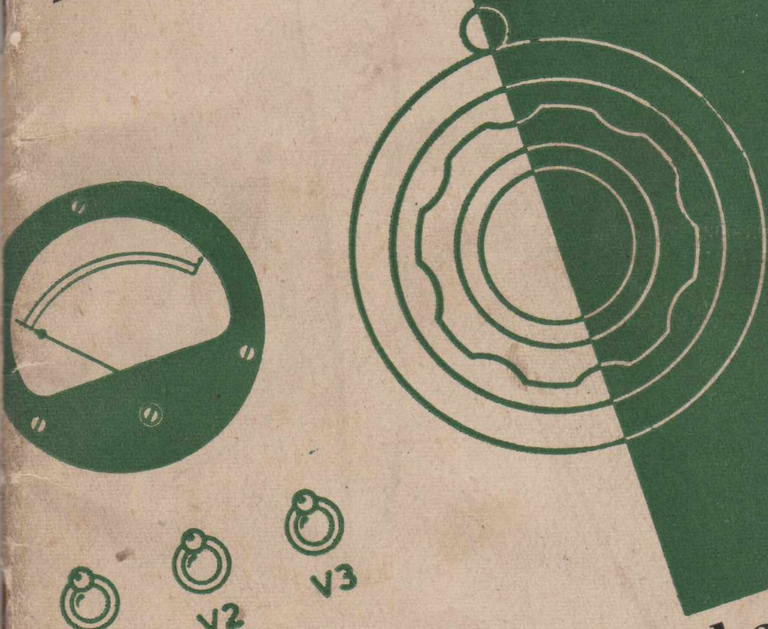
Wireless Amplifier Manual Number 2

3/-



edited by Bernard B. Babani

BERNARDS RADIO MANUALS ★ No. 90

WIRELESS AMPLIFIER
MANUAL No.2

L Hall

WIRELESS AMPLIFIER

MANUAL No. 2

edited by

BERNARD B. BABANI

LONDON

BERNARDS (Publishers) LTD.

FIRST PUBLISHED 1950

Printed for Bernards (Publishers) Ltd., The Grampians, Western Gate, London, W.6, by Lake, Sison & Brown, Ltd., 132-3, Upper Thames Street, London, E.C.4.

CONTENTS

The most important factors in the design of an amplifier for high quality sound reproduction are:—

(1) **Negligible non-linear distortion up to the maximum rated output.** (The term " non-linear distortion " includes the production of undesired harmonic frequencies and the inter - modulation of component frequencies of the sound wave.) This requires that the dynamic input/output characteristic should be linear for all audible frequencies and up to the maximum amplifier output.

(2) **Linear frequency-response at maximum output within the frequency range of at least 10-20,000 c/s.** This requirement is less stringent at the high-frequency end of the spectrum, but should the maximum power output at either end of the spectrum (but especially at the low-frequency end) be substantially less than that at medium frequencies, filters must be arranged to reduce the level of these frequencies before they reach the amplifier, otherwise severe inter-modulation will occur. This is especially noticeable during the reproduction of an organ on incorrectly designed equipment, where pedal notes of the order of 16-20 c/s may cause bad distortion, even though they may be inaudible in the output.

(3) **Negligible phase-shift within the audible range.** Although the phase relationship between the component frequencies of a complex steady-state sound does not appear to affect the audible quality of the sound, the same is not true of sounds of a transient nature, the quality of which may be profoundly altered by disturbance of the phase relationship between component frequencies.

(4) **Good transient response.** In addition to low phase-distortion, other factors which are essential for good transient response are: elimination of transient changes in the gain of the amplifier due to current or voltage cut-off in any stages; careful design of iron-cored components and the reduction of such items to a minimum.

(5) **Low output resistance.** This requirement is concerned with the attainment of good frequency and transient

response from the loud-speaker system by ensuring that it has adequate electrical damping.

The cone movement of a moving-coil loudspeaker is restricted by air loading, suspension stiffness and resistance, and electro-magnetic damping. In the case of a baffle-loaded loudspeaker, the efficiency is rarely higher than 5-10 per cent, and, therefore, the air loading, which determines the radiation, is not high. In order to avoid a high bass resonance frequency, the suspension stiffness in a high grade loudspeaker is kept low, and obviously the power loss in such a suspension cannot be large. Electro-magnetic damping is, therefore, important in controlling the motion of the cone. This effect is proportional to the current which can be generated in the coil circuit, and is, therefore, proportional to the total resistance of the circuit. Maximum damping will be achieved when the coil is effectively short-circuited, hence the output resistance of the amplifier should be much lower than the coil impedance.

(6) **Adequate power reserve.** The realistic reproduction of orchestral music in an average room requires peak power capabilities of the order of 15-20 watts when a baffle-loaded moving-coil loudspeaker of normal efficiency is used. The use of horn-loaded loudspeakers may reduce the power requirement to the region of 10 watts, but in each case it is essential that the amplifier should be able to supply the peak power without change in any of its characteristics.

ELEMENTS OF DESIGN OF AN OUTPUT STAGE

Before discussing details of design it should be pointed out that all the factors mentioned here must be considered jointly, and it may be found that one of them will be overriding in the choice to be made.

Single-Sided or Push-Pull

The simplest type of output circuit is one using a single valve and provided that only a small amount of power is required a pentode or tetrode, such as an Osram KT61 or

KT66, can be satisfactory. Push-pull circuits, however, are better from a quality point of view because of the possibility of reducing second harmonic distortion, apart from the greater power from given valves. It must be remembered, however, that the push-pull circuit has the same overall sensitivity as the single-sided circuit and, therefore, double output will necessitate the total grid input being doubled. The load impedance will vary with conditions of use, whether "Class A," "B" or "AB," and excepting "Class A" (where the grid bias is the same as for a single valve and the anode-to-anode load doubled) good regulation of the anode supply is essential.

Tetrodes and Pentodes

When equipment has to be operated from low-voltage anode supplies, a pentode or tetrode stage with negative feedback is the only choice, but where power supplies are not restricted triodes are preferable because their lower impedance is conducive to high fidelity.

Pentodes or "beam" output tetrodes used with negative feedback can, with care, be made to give a performance midway between that of triodes with and without feedback. The advantages to be gained from the use of tetrodes are increased power efficiency and lower drive voltage requirements.

Where negative feedback is used with tetrodes it must be emphasised that the characteristics of the stage are dependent solely on the character and amount of feedback used. The feedback must remain effective under all operating conditions for all frequencies within the audio-frequency spectrum if the quality is not to degenerate to the level usually associated with tetrodes without feedback. Great care must be taken with the design and operation of the amplifier to achieve this, and troubles such as parasitic oscillation and instability are liable to be encountered.

Triodes

Triode valves in push-pull circuits and without negative feedback are widely used in high fidelity amplifiers, but a stage of this type has a number of disadvantages. At maximum output it will have a minimum of 2-3% harmonic distortion and the input/output characteristic will be a gradual curve. With this type of characteristic, distortion will be introduced at all signal levels and inter-modulation with such a characteristic is very considerable and is responsible for the harshness and "mushiness" which characterises amplifiers of this type. In addition, further non-linearity and considerable inter-modulation will be introduced by the output transformer core.

If the load impedance is chosen to give maximum output the ratio of the load impedance/output resistance of the amplifier will be about 2, which is insufficient for good loudspeaker damping. Furthermore, it is extremely difficult to produce an adequate frequency-response characteristic in a multi-stage amplifier of this type as the effect of multiple valve capacitances and the output transformer primary and leakage inductances becomes serious at the ends of the audio-frequency spectrum.

The application of negative feedback to push-pull triodes results in the more or less complete solution of the disadvantages outlined above. Feedback should be applied over the whole amplifier, from the secondary winding of the output transformer to the input of the first stage, as this method improves the characteristics of the output transformer and makes no additional demands upon the output capabilities of any stage of the amplifier.

From the above it will be seen that the design of an amplifier for sound reproduction of the highest possible fidelity should centre around a push-pull triode output stage incorporating negative feedback.

CHOICE OF OUTPUT VALVES

Since the term "high fidelity" is only relative, some notes are given on valves other than triodes, but it is only with amplifiers using the latter that the highest quality can be obtained.

Details for three very popular medium power types are given below in Table 1, and the complete characteristics of the other types can be had on application to the G.E.C.,Ltd., Magnet House, Kingsway, London, W.C.

TABLE I.	OSRAM PX4.	OSRAM PX25.	OSRAM KT66.	
			As Triode.	As Tetrode.
Type of Cathode	Directly heated	Directly heated	Indirectly heated	Indirectly heated
Filament or heater voltage ...	4.0	4.0	6.3	6.3
Filament or heater current ...	1.0 amp.	2.0 amps.	1.27 amps.	1.27 amps.
Anode voltage (max.)	300	500	400	500
Anode dissipation (max.) ...	15 watts	30 watts	25 watts	25 watts
Screen voltage (max.)	—	—	—	300
Screen dissipation (max.) ...	—	—	—	3.5 watts
Anode current at max. Va ...	45 mA.	62.5 mA.	62.5 mA.	50 mA.
Screen current at max. Vg^2 ...	—	—	—	10
Grid bias for max. Ic/a ...	— 45 avge.	— 42 avge.	— 38 avge.	— 40 avge.
Anode impedance	830 ohms	1,265 ohms	1,450 ohms	22,500 ohms
Mutual conductance	6 mA/v.	7.5 mA/v.	5.5 mA/v.†	6.3 mA/v.‡
Base	4-pin BVA	4-pin BVA	International octal	International octal

† Measured at Va = 250. Vgl. = —19.

‡ Measured at Va = Vg2 = 250. Vgl. = —15.

The choice of valves from Table 1 depends largely upon the H.T. supply voltage available, the maximum output for the PX4 triodes being obtained at some 350 anode volts and the KT66 (triode connected) at some 440 volts. Triode connected, the KT66 has characteristics comparable with those of the PX25 directly heated triode.

TABLE 2.	OSRAM PX4. Two Valves in Push-Pull.	OSRAM KT66. Two Valves in Push-Pull.	
		As Triodes.	As Tetrodes.
H.T. supply voltage	350	450	425
Anode voltage	300	400	390†
Anode current (total)	90 mA.	125 mA.	125 mA.†
Screen voltage	—	—	275†
Screen current (total)	—	—	18 mA.†
Bias voltage approx.	— 45	— 38	— 25
Bias resistance per valve	1,000 ohms	600 ohms	500 ohms
Load resistance (anode to anode)	4,000 ohms	4,000 ohms*	8,000 ohms
Peak input voltage (grid to grid)	90	84	70
Power input	13.5 watts	14.5 watts	30 watts
Distortion per cent.	2.5	3.5	6

* May be 10,000 ohms in pure Class A. giving slightly reduced output and lower distortion.

† At full output.

Table 2 gives typical operating conditions for two valves of the PX4 and KT66 types respectively in a push-pull circuit.

THE OUTPUT TRANSFORMER

The output transformer is probably the most critical component in a high fidelity amplifier. Incorrectly designed it is capable of producing distortion which is often mistakenly attributed to the valves. Distortion producible directly or indirectly by the output transformer may be listed as follows:—

(a) Frequency distortion due to low winding inductance, high leakage inductance and resonance phenomena.

(b) Spurious distortion due to the phase-shift produced by effect of these aberrations when negative feedback is applied across the transformer. This usually takes the form of parasitic oscillation due to phase-shift produced in the high frequency region by a high leakage inductance.

(c) Inter-modulation and harmonic distortion in the output stage caused by overloading at low frequencies when the primary inductance is insufficient.

(d) Harmonic and inter-modulation distortion produced by the non-linear relationship between flux and magnetising force in the core material. This distortion is always present but will be greatly aggravated if the flux density in the core exceeds the safe limit.

(e) Harmonic distortion introduced by excessive resistance in the primary winding.

The design of a practical transformer has to be a compromise between these conflicting requirements and in addition the matching is extremely critical with pentodes and tetrodes if the greatest output and least harmonic distortion is to be fed into the loudspeaker speech coil. A load impedance less than optimum gives less power and greater second harmonic content while an impedance greater than optimum gives a little more power but bad third harmonic distortion. With triodes or pentodes or tetrodes triode-operated, a load less than the optimum also greatly increases the second harmonic content. For load resistances greater than optimum the output and distortion both decrease.

The correct ratio for an output transformer is given by the formula:—

$$\frac{\text{Primary turns}}{\text{Secondary turns}} = \sqrt{\frac{\text{Optimum anode load resistance}}{\text{Load resistance of the speech coil}}}$$

INPUT STAGES

The reduction of phase-shift in amplifiers which are to operate with negative feedback is of prime importance, as instability will result should a phase-shift of 180° occur at a frequency where the vector gain of the amplifier and feedback network is greater than unity. The introduction of more than one transformer into the feedback path is likely to give rise to trouble from instability, and since it is desirable to apply feedback over the output transformer the rest of the amplifier should be resistance-capacitance coupled.

Fig. 1 indicates an arrangement in which each stage in the amplifier is working well within its capabilities and negative feedback is taken from the output transformer secondary to the cathode of the first stage.

Suggested complete circuit diagrams for amplifiers incorporating these provisions and using the alternatives of PX4 or KT66 valves in the output stage are given in Figs. 2 and 3.

There must be no " tone control " in the amplifier—where such is required an additional stage is necessary. See " Tone Control Unit."

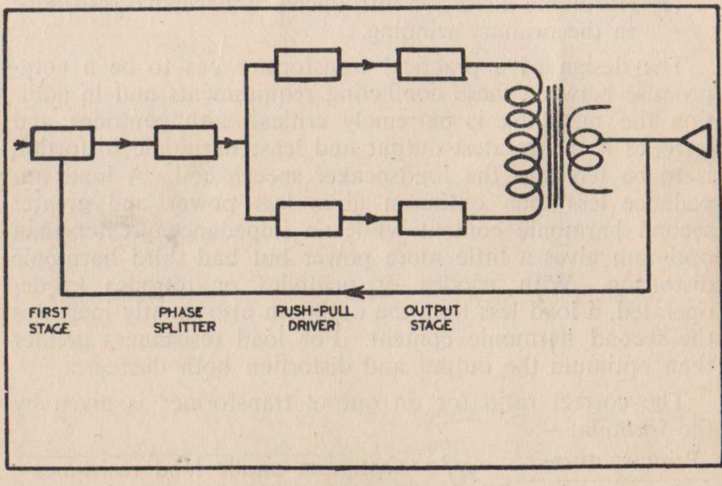


Fig 1.

