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.

(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).

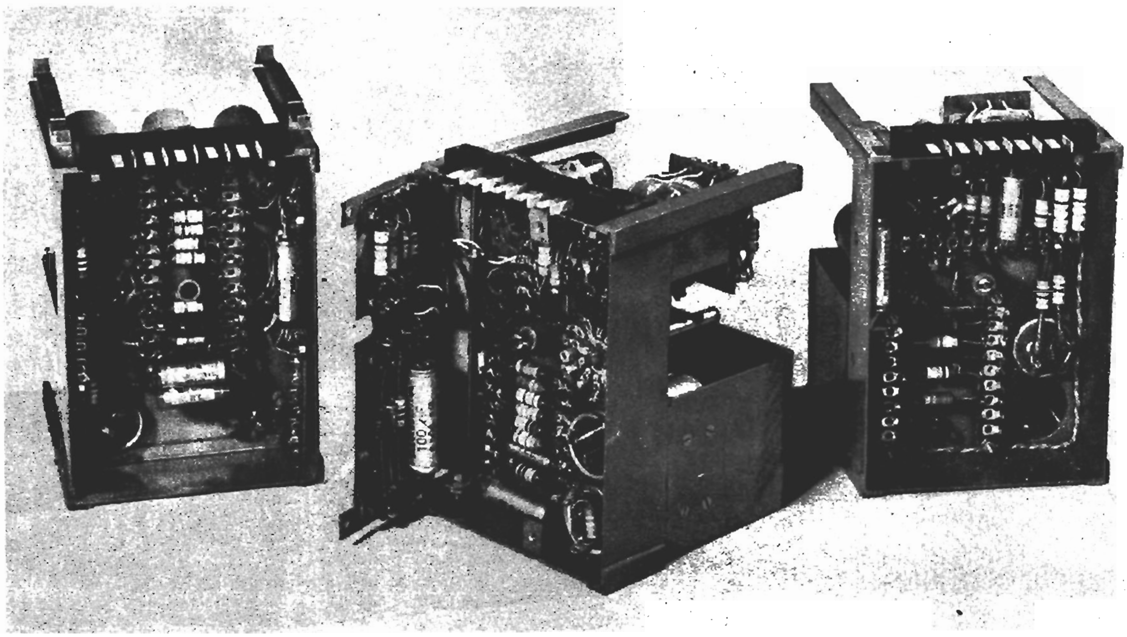


Fig. 21.1. Amplifiers MNA/3, GPA/4A and C/9

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

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.

