensuring equality of anode currents. For successful operation, the cathode resistors must be closely matched.

Operating Instructions

1. *Feeds*

Switch on mains unit and allow at least five minutes warming-up period to elapse. Check with feed meter that the anode currents of valves V4a and V4b are equal within 0·3 mA. If this equality does not occur, a faulty valve or other component is indicated.

Adjust the *Bias* control to give a reading of 8 mA for the total cathode current of valves V1 and V2.

2. *Hum*

Set the *Output Level* control to maximum and with an amplifier detector at high gain connected to the limiter output, adjust the *Hum Bal.* control to give minimum hum output, which should be not greater than −40 dB into 600 ohms. A rare specimen of CV 131 may not allow this, in which case the valve must be rejected. This adjustment is necessary only at long intervals or when a CV 131 valve is replaced.

Note: For the *Hum Bal.* control (R41) to function correctly, it is essential that an earthed centre-tap be connected across the heater supply; if this arrangement is not provided on the type of mains unit in use, one of the following measures should be adopted:

(a) If the heater supply is floating, two 47-ohm resistors should be connected across it in series, and their junction taken to earth.

(b) If the heater supply is already earthed on one side, this earth should be removed and replaced by the arrangement described under (a), unless the existing earth is essential for other equipment taking a heater supply from the same mains unit.

(c) If it is not permissible to disconnect an earth already existing on one side of the heater supply, the hum-suppression circuit may possibly still function for a particular pair of valves V1 and V2, but if it does not it can be made to do so if the heater-supply leads from the mains unit are interchanged.

3. *Balance*

This operation should only be necessary when
(i) the equipment is first installed,
(ii) either V1 or V2 is changed, or
(iii) it is suspected that the characteristics of the valves have changed through ageing or other causes.

To obtain correct balance conditions proceed as follows:

(a) adjust the total cathode current of V1 and V2 to 8 mA as indicated in (1).

(b) set the *Output Level* control at maximum, *Limiting dB* control fully anti-clockwise and *Timing* control at position 1.

(c) Connect output of limiter to loudspeaker at normal gain, or use headphones if necessary.

(d) Depress and release the *Set Bal.* push-button repeatedly, at intervals of at least one second to allow time for gain recovery, meanwhile adjusting the *Balance* control until the plops produced by the operation of the *Set Bal.* push-button are reduced to minimum loudness. When carrying out this operation, attention should be concentrated on the low-frequency component of the plop, the residual high-frequency click being relatively unimportant.

4. *Lining Up*

Although the output is normally zero volume, it can be increased to +8 dB.

Since the circuits with which the limiter is associated vary considerably at different centres, it is not desirable that a standard line-up instruction should be given here. Detailed information is issued in the Station Instructions at those centres where limiters are employed.

Valve Data

Valve	*Type*	*I_a,mA*	*I_s,mA*	*Remarks*
V1, 2	CV 131	3·5	0·5	
V3	CV 455			
V3a				Voltage across R11, 0·75 V*
V3b				Voltage across R44, 1·1 V*
V4	CV 455	7·2		Each section (*see Feeds, above*)
V5	CV 455			
V5a		0		No signal
V5b		4·5		No signal. Voltage across R27 25 V**
V6	CV 287			Voltage across R31, 43V**
V7	CV 140			

* Measured with AVO Model 40, 12 V range.
** Measured with AVO Model 40, 120 V range.

Total feed 42 mA at h.t. supply of 275 volts l.t. supply 6·3 volts a.c., 1·6 A.

General Data

Impedances

Input: 600 ohms
Output: 600 ohms
Normal load: 600 ohms

Normal working volume

Input 0 dB
Output 0 dB

Maximum output +8 dB
Normal limiting output 0 dB
Maximum gain between 600-ohm terminations with no limiting 13 ±1 dB.

Frequency Response

Test Conditions. Measured with 600-ohm source, working into 600 ohms. *Timing* switch set to position 1.

1. *No limiting* (*See table below*)
   Input level 0 dB.
   Limiting db control set at " 0."
   Limiting level control set fully anti-clockwise.
   Output level control set to give 0 dB gain at 1 kc/s.

2. *Limiting* 10 *dB* (*See table below*)

The limiter should first be set to limit at a level of +8 dB, as indicated below:

(a) Set *Limiting dB* control to " 0."
(b) Set *Limiting level* control fully anti-clockwise.
(c) Adjust *Output level* control to give 0 dB gain at 1 kc/s.
(d) Inject 1-kc/s tone at +8 dB level and increase *Limiting level* control setting until output is reduced by 0·2 dB.

With limiter adjusted as set out above inject 1-kc/s input tone at +8 dB level, and adjust *Limiting dB* control to " +10 "; the output should not increase by more than 0·5 dB.

The figures given in the table below are relative to the output at 1-kc/s.

Frequency c/s	*No Limiting* dB	*Limiting* 10 *dB* dB
40—100	+0	−1·5
100—1,000	+0	−0·5
1,000—10,000	±0·5	
40—10,000		±1·5

Noise

Test Conditions. Input terminated in 600 ohms. Output connected to 600-ohm input of amplifier detector, *Output level* control set for 0 dB gain at kc/s.

Noise level less than −48 dB.

SECTION 20

O.B. EQUIPMENT OBA/9

Introduction

The OBA/9 O.B. equipment is intended to replace the OBA/8 amplifier and its associated apparatus which have been in use since shortly before the war. The main advantages of the new design are smaller size and weight, both of which have been reduced by nearly 50 per cent, and the arrangement of the equipment to form a largely self-contained assembly which can be put into use with a minimum of time and effort. The general technical performance is not greatly altered, although some slight improvements from this aspect have also been made.

All the major units are of uniform dimensions and are so designed that they can be stacked together on a special two-wheeled trolley which facilitates transport and can be operated in this position without dismantling the stack. The trolley can if necessary be lifted bodily by two persons, and has special fittings for carrying microphone-cable drums which allow the cable to be run out, connected up and re-coiled without removing the drums. The total weight of the trolley when fully equipped is about 186 lb; in addition there is a loudspeaker unit and also a spares box with miscellaneous items which together weigh about another 86 lb. The loudspeaker and the spares box have the same width and depth as the other apparatus, and can thus be carried on a second trolley together with any supplementary units, when circumstances require.

Mechanical Design Considerations

The apparatus cases are constructed of aluminium alloy, with welded seams. Their overall dimensions, including face-plate covers, are 19¼ in. wide by 9 in. deep by 5⅞ in. high, an exception being the power-supply unit, with a height of 7⅞ in. Two lengthwise grooves are formed in the top of each case, and corresponding ridges are formed on the underside; these add to the rigidity of the construction and provide a means of locating the case in a stack and interlocking the cases when the ends of the stack are secured.

The cases fit closely within the framework of the trolley, where they are held by pressure applied to a groove of the uppermost case by captive thumbscrews working on a bar hinged to the trolley uprights; a raised strip at the base of the trolley prevents forward movement of the lowest case. By this means the apparatus assembly is rigidly locked in the trolley framework, although it may be released and removed in a few seconds.

The two wheels of the trolley have thick solid-rubber tyres and are mounted slightly above the platform so that with the trolley upright the wheels are just off the ground and the assembly stands firmly on three feet fitted to the base. Two hand-grips are provided at the front edge of the base. The trolley is of welded construction with a framework of cold-drawn mild-steel tubing and a sheet-steel base.

The overall height of the stack of apparatus excluding the trolley is 37 in. and the weight (including the batteries carried in the power supply unit) is 103 lb.

Electrical Design Considerations

The equipment has been designed so that it can be operated either from a.c. mains or from batteries. Normally the microphone amplifier in use is operated from the mains while the standby is fed from batteries, a changeover being instantaneous; no standby supply is provided for the loudspeaker amplifier (which also incorporates a trap-valve), but where no mains are available the whole equipment can be operated from batteries. The power-supply circuits are designed to operate on a.c. mains within the voltage range 200-250 volts and frequency range 45-60 c/s.

The valves and other components used have been chosen from the BBC or the Services preferred lists where a suitable type exists with a view to maintenance of supplies of spares.

The new equipment, like the one it replaces, is suitable for static use should circumstances require.

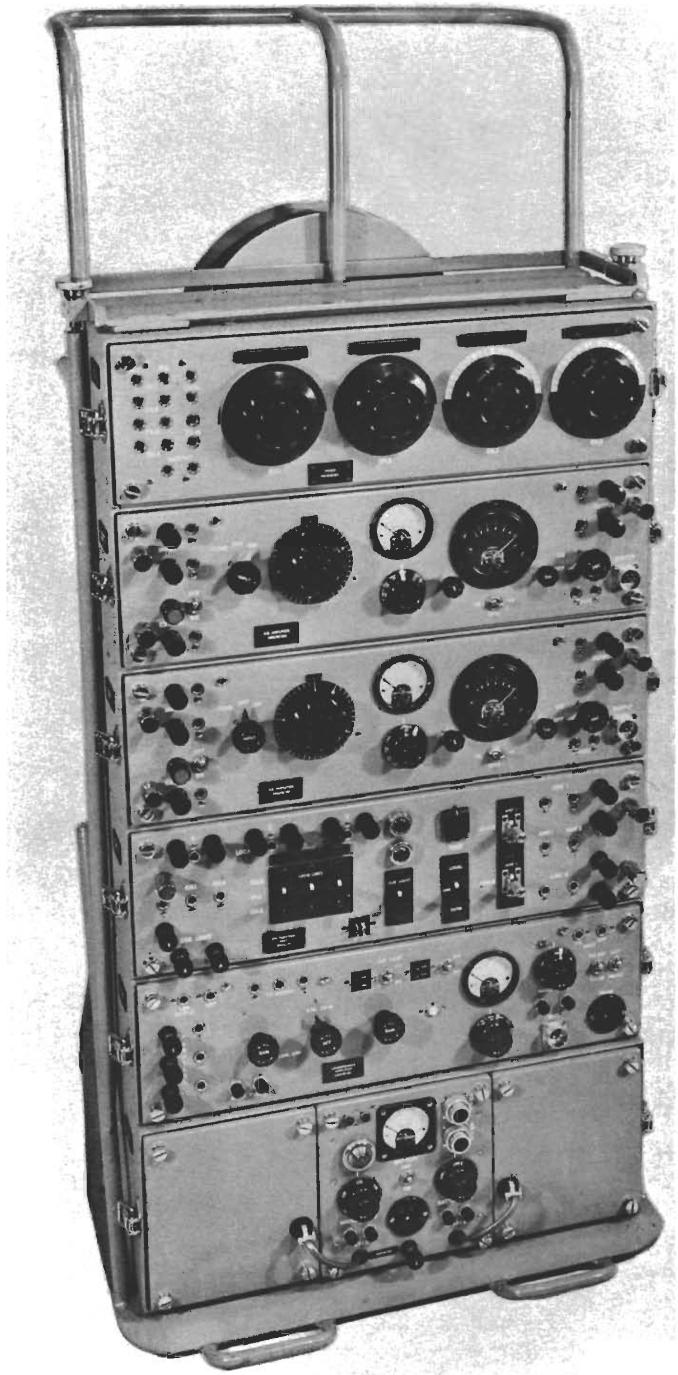


Fig. 20.1 OBA/9 Equipment: Trolley Assembly

Summary of Equipment

Trolley Assembly

The O.B. trolley, Type TRL/1, is shown fully equipped in Fig. 20.1 The apparatus mounted is as follows:

1 Mixer MX/29,
2 Amplifiers OBA/9,
1 Distribution Unit DU/1,
1 Amplifier LSM/9,
1 Supply Unit SUP/6,
3 Cable Drums DUM/6.

Additional Standard Items

Ignoring gear common to all O.B. equipments, such as a cue radio receiver and microphone stands, the additional items provided as standard for use with the OBA/9 are:

1 Loudspeaker Unit LSU/11,
3 Communication Units CMU/9,
1 Communication Unit CMU/10,
1 Wooden Box BW/9. This carries spares and minor items including cords and power cables and the three communication units Type CMU/9.

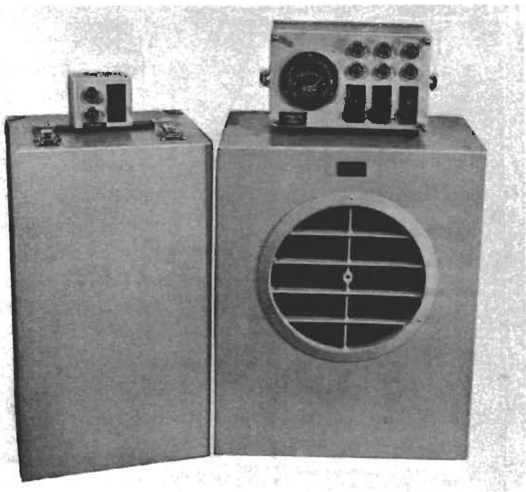


Fig. 20.2 CMU/9, CMU/10, BW/9 and LSU/11

Supplementary Items

A second mixer MX/29 can be carried on the trolley if required. To permit the consequent increase in the height of the stack of apparatus, the clamping bar has to be unhinged from the trolley uprights and reassembled to them higher up.

A variable-frequency oscillator Type PTS/16 may also be carried. This instrument is of a conveniently miniaturised design suitable for O.B. purposes, and is capable of taking its power supplies from the SUP/6 unit. It can if necessary be accommodated in place of other unwanted items in the spares box BW/9. For further information on the PTS/16, see Instruction S.4, Section 9.

It is in addition proposed to provide a separate trap-valve amplifier. This is for use when needed to supplement the trap-valve section of the LSM/9, or for operation at a point remote from the main stack of equipment if required. The proposed additional amplifier will have a self-contained mains unit, and will be of uniform dimension with the standard trolley-mounted items. A full description will be given in a later Section of this Instruction.

Weight of Gear

TRL/1	MX/29	OBA/9	DU/1
48 lb	15 lb	15 lb	10 lb
LSM/9	SUP/6	DUM/6	LSU/11
16 lb	32 lb	11 lb	25 lb

Interconnection Schematic

The general function of each piece of apparatus can be appreciated from the OBA/9 equipment interconnection schematic, Fig. 52.

Amplifier OBA/9 (Fig. 47)

General Description

Amplifier OBA/9 incorporates:

(a) A microphone amplifier fitted with a control potentiometer and capable of providing a maximum gain of the order of 90 dB.

(b) A line-up tone oscillator which, by appropriate switching, utilises the output valve of the microphone amplifier.

(c) A peak-programme meter and amplifier.

The OBA/9 is intended to be operated from a power-supply unit SUP/6, the input to which can be taken either from internal batteries or from a.c. mains.

Microphone Amplifier

This comprises three stages, with resistance-capacitance coupling and transformer input and output. The input impedance is 300 ohms nominal to match the 300-ohm source impedance of most microphone circuits; this source impedance is provided automatically when the amplifier is used with a mixer MX/29. The output impedance of the amplifier is 75 ohms, this value being suitable for working into a line the impedance of which may vary both with frequency and according to the nature of the circuit between limits of about 75 ohms and 2 kilohms.

The normal working output level and the maximum gain are similar to those of the OBA/8, as quoted in Section 13. Thus, with a 240-ohm load, the normal output level of 0 dB referred to 0·775 volt is obtained with a P.P.M. reading of 4 on steady tone, the output *power* referred to 1 mW being then + 4 dB. Working into the same load, the maximum voltage gain with the control potentiometer fully up is 90 dB.

The gain-control potentiometer, Type PF/5B1, is a single-gang unit arranged to vary both the degree of negative voltage feedback over V1 and V2 and also the coupling between V2 and V3. The control has 41 studs, the corresponding scale divisions being labelled 0-40. Maximum gain is obtained on stud 40, and 38 steps of 2 dB each are provided down to stud 2; there are then two larger steps down to stud 0, which provides an effective fade-out, with less than unity gain.

The amplifier is designed for a normal input level in the region of — 70 dB, which for zero-level output requires a gain 20 dB below the maximum, corresponding to a setting of stud 30 on the control. Overloading of the first stage occurs if the input level exceeds — 48 dB, which if the output level is to remain at zero necessitates a gain reduction of 42 dB, obtained on stud 19. (The overload point is indicated by a red line on the potentiometer scale between studs 19 and 18.) Thus, any source with a level higher than — 48 dB requires attenuation before the signal reaches the grid of the first valve. Such a source is likely to have a level in the neighbourhood of 0 dB, and a 50-dB loss-pad is therefore provided in the amplifier prior to the input transformer, ready for switching into circuit if circumstances require. Further pads, with losses of 50 and 70 dB respectively, are available in the MX/29.

Fig. 47 shows the circuit arrangement of the amplifier. Negative voltage feedback is applied from V2 anode to V1 cathode circuit via C12 and the PF/5B1. The lower end of the control is returned to earth via R8, and the output from V2 to V3, which is dependent upon the potentiometer setting, is tapped off via C4 and passes to V3 grid via a section of the *Oscillator* switch, SW B, and C14, R49. With the arrangement adopted, movement of the potentiometer slider *away* from the earthy end simultaneously increases negative feedback over V1 and V2 and increases attenuation between V2 and V3, both actions having the effect of reducing the amplifier gain. Furthermore, since the anode resistance of V2 is shunted by the feedback circuit, the total anode load of the valve is reduced progressively as the gain is lowered, to a negligible extent at first, but increasingly as the *Off* position is approached, and is finally composed, in effect, of the low resistance R3 in the cathode circuit of V1. When this position is reached, there is 100 per cent negative feedback from V2 to V1, and the attenuation between V2 and V3 is sufficient to annul the step-up off the input transformer TR 1 and the gain of the output stage. The amplifier as a whole then has less than unity gain and its output is effectively nil in normal conditions of use.

The form of gain control described is advantageous where, as in the present instance, it is necessary to fade smoothly from maximum gain to 'off'. In an amplifier of the type required, a difficulty in the design, without involving the introduction of additional stages, is to obtain sufficient gain to enable adequate negative feedback to be applied to the early stages under maximum-gain conditions when the feedback requirements of the output stage, e.g., in respect of output impedance, have been met. This makes it desirable that negative feedback should be increased as gain is reduced, and the performance of the amplifier correspondingly improved at the lower gain settings used for the greater part of the time. The scheme suggested is by no means new and was, in fact, employed in amplifier OBA/8. A feedback control alone cannot, however, be made to give the complete fade-out required, whereas with the arrangement now adopted feedback and attenuation are simultaneously controlled in a simple manner which avoids the use of a bulky and expensive double fader.

At maximum gain, the feedback over V1 and V2 causes a gain reduction of 12 dB, the feedback at lower gain settings being considerably greater. The negative feedback for the output stage is obtained from a tertiary winding on the output transformer, TR 2, and reduces the gain of this stage by 18 dB.

A monitoring output is provided in a low-impedance part of the circuit, this arrangement preventing the characteristics of the monitoring apparatus from having any appreciable effect on the main output.

With the maximum gain setting, the total harmonic content in the output, measured on tone at + 12dB (i.e., at 4 dB above programme peaks), is less than 1 per cent over the frequency range 50 c/s to 10 kc/s, and the response is flat to within 0·5 dB over this range. This performance is maintained for changes in load impedance between 75 ohms and 2 kilohms, and for usual voltage variations of batteries or mains. At the normal gain setting of about 70 dB, an improved performance is obtained owing to the greater amount of feedback applied. (It should be noted that the parallel combination of C14 and R49, between V2 and V3, provides a small amount of top-lift to compensate for stray-capacitance losses arising from the fact that neither end of the amplifier gain control is at earth potential.)

The noise output at maximum gain varies between 36 and 40 dB below normal output, depending upon the valve selected for use in the first stage; this noise is between 7 dB and 3 dB above the thermal agitation noise of the input circuit. At 70 dB gain the noise separation is at least — 50 dB, and is usually better than — 55 dB.

To minimise hum, special measures have been adopted with regard to the heater supply to the first stage. With an a.c. heater supply, very good heater-cathode insulation would be required to keep down hum at maximum gain, since the value of the feedback resistor R3 in V1 cathode circuit is from this point of view rather high. A proportion of valves of the type used are unsatisfactory in this respect, but the difficulty has been overcome by incorporating a circuit in the SUP/6 mains unit to provide V1 heater with a rectified and smoothed supply.

Line-up Tone Oscillator

The output stage V3 of the microphone amplifier can be converted into a line-up tone oscillator by operation of the *Oscillator* switch (Fig. 47 : SW B). A cathode-coupled circuit is used, giving an output of 1,150 c/s at normal level. A thermistor, TH 1, in the anode circuit acts as a limiting element and stabilises the output level with respect to supply voltage changes. A variable resistor, R38, in series with the thermistor gives an output-level adjustment of ± 2 dB.

When SW B is operated, the input circuit of V3 is disconnected from the output of V2 and returned to earth via the frequency-determining circuit L1, C8; V3 cathode is connected to L1 centre-tap via R37. Another contact of SW B connects C13, TH 1 and R38 between the anode and the cathode of V3.

Automatic cathode bias continues to be provided by R15, but the normal grid-leak, R14, is effectively replaced by R49. An antiparastic resistor, R46, remains in circuit, and serves to damp out oscillations in undesired modes.

Fig. 20.3 is a greatly simplified circuit diagram of the oscillator. In a valve circuit with an undecoupled cathode impedance and an earthed grid, the feedback would normally be negative; in this circuit, however, the feedback becomes positive at one particular frequency owing to the

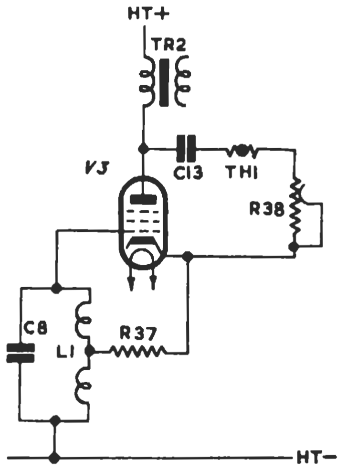


Fig. 20.3 OBA/9 Oscillator Stage: Simplified Circuit

phase-reversing action of the network L1-C8-R37 : the circuit therefore oscillates at this frequency. Advantages of the arrangement are a good frequency stability and an absence of harmonics and noise in the output.

Although there is a resemblance to a cathode-coupled Hartley circuit, the behaviour is in fact somewhat modified by the facts that the two sections of L1 have equal inductance and that a resistor is interposed between the tapping point and the valve cathode. A detailed examination of this type of circuit has appeared elsewhere.*

* Roddam, T. ' "Chameleon" Oscillator. Versatile Modified Hartley Circuit Giving High Frequency Stability.' *Wireless World*, Vol. 60, No. 2 (February 1954), pp. 52-55.

Peak Programme Meter Amplifier

A programme signal rectified by V4 is applied in a negative sense to the grid of the variable-mu pentode V5, which is operated under conditions which give an approximately logarithmic V_g/I_a law with grid-circuit time-constants of 2·5 milliseconds for charge and 1 second for discharge. The built-in meter, connected in the anode circuit of V5, has a right-hand no-current zero and is calibrated in six divisions, each of 4 dB.

Although the basic principles of the standard BBC method of programme-volume measurement are retained, the circuit differs in detail from those previously used. The changes have been made partly to suit the variable-mu valve, which is an EF41 instead of an AC/VP1, and partly to reduce variation of the characteristics caused by supply-voltage changes and by replacement of valves. With an EF41, the best performance is obtained if the impedance of the anode, screen and cathode circuits is kept low. A metal rectifier is employed to stabilise the screen voltage, since no suitable neon is available. The cathode-bias voltage, which is made variable to provide a meter zero control, is obtained from the d.c. heater supply to V1. The zero-control potentiometer is mounted on the OBA/9 face-plate, and is labelled *P.M.*

The meter 'law' is normally unaffected by valve changes, and as no adjustment is provided it may occasionally be necessary to reject a valve which does not conform.

The *Sensitivity* control is a pre-set potentiometer, R27, mounted inside the case, and should not require attention unless V5 is changed. The control is adjusted to give a P.P.M. reading of 4 when tone at zero voltage level is delivered by the microphone amplifier or oscillator into a 240-ohm load; this level corresponds to + 4 dB power referred to 1 mW. A switch, marked *P.P.M.*, on the front of the amplifier, permits the insertion of a 4-dB pad, R50—R52, in series with the *Sensitivity* control; with this loss-pad in circuit, the voltage level on tone with a P.P.M. reading of 4 is + 4 dB, corresponding to a power output of + 8 dB into 240 ohms. The two positions of the *P.P.M.* switch are marked respectively + 4 and + 8, which are the *power* levels delivered into 240 ohms with a meter reading of 4 on tone.

The need for inserting a buffer stage between the microphone amplifier and the P.P.M. amplifier is avoided by connecting the P.P.M. rectifier transformer TR 3 across the feedback winding of TR 2 where the impedance is less than a third of the total output impedance of the microphone amplifier, and additional separation is obtained by the insertion of a resistance network between the two transformers. With this arrangement the rectifier V4 has no perceptible effect on the performance of the microphone amplifier and, as the P.P.M. circuit is fed from a low-impedance source, the meter reading is nearly proportional to the e.m.f. of the amplifier output circuit, any variation in the line impedance having little effect.

P.P.M. and Oscillator Calibration

(i) With the *Oscillator* switch at *Off*, and no input applied to the OBA/9, adjust the meter to zero by means of the *P.M.* control on the front of the amplifier.

(ii) Check that the *Input* switch is at *On*, and apply 1-kc/s tone to the OBA/9 input, at a level of about − 70 dB. Connect a load resistance of 240 ohms, and adjust the amplifier gain to obtain zero level volts output, measured with a high-impedance instrument across this load.

(iii) With the *P.P.M.* switch at + 4, adjust the *Sensitivity* control to make the meter read 4.

(iv) With the same load, vary either the input level or the gain in 4-dB steps (i.e., two divisions at a time on the gain-control scale) and check the 'law'. If there is appreciable error, the variable-mu valve V5 may be unsuitable, and should be replaced. (It should normally be necessary to reject only some 5 per cent of specimens tried).

(v) Remove the input connection, and set the *Oscillator* switch to *On*. Adjust the oscillator level control on the left of the switch until the P.P.M. reads 4 with a 240-ohm load.

Mechanical Construction

The amplifier is constructed on a chassis attached at right-angles to the face-plate. Aluminium alloy is used and the chassis is braced by two rods which enable the amplifier to rest upside-down on a bench without damage to components. With the amplifier in its case, these rods rest against projections in the wall of the case as do also the outer bottom edges of the chassis. This construction supports the amplifier against the shocks of transport.

Most of the smaller components and wiring are below the chassis and are protected by a sheet of bakelised canvas. The first-stage valve is mounted on a small platform attached to the chassis with resilient rubber fastenings. This platform also carries the input transformer, thus giving extra mass to the assembly and improving the mechanical filtering effect. With this arrangement, microphony in the amplifier is very low.

All programme connections are on jacks, and the input and main output are also brought out to screw terminals provided with earth-clips for the cable screens. There is provision for connecting an external meter in series with the built-in programme meter; although it is normally convenient to connect any external meter via a break-jack, screw terminals are also fitted, together with a shorting-switch for use when these terminals are not required.

Valve Data: OBA/9

Valve	*Anode Current mA*	*Screen Current mA*	*Heater Volts*	*Heater Amps*
Mic. Ampr.				
V1: EF37A	0·45	0·1	5·0	0·2
V2: EF37A	1·0	0·3	6·1	0·2
V3: CV138	6·0	2·0	6·1	0·3
P.P.M. Ampr.				
V4: EB41			6·1	0·3
V5: EF41		3·2	6·1	0·2

Supplies

H.T. supply, 250 volts, 15 mA.

L.T. supplies, 6·1 volts, 1·0 amp a.c. or d.c.; 5 volts, 0·2 amp d.c.

NOTE.—The valve data refer to a mains-derived supply from an SUP/6, with no input signal applied. When the feed meter is switched to *V*1, *V*2 or *V*3, it indicates the anode current only; when switched to *L.T.*, it indicates V1 heater voltage. (N.B. When supplies are derived from the SUP/6 batteries, it must be remembered that the indicated *L.T.* voltage of V1 is only about 83 per cent of the l.t.-battery voltage.)

General Data: OBA/9

Impedances

Normal source $Z = 300\ \Omega$
Input $Z = 300\ \Omega \pm 15\%$ at 1 kc/s
Output $Z = 75\ \Omega \pm 10\%$, 60 c/s to 8 kc/s
Normal load $Z =$ Between 75 Ω and 2 kΩ

Normal Input Level

− 70 dB.

Normal Output Level

0 dB referred to 0·775 volt.

Normal Output Power

With 240-Ω load.
+ 4 dB referred to 1 mW.

Maximum Input Level

− 48 dB.

Gain Control Potentiometer

Type PF/5B1
Total number of studs, 41.
Scale engraved 0-40.
Stud 40 gives maximum gain.
Studs 39-2 give 38 steps, each with a loss of 2 dB. (Tolerance, per stud and cumulative, ± 0·3 dB)
Studs 1-0 give 2 larger steps to effective *Off* position.

Test Data: OBA/9

Maximum Voltage Gain

Measured at 1 kc/s with 240-Ω load.
$G = 90 \pm 1{\cdot}5$ dB.

Monitor Output

Test frequency, 1 kc/s.
Level at main output, 0 dB (volts) into 240 Ω.
Level at monitor output, measured with high-impedance amp. det., -2 ± 1 dB.

NOTE.—If monitor output is short-circuited, the level at main output should not fall by more than 0·2 dB.

Frequency Response

± 0·5 dB from 50 c/s to 10 kc/s.
± 1·0 dB from 30 c/s to 15 kc/s.

Percentage Total Harmonic Distortion

Output level, + 12 dB (volts) into 240 Ω.
At 60 c/s, < 1·0%.
At 1 kc/s, < 0·5%.

Noise Volume

Input termination, 300 Ω; load, 240 Ω.

Noise volume (unweighted), not greater than — 36 dB at maximum gain, and not more than — 50 dB at 70 dB gain (stud 30).

Line-up Tone Oscillator

Frequency, 1,150 c/s ± 5%.

Output level, adjustable over range, normal ± 2 dB.

Supply Unit SUP/6 (Fig. 48)

General Description

Supply unit SUP/6 is designed to feed two OBA/9 amplifiers simultaneously, one from a mains unit and the other from batteries. Normally, the amplifier used for transmission is supplied from the mains, and the standby amplifier from the batteries. A switch permits the interchange of mains-derived and battery supplies between the amplifiers, and a further switch allows the battery supply to be discontinued when not required. It is not possible to connect both amplifiers to the same supply.

A terminal and control panel is mounted centrally on the front of the apparatus, with the mains unit behind it, and the batteries disposed in covered recesses on either side. The supplies for the two amplifiers are brought out to the panel on 6-pin cable-connectors. The earthing terminal of the SUP/6 is connected to h.t. negative and serves as a common earth point for the complete set of O.B. gear; the earth connection to each amplifier is made via the respective power-supply cable and is extended to the remaining apparatus via sleeve circuits.

Mains Unit

The supplies provided by this unit are as follows:

(a) H.T. supply, 250 ± 10 volts, 15 milliamps.
(b) L.T. a.c. supply, 6·1 ± 0·2 volts, 1·0 amp.
(c) L.T. d.c. supply, 5·0 ± 0·2 volts, 0·2 amp.

The primary winding of the mains transformer is tapped for input voltages of 250, 235, 220 and 205; the tapping switch has also an *Off* position. A voltmeter and a neon indicator-lamp are fitted on the mains side of the switch, and a pair of fuses is also provided. The equipment can be used with a supply of any frequency between 45 and 60 c/s.

Fig. 48 shows the circuit arrangement; it will be seen that metal rectifiers are used for both the d.c. supplies. The h.t. supply is obtained from MR 2 and MR 3, and is smoothed by C1, R1 and C2; the use of metal rectifiers instead of a valve rectifier for this supply reduces heat dissipation and thus improves the life of the batteries and electrolytic capacitors. The l.t. d.c. supply, which is required for the heater of the first-stage valve in the OBA/9, is obtained from the bridge rectifier MR 1 and is smoothed by the 2,000-μF capacitor C3.

Batteries

The battery details are as follows:

(a) H.T. battery. 240 volts nominal. Comprises six Ever Ready 'Batrymax' Type-B104 45-volt dry batteries. Initial open-circuit voltage, 270 volts. Normal voltage on load, about 245 volts falling to 215 volts after 20 hours or more of intermittent use; the battery should be rejected when the on-load voltage falls below this latter figure.
(b) L.T. battery. This is a 6-volt dry accumulator comprising three Varley Type-VPT 9/14 cells in a waxed wooden box. The capacity at the required discharge rate of rather less than 1·2 amps is about 10 ampere-hours, so that the battery can be used for some eight to nine hours before it needs to be recharged.

Reactivation of H.T. Battery

A circuit is provided for reactivating the h.t. battery by charging it in a similar manner to accumulators; investigation* shows that a considerable increase in battery life can be obtained in this way. The mains-derived charging supply is taken from the reservoir capacitor C1, where a suitably high voltage is available. All the time the mains unit is switched on a trickle charge is given, limited by R3 to 1 or 2 milliamps depending on the state of the battery. When the mains unit is switched off, the metal rectifier MR 4 prevents the battery from discharging through the final-valve screen circuit of the mains-operated amplifier. The smoothing capacitor C4 ensures that no a.c. ripple is fed into the battery and its associated amplifier.

Mixer MX/29. (Fig. 49)

This is a four-channel unit with variable-impedance balanced series faders. Two input jacks are provided for each channel; one is for use with a ribbon microphone and connects

* Designs Department Test Report No. 23.

directly to the fader, whereas the other is for use with a moving-coil microphone and connects to the fader via a 30/300-ohm transformer and a 5-dB pad; this loss-pad is intended to minimise the difference in the volumes obtained from the two kinds of microphone, the specific value of 5 dB being approximately correct for a moving-coil microphone Type 4017-C on one channel and a ribbon microphone Type PGS or AXB on another.

Two further separate loss-pads, of 50 dB and 70 dB, are provided for use in attenuating high level inputs, such as may be obtained from a sub-control point, to a level suitable for mixing with the outputs from local microphones.

General Data : MX/29

Impedances

Normal source	Z =	30 Ω (m.c.), 300 Ω (ribbon).
M.C. input	Z =	36 Ω ± 10% at 1 kc/s with normal load Z.
Ribbon input	Z	Variable.
Output	Z	Variable.
Normal load	Z =	300 Ω.

Insertion Loss

Moving-coil mic. channel, 30/300 Ω, < 1·5 dB.
Ribbon microphone channel, 300/300 Ω, 0 dB.

Crosstalk Ratio

With one channel faded out and fed with 5-kc/s tone at 0 dB, the mixer output due to cross-talk when all other channels are faded up should not be greater than — 100 dB.

Fade Units

Type PZ/7M1

Number of studs, 22.

Loss per stud :

21	20-15	14-11	10-7	6-4	3-2	1	0
0 dB	1·5 dB	2 dB	3 dB	4 dB	6 dB	7 dB	∞

Maximum input level, 1 volt r.m.s.

Fixed Attenuators

Impedances, 300 Ω.
Loss, 50 ± 1 dB and 70 ± 1 dB.

Distribution Unit DU/1 (Fig. 50)

This unit provides programme and communication switching facilities commonly needed in O B practice. It is designed to accommodate:

(a) The outputs of two OBA/9 amplifiers.
(b) Two outgoing lines (i.e., one music and one control).
(c) Control telephone
(d) Three local lines
(e) Two input channels for the local lines
(f) One two-way cue-light circuit.

Provision is made for the following operations :

(1) Normal/reserve change-over on the OBA/9 amplifiers.
(2) Music/control change-over on outgoing lines.
(3) Switching the three local lines for feeding cue signals or programmes (e.g., from the local distribution or from a check receiver) to sub-control points or microphone sites ; the lines can also be used as a local telephone network, with access to the outgoing control line.
(4) Switching the control-point telephone to local or outgoing lines, or to both. A drop indicator gives recall facilities on an unoccupied telephone channel.
(5) The exchange of cue-light signals with a distant communication unit CMU/9. The necessary supply for the lamps, at either 6·3 or 8 volts according to line resistance, is provided by the mains unit of the LSM/9.

The detailed arrangements are shown on the DU/1 circuit diagram, Fig. 49, and on the OBA/9 equipment interconnection schematic, Fig. 52.

Amplifier LSM/9 (Fig. 51)

General

The LSM/9, Fig. 51, comprises a loudspeaker amplifier V1-V3 and V6, and a trap-valve amplifier V4. The inners of the input jack on the T.V. amplifier are connected to the outers of the corresponding jack on the L.S. amplifier, so that only one cord is needed for feeding both amplifiers with the same programme.

A built-in power-supply unit is provided, incorporating a mains transformer, TR5, and an h.t. rectifying valve, V5. A cue-light supply at either 6·3 or 8 volts a.c. is also provided.

Although it is intended that the power-supply shall normally be mains-derived, provision is also made for using external batteries, a " battery " power-input socket and switch being fitted for use when a suitable mains supply is not available.

A feed meter, with an associated selector switch, is provided; there is also a set of three paralleled jacks, with a pair of terminals, for miscellaneous testing or programme routing.

Loudspeaker Amplifier

This is a two-stage (four-valve) amplifier with input and output transformers. At maximum gain it produces 4 watts output for an input of — 7 dB (on steady tone) ; since, however, this gain may be inconveniently high for normal use, a 10-dB loss pad and shorting switch are connected between the secondary of the input transformer and the gain control which precedes the first stage.

The first stage consists of V1 and V6 which form a cathode-coupled phase-splitting circuit to give a push-pull drive for the output stage V2 and V3. In the original LSM/9 phase-splitting was carried out by employing cathode coupling in the push-pull

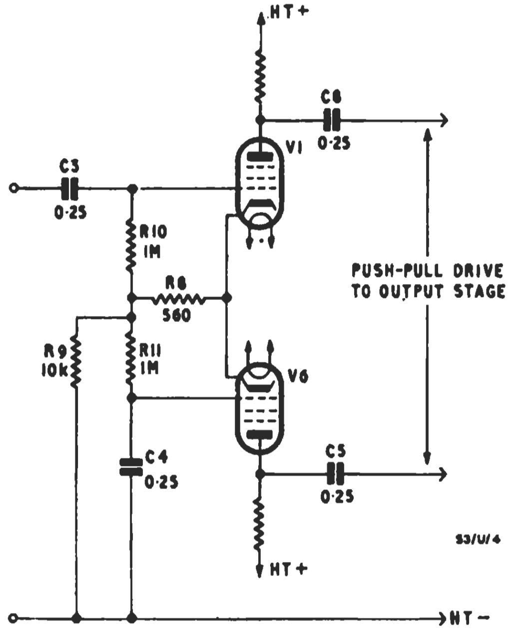


Fig. 20.4 LSM/9 First Stage: Simplified Circuit

output stage itself, and a single valve was employed in the first stage. The maximum output level obtained with this arrangement was + 12 dB, and it was found that for adequate loudspeaker volume in exceptionally noisy locations a maximum output level of + 20 dB was desirable. The amplifier was therefore modified to use larger output valves which are operated in Class AB to economise on power supply ; it was then possible to retain the original mains transformer and rectifier circuits, and to operate from a battery supply if necessary. Valve V6 was added to enable phase splitting to be carried out in the first stage since a cathode-coupled phase-splitting circuit can only operate in Class A.

The first valve, V1, has voltage negative feedback from the secondary of the output transformer via the network R41, C6 and R42, R2. R41, C6 and R44, C11, R5 are components introduced to alter the loop gain/frequency characteristic of the amplifier at frequencies above the audio range, to prevent the feedback causing instability. R46 and C16 were included to reduce the effect on the loop characteristic of varying impedance at the secondary of the input transformer TR1. The application of feedback results in an output impedance of about 2 ohms being presented to the LSU/11, and as the speech coil impedance is 12 ohms nominal, satisfactory damping is thus obtained.

The cathode-coupled phase-splitting circuit of the first stage is shown in simplified form in Fig. 20.4. A detailed analysis of this type of circuit has appeared in the *Wireless Engineer*,* and only a brief account will be given here.

The two valves V1 and V6 have a common biasing resistor R8, the grid bias being applied to the grids by the gridleaks R10 and R11 respectively. A further common cathode resistor R9 provides coupling between the two valves but because of the capacitors C3 and C4 has no effect on the grid bias.

Consider first the operation of V1 alone. The signal input to this valve is applied across R10 via R9. V1 cathode current flowing through R9 develops across this resistor a voltage in opposition to the original signal ; this voltage is of suitable phase to provide the inverted signal input required for V6. With this signal now applied to V6, the cathode current of this valve also flows through R9 but in antiphase to that of V1.

If the two valves had equal inputs, and were perfectly balanced, their cathode currents would also be equal and no resultant voltage would appear across R9. In this event, there would be no input to V6, and so, in practice, the cathode currents of the two valves must adjust themselves to unequal values, that of V1 being the greater. The closeness of balance obtained at the output between the two sides improves as the value of R9 is increased, but the presence of a d.c. voltage drop across this

* AMOS, S. W. "Push-pull Circuit Analysis". *Wireless Engineer*, **23**, No. 269 (February, 1946), pp. 43-46.

resistor necessitates a compromise depending upon the voltage of the h.t. supply. The circuit can be operated only in Class A.

The push-pull output stage is biased to Class AB by means of the battery of six cells. The quiescent anode current of V2 and V3 is thus reduced to approximately 10 mA each, rising to approximately 20 mA at 4 watts output. The resistors R20 and R40 prevent an excessive rise of cell current even when the amplifier is grossly overloaded by a steady-tone signal.

An output *Listen* jack, fed via two 47-ohm series resistors may be used as a source of programme for cueing purposes. This output should not be used when the highest quality is required, since the load provided by the loudspeaker itself affects the frequency response.

Trap Valve Amplifier

The trap valve is a single cathode-follower stage with input and output transformers. The input impedance is about 8 kilohms, and the impedance at the secondary of the output transformer is 28 ohms. Three output jacks are provided, in series with each of which is a resistance of 112 ohms ; the output impedance at any one jack with the remaining jacks on open circuit is thus 140 ohms ; any two outputs are separated by the equivalent of a 20-dB pad, and if one output is short-circuited, the fall in level at the others cannot exceed 2 dB. The maximum gain between 600-ohm terminations is about 1·5 dB. The maximum output level into 600 ohms is + 10 dB, with a total harmonic distortion at 1 kc/s of 0·5 per cent. The frequency response is flat to within 0·25 dB between 50 c/s and 10 kc/s.

A volume control is fitted between the input transformer and the grid of the valve. The cathode follower itself produces less than unity gain, and the amplification obtained is due to a 2: 1 difference in the ratios of the transformers. (See Fig. 51).

The trap valve is intended primarily for feeding miscellaneous services, such as recording and public-address equipment, with programme at up to zero volume. The input should be taken from the OBA/9 monitor output, when the maximum output obtainable from the trap valve will be about zero volume.

Valve Data: LSM/9

Valve	*Anode Current mA*	*Screen Current mA*	*Heater Volts*	*Heater Amps*
L.S. Ampr.				
V1: CV 138	1	0·2	6·3	0·3
V6: CV 138	1	0·2	6·3	0·3
V2: N 78	*10	*2·0	6·3	0.3
V3: N 78	*10	*2·0	6·3	0·3
T.V. Ampr.				
V4: CV 138	8·0		6·3	0·3
Rectifier				
V5: 6X5GT			6·3	0·6

* No signal condition

Supplies

H.T. supply, 285 volts, 37 mA,
L.T. supply, 6·3 volts, 2·2 amps a.c.
Cue-light supply, 6·3 or 8 volts a.c.

NOTE.—The valve and supply data relate to the use of the built-in mains unit and not to the emergency external-battery supply. H.T. feeds indicated by meter are anode currents only.

L.S. Amplifier Data

Impedances

Input Z = 10 kΩ ± 20% at 1 kc/s
Output Z = 1·7 Ω ± 20% at 1 kc/s
Normal load Z = 12 Ω nominal (LSU/11).

Maximum Input Level

+ 10 dB.

Maximum Output Level

+ 20 dB.

Maximum Voltage Gain

Frequency 1 kc/s, load 12 Ω resistive.
Gain G = 27 dB.

Frequency Response

± 0·5 dB from 30 c/s to 15 kc/s.

Percentage Total Harmonic Distortion

Output level + 20 dB, load 12 Ω resistive.
At 60 c/s, < 1%.
At 1 kc/s, < 1%.

Noise Volume

Volume control at maximum, input termination 600 Ω, load 12 Ω.
Maximum noise volume (unweighted), — 53 dB.

T.V. Amplifier Data

Impedances

Input $Z = 8\ k\Omega \pm 20\%$ at 1 kc/s.
Output $Z = 140\Omega \pm 10\%$ at 1 kc/s.

Maximum Input and Output Levels

+ 10 dB.

Maximum Voltage Gain

Frequency 1 kc/s, termination 600/600 Ω
Gain $G = 1{\cdot}5 \pm 1$ dB.

Frequency Response

$\pm 0{\cdot}25$ dB from 50 c/s to 10 kc/s.

Percentage Total Harmonic Distortion

Output level + 10 dB, load 600 Ω.
At 60 c/s, $< 1\%$.
At 1 kc/s, $< 0{\cdot}5\%$.

Noise Volume

Better than − 60 dB in 600 Ω.

Loudspeaker Unit LSU/11

The LSU/11 (Fig. 20.2) comprises an 8-inch Wharfedale moving-coil loudspeaker mounted in a closed felt-lined wooden case. The nominal value of the speech-coil impedance is 12 ohms. This loudspeaker, coded 8/CS/HP.227/05 by the maker, has a high efficiency and high sensitivity, and was selected to save weight and to make the most of the moderate power (about 1 watt) available from the LSM/9.

The wooden case, Type CS/24, has a metal grille in front, protected during transport by a metal cover. An input jack and set of terminals are fitted at the rear. The external dimensions are 19 in. by 15 in. by 9 in.

Communication Units CMU/9 and CMU/10

These units are provided for lamp signalling between the control point and microphone sites. The CMU/9 (Figs. 20.2 and 20.5) comprises a red and a green lamp together with a non-locking key and terminals, and is contained in a metal box measuring 3⅝ in. by 3¼ in. by 2⅝ in. The CMU/10 (Figs.20.2and20.6) embodies an extension P.P.M. instrument as well as three separate signal-lamp circuits similar to that of the CMU/9; the dimensions of the metal housing are 9 in. by 6⅞ in. by 5¼ in. All lamps are of the 2·5-volt 0·3-amp M.E.S. (i.e., ' torch-bulb ') type.

Where the signalling circuit is required between the control point and a single microphone site, one CMU/9 unit may be used in conjunction with the signal-lamps and key provided on distribution unit DU/1 (Fig. 50). With more complicated O.B. layouts, a CMU/10 unit can be used at the control point with up to three CMU/9 units placed at different microphone sites. Other layouts may be adopted as circumstances require.

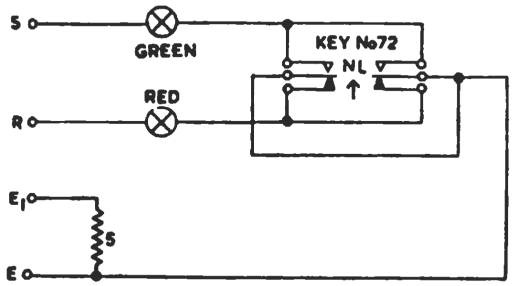


Fig. 20.5 Communication Unit CMU/9

All the lamp circuits are of the three-wire type with a local lamp and a remote lamp connected in series for each direction of signalling, so that a circuit fault is indicated at the sending end. Power at 6·3 or 8 volts may be taken from the LSM/9, or a separate battery may be used if desired. The choice of voltages available from the LSM/9 is provided to allow for different layouts, including the length of line; in addition, alternative terminals are provided for the common wire, one terminal, labelled E, being a direct connection, and the other, labelled E_1, introducing a 5-ohm series resistance for use with a short low-resistance line to prevent the lamps from being over-run.

When the supply is derived from the LSM/9, the terminals marked E_1 on the remote units should not be used unless all three conductors of the signalling circuit are insulated from earth, as one side of the supply is earthed at the LSM/9. When a separate battery supply is used, this restriction does not, of course, apply.

The connection between units should be made from S to R, R to S and E to E, the terminals marked E_1 being used instead of those marked E when circumstances require. The power supply should be connected in series with the common line; the DU/1 is fitted with a plug for this purpose, and the CMU/10 a plug in parallel with a pair of terminals. As the CMU/9 is normally used in conjunction with either the CMU/10 or the DU/1, no direct power-supply connection to it is required.

If it is desired to establish a signalling circuit between the DU/1 and a CMU/10, then provided that no CMU/9 units are employed, the power supply can be taken to either end of the circuit

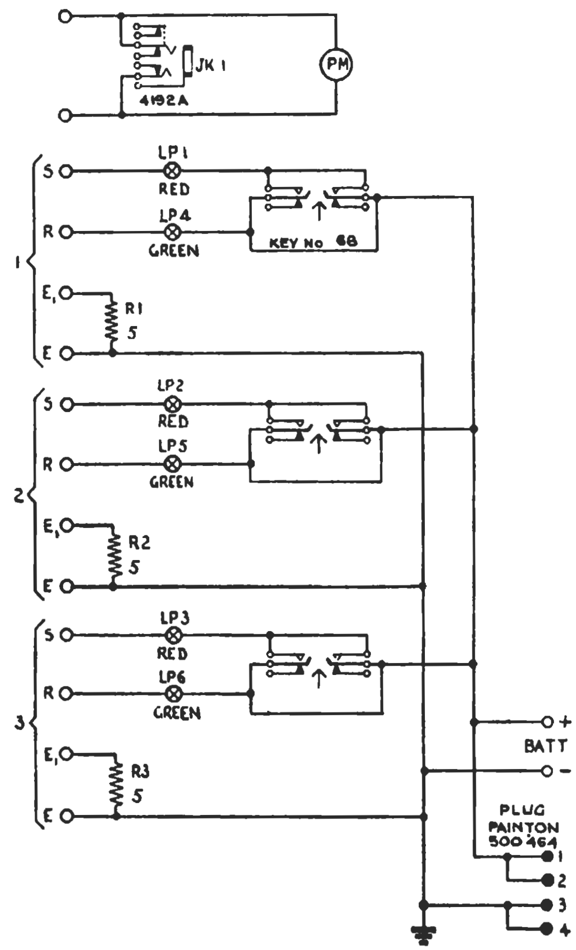


Fig. 20.6 Communication Unit CMU/10

as convenient, the supply connection at the other end being short-circuited. If, however, the CMU/10 is connected not only to the DU/1 but also to either one or two CMU/9's, the supply must be taken direct to the CMU/10, and the signalling-circuit supply connection on the DU/1 short-circuited. The requirements of the more elaborate arrangements occasionally needed should be worked out from the various circuit diagrams.

Communication Unit CMU/10A

The CMU/10A is similar to CMU/10 but has a P.P.M. calibrated for use with the P.P.M. valve of the OBA/9A.

Miscellaneous Equipment

Cable Drums DUM/6

Three cable drums Type DUM/6 (flange diameter $10\frac{1}{2}$ in., total width $3\frac{5}{8}$ in.) are provided as standard with each set of gear. Each drum carries 150 ft of RSF2/2 screened microphone cable, with the inner end terminated at a jack in the hub of the drum. The drums are intended to be mounted axially on pegs at the rear of the O.B. trolley, so that the cable can be paid out and later rewound (using a handle supplied) without removing the drum.

Spares Box BW/9

This is a wooden box (Fig. 20.2) measuring 19 in. by $10\frac{3}{4}$ in. by 9 in., fitted with six baize-lined compartments and a removable wooden tray. It is intended to accommodate the telephone set, the three CMU/9's, spare valves, all necessary cords and power cables and any small accessories.

Waterproof Canvas Covers

A suitable canvas cover is available for the trolley-mounted stack of apparatus, and is normally supplied with the gear. Specifications exist of covers for the individual standard-sized units and for the supply unit SUP/6; these additional covers are not normally provided, but can be supplied to order where required.

Cords and Power Cables

A set of 18 single- and double-ended cords is provided as part of the standard equipment. These are listed in detail on BBC drawing No. EA 8209.

A set of eight power cables is supplied as follows:

1 mains cable to SUP/6 and LSM/9,
2 cables for OBA/9 power supply from SUP/6,
1 cable for DU/1 cue-light supply from LSM/9,
1 cable for CMU/10 cue-light supply from LSM/9,
1 cable for CMU/10 cue-light supply from battery,
1 LSM/9 battery cable,
1 OBA/9 battery cable.

To assist identification, the battery cables have white sheaths, and most of the others grey. Further details of the cables are shown in Fig. 53.

