HIGH FIDELITY RADIO

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AC/VP1, L1-L2 should be mounted under the chassis on the rear apron near the aerial terminal and the position of V1 arranged so that the lead between grid and coil is kept short, L3-L4 is mounted above the chassis close to V1. Should the valve chosen have a top grid such as a VP4B or EF39, a more practical layout is obtained by mounting L1-L2 above the chassis and L3-L4 below. It is probable that some reduction in the number of turns will be necessary on each coil to compensate for the increased inductance due to the absence of the cans. A much neater layout is obtained by using screening cans, and there is less risk of instability. The coils may be mounted side by side and in line with the tuning condenser.

2. *The Low Frequency Amplifier.*—The quality seeker has here a choice between three kinds of amplifier, and it is proposed to describe each type in detail.

Fig. 2 gives a representative form of the "push-pull" method now enjoying considerable popularity in radio circles. The first stage and phase-splitter are combined within a single valve, a 6SN7. If so desired two separate valves such as 6J5's or L63's could of course be used. Because the anode of V2A is connected directly to the grid of the succeeding stage, no grid leak is required for this latter valve. The anode of the first valve must, of course, be de-coupled by means of a resistor and by-pass capacitor, as in the case of the phase-splitting stage. It will be seen that the phase-splitter passes the signal on to the first push-pull stage (V3A-B) via blocking condensers, and this stage in turn is similarly coupled to the push-pull output stage. A balancing potentiometer ensures the correct adjustment of the penultimate stage so that V3A-B function in opposite phase, whilst a potentiometer adjusts the cathode bias voltage to the output valves.

COMPONENTS LIST, FIG. 2

R1	100 Ω pot.
R2	470 Ω
R3-10-11	47 kΩ
R4	33 kΩ
R5-6-7	22 kΩ
R8-9	470 kΩ 10%
R12	25 kΩ pot.
R13	390 Ω
R14-15	270 kΩ 10% tol.
R16-17	1 kΩ
R18-19	100 Ω
R20	1 kΩ pot. wire wound
R21	4.7 kΩ 2 watt
R22	$\frac{1{,}200\Omega}{\sqrt{\text{Speech coil impedance}}}$

R23	220kΩ 2 watt
V2-3 A-B	6SN7GT Brimar
V4-5	PX4 Osram
C1-2-5	8 μF 350 v. electrolytic
C3-4	0.1 μF 350 v.
C6-7	0.25 μF 350 v.
C8-9	50 μF 50 v. electrolytic
T1	Output transformer to match 4,000 Ω load to speech coil
2	International Octal valve-holders
2	British 4-pin valve-holders