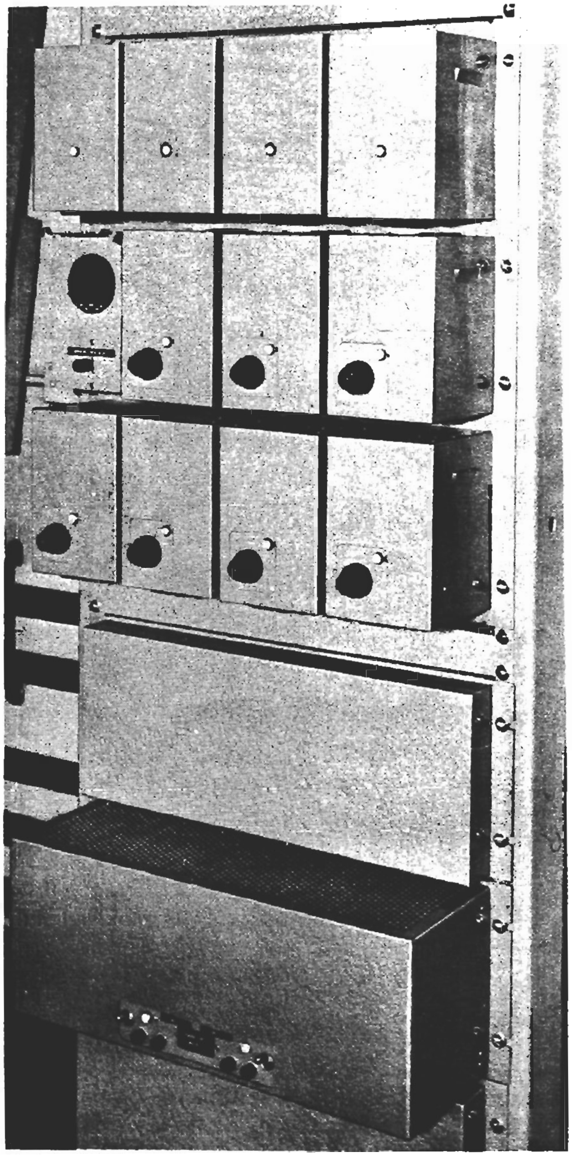


Fig. 21.2 Part of a 19-in. Amplifier Bay

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

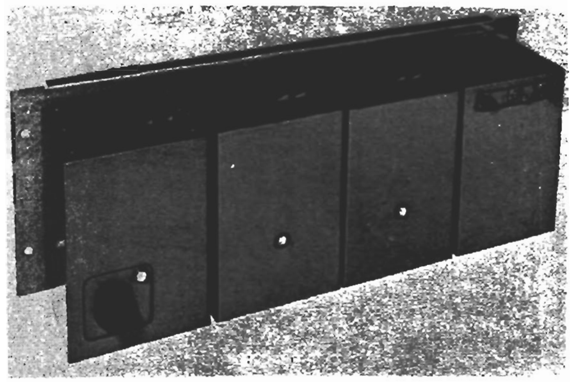


Fig. 21.3. Amplifier-mounting and Supply Panel AMS/1: General View

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.

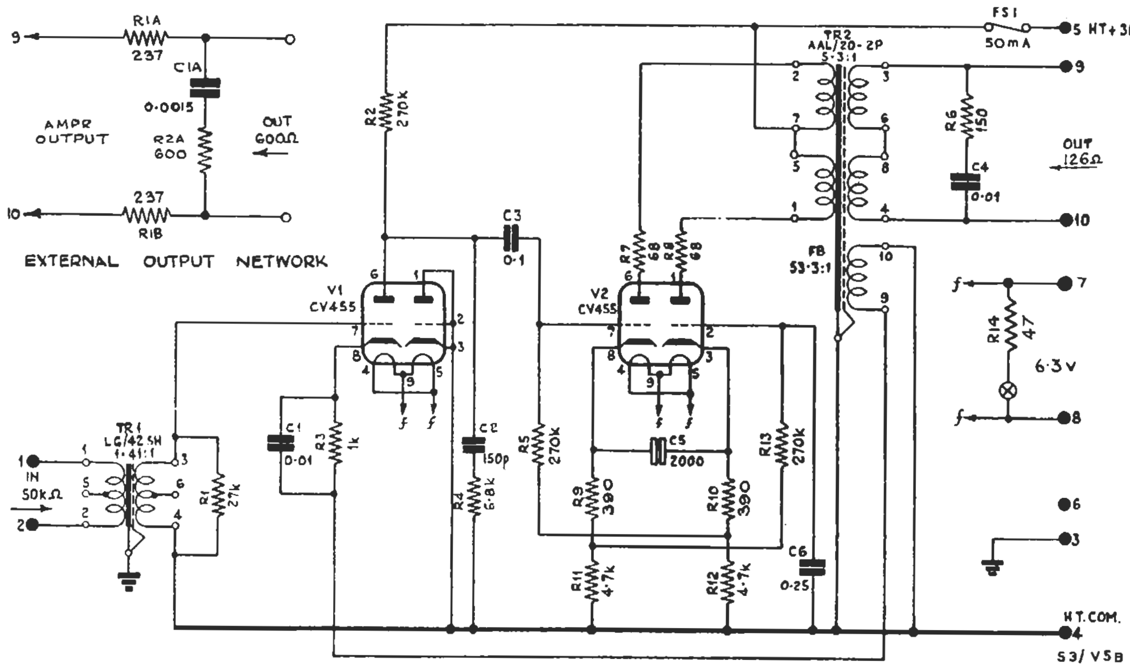


Fig. 21.4 Amplifier C/9: Circuit
Drawing No. EA 8550

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.

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-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 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.

Operation of Ring-main Circuit

A ring-main circuit can be operated from a C/9 amplifier using a transformer Type LL/59R (impedance ratio 31·5 : 1) instead of the external output network shown in Fig. 21.4. By this means a low-impedance feed of programme at approximately zero level is obtained.

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 ±0·2 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.

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.

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.