Amplifier OBA/9A

This amplifier is similar to the OBA/9 but has different valves. See Fig. 47, Notes 1 and 2.

SECTION 21

AMPLIFIERS C/9, GPA/4 AND 4A, MNA/3

Introduction

These amplifiers form a new series of three main types of small and uniform size designed around the CV 455 valve. They are normally mounted on 19-in. bays capable of accommodating 44 units each and designed to simplify installation.

The C/9 is intended as a replacement for earlier C-type and trap-valve amplifiers. The input impedance is 50 kilohms nominal; the output impedance is 126 ohms at the terminals, but may be increased by external padding to 600 ohms. The gain is 14·4 dB fixed with a 126-ohm output, corresponding to 10 dB with a 600-ohm output, the load in both instances being 600 ohms. The maximum sending volume 600/600 ohms is +10 dB.

The GPA/4 is a high-gain voltage amplifier for use in microphone circuits. The input and output impedances are 600 ohms. The gain is adjustable in 10-dB steps between 43 dB and 73 dB.

The GPA/4A is a sub-type of the GPA/4, with a modified input circuit making it suitable for use on incoming lines. A 3-dB loss-pad precedes the input transformer and restricts the reactive component of the input impedance as well as improving the balance to earth. A stud-type potentiometer following the transformer allows the gain to be adjusted in 0·5-dB steps.

The monitoring amplifier MNA/3 has two outputs, one of which feeds a peak programme meter for visual monitoring and the other a loudspeaker unit for aural monitoring. The amplifier has an input impedance of 50 kilohms nominal and an audio output impedance of 600 ohms designed to feed into a 2-kilohm load. When the MNA/3 is supplied from a 300-ohm source at zero programme volume, the output delivered to an L.S.U. is at not less than −2 dB.

Two new mains units have been designed for use with these amplifiers. One unit, Type MU/51, is intended for bay mounting, and comprises two sections capable of supplying 11 amplifiers each. The other unit is mounted on a panel Type AMS/1, together with three amplifiers for which it provides the power supplies.

Electrical Design Considerations

General

This group of amplifiers provides in a uniform manner for the basic electronic requirements of the sound programme chain and is intended to replace many obsolescent types. The new amplifiers permit the design of studio and control-room equipment which is operationally more efficient, more compact and easier to maintain than hitherto.

Electrical performance is superior in the following respects to that of earlier equivalent types:

(i) Both the frequency response and the phase-angle of the output impedance are better in the C/9 than in its immediate predecessor, the C/8.

(ii) The frequency response, the input impedance, and the distortion at peak output of the GPA/4 and 4A are improved by comparison with the GPA/1.

(iii) The stability of meter calibration with mains-voltage changes exhibited by the MNA/3 is superior to that of existing P.P.M.-amplifier types.

Valves

For simplicity, the same type of amplifying valve is used throughout, except in the first position on the GPA/4 and 4A. (See next paragraph). The type selected is the double triode CV 455, equivalent to a 12AT7 or ECC 81. This takes a low heater current and has the advantage of providing in a single valve envelope either two voltage-amplifying stages or a push-pull output stage. (Note that since small transformers are used, push-pull outputs are needed to give adequate power.)

In a low-level audio stage, the use of a CV 455 introduces problems of microphony, and for this reason the valve specified for the first position on the GPA/4 and 4A is the ‘Trustworthy’ variant, Brimar Type 6060 (CV 4024). This is the same electrically as the CV 455, but manufacture is more closely controlled and construction is more rigid. Even with the 6060, some selection is required, but approximately 90 per cent of the valves should be suitable for first-stage use, in contrast to only 40 per cent with the CV 455.

On the MNA/3 a variable-mu valve, Type CV 454 (equivalent to a 6BA6) and a neon stabiliser, Type CV 449 (85A2) are employed in the P.P.M.-amplifier circuit. These are in the same range as the CV 455 and being similarly on the Services preferred list are readily available.

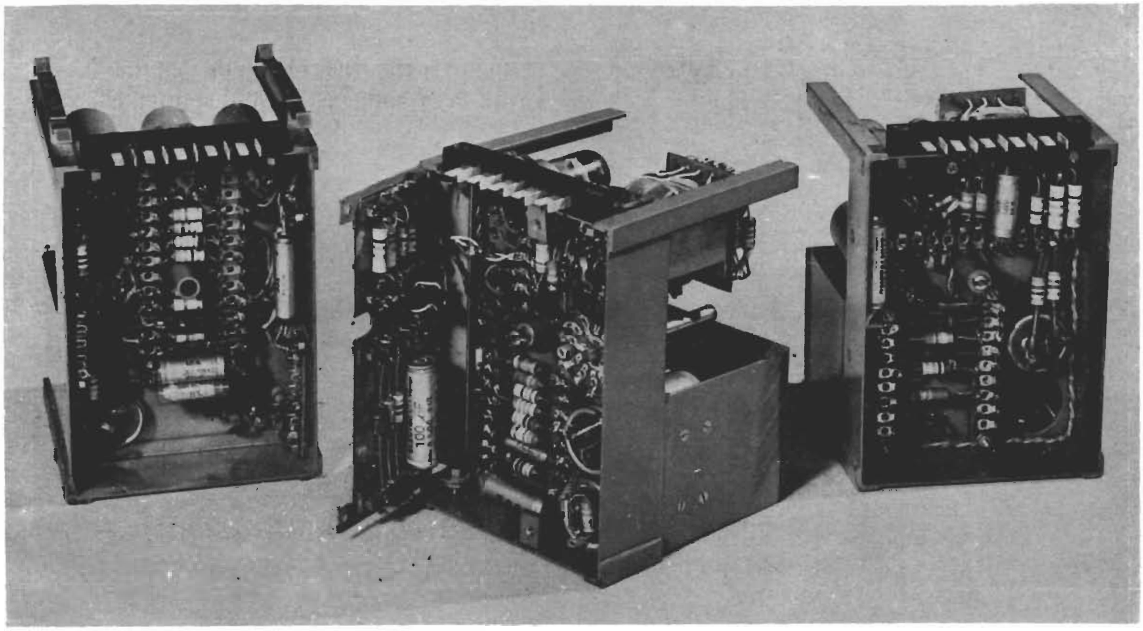


Fig. 21.1. Amplifiers MNA/3, GPA/4A and C/9

Output Circuits of C/9 and GPA/4

The output circuits of the C/9 and GPA/4 are similar, and employ a cathode-coupled pair in which the usual arrangement is modified to provide automatic balancing of anode feeds. This balance is important if distortion at peak output is to be low when a small transformer is used, since without some form of control, either automatic or manual, the anode feeds of the two triode sections might differ considerably.

In both amplifiers voltage negative feedback is taken from a winding on the output transformer to the cathode of the first stage, giving a gain reduction of 29 dB in the C/9, and 16 dB in the GPA/4 and 4A. A flat frequency response and accurate 600-ohm output impedance are required, particularly for the C/9, and these characteristics would be seriously affected by the stray impedances (chiefly leakage inductance) of the output transformer unless the strays were included in the feedback loop. The feedback is therefore taken from a tertiary winding closely coupled to the secondary, and although the additional phase-shift introduced into the feedback loop by this arrangement makes an adequate stability margin at high frequencies more difficult to attain, by fairly simple phase correction it has been found possible to allow a gain margin of 6 dB and a phase margin of 30 degrees under all conditions of load (and of gain on the GPA/4 and 4A).

Mechanical Construction (Figs. 21.1 and 21.2)

All the amplifiers have the same dimensions of framework and cover, and are of generally similar construction with the exception of an additional hinged flap on the GPA/4 and 4A. The components are carried on a tray-like vertical chassis, with a sub-panel for the pilot-lamp and any controls. The power-supply and signal circuits are terminated at a 10-way plug lying along the top of the chassis and engaging with a corresponding socket on the mounting. The amplifier is held firmly, when plugged into position, by a 'Dzus' quick-fastening pin. To prevent possible damage to the plug, due to the amplifier being tilted upwards as it is withdrawn, a small projection at the lower edge of the chassis engages with a hole in the mounting, and ensures that any pull is exerted in an essentially horizontal direction until the plug is freed.

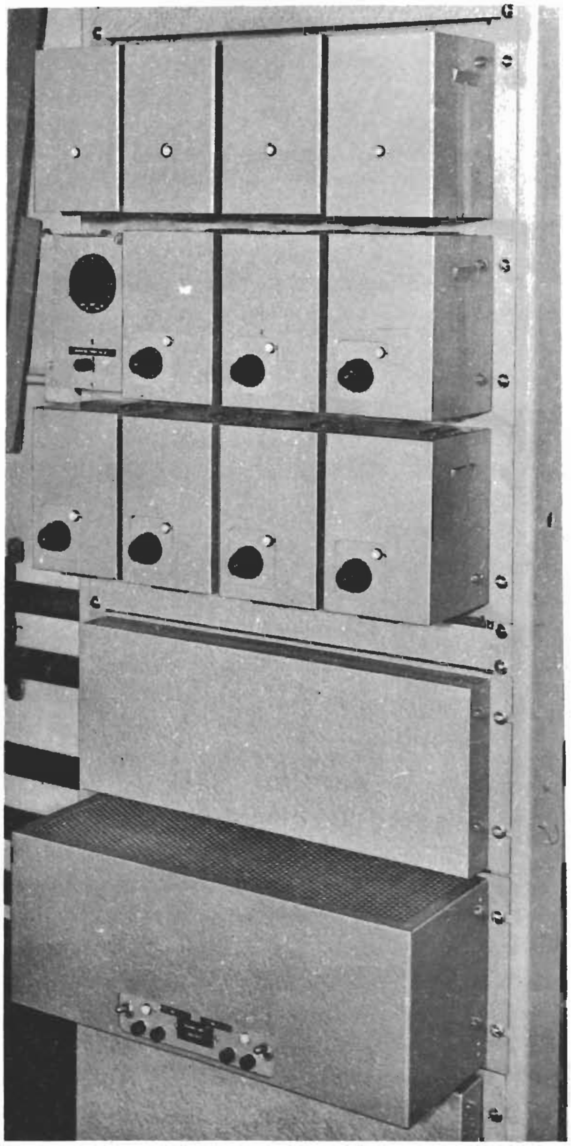


Fig. 21.2 Part of a 19-in. Amplifier Bay

The unit is enclosed by a dust-cover held in position by spring clips and provided with a cut-out exposing the pilot-lamp (and the input-volume control of the GPA/4A). The covered amplifier is $6\frac{1}{8}$ in. high, $4\frac{1}{8}$ in. wide and $4\frac{1}{4}$ in. deep. The weight is about 4 lb.

The valves developing the most heat, i.e., the output valves of the C/9 and GPA/4 and 4A and the amplifying valve of the MNA/3, are located in the upper right-hand part of the unit, and ventilating louvres, directed towards the side, are provided at a corresponding position in the top of the cover. Further louvres, directed toward the front, are provided on the underside.

To avoid confusion between the externally-similar amplifier types, coloured pilot-lamps are used. The code adopted is:

Green	C/9
White	GPA/4 or 4A
Blue	MNA/3

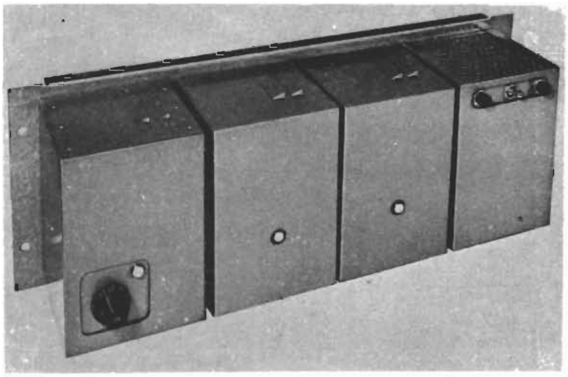


Fig. 21.3. Amplifier-mounting and Supply Panel AMS/1: General View

Mounting Arrangements

General

Two forms of mounting panel have been developed for use with these amplifiers: one (Fig. 21.2) for use in control rooms and in association with studio equipment, where large numbers of amplifiers are required, the other (Fig. 21.3), which includes a mains unit, for mounting up to three amplifiers only. Both panels are suitable for 19-in. bays.

Amplifier-mounting Panel AP/1 (Fig. 21.2)

The panel has a depth of 21 inches and carries 11 amplifiers, one a spare, arranged in three rows. A switch-and-key assembly at the twelfth position allows the spare to be paralleled with any other amplifier, so that a faulty unit may be withdrawn and replaced without interrupting programme. The panel is hinged near the bottom, and when the upper bolts securing it to the bay are removed, it lets down and may be held in position by chains and hooks; this arrangement facilitates maintenance and wiring operations on a double-sided bay.

The amplifier-sockets on the panel are wired to tag-strips for the programme connections and to 8-pin sockets for the power supplies, these latter being routed via further plugs and sockets on a supply distribution panel, so that a faulty mains unit may also be replaced by a spare.

Amplifier C/9

General

This amplifier is primarily intended for feeding programme to line. The input impedance is 50 kilohms nominal, so that a number of amplifiers can be bridged across a single source. The output impedance of the amplifier itself is 126 ohms, and a pad is fitted externally to give an accurate 600 ohms. Without the pad, the low output impedance makes the amplifier suitable for supplying ring-

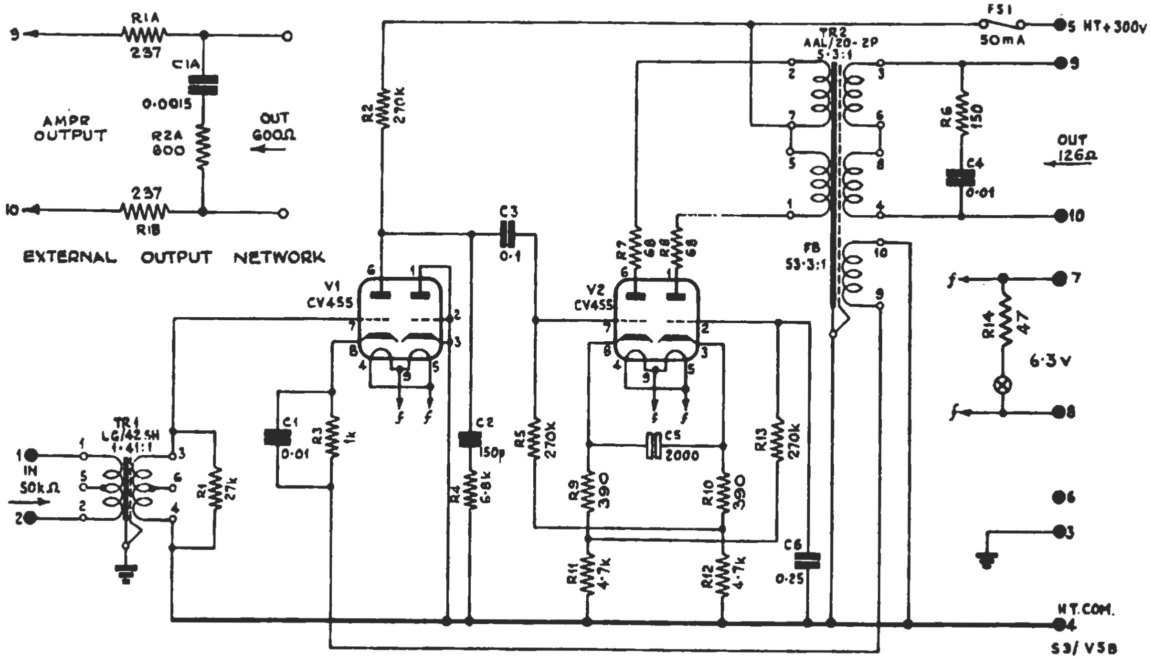


Fig. 21.4 Amplifier C/9: Circuit
Drawing No. EA 8550

mains, while with the pad in use, a high-quality monitoring point is available at the amplifier output terminals, no matter what impedance variations occur in the load. No volume control is provided, and the voltage gain without the pad is 14·4 dB into a 600-ohm load, the corresponding gain with the pad in circuit being 10 dB. The normal input volume is 0 dB, although an input at −10 dB can be accepted. With the 600-ohm output impedance, the normal output volume is +10 dB into a 600-ohm load, giving a peak output power of +18 dB, but to provide a margin for possible occasional excess volume, the amplifier has been designed to handle output peaks of up to +22 dB.

Since a dozen or more of these and other amplifiers may be used in cascade, precautions have been

Each fully-equipped 19-in. bay (Fig. 21.2) carries four panels Type AP/1A with a total of 40 available amplifiers and four spares, plus two double mains units Type MU/51 (Fig. 21.7) and a spare, and two supply distribution panels.

The panel AP/1A sometimes carries two jacks near its lower edge. One jack supplies line-up tone; the other is a break-jack on the input of the tenth amplifier, in these circumstances an MNA/3.

Amplifier-mounting and Supply Panel AMS/1

This panel, with a depth of seven inches, carries three amplifiers together with a mains unit of identical shape and size. No reserve-switching arrangements are provided. The mains-unit circuit, described later, is shown in Fig. 21.8.

taken to minimise non-linear distortion and to make the frequency-response characteristic as flat as possible.

Circuit Description (*Fig. 21.4*)

The amplifier comprises two triode stages, *RC*-coupled, with input and output transformers. The input stage employs one section of a CV 455. The output stage employs both sections of a second CV 455 in cathode-coupled push-pull. Automatic balancing of the anode feeds in the two sides of the push-pull stage is provided, and the external matching network following the output transformer gives an accurately resistive output impedance.

The input impedance of 50 kilohms nominal at the primary of transformer TR 1 is provided by the 27-kilohm resistor R1 across the secondary winding, as seen through the transformer. Voltage negative feedback giving a gain-reduction of 29 dB is applied to the cathode of the active section of V1 from a tertiary winding on transformer TR 2; the feedback loop is phase-corrected by C1, C2 and R4, and also by C4 and R6.

The push-pull output stage, V2 is similar to that described on pages 86 and 87 in connection with amplifier LIM/5. An analysis of the d.c. self-balancing property of this type of circuit has been given in the *B.B.C. Quarterly*.*

The 126-ohm output impedance at the amplifier terminals is padded out to 600 ohms by R1A and R1B. C4 and R6 correct the phase-angle of the feedback loop so as to maintain an adequate stability margin under conditions of high load impedance at high frequencies; C1A and R2A largely counteract the effects of TR2 leakage inductance on the amplifier output impedance at the higher audio frequencies. The network C1A, R1A–R1B–R2A is mounted externally to the amplifier on a separate panel with any loss-pad needed to reduce the sending voltage to the level required for the monitoring circuit.

Since the amplifier is readily demountable for servicing, no provision is made for metering the valve feeds.

Supplies

H.T. supply, 290 V, 16·8 mA.
L.T. supply, 6·3 V, 0·65 A a.c.

*Berry, S.D. 'Newly Developed Amplifiers for the Sound Programme Chain.' *B.B.C. Quarterly*, Vol. 9 No. 2 (Summer 1954), p. 122, Appendix II.

Valve Data: C/9

Valve	*Stage*	*Anode Current mA*	*Heater Volts*	*Heater Amps*
CV 455	V1	0·8 ± 15%	6·3	0·3
CV 455	V2A V2B	7·2 ±15% 7·2 ±15%	6·3	0·3

NOTE:—V2A and V2B anode currents should not differ by more than 0·3 mA.

General Data: C/9†

Impedances

Normal source $Z = 300\ \Omega$
Input $Z = 50\ k\Omega$ nominal (balanced)
Output $R = 600\ \Omega$ $+2\%$ (balanced) from 60 c/s to 10 kc/s
$X_L < 10\ \Omega$ at 10 kc/s
Normal load $Z = 600\ \Omega$

Normal Working Input Level

0 dB.

Normal Working Output Level

+10 dB.

Voltage Gain

300/600-Ω terminations. Frequency, 1 kc/s.
Gain, $G = 10$ db $\pm 0{\cdot}2$ dB.

Test Data: C/9†

Frequency Response

Relative to 1 kc/s; 300/600-Ω terminations.
60 c/s to 10 kc/s, +0 −0·1 dB.
30 c/s to 15 kc/s, +0 −0·2 dB.

Percentage Total Harmonic Distortion‡

Frequency	*Output Level into 600 Ω*	*Distortion (Maximum)*
60 c/s	+22 dB	0·6%
60 c/s	+18 dB	0·25%
1 kc/s	+22 dB	0·25%
1 kc/s	+ 18dB	0·1%

Noise Volume

Input termination, 300 Ω. Load, 600 Ω. Using normal mains-unit power supply.

Unweighted noise volume, less than −55 dB.

†With padding network in output circuit.
‡ With supply voltages specified, and with new valves. With these amplifiers, valves should be discarded when the harmonic content at 100 c/s and 1 kc/s becomes greater than 1·0% at + 22 dB.

Amplifiers GPA/4 and 4A

General

The GPA/4 and 4A are general-purpose voltage amplifiers with input and output impedances of 600 ohms. The gain of the GPA/4 is variable in 10-dB steps from 43 dB to 73 dB, and that of the GPA/4A effectively in 0·5-dB steps from 30 dB to 70 dB. The frequency response of both amplifiers is sensibly flat from 30 c/s to 15 kc/s, and non-linearity is negligible up to a peak output volume of at least +14 dB. The total noise output does not appreciably exceed that due to thermal-agitation currents in the input circuit.

Circuit Description (*Fig. 21.5*)

The circuit employs two double-triode valves giving between them three stages of gain. The first and second stages use the two halves of a Type 6060 valve, while the output stage, which is push-pull operated, uses both halves of a CV 455. Input and output transformers are fitted, and the push-pull stage is made self-balancing with respect to its anode-current feeds in the same way as on the C/9.

The 3-dB pad R1–R4 and potentiometer PN/9N/1 which precede and follow the input transformer TR 1 are fitted on the GPA/4A only, as explained under the previous sub-heading. On the GPA/4, R1–R3 are omitted, the value of R4 is increased from 1·48 to 2·6 kilohms and the PN/9N/1 is replaced by a fixed 75-kilohm resistor R5. In both amplifiers, however, the input transformer is loaded with two resistors (or their equivalent) in parallel, the smaller resistance being across the primary and the larger across the secondary winding. By a suitable choice of values the transformer input impedance is made more nearly constant and free from reactance than would be possible with an undivided load.

Voltage negative feedback from a tertiary

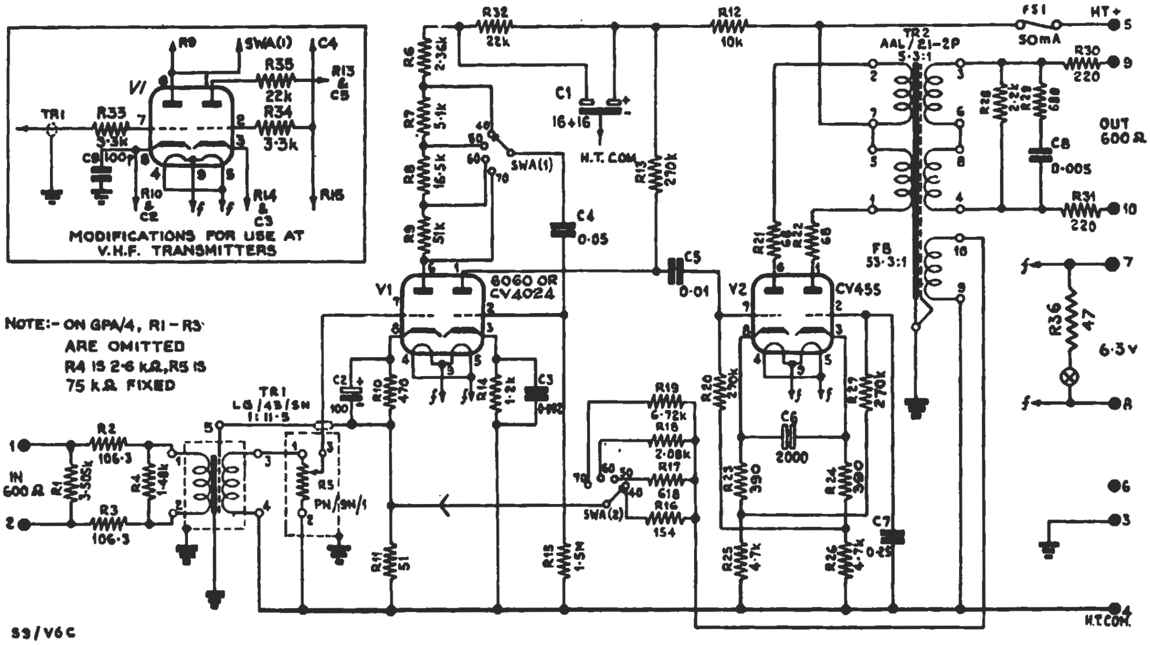


Fig. 21.5. Amplifiers GPA/4 and 4A: Circuit
Drawing No. EA 8566

The parent type, GPA/4, is intended for use where a coarse gain adjustment is sufficient and a highly accurate input impedance is not important, e.g., for a microphone amplifier, whereas the subtype, GPA/4A, is suitable for positions where a close adjustment of gain and an accurate resistive input impedance are essential, e.g., with an incoming-line equaliser. These requirements for the GPA/4A are met by the provision at the input of an additional gain control with 21 steps of 0·5 dB and a 3-dB loss-pad which halves the effects of transformer reactance and resistance variation on the amplifier input impedance.

winding on the output transformer TR 2 is applied to the cathode circuit of V1A. Gain adjustment is made by means of switch SW A, one section of which varies the forward gain in 10-dB steps, while the other maintains the gain-reduction caused by feedback at the constant value of 16 dB. The forward gain is varied by switching the coupling capacitor C4 to tapping points on V1A anode resistance, since the alternative of switching the high-impedance grid circuit of V1B would cause phase changes at high frequencies due to valve-input and stray capacitances, with consequent difficulties regarding stability. The maintenance of a constant gain-reduction from the feedback prevents changes in the output impedance and other characteristics of the amplifier as the forward gain is changed. (Equations (50) and (61) in the second issue of *Engineering Training Supplement No.* 3 apply).

The feedback loop and output impedance are phase-corrected at high frequencies by C3, C8, R28, R29 and at very low frequencies by the selection of suitable ratios for C4, R15 and C5, R20.

Valve Data: GPA/4 and 4A

Valve	*Stage*	*Anode Current mA*	*Heater Volts*	*Heater Amps*
6060 or CV 4024	V1A	2·2 ±15%	6·3	0·3
	V1B	0·8 ±15%		
CV 455	V2A	7·2 ±15%	6·3	0·3
	V2B	7·2 ±15%		

NOTE:—V2A and V2B anode currents should not differ by more than 0·3 mA.

Supplies

H.T. supply, 290 V, 19 mA.
L.T. supply, 6·3 V, 0·65 A a.c.

General Data: GPA/4 and 4A

Impedances

Normal source $Z = 600\ \Omega$
GPA/4 input $Z = 600\ \Omega \pm 10\%$ (balanced) at 1 kc/s
GPA/4A input $R = 600\ \Omega + 2\%\ -5\%$ (balanced) from 60 c/s to 10 kc/s
GPA/4A input $X_L < 55\ \Omega$ at 10 kc/s
Output $Z = 600\ \Omega \pm 3\%$ (balanced) from 60 c/s to 10 kc/s
Normal load $Z = 600\ \Omega$

Voltage Gain

600-Ω terminations. Frequency, 1 kc/s.
GPA/4: 43, 53, 63 or 73 dB ±0·2 dB.
GPA/4A: 40, 50, 60 or 70 dB ±0·2 dB with input-level control at maximum setting of 0 dB.

NOTE:—GPA/4A input-level control gives attenuation of up to 10·5 dB, adjustable in 21 steps of 0·5 ±0·1 dB.

Test Data: GPA/4 and 4A

Frequency Response

Relative to response at 1 kc/s. Measured between 600-Ω terminations at maximum-gain setting and an output level of 0 dB.

60 c/s to 10 kc/s, ±0·1 dB.
30 c/s, +0 −0·3 dB.
15 kc/s, ±0·3 dB.

Percentage Total Harmonic Distortion

All gain settings. Supply voltages as specified in Valve Data.

Frequency	*Output Level into 600 Ω.*	*Distortion (Maximum)*
60 c/s	+16 dB	0·7%
60 c/s	+12 dB	0·5%
1 kc/s	+16 dB	0·4%
1 kc/s	+12 dB	0·2%

Noise Volume

Measured with T.P.M.; 600-Ω terminations; earthed centre-tap resistors across l.t. supply; bandwidth 0 to 10 kc/s; unweighted.

Amplifier Gain	*Maximum Noise Volume*
73 or 70 dB	−50 dB
43 or 40 dB	−70 dB

NOTE:—The response of the GPA/4 and 4A is maintained up to frequencies as high as 100 kc/s, and as T.P.M.s have been found to exhibit a resonance at frequencies of this order, a significant noise measurement can be made only with the bandwidth restricted to the a.f. range. For this purpose a 0·1-μF capacitor across the 600-ohm T.P.M. input is effective. (A suitable component is a 0·1-μF ± 20%, 350-volt working, tubular, paper type, T.C.C. CP37N/PVC).

Amplifier MNA/3 (Fig.21.6)

General Description

The unit comprises a two-stage voltage amplifier, V1A and V1B, transformer-coupled to a double-diode valve, V2, supplying a rectified signal to a variable-mu pentode, V3, in the anode circuit of which is an external peak-programme-meter instrument. The input to the first stage, V1A, is taken via a transformer, TR 1, the input impedance being made 50 kilohms nominal to allow the amplifier to be bridged across the programme chain. An aural-monitoring output is taken from a tertiary winding on the rectifier transformer, TR 2, the earthy end of the primary winding on which is returned to V1B cathode, thus giving a small amount of voltage negative feedback to V1B. The main feedback path through the amplifier is from V1B anode to V1A cathode, via C3 and a 3-position switch which provides a gain-variation of ±8 dB for P.P.M. scale checking. *Zero*, *Sensitivity* and *Law* adjustments for the P.P.M. are provided as shown.

divisions (except between divisions 1 and 2, where the interval is 6 dB).

In all previous P.P.M.-amplifier types, the logarithmic law was obtained by adjusting the screen and anode potentials and impedances of the variable-mu valve while the no-signal anode current was maintained at the value required to bring the instrument pointer to the left-hand zero. In the MNA/3, the screen voltage is held constant by a neon tube and the *Law* adjustment is made by varying a resistor R20 in the cathode circuit of the valve, while the *Zero* adjustment is provided by a variable shunt R26 across the anode-circuit resistance and the meter. This method of

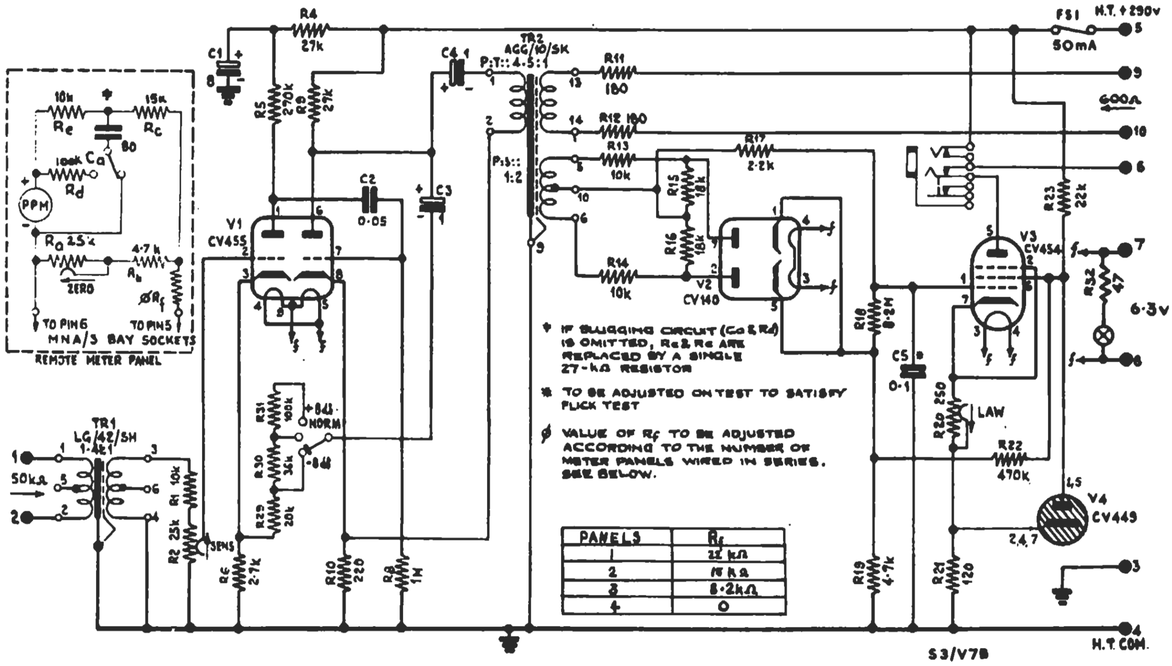


Fig. 21.6. Amplifier MNA/3: Circuit
Drawing No. EA 8581

P.P.M. Amplifier

The signal amplified by V1A and V1B is rectified full-wave by V2, the rectifier circuit having the usual time constants of 2·5 milliseconds for charge and 1 second for discharge. The resulting negative-going pulses are applied to V3 grid under circuit conditions adjusted to give an approximately logarithmic I_a/V_g curve over a range of 26 dB. The indicating meter in V3 anode circuit is of the usual type, with a 1·5-mA movement, a right-hand no-current zero and a scale calibrated in 4-dB

obtaining the required characteristic corresponds approximately to the selection of a particular part of a given I_a/V_g curve with constant anode and screen volts, instead of selecting one of a family of I_a/V_g curves with constant anode volts and treating the screen voltage as the variable parameter. With the CV 454 valve a better scale-shape is obtained by the present method, which also allows the *Zero* control to be mounted with a remote meter.

The meter circuit, which is connected between pins 5 and 6 of the 10-way amplifier-plug, is shown inset at the left of Fig. 21.6. The components R_a, R_b and a 27-k Ω resistor replacing R_c and R_e are fitted as standard. C_a, R_c, R_d, R_e and the switch are provided only if a slugging circuit is required. This circuit, where fitted, is used to read ' average ' peaks in comparing two meters, the switch being set to the position shown; for all normal purposes, the switch is set to its other position. The arrangement is generally similar to that used with the PPM/2.

Compensation for meter drift with supply voltage is provided by feeding the neon tube via R21 in the cathode circuit. If the h.t. voltage varies, a proportionately larger variation of neon current takes place, and this alters the cathode bias in a direction tending to stabilise the anode current. Since the standing cathode bias due to the compensating circuit is more than the valve can tolerate, a roughly equal bias of the same sign is applied to the control-grid; this counterbias is obtained from the constant voltage at the screen, and is applied to the grid via R18 and the potential divider R22, R19. By suitable choice of values for R22 and R19 the standing bias due to R21 is virtually cancelled, although the compensating variations remain.

For a range of mains-voltage variation of +5 to —12 per cent away from normal, the arrangement described restricts the maximum meter error to between 0·3 and 0·5 dB, depending on the particular valve. It is, however, important to ensure that the heater supply does not fall below 5·5 volts, or serious decalibration will occur. Note that it may be necessary to reject an occasional CV 454 valve which cannot be made to conform with the required law, although at least 90 per cent of specimens tried should be satisfactory.

Adjustment of the amplifier is facilitated by the provision of a portable test meter, PTM/9, comprising a meter with zero-control assembly (less slugging components), fitted in a small box and connected to a test-jack on the amplifier via a single-ended cord. The jack on the amplifier is mounted on a sub-panel behind the cover, together with the feedback switch which alters the gain in ±8-dB steps for scale checking. The law adjustment is made by inter-related variation of the *Law* and *Zero* controls; a clockwise movement of the *Law* control expands the scale.

Audio Monitoring Output

The audio monitoring output, which appears at pins 9 and 10, is taken from the tertiary winding of the rectifier transformer TR 2. Audio distortion due to rectifier action is prevented by the 10-kilohm buffer resistors R13 and R14. The impedance at the tertiary winding is 240 ohms, made up of a reflected source impedance of 75 ohms and a winding resistance of 165 ohms; the two 180-ohm padding resistors R11 and R12 bring the audio output impedance up to 600 ohms.

The amplifier is designed to provide approximately zero programme volume when connected to a normal 2-kilohm load, the precise volume being subject to a ±2-dB variation according to the *Sensitivity* adjustment for the variable-mu valve in the meter circuit. Note that the meter reading may be affected if the audio-output load is less than 1 kilohm.

Valve Data: MNA/3

Valve	*Stage*	*Anode Current mA*	*Screen Current mA*	*Heater Volts*	*Heater Amps*
CV 455	V1A V1B	0·6 ± 15% 5·0 ± 15%		6·3	0·3
CV 140	V2			6·3	0·3
CV 454	V3	variable up to 6	variable up to 2	6·3	0·5
CV 449	V4	7–9			

Supplies

H.T. supply, 290 V, 22 mA (maximum).
L.T. supply, 6·3 V, 0·95 A a.c.

General Data: MNA/3

Impedances

Normal source Z = 300 Ω
Input Z = 50 kΩ nominal (balanced)
Audio output Z = 600 ±40 Ω (balanced)
Normal load Z = 2 kΩ approx. (at audio output)

Normal Working Input Level

0 dB.

Normal Working Output Level (Audio)

With P.P.M. circuit properly adjusted, and an input of zero-level 1-kc/s tone, the audio output level into 2 kΩ should be not less than —2 dB.

Test Data: MNA/3

Frequency Response

At audio or meter output. Audio output loaded with 2 kΩ.

50 c/s to 10 kc/s, ±0·2 dB.

Percentage Total Harmonic Distortion (Audio)

Frequency	Input Level	Distortion (Maximum)
60 c/s	+12 dB	0·8%
60 c/s	+8 dB	0·3%
1 kc/s	+12 dB	0·5%
1 kc/s	+8 dB	0·3%

Noise Volume

Input termination, 300 Ω. Load, 2 kΩ.

Unweighted noise volume, measured with T.P.M., less than —60 dB.

Mains Unit MU/51 (Fig.21.7)

The MU/51 comprises two separate units, mounted side-by-side on a pressed-steel panel 7 in. deep designed for use with a 19-in. bay. The two units are protected by a single ventilated cover, leaving switches, pilot-lamps and fuses exposed. The mains input to each unit is via an individual 3-way plug and socket. Amplifier supplies are taken out by way of two pigtails of 8-way cable terminating on 8-way Jones-type sockets. Each unit can supply from 3 to 11 amplifiers Type C/9, GPA/4, GPA/4A or MNA/3.

Fig. 21.7 shows the input and output connections and the circuit of one of the two units. Primary tappings on the mains transformer provide for an input at 200, 210, 220, 230, 240 or 250 volts 50 c/s a.c. The h.t.-supply circuit comprises a full-wave rectifier with choke-capacitance smoothing incorporating a tuned 100-c/s rejector. The h.t. output is intended to be at 285 volts and three pairs of secondary tappings are available, marked 315, 292 and 264 volts respectively, for use according to the maximum current required, which may be 200, 140 or 80 mA d.c. Three separate l.t. outputs are provided, each giving 2·5 amps at 6·5 volts a.c.

Test Data: MU/51

Output Voltage

The sub-unit under test should be provided with a mains supply accurately suited to the transformer primary tapping and the output voltages should be measured under conditions (a), (b) and (c). Before test readings are taken, power should be applied under the load conditions required for at least five minutes to give the Brimistor time to reach its working temperature.

	H.T. Tap	H.T. Load	L.T. Load
(a)	315 V	200 mA	2·5 A on all three windings
(b)	292 V	140 mA	2·5 A on two windings only
(c)	264 V	80 mA	2·5 A on one winding only

In all these conditions the h.t. voltage should be 285 ±15 volts and the r.m.s. voltage across any loaded l.t. winding should be 6·5 ±0·15 volts.

Ripple

The ripple measured across the h.t. terminals with an amplifier detector AD/4 isolated from d.c. by a 2-μF capacitor should not exceed —20 dB when the unit is working under condition (a).

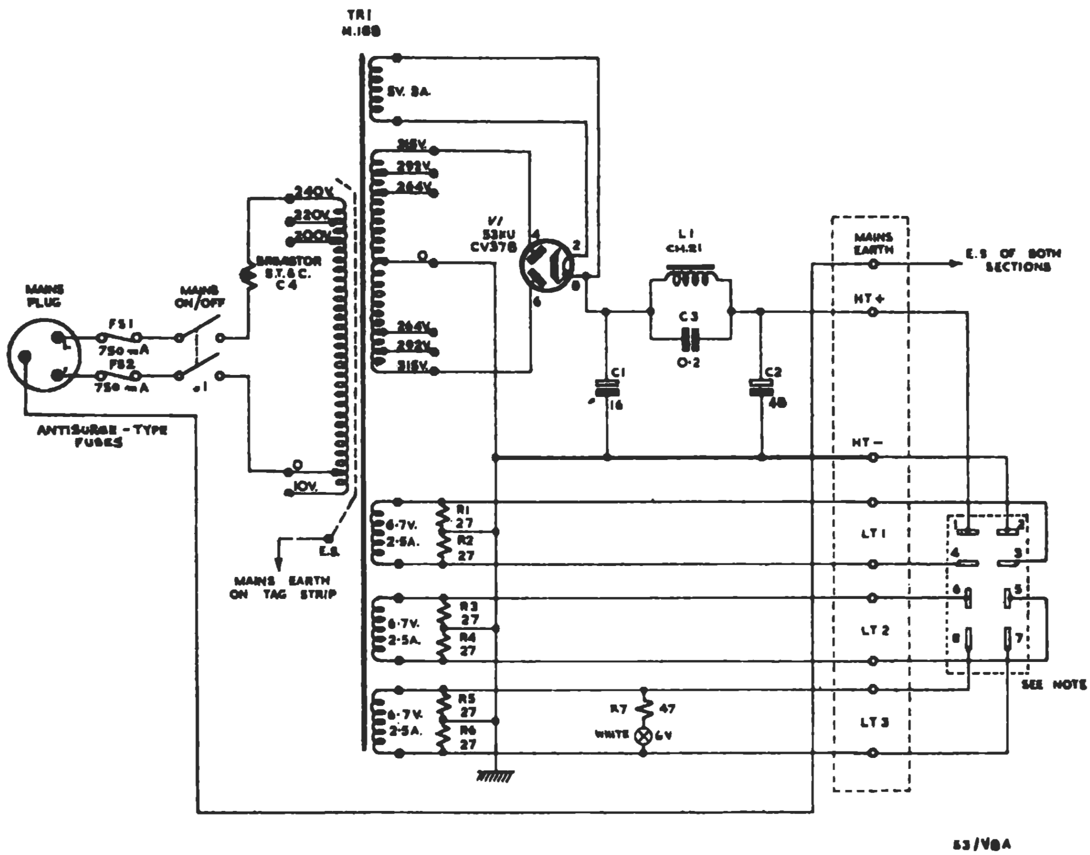
Amplifier-mounting and Supply Panel AMS/1: Mains Unit (Fig.21.8)

Panel AMS/1 is intended as stated earlier for mounting three amplifiers, for which it provides the h.t. and l.t. supplies.

The circuit is shown in Fig. 21.8. The mains input at the permanently wired tags L, N and E is taken via 1-amp fuses and a switch SW to transformer TR 1. This is tapped for 200-250 volts 50-c/s a.c., and has provision for reducing the turns ratio when feeding less than three amplifiers, by eliminating the section of winding between strapping points A and C. The output can be either 38 mA at 285 volts d.c. and 1·3 amps at 6·3 volts a.c. (with A strapped to B), or 55 mA at 285 volts and 2 amps at 6·3 volts (with B strapped to C).

Connection with the amplifiers is made via the usual 10-way sockets, which are shown at the right of the diagram. The power-supply pins of all three sockets are commoned, the programme pins being wired to tag-strips shown at the left of the diagram.

The mains transformer and choke have mu-metal screens to prevent hum induction with an adjacent high-gain amplifier GPA/4 or 4A.



NOTE:– 1. MU/51 CONSISTS OF TWO IDENTICAL SECTIONS AS SHOWN ABOVE
2. THE WIRING TO THE OUTPUT SUPPLIES SOCKET IS SHOWN VIEWED FROM THE REAR
3. MU/51A IS SIMILAR TO MU/51 BUT HAS LT OUTPUT OF EACH UNIT IN PHASE

Fig. 21.7. Mains Unit MU/51: Circuit

Drawing No. DB 2001

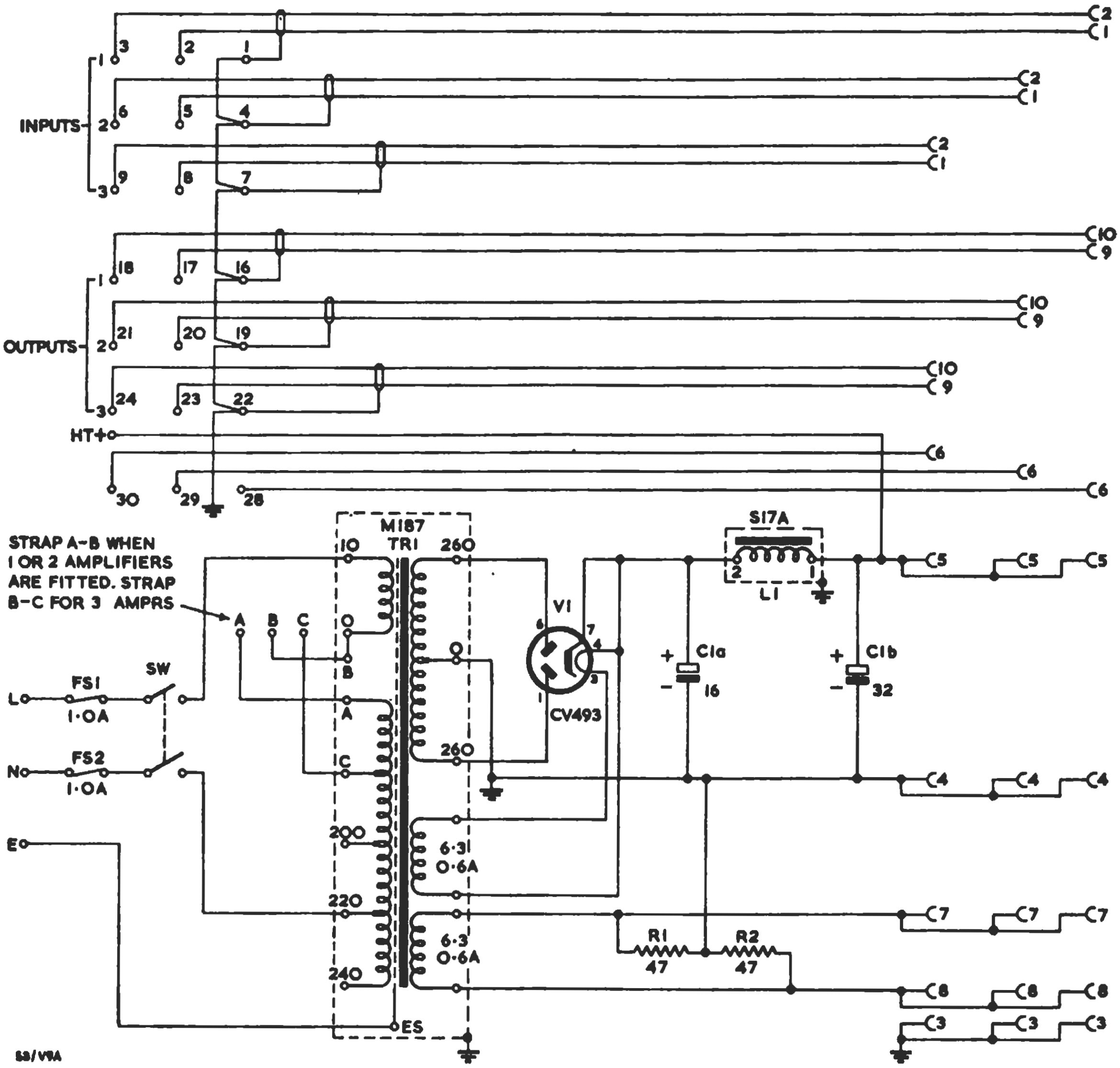


Fig. 21.8 Amplifier-mounting and Supply Panel AMS/1: Circuit
Drawing No. EA 8632

Test Data: AMS/1

Output Voltage

The panel should be provided with a mains supply at a voltage accurately suited to the primary tap in use and the output voltages should be measured under the following conditions:

	Transformer Link	*H.T. Load*	*L.T. Load*
(a)	B–C	55 mA	2 A
(b)	A–B	38 mA	1·3 A

In both conditions the h.t. voltage should be 285 ±15 volts and the r.m.s. voltage across the transformer l.t. winding should be 6·3 ±0·15 volts.

Ripple

The ripple measured across the h.t. supply with an amplifier detector AD/4 isolated from d.c. by a 2-μF capacitor should not exceed —15 dB when the mains unit is operating under condition (a).

SECTION 22

TRAP-VALVE AMPLIFIER TV/25

General Description

The TV/25 is a portable trap-valve amplifier designed for O.B. use, in particular with equipment Type OBA/9. (Section 20.) It has two separate inputs, each providing two outputs, and embodies four pentode valves. The impedance at each input is 18 kilohms nominal, and the impedance at all four outputs is 75 ohms. The gain of each unit is independently variable, with a 9·5-dB maximum, and provision is made for switching a 50-dB loss-pad into any output circuit to provide a low-level signal suitable for feeding an O.B. amplifier. The normal working input level is 0 dB approximately, and the normal output level (volts) either 0 to +4 dB into 240 ohms or, with the loss-pad in circuit, about −50 dB.

A built-in mains unit is provided capable of operating from 200–250 volts 45–60 c/s a.c.; where no mains supply is available, external batteries can be used.

The amplifier is built into a grooved case of similar construction and dimensions to that of the OBA/9. The total weight is about 22 lb.

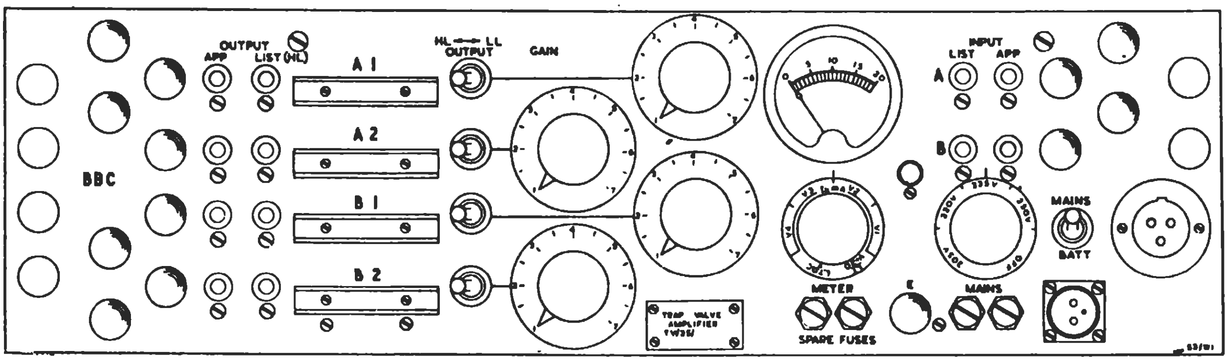


Fig. 22.1 TV/25: Face Panel

Drawing No. E.K. 8618

Circuit Description (Fig. 54)

The two inputs of the TV/25 are referred to as A and B, the outputs being designated A1, A2, B1 and B2. Since the A and B sections of the amplifier are identical, only one will be described.

The secondary of input transformer TR 1 (Fig. 54) is coupled to the grids of two single amplifying valves, a 100-kilohm volume control being included in the grid circuit of each valve. The two volume controls, one of which is shown in Fig. 54, are thus in parallel across TR 1 secondary, also loaded by R13 which has a value of 120 kilohms. Since the impedance ratio of TR 1 is 1 : 2, the input impedance of the TV/25 is about 18 kilohms.

Voltage negative feedback is applied to the cathode of each valve from a tertiary winding on its output transformer, TR 2. The secondary circuit of this transformer is padded out by R5 and R6 to bring the output impedance up to 75 ohms, a value selected as being the most suitable for feeding into O.B. lines. With an input at zero programme volume, the output under normal gain conditions is intended to be in the region of zero or +4 dB, but for a low-level output the 50-dB pad R7–R9 may be switched into circuit, the output impedance remaining at 75 ohms.

Each input to the TV/25 has an *Apparatus* and a *Listen* jack, together with a set of terminals in parallel. Each output has an *Apparatus* jack with parallel terminals; the *Output Listen* jack is connected in a part of the circuit prior to the 50-dB pad to prevent an alteration in listening level when the 50-dB loss switch is thrown.