MINIMISING PHASE-SHIFT

In order to keep the phase-shift in the amplifiers shown in Figs. 2 and 3 as small as possible at low frequencies the first stage has been directly coupled to the phase-splitter, eliminating one resistance-capacitance coupling. The first two stages are thus designed as a single entity. The phase-splitter section, which consists of a triode with equal loads in anode and cathode circuits, operates partly as a cathode-follower, its grid being some 100v. positive with respect to chassis. The anode of the first triode is also arranged to be about 100v. positive and is coupled to the phase-splitter grid. Owing to the cathode-follower action of V2 the operating conditions are not critical. The cathode bias resistor of V1, to which feedback is applied from the output transformer secondary, is kept as small as practicable to avoid a gain reduction in the first stage, due to series feedback.

NEGATIVE FEEDBACK

The reasons for the use of negative feedback may be said to be:—

(a) To improve the frequency response of the amplifier and output transformer.

(b) To improve the linearity of the amplifier and output transformer.

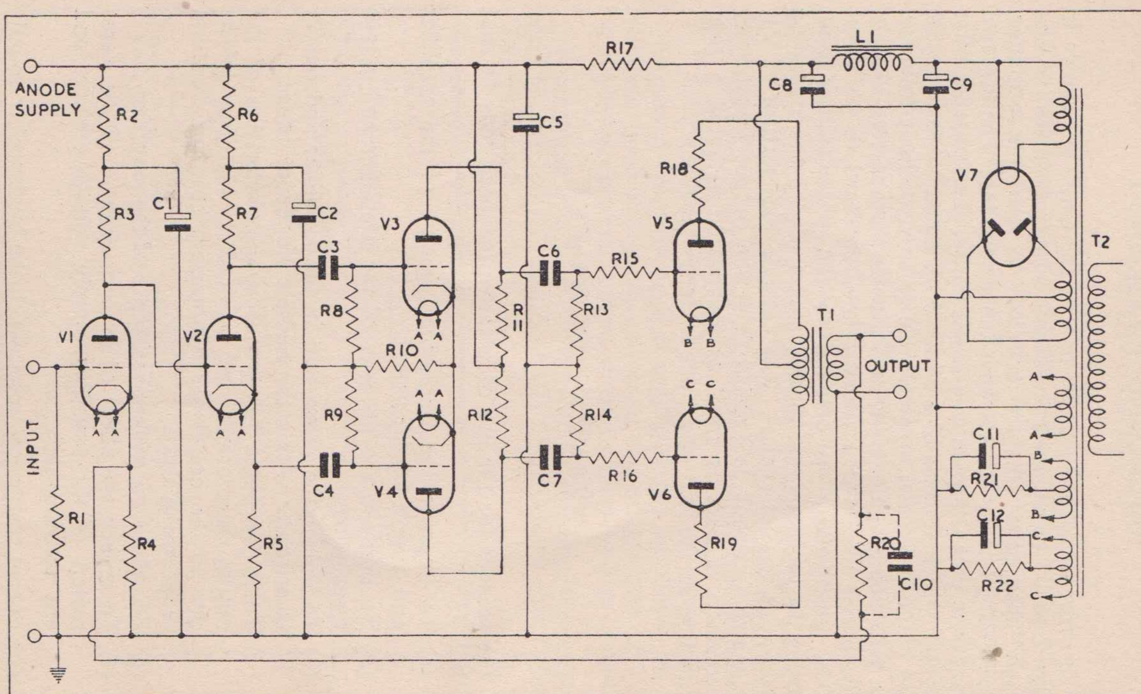
(c) To reduce the phase-shift in the amplifier and output transformer within the audible frequency range.

(d) To improve the low-frequency characteristics of the output transformer, and particularly to offset defects due to the non-linear relationship between flux and magnetising force.

(e) To reduce the output resistance of the amplifier.

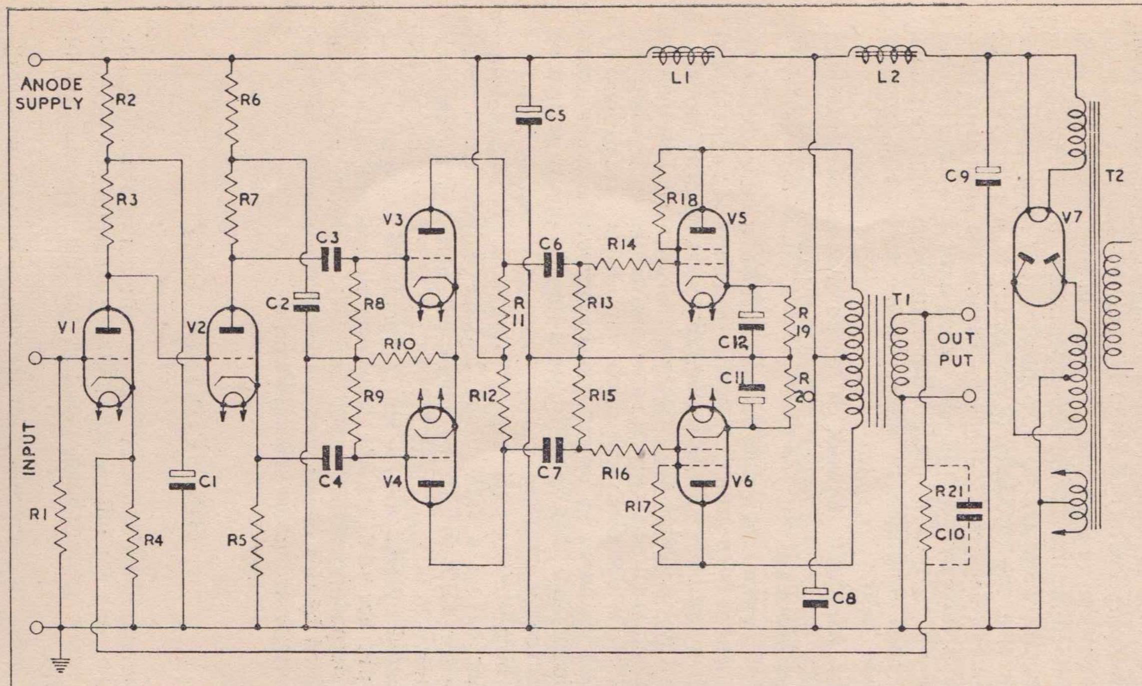
(f) To reduce the effect of random changes of the parameters of the amplifier, supply voltage changes and any spurious defects.

The output resistance, upon which the loudspeaker usually depends for the majority of the damping required, can be



ANODE SUPPLY
INPUT
OUTPUT
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
V1
V2
V3
V4
V5
V6
V7
L1
T1
T2

Fig. 2



ANODE SUPPLY
INPUT
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R 11
R12
R13
R14
R15
R16
R17
R18
R 19
R 20
R21
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
V1
V2
V3
V4
V5
V6
V7
L1
L2
T1
T2
OUT PUT

Fig. 3

reduced to a small fraction of the speech coil impedance. A ratio of load impedance/output resistance (sometimes known as Damping Factor) of 20-30 is easily obtained.

The design of the amplifiers given in Figs. 2 and 3 is such that no difficulty should be experienced in the application of negative feedback up to a maximum of some 30dB. Provided that the threshold of instability is not reached, the benefits of negative feedback increase as the amount of feedback is increased at the sole expense of loss of gain, but there will be little if any audible improvement to be gained with these amplifiers by increasing the amount of feedback beyond 20dB.

The feedback network is a purely resistive potential divider, the bottom limb of which is the cathode bias resistor of the first stage.

With component values as specified no trouble should be experienced from instability due to the effects of unintentional positive feedback. Should instability arise it will probably appear as oscillation at a supersonic frequency. This may be transient, occurring only at some part of the cycle when the amplifier is operated near maximum output. Its cause may be bad layout or an output transformer with a higher leakage inductance than specified, or it may be due to resonance in the output transformer.

If instability is experienced because of the output transformer having a rather high leakage inductance, a small capacitor C10 should be connected across the feedback resistor R20 in Fig. 2 and R21 in Fig. 3. The value should be found by trial, but it will probably be between 30 and 300 pF, according to the transformer's leakage inductance and output impedance used. Satisfactory results have been obtained by this means with a transformer having a leakage inductance as high as 100 millihenries.

TONE CONTROL UNIT

The amplifiers described require an input of approximately 2 volts peak for full output, and a pre-amplifier is required with most gramophone pick-ups for the reproduction of records.

In order to compensate for the loss of bass in the recording, the amplifier should be capable of providing a rising characteristic of 6dB. per octave at frequencies below 250 c/s.

An amplifier capable of providing a wide range of responses is shown in Fig. 4, and the stage gain when the controls are set for a level response is 20dB. (10:1) and, a total rise of 20dB. is available at 50 and 20,000 c/s. and a total fall of 15dB. at the same frequencies. Full output from the power amplifier is obtainable with an input of 200 milli-volts peak applied to this pre-amplifier. If a higher gain is required an additional stage of amplification should be used between the two amplifiers.

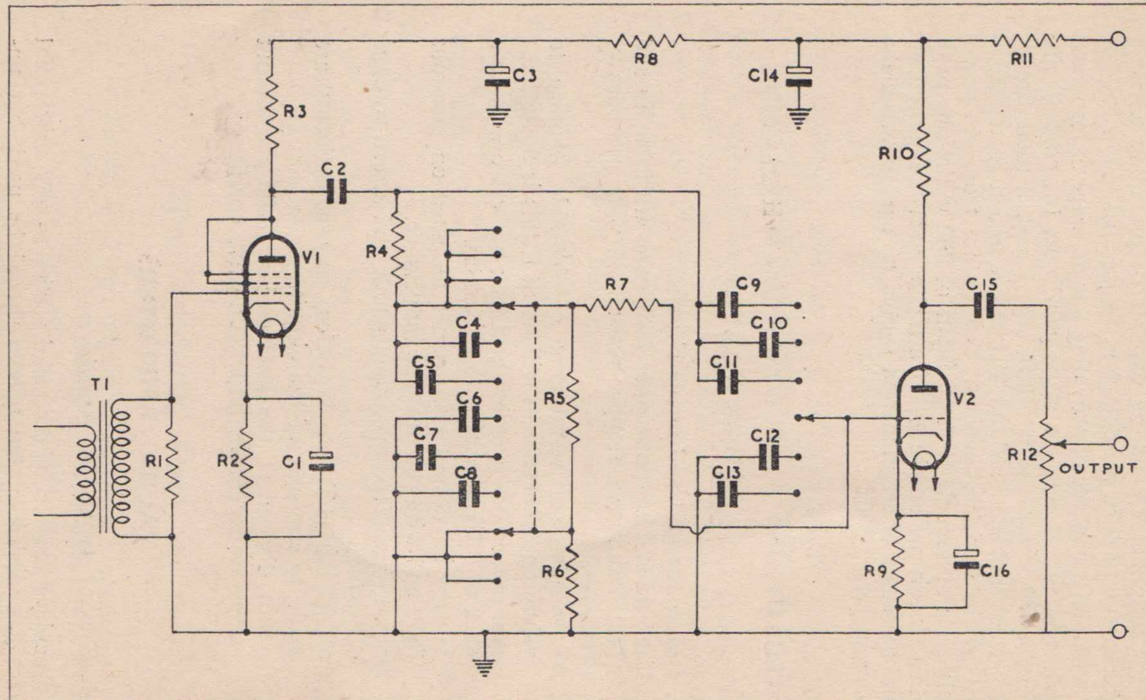
PRECAUTIONS TO BE OBSERVED WHEN USING POWER VALVES

1. Isolate the grid and anode circuits.
2. Use grid and anode stopper resistances with triodes and grid and screen stopper resistances with pentodes or tetrodes.
3. Allow adequate ventilation; considerable damage to valves and components will result if this is neglected.
4. Never exceed 0.5 megohm grid leak per valve with auto bias, or 0.1 megohm with fixed bias.
5. Use only an output transformer designed on generous lines and with low leakage inductance.
6. Do not exceed the maximum anode and screen wattage dissipation.
7. Cut off the H.T. supply before any adjustments are made to any part of the circuit.
8. Do not disconnect the loudspeaker while the output valves are operating under full drive conditions.

AC/DC AMPLIFIERS

Limitations of an AC/DC Amplifier

To achieve the results discussed earlier to any substantial degree it is desirable that triodes should be used, but unfortunately in AC/DC amplifiers there is a limitation of



R3
C3
R8
C14
R11
R10
C2
V1
R4
R7
C9
C15
C4
C10
C5
C11
T1
C6
R5
V2
C12
C7
R1
R2
C1
R12
OUTPUT
C8
C13
R6
R9
C16

Fig. 4

anode voltage which rules out triodes except for very low output powers, a circumstance contrary to condition (6) in the Design Factors section.

Therefore to obtain anything like the power output desired for good quality reproduction pentodes or "beam" output tetrodes must be used, with a generous amount of negative feedback to reduce impedance and minimise distortion.

It is emphasised, however, that the characteristics of such an amplifier are dependent solely upon the character and amount of the negative feedback used. The feedback must remain effective at all frequencies within the audio-frequency range and under all operating conditions if the quality is not to degenerate to the level usually associated with tetrodes without feedback. Great care must be taken with the design and operation of the amplifier to achieve this, and troubles such as parasitic oscillation and instability are liable to be encountered.

The amplifier to be described is based on two Osram output tetrodes type KT33C, and when operated from a DC or AC supply between 190 and 250 volts will deliver corresponding powers of 7 and 14 watts with a reasonably high degree of fidelity. The distortion is below 0.5%, up to 90% of full output, which is achieved with an input of about 1.5 volts R.M.S.

CIRCUIT DESCRIPTION

(1) Amplifier Unit

The overall amplifier (see Fig. 5) consists of a single-sided input stage using a resistance-capacitance coupled pentode, Osram type Z63, followed by a phase-splitting triode, type L63, having equal anode and cathode resistances.

The output stage consists of two Osram type KT33C tetrodes arranged in push-pull and transformer coupled to the loudspeaker.

As explained earlier, the output impedance of the amplifier must be substantially lower than the impedance of the loudspeaker speech coil if the essential damping of the latter is to be obtained.