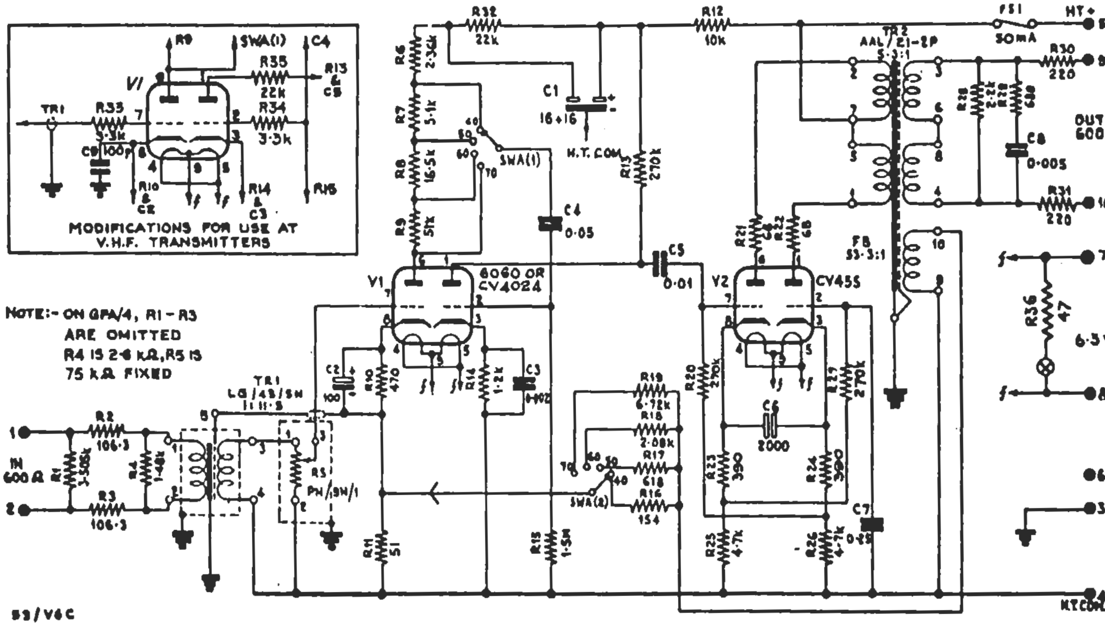


Fig. 21.5. Amplifiers GPA/4 and 4A: Circuit
Drawing No. EA 8566

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 subheading. 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 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.

Ring-main Circuit Operation

When programme has to be fed from a main building to ring-main circuits in a subsidiary building, the use of a separate C/9 amplifier can be avoided by modifying the output circuit of the GPA/4A line amplifier. For this purpose the building-out resistors R30 and R31 on the secondary of the GPA/4A output transformer (Fig. 21.5) are strapped out and the ring-main circuit is fed direct through a transformer Type LL/59R. Amplifiers with R30 and R31 short-circuited are marked on the chassis below the lamp with a letter *A*.

Modification at V.H.F. and Short-wave Stations

Existing amplifiers in use at v.h.f. transmitters have the circuit of V1 modified as shown by the sketch inset in Fig. 21.5, and are marked with a transfer letter *C*. New amplifers at v.h.f. and short-wave stations have a 0.001-μF capacitor in place of the value shown for C9 and are marked with a transfer letter *B*.

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 noiso 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