The built-in mains unit, which supplies all four amplifying valves, is shown in the lower part of Fig. 54. A mains-voltage switch is provided to select the appropriate primary tapping on transformer TR 3, and a pilot-lamp lights when the mains or l.t.-battery supply is on. A meter and switch are fitted for checking the h.t. voltage and the cathode currents of the valves.

Valve Data

Valve	*Cathode Current mA*	*Heater Volts*	*Heater Amps*
V1–V4 All CV 138	6±1 each	6·2	0·3 each
V5 CV 493		6·2	0·6

ed

Supplies

Mains supply, 200–250 volts, 45–60 c/s.
H.T. supply, 275±10 volts, 24±4 mA.
L.T. supply to V1–V4, 6·2 volts, 1·2 amps a.c.

NOTE:—The valve and supply data relate to the use of the built-in mains unit and not to an external battery supply. The mains voltage during measurements should be accurately suited to the transformer tap in use. If batteries are used, they should provide the normal h.t. voltage and a 5-volt heater supply.

General Data

Impedances

Input Z = 18 kΩ nominal.
Output Z = 75Ω±5% (measured by resistance substitution).
Normal load Z = 240 Ω.

Normal Working Input Level

0 dB approx.

Normal Working Output Levels

Voltage levels into 240 Ω load.
Either 0 to +4 dB or −50 dB approx.

Test Data

Output Termination

240 Ω.

Maximum Voltage Gain

Test frequency, 1 kc/s.
Gain, G=9·5± 1·0 dB.

Output Attenuator

When the *Output Attenuator* switch is thrown from *High Level* to *Low Level*, the level of the output should fall by 50± 1 dB.

Frequency Response

Reference frequency, 1 kc/s. Any gain setting.
±0·5 dB from 40 c/s to 15 kc/s.

Percentage Total Harmonic Distortion

Output level, +8 dB (volts) = +12 dB (power).
At 60 c/s, < 1%
At 1 kc/s, < 0·2%
Output level, +12 dB (volts) = +16 dB (power).
At 60 c/s, < 1·5%
At 1 kc/s, < 0·25%

Noise Volume

Input Termination, 600 Ω.
Noise volume (unweighted), measured with T.P.M., not greater than −60 dB.

SECTION 23

AMPLIFIER AMC/5

General

The AMC/5 is derived from the general purpose amplifier GPA/4 described in Section 21, and embodies improvements on the GPA/4 input circuit which give the highest practicable ratio of signal to thermal-agitation noise. The AMC/5 was originally developed to replace the GPA/4 where used as a microphone amplifier, but to avoid the continuance of two separate types it has been decided to employ the AMC/5 in all applications.

The AMC/5 carries an amber-coloured pilot-lamp, in contrast to the white pilot-lamp fitted to the GPA/4.

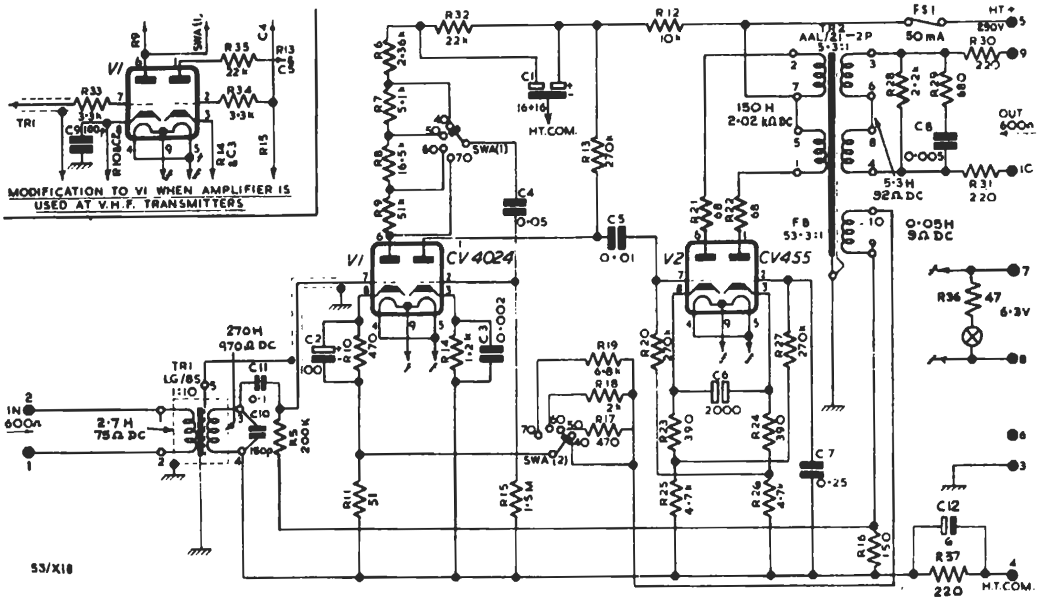


Fig. 23.1 Amplifier AMC/5: Circuit

Drawing No. DA 3697

Circuit Description (Fig.23.1)

The circuit of the AMC/5 is shown in Fig. 23.1, and the layout of the components in Fig. 55. The resistive loading on the primary and secondary sides of the GPA/4 input transformer TR 1 has been removed, and an artificially derived 600-ohm input impedance has been obtained by means of parallel-connected voltage negative feedback* applied via R5 to the grid of V1A. To provide a point from which this parallel feedback could be obtained, the resistors in the main feedback chain have been re-arranged. A new input transformer, TR 1, with a slightly smaller turns ratio and a lower winding resistance than before, has also been supplied.

The use of the artificially derived input impedance and the reduction in TR 1 winding resistance give an improvement in the signal to thermal-agitation noise ratio of the order of 5 dB. The resulting noise level of the input circuit is within about 1 dB of the lowest theoretically obtainable with a source of 600 ohms, and the amplifier is thus very suitable for use with low-output microphones or comparably attenuated grams.

* See *Engineering Training Supplement No.* 3, Issue 2, pages 45–47.

A capacitor, C10, has been connected across TR 1 secondary winding to improve the frequency response, which was found to be affected by the winding capacitance of the new transformer. A further capacitor, C11, is used to introduce a slight phase-change in the feedback path to the grid of V1A with the object of improving stability. Various minor changes in component values have also been made to enable stock preferred values to be used.

Note that in spite of the improvement in thermal noise, the *measured* noise may not differ significantly from that of the GPA/4. The measured noise, however, is largely hum, which is much less audible than thermal noise. C12 and R37 in the common h.t. lead put a slight bias on the valve heaters; this tends to reduce the hum and makes the selection of the first stage valve less critical. Apart from the question of noise, the general performance of the AMC/5 is similar to that of the GPA/4, as given on page 21.7 of this instruction except that the gain at each setting is increased by 1 dB and that tolerances on gain and frequency response are not quite so rigidly maintained. The detailed effect on the amplifier performance specification can be seen by comparing the figures for the GPA/4 with those for the AMC/5.

Test Data:

General

The power supplies required and the valve feeds are the same as those for the GPA/4. The electrical performance should conform to the limits given in Section 21 for the GPA/4 except as set out below:—

Gain

The 600/600-ohms gain at 1 kc/s should be 44, 54, 64 or 74 dB ±0·5 dB according to the gain-switch setting.

Frequency Response

At the maximum gain setting and an output level of 0 dB the 600/600-ohms frequency response should be within the following limits relative to the gain at 1 kc/s:—

60 c/s to 10 kc/s, ± 0·5 dB
30 c/s to 15 kc/s, ± 0·8 dB.

Input Impedance

When measured by resistance substitution across a 600/600-ohms circuit, the input impedance should appear to be 600 ohms ± 10 per cent at 1 kc/s. This test must be made at a sufficiently low level with the amplifier switched on. The amplifier gain should, for convenience, be at minimum.

Valve Data*

	Avometer Model 40			Avometer Model 7		
Valve	*Anode Volts*	*Cathode Volts*	*Grid Volts*	*Anode Volts*	*Cathode Volts*	*Grid Volts*
V1A	68 (480) 36 (120)	0·3 (1·2)	0	57 (100)	0·5 (1)	0
V1B	40 (480) 18 (120)	0·14 (1·2)	0	31 (100)	0·27 (1)	0
V2A & B	280 (480)	29 (120)	0·0008 (0·12)	280 (400)	30 (100)	0·015 (1)
H.T.+		290 (480)			290 (400)	

* Measured from positive end of R37 to points stated. Figures in parentheses are Avometer voltage ranges.

SECTION 25

PAMPHONIC PUBLIC-ADDRESS EQUIPMENT

Introduction

Pamphonic public-address equipment commonly used within the Corporation comprises 30- and 50-watt amplifiers and line-source loudspeakers. Information on these items is given here. A few 10-watt amplifiers are also in use. This type is described in Instruction RX.2. (See page 52 and Fig. 4.)

General Description

The Pamphonic amplifiers, Type 601V (30 watts) and Type 602V (50 watts), are transportable loudspeaker amplifiers of commercial design and manufacture. They are used by the BBC for calling systems and for sound reinforcement in auditoria. For the latter purpose, they are generally used respectively to feed up to six or up to ten Pamphonic 6-ft line source loudspeakers Type 780.

The circuit of the 30-watt amplifier is given in Fig. 60 and that of the 50-watt amplifier in Fig. 61. The two circuits are similar except for the output stage and the h.t. rectifier.

Both types of amplifier are mains-operated, and have a (normally) 30-ohm microphone input and an input for gramophone or radio at two levels. Separate volume controls allow mixing at any level. A visual indication of level and overloading is provided and there are separate bass and treble controls for tone balance. In some of the early amplifiers the microphone-input transformer has been changed to give a 300-ohm input.

A socket is provided to take a plug-in relay for remote-control purposes if required. The relay switches between the microphone input and the gram/radio input, and is energised by a dry battery, for which a compartment is provided; the relay is controlled by a single-pole switch at the remote position. A mains-supply socket for a gramophone is fitted.

Each amplifier in its case measures 18⅞ in. wide by 11¾ in. deep by 13⅛ in. high. The 30-watt amplifier weighs 45 lb and the 50-watt amplifier 57 lb. Each chassis can be removed from its case and fitted to a 19-in. bay if desired.

Circuit Description (Figs. 60 and 61)

In both amplifiers, the microphone input transformer, T1, is connected to first-stage amplifying valve, V1, which is coupled via gain control P1 and bass and treble controls P3, P4, to the double-triode phase-splitter V3. The low-level input for gramophone or radio goes direct to first-stage amplifying valve V2, the high-level input being taken via potential divider R2, R1. V2 is coupled via gain control P2 to the tone controls, in parallel with the output from V1 via P1.

The two sections of V3 are connected to a driver stage comprising the two sections of another double-triode V4. From this point on the two amplifiers differ in order to provide the output power required. In the 30-watt amplifier (Fig. 60) the output stage comprises two valves, V5, V6, whereas in the 50-watt amplifier this stage has four valves, V5, V6, V7, V8, operating in parallel push-pull pairs. In both amplifiers an output transformer, T2, is fitted, with level indicator V7 in its secondary circuit.

Voltage negative feedback is applied by cathode injection to each section of V4 from the ends of T2 primary winding.

When the remote-control system is used, the pins marked 1, 2, 6, 7 and 8 on the relay engage with corresponding sockets on the amplifier. Pins 1 and 8 connect the battery and remote-control switch to the winding. Pins 6, 7 and 2 pick up the outputs of V1 and V2 and the earth line. With the control switch open, the relay is unoperated, pins 6 and 2 are connected together via the contact-springs, and the microphone input is short-circuited. With the control switch closed, the relay is operated, pins 7 and 2 are connected, and the gram/radio input is short-circuited instead.

Amplifier Type 601V: General Data

Output

30 watts at 100 volts.

Harmonic Distortion

Less than 3 per cent at 1 kc/s.

Sensitivity
Microphone: 440 μV for 30 watts at 1 kc/s.
Radio or gram: 50 or 270 mV for 30 watts at 1 kc/s.

Input Impedance
Microphone: 30 ohms.
Radio or gram: 220 kilohms, either input.

Noise Level
Both volume controls at minimum: better than − 60 dB.
Gram volume control at maximum: better than − 60 dB.
Microphone volume control at maximum: better than − 50 dB.

Frequency Characteristic
Gram: 6-dB bass lift at 100 c/s, substantially flat from 1 kc/s to 15 kc/s.
Microphone: substantially flat from 200 c/s to 10 kc/s.

Valves
2 EF86, 1 ECC83, 1 ECC82, 2 KT66, 1 GZ32, 1 DM70.

Mains Consumption
Full drive: 140 VA.
Quiescent: 120 VA.

Amplifier Type 602V: General Data

As for amplifier Type 601V except as indicated in next column.

Output
50 watts at 100 volts.

Valves
2 EF86, 1 ECC83, 1 ECC82, 4 KT66, 2 GZ32, 1 DM70.

Mains Consumption
Full drive: 284 VA.
Quiescent: 254 VA.

Line Source Loudspeaker Type 780

The Pamphonic line-source loudspeaker Type 780 comprises an acoustically-treated wooden cabinet, 6 ft high, containing two columns of loudspeaker units, eight in one column and five in the other, on an internal wooden baffle board.

The speakers in each column are mounted vertically above one another and are linked internally by specially-designed attenuators so that the resultant sound emerges as a fan-shaped beam without secondary lobes. This beam has a vertical main-beam angle of 37 degrees and a horizontal coverage of approximately 120 degrees at 4 kc/s. The vertical angle is maintained reasonably constant down to 800 c/s.

The maximum power output is 5 watts. The number of loudspeakers used for sound-reinforcement purposes is governed by the field to be covered.

W.G.4/61

PAMPHONIC AMPLIFIER TYPE 661W

Introduction

The Pamphonic amplifier Type 661W is a modern replacement for the Pamphonic amplifier Type 601V, described earlier in this section, although many amplifiers Type 601V remain in service. Minor differences exist between the two types in that the new model has an additional microphone input but does not possess the level indicator and remote control facilities of the older one. In the BBC, the amplifier Type 661W is used for calling and talkback systems, for studio loudspeaker foldback and for sound reinforcement in auditoria.

General Specification

Output

30 watts at 100 volts.

Harmonic Distortion

Less than 2% for 30 watts output at 1 kc/s.

Sensitivity

Microphone:	100 μV for 30 watts output at 1 kc/s.
Gramophone:	200 mV for 30 watts output at 1 kc/s.
Radio or Tape:	250 mV for 30 watts output at 1 kc/s.

Input Impedances

Microphone:	30 ohms (balanced).
Gramophone:	100 kilohm (unbalanced).
Radio or Tape:	250 kilohm (unbalanced).

Noise Level

Better than 55 dB below full output.

Frequency Characteristic

With bass and treble controls set for flat response from 20 c/s to 17 kc/s:	±3 dB with respect to level at 1 kc/s.
Treble control range:	−14 dB to +9 dB at 10 kc/s.
Bass control range:	−10 dB to 0 dB at 100 c/s.

Valves

3 ECC83, 1 ECC81, 2 KT88, 1 GZ34.

Mains Consumption

110 watts.

General Description

The amplifier is a transportable 30-watt loudspeaker amplifier designed to work into a 100-volt line. All stages prior to the output stage utilise a printed wiring board. The output stage together with the mains-power supply is chassis mounted.

One gramophone input, one radio or tape input and two microphone inputs are provided. Each input has an associated gain control which permits variable level mixing. Separate bass and treble controls operate after the mixing stage.

Normally the amplifier is supplied in a case with fitted end-piece stands that are shaped to give the amplifier a slight tilt backwards. The dimensions of the amplifier in its case are 21 in. wide by 11 in. high by 10 in. deep; it weighs 25 lb. However, the chassis may be removed from the case and fitted in a 19-in. bay. In this form, known as Type 661W/RM when supplied by the manufacturer, the vertical panel space required is 7 in.; the other dimensions are unchanged.

Circuit Description (Fig. 70)

Amplifier Type 661W comprises a 30-watt power amplifier preceded by three triode preamplifiers, V1A, V1B, V2B, and one triode mixing stage V2A.

The two low-level microphone input sockets, SKT 1 and SKT 2, are transformer coupled to their respective preamplifiers, V1A and V1B. The gramophone input socket SKT4 is connected by way of gain control RV4 to preamplifier V2B. All three preamplifiers, together with the high-level radio input socket SKT3, are coupled to the grid of the mixing amplifier V2A. Coupling of V1A, V1B and SKT3 is achieved by way of gain controls RV1, RV2 and RV3 and the star mixing network comprising resistors R6, R7 and R9. The output of the gramophone preamplifier is passively equalised to the RIAA replay characteristic by the network consisting of C7, C8, C26, R14 and R15; coupling of the preamplifier to the grid of V2A is completed by the stand-off resistor R13. To provide a low mixing-impedance at the grid of V2A, parallel-applied voltage negative feedback is applied to V2A by C4 and R8.

The mixed output at V2A anode is coupled, by bass and treble control networks, to the grid of triode amplifier V3A and this stage is followed by a phase splitter V3B. Fine balance of the phase splitter is obtained by adjustment of variable cathode resistance RV7.

Outputs, taken from the anode and cathode of V3B, feed push-pull driver stages V4A and V4B and these are followed by a push-pull output stage comprising V5 and V6 which is connected in a class AB_1, ultra-linear mode.

Several feedback circuits have been employed in the output stages to reduce distortion and provide a good output regulation. A resistor, directly connected from the anode of each output valve to the cathode of its preceding stage, provides voltage negative feedback between associated output and driver stages. Current negative feedback is applied to each driver stage by the omission of cathode decoupling components. It should be noted that the output stage feedback resistors R43 and R44 also contribute towards the biasing of the driver stages, owing to their direct connections.

Overall voltage negative feedback is applied from a tertiary winding of the output transformer T3 to the cathode of amplifier stage V3A.

Power-supply requirements are met by a full-wave rectifier circuit consisting of mains transformer T4, rectifier V7 and series connected reservoir capacitors C24 and C27; resistance capacity smoothing is provided by C25 and R53. The potential divider chain R56 and R57 tends to equalise the voltages across the electrolytic smoothing capacitors. A hum-balance control RV6 is connected across the 6·3-volt supply.

The double pole switch SW1, marked as *Stand-by* on the amplifier front panel, breaks simultaneously the amplifier output feed to line and the h.t. rail to all stages except the power output stage. This arrangement provides instant muting, which may be desirable in some public address installations, and also ensures that the output stage is not driven by a signal when it is off-load in the stand-by condition.

CEW/0566

PAMPHONIC AMPLIFIER TYPE 602W

General Description

The Pamphonic Type-602W equipment is a bay-mounting loudspeaker amplifier delivering a maximum output of 50 watts to a 100-volt line. It is mains-operated, and has a high-impedance input circuit. A socket is provided at which the h.t. and heater supplies, together with a 26-volt negative supply, are available for connection to other apparatus. The amplifier is carried on a standard 19-in. panel which is 7 in. high and has an overall depth of 12 in.; when bay-mounted, it projects through the bay.

Circuit Description (Fig. 71)

A circuit diagram of the amplifier is given in Fig. 71. The early stages are built on a printed-wiring board; the output stage and power-supply circuits are of conventional construction.

A gain control precedes the first two stages, formed by cascaded arrangement of a double-triode V1. These work with negative feedback applied via R6 from the second anode to the first cathode. The second-stage cathode resistor is shunted by a small-value capacitor C4, to enhance circuit stability by compensating for phase shifts in the two stages.

The third stage employs a triode-connected pentode V2 as a phase-splitter. The cathode-circuit load includes RV2 to allow accurate matching of the signal voltages taken from anode and cathode to individual sections of another double-triode V3. These feed a push-pull output stage using beam tetrodes V4 and V5.

Negative feedback for the last two stages is provided by connecting the V4 and V5 anodes through C9, R20 and C10, R21, respectively, to the associated V3 cathodes. For phase-shift compensation the grid resistors of the output stage are shunted by series *RC* combinations, C12, R23 and C13, R24. R29 is connected between the V4 and V5 cathodes to improve the stability of output-stage balance, by reducing bias-voltage inequality where different cathode currents flow because the valves are imperfectly matched.

The only unusual feature of the h.t. supply circuit is the use of paired capacitors in series connection to obtain shunt elements capable of withstanding the high voltage, about 530 volts on load. Resistors across the capacitors ensure equal sharing of the working voltage. Tappings on the T2 h.t. winding are used in connection with a metal rectifier producing the 26-volt negative supply for external use. To improve output-voltage regulation the *RC* filtering of this supply is effected with paralleled thermistors instead of a resistor. R35 is used to avoid a no-load condition.

Note that the negative side of the amplifier and its supply circuit is connected to chassis via a low-value resistor (R30), whereas the earth pin of PL2 is directly connected to chassis. Thus the resistor is placed between the mains earth and the programme-earth connection via the PL1 outer contact, so it serves to limit unwanted circulation of hum-producing current in the loop completed via the two earth connections.

General Data

Input impedance	100 kilohms
Sensitivity	200 mV at 100 kilohms
Frequency response	Better than ±1 dB between 30 Hz and 20 kHz
Output	50 watts (at 100 volts)
Harmonic distortion	Less than 2 per cent for 50-watt output at 1 kHz
Noise level	−70 dB with respect to full output
Valves	1 ECC83, 1 EF86, 1 ECC81, 2 KT88, 1 GZ34

DEH/0766

ERRATA

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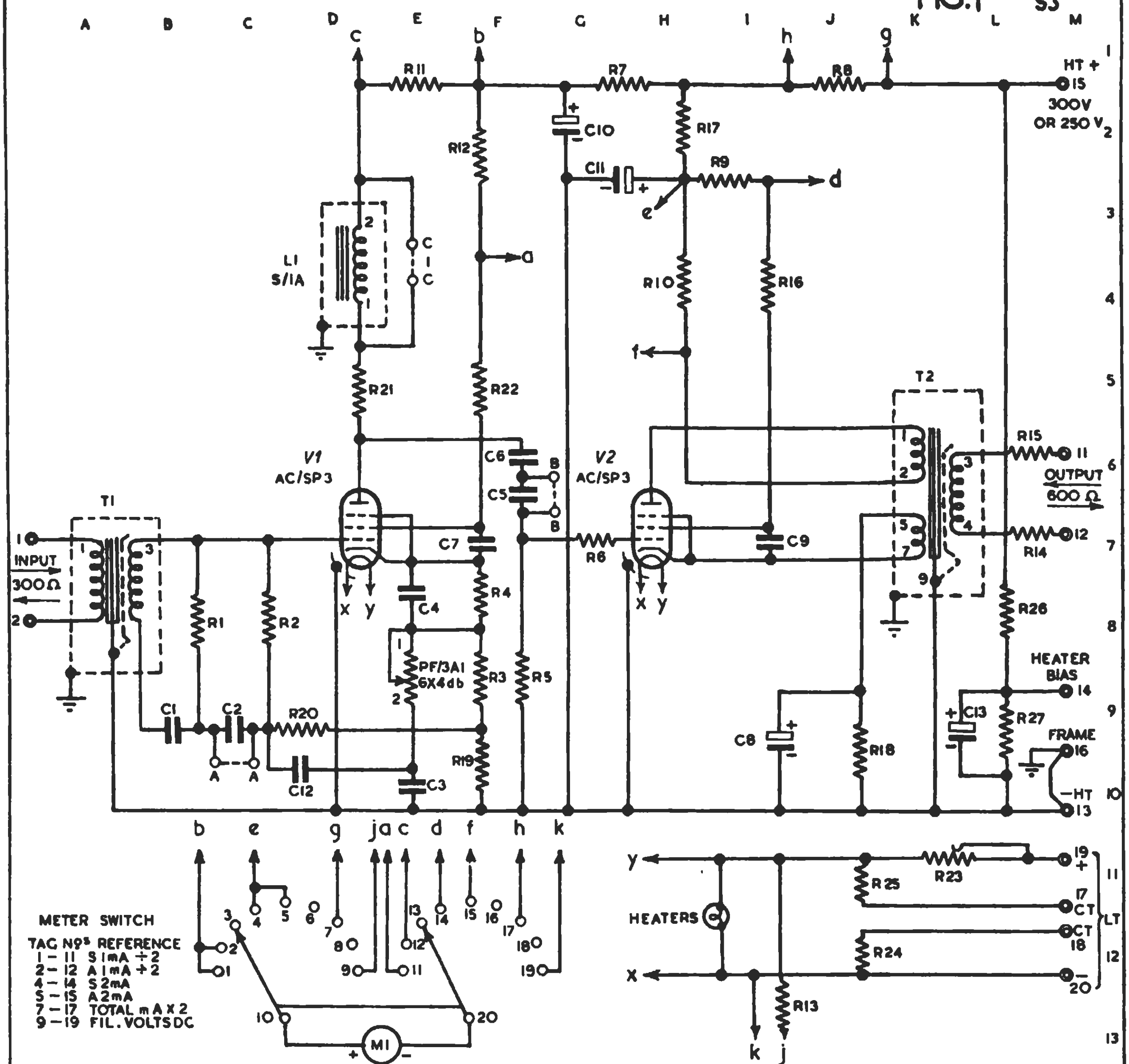
64103A/S3/AJP

FIG. 1 S3

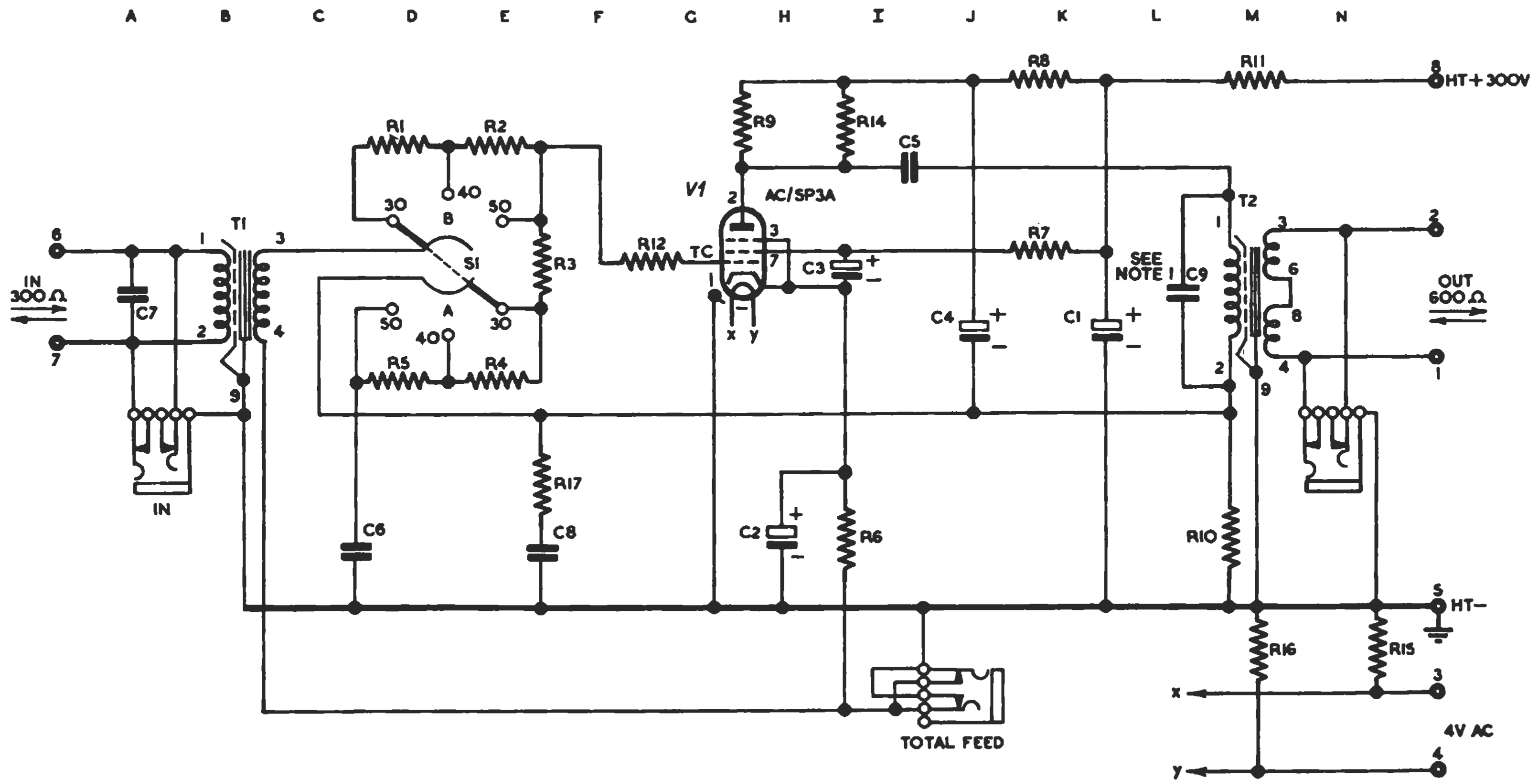


A – A OPEN FOR RIBBON MIC BASS CORRECTION
B – B " " " " " "
C – C " " " " TREBLE "

COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	B9	0·04 μF	TYPE 431	R1	B8	330 000 Ω	0·25 W	R20	D9	250 000 Ω	0·25 W
C2	C9	0·005 "	" "	R2	C8	500 000 "	0·25 "	R21	D5	150 000 "	1 "
C3	E10	2 "	" 65	R3	F9	650 "	0·25 "	R22	F5	500 000 "	0·25 "
C4	E8	0·02 "	" 431	R4	F8	350 "	0·25 "	R23	K11	2 "	TYPE 3B1
C5	F6	0·01 "	" "	R5	F9	300 000 "	0·25 "	R24, R25	J12, J11	10 "	
C6	F6	0·1 "	" "	R6	G7	5 000 "	0·25 "	R26	L8	150 000 "	1 W
C7	F7	2 "	" 87	R7	G1	20 000 "	0·25	R27	L9	50 000 "	1 "
C8	I9	250 "	20V WKG	R8	J1	14·3 "					
C9	I7	2 "	TYPE 87	R9 10	I2 H4	33·3 "					
C10, 11	G2, H3	16 "	500V WKG	R11 12	E1 F2	100 "		L1	D4	3·09 – 3·41H	
C12	D10	0·1 "	TYPE 431	R13	I13	3900 "	TYPE P301				
C13	K9	2 "	" FW	R14 15	L7 L6	200 "	0·25 W				
				R16	I4	100 000 "	0·5 "	T1	A8	1:25·8	LG/13 RB
				R17	H2	10000 "	0·25 "	T2	K6	8·05:1	AL/6 RA
M1	E13		0–1·5mA	R18	J9	250 "	0·5 "				
				R19	F10	18 000 "	0·25 "				

A AMPLIFIER A/11

64101B/S3/DJE
SD/LF1/777



COMP.	LOCATION	VALUE	TYPE	COMP.	LOCATION	VALUE	TYPE
C1	K4	16 μF	BEC CE15129	R6	I6	180 Ω ± 2%	ERIE108 ·25W
C2	H6	100 "	12V AS10697	R7	K3	68000 " 10	" 0·5W
C3	I3	2 "	TCC FW	R8	K1	4700 " "	" "
C4	J4	16 "	BEC CE15129	R9	H1	22000 " "	" 2W
C5	I2	2 "	TCC 87	R10	M6	1500 " "	" 0·25W
C6	D6	{·002 "	" M2N	R11	M1	4700 " "	" 1W
		{·005 "	" M3N	R12	G3	3300 " "	" 0·25W
C7	A3	{·02 "	" 545	R14	I2	220000 " "	" "
		{·02 "	" "	R15	N7	22 " "	" "
C8	E6	·002 "	" M2N	R16	M7	22 " "	" "
C9	L3	200 μμF		R17	E5	560 " "	" "
R1	D2	56000 Ω ± 10%	ERIE 0·25W				
R2	E2	180000 " "	" " "				
R3	E3	180000 " "	" " "	T1	B3	1 : 28·8	LG/32RB
R4	E4	470000 " "	" " "	T2	M3	5·9 : 1	AL/20RD
R5	D4	1·5 MΩ					

MICROPHONE AMPLIFIER AMC/2

FIG. 2 S3

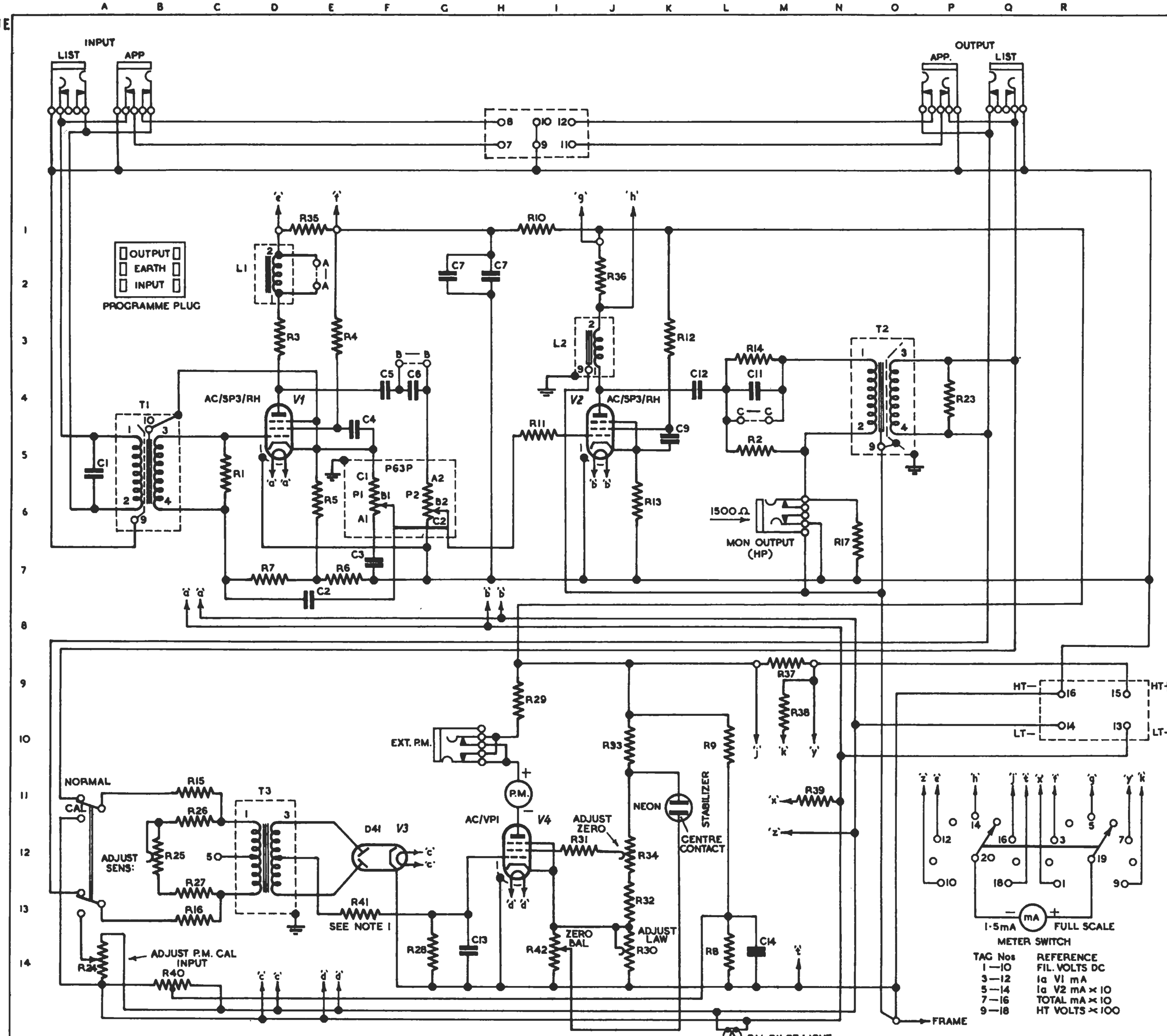
3rd ISSUE

ISSUE	AMENDMENT
2	TURNS RATIO OF T2 WAS 6·9:1 C9 ADDED
3	R6 WAS 220 Ω ± 10%

64104B/S3/DJE

FIG.3 S3

ISSUE	AMENDMENT
2	R41 & 42 ADDED ALSO VALUES OF R8 & 9 ENTERED IN COMP. TABLE R30 WAS ADJUST ZERO. R34 WAS ADJUST LAW



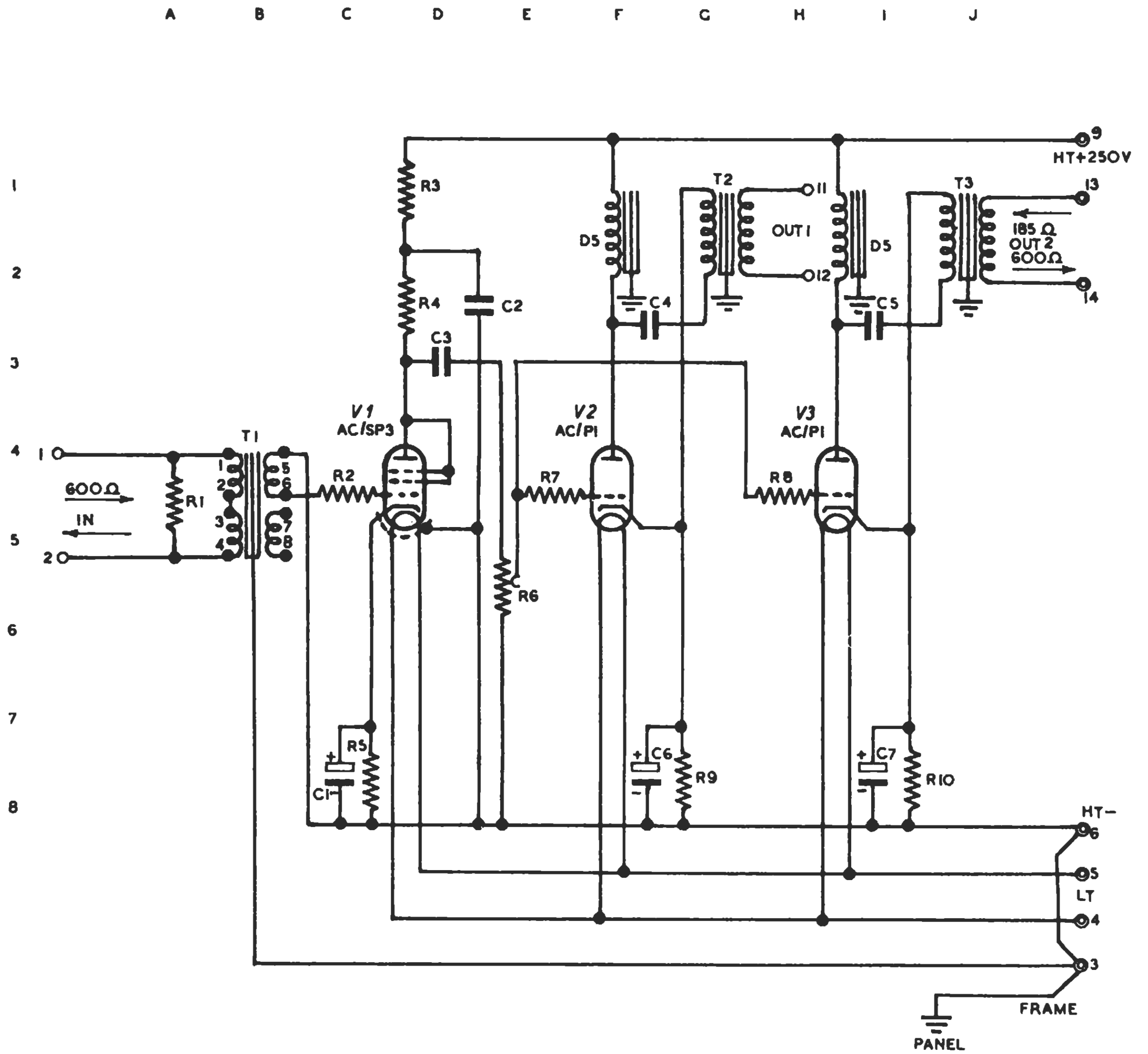
AMPLIFIER APM/1

COMP.	LOC.	VALUE	TYPE
C1	A5	0·05 μF	431
C2	E7	1·0 "	"
C3	F7	2·0 "	87
C4	E4	2·0 "	"
C5	F4	0·1 "	431
C6	F4	0·006 "	M
C7	H2	2·0 "	87
C9	K5	4 "	"
C11	M4	0·06 "	431
C12	K4	0·35 "	"
C13	G14	0·05 "	"
C14	M14	2·0 "	87
L1	D2	3·09—3·41 H	S/1A
L2	J3	170 — 230 H	R/1A
R1	C5	300 000 Ω	0·25W
R2	L5	100000 "	"
R3	D3	150 000 "	1W
R4	E3	500 000 "	0·25W
R5	E6	1 000 "	"
R6	E7	2000 "	"
R7	D7	100000 "	"
R8	L14	15 000 "	1W
R9	L10	100 000 "	"
R10	H1	20000 "	"
R11	H5	5000 "	0·25W
R12	K3	20 000 "	1W
R13	J6	120 "	0·25W
R14	L3	100 000 "	"
R15	C11	600 "	"
R16	C13	600 "	"
R17	N6	1500 "	"
R23	P4	400 "	"
R24	A14	1000 "	LHAR 10250
R25	B12	10000 "	MNAP 10350
R26	C11	300 "	0·25W
R27	C13	300 "	"
R28	G14	20MΩ	1W
R29	H9	100 000 Ω	"
R30	J14	1000 "	LHAR 10250
R31	J12	50 000 "	0·25W
R32	J13	75000 "	0·5W
R33	J10	30000 "	1W
R34	J12	50 000 "	MNAP 50350
R35	E1	66·6 "	METER SHUNT
R36	J2	3·51 "	" "
R37	M8	3·51 "	" "
R38	M9	200000 "	1W
R39	M11	4000	0·5W
R40	B14	20Ω CT	
R41	F13	5000 Ω	
R42	I14	5000 "	LHAP 50250
T1	B5	1 : 31·6	LG/1RB
T2	O4	7·08 : 1	AL/11RA
T3	D12	1 : 10	LGG/35A
R8	L14	50 000 Ω	
R9	L10	100 000 "	

NOTE 1 R41 TO BE ADJUSTED ON FLICK TEST IF NECESSARY

A—A OPEN FOR RIBBON MIC TREBLE CORRECTION
B—B, C—C " " " " BASS "
FOR NORMAL USE ALL STRAPS CLOSED

FIG. 4 S3

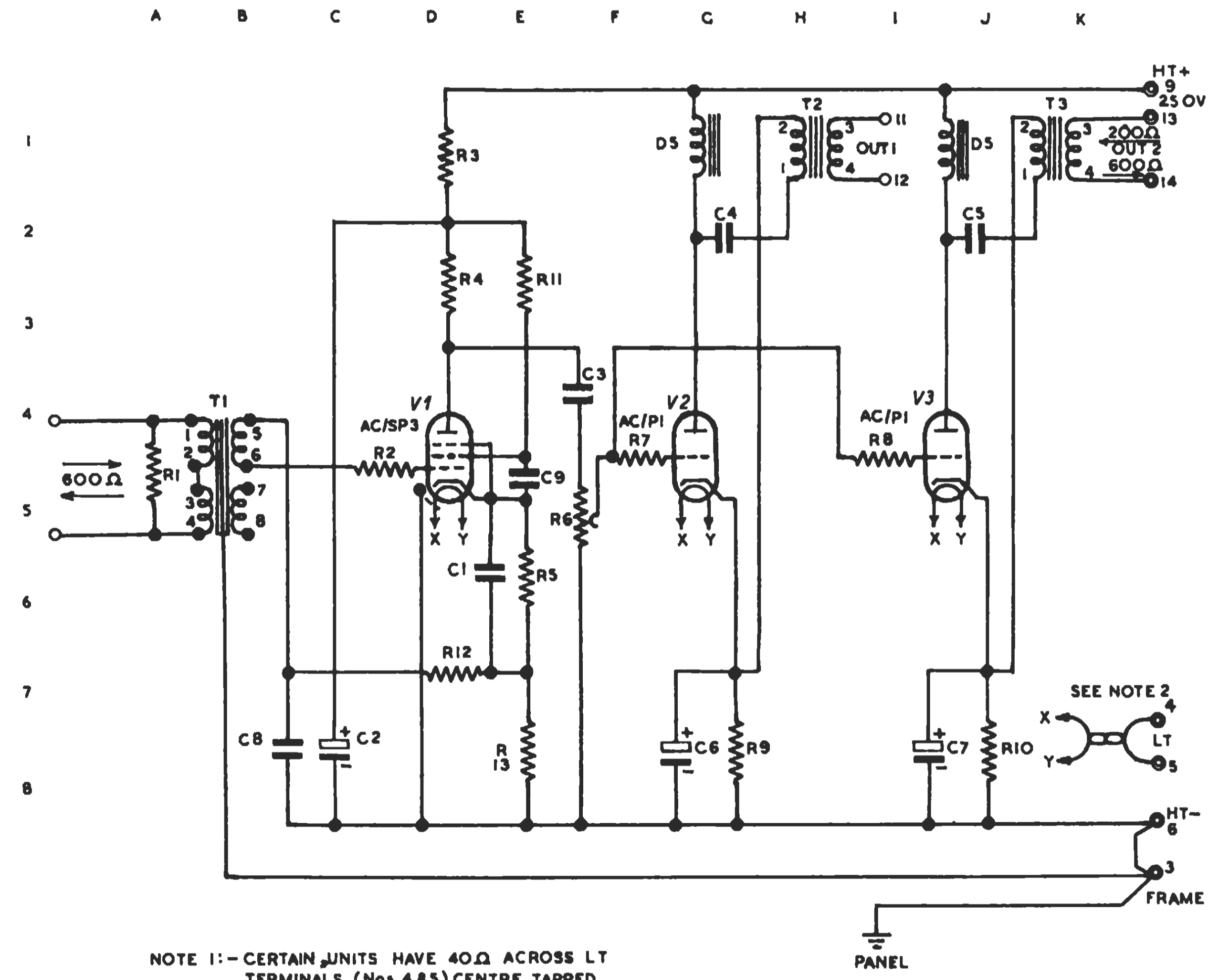


COMP.	LOC.	VALUE	RATING	COMP.	LOC.	VALUE	RATING
C1	C8	50 μF		R4	D2	60 000 Ω	·5W
C2	D2	4 "		R5	C8	1000 "	·5 "
C3	D3	0·5 "		R6	G8	250 000 "	MNAP 25450
C4,5	F3, I2	4 "		R7,8	E4 H4	600 "	25W
C6,7	F8, I8	50 "		R9,10	G8 I8	1500 "	·5 "
R1	A4	600 Ω	·25W	T1	B4	1: 14 · 3	I.T.256
R2	C4	5000 "	·25 "	T2 T3	G1 J1	4·47 :1	No 105
R3	D1	10 000 "	·5 "				

B AMPLIFIER B/14

64106A/S3/AJP

FIG.5 S3



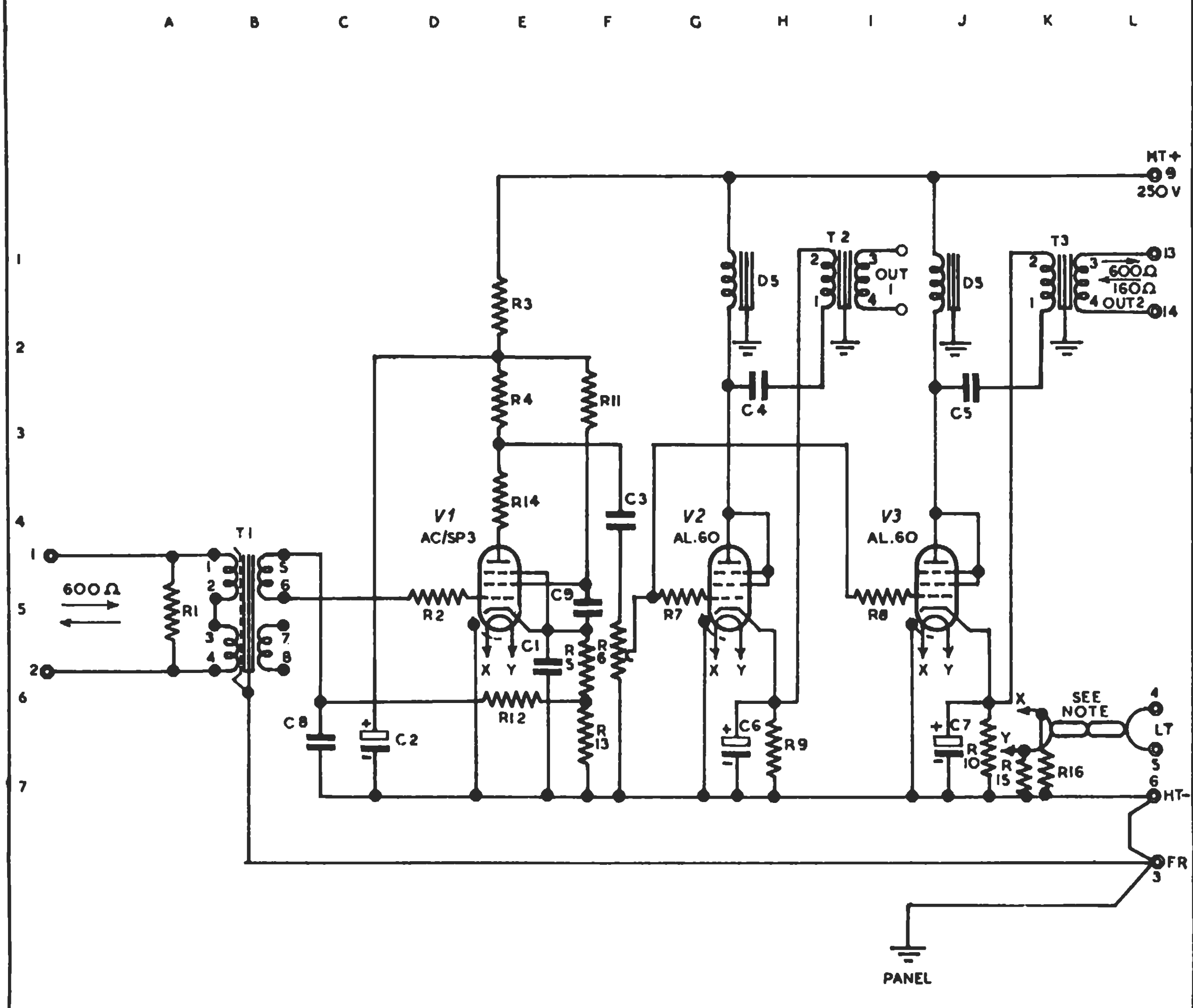
NOTE 1:- CERTAIN UNITS HAVE 40Ω ACROSS LT TERMINALS (Nos. 4 & 5) CENTRE TAPPED TO FRAME TERMINAL (No. 3)

COMP.	LOC.	VALUE	RATING	COMP.	LOC.	VALUE	RATING
C1	E6	0·025 µF		R6	F5	250000 Ω	MNAP 25450
C2	C8	16 "		R7,8	F4,14	600 "	·25 W
C3	F4	0·5 "		R9,10,13	G8,J8,E8	1500 "	·5 "
C4,5	G2,J2	4 "		R11	E2	500 000 "	·25 "
C6,7	G8,J8	50 "		R12	D7	250000 "	·25 "
C8,9	B8,E5	2 "					
				T1	B4	1:14·3	CA4201-23 OR IT256
R1	A5	600 Ω	·25 W	T2,3	H1,K1	4·47:1	No 105
R2	D5	5000 "	·25 "				
R3	D1	20000 "	·5 "				
R4	D2	150 000 "	·5 "				
R5	E6	1000 "	·5 "				