The design of this amplifier is such that no difficulty should be experienced in the application of negative feedback up to

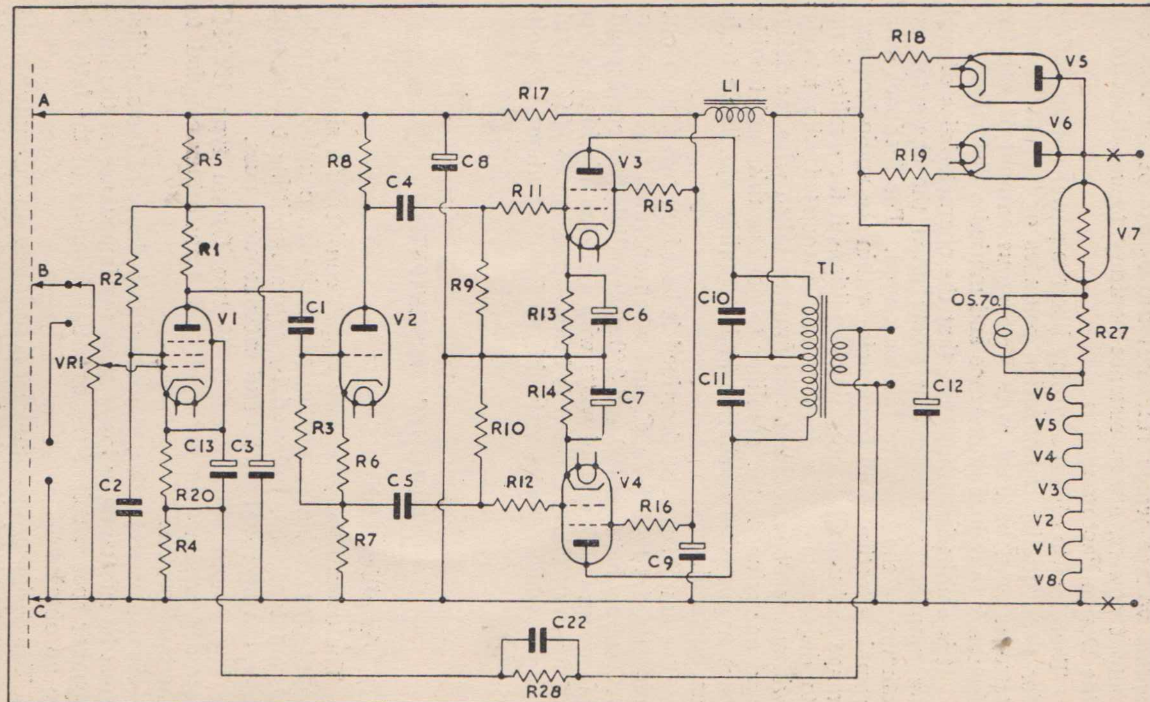

A
B
C
R5
R1
R2
VR1
V1
C13
C3
R20
R4
C2
R8
C4
C1
V2
R3
R6
R7
C5
C8
R17
R11
R9
R10
R12
V3
R15
R13
C6
R14
C7
V4
R16
C9
L1
C10
C11
T1
C12
C22
R28
R18
R19
V5
V6
V7
OS.70.
R27
V6
V5
V4
V3
V2
V1
V8

Fig. 5

a maximum of some 26 dB. Provided that the threshold of instability is not reached, the benefits of negative feedback increase as the amount of feedback is increased at the sole expense of loss of gain, but there will be little, if any, audible improvement to be gained with this amplifier by increasing the amount of feedback beyond 26 dB., and in circumstances that will be discussed later it could be somewhat less.

Negative feedback is applied from the secondary winding of the output transformer to the cathode of the pentode via the phase-correcting network composed of capacitor C22 and resistor R28. Approximately 26 dB. of feedback is recommended and a response flat within ± 0.5 dB. should be obtainable without difficulty for the frequency range of 20 to 20,000 c/s. Use of this capacitor permits the substantial amount of feedback necessary to produce high quality without introducing the danger of instability. Its value will depend on the characteristics of the output transformer and the impedance of the loudspeaker, but is generally between 0.05 and 0.002 mfd. It will also enable a transformer with less sectionalising to be used, and satisfactory results have been obtained with a transformer having a leakage inductance as high as 75 millihenries.

For the usual range of loudspeaker impedances the value of the resistor R28 will be as follows:—

Loudspeaker impedance Zs (ohms)	Value of R28 (ohms)
15	560
10	470
5	330
2.5	220

With other values of loudspeaker impedance the following formula will be found satisfactory:—

$$R_D = 150 \sqrt{Zs}$$

where R_D = value of resistor R28 in ohms and Zs = loudspeaker impedance in ohms.

If instability is experienced due to the use of an output transformer having an excessive leakage inductance, the amount of feedback may be reduced to 20 dB. and the value of resistor RD taken from the following table:—

Loudspeaker Impedance Zs (ohms)	Value of RD (ohms)
15	1,000
10	820
5	560
2.5	390

or by using the formula:—

$$R_D = 250 \sqrt{Zs}.$$

It is, however, strongly recommended that a transformer having a low value of leakage inductance should be used in order to maintain the fidelity at the highest possible level.

POWER SUPPLY UNIT

Mains Supply

The anode supply to the amplifier is obtained from a half-wave rectifier consisting of two Osram type U31 valves in parallel, with resistors R18, R19 in series to serve the following purposes:—

(a) To limit the voltage across capacitor C12 to a value that is approximately equal for DC and AC mains supplies.

(b) To limit the peak current through the valves.

(c) To equalise the currents through the rectifier valves.

If it is not required to operate the amplifier from AC mains the series resistors R18, R19 and the smoothing capacitor C12 may be omitted, but it should be remembered that there will then be no protection for the electrolytic capacitors, C3, C8 and C9 against a supply of reversed polarity, and paper capacitors of about 4 mfd. should be used in these positions.

As shown, the amplifier and power unit will operate perfectly satisfactorily from any DC or AC supply between 190 and 250 volts. If, however, the equipment is to be used continuously from an AC supply between 240 and 260, the values of resistors R18, R19 should be increased to 180 ohms.

If operation is to be solely on DC or AC mains between 220 and 260, an Osram barretter type 304 may be substituted for type 303, but if this is done the valve heater current will be too low on mains voltages below 220.

TONE CONTROL STAGE

For full output the amplifier requires an input of approximately two volts peak, and with most gramophone pick-ups an additional input amplifier is needed having a rising low frequency input to compensate for losses in recording. A simple combined amplifier and bass compensating stage using an Osram type Z63 pentode is included in Fig. 6. If a wider range of tone control is required, the two-valve input amplifier, shown in Fig. 7, also employing Osram type Z63 pentodes should be used. The amplifier has an overall gain of about 20 dB. and enables full output to be obtained from the main amplifier for a 200 millivolt signal from the secondary winding of the pick-up transformer.

In gramophone reproduction it is usually desirable to have some control over the high frequency response to enable older

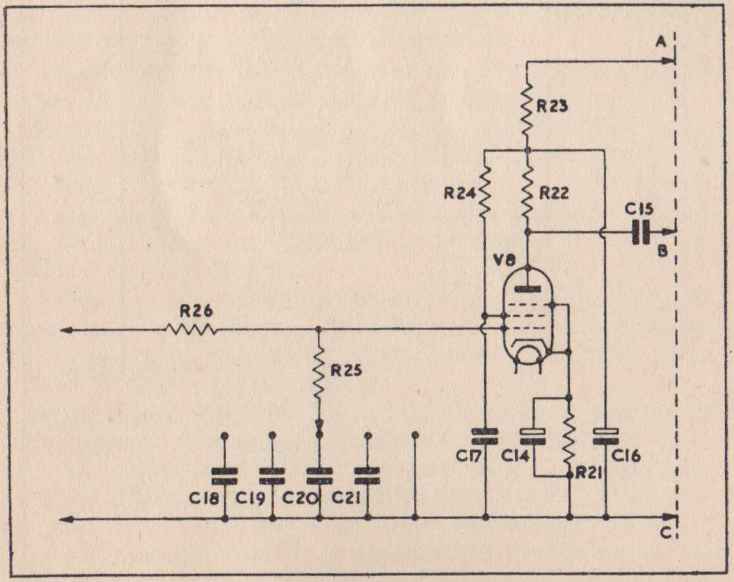


Fig. 6

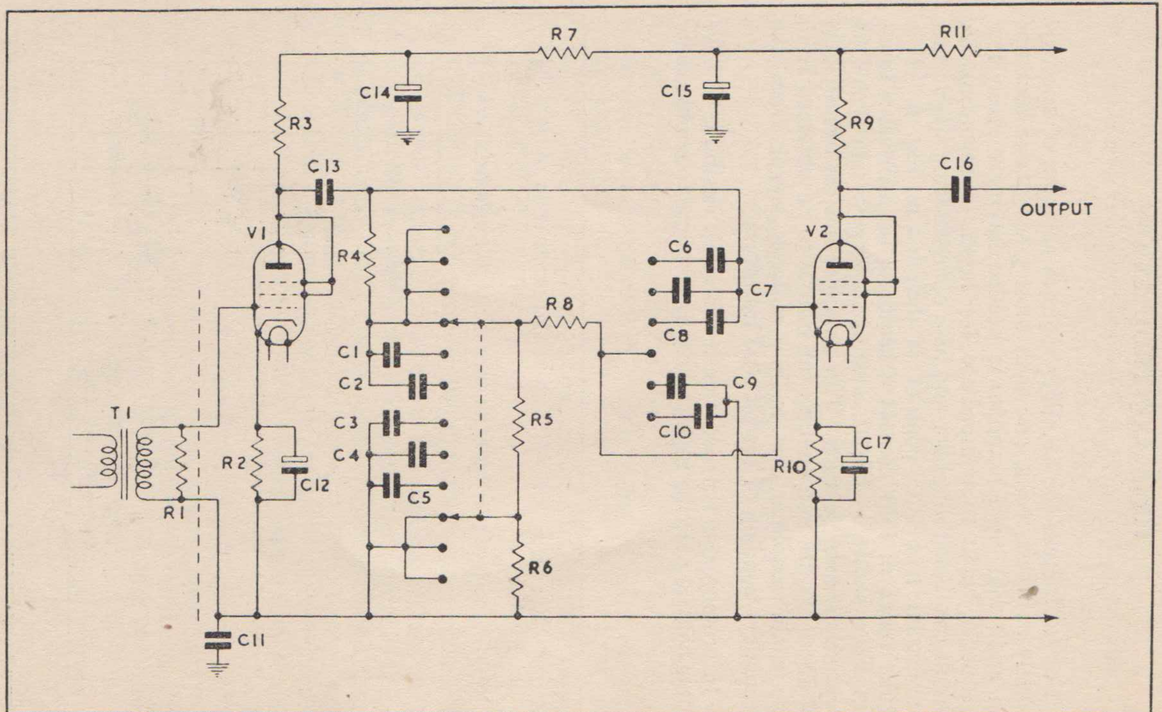

R7
R11
C14
C15
R3
R9
C13
C16
OUTPUT
V1
V2
R4
C6
C7
R8
C8
C1
C2
C9
C3
R5
C10
C4
T1
R2
C12
C5
C17
R10
R1
R6
C11

Fig. 7

records to be played with the minimum of scratch This control is represented by the resistance-capacitance networks R25, C18-21 shown connected across the pick-up connections in Fig. 6.

Where the pick-up is coupled to the input amplifier by means of a transformer it is essential that the latter should have a high secondary impedance if the scratch filter is to be effective.

NOTES ON COMPONENTS AND LAYOUT

To obtain satisfactory results it is essential that the right design of output transformer should be used. This implies that the leakage inductance and the resistance of the windings should be as low as possible. It is impossible with DC mains to increase the anode voltage in order to overcome inefficiency in the transformer.

It is important to use separate bias resistors R13 and R14 not only to ensure correct operation of the valves but to prevent instability at the lower frequencies.

Resistors R7 and R8 should be within 5% of each other in value, though the precise resistance is not critical.

Resistor R27 must be of 3-watt rating since if the lamp fails the resistor will have to carry the full heater current of 0.3 amp.

Capacitor C12 must be capable of carrying a ripple current of 200/250 milliamps; the type recommended in the components list will do this.

Although only the suggested valves are suitable for the input and output stages, the choice of the phase-splitting triode is not so important; either Osram Z63, triode connected, or L63 are quite suitable.

With regard to layout there are obviously a number of arrangements that will be satisfactory; but that shown in Fig. 8 is suggested as being convenient. It is very important, however, that the input stages of the amplifier should be well screened from the output stage and power supply section.

With component values as specified no trouble should be experienced from instability due to the effects of unintentional positive feedback. Should instability arise it will probably

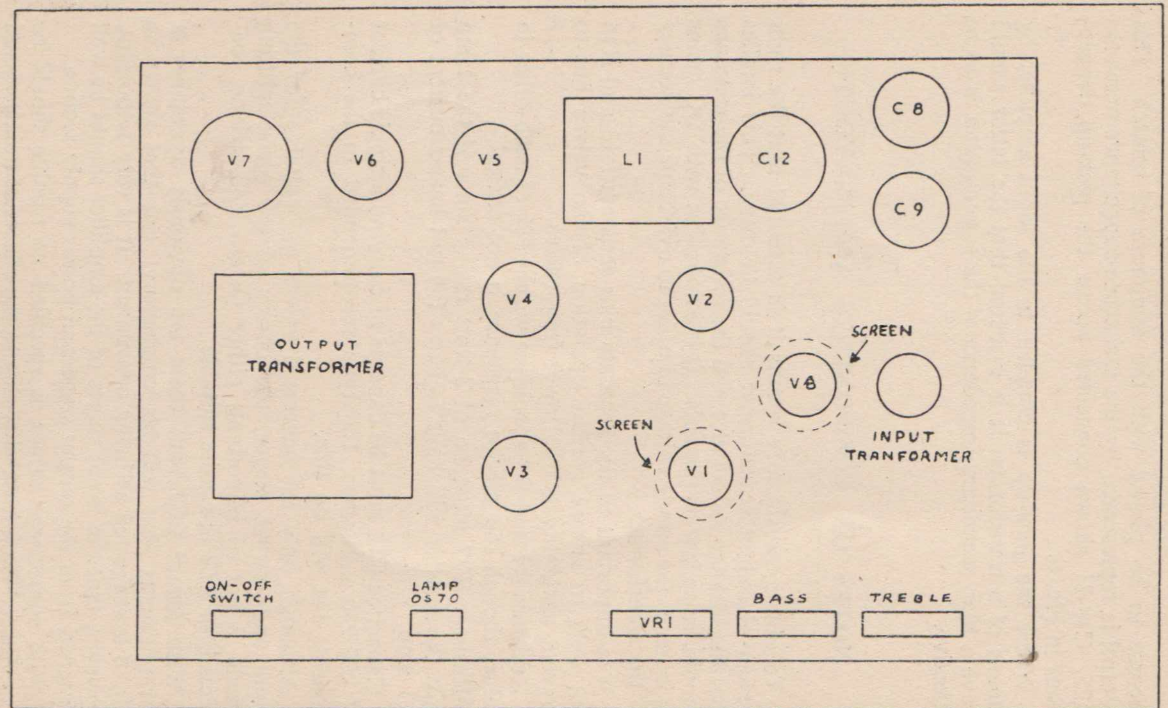

V7
V6
V5
L1
C12
C8
C9
OUTPUT
TRANSFORMER
V4
V2
SCREEN
V8
SCREEN
V3
V1
INPUT
TRANFORMER
ON-OFF
SWITCH
LAMP
OS70
VR1
BASS
TREBLE

Fig. 8

appear as oscillation at a supersonic frequency. This may be transient, occurring only at some part of the cycle when the amplifier is operating near maximum output. Its cause may be bad layout or an output transformer with a higher leakage inductance than specified.