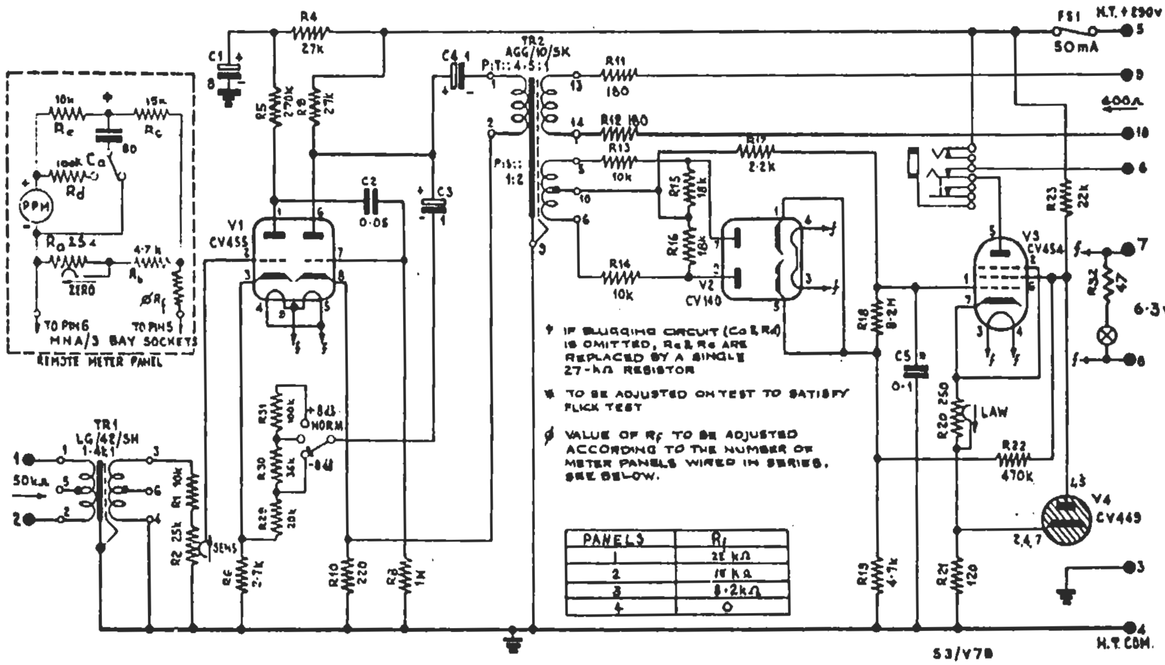


Fig. 21.6. Amplifier MNA/3: Circuit
Drawing No. EA 8581

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-kΩ 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 $Z = 300\ \Omega$
Input $Z = 50\ k\Omega$ nominal (balanced)
Audio output $Z = 600 \pm 40\ \Omega$ (balanced)
Normal load $Z = 2\ k\Omega$ 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).

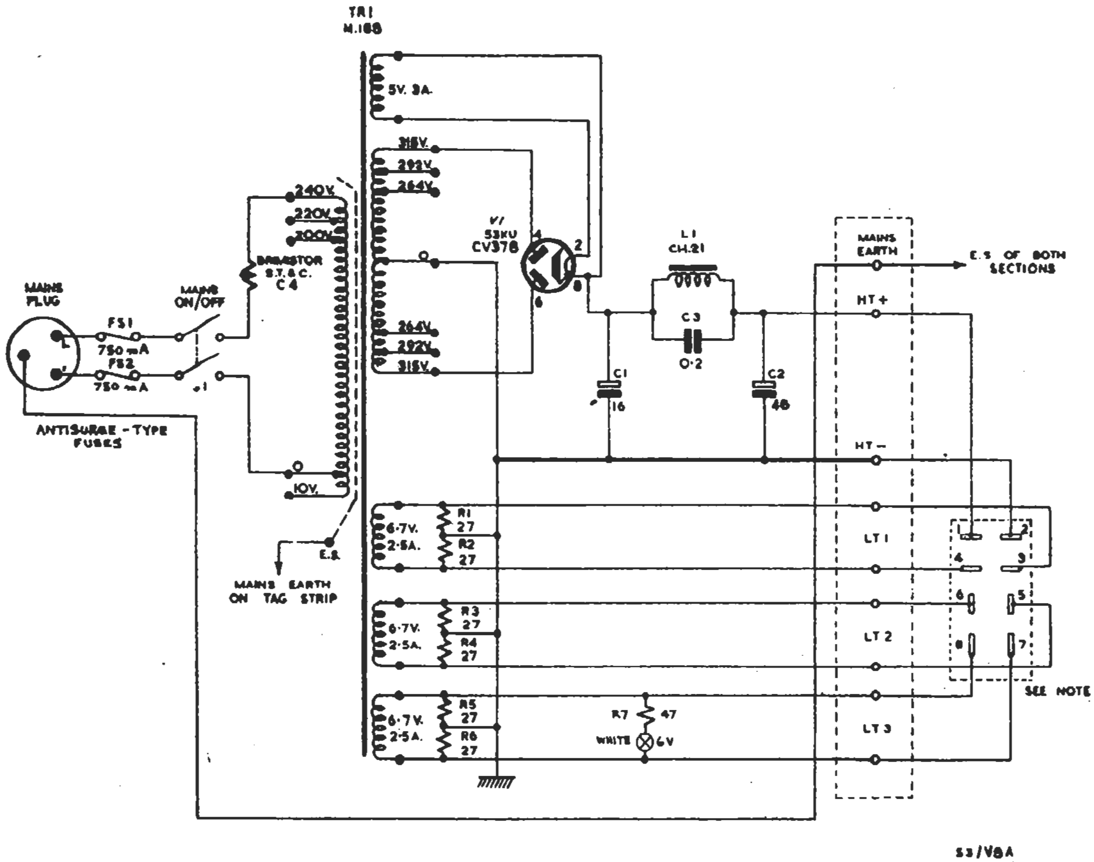
Amplifier-mounting and Supply Panel AMS/1: Mains Unit (Fig.21.8)