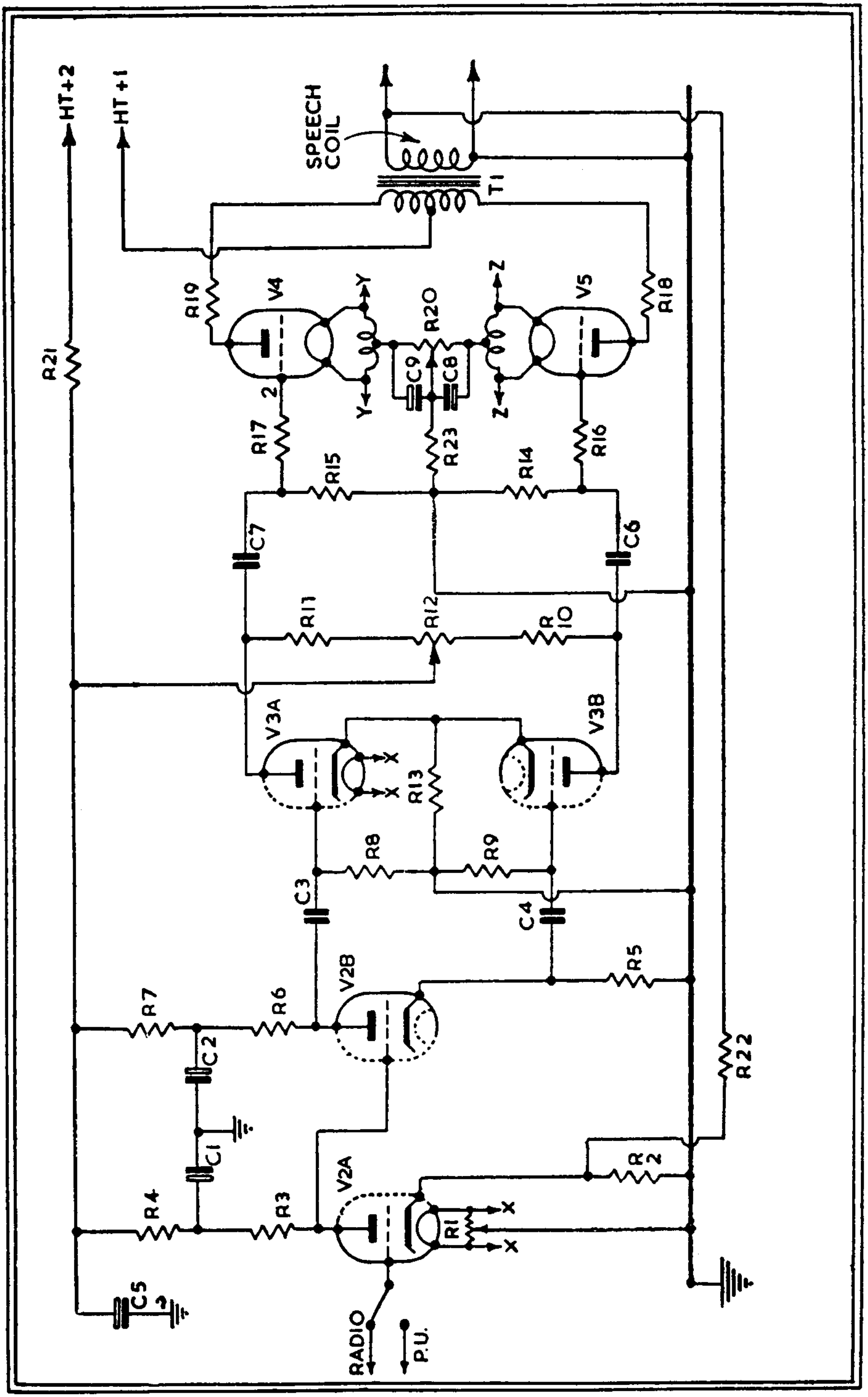

FIG. 2.—*A Push-Pull Amplifier.*

Negative feed-back is applied from the secondary winding of the output transformer to the cathode of the first L.F. valve via the resistor R22, the value of which can be worked out from the formula given in the components list. The undistorted output from the two PX4 valves is ten watts.

This method of amplification can undoubtedly claim certain distinct advantages over others, chief of which are the following:

(*a*) The maximum degree of undistorted output in watts can be delivered to the loudspeaker with the minimum amount of voltage supply from the high tension source; for example, using a couple of KT66 beam tetrodes in push-pull output on 400 volts and passing 60 milliamperes on each valve, it is possible to obtain an undistorted output of 50 watts. Two DA250 valves in push-pull can dissipate 800 watts! For abnormally big outputs such as are required for large halls, to say nothing of open spaces, this method of amplification is essential.

(*b*) Another advantage is the elimination of direct current from the primary winding of the output transformer, thus reducing to a minimum the risk of "core magnetisation."

(*c*) Further, a high percentage of negative feedback can be applied to the whole of the amplifier (as shown in Fig. 2), so that background noise as well as harmonic distortion can be reduced to a negligible degree. In the present stage of radio research no alternative system of amplification would appear to be available for the provision of very large undistorted outputs required for feeding banks of loudspeakers in connection with talkie films, public relay systems and electronic organs. Whether it is the best method of amplifying rectified signals in the home receiver is another question, since it does not completely solve the problem of reproducing the *higher* audio frequencies.

The second method of amplification is that shown in Fig. 3A. This is known as the "direct coupled amplifier" because the anodes of the valves are in each case directly connected to the grids of the succeeding valves instead of by means of a blocking condenser and grid leak. This means that the anode voltage of, say, V2 is applied to the grid of V3, and in order that the grid of V3 may be correctly biased, its cathode must be given a positive voltage in excess of that applied to the grid.