B AMPLIFIER B14/A

64107A/S3/AJP

FIG.6 S3

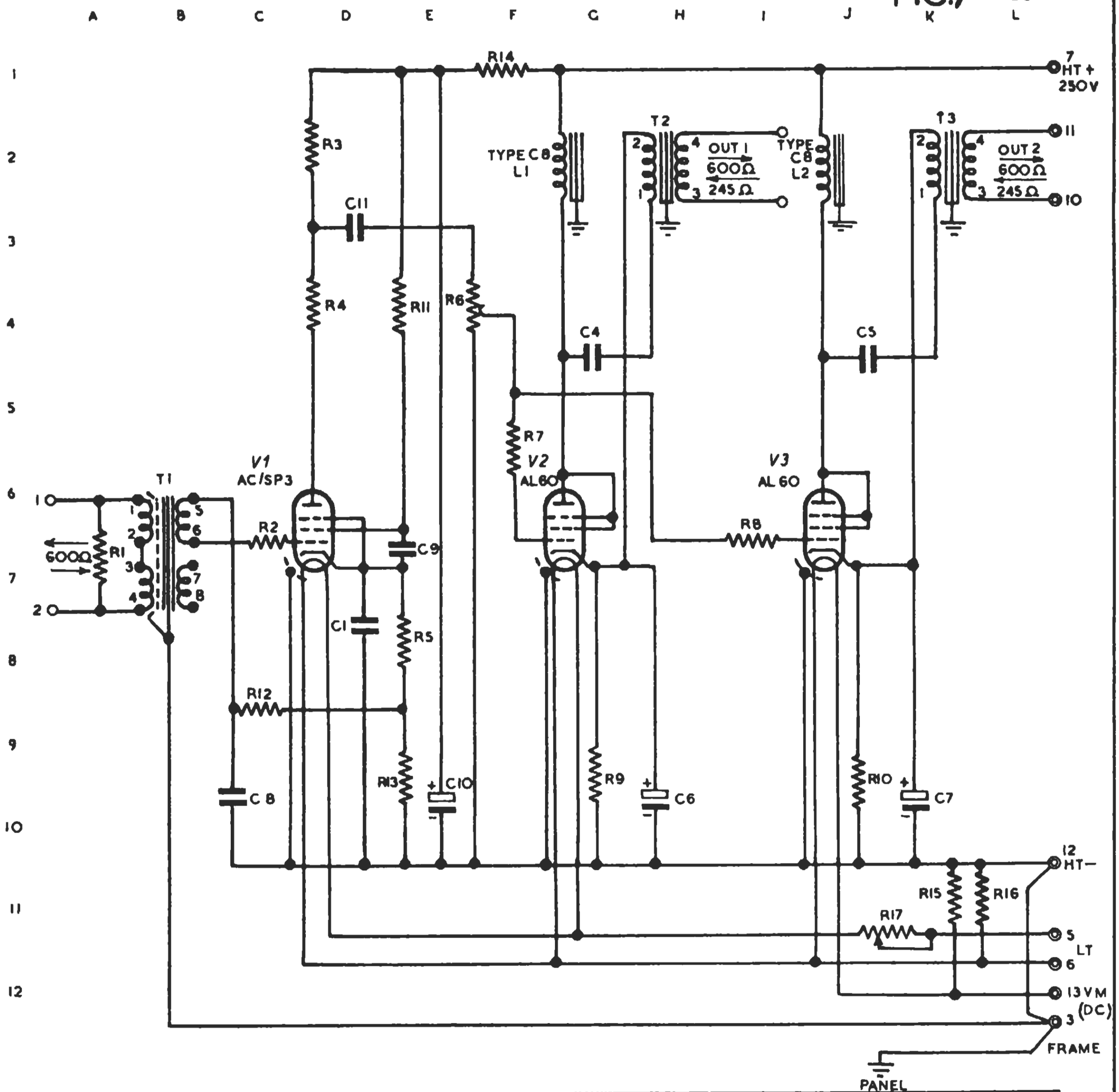


COMP.	LOC.	VALUE	RATING	COMP.	LOC.	VALUE	RATING
C1	E6	0·008 μF		R7,8	G5,I5	600 Ω	·25W
C2	C7	16 "		R9,10	H7,J7	300 "	·5 "
C3	F4	0·5 "		R11	F3	500 000 "	·25 "
C4 5	G2,J2	4 "		R12	F6	250 000 "	·25 "
C6,7.	G7,J7	50 "		R13	F7	1500 "	·5 "
C8,9	C7,F5	2 "		R14	E4	100 000 "	·5 "
				R15,16	K7,K7	20 "	·5 "
R1	A5	600 Ω	·25W				
R2	D5	5000 "	·25 "				
R3	E1	20 000 "	·5 "	T1	B	1:14·3	CA4201–23ORIT256
R4	E3	60 000 "	·5 "	T2,3	I1,K1	4·47:1	No 105
R5	F6	1 000 "	·5 "				
R6	F5	250 000 "	MNAP 25450				

B AMPLIFIER B/14 B

64108A/S3/AJP

FIG.7 S3

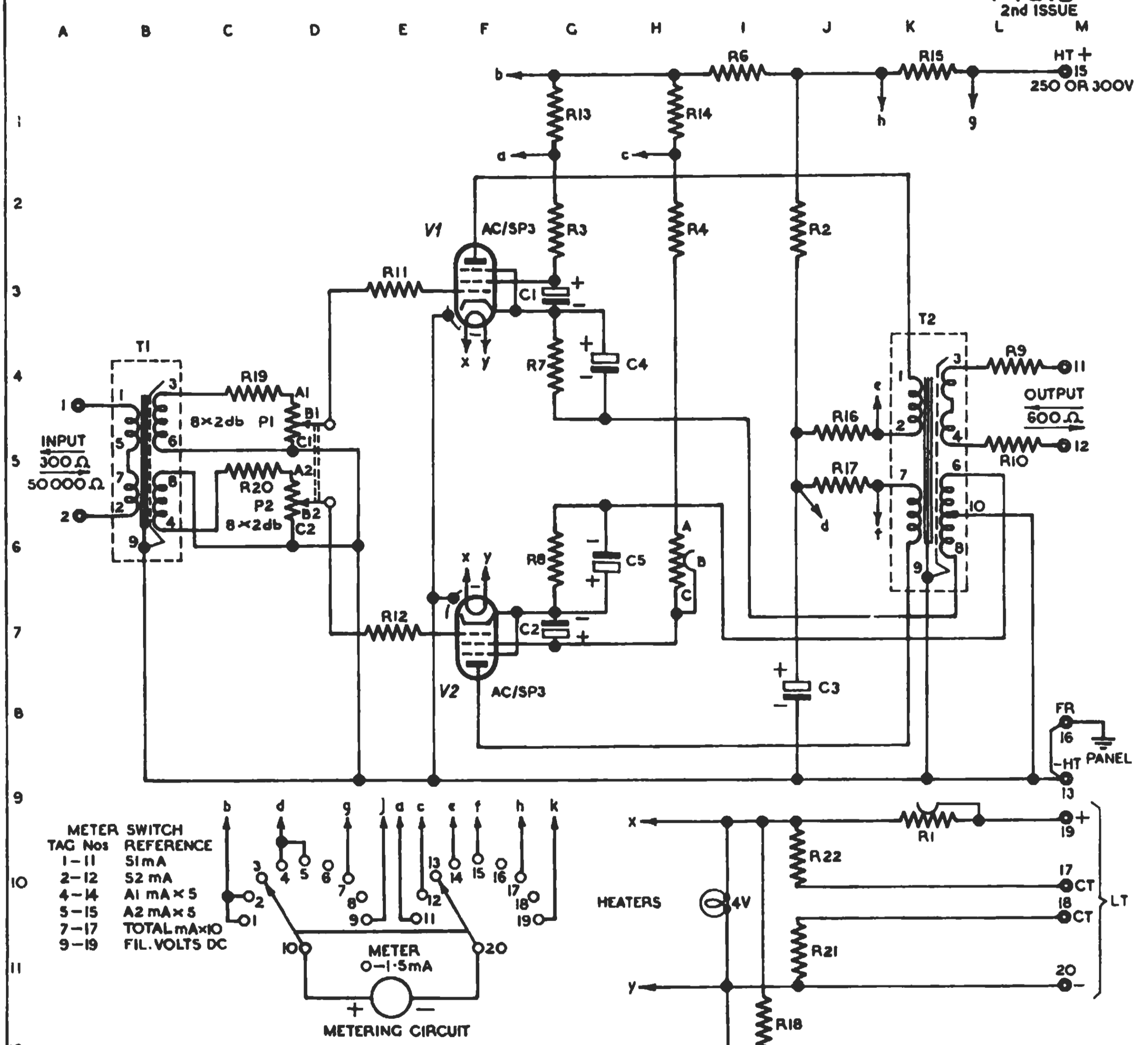


COMP.	LOC.	VALUE	RATING	COMP.	LOC.	VALUE	RATING
C1	D8	0·008 µF		R4	D4	100 000 Ω	25 W
C4	G4	40R6 "		R5	E8	1000 "	·5 "
C5	J4	40R6 "		R6	E4	250 000 "	MNAP 25450
C6	H10	50 "		R7,8	F5,I7	600 "	·5 "
C7	K10	50 "		R9,10	G9,J9	300 "	·5 "
C8	C10	2 "		R11	E4	500 000 "	·25 "
C9	E7	2 "		R12	C8	250 000 "	·25 "
C10	E10	16 "		R13	E9	1500 "	·5 "
C11	D3	0·5 "		R14	F1	20 000 "	·5 "
				R15,16	K11,L11	20 "	·5 "
				R17	K11	0-1·70R0-0·85 "	
L1,2	G2,J2	C8	52 H				
				T1	B7	1 : 14·3	CA4201 – 23 OR IT 256
R1	A7	600 Ω	·25 W				
R2	C6	5000 "	·25 "	T2,3	H2,K2	2·835:1	No 186
R3	D2	50000 "	·25 "				

B AMPLIFIER B/14C

64019B/S3/DJE

FIG.8 S3
2nd ISSUE



NOTE 1. R6 SHORTED WHEN USING 250V SUPPLY

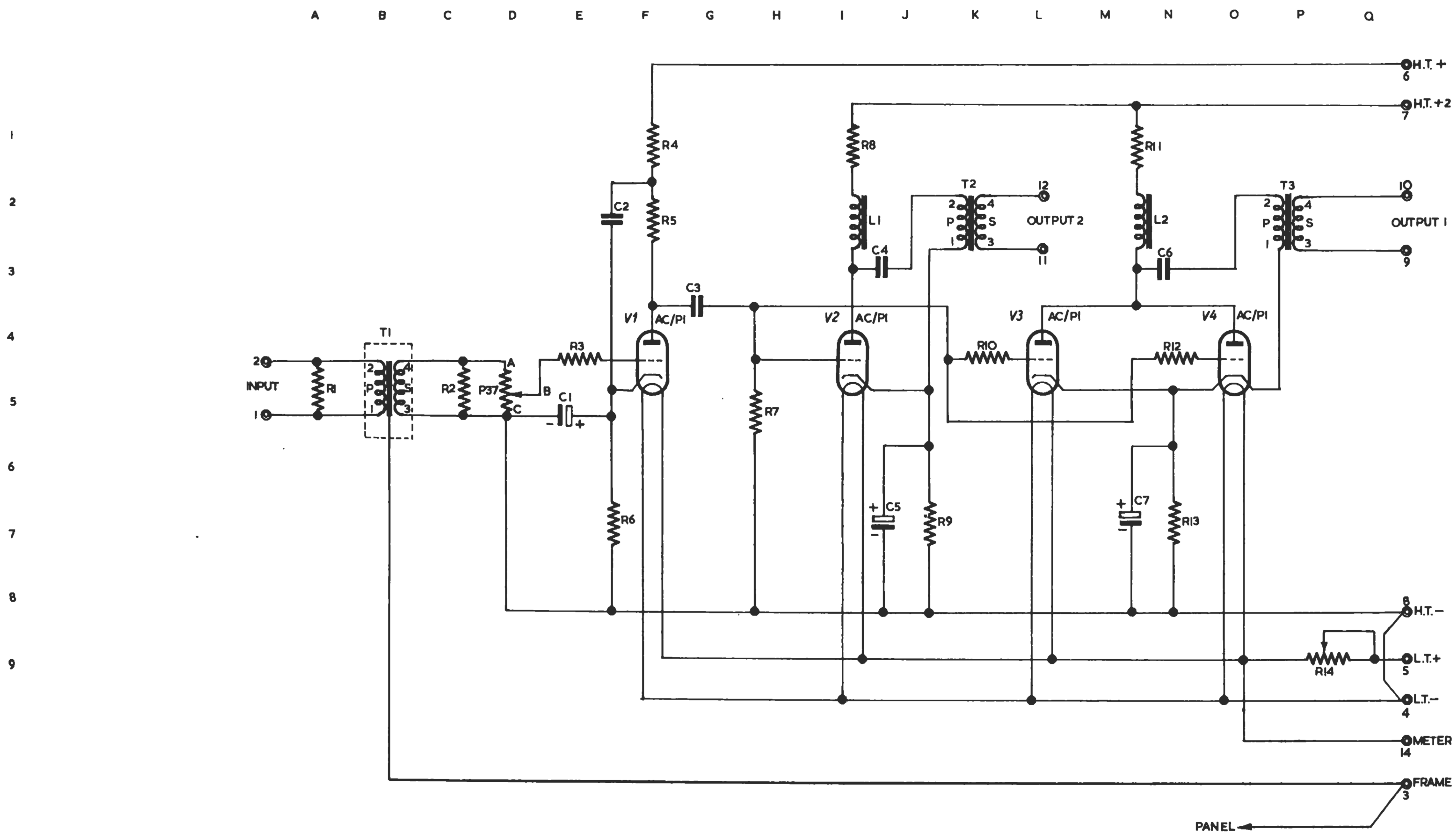
2. WHEN LT SUPPLY IS AC TERMINALS 13, 17 & 18 ARE TO BE STRAPPED. R1 TO BE SHORTED BY ADJUSTING SLIDER

COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1,2,3	G3,G7,J8	16 μF	MA14556	R9,10.	L4,L5	140 Ω	0·25W
C4,5	G4,G6	250 "	MA14580 20V WKG	R11,12	E3,E7	5000 "	"
				R13,14	G1,H1	33·3 "	RES. CARD
				R15	K1	2·56 "	" "
P1,2	D5	25000 Ω		R16,17	J5	5·26 "	" "
R1	K9	2 "	PAINTON 3B1	R18	I12	3900 "	PAINTON 301
R2	J2	2000 "	" 301	R19,20	C4 C5	3000 "	0·25W
R3	G2	20 000 "	1W	R21,22	J10,J11	10 "	RES CARD
R4	H2	15000 "	"				
R5	G6	10000 "	MNAP 10350				
R6	I1	5000 "	1W	T1	B5	1 : 1	LGQ/6RB
R7,8	G4,G6	150 "	0·5W	T2	K5	7·57 : 1	AAL/8RA

C AMPLIFIER C/4

74031/S3/AJP

FIG 9 S3



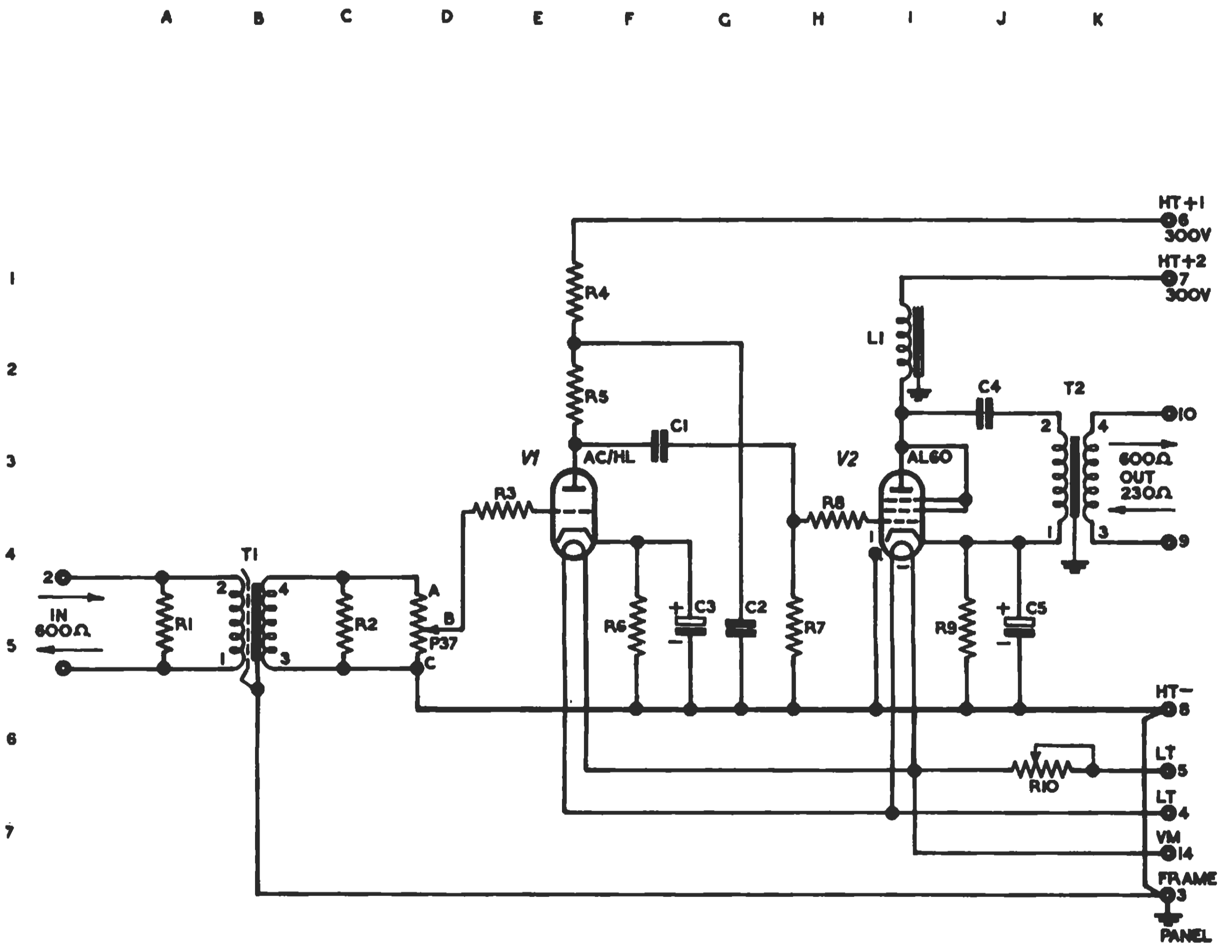
COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	E5	50 μF		R4	F1	20 000 Ω	
C2	E2	2·0 „		R5	F2	50 000 „	
C3	G4	0.5 „		R6	E7	500 „	
C4	J3	6·0 „		R7	H5	250 000 „	
C5	J7	50 „		R8	I1	2 000 „	
C6	N6	12·0 „		R9	J7	1500 „	
C7	M7	50 „		R10	K4	500 „	
				R11	M1	2000 „	
				R12	N4	500 „	
L1	I2		D5	R13	N7	750 „	
L2	N2		D3	R14	P9	0–0·85 „	
R1	A5	692 Ω		T1	B5		No 54
R2	C5	0.1 MΩ		T2	K2		No 102
R3	E4	10 000 Ω		T3	P2		No 106

D AMPLIFIER D/8

54061A/S3/DJE

FIG.10

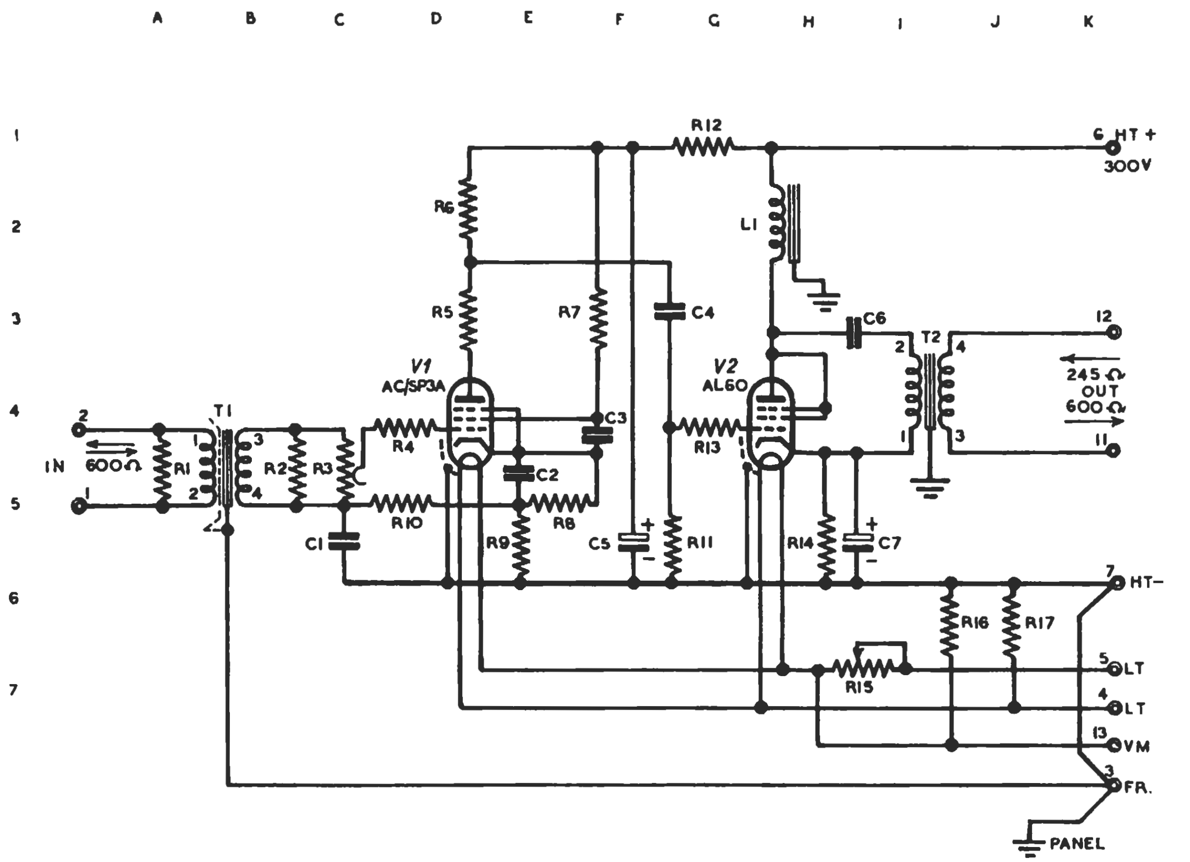
S3



COMP.	LOC.	VALUES	TYPE	COMP.	LOC.	VALUES	TYPE
C1	F3	0·5 μF		R6	F5	500Ω	0·5WATT
C2	G5	2 "		R7	H5	250 000 "	0·25 "
C3	F5	250 "		R8	H4	500 "	" "
C4	J2	12 "		R9	J5	300 "	1·0 "
C5	J5	50 "		R10	J6	0—0·85 "	
R1	A5	692Ω	0·25 WATT				
R2	C5	100 000 "	" "	L1	J2		D3
R3	E3	10 000 "	" "	T1	B5	1 : 3·31	No54
R4	E1	20 000 "	" "	T2	K3	3·16 : 1	No106
R5	E2	50 000 "	" "				

D AMPLIFIER D/8A

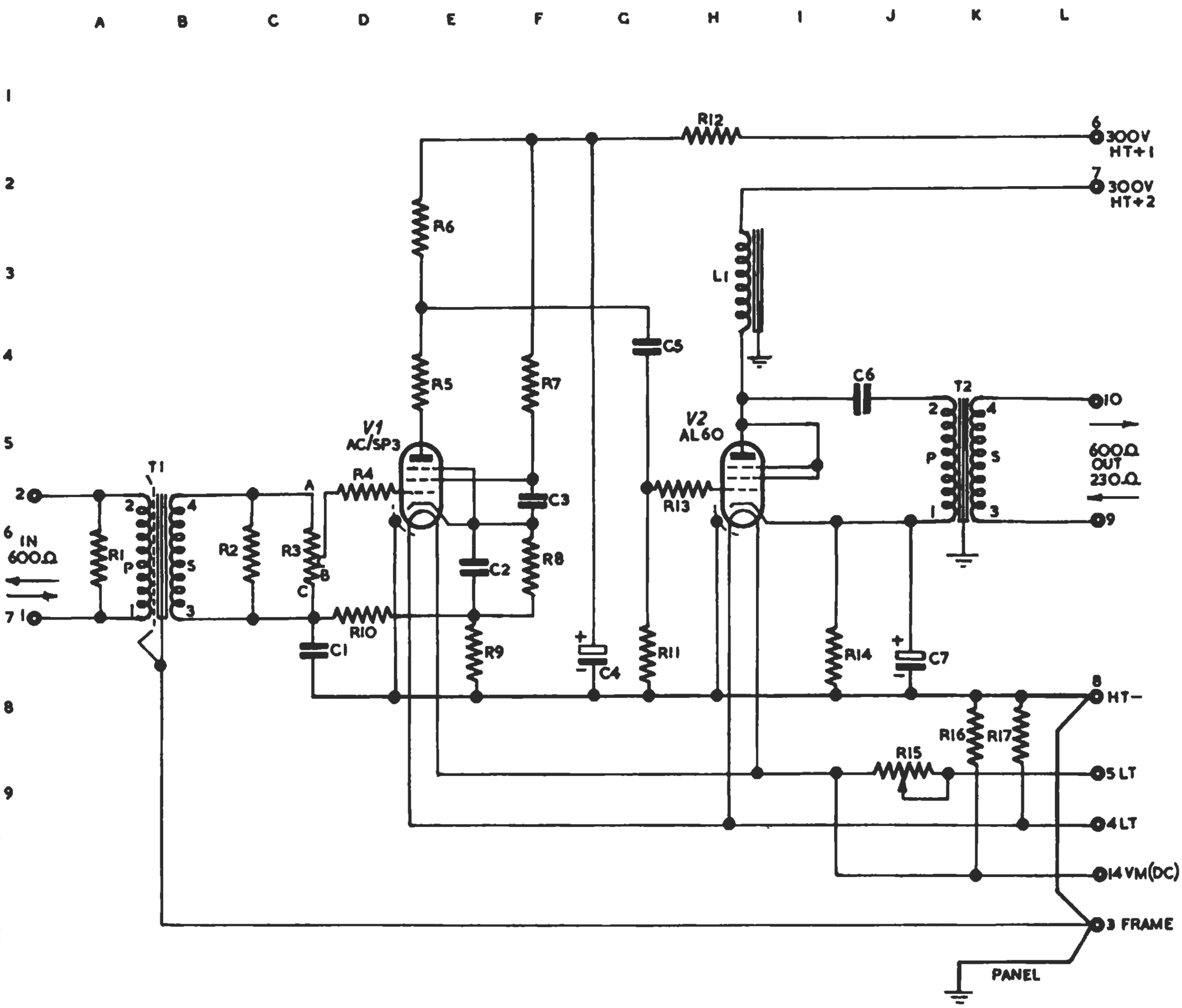
FIG.11



COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	C5	2 μF		R6	D2	100 000 Ω	0·25W
C2	E5	0·025 "		R7	F3	500 000 "	"
C3	G4	2 "		R8	E5	1 000 "	0·5 "
C4	F3	0·5 "		R9	E6	1 500 "	0·25 "
C5	F5	16 "		R10,11	D5	250 000 "	"
C6	H3	6 "		R12	F5	20 000 "	0·5 "
C7	H5	50 "		R13	G1	500 "	0·25 "
				R14	H6	300 "	1 "
				R15	H7	0—1·7 "	
R1	A5	680 Ω	0·25W	R16,17	I6,J6	20 "	0·25 "
R2	B5	30 000 "	"				
R3	C5	50 000 "	"	L1	H2	C8	
R4	D4	5 000 "	"	T1	T5	1 : 2·04	No 185
R5	D3	50 000 "	"	T2	I4	2·835 : 1	No 186

D AMPLIFIER D/8B

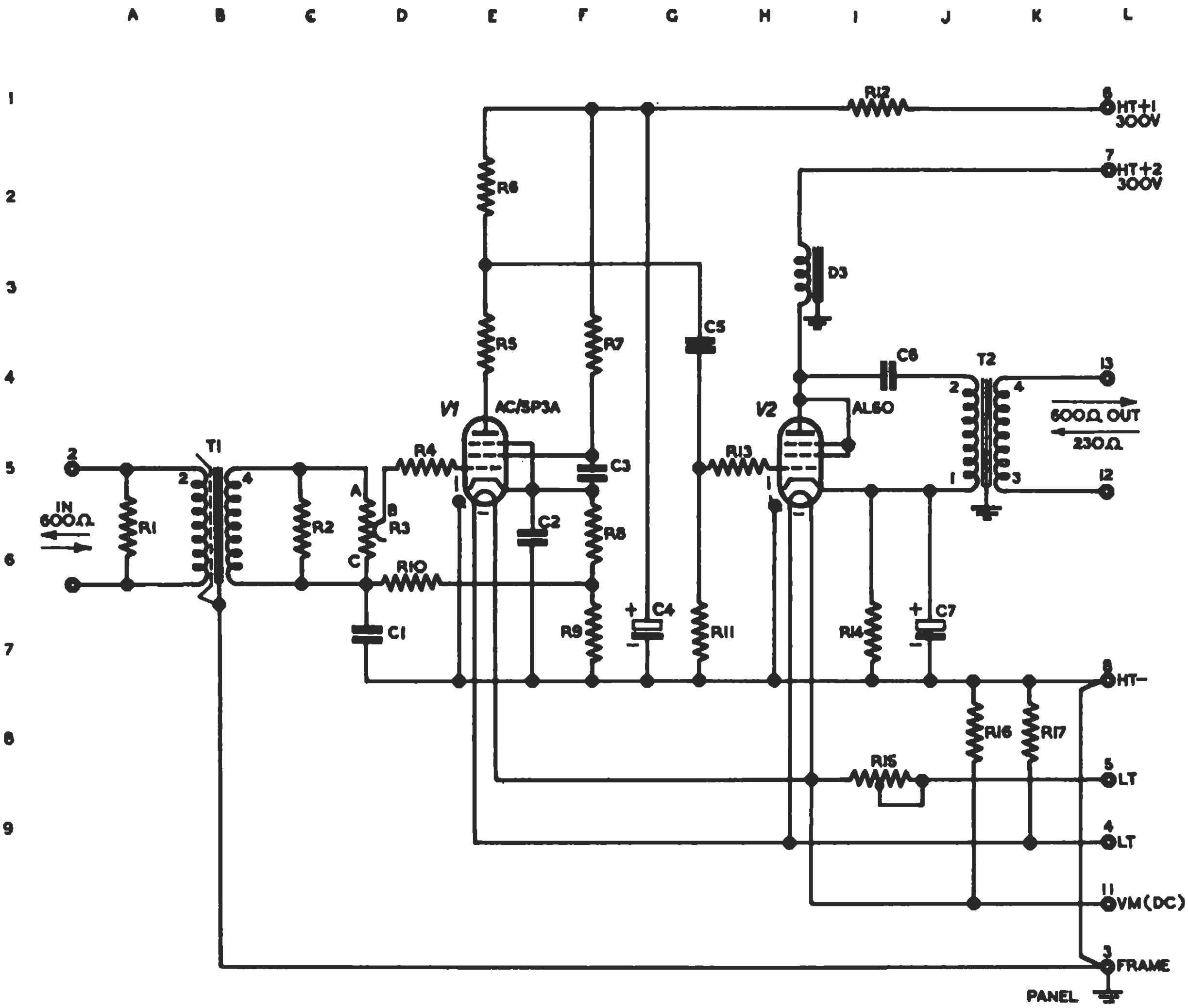
FIG.12 S3



COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1, 3	C7, F5	2μF		R6	E2	100 000 Ω	0·5W
C2	E6	0·025 "		R7	F4	500 000 "	0·25 "
C4	G7	16 "		R8	F6	1000 "	0·5 "
C5	G4	0·5 "		R9	E7	1 500 "	0·25 "
C6	J4	12 "		R10,11	D7, G7	250 000 "	0·25 "
C7	J8	50 "		R12	H1	20000 "	0·5 "
				R13	G5	500 "	0·25 "
L1	H3		D3	R14	J7	300 "	1·0 "
				R15	J9	0–0·85 "	
R1	A6	692 Ω	0·25 W	R16,17	K8, L8	20 "	0·25 "
R2	C6	100000 "					
R3	D6	POT-METER	P/37	T1	B6	1:3·31	No 54
R4	D5	10000Ω	0·25W	T2	K5	3·16:1	No 106
R5	E4	50000 "	0·5 "				

D AMPLIFIER D/8C

FIG.13

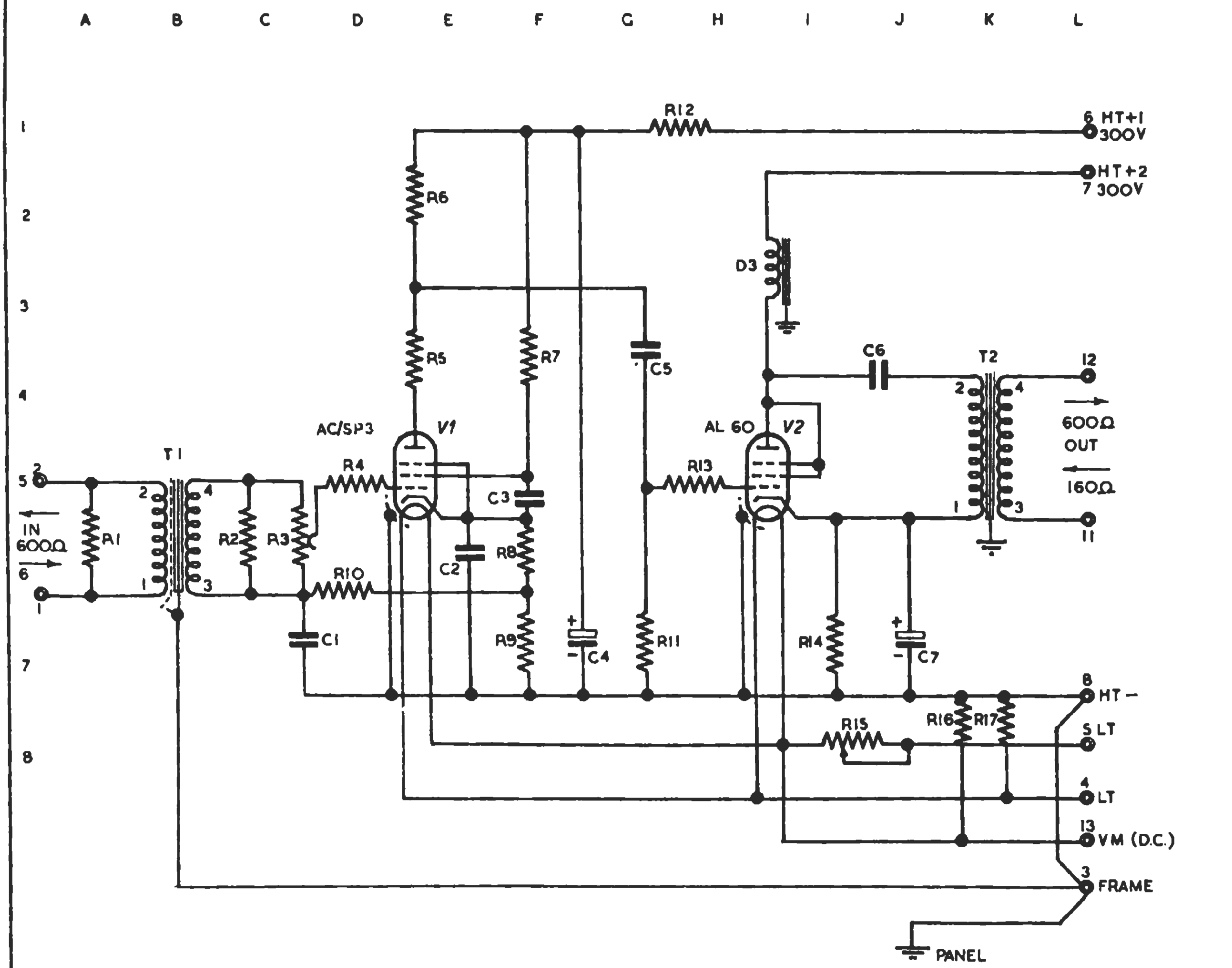


COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	D7	2µF		R6	E2	100 000Ω	0·5W
C2	E6	0·008 ″		R7	F3	500 000Ω	0·25W
C3	F5	2 ″		R8	F6	1 000 ″	0·5W
C4	G7	16 ″		R9	F7	1 500 ″	0·25W
C5	G4	0·5 ″		R10,11	D6,G7	250 000 ″	″
C6	I4	12 ″		R12	I1	20 000 ″	0·5W
C7	J7	50 ″		R13	H5	500 ″	0·25W
				R14	I7	300 ″	1·0W
				R15	I8	0—0·85 ″	
R1	A6	692Ω	0·25W	R16,17	J8,K8	20 ″	0·25W
R2,3	C6,D6	100 000 ″	″				
R4	D5	10 000 ″	″	T1	B6	1:3·31	No54
R5	E4	50 000 ″	0·5W	T2	J5	3·16:1	No106

D AMPLIFIER D/8D

A34038/S3/AJP

FIG. 14 S3



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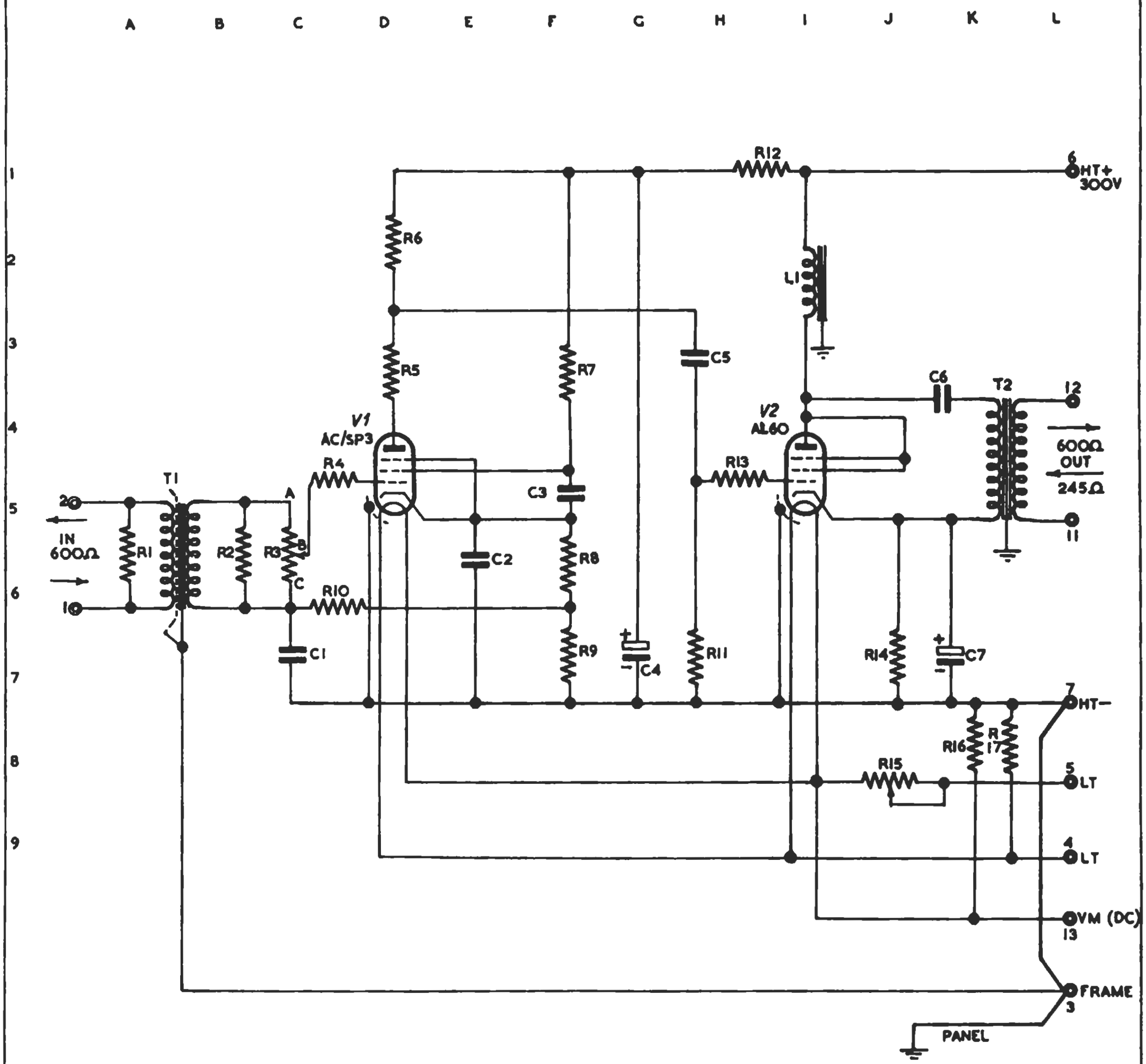
COMP.	LOC.	VALUE	TYPE
C1	C7	2 μF	
C2	E6	·008 "	
C3	F5	2 "	
C4	F7	16 "	
C5	G3	0·5 "	
C6	J4	12 "	
C7	J7	50 "	
R1	A6	692Ω	0·25W
R2,3	C6	100 000 "	" "
R4	D5	10 000 "	" "
R5	E4	50 000 "	0·5 "
R6	E2	100 000 "	0·25 "
R7	F4	500 000 "	" "
R8	F6	1 000 "	1·0 "
R9	F7	15 000 "	0·25 "
R10,11	D6, G7	250 000 "	" "
R12	H1	20 000 "	0·5 "
R13	H5	500 "	0·25 "
R14	I7	300 "	1·0 "
R15	J8	0 – 0·85 "	
R16,17	K8	20	0·25 "
T1	B6	1:3·31	No 54
T2	K4	4·47:1	No 105

D AMPLIFIER. D/8E

A34039/S3/AJP

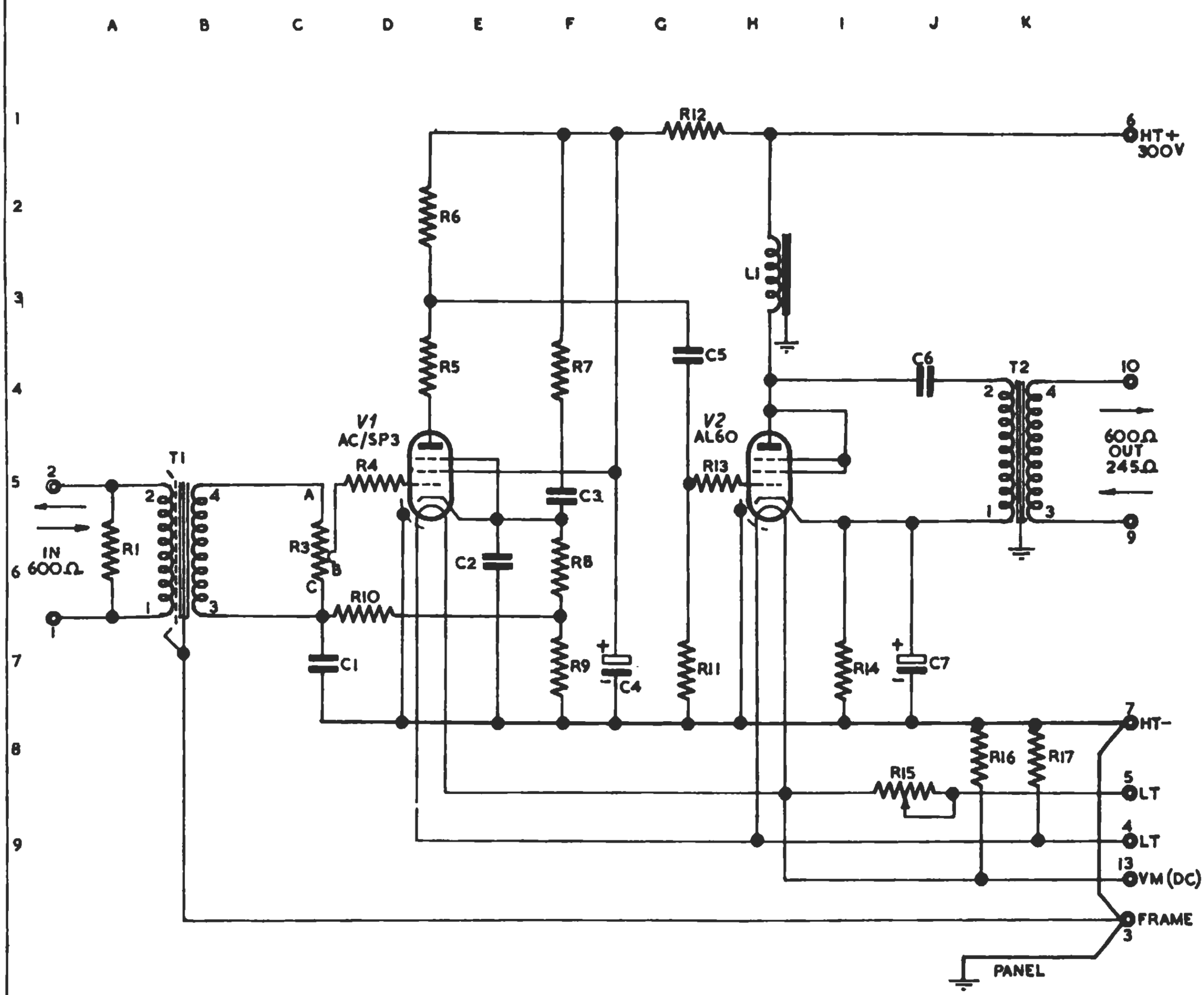
FIG.15 S3



COMP.	LOC.	VALUE	TYPE	COMP.	LOC	VALUE	TYPE
C1	C7	2 µF		R6	D2	100 000Ω	0·5 W
C2	E6	·008 "		R7	F3	500 000 "	0·25 "
C3	E5	2 "		R8	F6	1 000 "	0·5 "
C4	G7	16 "		R9	F7	1 500 "	0·25 "
C5	H3	0·5		R10, 11	D6, H7	250 000 "	0·25 "
C6	K4	6		R12	H1	20 000 "	0·5 "
C7	K7	50		R13	H5	500 "	0·25 "
				R14	J7	300 "	1·0 "
L1	I1		C8	R15	J8	0–0·85 "	
				R16, 17	K8	20 "	0·25 "
R1	A5	918 Ω	0·25W				
R2, 3	B5	100 000 "	0·25 "				
R4	C5	5 000 "	0·25 "	T1	B5	1:5·36	No 203
R5	D3	50 000 "	0·5 "	T2	K4	2·835:1	No 186

D AMPLIFIER D/8F

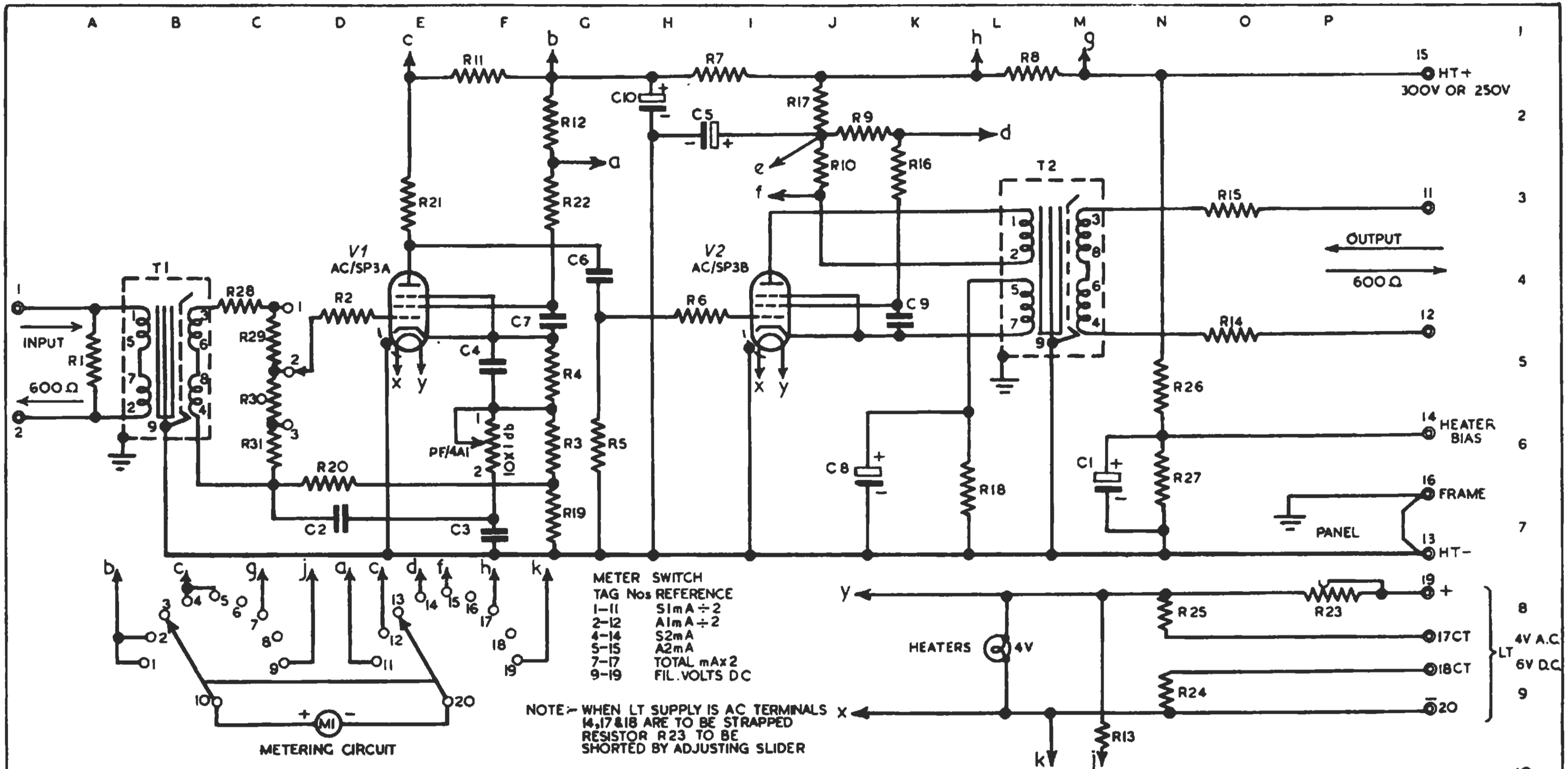
FIG.16



COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	C7	2 μF		R6	D2	100000 Ω	0·5 W
C2	E6	·008 "		R7	F4	500000 "	0·25 "
C3	F5	2 "		R8	F6	1000 "	0·5 "
C4	G7	16 "		R9	F7	1500 "	0·25 "
C5	G4	0·5 "		R10, 11	D7 G7	250 000 "	0·25 "
C6	J4	6 "		R12	G1	20 000 "	0·5 "
C7	J7	50 "		R13	H5	500 "	0·25 "
				R14	I7	300 "	1·0 "
L1	H3		C8	R15	J8	0−1·7 "	
				R16, 17	J8 K8	20 "	0·25 "
R1	A6	692 Ω	0·25 W				
R3	C6	50 000 "	0·25 "	T1	B6	1:3·31	No 54
R4	D5	5000 "	0·25 "	T2	K5	2·835:1	No 186
R5	D4	50000 "	0·5 "				