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

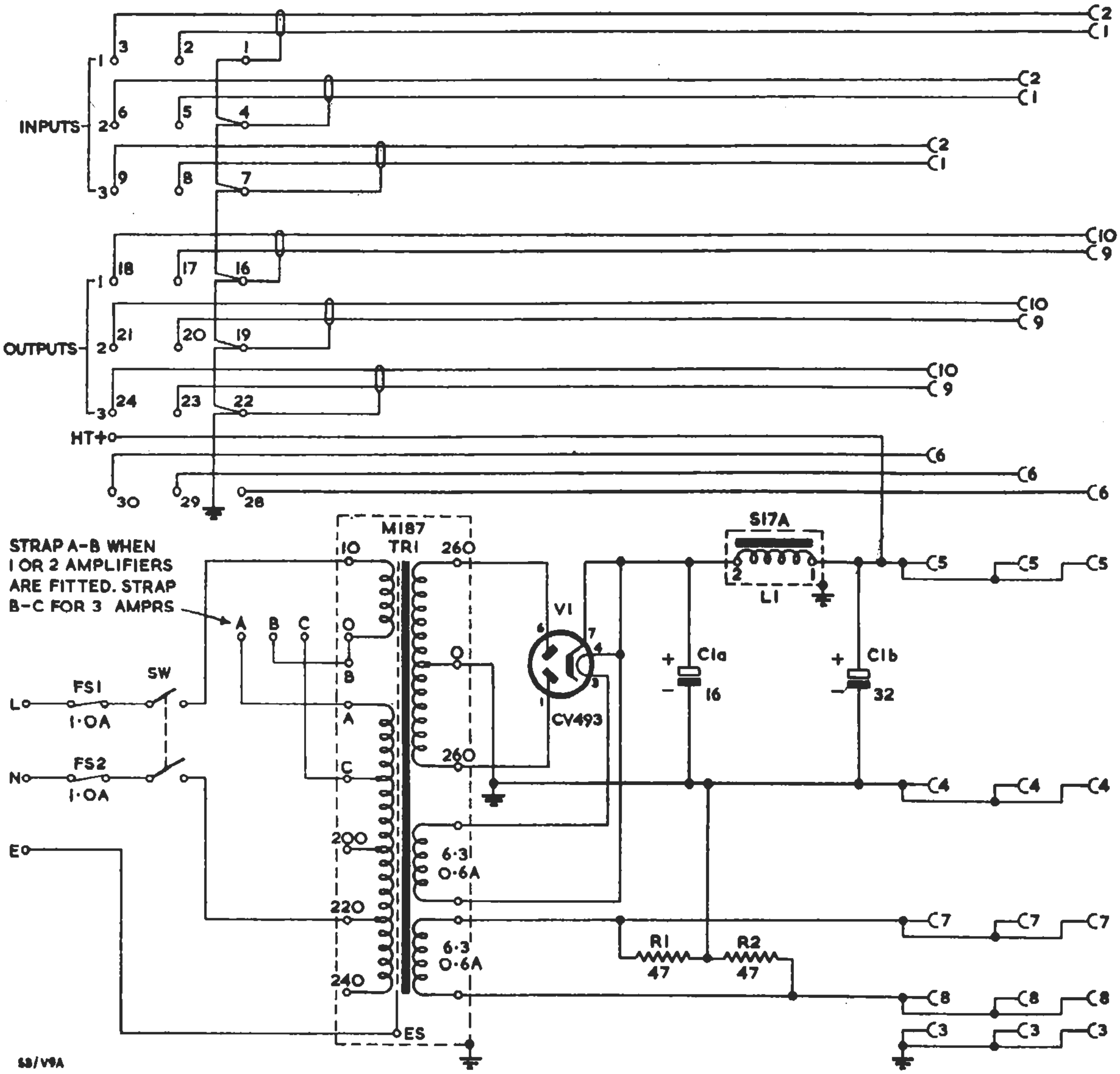


Fig. 21.8 **Amplifier-mounting and Supply Panel AMS/1: Circuit**
Drawing No. EA 8632

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).