In this amplifier V3 is directly coupled to the output valves (V4, V5), and the latter are correctly biased by making their heaters positive in respect of the grids. There are various ways of direct coupling that may be used, but this amplifier has been specially designed—indeed it has passed through several stages of evolutionary development—to solve the sound problems described in Chapter Two from the musician's point of view. The salient features of the circuit will now be dealt with seriatim:

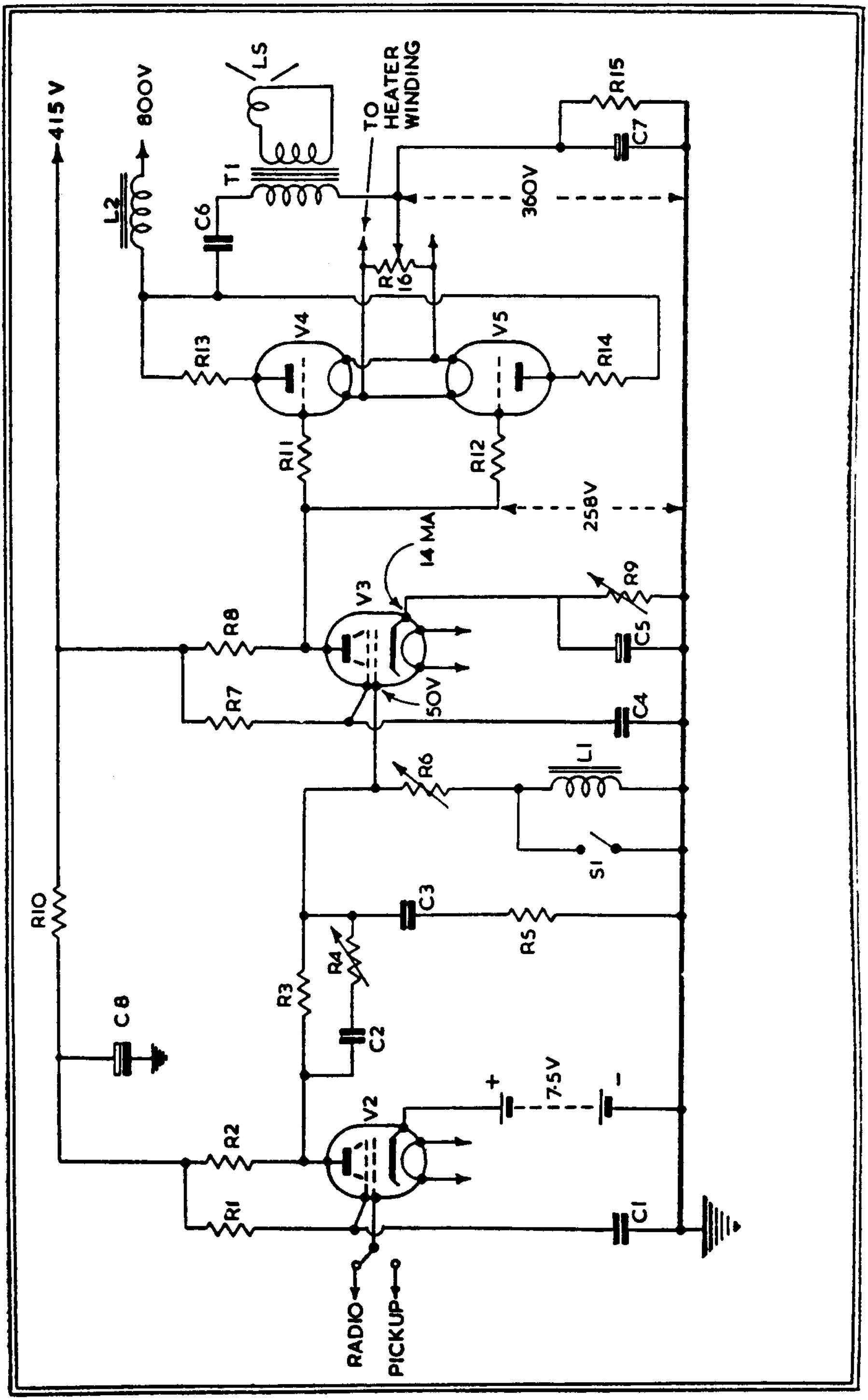

FIG. 3A.—*The Direct Coupled Amplifier.*

COMPONENTS LIST, FIG. 3A

R1	150 kΩ 10%	C1-4	1 μF
R2	15 kΩ 3 w. 10%	C2	0.01 μF
R3	39 kΩ	C3	0.05 μF
R4	1 MΩ pot.	C5	16 μF 150 v. electrolytic
R5	8.2 kΩ 10%		
R6	25 kΩ pot.	C6	8 μF 500 v.
R7	100 kΩ 10%	C7	24 μF 450 v. electrolytic
R8	12 kΩ 3w 10%		
R9	5 kΩ pot.	C8	16 μF 450 v. electrolytic
R10	7.5 kΩ 2 w. (2, 15 kΩ 1 watt in parallel) 10%	L1	200 H. 3 mA
		L2	40 H. 120 mA
R11-12	22 kΩ 10%	T1	To match speech coil to 3,000 Ω load
R13-14	100 Ω		
R15	3 kΩ 75 w.	V2-3	MKT4, KT63, etc. Osram
S1	S.P. Switch		
		V4-5	DA30 Osram
			Valve-holders to suit types selected

(*a*) In order to "drive" the output stage efficiently it is necessary to employ a tetrode of the MKT4 class (or KT63), and in addition to the high amplification factor required there is the great advantage of the reduction of the "Miller effect" on the upper audio-frequencies due to the screen-grid, thus ensuring an increased liveliness in the reproduction. The first L.F. valve may be either a tetrode or a triode, but if the latter it must have a high amplification factor and a small grid swing; a valve of the AC/HL type is quite suitable, with 3 volts positive cathode bias and passing 4 to 4.5 mA on its anode. Although a tetrode is shown in Fig 3A the triode is recommended, as there is less likelihood of pick-up hum. If a triode is used, R1-C1 are omitted, R2 increased to 47 kΩ ½ w and the cathode bias reduced to 3 volts.

(*b*) The coupling of V2 to V3 differs from the more usual form of direct coupling in that the voltage applied to the grid of V3 is controlled by means of a resistor. One good reason for this is that it enables the designer to employ a suitable high tension voltage feed to the first stage in relation to the second. If the anode of the first L.F. valve (V2) were directly connected to the grid of the second (V3) with no resistance leak between grid and earth (as between V3 and output), the anode potential of V2 would have to be of some 50 volts only, or else that of V3 would have to be supplied from a much higher voltage source in order to balance the stages correctly. The difficulty is avoided by introducing a resistor, R6, which drops the voltage applied to the grid of V2 to the required value. In addition to this signal advantage there is an even greater one—the effect on the quality of reproduction. "Direct resistance coupling," as I call it, is responsible for the really beautiful upper frequency reproduction that characterises this amplifier, so clear and sweet and "peak-free." One has only to insert a blocking condenser (say 0.1 mfd.) between anode and grid to realise the difference in effect between resistance capacity and direct resistance coupling, making, of course, the necessary changes to grid and cathode resistance to suit either coupling. The optimum value of the grid resistor (R6) is some 22 kΩ in Fig. 3A and 62 kΩ in Fig. 3C. The cathode resistor, R9, is adjusted to suit, so that the correct anode currents may be passed on V3, V4 and V5. The choke shown in series with the grid resistor is intended to be switched in circuit if an increased bass lift is required, as for instance with certain types of gramophone pick-up and for certain records.

(*c*) The coupling of V3 to the output stage is direct, as already explained. Thus, the grids of the two DA30 valves are made negative in respect of the heaters or cathode by applying 360 volts at 120 milliamperes to the latter through the bias resistor of 3,000 ohms (R15). Since the voltage between anode of V3 and earth is 258 volts, it is necessary to add 102 volts (representing the negative grid volts required for V4-V5) to this voltage of 258 by means of the cathode resistor R15. The actual voltage at the anode of V3 will be 258 minus the volts dropped through R9: if the latter is 4,800 ohms, the voltage applied to the cathode of V3 will at 4 milliamperes be approximately 67, thus the anode/cathode voltage is 191. The exact voltage applied to the cathode can be obtained by adjusting the variable resistor R9. (Note the current passed through R9 = the anode current + the screen current.) The voltage applied to the grid of V3 must, of course, be less by 10 volts and is determined by the value of R6.