A remedy, which should only be used as a temporary measure, is to reduce the high-frequency response of one of the amplifier stages. This may conveniently be done by connecting a small capacitor say (200 pF.) from the anode of V1, Fig. 5, to chassis.

IN CONCLUSION

These remarks on the essential points to be observed in the construction of high fidelity audio frequency amplifiers are intended to serve only as a guide and much of the desired result depends on layout and circuit components. Practical amplifiers have been constructed to the basic circuits described in these pages and used in conjunction with a gramophone pick-up, microphone or radio receiver at one end of the chain and a high fidelity loudspeaker at the other. They have demonstrated the high fidelity of reproduction possible with good modern components and careful amplifier design, even with limited anode voltages.

Although every care has been taken in the compilation of this information the G.E.C. can accept no responsibility for any dissatisfaction with results in individual cases, owing to the many details that must necessarily be dependent on the actual construction.

The circuit information given in this article does not imply any licence under patents which may be involved.

NOTE.—This article dealing with the design and construction of amplifiers for high fidelity sound reproduction is reproduced by courtesy of G.E.C. Ltd., Magnet House, Kingsway, London, W.C.

COMPONENT LIST FOR FIG. 2

R1	1 MΩ	¼ Watt
R2	33 KΩ	1 Watt
R3	47 KΩ	1 Watt
R4	470 KΩ	1 Watt
R5-6-7	22 KΩ	1 Watt
R8-9	470 KΩ	¼ Watt
R10	390 Ω	¼ Watt
R11-12	56 KΩ	1 Watt
R13-14	270 KΩ	¼ Watt
R15-16	1 KΩ	¼ Watt
R17	5 KΩ	5 Watt
R18-19	100 Ω	½ Watt
R20	$1{,}200\sqrt{S}\,\Omega$ ¼ Watt (S = speech coil impedance)	
R21-22	1 KΩ	Wire wound
C1-2-5	8 mfd. 450 v.wg.	T.C.C. CE19P
C3-4	0.05 mfd. 500 v.wg.	T.C.C. 543
C6-7	0.1 500 v.wg.	T.C.C. 543
C8-9	8 mfd. 600 v.wg.	T.C.C. type 922
C10	See text	
C11-12	50 mfd. 50 v.wg.	T.C.C. CE61D
L1	10 H at 150 m/A	Stewart Transformers
T1	20 Watt output transformer overall turns ratio $\sqrt{\frac{4000}{S}}$ (S = speech coil impedance)	Partridge
T2	Power transformer.	Pri. to suit mains. Sec. 325-0-325 v. 150 m/A 5 v. 3 A. 6.3 v. 2 A. C.T. 4 v. 1 A. C.T. 4 v. 1 A. C.T. Stewart Transformers
V1-4	Osram L63 (2 Osram type B65 twin triodes may be used)	
V5-6	Osram PX4	
V7	Osram U52	

COMPONENT LIST FOR FIG. 3

C1-2-5	8 mfd. 450 v.wg.	T.C.C. CE19P
C3-4	0.05 mfd.	T.C.C. 543
C6-7	0.25 mfd.	T.C.C. 543
C8-9	8 mfd. 600 v.wg.	T.C.C. 922
C10	See text	
C11-12	50 mfd. 50 v.wg.	T.C.C. CE61D
L1	30 H. 40 m/A	Stewart Transformers
L2	10 H. 180 m/A	Stewart Transformers
R1	1 MΩ $\frac{1}{4}$ Watt 20%	
R2	33 KΩ 1 Watt 20%	
R3	47 KΩ 1 Watt 20%	
R4	470 Ω $\frac{1}{4}$ Watt 10%	
R5-6-7	22 KΩ 1 Watt 10%	
R8-9	470 KΩ $\frac{1}{4}$ Watt 20%	
R10	390 Ω $\frac{1}{4}$ Watt 10%	
R11-12	56 KΩ 2 Watt 10%	
R13-15	100 KΩ $\frac{1}{4}$ Watt 20%	
R14-16	1 KΩ $\frac{1}{4}$ Watt 20%	
R17-18	100 Ω $\frac{1}{2}$ Watt 20%	
R19-20	500 Ω 5 Watt 5%	
R21	1200 $\sqrt{S}$Ω $\frac{1}{4}$ Watt (S = speech coil impedance)	
T1	20 Watt output transformer overall turns ratio $\sqrt{\frac{10{,}000}{S}}$ * Primary incremental inductance 100 H (min.) Leakage inductance 30 mH. (max.)	
T2	Power Trans. Pri. to suit mains. Sec. 425-0-425 v. 180 m/A 5 v. 3A 6.3 v. 4A. C.T.	
V1-2-3-4	Osram L63 or two B65's (twin triodes)	
V5-6	Osram KT66	
V7	Osram U52	

* Pure Class A condition. For maximum power output, turns ratio = $\sqrt{\frac{4000}{S}}$ (see Table 2)

COMPONENT LIST FOR FIG. 4

C1-16	50 mfd. 12 v.wg.	Ediswan—B.E.C. 71440
C2-8-15	0.25 mfd. 500 v.wg.	T.C.C. 543
C3-14	8+32 mfd. (C3 = 8 mfd. C14 = 32 mfd.)	Ediswan—B.E.C. 71429
C4	0.01 mfd.	T.C.C. 543
C5	0.005 mfd.	T.C.C. 543
C6	0.05 mfd.	T.C.C. 543
C7	0.1 mfd.	T.C.C. 543
C9	47 pf.	T.C.C. type 101 S.M.P.
C10	27 pf.	T.C.C. type 101 S.M.P.
C11	10 pf.	T.C.C. type 101 S.M.P.
C12	220 pf.	T.C.C. type 425 S.M.P.
C13	470 pf.	T.C.C. type 501 S.M.P.
R1	Determined by transformer impedance usually embodied in T1.	
R2-9	2.2 KΩ	
R3-10	56 KΩ	
R4-7	100 KΩ	
R5	5.6 KΩ	
R6	1 MΩ	
R8	22 KΩ	
R11	44 KΩ for 440 v. H.T. line 22 KΩ for 275 v. H.T. line	
R12	100 KΩ variable potentiometer	
V1	Z63, KTZ63	Osram
V2	L63	Osram
T1	Transformer to suit low impedance P/U (most high fidelity miniature pick-ups are supplied complete with transformer)	

COMPONENT LIST FOR FIG. 5

C1	0.05 mfd.	T.C.C.	343
C2	0.25 mfd.	T.C.C.	343
C3	4 mfd.	T.C.C.	CE18L
C4-5	0.1 mfd.	T.C.C.	343
C6-7	25 mfd. 25 v.wg.	T.C.C.	CE32C
C8-9	30 mfd. 350 v.wg.	T.C.C.	CE29L
C10-11	1500 pf. mica.	T.C.C.	M3G0

C12	32 mfd. 450 v.wg. T.C.C.	CE37P
C13	50 mfd. 12 v.wg. T.C.C.	CE32B
C22	See text	
V1	Z63	Osram
V2	L63	Osram
V3-4	KT33C	Osram
V5-6	U31	Osram
V7	Barretter type 303	Osram

Output Transformer.

Pri. 3200 Ω anode to anode load.
Sec. to suit speech coil.

No.	Value.	Tol.	Wattage.
R1	220 KΩ	10%	½
R2	1 MΩ	10%	½
R3	2.2 MΩ	20%	½
R4	47 Ω	10%	½
R5-11-12	15 KΩ	20%	½
R6	1.5 KΩ	10%	½
R7-8	15 KΩ See text		1
R9-10	220 KΩ	20%	½
R13-14	220 Ω	5%	1
R15-16	100 Ω	20%	½
R17	15 KΩ	10%	1
R18-19	100 Ω	10%	5
R20	2.2 KΩ	10%	½
R27	22 Ω	10%	3
R28	See text		
VR1	¼ meg. potentiometer.		

COMPONENT LIST FOR FIG. 6

R21	2.2 KΩ	10% tol. ½ Watt.
R22	220 KΩ	10% tol. ½ Watt.
R23	27 KΩ	10% tol. ½ Watt.
R24	1 MΩ	10% tol. ½ Watt.
R25	10 KΩ	10% tol. ½ Watt.
R26	150 KΩ	10% tol. ½ Watt.
C14	50 mfd. 12 v. Ediswan—B.E.C. type 71440	
C15	0.02 Ω T.C.C. type 543	

C16	8 mfd. 450 v.wg. Ediswan—B.E.C. type 71416
C17	0.25 mfd. T.C.C. type 343
C18	0.025 mfd. (0.005 + 0.02) T.C.C. type 543
C19	0.05 mfd. T.C.C. type 343
C20	0.1 mfd. T.C.C. type 343
C21	0.2 mfd. T.C.C. type 343
V8	Z63 Osram.

COMPONENT LIST FOR FIG. 7

C1	0.01 mfd.	T.C.C. type 543
C2	0.005 mfd.	T.C.C. type 543
C3	0.05 mfd.	T.C.C. type 543
C4	0.1 mfd.	T.C.C. type 543
C5	0.25 mfd.	T.C.C. type 543
C6	47 pf.	T.C.C. type 101 S.M.P.
C7	27 pf.	T.C.C. type 101 S.M.P.
C8	10 pf.	T.C.C. type 101 S.M.P.
C9	220 pf.	T.C.C. type 425 S.M.P.
C10	470 pf.	T.C.C. type 501 S.M.P.
C11	0.1 mfd.	T.C.C. type 543
C12-17	50 mfd. 12 v.	Ediswan—B.E.C. type 71440
C13	0.25 mfd.	T.C.C. type 543
C14, C15	8 + 32 mfd.	Ediswan—B.E.C. type 71429
C16	0.02 mfd.	T.C.C. type 543
R1	Determined by transformer impedance usually embodied in T.1.	
R2-10	1.5 KΩ	
R3-9	56 KΩ	
R4-8	100 KΩ	
R5	5.6 KΩ	
R6	1 MΩ	
R7-11	10 KΩ	
V1-2	Osram Z63 or KTZ63	
T1	Transformer to suit low impedance P/U	

(Most high fidelity miniature pick-ups are supplied complete with transformer.)

TWO 50 WATT AMPLIFIERS

For constructors who require a very large output, a pair of Osram KT66's form an excellent combination used in Class AB1. With automatic bias an output of some 30 watts is readily obtainable. When outputs in excess of 30 watts are required, four valves in parallel push-pull may be used to obtain outputs up to 60 watts.

An alternative method of obtaining an output in the neighbourhood of 50 watts, but employing only two KT66's is shown in Figs. 9 and 10. The valves are operated with fixed bias but, as no grid current is drawn, a low impedance driver stage is not required. The circuit used in Fig. 9 uses a push-pull transformer having a ratio of about 1:4 and each half secondary is connected to a variable bias supply. An alternative circuit is shown in Fig. 10, using a phase-splitter.

A convenient method of obtaining the required negative bias is shown in the power pack diagram, Fig. 11. It is somewhat unorthodox but avoids the need for a special bias transformer. The rectifier is fed from the anode supply transformer via a high voltage 0.02 mfd. capacitor. Because of the large variation in screen current between quiescent and full output, a gas-filled cold-cathode diode, type S130, is used to supply the screen voltage. As the voltage drop across this diode does not change materially with varying current, the screens are maintained at approximately 115 volts below the anode supply voltage under all conditions of operation. This reduced voltage may be used to supply the earlier valves. Under no circumstances must the screens be directly connected to the 500 volt supply.

The purpose of the meter shown in the two amplifier diagrams is to enable the KT66's to be accurately matched.

A low reading instrument is used shunted by resistors permanently wired in the cathodes of the output valves. These shunts make up the full scale deflection of the meter to 100 m/Amps. To calculate the resistance value of the shunt (R) determine the internal resistance of the meter (rM) by consulting the manufacturer (in many cases it is printed on the dial), note the factor (f) by which the present current scale is to be multiplied, divide the meter resistance by f - 1

$$R = \frac{rM}{f-1}$$

Where R is the required shunt value in ohms, rM the internal resistance of the meter, f the scale multiplication factor.

Example.—Find the value of shunt resistance (R) required to convert an 0-1 milliammeter to read 100 m/As. full scale. The internal resistance of the meter is 100Ω.

Answer.—The factor f is 100, rM is 100.

$$R = \frac{100}{100-1} = \frac{100}{99} = 1.01\Omega$$

The output transformer should be supplied by a reputable manufacturer; when ordering, full details concerning speech coil impedance required together with anode to anode load (6,000 ohms for either of these amplifiers) and the wattage rating should all be given. The intervalve transformer should not be of the type using a mu-metal core; the manufacturer should be informed that the preceding valve is an L63 and that the anode current of this valve passes through the primary winding.

The two 50-watt Amplifier and Power Pack designs are reproduced by courtesy of the G.E.C., Magnet House, Kingsway, London, W.C.