D AMPLIFIER D/8G

64010A/S3/AJP

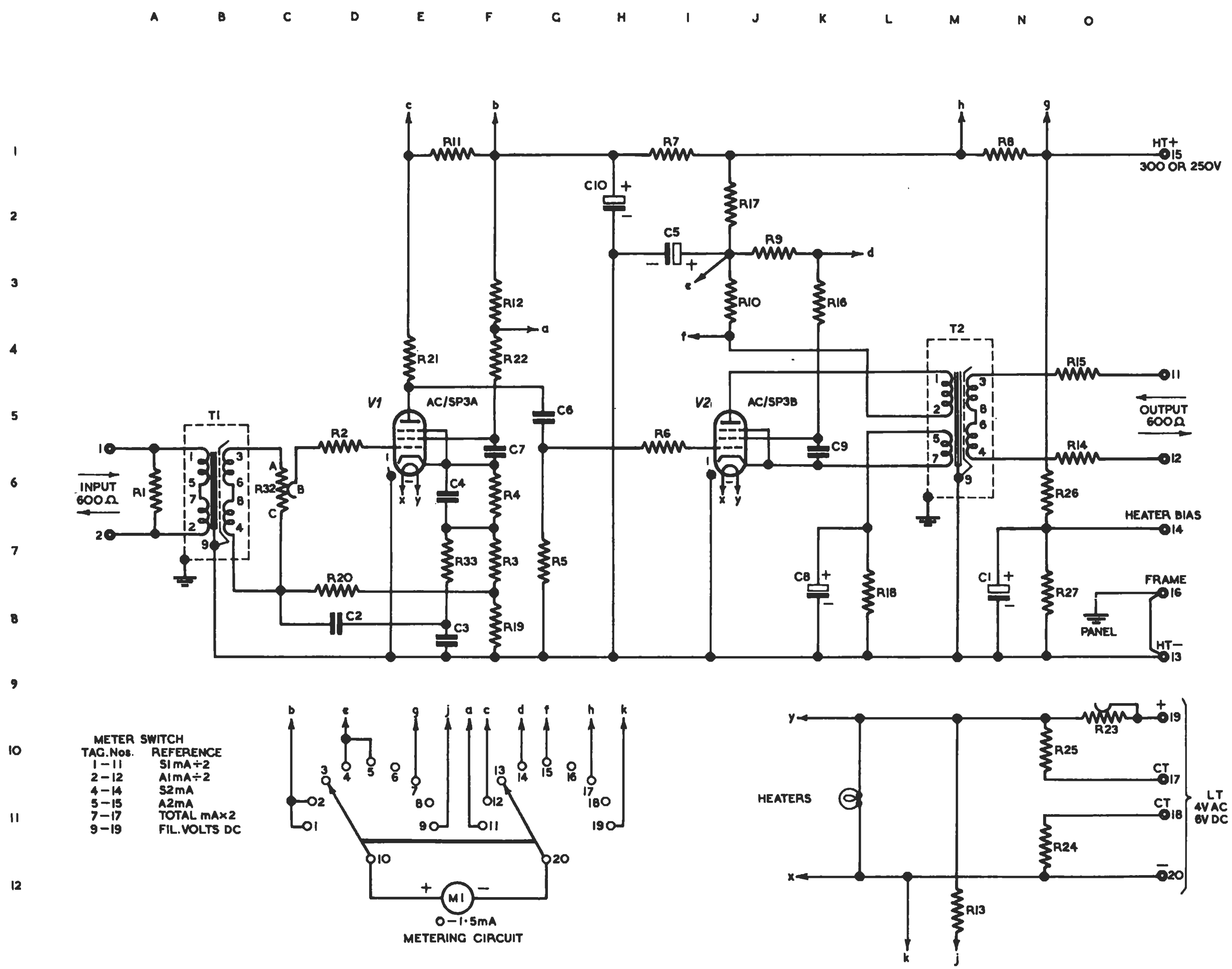


COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE	COMP.	LOC	VALUE	TYPE	COMP.	LOC	VALUE	TYPE
C1	M6	2 µF	FW	M1	D9		0–1·5 mA	R12	G2	100 Ω		R26	N5	150 000 Ω	1·0 W
C2	D7	0·1 "	431					R13	M10	3900 "		R27	N6	50000 "	1·0 "
C3	F7	2 "	65	R1	A5	900 Ω	0·25 W	R14,15	O3,O5	200 "	0·25 W	R28	C4	5000 "	0·25 "
C4	F5	0·02 "	431	R2	D4	5000 "	0·25 "	R16	K3	100000 "	0·5 "	R29	C5	1000 "	0·25 "
C5	H2	16 "	500V WKG	R3	G6	650 "	0·25 "	R17	J2	10000 "	0·5 "	R30	C5	1000 "	0·25 "
C6	G4	0·1 "	431	R4	G5	350 "	0·25 "	R18	L7	250 "	0·5 "	R31	C6	13000 "	0·25 "
C7	G5	2 "	87	R5	G6	300 000 "	0·25 "	R19	G7	18000 "	0·25 "				
C8	J6	250 "	20V WKG	R6	H4	5000 "	0·25 "	R20	D6	250 000 "	0·25 "				
C9	K4	2 "	87	R7	L1	20000 "	0·5 "	R21	E3	150 000 "	1·0 "				
C10	H2	16 "	500V WKG	R8	L1	14·3 "		R22	G3	500 000 "	0·25 "	T1	B5	1:3·16	LG/18RB
				R9	J2	33·3 "		R23	P8	2 "		T2	M4	8·05:1	AL/6 RA
				R10	J3	33·3 "		R24	N9	10 "					
				R11	F1	100 "		R25	N8	10 "					

D AMPLIFIER D/9

FIG. 17

FIG 18



COMP.	LOC.	VALUE	TYPE
C1	N7	2 μF	FW
C2	D8	0·1 "	431
C3	E8	2 "	65
C4	E6	0·02 "	431
C5	I3	16 "	500V WKG
C6	G5	0·1 "	431
C7	F6	2 "	87
C8	K7	250 "	20V WKG
C9	K5	2 "	87
C10	H2	16 "	500V WKG
R1	A6	900 Ω	0·25W
R2	D5	5000 "	"
R3	F7	650 "	"
R4	F6	350 "	"
R5	G7	300 000 "	"
R6	I5	5000 "	"
R7	I1	20 000 "	0·5W
R8	N1	14·3 "	
R9,10	J2, J3	33·3 "	
R11,12	E1 F3	100 "	
R13	M12	3900 "	
R14,15	O6 O4	200 "	0·25W
R16	K3	100 000 "	0·5W
R17	J2	10 000 "	"
R18	L8	250 "	"
R19	F8	18 000 "	0·25W
R20	D8	250 000 "	"
R21	E4	150 000 "	1·0W
R22	F4	500 000 "	0·25W
R23	O9	2 "	
R24,25	N11,N10	10 "	
R26	N6	150 000 "	1·0W
R27	N8	50 000 "	1·0W
R32	D6	20 000 "	
R33	E7	1000 "	
T1	B6	1 : 3·16	LC/18RB
T2	M5	8·05 : 1	AL/6RA

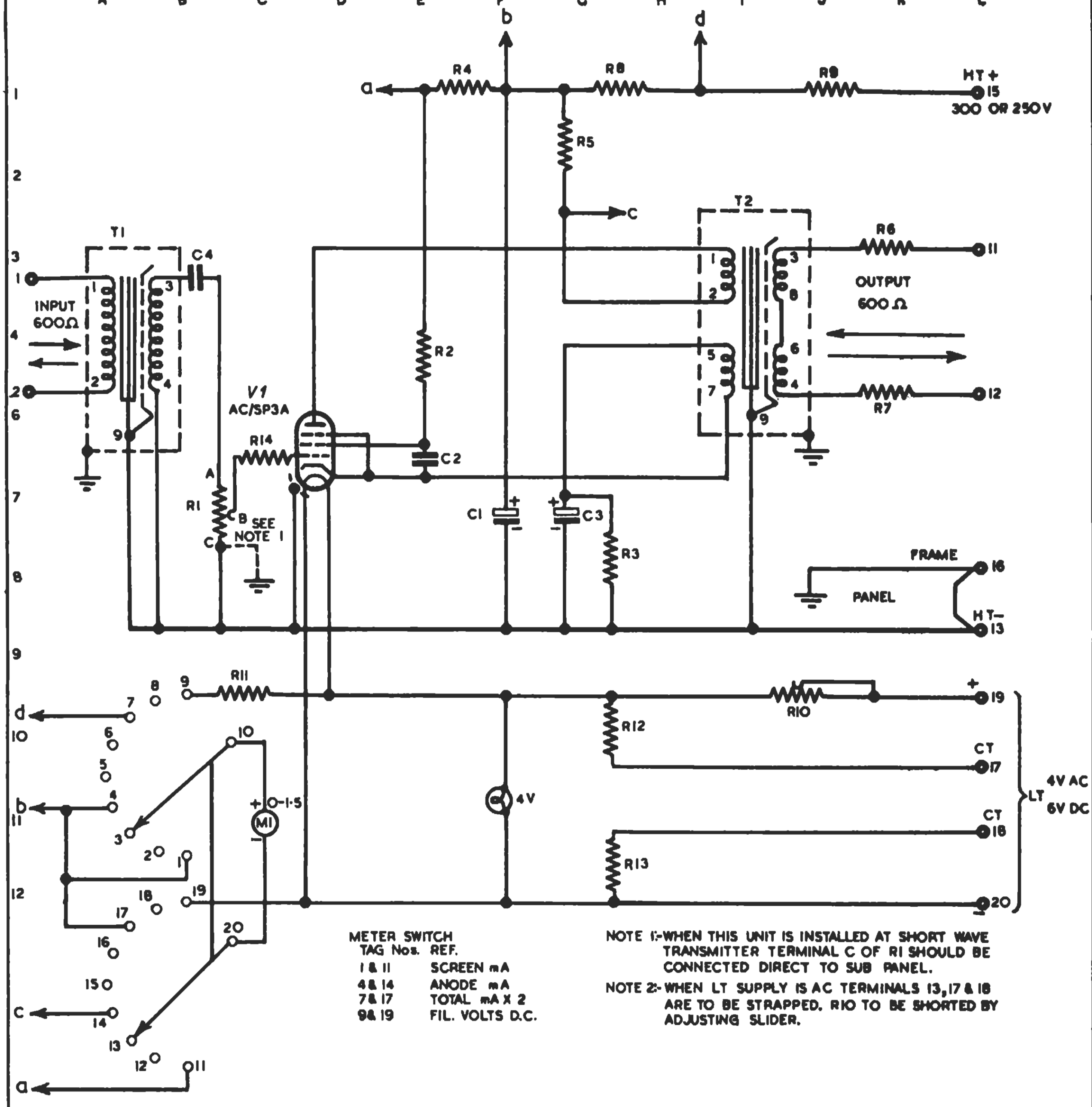
NOTE. 1 WHEN LT SUPPLY IS AC TERMINALS 14, 17 & 18 ARE TO BE STRAPPED, R23 TO BE SHORTED BY ADJUSTING SLIDER. THIS IS TO BE DONE ON ONE ONLY OF A PAIR OF AMPLIFIERS IF THEY ARE RUN FROM A SINGLE MAINS UNIT.

2 ON CERTAIN UNITS THE METER IS REPLACED BY A JACK, TAG 10 OF METER SWITCH BEING TAKEN TO THE "TIP" OF JACK AND TAG 20 TO THE "RING".

3 IN D/9B T1 = LC/13RB 1:25·8

D AMPLIFIER D/9A. & 9B

FIG. 19 S3



METER SWITCH

TAG Nos.	REF.
1 & 11	SCREEN mA
4 & 14	ANODE mA
7 & 17	TOTAL mA X 2
9 & 19	FIL. VOLTS D.C.

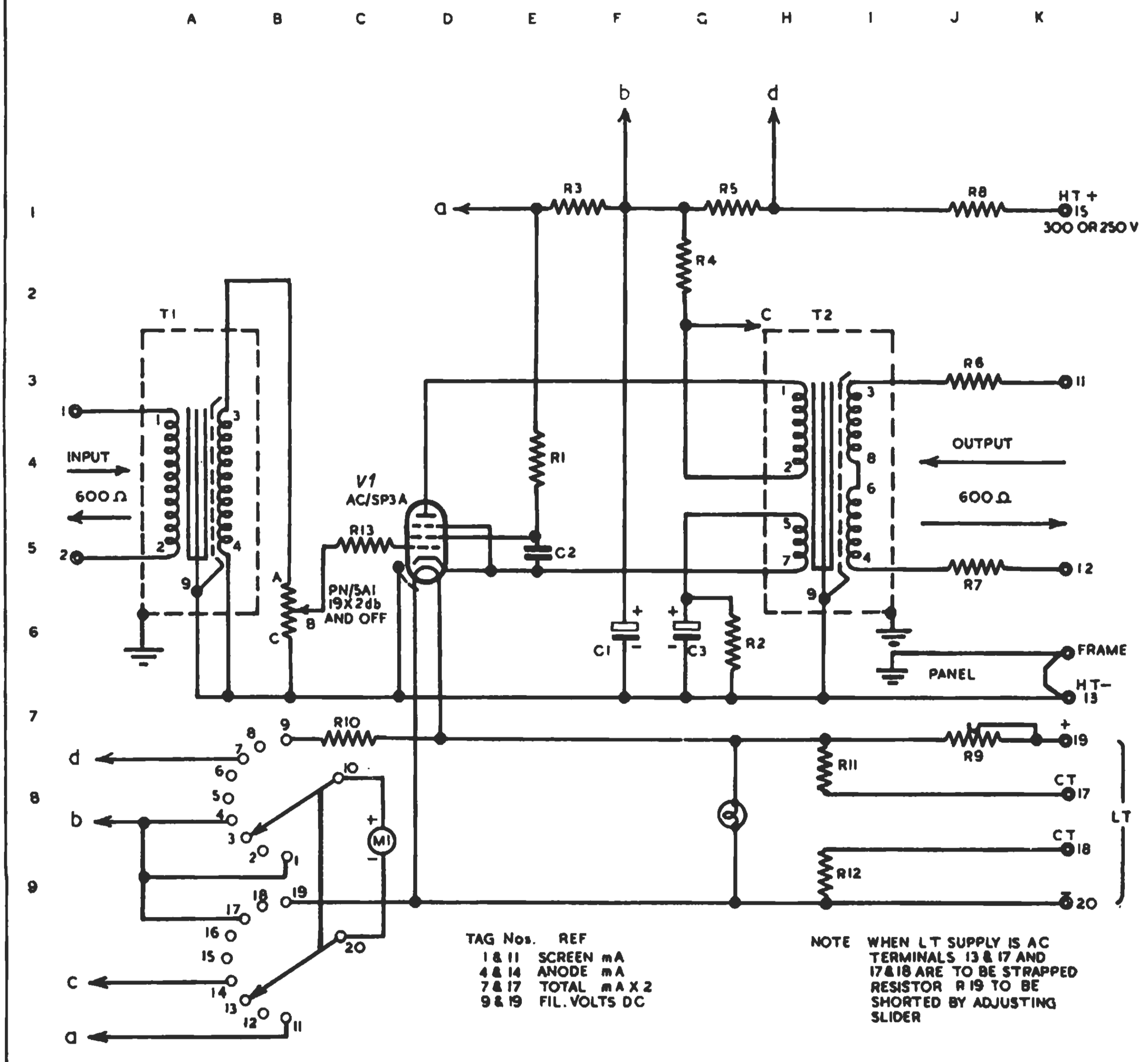
NOTE 1:- WHEN THIS UNIT IS INSTALLED AT SHORT WAVE TRANSMITTER TERMINAL C OF R1 SHOULD BE CONNECTED DIRECT TO SUB PANEL.

NOTE 2:- WHEN LT SUPPLY IS AC TERMINALS 13, 17 & 18 ARE TO BE STRAPPED. R10 TO BE SHORTED BY ADJUSTING SLIDER.

COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	F7	16 µF	BEC MA 14556	R7	K6	200 Ω	0·25 W
C2	E7	2·0 "	TCC TYPE 87	R8	G1	14·3 "	
C3	G7	250 "	BEC MA 14580	R9	J1	10 000 "	0·5 "
C4	B3	0·03 "	TCC TYPE 431	R10	J9	0–6 "	
				R11	C10	3900 "	
				R12, 13	C10, G12	10 "	
R1	C7	250 000 Ω		R14	C6	5000 "	0·25 "
R2	E4	100 000 "	0·5W				
R3	G8	250 "	0·5 "				
R4,5	E1, G2	33·3 "		T1	A4	1:20·4	LG/14RB
R6	K3	200 "	0·25 "	T2	1.4	8·05:1	AL/6RA

D AMPLIFIER D/10

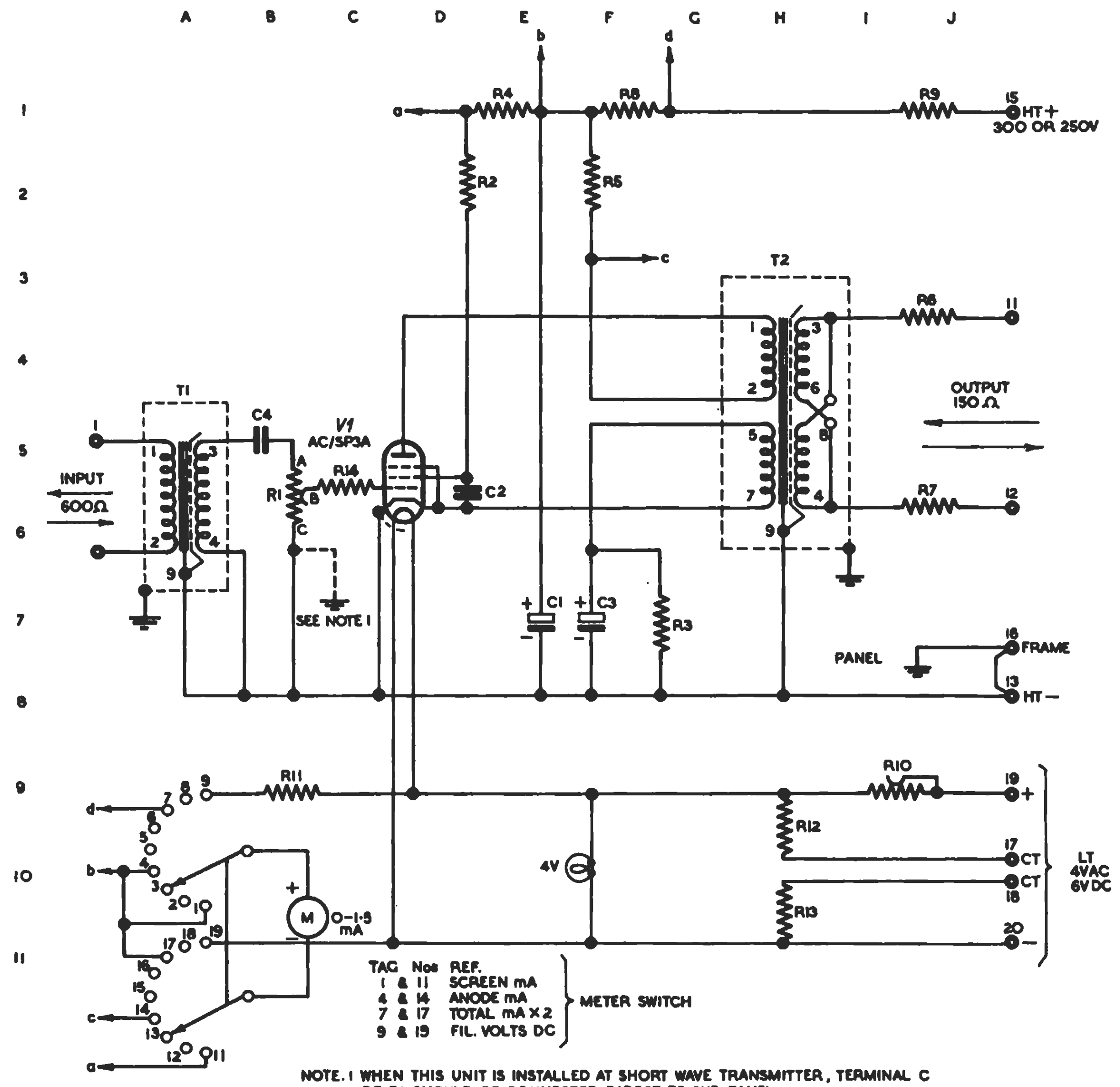
FIG. 20 S3



COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	F6	16 µF	BEC MA14556	R8	J1	10 000 Ω	0·5 W
C2	E5	2 "	TCC TYPE 87	R9	J7	0–6 "	
C3	C6	250 "	BEC MA14580. 20V WKG	R10	C7	3900 "	
				R11,R12	H8,H9	10 "	
				R13	C5	5000 "	0·25 "
R1	E4	100 000 Ω	0·5 W				
R2	G6	250 "	0·5 "				
R3,R4	E1,C2	33·3 "		T1	A4	1:12·9	LG/20RB
R5	G1	14·3 "		T2	H4	8·05:1	AL/6RA
R6,R7	J3,J5	200 "	0·25 "				

D AMPLIFIER D/10A

FIG.21 S3



NOTE. 1 WHEN THIS UNIT IS INSTALLED AT SHORT WAVE TRANSMITTER, TERMINAL C OF R1 SHOULD BE CONNECTED DIRECT TO SUB PANEL

2 WHEN LT SUPPLY IS AC TERMINALS 13, 17 & 18 ARE TO BE STRAPPED, R10 TO BE SHORTED BY ADJUSTING SLIDER

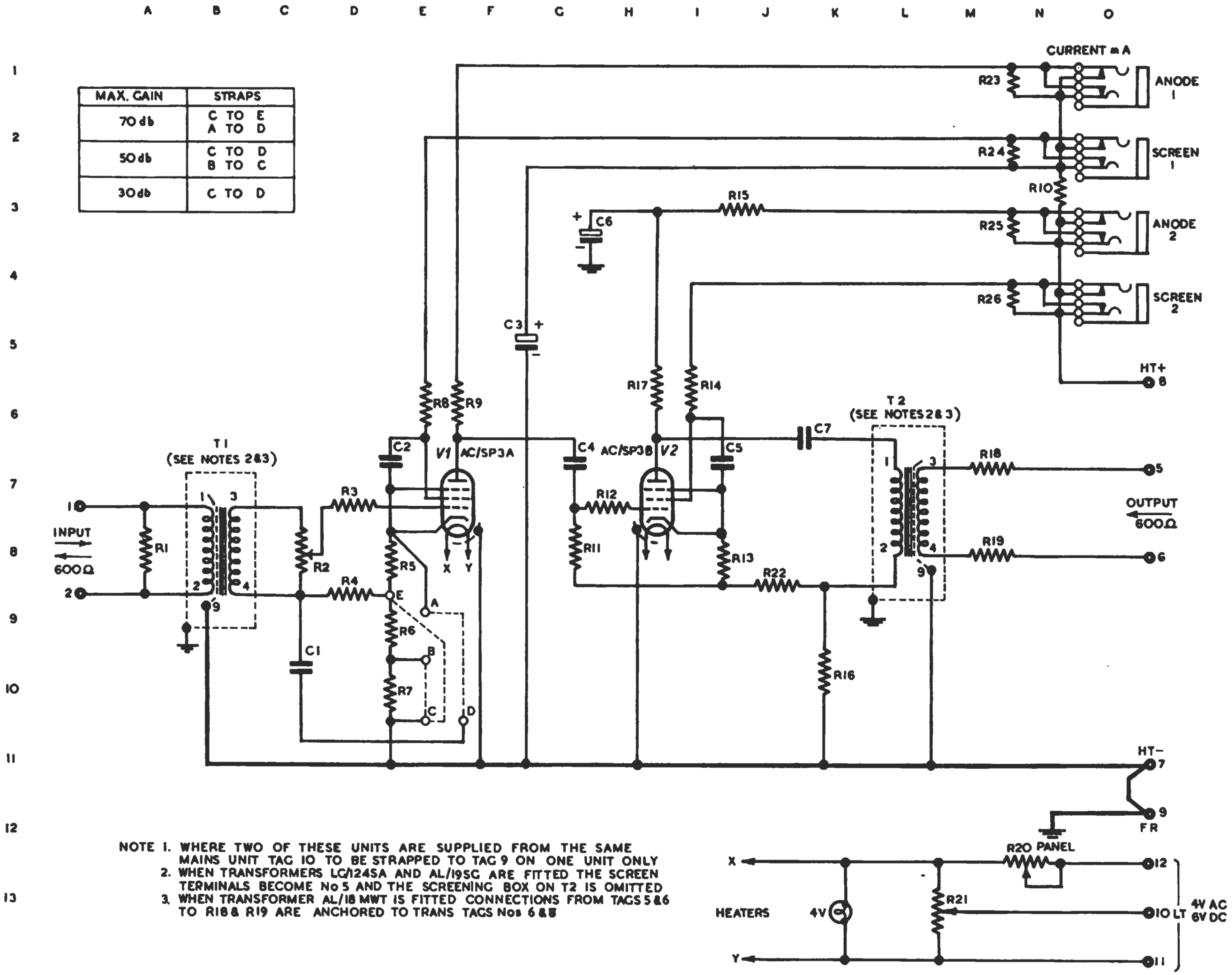
COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	E7	16 μF	BECMA 14556	R8	F1	14·3 Ω	
C2	D6	2 "	TCC TYPE 87	R9	J1	10 000 "	0·5W
C3	F7	250 "	BEC MA14580	R10	J9	0 – 6 "	PAINTON TYPE 381
C4	B5	0·03 "	TCC TYPE 431	R11	B9	3900 "	" " "
				R12 13	H9 H11	10 "	
				R14	C5	5000 "	0·5W
R1	B6	250 000 Ω	MNAP 25450				
R2	D2	100000 "	0·5W				
R3	G7	250 "	"	T1	A5	1 : 20·4	LG/14 RB
R4, 5	E1, F2	33·3 "		T2	H5	8·05 : 1	AL/6 RA
R6, 7	J3, J6	50 "	0·25W				

D AMPLIFIER D/10B

64002A/S3/AJP

FIG 22

MAX. GAIN	STRAPS
70 db	C TO E A TO D
50 db	C TO D B TO C
30 db	C TO D



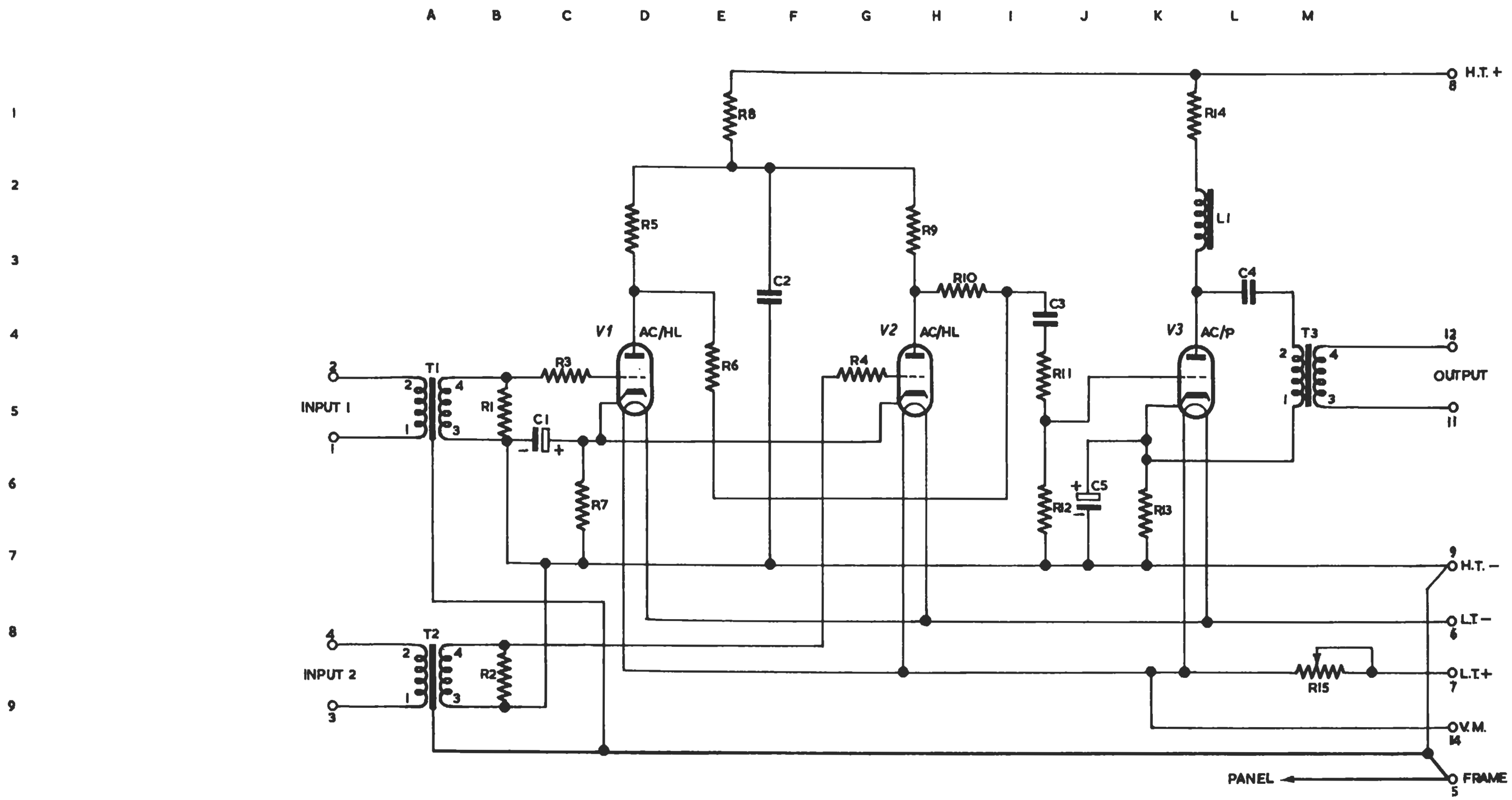
NOTE 1. WHERE TWO OF THESE UNITS ARE SUPPLIED FROM THE SAME MAINS UNIT TAG 10 TO BE STRAPPED TO TAG 9 ON ONE UNIT ONLY
2. WHEN TRANSFORMERS LG/124SA AND AL/19SG ARE FITTED THE SCREEN TERMINALS BECOME No 5 AND THE SCREENING BOX ON T2 IS OMITTED
3. WHEN TRANSFORMER AL/18 MWT IS FITTED CONNECTIONS FROM TAGS 5 & 6 TO R18 & R19 ARE ANCHORED TO TRANS TAGS Nos 6 & 5

COMP.	LOC.	VALUE	TYPE
C1	C10	2μF	87
C2	E7	2 "	"
C3	G5	16 "	MA15129
C4	G7	0·1 "	431
C5	I7	2 "	87
C6	G3	16 "	MA15129
C7	K6	1·0 "	87
R1	A8	2000Ω	0·25W
R2	C8	100 000 "	MNAP
R3	D7	5000 "	0·25W
R4	D9	250 000 "	"
R5	E8	1000 "	0·5W
R6	E9	2400 "	"
R7	E10	34000 "	1·0W
R8	E6	500000 "	0·5W
R9	F6	150000 "	1·0W
R10	N3	20000 "	"
R11	G8	500000 "	0·5W
R12	H7	5000 "	0·25W
R13	I8	180 "	0·5W
R14	I6	30000 "	1·0W
R15	J3	2000 "	0.5W
R16	K10	1500 "	"
R17	I6	18700 "	1·0W
R18	M7	150 "	0·25W
R19	M8	150 "	"
R20	N12	2 "	PAINTON
R21	M13	25 "	"
R22	J9	50 "	0·5W
R23	M1	2000 "	0·25W
R24	M2	2000 "	"
R25	M3	2000 "	"
R26	M4	2000 "	"
T1	B8	1:11·5	LG/122MWT OR LG/124SA
T	L8	4·44:1	AL/18MWT OR AL/19SG

AMPLIFIER D/11

FIG 23
2nd ISSUE

S3

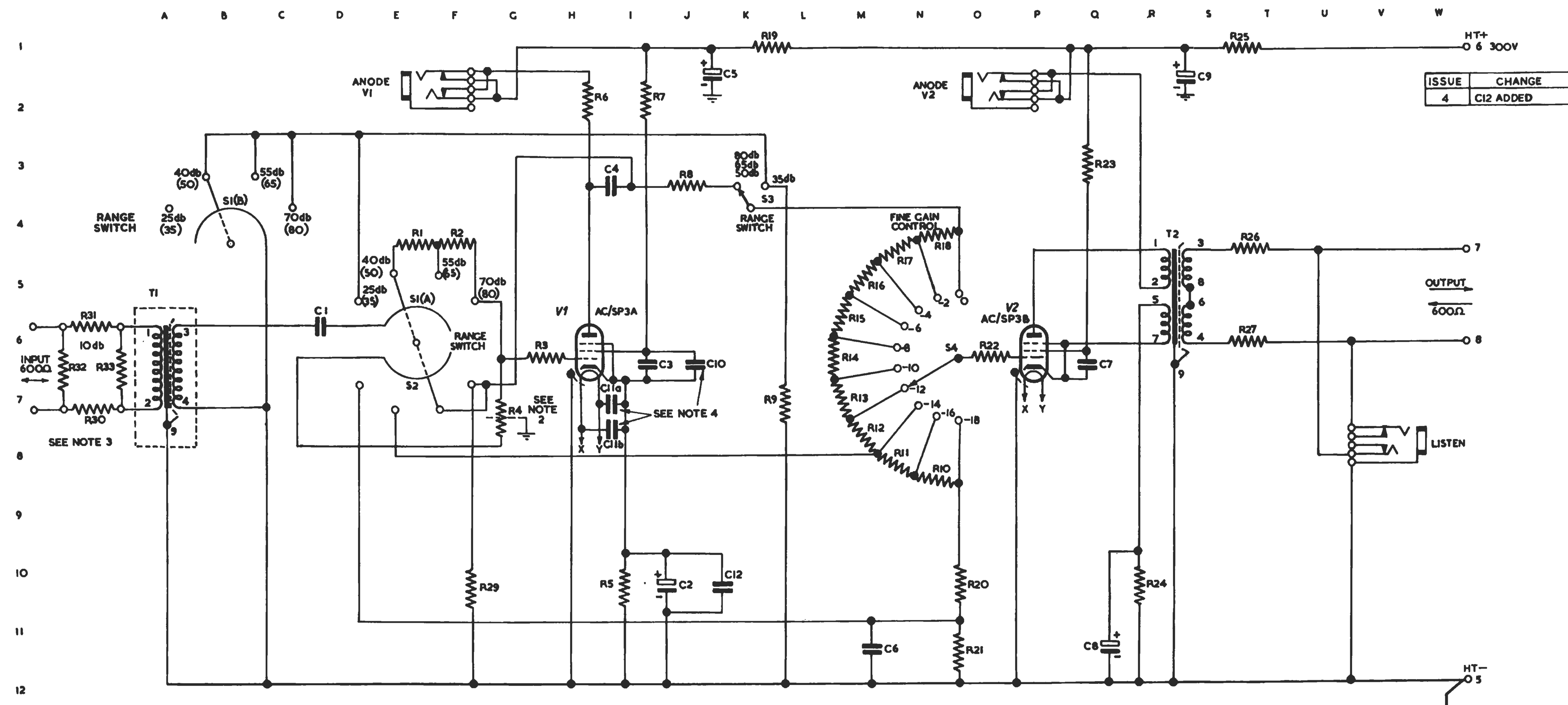


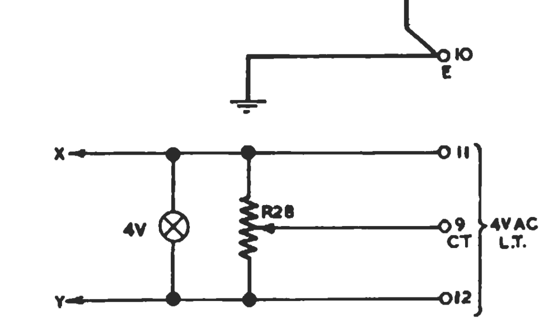
COMP.	LOC.	VALUE	TYPE	COMP	LOC.	VALUE	TYPE
C1	C5	50		R8	F1	10K	
C2	F3	2		R9	H3	50K	
C3	J3	0·5		R10	H4	25K	
C4	L3	4		R11	J5	150K	
C5	J6	50		R12	J6	50K	
				R13	K6	1K	
				R14	L1	5K	
L1	L2		C9	R15	M8	0−1·7	
R1, 2	B 5, 9	10K		T1	A5		No 200B
R3, 4	C4 G4	5K		T2	A9		No 200B
R5	D3	50K		T3	M4		No 118 A
R6	E4	25K					
R7	C6	300					

AMPLIFIER ECA/2

FIG 24 S3
4TH ISSUE

ISSUE	CHANGE
4	C12 ADDED



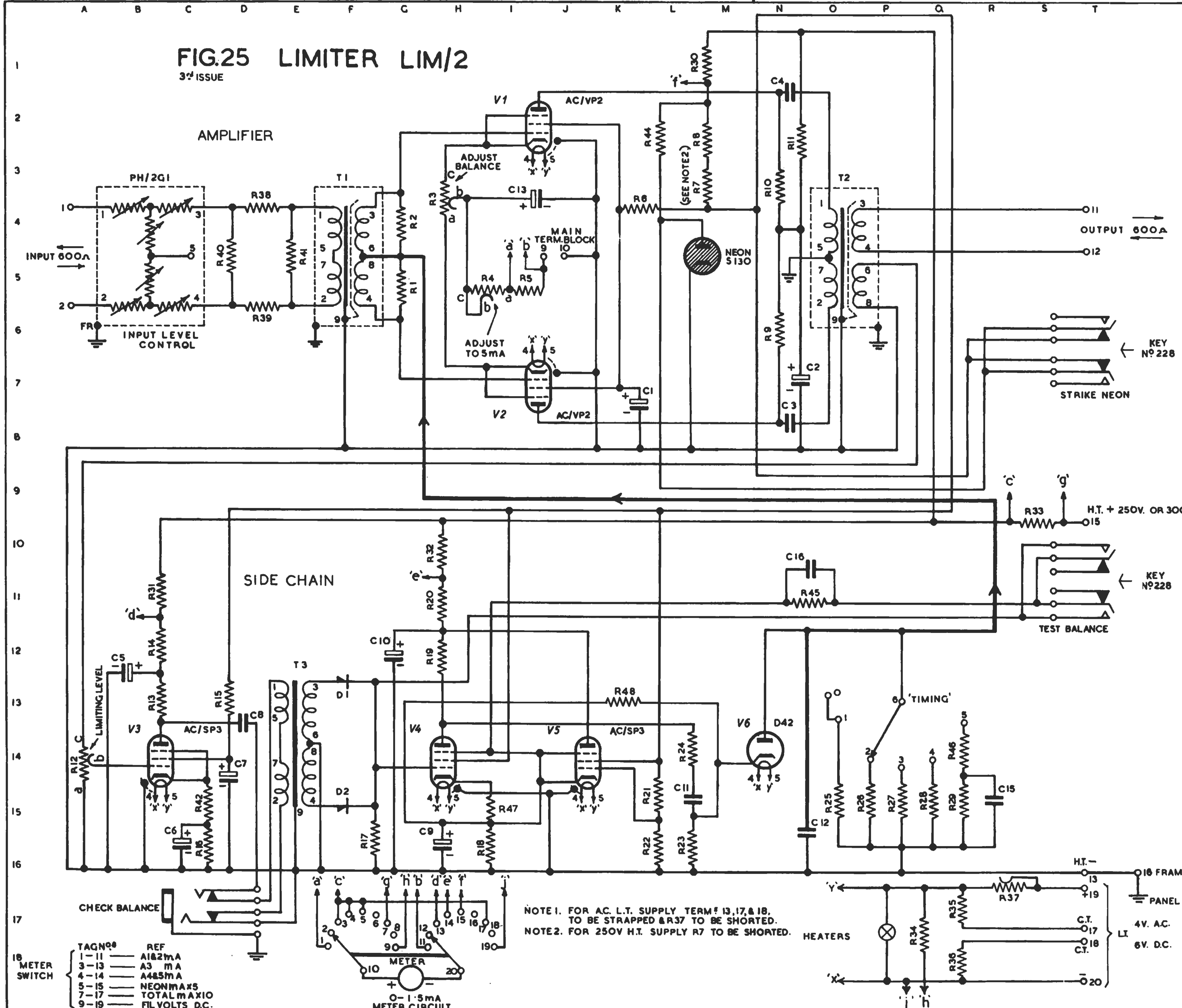


COMP	LOC	VALUE	TYPE	COMP	LOC	VALUE	TYPE	COMP	LOC	VALUE	TYPE
C1	D6	0·03 ± 20%	TCC TYPE 441	R4	G7	2M	1/4W ± 10% ERIE	R22	O6	5·6k	1/4W ± 10% ERIE
C2	J10	100	BEC CE 14680	R5	I10	1k	1W ± 10% ERIE	R23	Q3	150k	1/2W ± 10% ERIE
C3	I6	2 ± 20%	TCC TYPE 87	R6	H2	100k	1/4W ± 10% ERIE	R24	R10	270	1/4W ± 10% ERIE
C4	I3	0·1 ″ ″	″ ″ 341	R7	I2	390k	″ ″ ″ ″	R25	T1	2·7k	1/2W ± 10% ERIE
C5	J1	16	BEC CE 15129	R8	J3	47k	″ ″ ″ ″	R26,27	T4, T6	180	1/4W ± 10% ERIE
C6	M11	0·0005 ± 10%	TCC TYPE M2	R9	L7	1·8M	″ ″ ″ ″	R28	U14	25	PAINTON CV2/25P
C7	Q6	2 ± 20%	″ ″ 87	R10	N8	10k	″ ″ ″ ″	R29	F10	10M	1/4W ± 10% ERIE
C8	Q11	100	BEC CE 14680	R11	N8	12k	″ ″ ″ ″	R30	A7	430	
C9	S1	16	″ ″ 15129	R12	M7	15k	″ ″ ″ ″	R31	A6	430	
C10	J6	680p	UIC TYPE CTH 310	R13	M7	18k	″ ″ ″ ″	R32,33	A6	1·155k	
C11	I8	1000p	UIC TYPE 2CTH 310	R14	M6	27k	″ ″ ″ ″				
C12	K10	0·1	TCC TYPE M3N	R15	M6	27k	″ ″ ″ ″				
				R16	M5	39k	″ ″ ″ ″				
				R17	M4	47k	″ ″ ″ ″	T1	A6	1:20·4	LG/14RB
				R18	N4	60k	″ ″ ″ ″	T2	R5	8·08:1	AL/6RC
R1	E4	47k	1/4W ± 10% ERIE	R19	K1	10k	″ ″ ″ ″				
R2	F4	210k	″ ″ ″ ″	R20	O10	27k	″ ″ ″ ″				
R3	H6	5·6k	″ ″ ″ ″	R21	O11	10k	″ ″ ″ ″				

NOTES:-
1. R8 TO BE ADJUSTED IF NECESSARY TO STANDARDISE GAIN AT 80db.
2. R4 IS MOUNTED THROUGH PANEL.
3. FIGURES IN BRACKETS ON S1(A) S1(B) AND S2 ARE GAIN FIGURES WITHOUT INPUT ATTEN (R30 R31 R32 R33) WHICH MAY BE DISCONNECTED IF NOT REQUIRED
4. CAPACITORS C10 C11 & C12 TO BE FITTED ONLY AT UHF STATIONS

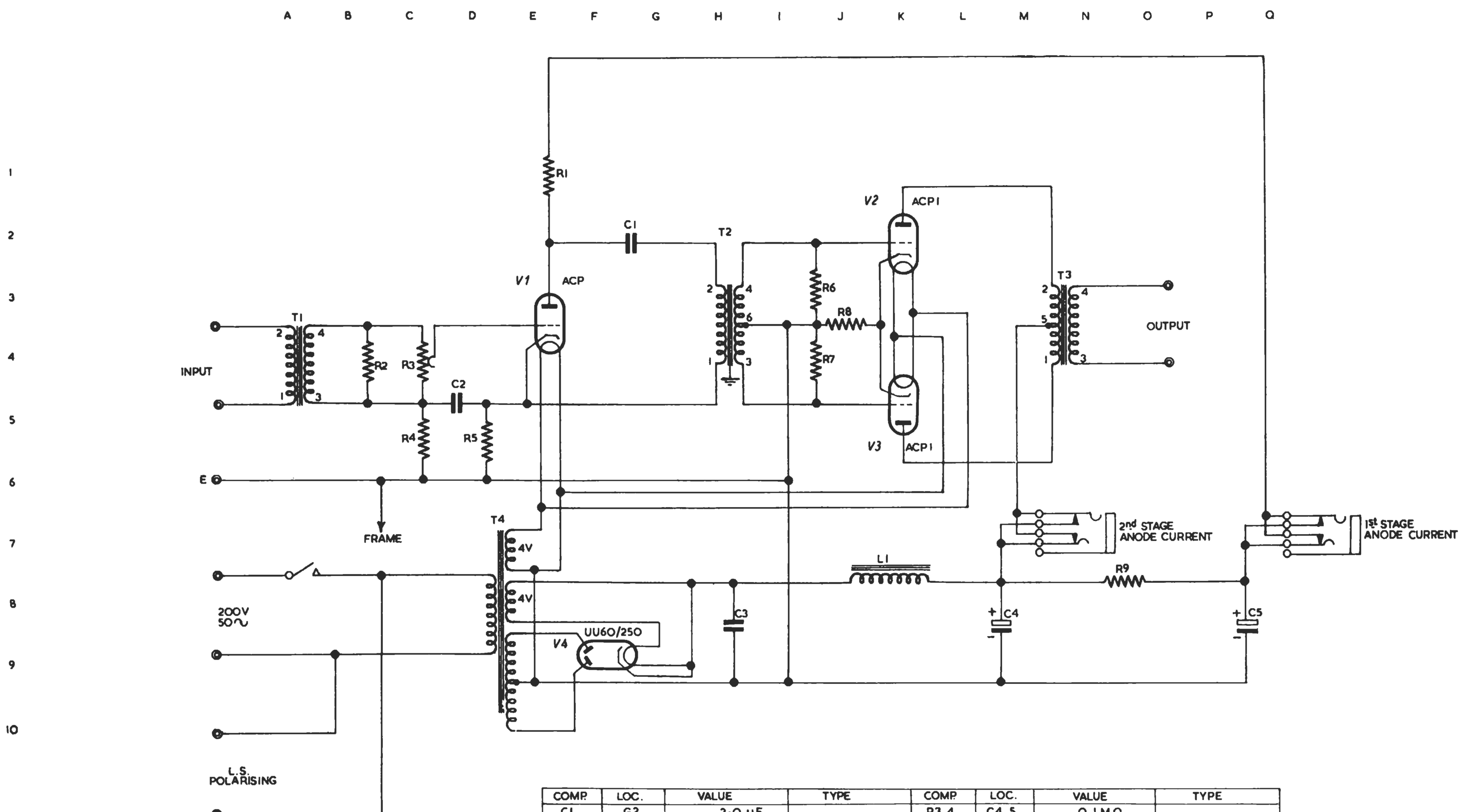
GENERAL PURPOSE AMPLIFIER GPA/1

64110B/S3/DJE



S3

COMP.	LOC.	VALUES	RATINGS
R1	G5	50K	0·25 W
R2	G4	50K	0·25 "
R3	H4	400	TYPE MNAP
R4	I.5	1K	" "
R5	J5	33·3	RES.CARD
R6	K4	20K	1·0 W
R7	M3	4K	1·0 "
R8	M2	10K	2·0 "
R9	N6	20K	0·5 "
R10	N3	20K	0·5 "
R11	N2	20K	1·0 "
R12	A14	100K	TYPE MNAP
R13	C13	20K	1·0W
R14	C12	20K	1·0 "
R15	D13	20K	0·5 "
R16	C16	100	0·25 "
R17	G15	100K	0·25 "
R18	I16	5K	0·5 "
R19	G12	250K	0·5 "
R20	C11	20K	1·0 "
R21	L15	250K	0·25 "
R22	L16	50K	0·25 "
R23	L16	250K	0·25 "
R24	L14	47K	0·25 "
R25	O15	500K	0·25 "
R26	P15	2M	0·25 "
R27	P15	10M	0·5 "
R28	Q15	40M	0·5 "
R29	R15	2M	1·0 "
R30	M1	5·26	RES.CARD
R31	B11	33·3	" "
R32	H10	33·3	" "
R33	S10	2·56	" "
R34	Q17	3·9K	PAINTON
R35	Q17	10	RES.CARD
R36	Q18	10	" "
R37	R16	2	PAINTON
R38	D4	225	0·25W
R39	D6	225	0·25 "
R40	D5	1·8K	0·25 "
R41	E5	1·8K	0·25 "
R42	C15	150	0·25 "
R44	L2	250K	0·25 "
R45	O11	0·5M	1·0 "
R46	R14	0·5M	0·25 "
R47	I15	4·7K	
R48	K13	1·0M	0·5 "
C1	K7	16	MA15129
C2	N7	16	" 15129
C3	N8	2	TYPE 87
C4	N2	2	" 87
C5	B12	16	MA15129
C6	C15	250	" 14680
C7	D14	16	" 15129
C8	D13	0·5	TYPE 87
C9	H15	25	" C
C10	G12	16	MA15129
C11	L15	0·01	TYPE 431
C12	N15	0·2	" 87
C13	J3	250	MA14680
C15	R15	4·0	TYPE 87
C16	O10	0·05	
T1	F5	1·12·9	LGG/9RB
T2	O5	7·83:1 1·96:1	AAL/10RA
T3	F14	1:3·17	AGG/3RC
D1, 2.	F13 F15	WX6	

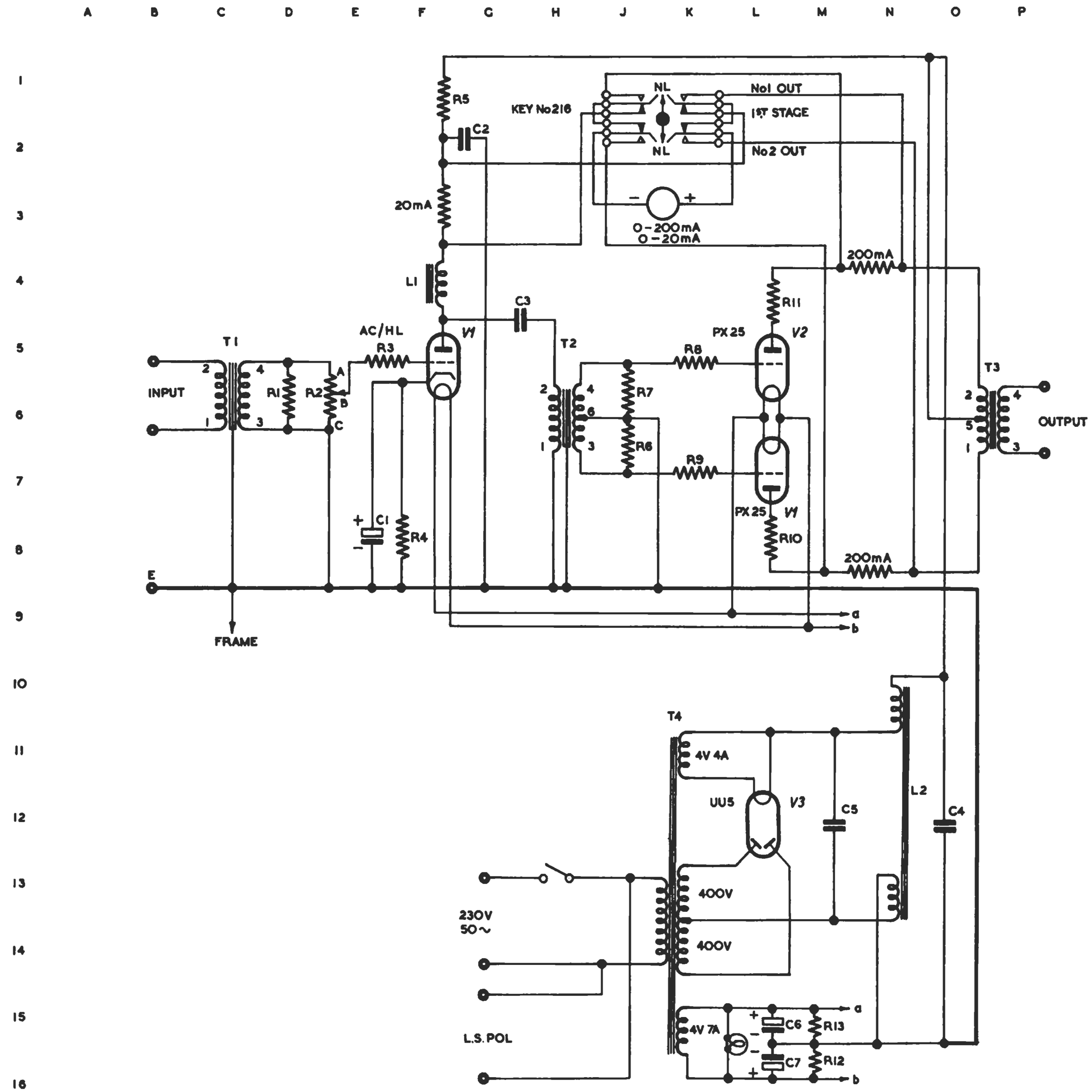


COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	G2	2·0 μF		R3,4	C4,5	0·1 MΩ	
C2	D5	0·5 "		R5	D5	1200 Ω	
C3	H8	4·0 "		R6,7	J3,4	0·1 MΩ	
C4,5	M8,Q8	7·0 "		R8	J3	940Ω	
				R9	N7	10 000 "	
L1	K7		D14				
				T1	A4		No 60
				T2	H3		No 128
R1	E1	10 000Ω		T3	N3		No 129
R2	B4	0·2 MΩ		T4	E8		A.G.1. M20