(*d*) Three stages of amplification have been chosen for the amplifier for the following reasons: (1) undue amplification at any one stage is avoided—an important proviso where smooth cascading is desired with a view to eliminating peaks in the frequency spectrum; (2) it would be difficult in any case to load the DA30 output stage with a single driver stage; (3) an opportunity is provided of introducing correction network into the amplifier. The only place where this can be done without upsetting the general design is between the first and second stages. If introduced before the first stage the output from V3 is not sufficient to load the DA30 valves, while it is impossible to insert the network in the coupling of V3 to the DA30 valves. Another reason for employing a third stage is that only by doing so is it possible to ensure that all-important quality of *liveliness* which is a prominent feature of this amplifier's performance. It will be noticed that in place of the more usual automatic bias resistance and shunt condenser there is a battery in the cathode circuit of V2.

This battery bias is essential to good results, since if a cathode resistor is employed it must be shunted by a large capacity condenser, and this condenser exercises a coupling effect with the automatic bias circuit of V3. The effect of this latter arrangement on frequency separation—another exceptional feature of the amplifier—is disastrous and must be avoided at all costs. The battery is on charge while the amplifier is in use, so that it can be depended on to last for quite twelve months without needing replacement. The frequency correction network is not new: it has been employed in various gramophone amplifiers for the purpose of boosting the lower frequencies in particular. There is incorporated, however, a "treble control" which is extremely useful. The network comprising R3, R4, C2 is responsible for the control of the frequencies above 1,000 c.p.s., while the network R5, C3 gives the requisite degree of bass lift both for record playing and for varying conditions of wireless reception. The theory underlying tone-correction filters is explained in Appendix II, to which the reader is referred. In Figs. 3B and 3C other filtering arrangements are given.

In the circuit of Fig. 3B, bass control is effected by the network C3-R5-R7 instead of the choke L1 and R6 of Fig. 3A. The top register is controlled by C2-R4 as before. For many readers this circuit will provide sufficient range of control and the expense of the choke is avoided. The circuit of Fig. 3C is a combination of Figs.