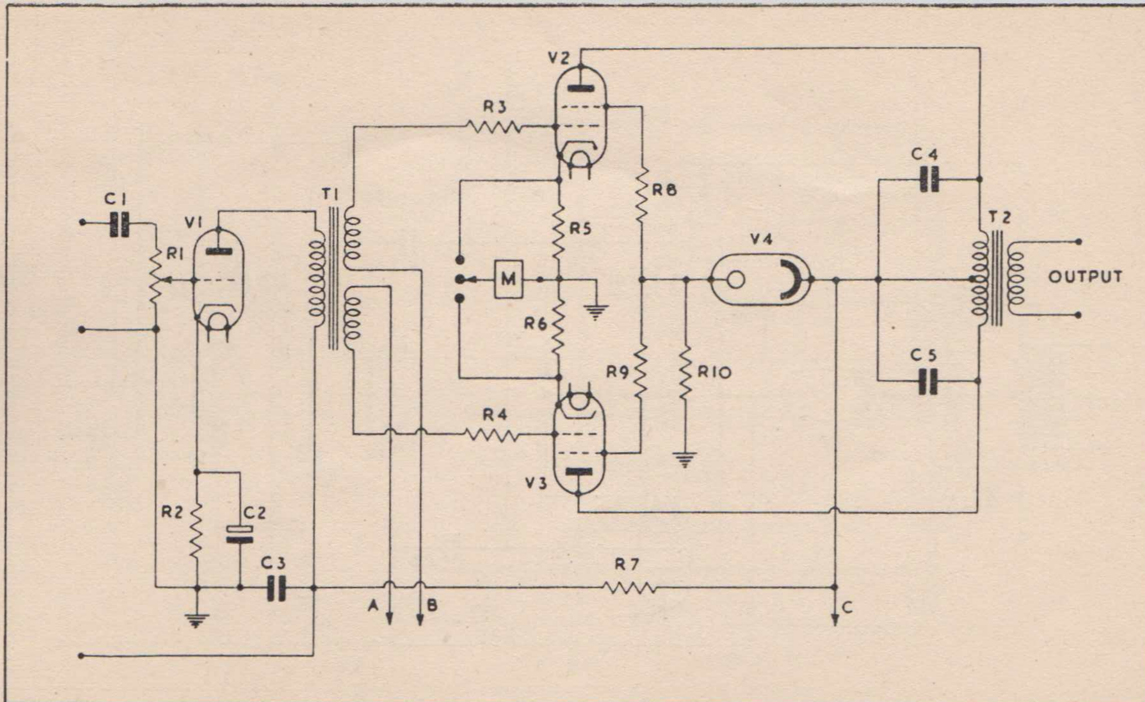

C1
R1
V1
R2
C2
C3
T1
A
B
R3
V2
R5
M
R6
R4
V3
R8
R9
R10
R7
V4
C
C4
C5
T2
OUTPUT

Fig. 9

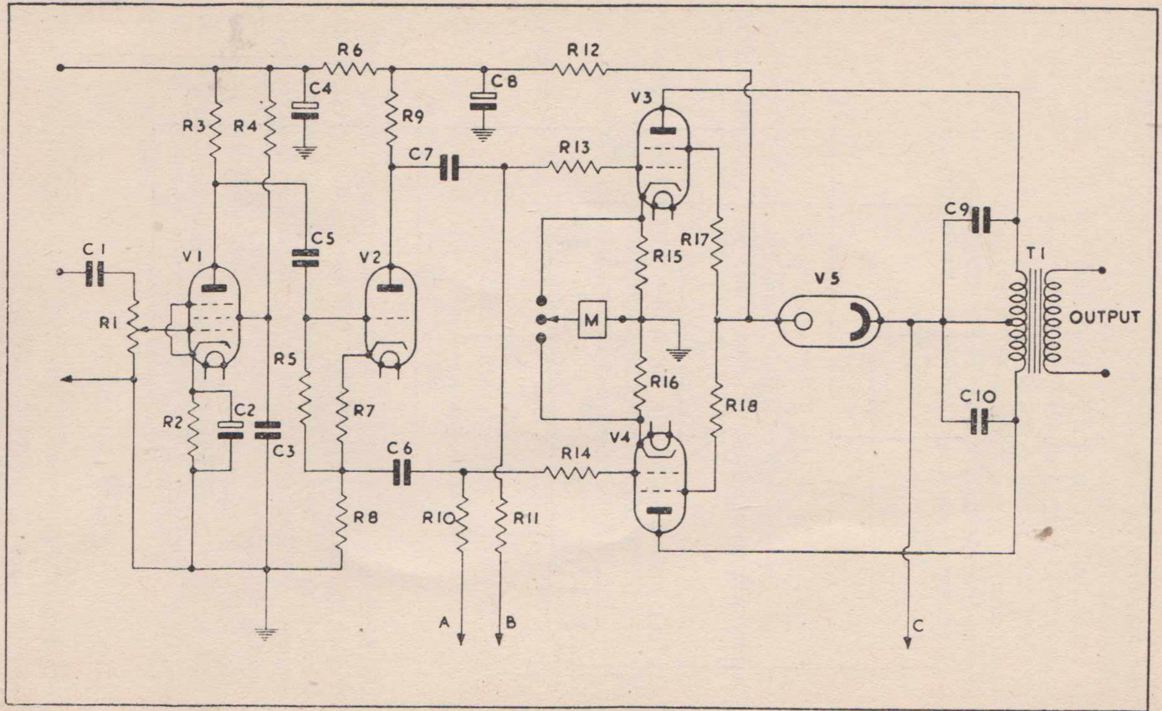

R6
R12
C4
C8
V3
R3
R4
R9
C7
R13
C5
C1
V1
V2
R17
R15
T1
C9
V5
R1
M
OUTPUT
R5
R16
C2
R7
R18
C10
R2
C3
V4
C6
R14
R8
R10
R11
A
B
C

Fig. 10

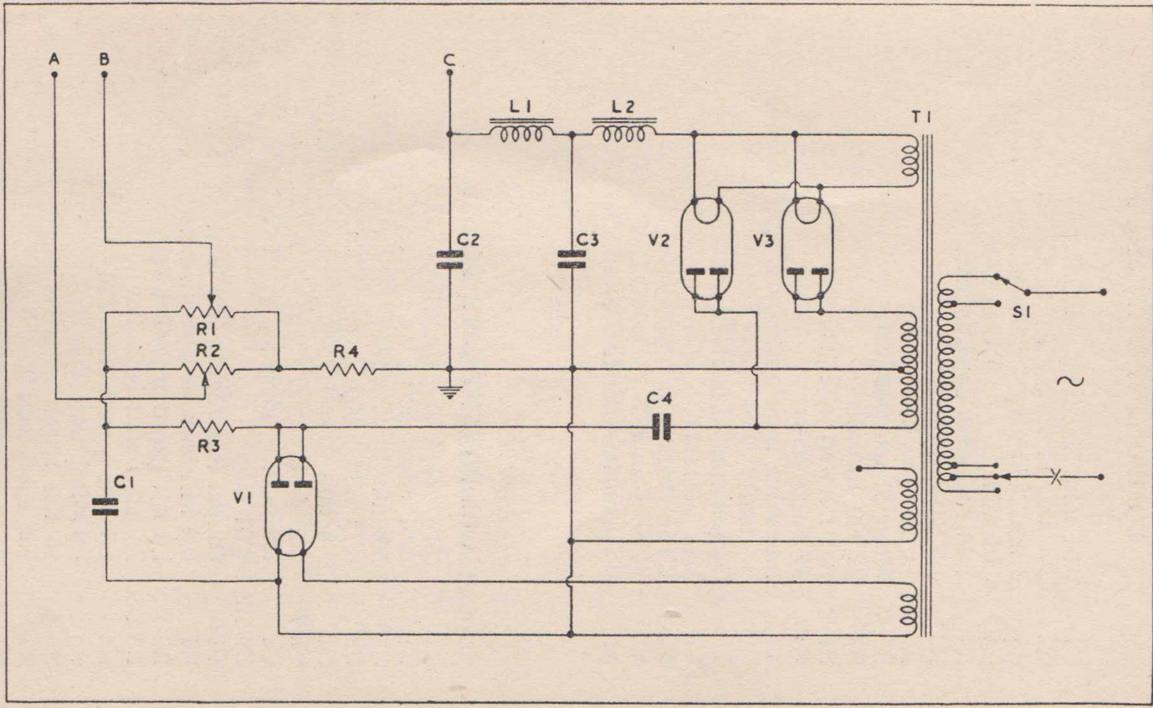


Fig. 11

COMPONENT LIST, FIG. 9

C1	0.01 mfd. 500 v.wg. T.C.C. 543
C2	50 mfd. 12 v.wg. T.C.C. CE32B.
C3	8 mfd. 450 v.wg. Ediswan B.E.C. 71416
C4-5	0.01 mfd. T.C.C. 1545
R1	1 MΩ variable potentiometer
R2	1.5 KΩ $\frac{1}{2}$ watt 10% Tol.
R3-4	5.6 KΩ $\frac{1}{4}$ watt 20% Tol.
R5-6	Meter Shunts (see text)
R7	22 KΩ 10 watts
R8-9	100 Ω $\frac{1}{2}$ watt 20% Tol.
R10	47 KΩ 5 watts
T1	Intervalve transformer with split secondary (see text)
T2	Output transformer (see text)
V1	L63 Osram
V2-3	KT66 Osram
V4	S130 Osram
M	0-1 milliammeter (see text)

COMPONENT LIST, FIG. 10

C1-5	0.01 mfd.	500 v.wg.	T.C.C. 543
C2	50 mfd.	12 v.wg.	T.C.C. CE32B
C3	0.25 mfd.	500 v.wg.	T.C.C. 543
C4	2.0 mfd.	450 v.wg.	T.C.C. CE18P
C6-7	0.1 mfd.	500 v.wg.	T.C.C. 543
C8	8.0 mfd.	450 v.wg.	T.C.C. CE11P
C9-10	0.01 mfd.		T.C.C. 1545
T1	Output transformer (see text)		
R1	0.5 MΩ variable potentiometer		
R2-7	1.5 KΩ $\frac{1}{2}$ watt 10% Tol.		
R3-8-9	22 KΩ 1 watt 10% Tol.		
R4	1.5 MΩ $\frac{1}{2}$ watt 20% Tol.		
R5	1.0 MΩ $\frac{1}{4}$ watt 20% Tol.		
R6-12	10 KΩ 1 watt 20% Tol.		
R10-11	100 KΩ $\frac{1}{4}$ watt 20% Tol.		
R13-14	3.3 KΩ $\frac{1}{4}$ watt 20% Tol.		
R15-16	Meter shunts (see text)		

R17-18	100 Ω ½ watt 20% Tol.	
V1	KTZ63 or Z63	Osram
V2	L63	Osram
V3-4	KT66	Osram

POWER PACK, FIG. 11

Component List

T1	600-0-600 v. 250 m/A.		
	6.3 v. 4 Amps.		
	5.0 v. 2 Amps.		
	4.0 v. 6 Amps.		
L1-2	10 H. 250 m/A.		
C1	8 mfd.	T.C.C.	CE19P
C2-3	8 mfd.	T.C.C.	Type 111 (Paper)
C4	0.02 mfd.	T.C.C.	848
R1-2	50 KΩ wire wound (Reliance)		
R3	100 KΩ 1 watt 10% Tol.		
R4	27 KΩ 1 watt 10% Tol.		
V1	U50 Osram.		
V2-3	U18/20 Osram.		

SMALL BATTERY AMPLIFIER SUITABLE FOR USE AS HEARING AID. FIG. 12

The construction of this amplifier calls for no special comment. The valve holders should be mounted on a strip of metal and the appropriate resistors and condensers wired to their respective stages, the whole unit together with batteries can be conveniently housed in a wooden container similar to a small cigar box. For the convenience of constructors battery measurements are given in the component list.

COMPONENT LIST

R1-5	220 KΩ ¼ Watt
R2-6	680 KΩ ¼ Watt
R3	2.2 MΩ ¼ Watt
R4	2 MΩ V/C
R7	6.8 MΩ ¼ Watt

(Continued on page 43)

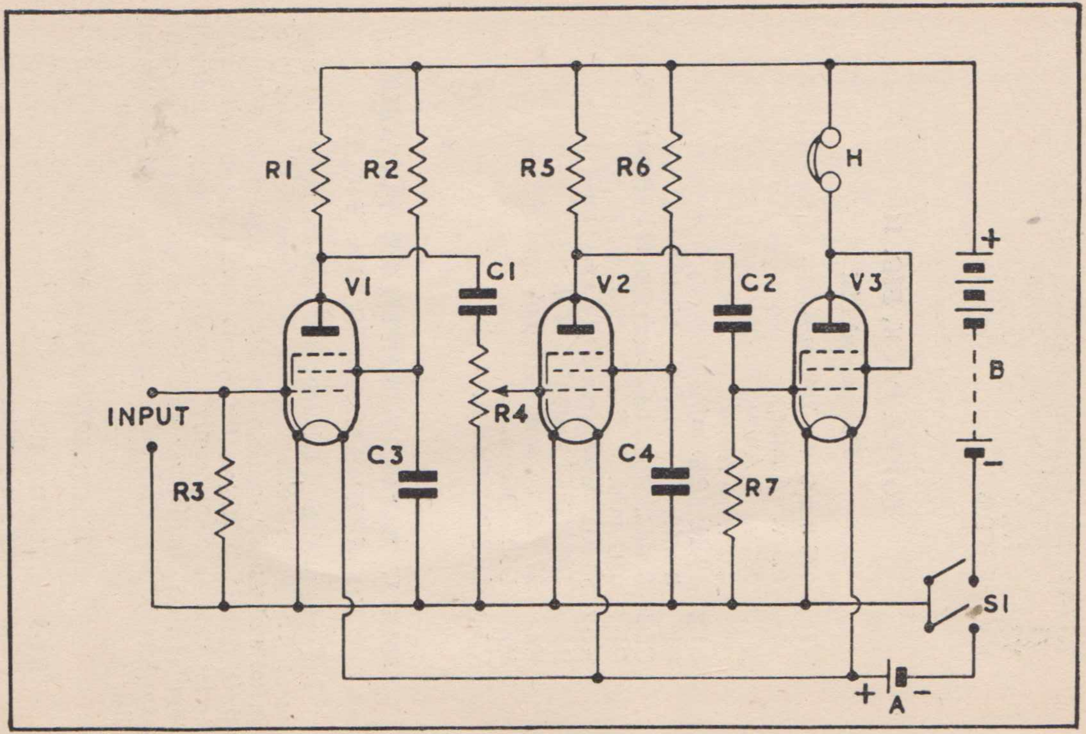


Fig. 12

C1-2-3-4	0.1 mfd. T.C.C. 246
S1	D.P.S.T. Toggle switch
V1-2-3	1T4, DF91
	45 v. H.T. battery. Ever Ready B 109—$2\frac{5}{8}$" x 1" x $3\frac{29}{32}$"
	1.5 v. L.T. battery. Ever Ready D 12—$1\frac{1}{16}$" x $\frac{9}{16}$" x 2"

4 WATT A.C. AMPLIFIER WITH SELECTIVE FEEDBACK. FIG. 13

In response to requests by many of our constructors we are presenting a small amplifier consisting of only two stages plus rectifier. This amplifier and the circuit constants is reproduced by courtesy of the Mullard Wireless Service Company.