MAINS-OPERATED LOUDSPEAKER AMPLIFIER LSM/1

74026/S3/DJE

FIG 28

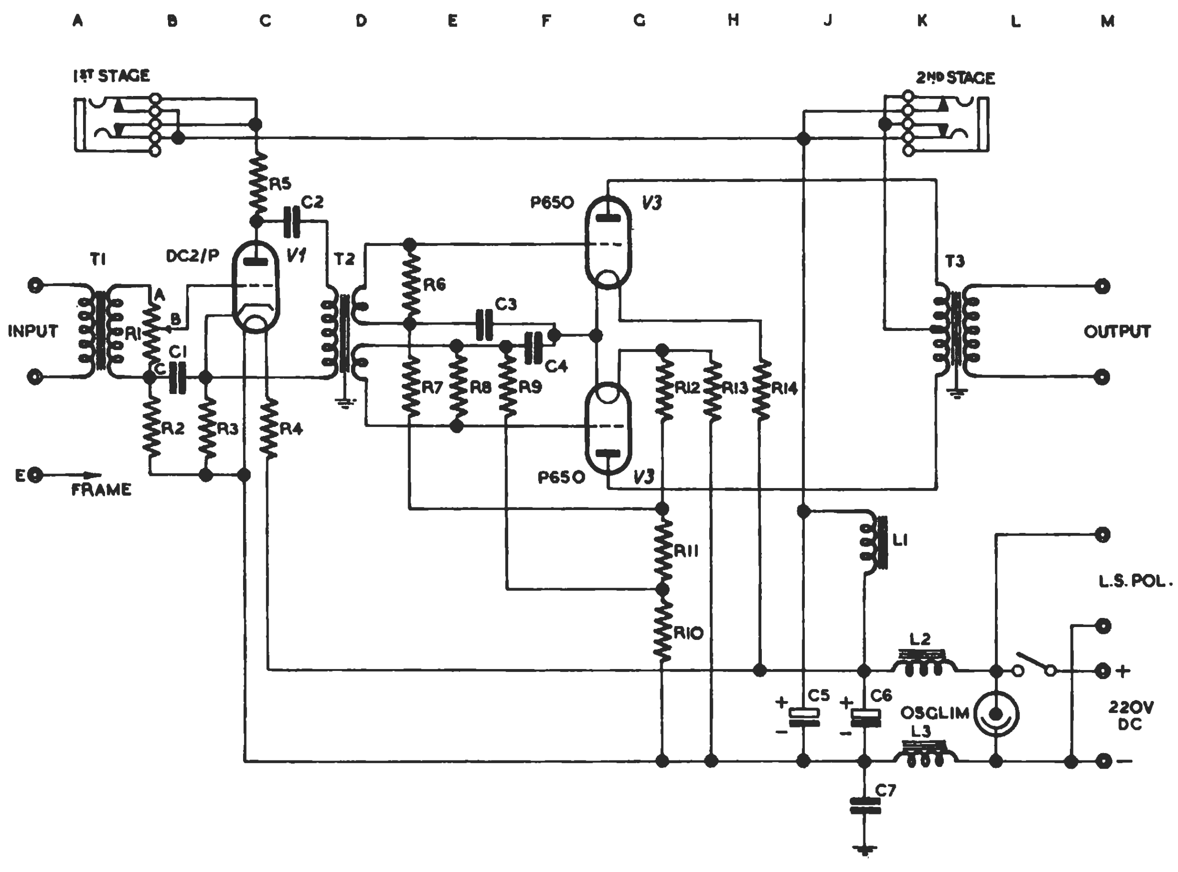


COMP.	LOC.	VALUE	TYPE
C1	E8	50 μF	
C2	G2	2 "	
C3	H5	0·5 "	
C4	O12	6 "	
C5	M12	6 "	
C6	M15	8 "	
C7	M16	8 "	
L1	F4		C.11
L2	N12		F.1
R1	D6	100 000 Ω	
R2	E6	100 000 "	
R3	F5	20 000 "	
R4	F8	350 "	
R5	F1	20 000 "	
R6	J7	0·1 MΩ	
R7	J6	0·1 "	
R8	K5	5000 Ω	
R9	K7	5000 "	
R10	L8	100 "	
R11	L4	100 "	
R12	M16	600 "	
R13	M15	600 "	
T1		1 : 3·31	No 45
T2		1 : 1·55	No 221
T3		22·6 : 1	No 168
T4	K11		

MAINS-OPERATED LOUDSPEAKER AMPLIFIER LSM/2

74025/S3/DJE

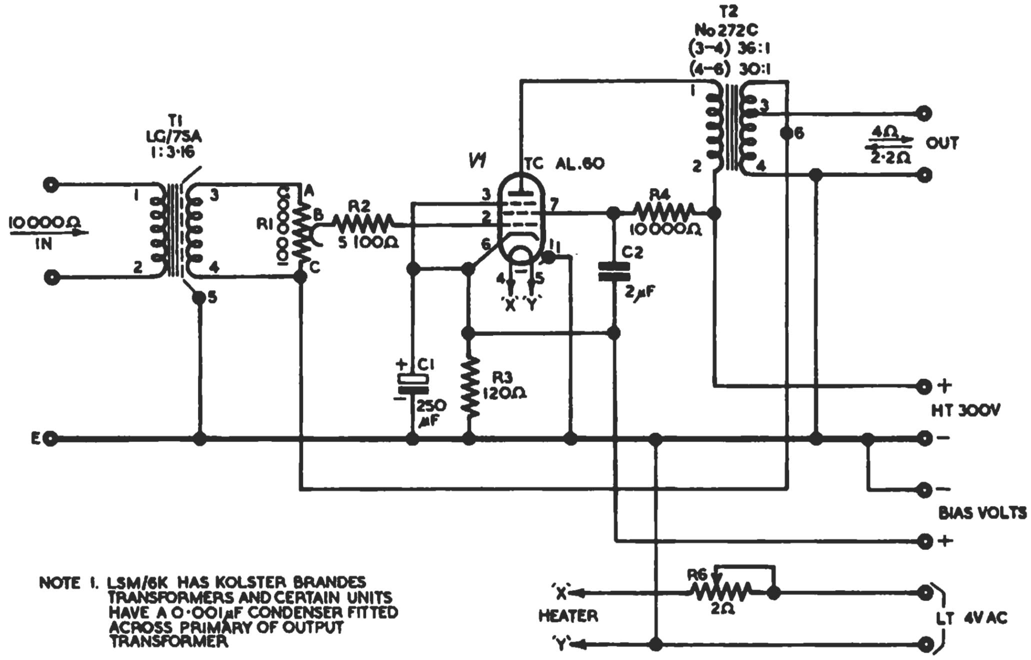
FIG.29 S3



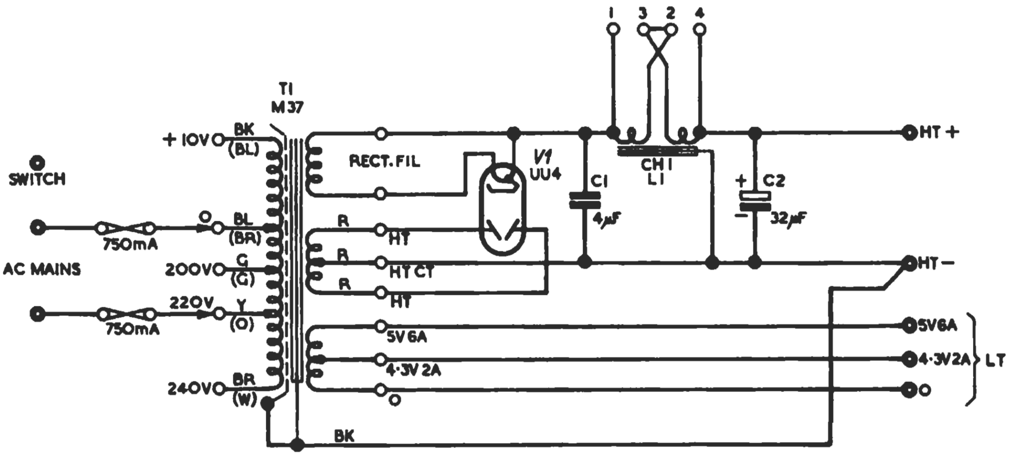
COMP	LOC.	VALUE	TYPE	COMP	LOC.	VALUE	TYPE
C1	B4	1 μF		R4	C4	1750 Ω	
C2	C2	2 "		R5	C2	10 000 "	
C3	E3	1 "		R6	E3	0·1 MΩ	
C4	F3	1 "		R7	E4	0·1 "	
C5	J7	7 "		R8	E4	0·1 "	
C6	K7	7 "		R9	F4	0·1 "	
				R10	J6	600 Ω	
				R11	J7	940 "	
L1	K6		D14	R12	G4	3260 "	
L2	K7		D17	R13	H4	72 "	
L3	K8		"	R14	J4	356 "	
R1	B3	50 000 Ω		T1	A3	1 : 5·52	No60
R2	B4	0·1 MΩ		T2	D3	1 : 4	No128A
R3	B4	1000 Ω		T3	K3	24·6 : 1	No129

MAINS-OPERATED LOUDSPEAKER AMPLIFIER LSM/3

FIG.30 S3
ISS 2



NOTE 1. LSM/6K HAS KOLSTER BRANDES TRANSFORMERS AND CERTAIN UNITS HAVE A 0·001μF CONDENSER FITTED ACROSS PRIMARY OF OUTPUT TRANSFORMER



NOTE 2. FOR MUE/1K

1. 2 AMP FUSES ARE FITTED.
2. TRANSFORMERS & CHOKE REF. DO NOT APPLY
3. WIRE COLOURS ON PRIMARY OF TRANSFORMER AS SHOWN IN BRACKETS
4. SERIES OR PARALLEL TERMINALS ON CHOKE NOT FITTED

LS AMPLIFIER LSM/6 & MAINS UNIT MUE/1

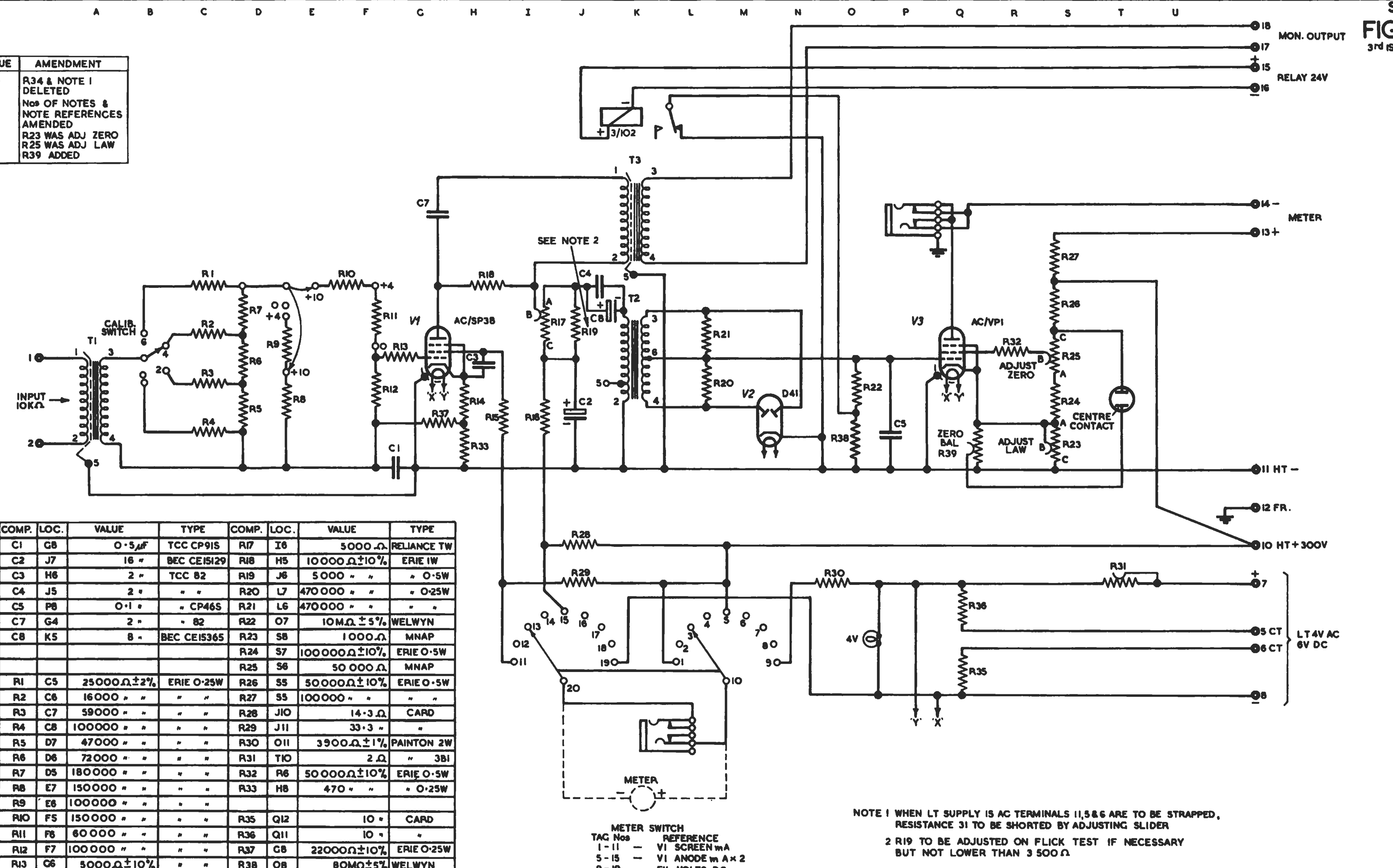
64102/S3/DJE

S3

FIG.31

3rd ISSUE

ISSUE	AMENDMENT
3	R34 & NOTE 1 DELETED Nos OF NOTES & NOTE REFERENCES AMENDED R23 WAS ADJ ZERO R25 WAS ADJ LAW R39 ADDED



NOTE 1 WHEN LT SUPPLY IS AC TERMINALS 11,5&6 ARE TO BE STRAPPED, RESISTANCE 31 TO BE SHORTED BY ADJUSTING SLIDER

2 R19 TO BE ADJUSTED ON FLICK TEST IF NECESSARY BUT NOT LOWER THAN 3 500 Ω

METER SWITCH

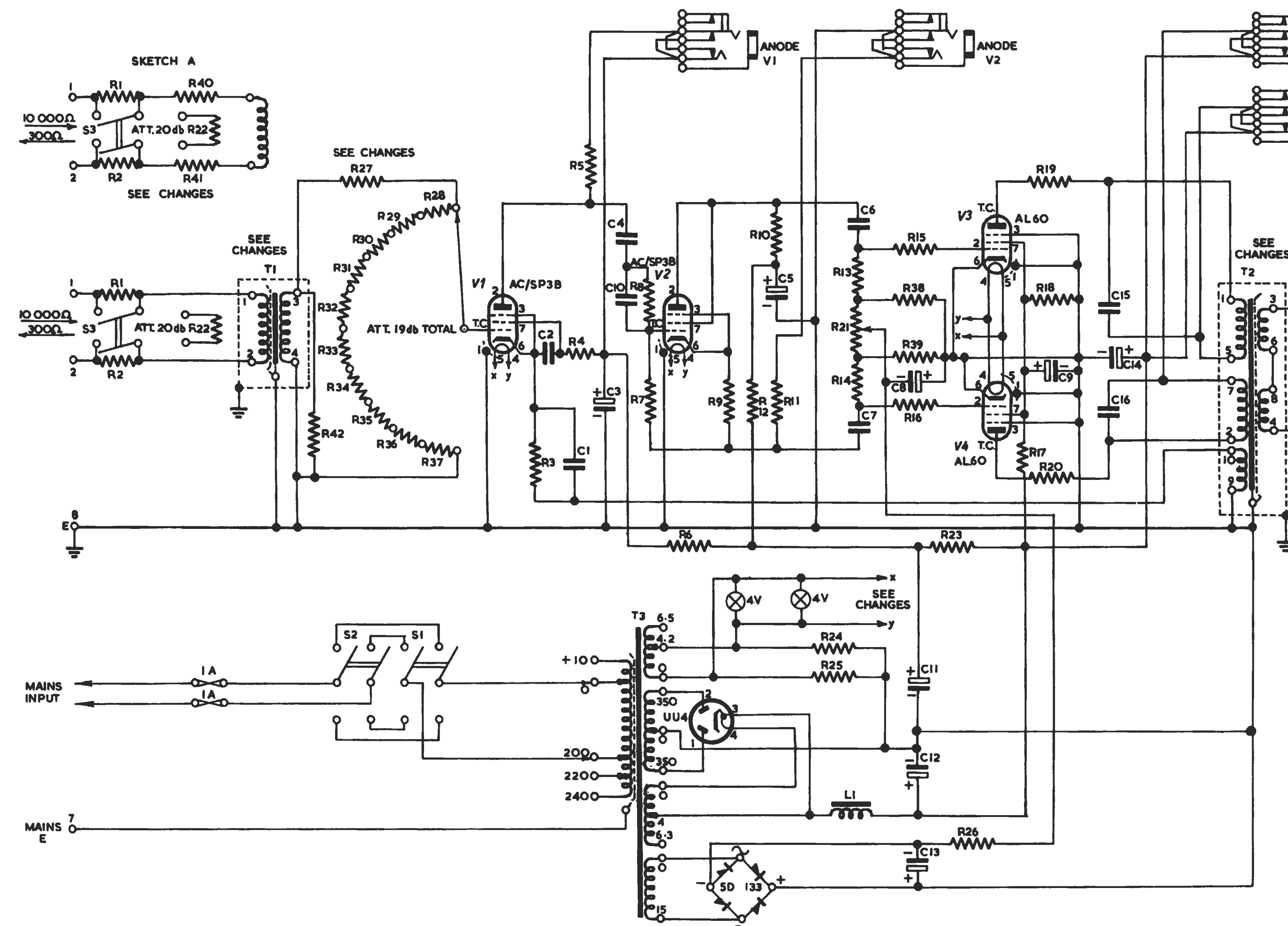
TAG Nos		REFERENCE
1 - 11	—	V1 SCREEN mA
5 - 15	—	V1 ANODE m A × 2
9 - 19		FIL VOLTS DC

COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	G8	0·5μF	TCC CP91S	R17	I6	5000 Ω	RELIANCE TW
C2	J7	16 "	BEC CE15129	R18	H5	10000 Ω ±10%	ERIE 1W
C3	H6	2 "	TCC 82	R19	J6	5000 " "	" 0·5W
C4	J5	2 "	" "	R20	L7	470 000 " "	" 0·25W
C5	P8	0·1 "	" CP46S	R21	L6	470000 " "	" "
C7	G4	2 "	" 82	R22	O7	10MΩ ±5%	WELWYN
C8	K5	8 "	BEC CE15365	R23	S8	1000 Ω	MNAP
				R24	S7	100000 Ω ±10%	ERIE 0·5W
				R25	S6	50 000 Ω	MNAP
R1	C5	25000 Ω ±2%	ERIE 0·25W	R26	S5	50000 Ω ±10%	ERIE 0·5W
R2	C6	16000 " "	" "	R27	S5	100000 " "	" "
R3	C7	59000 " "	" "	R28	J10	14·3 Ω	CARD
R4	C8	100000 " "	" "	R29	J11	33·3 "	"
R5	D7	47000 " "	" "	R30	O11	3900 Ω ±1%	PAINTON 2W
R6	D6	72000 " "	" "	R31	T10	2 Ω	" 3B1
R7	D5	180000 " "	" "	R32	R6	50000 Ω ±10%	ERIE 0·5W
R8	E7	150000 " "	" "	R33	H8	470 " "	" 0·25W
R9	E6	100000 " "	" "				
R10	F5	150000 " "	" "	R35	Q12	10 "	CARD
R11	F6	60000 " "	" "	R36	Q11	10 "	"
R12	F7	100000 " "	" "	R37	G8	22000 Ω ±10%	ERIE 0·25W
R13	G6	5000 Ω ±10%	" "	R38	O8	80MΩ ±5%	WELWYN
R14	H7	330 Ω ±2%	" "	T1	A6	1 : 3·16	LG/7SG
R15	I7	27000 Ω ±10%	" 0·5W	T2	K6	1 : 5	LGG/115SH
R16	"	3300 " "	" "	T3	K3	4·44:1	AL/19SG
				R39	Q8	5000 Ω	LHAP

MONITORING AMPLIFIER MNA/1

FIG 32
3rd ISSUE

S3



UNITS WITH SERIAL NUMBERS 101 TO 331 HAVE THE FOLLOWING DIFFERENCES:-	
101 – 161	T2-273C OLD STYLE R27 FITTED BETWEEN TAG 3 OF T1 AND R28
101 – 271	T1 - LG/26RB
101 – 338	T3-M127 WITH RESISTOR FITTED IN HEATER CIRCUIT TO DROP VOLTAGE TO 4V
162 – 271	R40 AND R41 ADDED (500Ω) SEE SKETCH 'A' T2-273C STYLE 3
272 – 338	T2-273C STYLE 3 T1 LG/35RB R42 ADDED R40 AND R41 CHANGED TO 560Ω

COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	H7	0·0005 ±20%	I.S.C.	L1	N12	14H	C6A	R15,16	O4,6	5·6K ±10%	ERIE 0·25W	R31	E4	23·1K ±10%	ERIE 0·25W
C2	H5	0·1 "	"					R17	Q7	1·2K	PAINTON 3W 301	R32	E5	18·3K "	" "
C3	J6	16	CE15129 B.E.C.	R1,2	A4,5	4·5K ±10%	ERIE 0·25W	R18	Q5	12K	" 7·5W 302	R33	E5	14·5K "	" "
C4	J3	0·1 ±20%	I.S.C.	R3	H7	1K "	" 0·5 "	R19,20	Q2,7	100 ±10%	ERIE 0·25W	R34	E6	11·5K "	" "
C5	M4	16	CE15129 B.E.C.	R4	H5	390K "	" " "	R21	N5	1K	VARIABLE TW RELIANCE	R35	E6	9·2K "	" "
C6,7	N3,7	0·5 ±20%	I.S.C.	R5	J2	100K "	" 1 "	R22	C5	1·1K ±10%	ERIE 0·25W	R36	F7	7·1K "	" "
C8	O6	250	CE 10730 B.E.C.	R6	K8	22K "	" 0·5 "	R23	O8	4·7K "	" 0·5 "	R37	F7	28·1K "	" "
C9	Q6	16	CE15129 "	R7	K6	470K "	" 0·25 "	R24,25	N10	10 "	" " "	R38,39	O4	5·6K "	" "
C10	J4	0·001 ±20%	I.S.C.	R8	K5	3·3M "	" " "	R26	P13	1·2K "	" " "	R40,41	B1,2	560 "	
C11,12	O10,12	16	CE 15129 B.E.C.	R9	L6	6·8K "	" 0·5 "	R27	E2	27K "	" 0·25 "	R42	E7	2·2M "	
C13	O14	250	CE10730 "	R10,11	M3,6	56K ±20%	" " "	R28	F3	46K "	" " "	T1	C5	1 : 5	LG/35RB
C14	R5	16	CE15129 "	R12	L6	10K ±10%	" " "	R29	E3	36K "	" " "	T2	T6	20·3 : 1	273C
C15,16	R4,6	0·003	MATCHED TO ±5% I.S.C.	R13,14	N4,6	220K ± 5%	" 0·25 "	R30	E3	29·2K "	" " "	T3	K12		M127

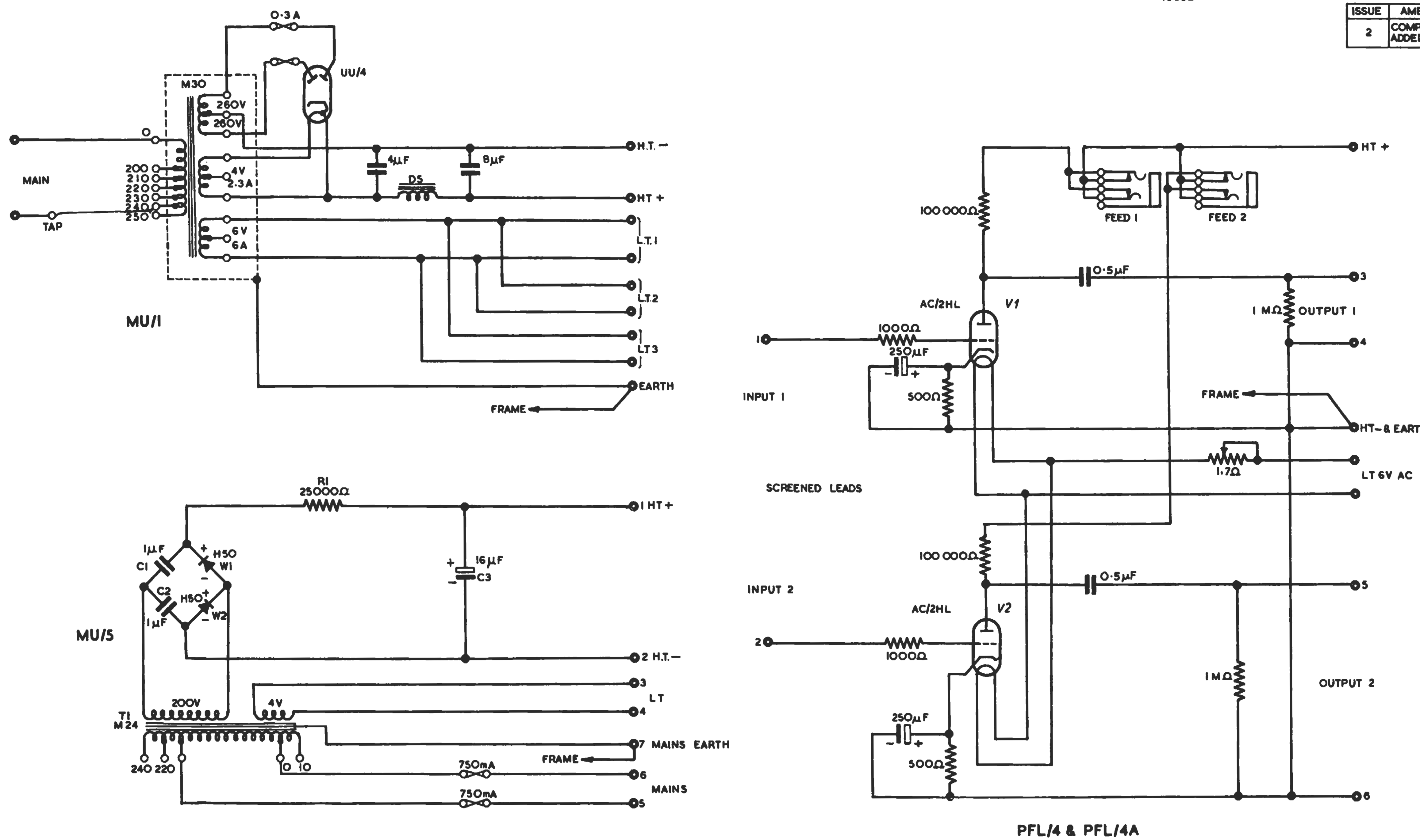
MISCELLANEOUS POWER AMPLIFIER MPA/1

54006/S3/AJP

FIG 33
2nd ISSUE

S3

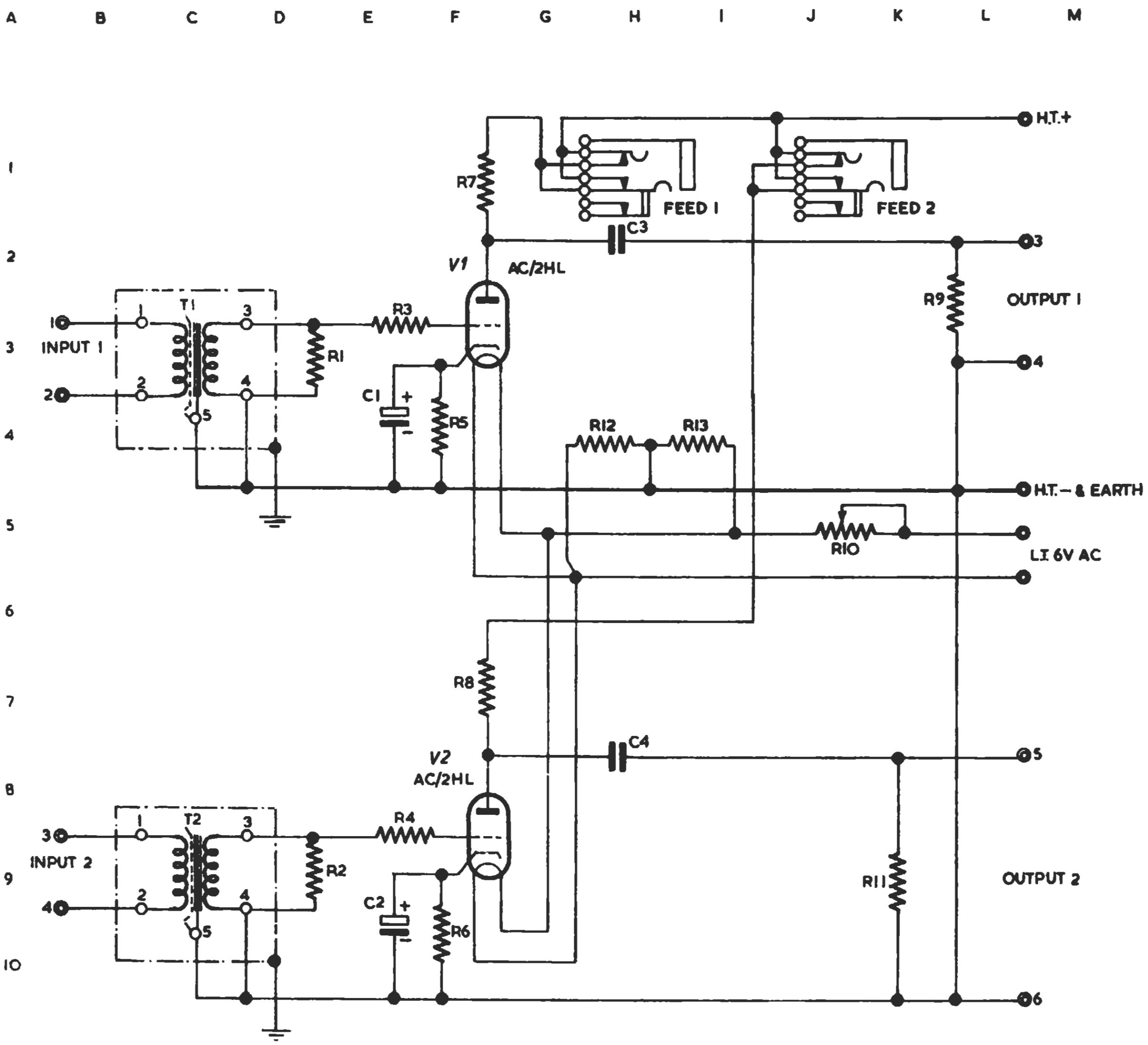
ISSUE	AMENDMENT
2	COMPONENT Nos ADDED TO MU/5



PRE-FADE AMPLIFIER PFL/4 & PFL/4A & MAINS UNITS

B54028/S3/AJP

FIG.34 S3
ISSUE 3



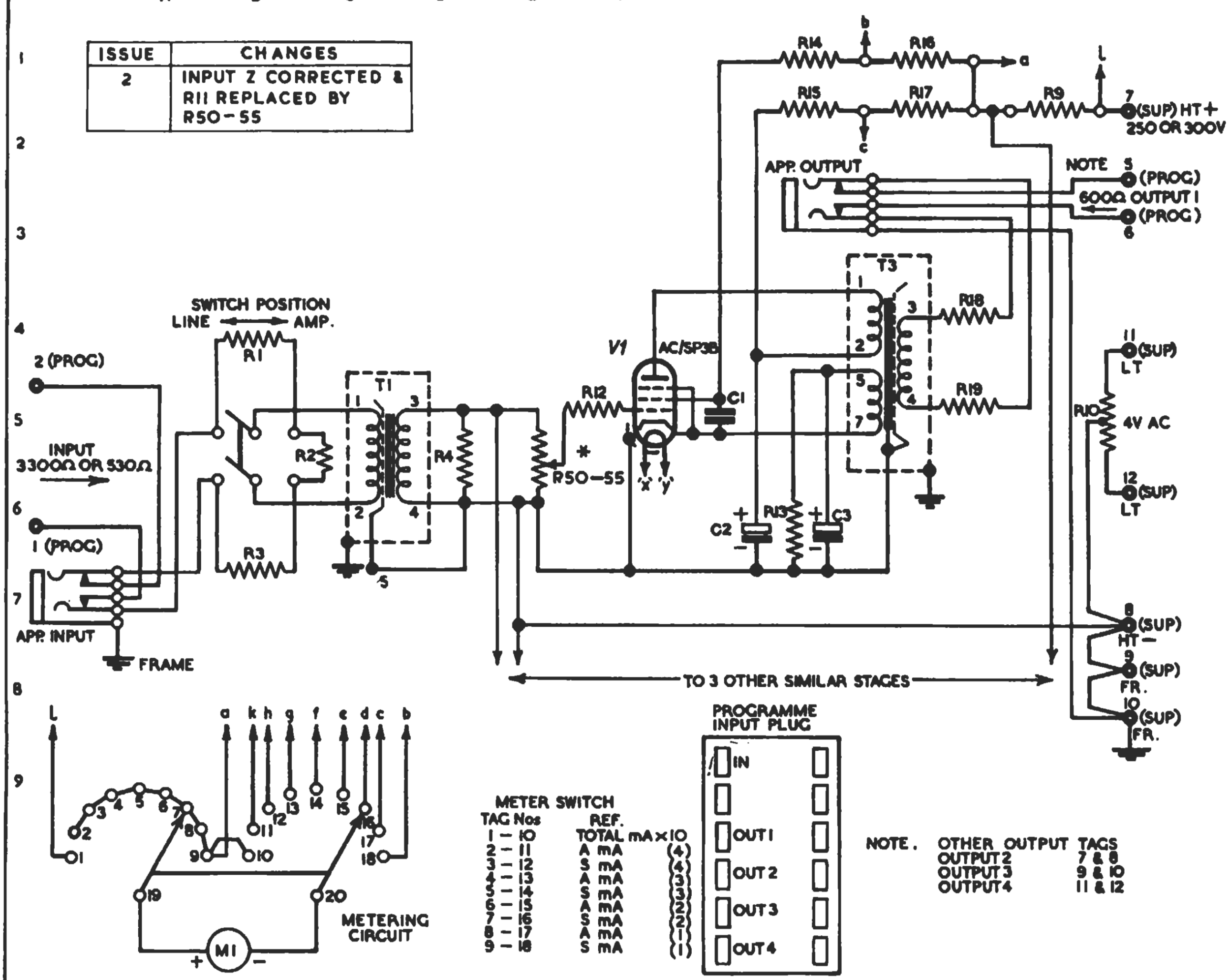
COMP.	LOC.	VALUE	TYPE
C1,2	E4,10	250 µF	TCC CE24B
C3,4	H2,8	0·5 „	MUIRHEAD 39AT
R1,2	D3,9	100 000 Ω	ERIE 8 ½W
R3,4	E3,8	1 000 „	„ 9 ¼ „
R5,6	F4,10	500 „	„ 8 ½ „
R7,8	F1,7	100 000 „	„ „ „ „
R9	L2	1 MΩ	„ 9 ¼ „
R10	J5	2 Ω	PAINTON 3B1
R11	K9	1 MΩ	ERIE 9 ¼W
R12 13	H4	22 Ω	„ 2 1 „
T1	C3	1 : 3·16	LG/7SA
T2	C9	1 : 3·16	LG/7SA

PRE–FADE LISTENING AMPLIFIER PFL/4B

54056/S3/DJE

FIG.35 S3
2ND ISSUE

ISSUE	CHANGES
2	INPUT Z CORRECTED & R11 REPLACED BY R50-55



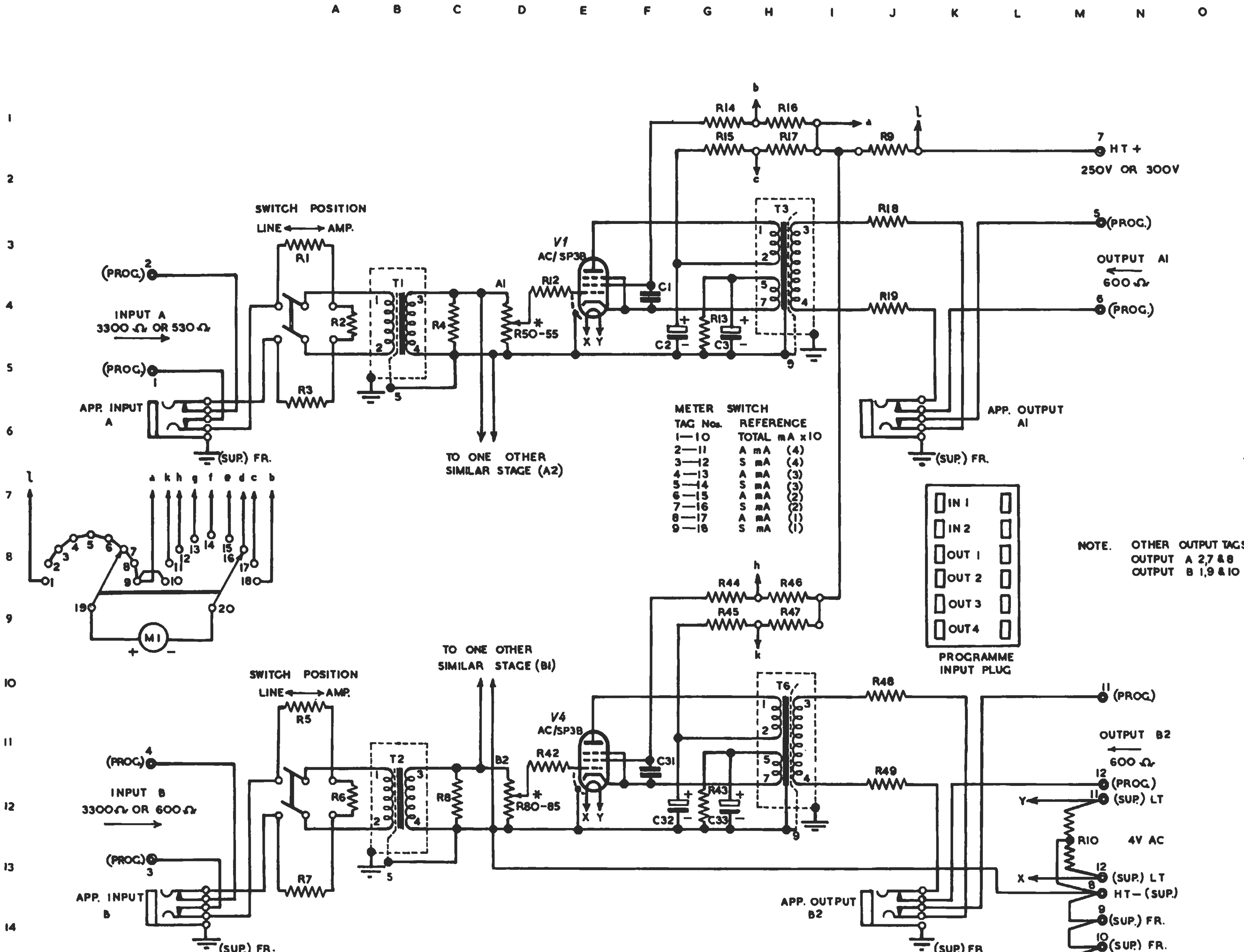
* VOLUME-CONTROL POTENTIOMETERS R50-55 ETC CAN BE SWITCHED FOR OUTPUT LEVELS OF +6, +4, +2, 0, −2 & −4db OR TO 'OFF'

COMP	LOC	VALUES	TYPE	COMP	LOC	VALUES	TYPE
C1	G5	2μF	78	R15	H2	10 000Ω	0·25 WATT
C2	G6	16 "	MA14556	R16	I1	33·3 "	
C3	H6	250 "	MA10154	R17	I2	33·3 "	
				R18	J4	200 "	0·25 WATT
				R19	J5	200 "	" "
R1	B4	1500Ω	0·25 WATT	R50	E5	62 000Ω ±5%	0·125 WATT
R2	C5	600 "	" "	R51	E5	47 000 " "	" "
R3	B7	1500 "	" "	R52	E5	39 000 " "	" "
R4	D5	300 000Ω	" "	R53	E5	30000 " "	" "
R9	K2	2·56Ω		R54	E6	24000 " "	" "
R10	K5	10+10 "		R55	E6	100000 " "	" "
R12	F5	5000 "	0·25 WATT				
R13	H6	250 "	" "	T1	C5	1:10	LG/8SA
R14	H1	100 000Ω	" "	T3	I4	8·05:1	AL/6RA

TRAP VALVE AMPLIFIER TV/17

FIG 36

ISSUE	CHANGES
2	INPUT Z CORRECTED & R11, R41 REPLACED BY R50-55, R80-85



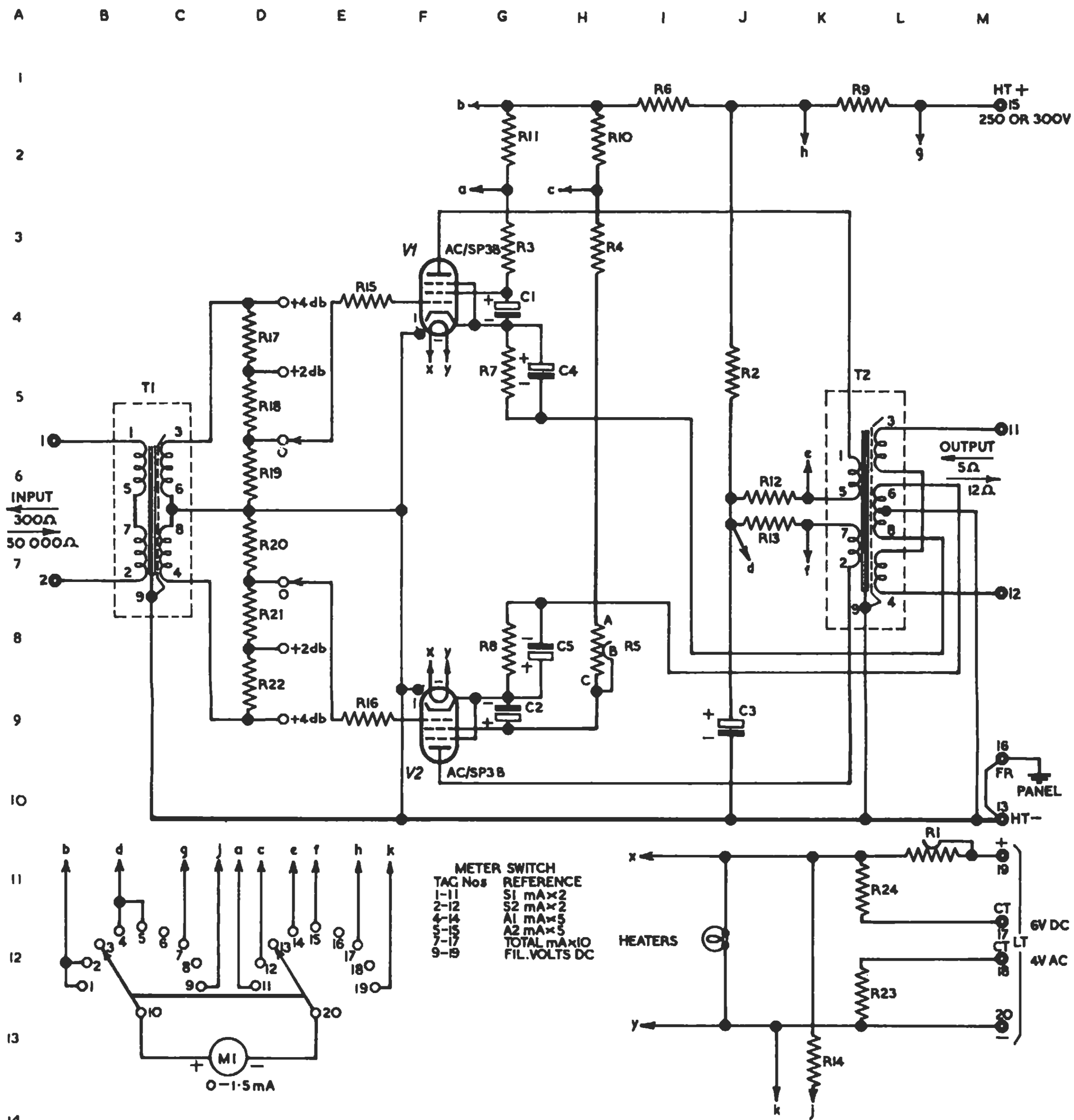
* VOLUME-CONTROL POTENTIOMETERS R50-55, R80-85, ETC, CAN BE SWITCHED FOR OUTPUT LEVELS OF +6, +4, +2, 0, -2 & -4db OR TO 'OFF'

TRAP VALVE AMPLIFIER TV/18

COMP.	LOC.	VALUE	TYPE
C1	F4	2 μF	TCC TYPE 87
C2	F5	16 "	BEC MA 14556
C3	G5	250 "	BEC MA 10154
C31	F11	2 "	TCC TYPE 87
C32	F12	16 "	BEC MA 14556
C33	G12	250 "	BEC MA 10154
R1	A3	1500 Ω	0·25 WATT
R2	A4	600 "	" "
R3	A6	1500 "	" "
R4	C4	100 000 "	" "
R5	A10	2 000 "	" "
R6	A12	600 "	" "
R7	A13	2 000 "	" "
R8	C12	100 000 "	" "
R9	J2	2·56 "	
R10	M13	10 + 10 "	
R12	E4	5 000 "	0·25 WATT
R13	G4	250 "	" "
R14	G1	100 000 "	0.5 "
R15	G2	10 000 "	" "
R16,17	H1,2	33·3 "	
R18,19	J3,4	200 "	0·25 "
R42	D11	5 000 "	0·25 "
R43	G12	250 "	" "
R44	G9	100 000 "	0·5 "
R45	G9	10 000 "	" "
R46,47	H8 H9	33·3 "	
R48,49	J10,J12	200 "	0·25 "
T1	B4	1 : 10	LG/8SA
T2	B12	1 : 10	LG/8SA
T3	H3	8·05 : 1	AL/6RA
T6	H11	8·05 : 1	AL/6RA
R50,80	D4, D11	62 000 Ω ± 5%	0·125 WATT
R51, 81	D4, D11	47 000 " "	" "
R52,82	D4, D12	39 000 " "	" "
R53,83	D5, D12	30 000 " "	" "
R54,84	D5, D13	24 000 " "	" "
R55,85	D5, D13	100 000 " "	" "

54058/S3/DJE

FIG.37 S3



NOTE 1 R6 SHORTED WHEN USING 250V HT SUPPLY

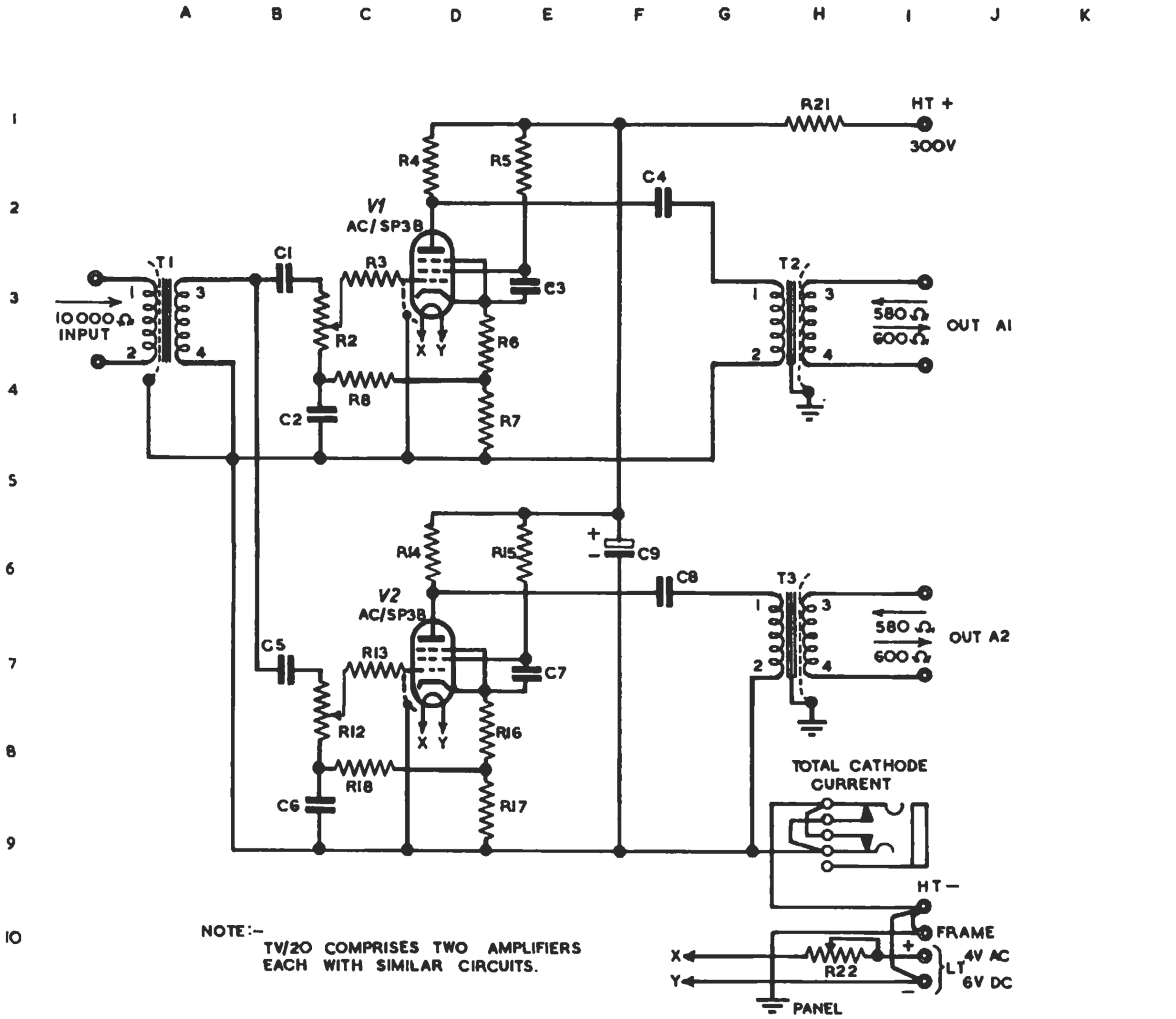
2 WHEN LT SUPPLY IS AC TERMINALS 13 & 17 AND 17 & 18 ARE TO BE STRAPPED R1 TO BE SHORTED BY ADJUSTING SLIDER

COMP.	LOC.	VALUES	TYPE	COMP.	LOC.	VALUES	TYPE	COMP.	LOC.	VALUES	TYPE
C1,2,3	G4,9,J9	16 μF	MA14556	R6	I1	5000Ω	1·0 WATT	R18	D5	50 000Ω	0·25 WATT
C4,5	G5,8	250 "	MA14580	R7,8	G5,8	150 "	·5 "	R19,20	D6,7	210 000 "	" "
				R9	K1	2·56 "		R21	D8	50 000 "	" "
				R10,11	H2,G2	14·3 "		R22	D9	70 000 "	" "
R1	L11	2Ω		R12	J6	5·26 "		R23,24	K12,11	10 "	
R2	J5	2000 "		R13	J6	5·26 "					
R3	G3	20 000 "	1·0 WATT	R14	J13	3900 "					
R4	H3	15000 "	" "	R15,16	E4,9	5000 "	0·25 "	T1	C6	1:3·63	LGG/7R B
R5	H8	10000 "		R17	D4	70000 "	" "	T2	L6	64·8:1	ALL/9RA

TRAP VALVE AMPLIFIER TV/19

54059/S3/SAC

FIG.38 S3



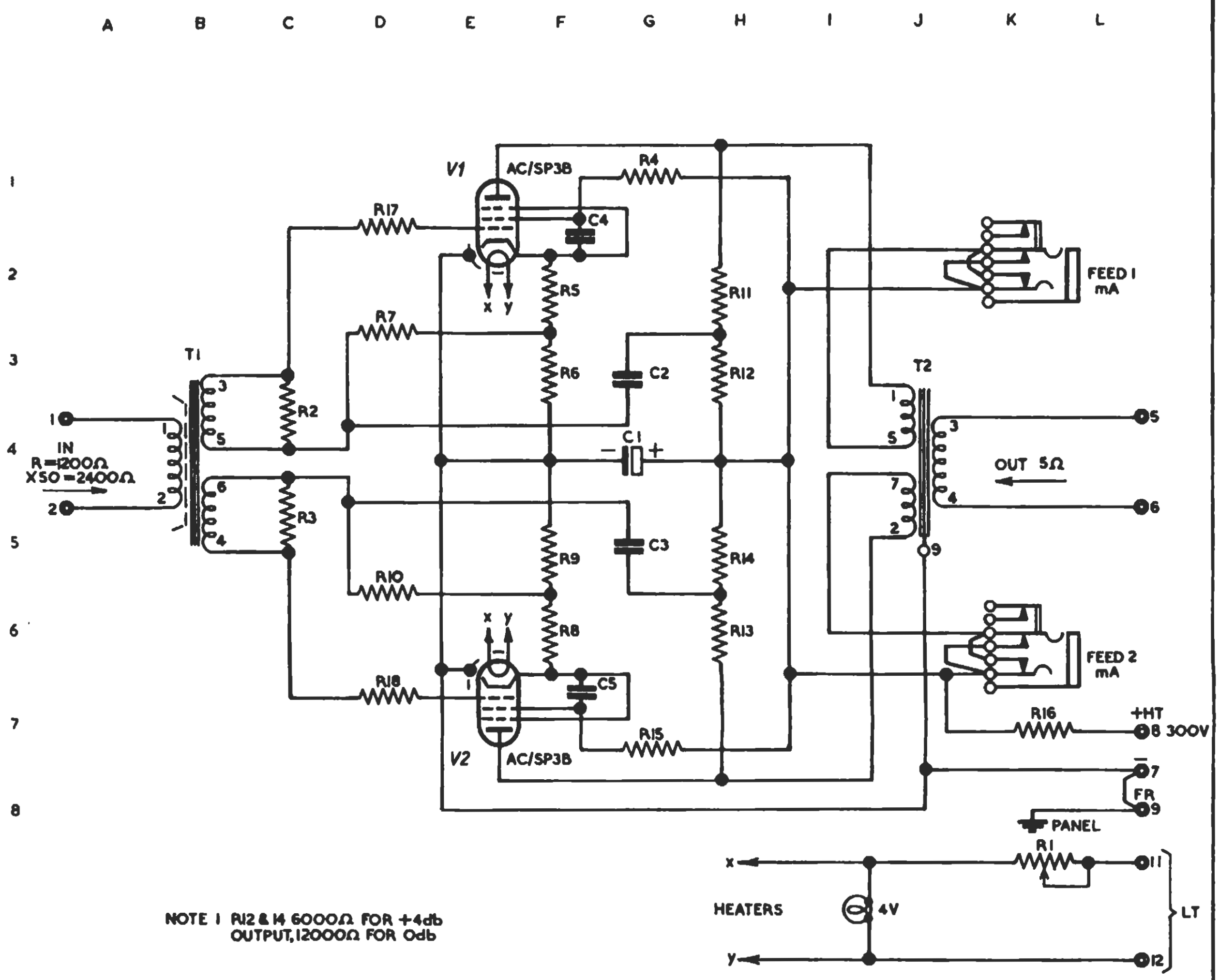
NOTE:–
TV/20 COMPRISES TWO AMPLIFIERS EACH WITH SIMILAR CIRCUITS.

COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	B3	0·2 µF	TCC TYPE 431	R2	C3	200 000 Ω		R16	E8	250 Ω	0·5 W
C2	C4	0·5 "	" " 87	R3	C3	5 000 "	0·25 W	R17	E9	1300 "	0·5 "
C3	E3	2 "	" " "	R4	D2	20 000 "	3 "	R18	C8	100 000 "	0·25 "
C4	F2	0·5 "	" " "	R5	E2	30 000 "	1 "	R21	H1	1 000 "	1 "
C5	B7	0·2 "	" " 431	R6	D3	250 "	0·5 "	R22	H10	2 "	
C6	C9	0·5 "	" " 87	R7	D4	1300 "	0·5 "	T1	A3	1:3·16	LG/7SG OR LG/16RD
C7	E7	2 "	" " "	R8	C4	100 000 "	0·25 "				
C8	F6	0·5 "	" " "	R12	C8	200000 "		T2	H3	5·9 : 1	No 271C OR AL/20RD
C9	F6	16 "	TYPE BEC MA 14556	R13	C7	5 000 "	0·25 "				
				R14	D6	20 000 "	3 "	T3	H7	5·9 : 1	No 271C OR AL/20RD
				R15	E6	30 000 "	1 "				

TRAP VALVE AMPLIFIER TV/20

54060A/S3/DJE

FIG.39 S3
2ND ISSUE



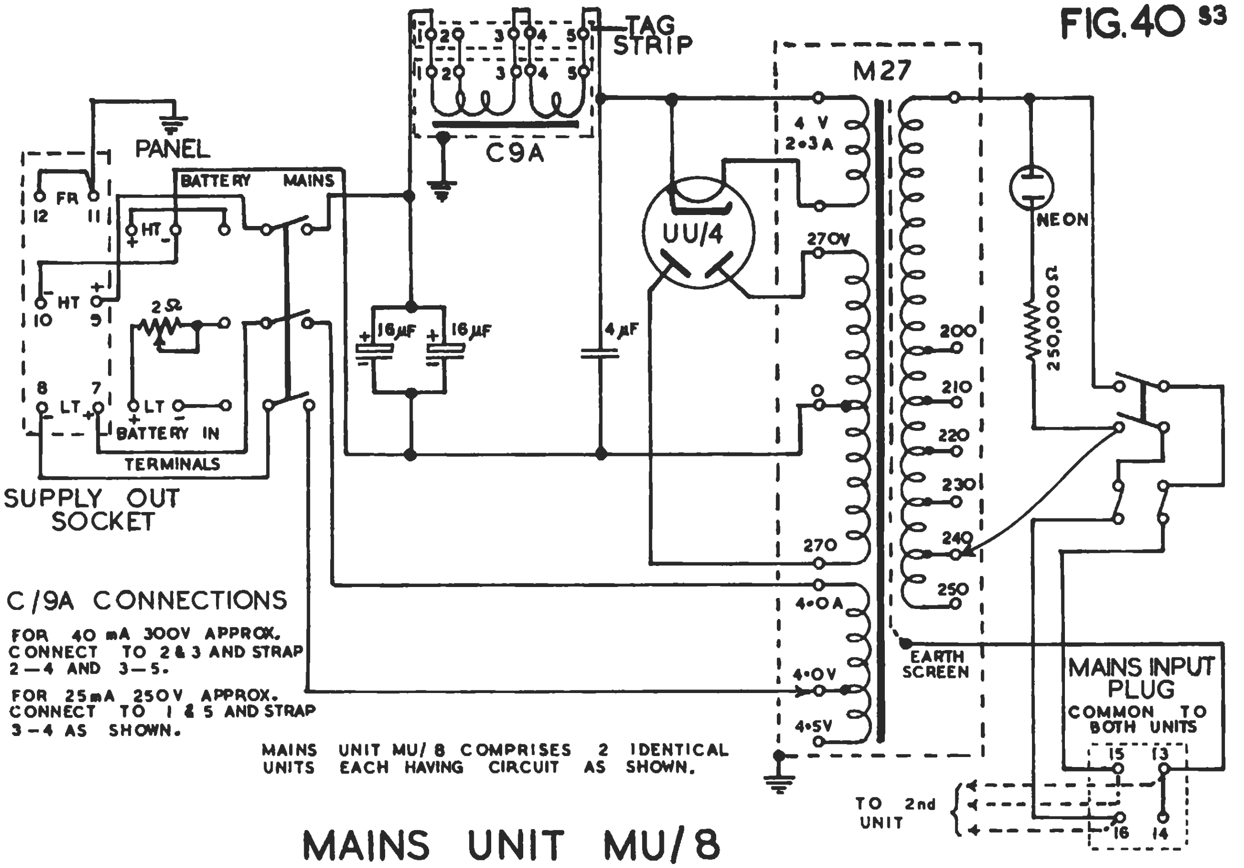
COMP.	LOC.	VALUES	TYPE	COMP.	LOC.	VALUES	TYPE
C1	G4	16 μF	BEC MA15129	R9	F5	240 Ω	0·25W OR ·5W
C2,3	G3,5	0·1 "	TCC 431	R10	D6	200000 "	0·25W
C4,5	F1, 7	2 "	" 87	R11	H2	110000 "	0·25W OR ·5W
				R12	H3	SEE NOTE	" " "
				R13	H6	110000Ω	" " "
R1	L8	2Ω	PAINTON 3B1	R14	H5	SEE NOTE	" " "
R2,3	C4,5	50000 "	0·25W	R15	G7	20000Ω	·5W
R4	G1	20000 "	·5W	R16	K7	1000 "	1W
R5	F2	170 "	0·25W OR ·5W	R17,18	D1,7	5000 "	0·25W
R6	F3	240 "	" " "				
R7	D3	200000 "	0·25W	T1	B4	1 : 10 OVERALL	LGG/135A
R8	F6	170 "	0·25W OR ·5W	T2	J4	70·7 : 1	AAL/11RD

TRAP VALVE AMPLIFIER TV/21

34041/S3/EJC

A 5842
A 6245

FIG.40 S3



C/9A CONNECTIONS

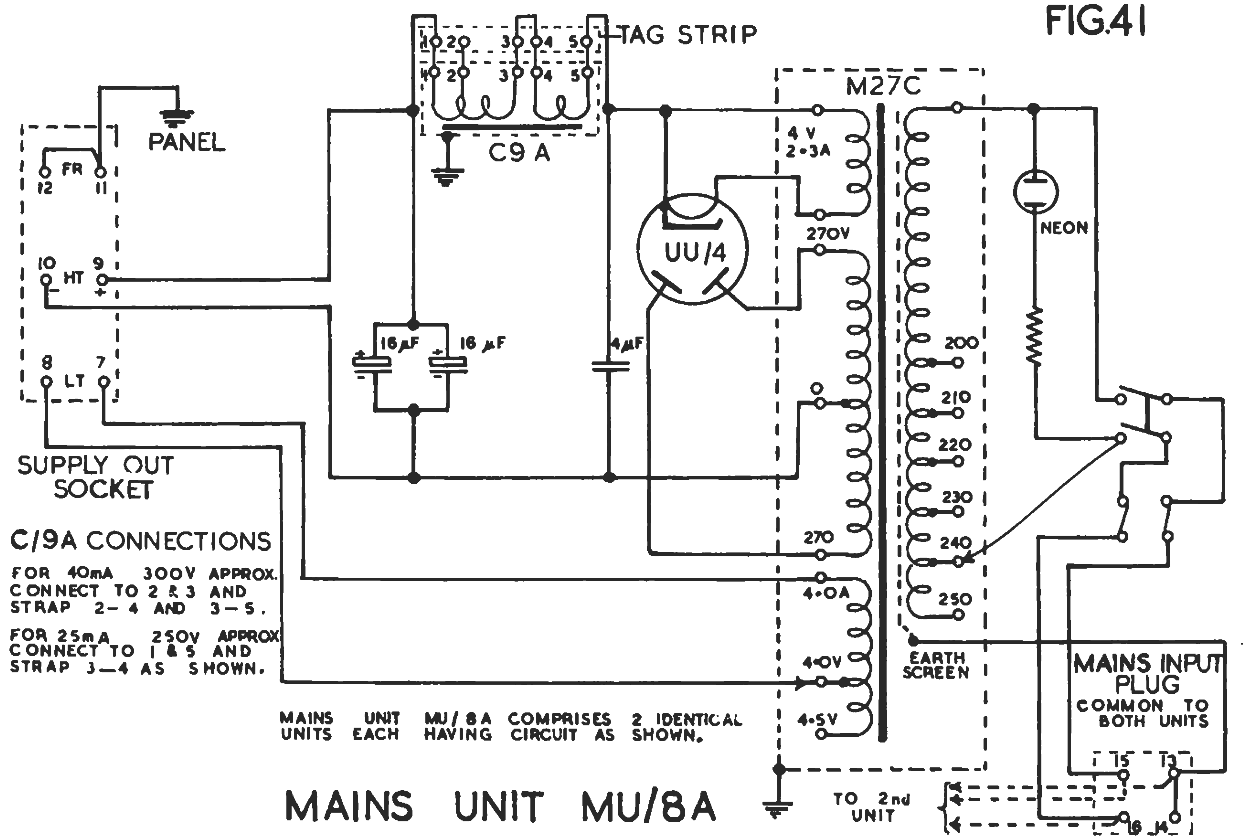
FOR 40 mA 300V APPROX. CONNECT TO 2 & 3 AND STRAP 2—4 AND 3—5.

FOR 25mA 250V APPROX. CONNECT TO 1 & 5 AND STRAP 3—4 AS SHOWN.

MAINS UNIT MU/8 COMPRISES 2 IDENTICAL UNITS EACH HAVING CIRCUIT AS SHOWN.

MAINS UNIT MU/8

FIG.41



C/9A CONNECTIONS

FOR 40mA 300V APPROX. CONNECT TO 2 & 3 AND STRAP 2—4 AND 3—5.

FOR 25mA 250V APPROX CONNECT TO 1 & 5 AND STRAP 3—4 AS SHOWN.

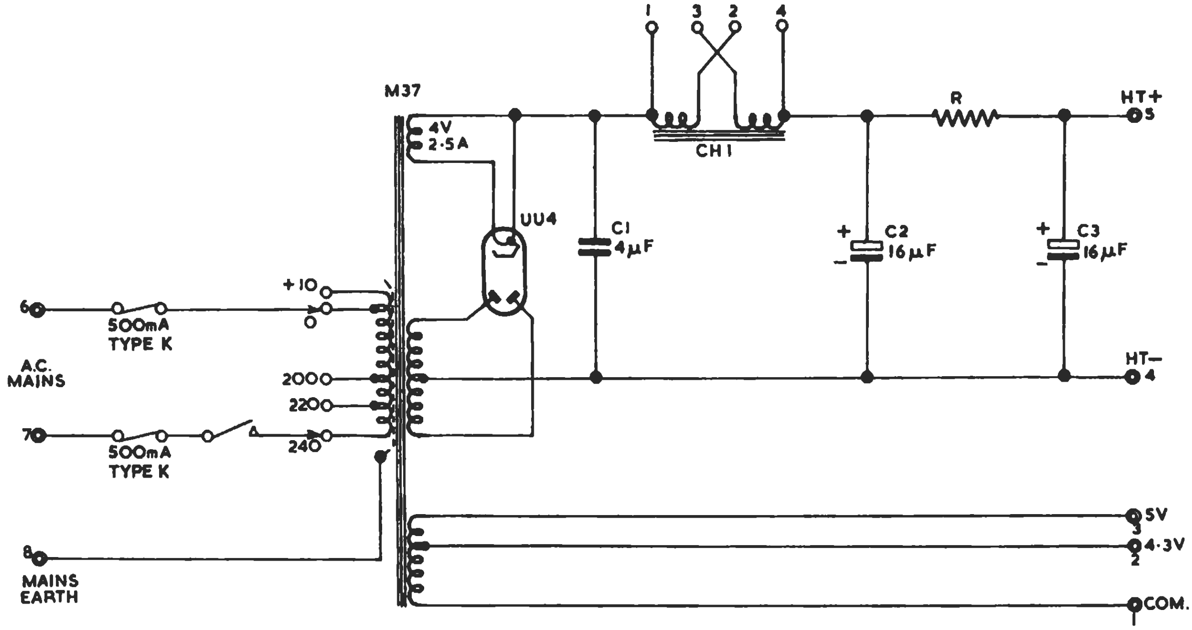
MAINS UNIT MU/8A COMPRISES 2 IDENTICAL UNITS EACH HAVING CIRCUIT AS SHOWN.

MAINS UNIT MU/8A

34042/S3/AJP

ISS	CHANGE
2	FUSES WERE 750 mA

FIG. 42 S3
2nd ISSUE



NOTE:- VOLTAGE DROPPING RES. 'R' TO BE INSERTED AS SHOWN WHEN NECESSARY

CHOKE SECTIONS	CHOKE CONNECTIONS	MAX. H.T. LOAD
SERIES	STRAP TAG 2 TO 3	40mA
PARALLEL	STRAP TAGS } 1 TO 3, 2 TO 4	80mA

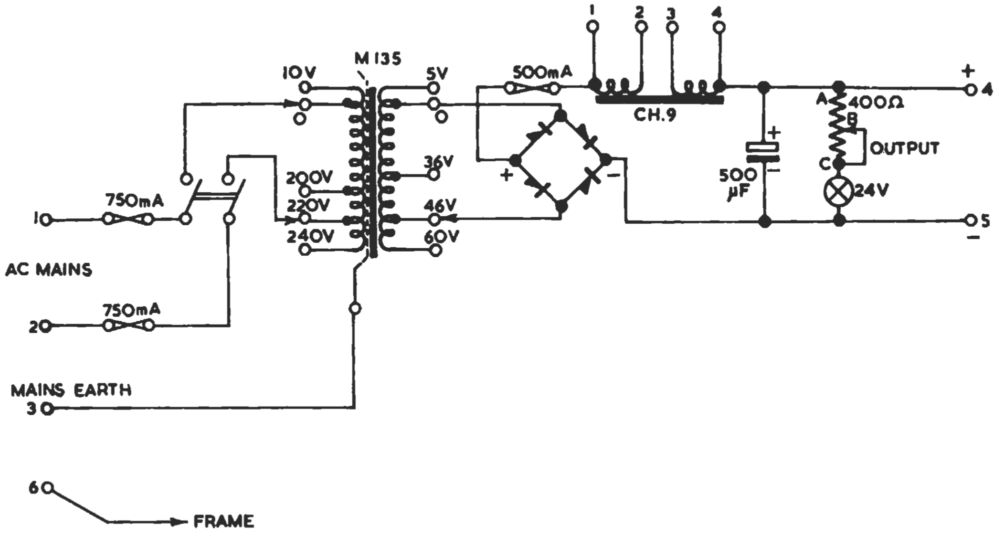
MAINS UNIT MU/16

84010B/S3/AJP

FIG.43 S3

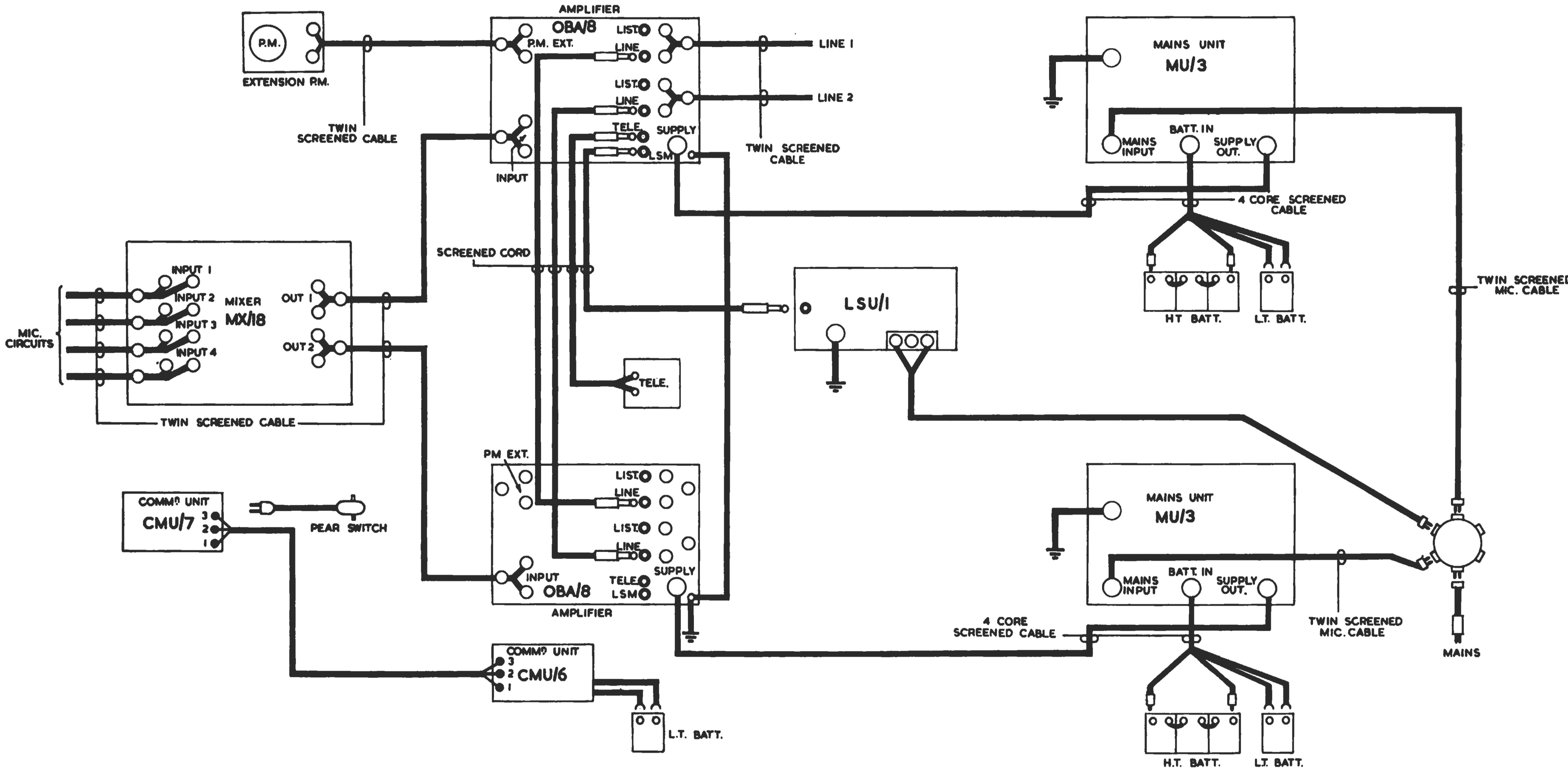
3rd ISSUE

ISSUE	AMENDMENT
3	TAG 3 ADDED M135 SCREEN RE-CONNECTED TO TAG 3



CHOKE SECTIONS	CHOKE CONNECTIONS	MAX. H.T.LOAD
SERIES	STRAP TAG 2 TO 3	50mA
PARALLEL	STRAP TAGS } 1 TO 3, 2 TO 4	250mA

MAINS UNIT MU/29



GENERAL ARRANGEMENT. OBA/8 & ASSOCIATED EQUIPMENT

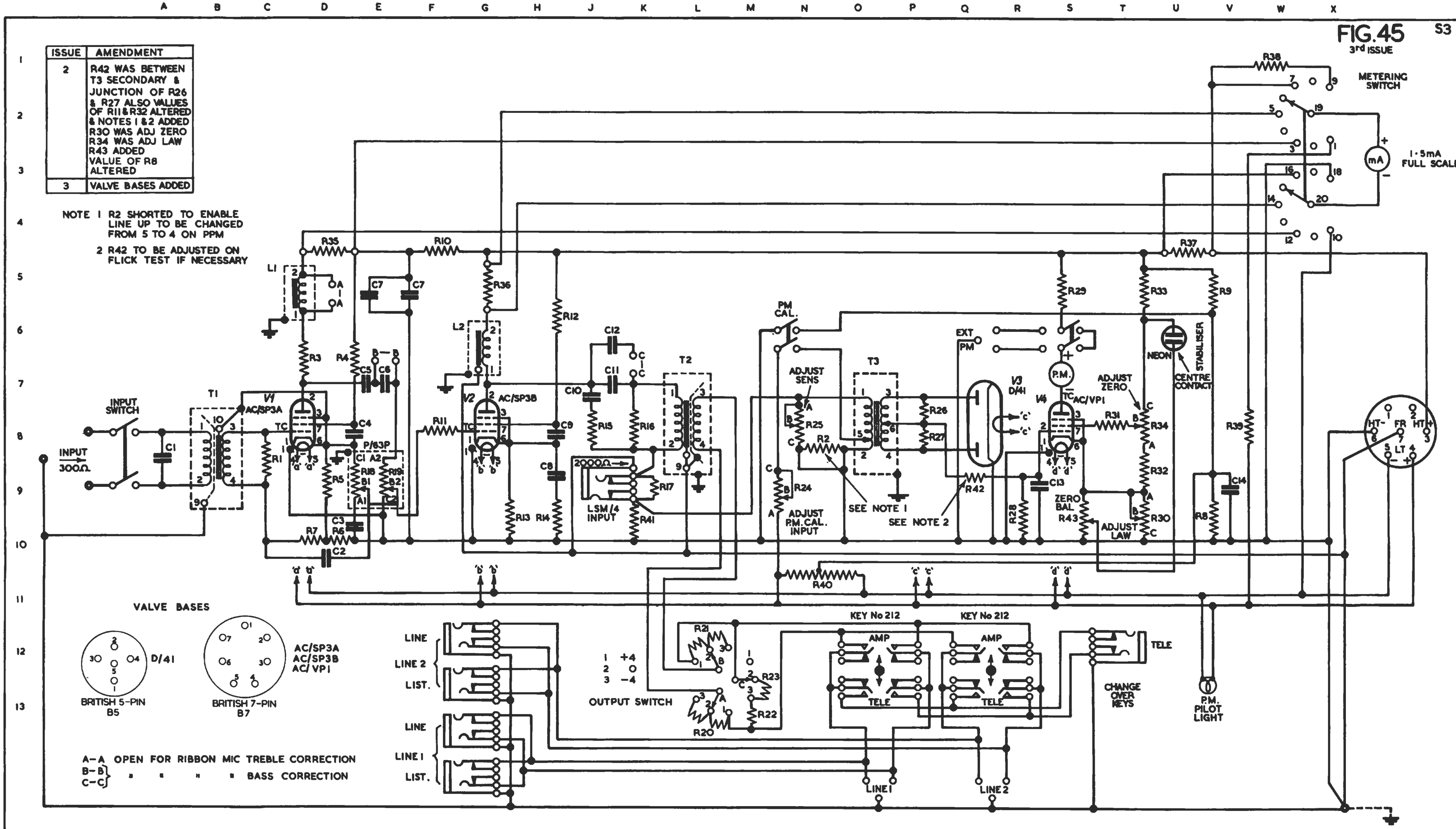
54046/S3/DJE

FIG.45 3rd ISSUE S3

ISSUE	AMENDMENT
2	R42 WAS BETWEEN T3 SECONDARY & JUNCTION OF R26 & R27 ALSO VALUES OF R11 & R32 ALTERED & NOTES 1 & 2 ADDED R30 WAS ADJ ZERO R34 WAS ADJ LAW R43 ADDED VALUE OF R8 ALTERED
3	VALVE BASES ADDED

NOTE 1 R2 SHORTED TO ENABLE LINE UP TO BE CHANGED FROM 5 TO 4 ON PPM

2 R42 TO BE ADJUSTED ON FLICK TEST IF NECESSARY



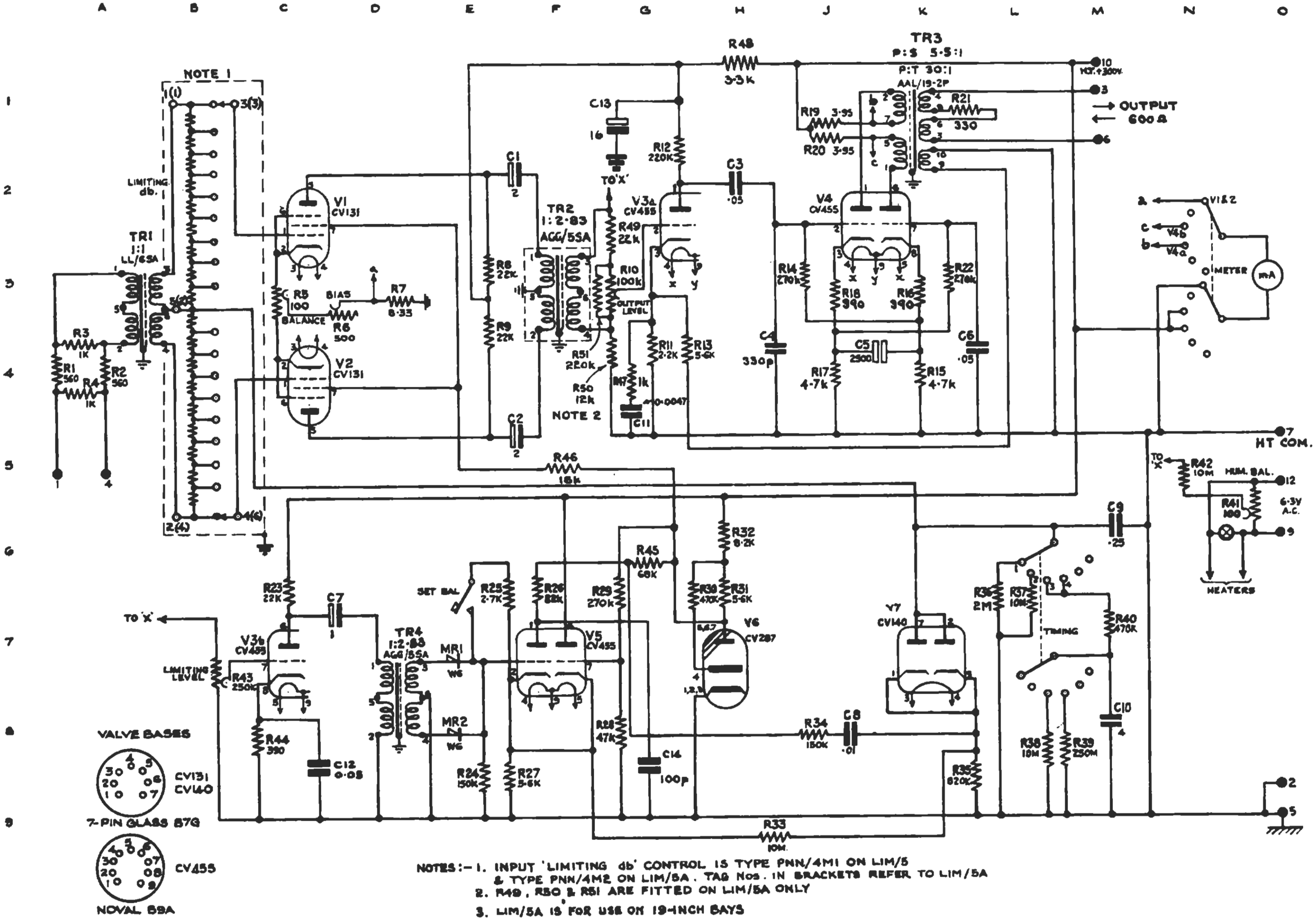
COMP.	LOC.	VALUES	TYPE	COMP.	LOC.	VALUES	TYPE	COMP.	LOC.	VALUES	TYPE
C1	A8	0·05μF		C12	J6	0·1 μF		R6	D10	2000Ω	
C2	D10	1·0 "		C13	R9	0·05 "		R7	D10	100 000 "	
C3,4	E10,8	2·0 "		C14	V9	2·0 "		R8	V10	15 000 "	
C5	E7	0·1 "						R9	V5	100 000 "	
C6	E7	0·006 "						R10	F4	20 000 "	
C7	E5	2·0 "		R1	C8	300 000Ω		R11	F8	5 100 "	
C8	H9	0·1 "		R2	N8	1500 "		R12	H6	33 000 "	
C9	H8	4 "		R3	D6	150 000 "		R13	G10	120 "	
C10	J7	0·25 "		R4	E6	500 000 "		R14	H10	100 "	
C11	J7	0·05 "		R5	D9	1000 "		R15	J8	100 000 "	

COMP.	LOC.	VALUES	TYPE	COMP.	LOC.	VALUES	TYPE	COMP.	LOC.	VALUES	TYPE
R16	K8	50 000Ω		R28	R10	20 MΩ		R39	V8	4000Ω	
R17	K9	2000 "		R29	S5	100 000 "		R40	N11	20 "	
R18	E9	10 000 "		R30	T10	1000 "		R41	K10	2000 "	
R19	E9	250 000 "		R31	T8	50 000 "		R42	Q9	5000 "	
R20,21	L12,13	57 "		R32	T9	75 000 "		R43	S10	5 000 "	LHNAP
R22	M13	125 "		R33	T5	30 000 "		L1	D5		S/1A
R23	M13	79 "		R34	T8	50 000 "		L2	G6		R/1A
R24	M9	1000 "		R35	D4	66·6 "		T1	B8	1 : 31·6	LG/1RB
R25	N8	5000 "		R36,37	G5,U4	3·51 "		T2	L8	20 : 1	AL/1RA
R26,27	P7,8	500 000 "		R38	W1	200 000 "		T3	O8	1 : 10 LCG/35A OR LCG/35H	

AMPLIFIER OBA/8

53/GGJ/OOI/NIB
DB1337
EB8230
8717

ISS	CHANGE
3	REVISED TO EB8230 & 8717 ISS 4



NOTES:– 1. INPUT 'LIMITING db' CONTROL IS TYPE PNN/4M1 ON LIM/5 & TYPE PNN/4M2 ON LIM/5A. TAG Nos. IN BRACKETS REFER TO LIM/5A
2. R49, R50 & R51 ARE FITTED ON LIM/5A ONLY
3. LIM/5A IS FOR USE ON 19-INCH BAYS

LIMITERS LIM/5 & 5A: CIRCUIT

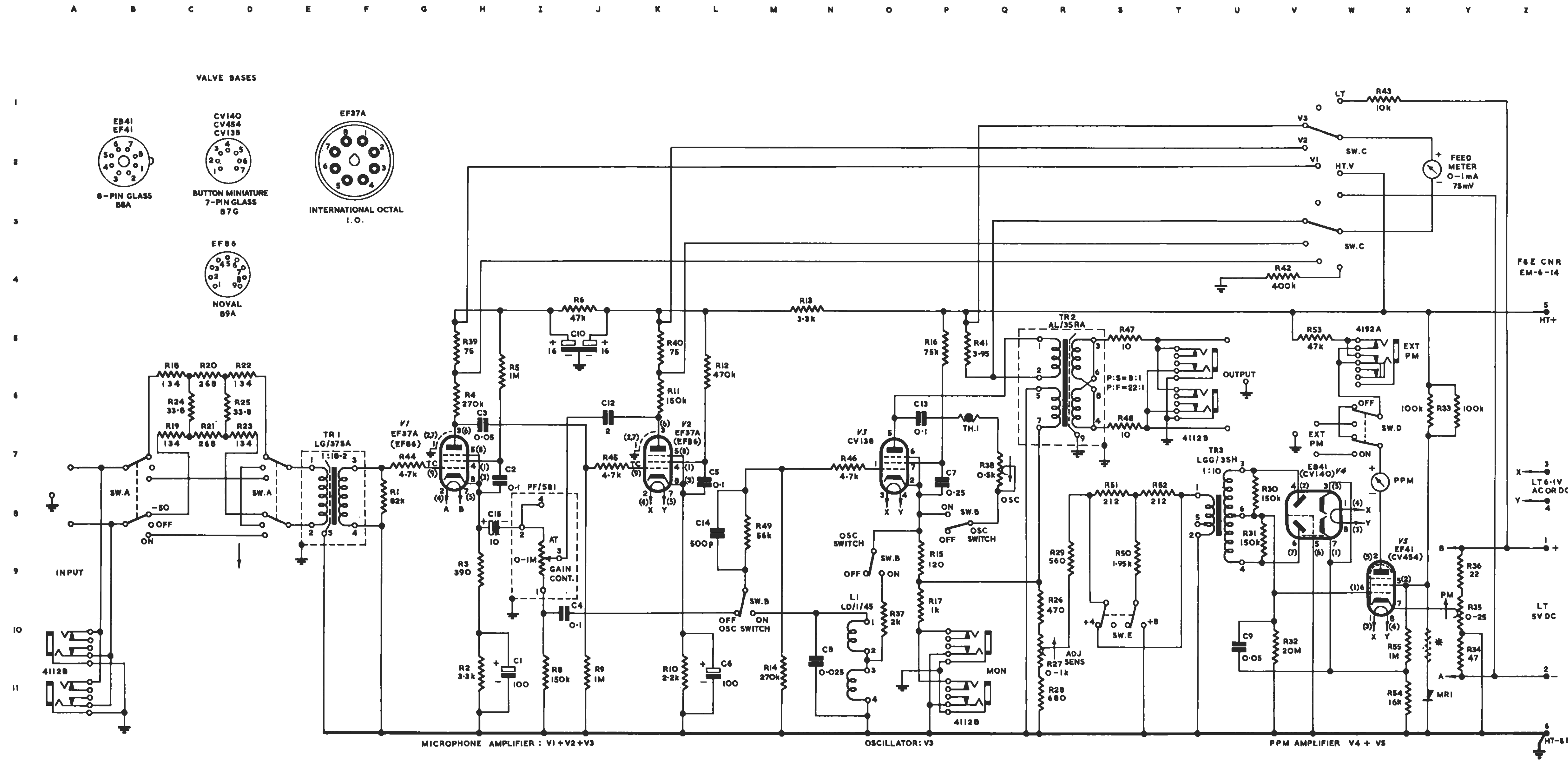
FIG 46
ISS 4

COMPONENT TABLE: FIG. 47

Comp.	Loc.	Type	Tolerance per cent	Comp.	Loc.	Type	Tolerance per cent
C1	I11	T.C.C. CE32A/PVC		R27	R11	LHNAP 10250 1" Sp	
C2	H7	,, CP37N/PVC		R28	R11	Erie 9	± 10
C3	H7	,, CP35N/PVC		R29	R9	,, ,,	,,
C4	J10	,, CP37N/PVC		R30	U8	,, ,,	,,
C5	L7	,, ,,		R31	U9	,, ,,	,,
C6	L11	,, CE32A/PVC		R32	V11	Welwyn SA3623	± 5
C7	P8	,, CP47N/PVC		R33	Y6	Dubilier BTB	± 10
C8	N11	L.E.M. 2515	± 5	R34	Y11	Erie 9	± 10
C9	U10	,, 3220 Filter	,,	R35	Y10	Painton 2-W Pot	
C10	J5	Plessey 822/1		R36	Y9	Erie 9	± 10
C12	J6	Hunt W54 WP210		R37	O10	,, ,,	± 5
C13	P6	T.C.C. CP37N/PVC		R38	Q8	Painton 2-W Pot	
C14	L8	,, CM20N	± 20	R39	H5	,, P406	± 1
C15	H8	,, SCE70C/PVC		R40	K5	,, ,,	,,
				R41	Q5	,, ,,	,,
L1	N10	LD/1/4S		R42	V4	Welwyn SA3623	,,
				R43	X1	,, SA3622	,,
MR1	X11	Westinghouse 16HT64		R44	G7	Erie 9	± 10
				R45	J7	,, ,,	,,
R1	F8	Erie 9	± 10	R46	N7	,, ,,	,,
R2	H11	,, ,,	,,	R47	S5	,, ,,	± 5
R3	H9	Welwyn SA3611	± 2	R48	S7	,, ,,	,,
R4	H6	,, SA3623	± 5	R49	M9	,, ,,	± 10
R5	I6	Erie 9	± 10	R50	S9	Welwyn SA3611	± 2
R6	J5	,, ,,	,,	R51	S8	,, ,,	,,
R8	I11	,, ,,	,,	R52	T8	,, ,,	,,
R9	J11	,, ,,	,,	R53	V5	Dubilier BTB	± 10
R10	K11	,, ,,	,,	R54	X11	Erie 9	,,
R11	K6	,, ,,	,,	R55	X11	,, ,,	,,
R12	L6	,, ,,	,,				
R13	N5	,, ,,	,,	SW A	C8	Oak H 4-P 3-W N.S.F.	
R14	M11	,, ,,	,,		L10		
R15	P9	,, ,,	,,	SW B	O9	A.B. Metal M1 3-P 2-W	
R16	P5	,, ,,	,,		P8		
R17	P10	,, ,,	,,	SW C	W3	,, ,, ,, 2-P 6-W	
R18	C6	Welwyn SA3611	± 2	SW D	W7	Arrow D.P.D.T. 20905	
R19	C7	,, ,,	,,	SW E	S10	,, ,, ,,	
R20	C6	,, ,,	,,				
R21	C7	,, ,,	,,				
R22	D6	,, ,,	,,	TH1	P7	S.T.C. A5412/100	
R23	D7	,, ,,	,,				
R24	C6	,, ,,	± 5	TR1	E8	LG/37SA	
R25	D6	,, ,,	,,	TR2	R6	AL/35RA	
R26	R10	Erie 9	± 10	TR3	U8	LGG/3SH	

53/GH/161/DJE
ED8241
ISS.3
ED8931
ISS. 2

FIG 47 S3
ISSUE 3



NOTES:- 1 VALVE TYPES AND PIN NUMBERS IN BRACKETS REFER TO OBA/9A

2 PPM METER IS TO SPEC No1470 FOR OBA/9 & TO SPEC No 1471 FOR OBA/9A

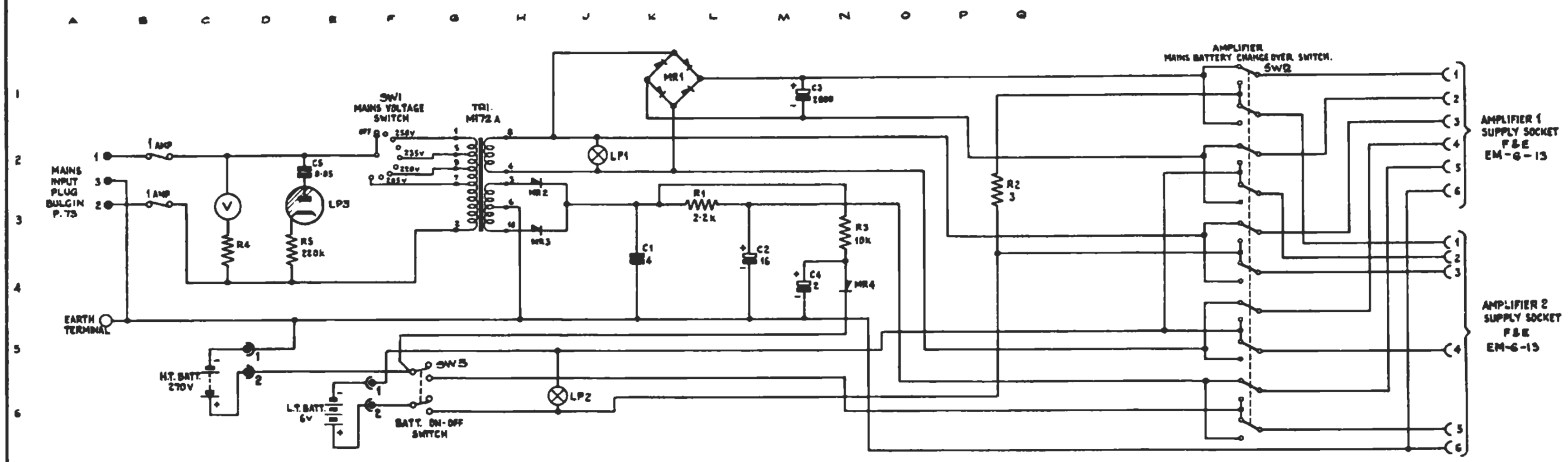
* THIS RESISTOR TO BE SELECTED AND FITTED ON TEST WHEN NECESSARY, TO SUIT RECTIFIER MR1

AMPLIFIERS OBA/9 & OBA/9A: CIRCUIT

COMPONENT TABLE: FIG. 48

COMP.	LOC.	TYPE	TOLERANCE (PER CENT)
C1	K4	Muirhead 39 AT,450-V Wkg	
C2	L4	B.E.C. 511/15, 450-V Wkg	
C3	M1	T.C.C. CE41B, 12-V Wkg	
C4	M4	T.C.C. CE18P, 350-V Wkg	
C5	E2	T.C.C. CP37S	
LP 1	H2	P.O. 6-V No.2	
LP 2	J5	P.O. 6-V No.2	
LP 3	D3	Osram Neon F	
MR 1	K1	S.T.C. B45.1.B1W	
MR 2	H2	Westinghouse 16 HT 24	
MR 3	H3	Westinghouse 16 HT 24	
MR 4	N4	Westinghouse 16 HT 24	
R1	L3	Erie 2	±10
R2	Q3	Painton MV/1	
R3	N3	Erie 9	
R4	C3	Turner 110/2	
R5	D3	Erie 9	
SW 1	F2	A.B. Metals M1 1-P 9-W	
SW 2	T1-6	Oak H 10-P 2-W Wafer	
SW 3	F5	Arrow 20905	
TR 1	G2	M.172A	

53/GWH/163/DJE
ED8222



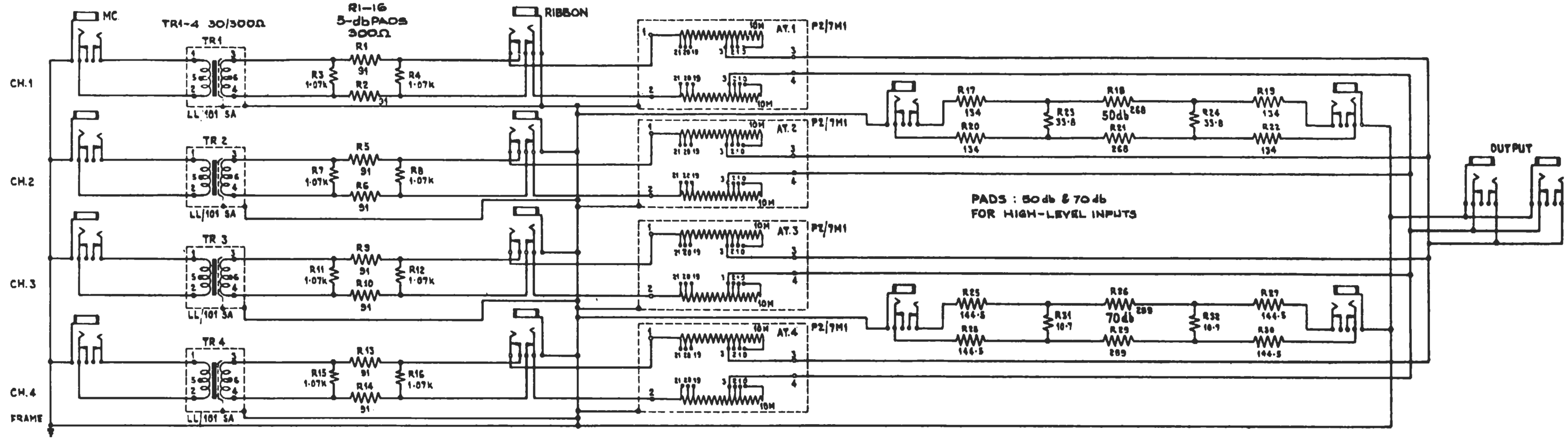
SUPPLY UNIT SUP/6: CIRCUIT

FIG 48
ISSUE 2

53/GWH/162
ED8265
ISS1

FIG 49

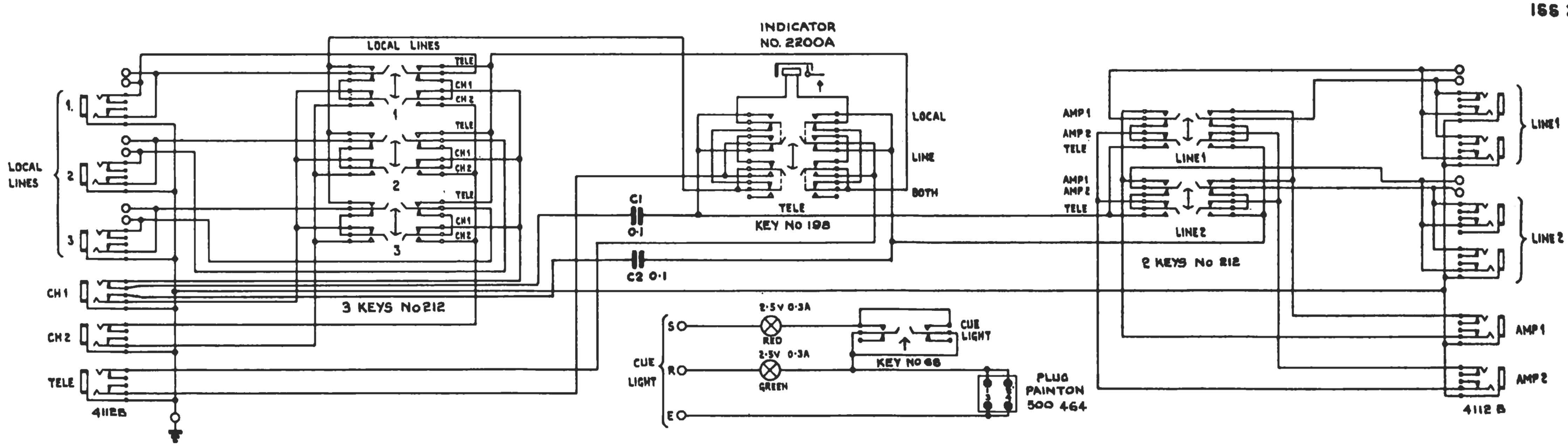
53



MIXER MX/29 : CIRCUIT

ISS	CHANGE
2	C1 & C2 ADDED

FIG 50
ISS 2



DISTRIBUTION UNIT DU/1 : CIRCUIT

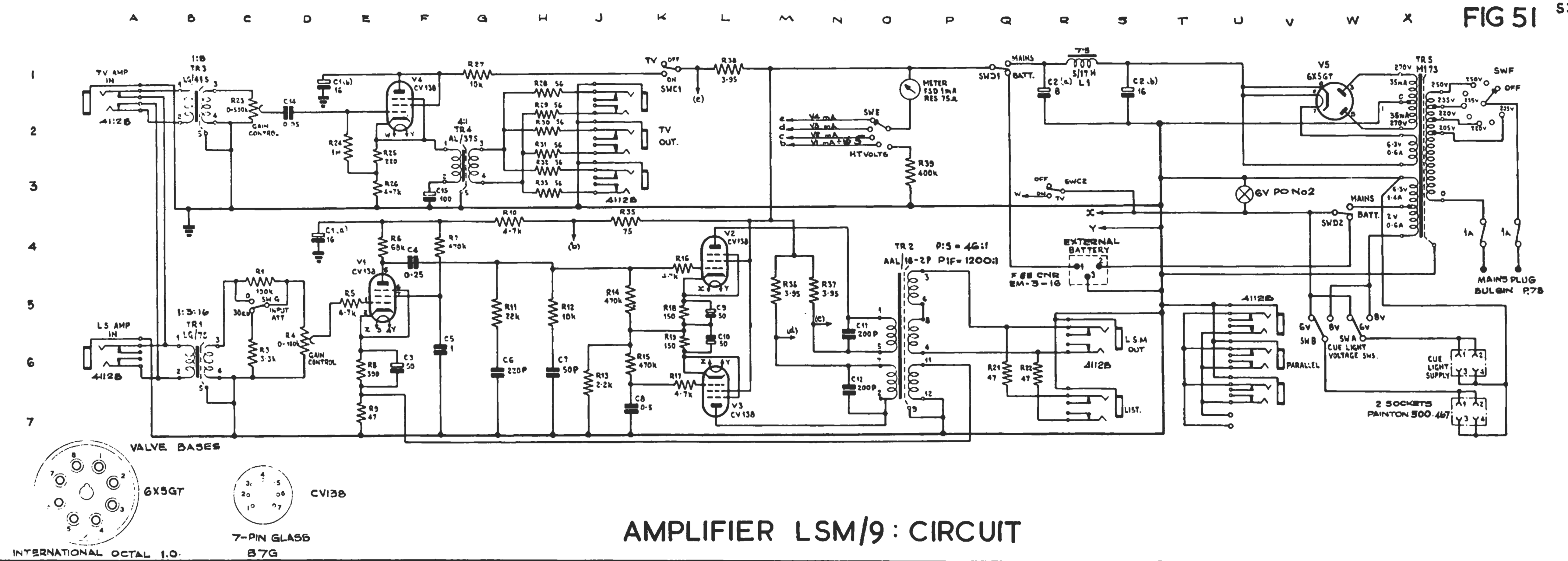
53/GWH/164
ED8228
ISS2

COMPONENT TABLE: FIG. 51

Comp.	Loc.	Type	Tolerance	Comp.	Loc.	Type	Tolerance
C1a	D4	T.C.C. CE28L		R19	K6	Erie 9	±5%
C1b	D1			R21	Q6	" "	±10%
C2a	Q1	T.C.C. CE29P		R22	R6	" "	"
C2b	S1			R23	C2	MNAP 50410 $\frac{7}{8}$ in. Sp.	
C3	E6	T.C.C. CE32B		R24	E3	Erie 9	±10%
C4	E4	T.C.C. CE48N		R25	E3	" "	"
C5	F6	Muirhead 39AT	±10%	R26	E3	" "	"
C6	G6	T.C.C. SCH.2	"	R27	G1	Erie 2	"
C7	H6	T.C.C. SCH.1	"	R28	H1	Erie 9	"
C8	J7	Muirhead 33AT	"	R29	H2	" "	"
C9	L5	T.C.C. CE32B		R30	H2	" "	"
C10	L6	" "		R31	H3	" "	"
C11	N6	T.C.C. SCH.2		R32	H3	" "	"
C12	N7	" "		R33	H3	" "	"
C14	D2	T.C.C. CP37S		R35	K4	Painton P406	±2%
C15	F3	T.C.C. CE26D		R36	M5	" "	"
				R37	N5	" "	"
L1	R1	S/17H		R38	L1	" "	"
				R39	O3	Welwyn SA3623	"
R1	C5	Erie 9	±5%				
R3	C6	" "	"	SW A	W5	Arrow 20905 LT13	
R4	D6	MNAP 10410 $\frac{7}{8}$ in. Sp.		SW B	V5	" " "	
R5	E5	Erie 9	±10%	SW C	K1	" " "	
R6	E4	" "	"		R3		
R7	F4	" "	"	SW D	Q1	" " "	
R8	E6	" "	"		W3		
R9	E7	" "	"	SW E	N2	A.B. Metal 1-P 5-W	
R10	H4	" "	"	SW F	Y1	A.B. Metal 1-P 9-W	
R11	G5	" "	"	SW G	C5	A.B. Metal Oak 23 1-P 2-W	
R12	H5	" "	"				
R13	J7	Erie 2	"				
R14	J5	Erie 9	"	TR 1	B6	LG/7SA	
R15	J6	" "	"	TR 2	O6	AAL/18-2P	
R16	K5	" "	"	TR 3	B1	LG/41SA	
R17	K7	" "	"	TR 4	G3	AL/37SA	
R18	K5	" "	±5%	TR 5	X2	M.173	