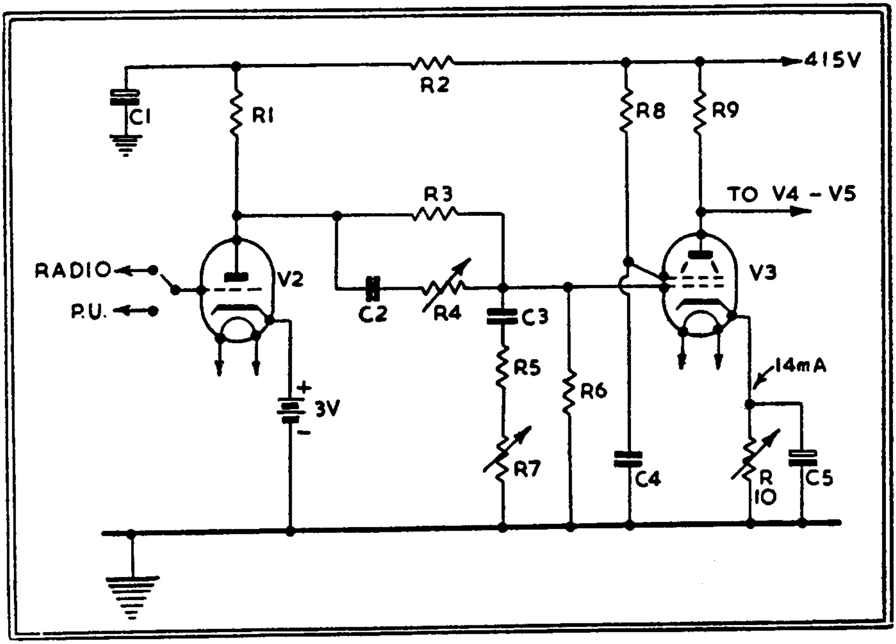

FIG. 3B.—*A Triode Input Stage.*

3A and 3B and is particularly suitable for general purpose amplification in the home. In a small room the overall volume level of the reproduction is such as to necessitate the use of both bass and treble filters in combination in order that the registers may be properly balanced in relation to each other and realism be obtained. The characteristic curve of the amplifier gives the necessary attenuation of the middle register with a fairly steep rise below 400 c.p.s. and a variable modification up or down of the frequency band above 1,000 c.p.s. Certain types of pick-up will require the full bass boost, including the choke there shown in series with R5. If the condenser C2 is reduced to 0.01 μF, the bass lift is too great for most pick-ups and is apt to produce "thuddy" effects even with the choke omitted. The piezo-electric or crystal pick-up, of course, requires no bass correction; the natural resonances produced by this type of pick-up have to be neutralised by a special network which the makers are always pleased to supply. The choke referred to is best of the radio-metal type and its inductance should not be less than 200 henries

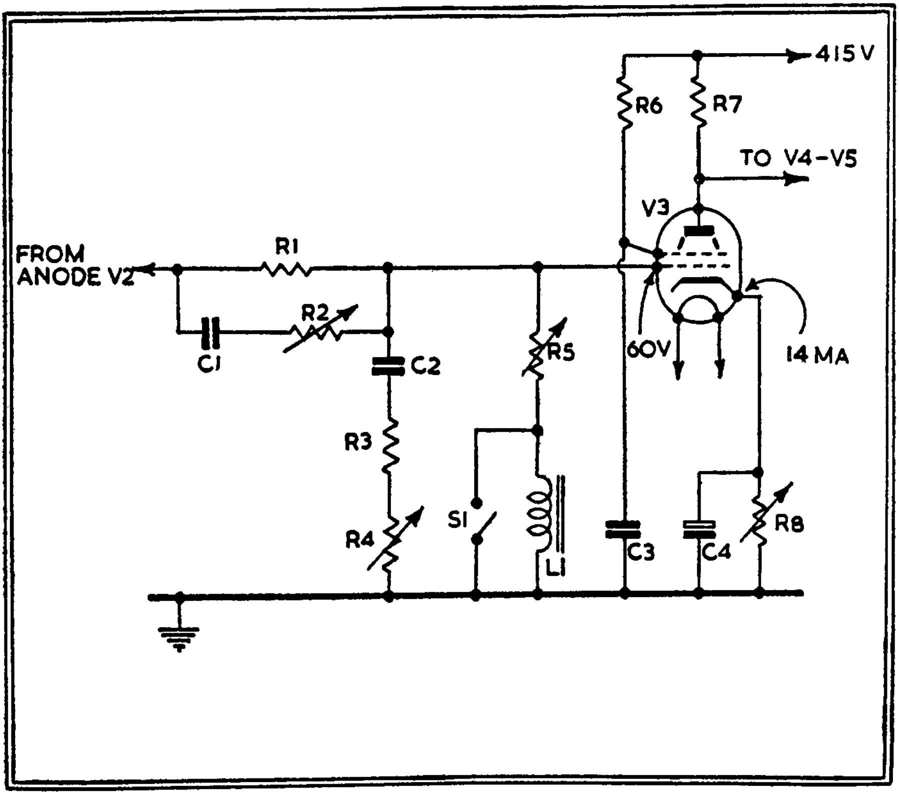

FIG. 3C.—*Alternative Tone Control Constants.*

COMPONENTS LIST, FIG. 3B

R1	47 kΩ 10%	C1	16 μF 350 v. electrolytic
R2	33 kΩ 10%	C2	1,000 pF mica
R3	120 kΩ	C3	0.02 μF
R4	1 MΩ pot.	C4	1 μF
R5	10 kΩ	C5	16 μF 150 v. electrolytic
R6-8	100 kΩ 10%	V2	AC/HL Mazda or EBC 33 Mullard
R7	25 kΩ pot.	V3	MKT4 Osram or 6F6G Brimar
R9	12 kΩ 10%		Valve-holders to suit
R10	5 kΩ pot.		