The design of this amplifier is such that good quality reproduction of gramophone recordings is possible at a maximum output of 3.5 watts. Bass and treble tone controls are incorporated in the feedback circuit. Care must be taken when connecting up the feedback loop to ensure that the voltage fed back is in phase with the input voltage. If the phase relationship is incorrect the amplifier will oscillate. The degree of feedback is determined by the ratio of the output transformer and the value of R4. Suitable values are shown below for various output transformer ratios:—

Transformer ratio	**Speech coil impedance**	**Value of R4**
22 : 1	15	120
32 : 1	7	180
48 : 1	3	270

The recommended value of R1 is suitable for all normal armature pick-ups; its value may, however, be changed to suit any particular type of pick-up employed.

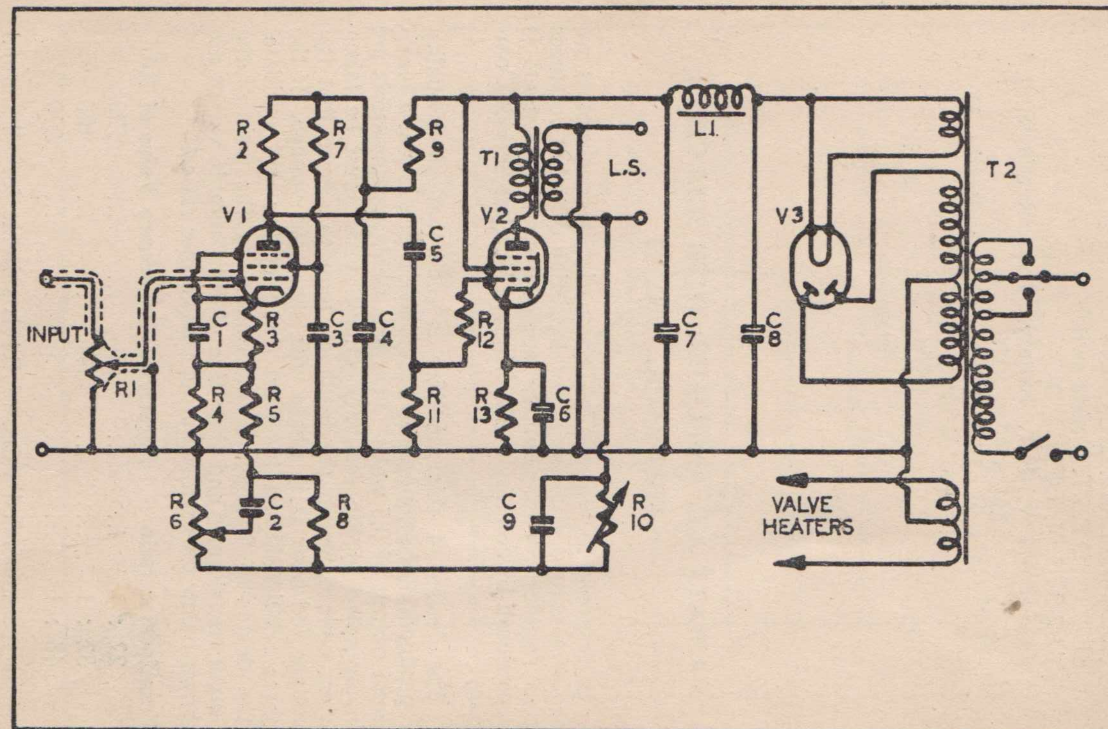

R 2
R 7
R 9
T1
L.S.
L.I.
T 2
V1
V2
V3
C 5
INPUT
C 1
R 3
C 3
C 4
R 12
C 7
C 8
R1
R 4
R 5
R 11
R 13
C 6
R 6
C 2
R 8
C 9
R 10
VALVE
HEATERS

Fig. 13

COMPONENT LIST, FIG. 13

R1	220 KΩ variable potentiometer	
R2	100 KΩ $\frac{1}{2}$ watt	
R3-5	1 KΩ $\frac{1}{2}$ watt	
R4	See text	
R6	25 KΩ variable potentiometer	
R7	470 KΩ $\frac{1}{2}$ watt	
R8	3.9 KΩ $\frac{1}{4}$ watt	
R9	10 KΩ $\frac{1}{2}$ watt	
R10	100 KΩ variable potentiometer	
R11	1 MΩ $\frac{1}{4}$ watt	
R12	1 KΩ $\frac{1}{4}$ watt	
R13	150 Ω $\frac{1}{2}$ watt	
C1-6	100 mfd. 12 v.wg. Electrolytic	
C2	0.05 mfd.	
C3	0.1 mfd. 350 v.wg.	
C4	8.0 mfd. 350 v.wg. Electrolytic	
C5	0.02 mfd. 350 v.wg.	
C7-8	32 mfd. 320 v.wg. Electrolytic	
C9	0.2 mfd.	
L1	10 H 60 m/A.	
T1	Output transformer.	Primary winding Current rating 50 m/A For ratio see text
T2	Power transformer.	Pri. to suit mains Sec. 250-0-250 v. 60 m/A 6.3 v. 2 A. centre tapped. 4.0 v. 1 A.
V1	EF37 EF39	Mullard
V2	EL33	Mullard
V3	AZ31	Mullard

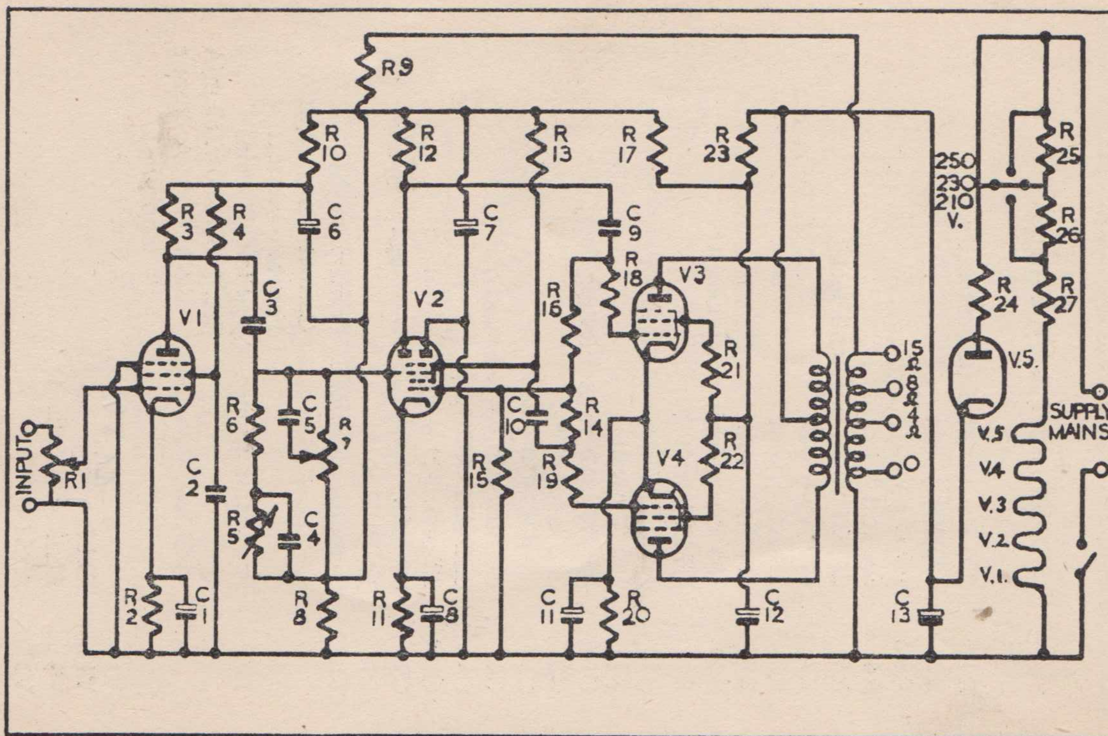

INPUT
R1
V1
R2
C1
R3
R4
C2
C3
R6
C5
R7
R5
C4
R8
R9
R10
C6
V2
R11
C8
R12
C7
R13
R15
C10
R14
R16
R19
C11
R20
R17
C9
R18
V3
V4
R21
R22
R23
C12
15 Ω
8 Ω
4 Ω
250
230
210 V.
R24
V.5.
R25
R26
R27
C13
V.5
V.4
V.3
V.2
V.1.
SUPPLY MAINS

Fig. 14

10 WATT AC/DC AMPLIFIER. FIG. 14

This amplifier is suitable for the reproduction of speech and music and is capable of providing an audio output of approximately 10 watts peak for an input to the grid of V1 of 50 m/V. Bass and treble tone controls incorporated between V1 and V2 provide a wide range of tone correction. Care must be taken in the construction of this stage to ensure that if a metal-cased component is used for C6, the case is not connected to the chassis.

In order to eliminate the switching of mains voltage dropping resistors, it is possible over a supply voltage range 200/250 v. to replace R25-6-7 by a Philips barretter type C1. The same remarks, re phasing the feedback voltage, apply as for the 4 watt amplifier.

This design is reproduced by courtesy of the Mullard Wireless Service Co.

COMPONENT LIST

R1	0.5 MΩ variable potentiometer
R2	4.7 KΩ ¼ watt 10% tol.
R3	470 KΩ ½ watt high stability 10% tol.
R4	2.2 MΩ ¼ watt. 10% tol
R5-7	2 MΩ variable potentiometer
R6	100 KΩ ¼ watt 10% tol.
R8	100Ω ¼ watt 10% tol.
R9-11	1.2 KΩ ¼ watt 10% tol.
R10	47 KΩ ¼ watt 10% tol.
R12-13	100 KΩ ½ watt 10% tol.
R14	470 KΩ ¼ watt high stability 2% tol.
R15	270 KΩ ¼ watt 10% tol.
R16	330 KΩ ¼ watt high stability 2% tol.
R17	10 KΩ ¼ watt 10% tol.
R18-19	1 KΩ ¼ watt 20% tol.
R20	220Ω 2 watt wire wound 5% tol.
R21-22	47Ω ¼ watt 20% tol.
R23	1 KΩ 1 watt 10% tol.
R24	150Ω 5 watt wire wound 10% tol.
R25-26	100Ω 5 watt wire wound 10% tol.
R27	550Ω 15 watt wire wound 5% tol.

C1-8	100 mfd. 6 v.wg. Electrolytic	
C2	0.1 mfd. 350 v.wg.	
C3-9-10	0.02 mfd. 500 v.wg.	
C4	5000 pf. 350 v.wg. 10% tol.	
C5	2000 pf. 350 v.wg. 10% tol.	
C6-7	4 mfd. 350 v.wg. Electrolytic	
C11	50 mfd. 25 v.wg. Electrolytic	
C12-13	40 mfd. 350 v.wg. Electrolytic	
T1	Output transformer. Effective primary impedance 5500 (anode to anode). Secondary 0-4-8-15Ω.	
V1	EF37	Mullard
V2	CCH35	Mullard
V3-4	CL33	Mullard
V5	CY31	Mullard

Q.P.P. 1 WATT AMPLIFIER. FIG. 15

This amplifier has been designed to provide a cheap and easy method of obtaining electrical reproduction from gramophone records for the less fortunate members of the radio fraternity who have no mains supply on tap or for those who wish to possess portable equipment for use on the river or for weekends in the country.

The output transformer, T2, should match the loudspeaker to a 16,000 anode to anode load. T1 is a centre tapped 3.5 - 1 audio transformer. If no component of this nature is readily available, an untapped transformer may be used with the modification shown in Fig. 16. It will be seen that the only extra components needed are a pair of 10 K ¼ watt resistors.

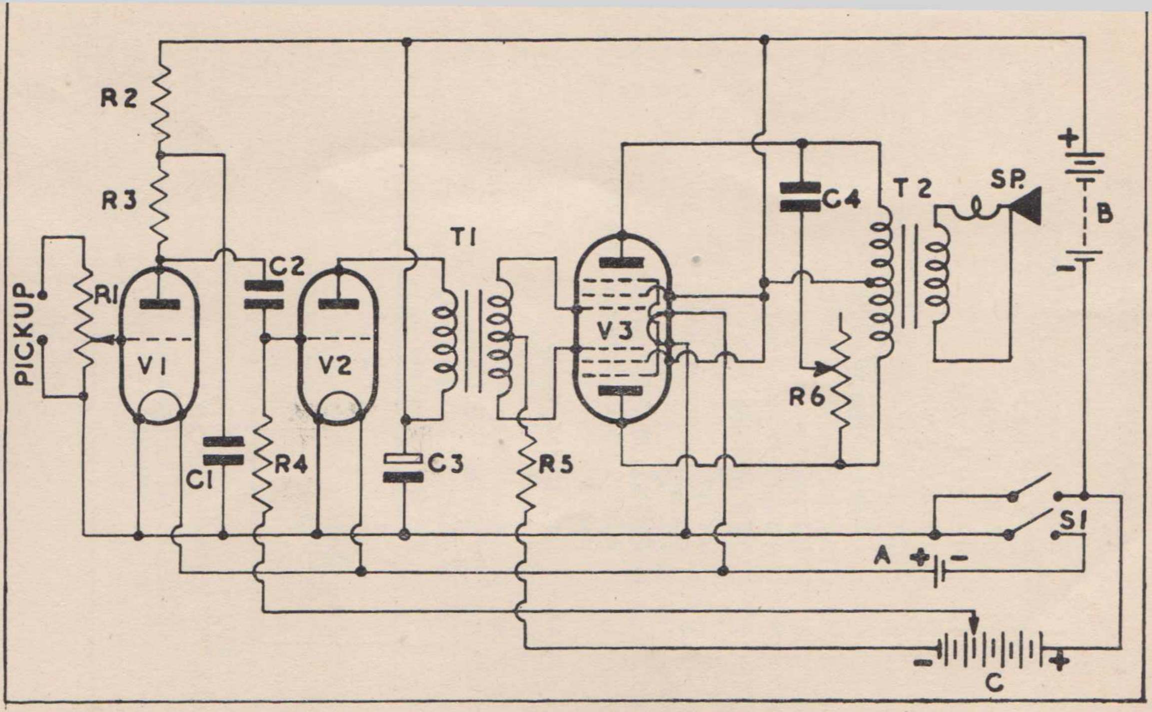


Fig. 15

COMPONENT LIST, FIG. 15

R1	0.25 MΩ variable potentiometer
R2	22 KΩ $\frac{1}{4}$ watt
R3	47 KΩ $\frac{1}{4}$ watt
R4	470 KΩ $\frac{1}{4}$ watt
R5	100 KΩ $\frac{1}{4}$ watt
R6	100 KΩ variable potentiometer (Tone control)
R7	10 KΩ $\frac{1}{4}$ watt (if required)
C1	
C2	0.1 mfd.
C3	8.0 mfd.
C4	2000 pf. mica
T1	See text
T2	See text
S1	D.P.S.T. switch
V1	KBC32 (strap diodes to ground)
V2	PM2A
V3	KLL32 (Mullard)

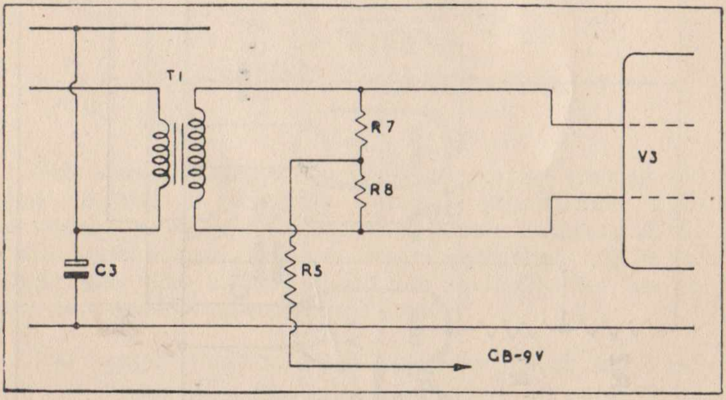


Fig. 16

TRANSMITTING RECORD PLAYER. FIG. 17

This type of player, though popular in America, is still comparatively unknown in England. It has several advantages over the more conventional amplifier and speaker though, of course, a standard broadcast receiver is necessary. Not the least of its advantages is that it can be placed on a table and operated from the comfort of one's fireside while the main equipment can be in another part of the room. The unit, together with turntable and pick-up, can be housed in a wooden box, the lid of which should be well felted to prevent mechanical chatter (a bad fault often found with home-built and the cheaper commercial radio-grams) from spoiling the listening pleasure.