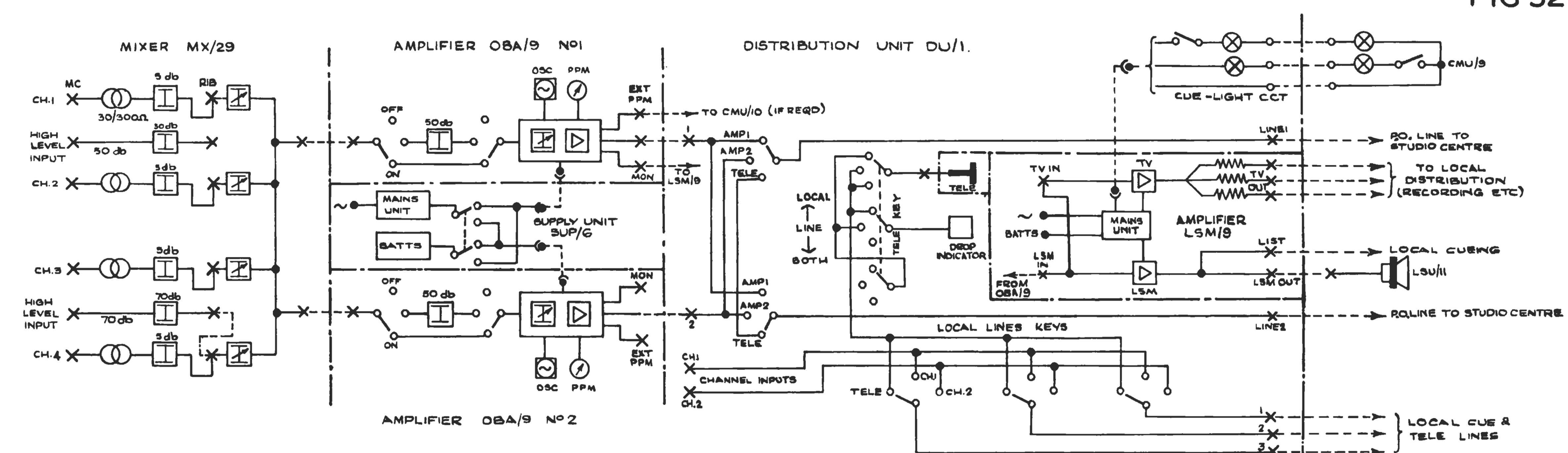
53/GWH/165
ED8198
ISS I

FIG 51 S3



AMPLIFIER LSM/9 : CIRCUIT

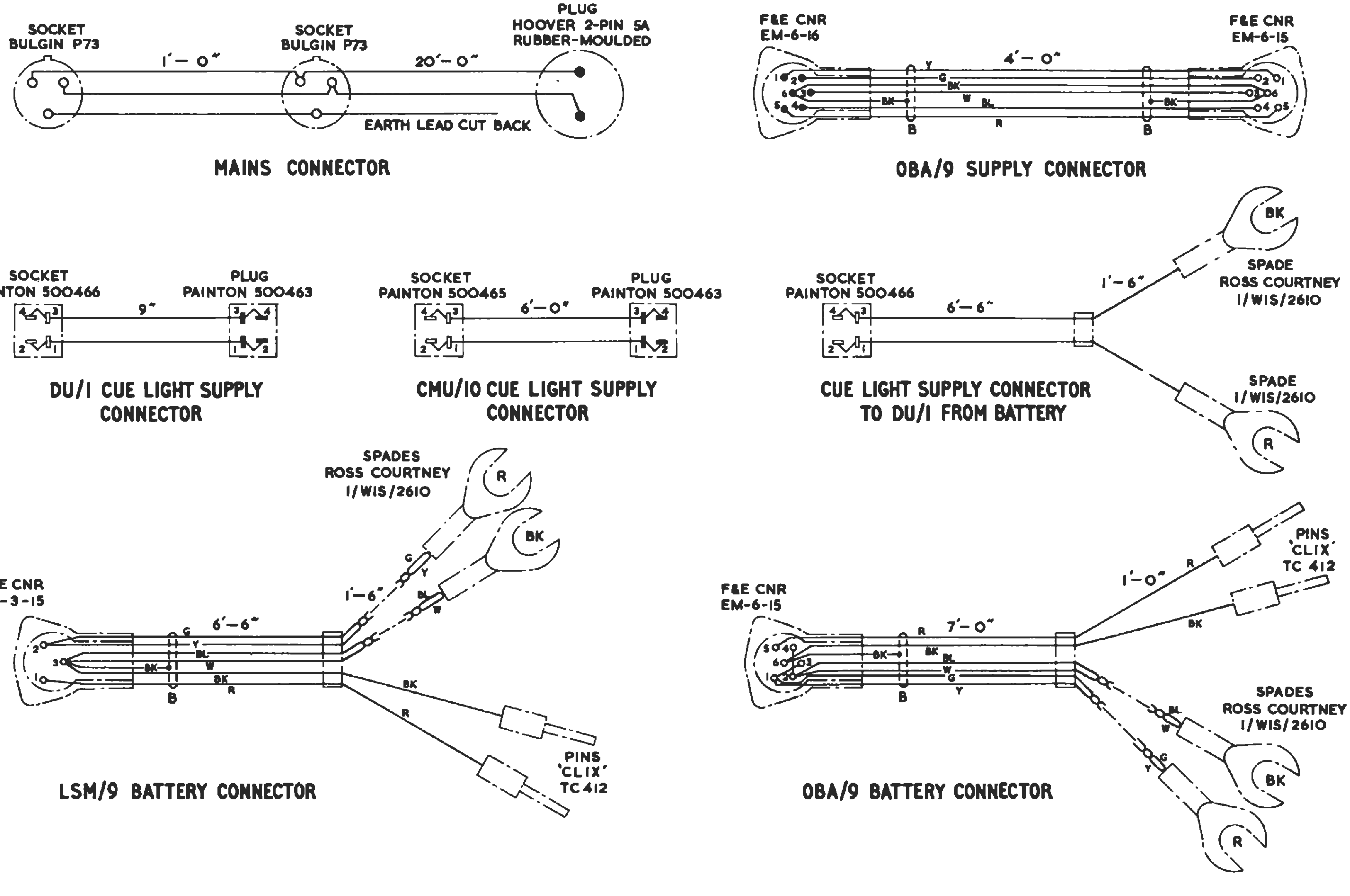
FIG 52



OBA/9 EQUIPMENT : INTERCONNECTION SCHEMATIC

54/GWH/102
DSKB1609

54/GWH/101/DJE
EH 8210



OBA/9 EQUIPMENT : CONNECTOR CABLES

FIG 53

INSTRUCTION S.3:

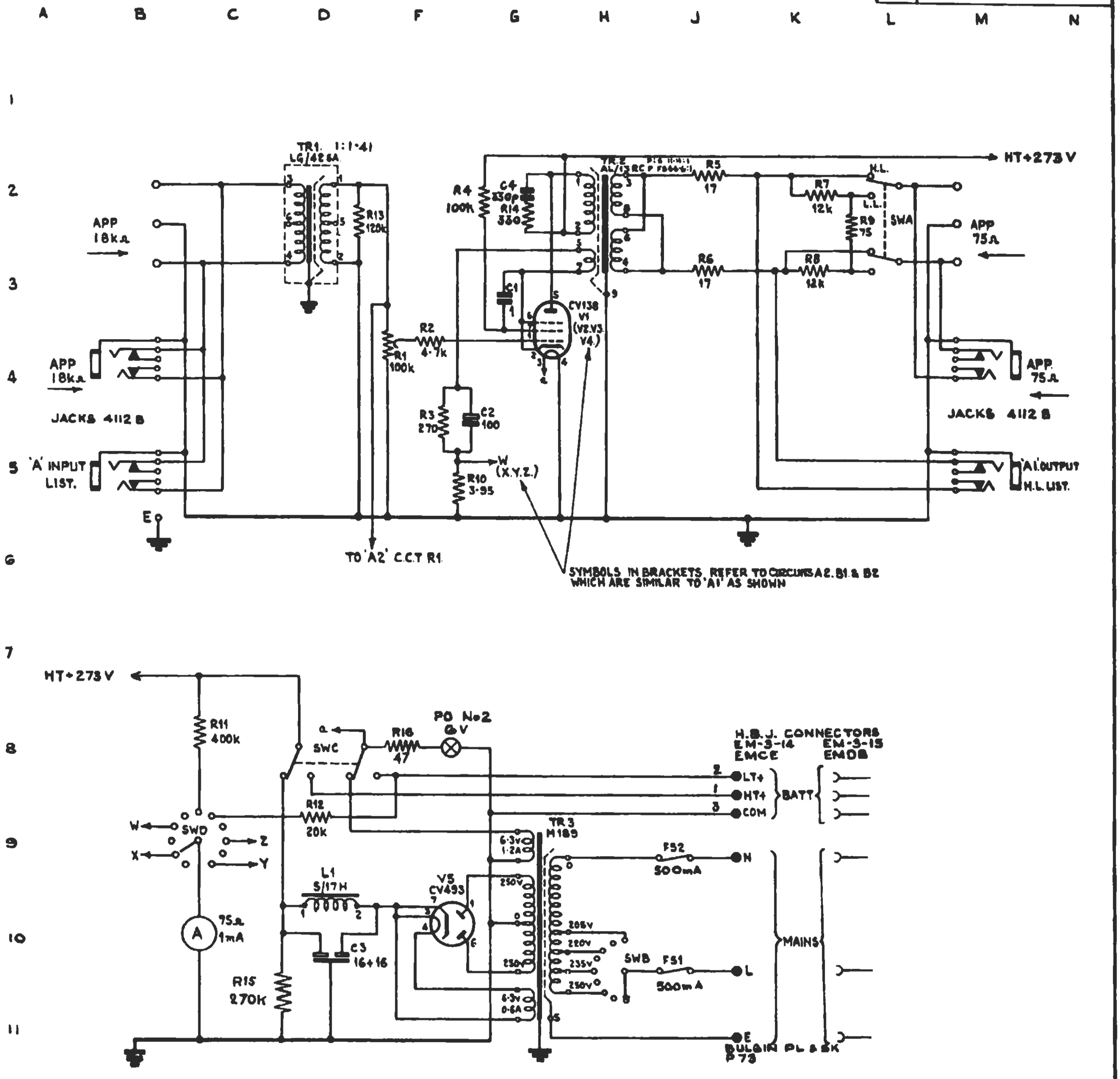
COMPONENT TABLE: FIG. 54

COMP.	LOC.	TYPE	TOLERANCE (PER CENT)
C1	F4	T.C.C. CP142T	
C2	G3	T.C.C. CE32A	
C3	D10	B.E.C. CE816/1	
C4	G2	T.C.C. CSM20N	±5
L1	D10	S/17H	
R1	D4	Morganite HNAR 10410 26000	
R2	F4	Erie 9	±10
R3	F4	Erie 9	±10
R4	G2	Erie 9	±10
R5	J2	Painton 72	±2
R6	J3	Painton 72	±2
R7	K2	Painton 72	±2
R8	K3	Painton 72	±2
R9	K2	Painton 72	±2
R10	F5	Painton P406	±1
R11	C8	Painton 73	±2
R12	D9	Erie 108	±2
R13	D2	Erie 9	±10
R14	G2	Erie 16	±10
R15	C11	Erie 8	±10
R16	F8	Painton MV1	±5
TR 1	D2	LG/42SA	
TR 2	H2	AL/13RC	
TR 3	G10	M.189	

55/GH/105/DFE
EC 8617

FIG 54 S3

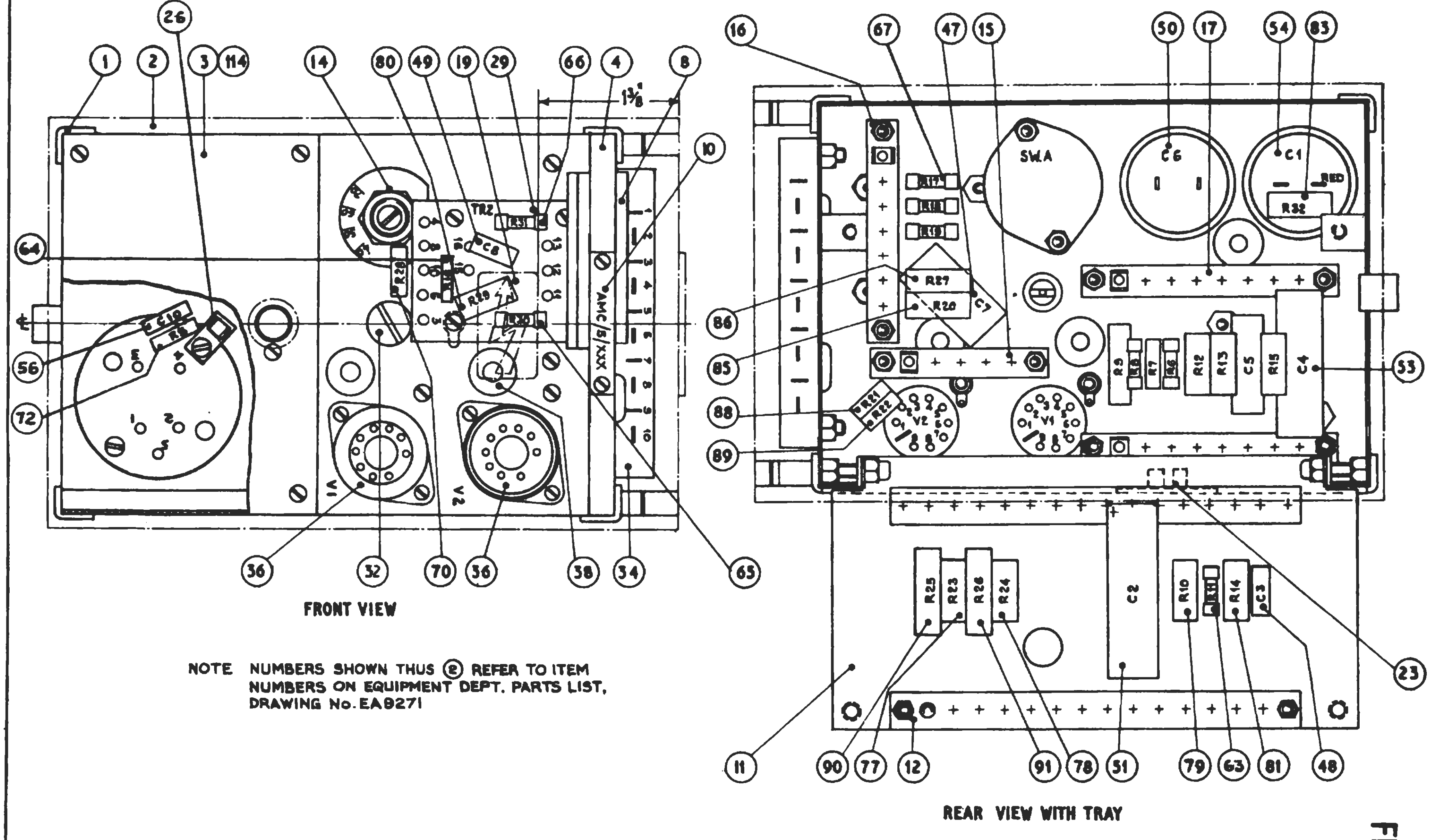
ISS	CHANGE
2	TR1 RATIO WAS 1·41:1 TR2 INPUT REVERSED C4, R14, R15, ADDED



NOTE:- AMPLIFIER TV 25 HAS TWO SEPARATE INPUTS, 'A' & 'B', EACH WITH TWO OUTPUTS '1' & '2'.

TRAP-VALVE AMPLIFIER TV/25: CIRCUIT

S7/GH/101
EC 9272



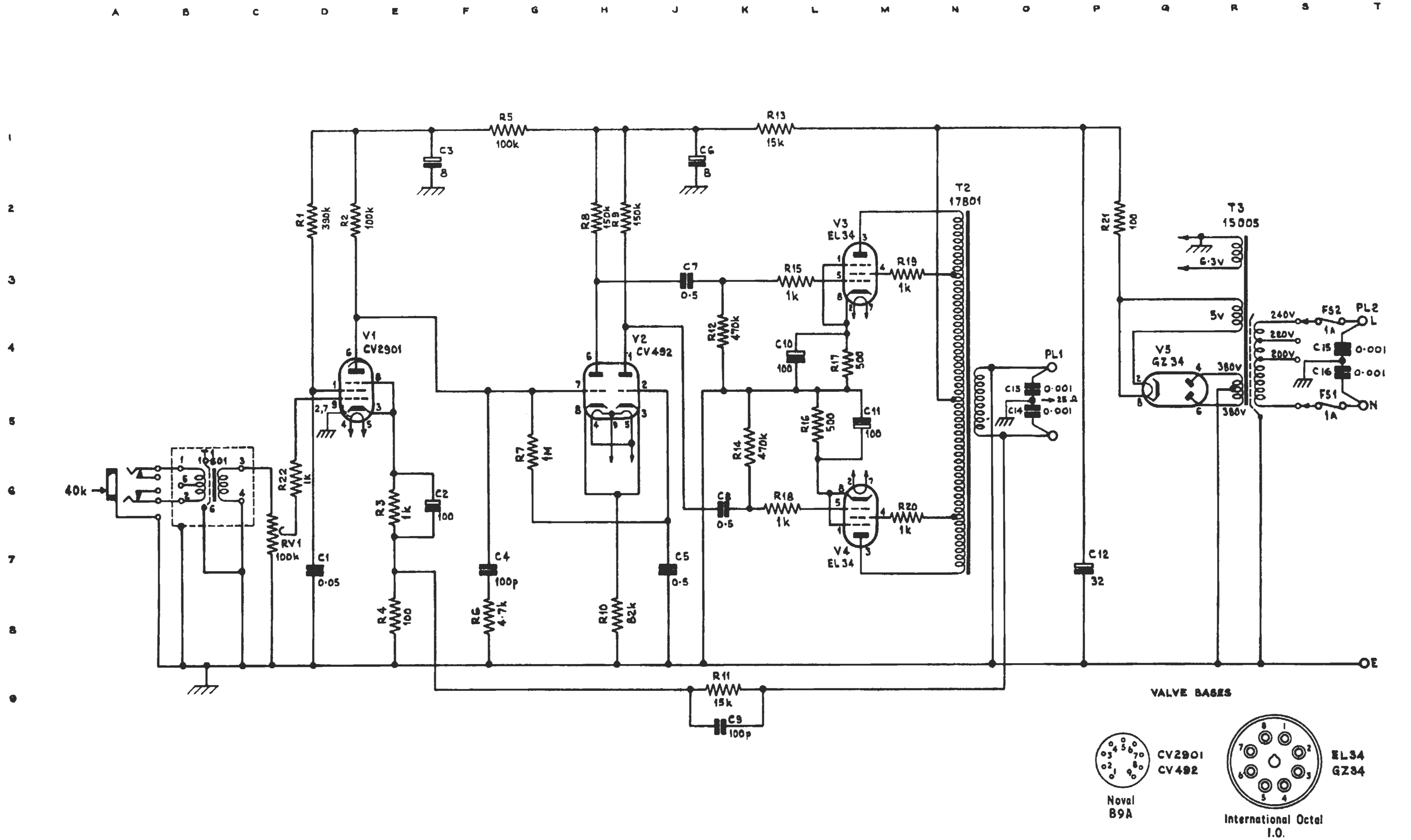
NOTE NUMBERS SHOWN THUS ② REFER TO ITEM NUMBERS ON EQUIPMENT DEPT. PARTS LIST, DRAWING No. EA9271

AMPLIFIER AMC/5: COMPONENT LAYOUT

FIG 55

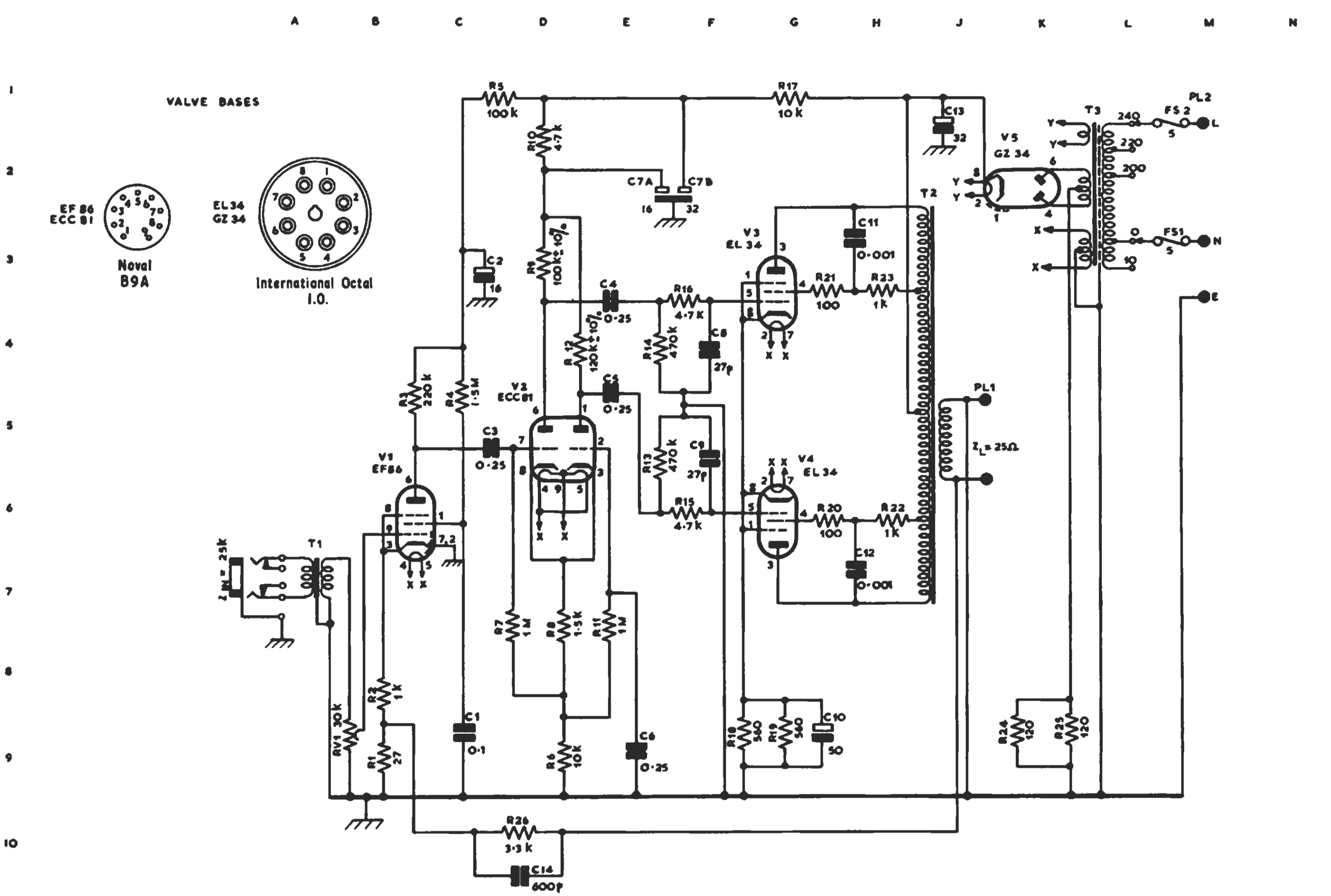
60/WG/104/DJE
EC10090

FIG. 56
ISSUE 2



LOUDSPEAKER AMPLIFIER AM8/1 : SERIAL Nos. 101–150 : CIRCUIT DIAGRAM

60/WG/127/AP
EB10662



LOUDSPEAKER AMPLIFIER AM8/1: SERIAL Nos. 157-186: CIRCUIT DIAGRAM

FIG. 56A

60/WG/128/AP
EA 10790

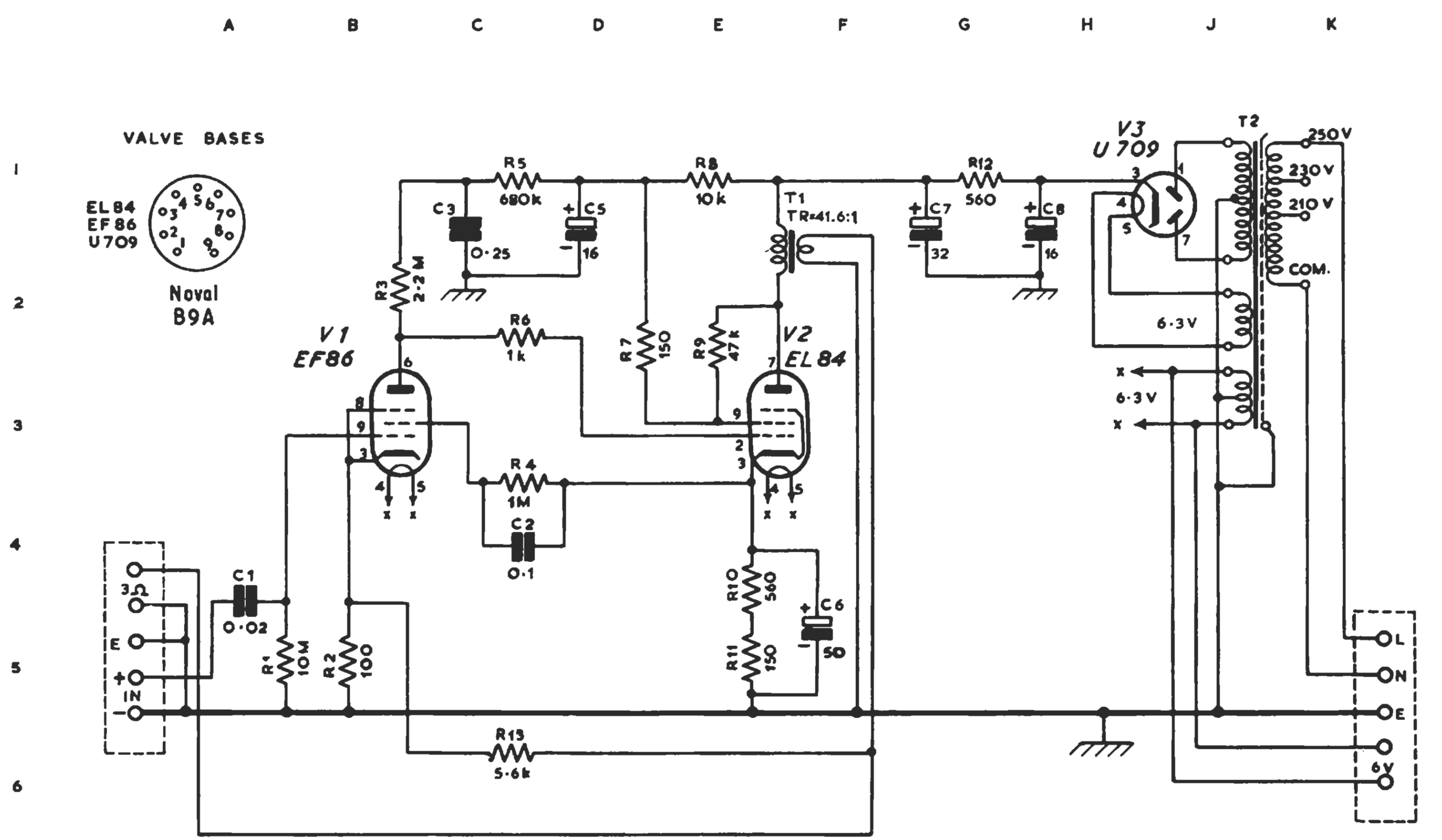


FIG 57

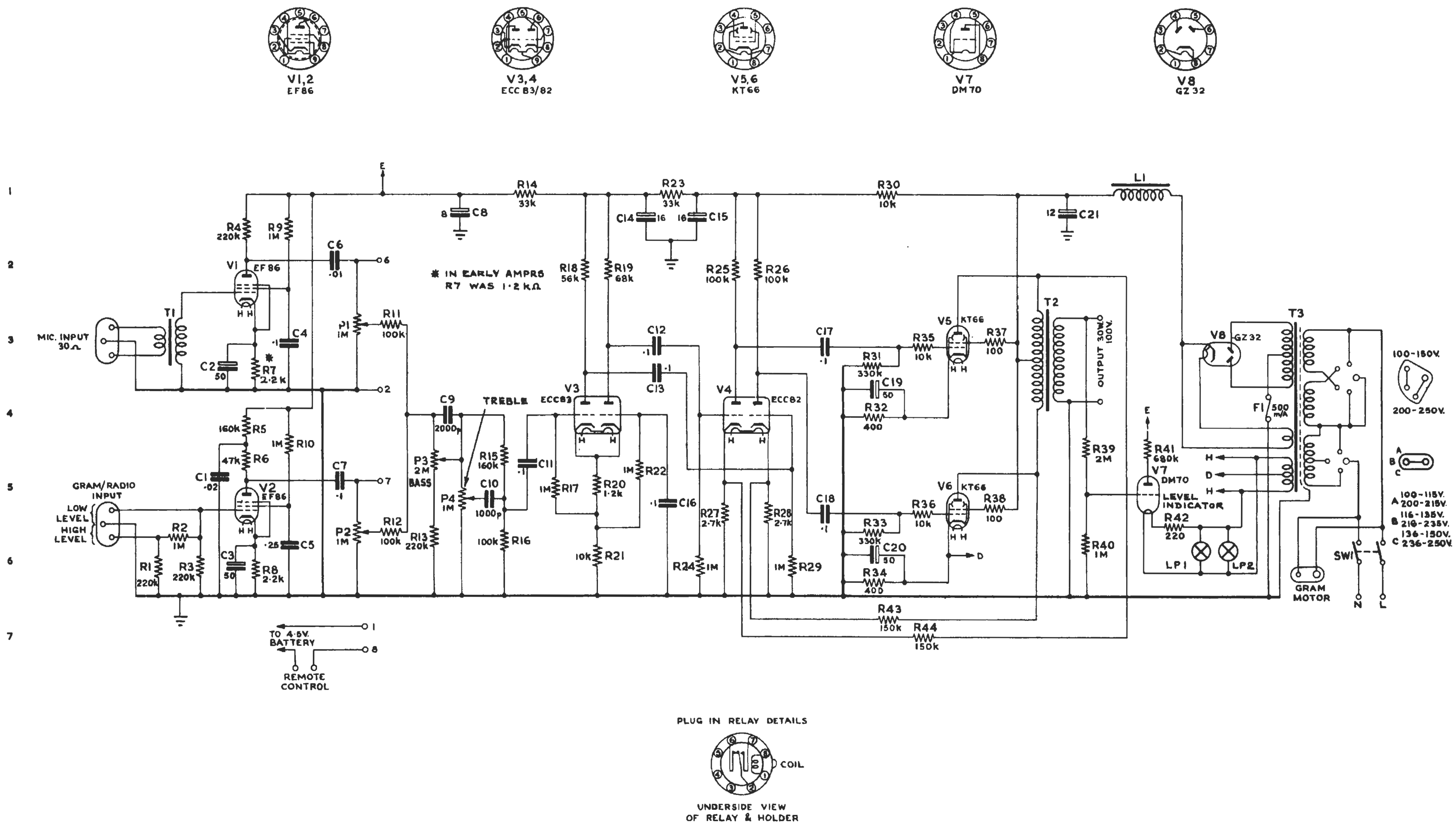
LOUDSPEAKER AMPLIFIER AM8/2: CIRCUIT DIAGRAM

COMPONENT TABLE: FIG. 60

Comp.	Loc.	Type	Tolerance per cent	Comp.	Loc.	Type	Tolerance per cent
C1	B5	350V tubular		R6	B5	¼W	10
C2	B3	25V tubular electrolytic		R7	B3	¼W	10
C3	B6	25V tubular electrolytic		R8	B6	¼W	10
C4	C3	350V tubular		R9	C1	¼W	20
C5	C6	350V tubular		R10	C4	¼W	20
C6	C2	350V tubular		R11	D3	¼W	20
C7	C5	350V tubular		R12	D6	¼W	20
C8	E1	450V electrolytic		R13	E6	¼W	20
C9	E4	Moldseal	20	R14	F1	¼W	20
C10	E5	Moldseal	20	R15	F5	¼W	20
C11	F5	350V tubular		R16	F6	¼W	20
C12	H3	350V tubular		R17	F5	¼W	20
C13	H3	350V tubular		R18	G2	¼W	5
C14	H1 }	450V electrolytic		R19	G2	¼W	5
C15	H1 }			R20	G5	¼W	10
C16	H5	350V tubular		R21	G6	¼W	10
C17	K3	500V tubular		R22	H5	¼W	20
C18	K5	500V tubular		R23	H1	¼W	20
C19 }	L4	50V electrolytic		R24	H6	¼W	20
C20 }	L6	50V electrolytic		R25	J2	¼W	5
C21	N1	400V paper		R26	J2	¼W	5
				R27	J5	¼W	5
				R28	J5	¼W	5
				R29	K6	¼W	20
LP1	P6	6·3V 0·3A M.E.S.		R30	L1	¼W	20
LP2	P6	6·3V 0·3A M.E.S.		R31	L3	¼W	5
				R32	L4	¼W	5
				R33	L5	¼W	5
P1	C3	Logarithmic		R34	L6	¼W	5
P2	C5	Logarithmic		R35	L3	¼W	20
P3	E5	Linear		R36	L5	¼W	20
P4	E5	Linear		R37	M3	¼W	20
				R38	M5	¼W	20
			20	R39	M4	¼W	20
R1	A6	¼W	20	R40	O6	¼W	20
R2	A6	¼W	20	R41	O4	¼W	5
R3	A6	¼W	10	R42	O6	1W	5
R4	B1	¼W	10	R43	L7	1W	5
R5	B4	¼W		R44	L7	1W	5

61/WG/211
PID 3038.3.2C

FIG 60



PAMPHONIC 30-WATT AMPLIFIER 601V: CIRCUIT DIAGRAM

COMPONENT TABLE: FIG. 61

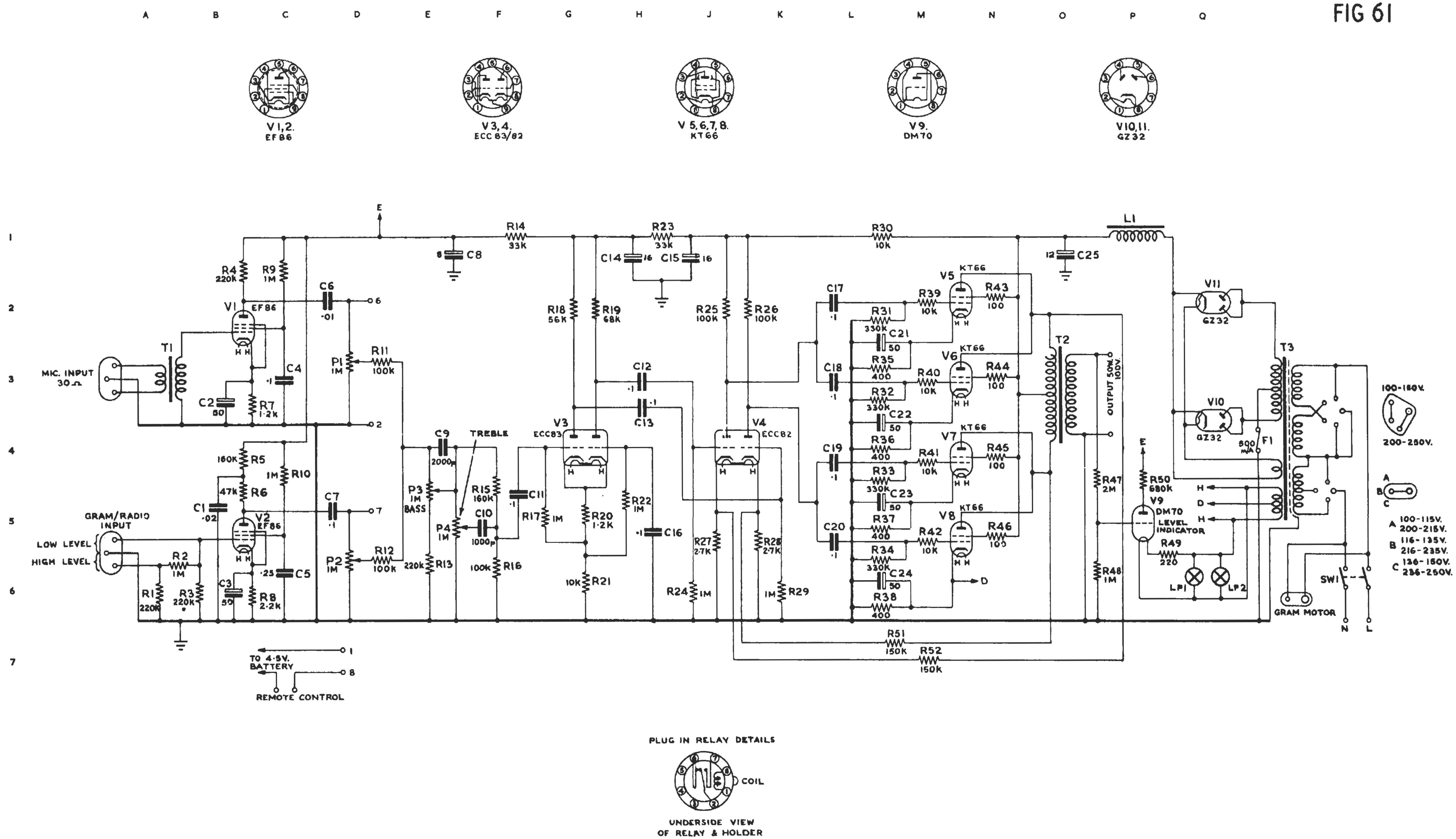
Comp.	Loc.	Type	Tolerance per cent
C1	B5	350V tubular	
C2	B3	25V tubular electrolytic	
C3	B6	25V tubular electrolytic	
C4	C3	350V tubular	
C5	C6	350V tubular	
C6	C2	350V tubular	
C7	C5	350V tubular	
C8	E1	450V electrolytic	
C9	E4	Moldseal	20
C10	E5	Moldseal	20
C11	F5	350V tubular	
C12	H3	350V tubular	
C13	H3	350V tubular	
C14	H1	450V electrolytic	
C15	H1		
C16	H5	350V tubular	
C17	L2	500V tubular	
C18	L3	500V tubular	
C19	L4	500V tubular	
C20	L5	500V tubular	
C21	L2	50V electrolytic	
C22	L3		
C23	L5	50V electrolytic	
C24	L6		
C25	O1	400V paper	
LP1	Q6	6·3V 0·3A M.E.S.	
LP2	Q6	6·3V 0·3A M.E.S.	
P1	C3	Logarithmic	
P2	C5	Logarithmic	
P3	E5	Linear	
P4	E5	Linear	
R1	A6	¼W	20
R2	A6	¼W	20
R3	A6	¼W	20
R4	B1	¼W	10
R5	B4	¼W	10
R6	B5	¼W	10
R7	B3	¼W	10
R8	B6	¼W	10

Comp.	Loc.	Type	Tolerance per cent
R9	C1	¼W	20
R10	C4	¼W	20
R11	D3	¼W	20
R12	D6	¼W	20
R13	E6	¼W	20
R14	F1	¼W	20
R15	F5	¼W	20
R16	F6	¼W	20
R17	F5	¼W	20
R18	G2	¼W	5
R19	G2	¼W	5
R20	G5	¼W	10
R21	G6	¼W	10
R22	H5	¼W	20
R23	H1	¼W	20
R24	J6	¼W	20
R25	J2	¼W	5
R26	J2	¼W	5
R27	J5	¼W	5
R28	K5	¼W	5
R29	K6	¼W	20
R30	L1	¼W	20
R31	L2	¼W	5
R32	L3	¼W	5
R33	L4	¼W	5
R34	L5	¼W	5
R35	L3	4W wire-wound	5
R36	L4	4W wire-wound	5
R37	L5	4W wire-wound	5
R38	L6	4W wire-wound	5
R39	M2	¼W	20
R40	M3	¼W	20
R41	M4	¼W	20
R42	M5	¼W	20
R43	N2	½W	20
R44	N3	½W	20
R45	N4	½W	20
R46	N5	½W	20
R47	O4	½W	20
R48	O6	½W	20
R49	P6	1W	5
R50	P5	½W	5
R51	M7	1W	5
R52	M7	1W	5

WG/212
3038.3.3C

PAM

FIG 61



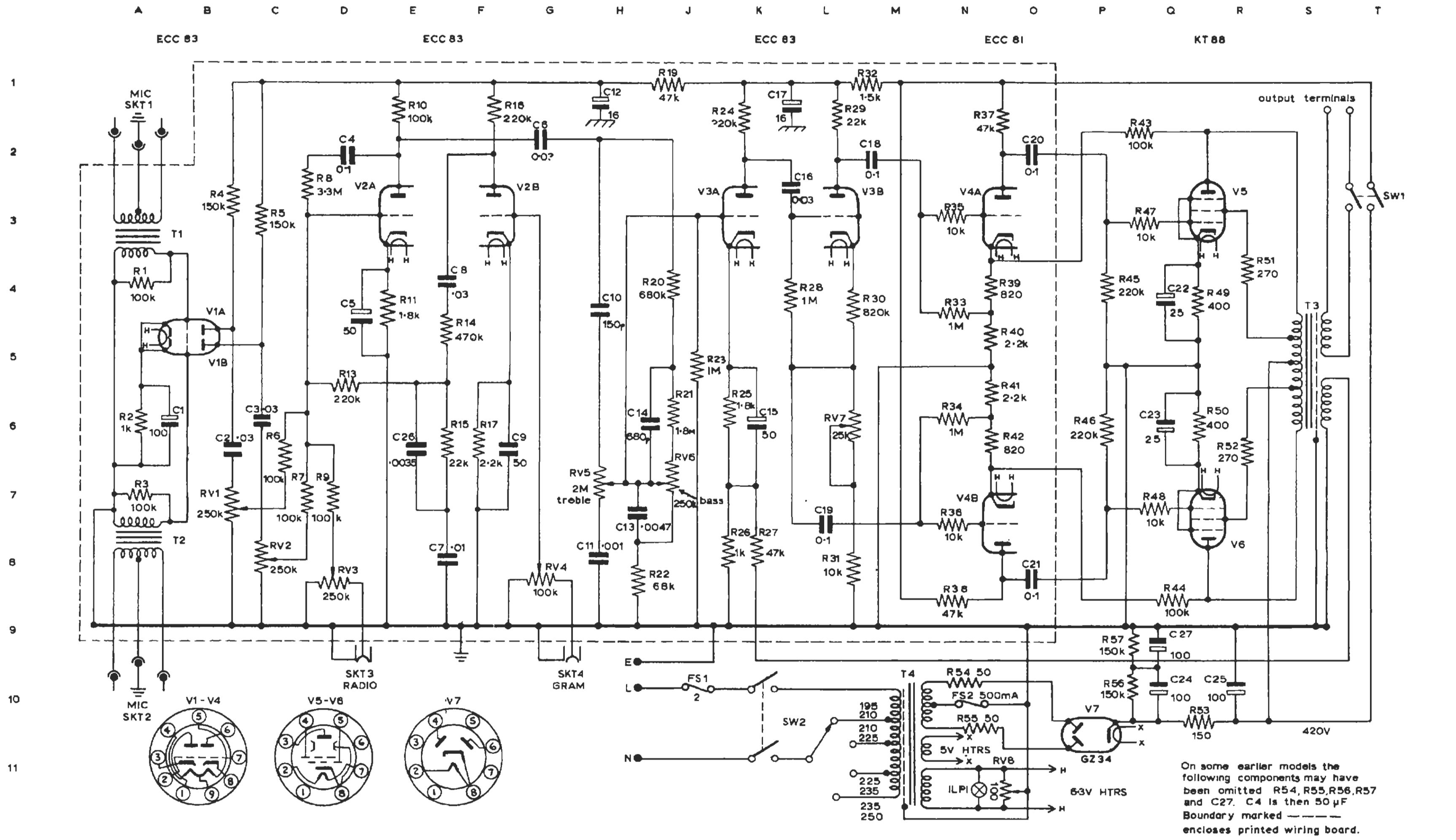
PAMPHONIC 50-WATT AMPLIFIER 602V: CIRCUIT DIAGRAM

COMPONENT TABLE: FIG. 70

Comp.	Loc.	Type	Tolerance per cent	Comp.	Loc.	Type	Tolerance per cent
C1	B6	6V electrolytic		R20	J4	¼W	10
C2	B6	500V ceramic		R21	J6	¼W	10
C3	C6	500V ceramic		R22	H9	¼W	10
C4	D2	250V tubular paper		R23	J5	¼W	10
C5	D4	12V electrolytic		R24	K2	¼W	10
C6	G2	500V ceramic		R25	K6	¼W	10
C7	F8	150V electrolytic		R26	K8	¼W	10
C8	E4	500V ceramic		R27	K8	¼W	5
C9	F6	12V electrolytic		R28	K4	¼W	10
C10	H4	silver mica	10	R29	L1	¼W	10
C11	H8	silver mica	10	R30	L4	¼W	10
C12	H1	450V electrolytic		R31	L8	¼W	20
C13	H7	silver mica	10	R32	M1	¼W	10
C14	H6	silver mica	10	R33	N4	¼W	10
C15	K6	12V electrolytic		R34	N6	¼W	10
C16	K2	500V ceramic		R35	N3	¼W	20
C17	K1	450V electrolytic		R36	N7	¼W	20
C18	M2	450V tubular paper		R37	O2	½W	10
C19	L7	450V tubular paper		R38	N8	½W	10
C20	O2	450V tubular paper		R39	N4	¼W	10
C21	O8	450V tubular paper		R40	N5	¼W	10
C22	Q4	100V electrolytic		R41	N6	¼W	10
C23	Q6	100V electrolytic		R42	N6	¼W	10
C24 *	Q10	350V electrolytic		R43	P2	2·0W	5
C25	R10	450V electrolytic		R44	Q8	2·0W	5
C26	E6	silver mica	10	R45	P4	¼W	10
C27	Q9	350V electrolytic		R46	P6	¼W	10
				R47	Q3	¼W	20
				R48	Q7	¼W	20
R1	A3	¼W	10	R49	Q4	5·0W	5
R2	A6	¼W	10	R50	Q6	5·0W	5
R3	A7	¼W	10	R51	R3	¼W	20
R4	B3	⅛W high stability	10	R52	R6	¼W	20
R5	C3	⅛W high stability	10	R53	Q10	10W	5
R6	C6	¼W	10	R54	N10	3W	5
R7	C7	¼W	10	R55	N10	3W	5
R8	C2	¼W	10	R56	P10	½W	20
R9	D7	¼W	10	R57	P9	½W	20
R10	E1	¼W	10				
R11	E4	¼W	10				
R12		no resistor fitted		RV1	B7	logarithmic	
R13	D5	¼W	10	RV2	C8	logarithmic	
R14	F4	¼W	10	RV3	D8		
R15	F6	¼W	10	RV4	G8	logarithmic	
R16	F1	¼W	10	RV5	H7	logarithmic	
R17	F6	¼W	10	RV6	J7	logarithmic	
R18		no resistor fitted		RV7	L6	wire wound	
R19	J1	¼W	10	RV8	O11	wire wound	

*C24 is 450V electrolytic in early versions

65/CW/101
PID3038·3 7C
ISS2



PAMPHONIC 30-WATT AMPLIFIER 661 W : CIRCUIT

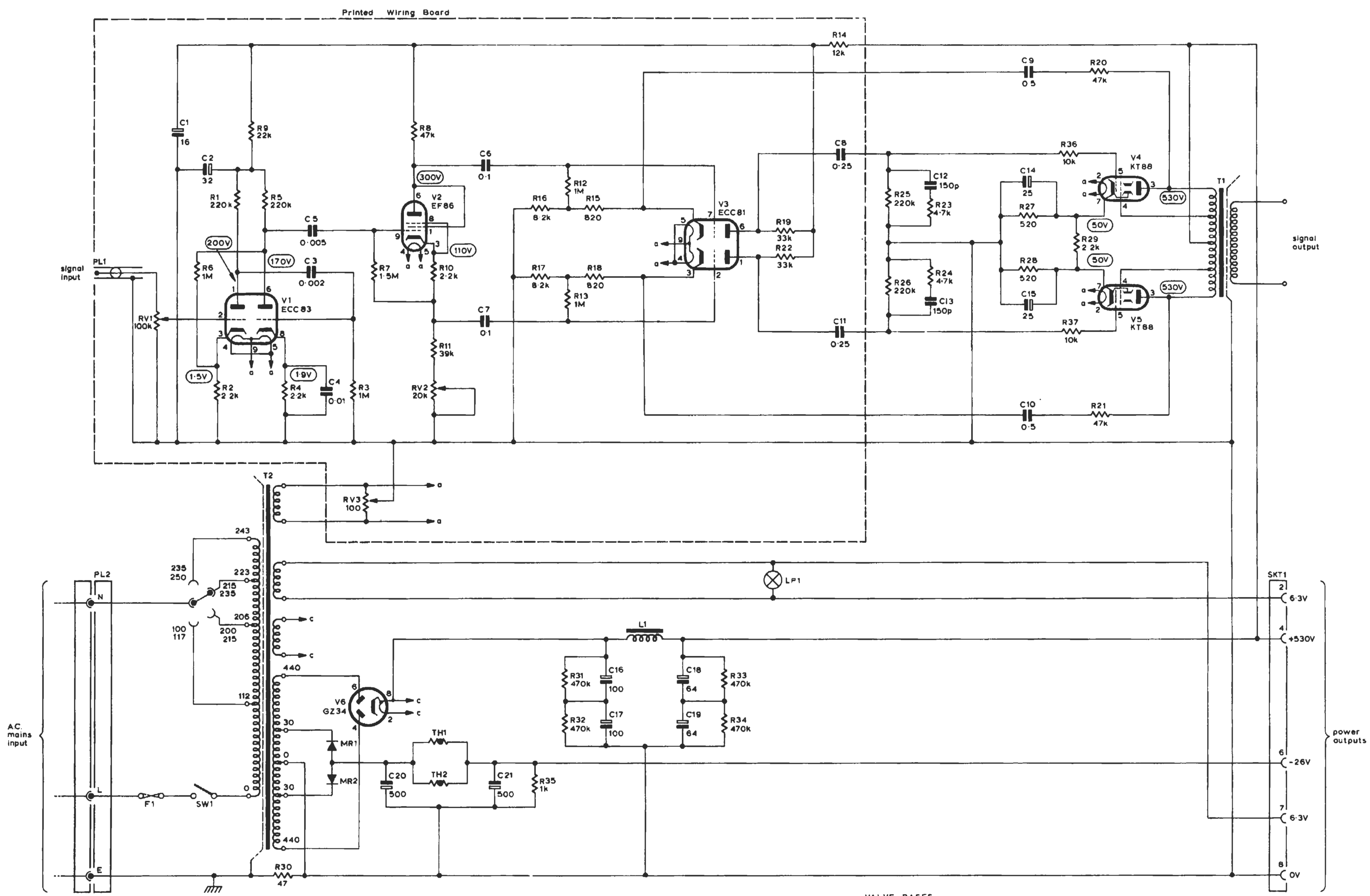
FIG. 70

SECTION 25

66/DEH/02/VH
PID 3038.3.6C
ISSUE 2

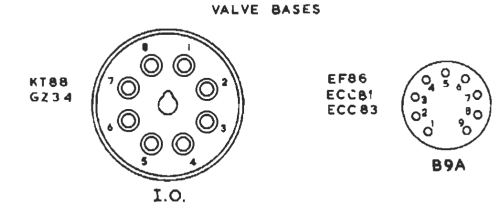
PAMPHONIC

FIG. 71



PAMPHONIC 50-WATT AMPLIFIER 602W : CIRCUIT

VALVE BASES



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