COMPONENTS LIST, FIG. 3C

R1	120 kΩ	C1	1,000 pF mica
R2	1 MΩ pot.	C2	0.02 μF
R3	10 kΩ	C3	1 μF
R4	10 kΩ pot.	C4	16 μF 150 v. electrolytic
R5	100 kΩ pot.	V2	MKT4 Osram, 6F6G Brimar, etc.
R6	100 kΩ		
R7	12 kΩ 10%	L1	200 H. 1 mA
R8	5 kΩ pot.	S1	S.P. Switch

when a current of 2.3 milliamperes is passing through its windings.

There remains the coupling of the output stage to the loudspeaker voice coil. (See also Appendix I, note 15.) It will be observed that the transformer is choke-coupled and not directly fed from the output valves. There is a good reason for this arrangement. Transformer cores do not like direct current, and in a single or a parallel output stage it is far better to use a good sectionally wound choke winding to take the current instead. C7 is the *only* coupling capacitor in the whole of the amplifier and is of large capacity in order to ensure a suitable "time-constant." A high inductance choke is essential for preserving the low frequencies. The matching transformer needs no special description, since there are a number of manufacturers who are able to supply a first-class component of correct design. Either the silicon core type or the radiometal type may be employed. The optimum ratio of step-down between primary and secondary windings in order to match the output load impedance to the impedance of the voice coil of the loudspeaker is determined by the well-known formula:

$$\text{Ratio} = \sqrt{\frac{\text{optimum load}}{\text{coil impedance}}} \quad \text{at 400 c.p.s.}$$