The layout and construction require no comments—almost any form can be adopted. When completed the unit should be switched on and allowed to warm up. The aerial is simply a small piece of wire run from the unit and placed near the receiver; no attempt should be made to use a large aerial, in many cases it is probable that no aerial will be required.

The main receiver should be tuned to a quiet spot between 500 and 550 metres and while a record is being played, adjust C5 until the " transmission " is tuned in. The setting of the capacitor C5 will be almost at maximum. To check the action of the oscillator connect a low-reading m/Ammeter between R6 and the cathode of V1. Leaving R5, C6 undisturbed, a reading will be obtained if the triode section is functioning. Should no results be obtained, reverse the anode coupling winding on L, since the valve can only oscillate when the windings are correctly coupled.

COMPONENT LIST, FIG. 17

L	Wearite "P" coil type P02
C1-4	100 pf. T.C.C. CM20N
C2-3-6	0.1 350 v.wg. T.C.C. 343
C5	500 pf. trimmer (an old tuning condenser may be used)
C7-8	8 + 8 mfd. Ediswan-B.E.C. 71425
R1	47 KΩ ½ watt
R2	33 KΩ ½ watt
R3	68 KΩ 1 watt
R4	1 MΩ ¼ watt
R5	330 Ω ¼ watt
R6	47 KΩ ¼ watt
R7	10 KΩ 1 watt
F	100 m/A fuse and holder
S1	D.P.S.T. switch
T1	Power Transformer. Pri. to suit mains Sec. 250-0-250 v. 30 m/A 6.3 v. 2A. Stewart Transformers.
V1	ECH35 Mullard
V2	EZ35 Mullard

12-15 WATT AMPLIFIER FOR AC OPERATION.

FIG. 18

This amplifier provides two input channels which provide a microphone input and gram. input. This avoids the use of an external mixing amplifier usually necessary with standard home constructed amplifiers. The only critical component is the output transformer which must be of first class design if disappointing results are to be avoided. On the gram. side an input voltage of 1.5 is required and the required microphone input is 15 m/V. If one of the miniature high fidelity pickups is to be used, a preamplifier as described earlier is advisable.

The circuitry and component values of this design are reproduced by courtesy of Standard Telephones and Cables Ltd., London.

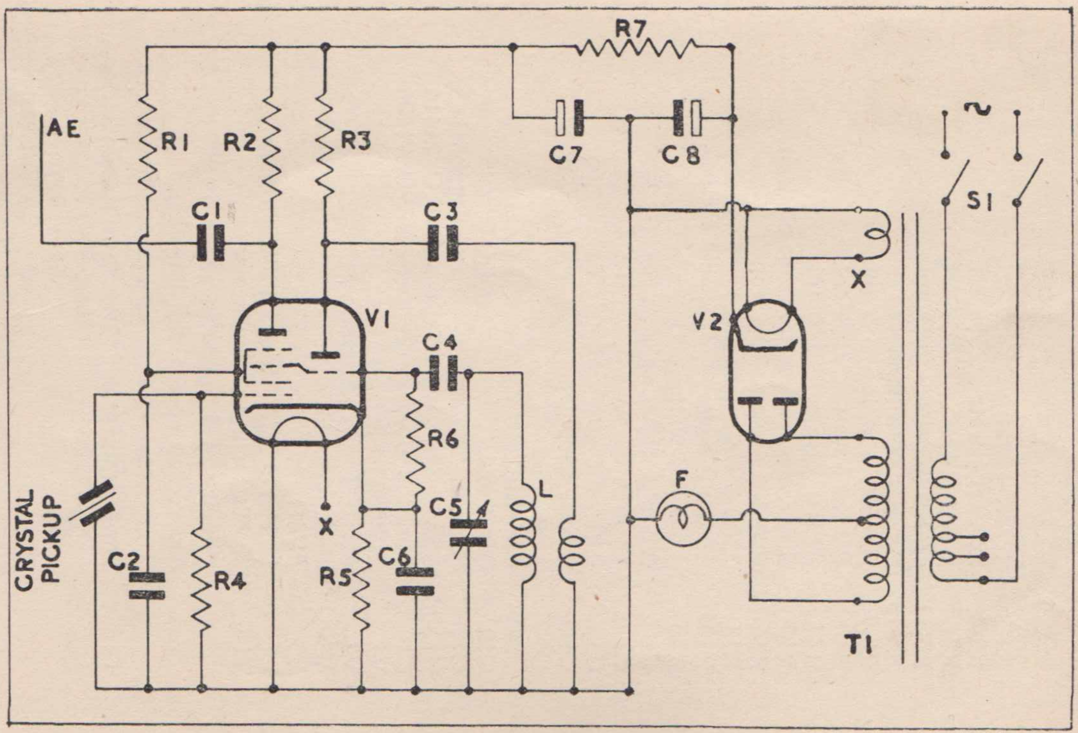
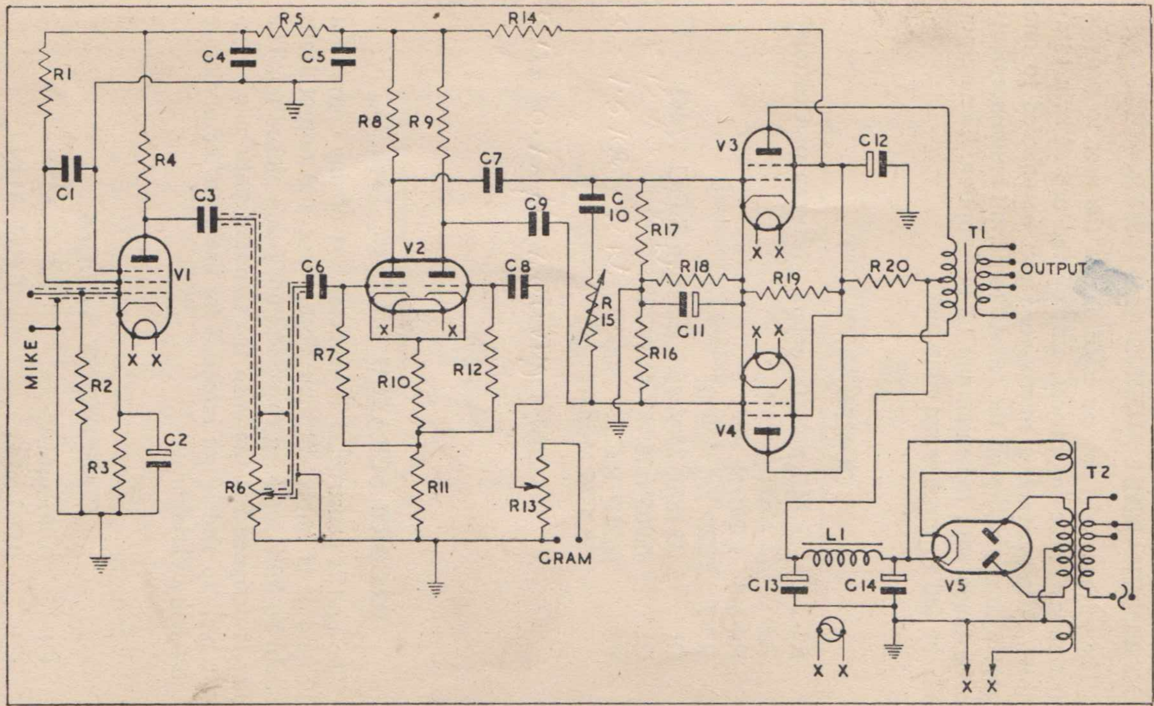

AE
R1
R2
R3
R7
C7
C8
~
S1
C1
C3
V1
C4
V2
X
R6
F
CRYSTAL PICKUP
C5
L
X
C2
R4
R5
C6
T1

Fig. 17

COMPONENT LIST, FIG. 18

R1-7-12	1 MΩ $\frac{1}{2}$ watt	20% tol.	
R2-4	220 KΩ $\frac{1}{2}$ watt	20% tol.	
R3	1 KΩ $\frac{1}{2}$ watt	20% tol.	
R5-11	47 KΩ $\frac{1}{2}$ watt	20% tol.	
R6-13	500 KΩ potentiometer		
R8-9	100 KΩ $\frac{1}{2}$ watt	5% tol.	
R10	2.2 KΩ $\frac{1}{2}$ watt	20% tol.	
R14	22 KΩ $\frac{1}{2}$ watt	10% tol.	
R15	250 KΩ potentiometer (tone control)		
R16-17	220 KΩ $\frac{1}{2}$ watt	10% tol.	
R18	220Ω 3 watts (see note)		
R19	15 KΩ 8 watts		
R20	1.5 KΩ 2 watts		
C1	0.1 mfd. 400 v.wg.		T.C.C. 545
C2	12 mfd. 25 v.wg.		T.C.C. CE31C
C3	0.02 mfd. 400 v.wg.		T.C.C. 545
C4-5	2 mfd. 450 v.wg.		T.C.C. CE18P
C6-7-8-9-	0.01 mfd. 400 v.wg.		T.C.C. 545
C10	0.002 mfd.		T.C.C. 645
C11	50 mfd. 50 v.wg.		T.C.C. CE61D
C12-13	8 mfd. 450 v.wg.		Ediswan-B.E.C. 71416
C14	8 mfd. 450 v.wg.		Ediswan-B.E.C. 71406
V1	6J7G/GT	Brimar	
V2	6SL7GT	Brimar	
V3-4	6V6G/GT	Brimar	
V5	5V4G		
L1	14 H 125 m/A Stewart Transformer		
T1	20 Watt output transformer Primary load anode to anode 10,000 Sec. to suit speech coil impedance Turns ratio = S = speech coil impedance		
T2	Power transformer. Pri. to suit mains Sec. 350-0-350 v. 6.3 v. 3 A 5 v. 2A (Stewart Transformers)		

Note.—The bias resistor value R18 should be adjusted to give 20 volts bias under zero sig. conditions.



R5
R14
R1
C4
C5
R8
R9
R4
C1
C7
C12
V3
C3
C9
C
10
R17
V1
V2
C6
C8
R18
R20
R19
T1
OUTPUT
R
15
C11
MIKE
R7
R10
R12
R16
R2
C2
R3
V4
R6
R11
R13
T2
GRAM
L1
C13
C14
V5
X

Fig. 18

TWIN CHANNEL MIXING AMPLIFIER. FIG. 19

The purpose of this unit is to enable the user to provide continuous music for dances, etc., by the use of twin turntables. Alternatively, a microphone can be coupled to one input with a pick-up on the second to permit announcements to be made with the minimum of interruption. The output may be fed to any normal amplifier.

COMPONENT LIST

R1-2	0.5 MΩ potentiometers. Morgan or Centralab
R3	2.2 KΩ ½ watt
R4-6-8	1 MΩ ½ watt
R5-7	220 KΩ ½ watt
C1	25 mfd. 25 v.wg. Ediswan-B.E.C. 71441
C2	0.005 mfd. T.C.C. 743
V1	6SL7 R.C.A., etc. ECC35 Mullard

Design reproduced by courtesy of R.C.A.

RECORD SCRATCH FILTER. FIG. 20

The unit is constructed in a metal box of any convenient size and it is important that both input and output leads should be fully screened to avoid hum being picked up. The filter is designed for use with the standard pattern of magnetic pick-up and is not intended for use with the miniature high-fidelity variety.

COMPONENT VALUES

C1	0.001 mfd.	T.C.C. M2N
C2	0.003 mfd.	T.C.C. M3N
R1-2	680 KΩ ¼ watt	

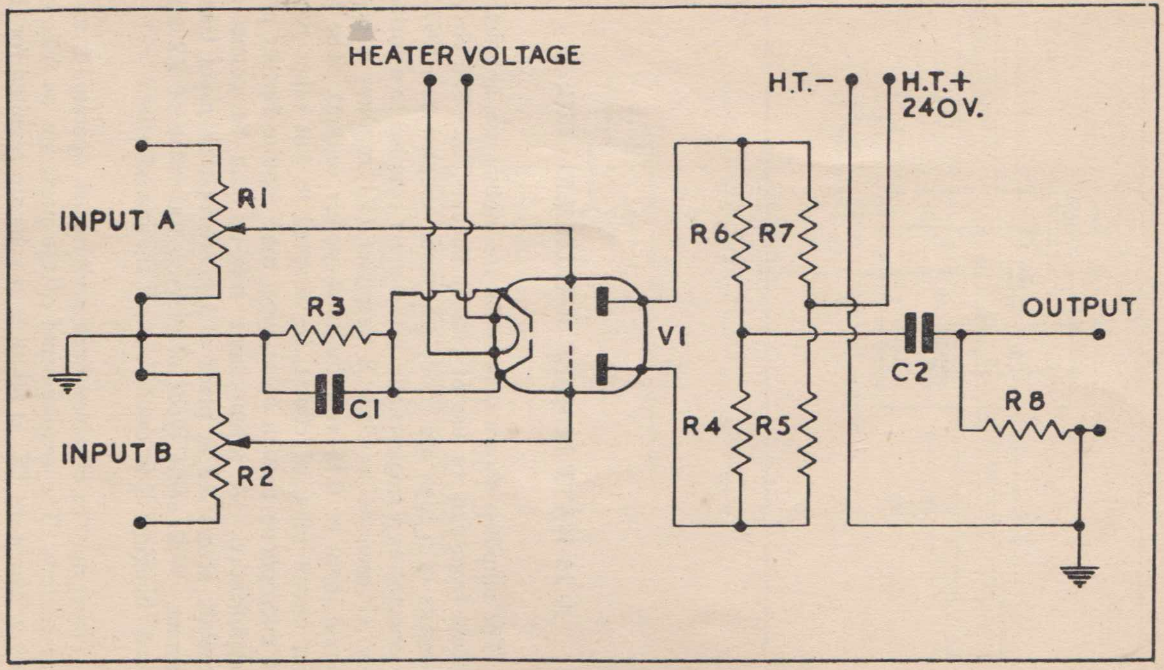

HEATER VOLTAGE
H.T.−
H.T.+
240V.
INPUT A
R1
R3
C1
INPUT B
R2
V1
R6
R7
R4
R5
OUTPUT
C2
R8

Fig. 19

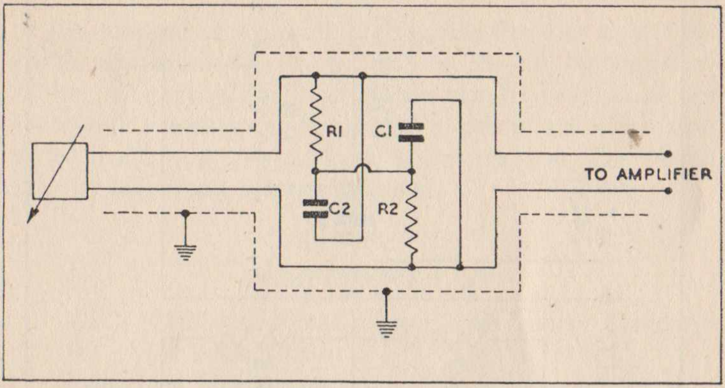


Fig. 20

A 10 WATT MOBILE AMPLIFIER. FIG. 21

The amplifier shown is intended for mobile use, announcements from cars or use at charity bazaars, etc. The circuit consists of a high mu triode resistance coupled to a 6N7/G connected as a single triode, transformer coupled to a further 6N7/G used as a Class B amplifier (V1 requires a peak signal input of 0.15 volt for max. power output). The input circuit may, of course, be adapted to suit other types of microphone though some types may require further pre-amplification. A gramophone pick-up can be connected directly across R2 in place of the microphone input transformer. With some types of pick-up the value of R2 may need changing; if in doubt consult the manufacturer.

Power may be obtained from a vibropack operated from a car battery. The requirements of the pack are as follows: 300 v. smoothed DC at 80 m/A; 6 volts are required for the valve heaters.

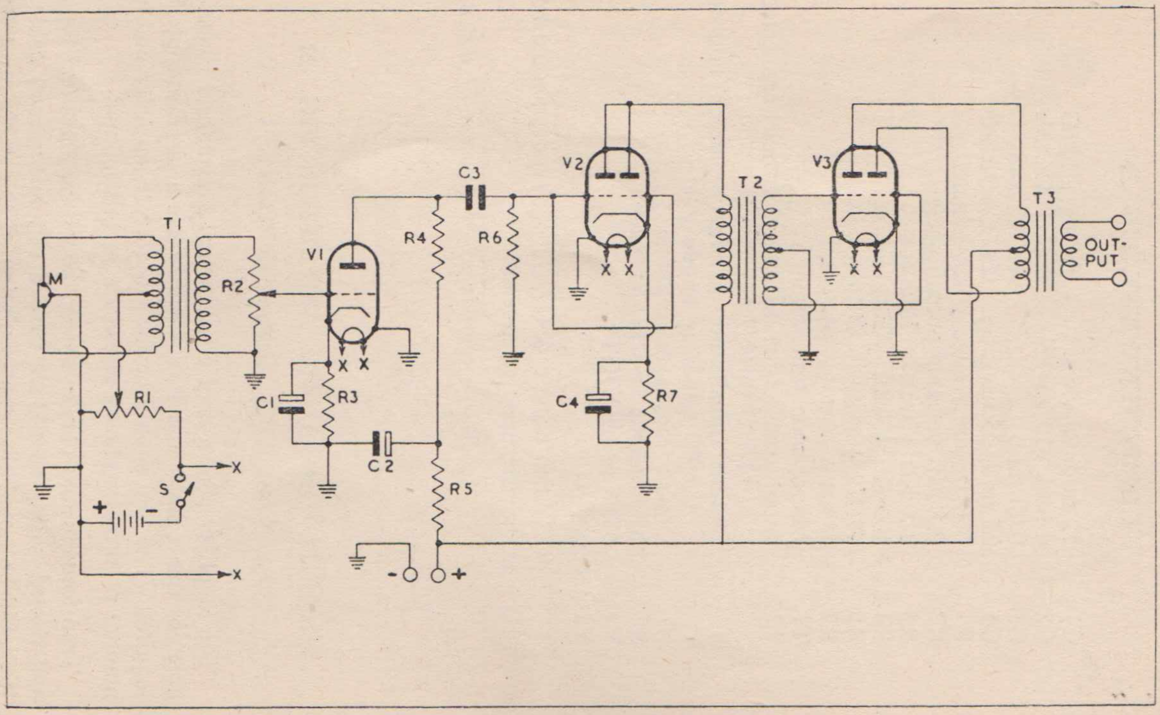


Fig. 21

COMPONENT LIST, FIG. 21

C1	12 mfd. 25 v.wg.	T.C.C. CE31C
C2	4 mfd. 350 v.wg.	T.C.C. CE18L
C3	0.02 mfd.	T.C.C. 543
C4	25 mfd. 25 v.wg.	T.C.C. CE32C
R1	500 Ω wire wound potentiometer	
R2	0.5 MΩ variable potentiometer	
R3	1.5 KΩ ½ watt	10% tol.
R4-6	100 KΩ ½ watt	20% tol.
R5	47 KΩ ½ watt	20% tol.
R7	1 KΩ ½ watt	10% tol.
T1	Microphone transformer	
T2	Input transformer to match parallel-connected 6N7/G to 6N7/G Class B.	
T3	Output transformer to match speech coil to 8000 anode to anode load	
M	Double button microphone	
S	Microphone and heater switch	
V1	6SF5 or 6SQ7/GT*	
V2-3	6N7/G	

* When using a 6SQ7/GT the diodes should be strapped to ground.

Design reproduced by courtesy of R.C.A.

HIGH POWER AUDIO AMPLIFIER, FIG. 22

Class AB2. Output 45 Watts

The amplifier shown is of conventional design, and is suitable for dance halls and P.A. work where a large output is required. The 6F6 should be fed from a pre-amplifier and a number of these is shown elsewhere in this manual.

Transformers and chokes should be of the shrouded type and dotted wiring should be carried out in screened cable. It should be noted that the insulation of this cable must be able to withstand the full H.T. voltage of the amplifier and

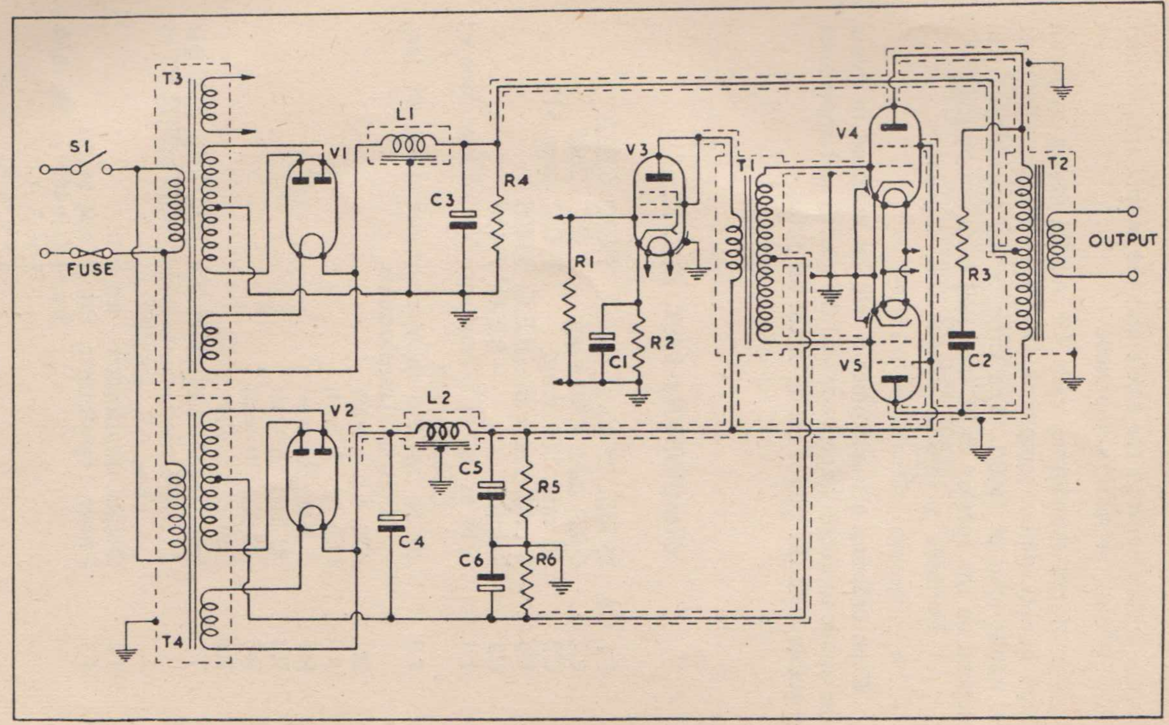

S1
FUSE
T3
T4
V1
V2
L1
L2
C3
R4
C4
C5
C6
R5
R6
V3
R1
C1
R2
T1
V4
V5
R3
C2
T2
OUTPUT

Fig. 22

in the wiring between the 6L6's and the output transformer there is also the audio component.

The output transformer calls for careful design as in all high quality audio equipment, the 6L6's require an anode to anode load of 3800Ω. The ratio of the transformer will depend on the speaker to be used and is shown by the

Formula $\sqrt{\frac{3800}{S}}$ S = speech coil impedance.

When ordering a transformer it will be sufficient to quote the anode to anode impedance and the speech coil impedance together with the power rating of the amplifier.

COMPONENT LIST, FIG. 22

C1 C6	25 mfd. 25 v.wg.	T.C.C. CE32C
C2	0.025 mfd. 1500 v.wg.	T.C.C. 2045
C3	16 mfd. 500 v.wg.	T.C.C. type 512
C4	8 mfd. Ediswan—B.E.C. 71406	
C5	8 mfd. „ —B.E.C. 71416	
L1	5 H. at 250 m/A resistance 50Ω or less. Stewart Transformers	
L2	20 H. at 150 m/A resistance 100Ω or less. Stewart Transformers	
R1	470 KΩ ½ watt	
R2	650 Ω ½ watt	
R3	5 KΩ 20 watt	
R4	50 KΩ 5 watt	
R5	3.5 KΩ 30 watt	
R6	200 Ω 5 watt	
T1	Interstage transformer for matching a single 6F6 triode connected to push-pull 6L6's as class AB_2 amplifiers	
T2	Output transformer—see text.	
T3	Power Transformer. Pri. to suit mains Sec. 440-0-440 v. 200 m/A 5 v. 3 A. 6.3 v. 4 A. Stewart Transformers	

T4	Power Transformer. Pri. to suit mains. Sec. 315-0-315 v. 150 m/A. 5 v. 3 A. Stewart Transformers
V1	5V4G (Brimar)
V2	5U4 U52 (Osram)
V3	6F6/G KT63 (Osram)
V4-5	6L6/G KT66 (Osram)

Design reproduced by courtesy of R.C.A.

BERNARDS RADIO BOOKS

37.	Manual of Direct Disc Recording	2/-
42.	Shortwave Radio Handbook	2/-
43.	Modern Radio Test Gear Construction ...	1/6
44.	Radio Service Manual	2/6
45.	Radio Reference Handbook	12/6
48.	Radio Coil and Transformer Manual	2/-
52.	Radio Tuner Unit Manual	2/6
53.	Radio Constructors' Manual	3/-
54.	Radio Resistor Chart	1/6 & 1/-
55.	Handbook of Radio Circuits No. 2	2/6
56.	Radio Aerial Handbook	2/6
57.	Ultra Shortwave Handbook	2/6
58.	Radio Hints Manual	2/6
59.	Television Construction Manual	3/6
60.	Radio Repairs Manual	2/6
61.	Amateur Transmitters' Construction Manual...	2/6
62.	Car and Portable Radio Constructors' Manual	2/6
63.	Radio Calculations Manual	3/6
64.	Sound Equipment Manual	2/6
65.	Radio Designs Manual	2/6
66.	Communications Receivers' Manual	2/6
67.	Radio Valve Equivalents Manual	2/6
68.	Frequency Modulation Receivers' Manual ...	2/6
69.	Radio Inductance Manual...	2/6
70.	Loudspeaker Manual	2/6
71.	Modern Battery Receivers' Manual	2/6
72.	Experimental Circuits Manual	2/6
73.	Radio Test Equipment Manual	2/6
74.	Radio Valve Applications Manual	5/-
75.	International Radio Tube Encyclopædia ...	42/-
76.	Radio Anti-interference Manual	2/6
77.	Walkie-talkie Construction Manual	2/6
78.	Radio and Television Laboratory Manual ...	2/6
79.	The Radio Modernisation Manual	3/6
80.	Television Servicing Manual	4/6
81.	Using Ex-Service Radio Apparatus	2/6
82.	AC/DC Receiver Construction Manual... ...	2/6
84.	International World Radio Station List ...	1/6
85.	Miniature Radio Equipment Construction Manual	2/6
86.	Midget Radio Construction Manual	2/6
87.	The Oscilloscope: Design and Construction...	2/6
88.	Wire Recorder Construction Manual	2/6
89.	High Definition Television Construction Manual	3/6
	Ham Notes for the Home Constructor (Nos. 1 to 4) ea.	1/-

In Preparation

Radio Instruments and their Construction
An Introduction to "Ham" Radio
Circuits Manual No. 3
Handbook of Audio Designs
Low Frequency Equipment Manual
Valve Data Manual
Ham Notes (continuation of series)