A 3,000 ohm load is required, and for a voice coil impedance of

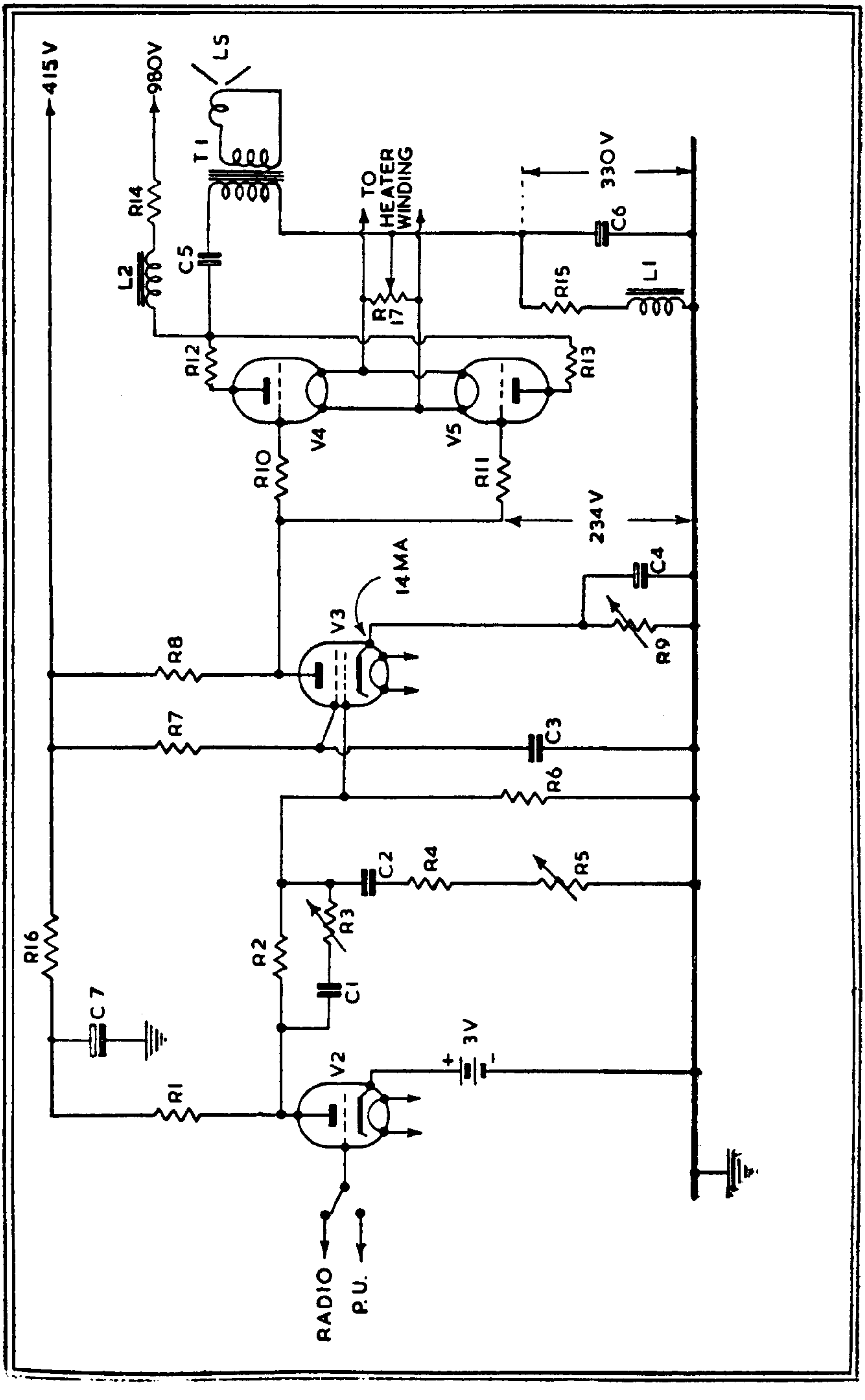

FIG. 4.—*The De Luxe Direct Coupled Amplifier.*

30 ohms, the ratio will be 10 : 1. For a 15 ohm coil it will be 14 : 1, and for a 3.5 ohm coil 29 : 1. When two loudspeaker units are coupled in parallel, the formula is

$$\text{Ratio} = \sqrt{\frac{\text{optimum load}}{\frac{1}{2}\text{ coil impedance}}}$$

so that two 3.5 ohm coils in parallel will be matched by a transformer giving a step-down ration of 41.5 : 1 (say 40 : 1).

A further question arises: Should the matching transformer be placed with the amplifier or with the loudspeaker? The answer is that with a choke-fed transformer the choke should obviously be placed close to the output valves, while the transformer should be placed close to the loudspeaker coil, and this is even more important if two speaker units are used and placed near to one another.

An alternative design is shown in Fig. 4. It represents the result of numerous experiments carried out since Fig. 3A was designed. The H.T. supply to the output stage has been increased and a choke included in the heater return, also a certain amount of resistance is included in the anode circuit of the output valves. This circuit represents the most modern advancement of the direct coupled amplifier to date, and for critical high fidelity enthusiasts is probably the finest of its type that can be constructed. Due to the higher voltage required from the power pack, construction cost is higher but the results obtained fully justify the extra expenditure involved.

For those who do not wish to go to the expense of the amplifiers shown in Figs. 3A and 4 a simpler version is shown is Fig. 5. A single ended output stage is used, essentially a triode, and either a Mazda V503 or an Osram DA30 may be used. The former is strongly recommended on account of its exceptional characteristics. Its impedance is 425 Ω and optimum load 2,000 Ω.

COMPONENTS LIST, FIG. 4

R1	47 kΩ 10%	C1	1,000 pF
R2	120 kΩ	C2	0.02 μF
R3	1 MΩ pot.	C3	1 μF
R4	10 kΩ	C4	16 μF
R5	25 kΩ pot.	C5	8 μF
R6-7	100 kΩ 10%	C6	4 μF
R8	15 kΩ 10%	L1-2	40 Henry 120 mA
R9	5 kΩ pot.	V2	AC/HL Mazda
R10-11	22 kΩ 10%	V3	KT41 or MKT4 Osram
R12-13	100 Ω	V4-5	DA30 Osram, V503 Mazda
R14	1.5 kΩ 100 w.		
R15	2.5 kΩ 100 w.	T1	To match speech coil to 3,000 Ω load
R16	33 kΩ 10%		
R17	100 Ω pot.		Valve-holders to suit types selected

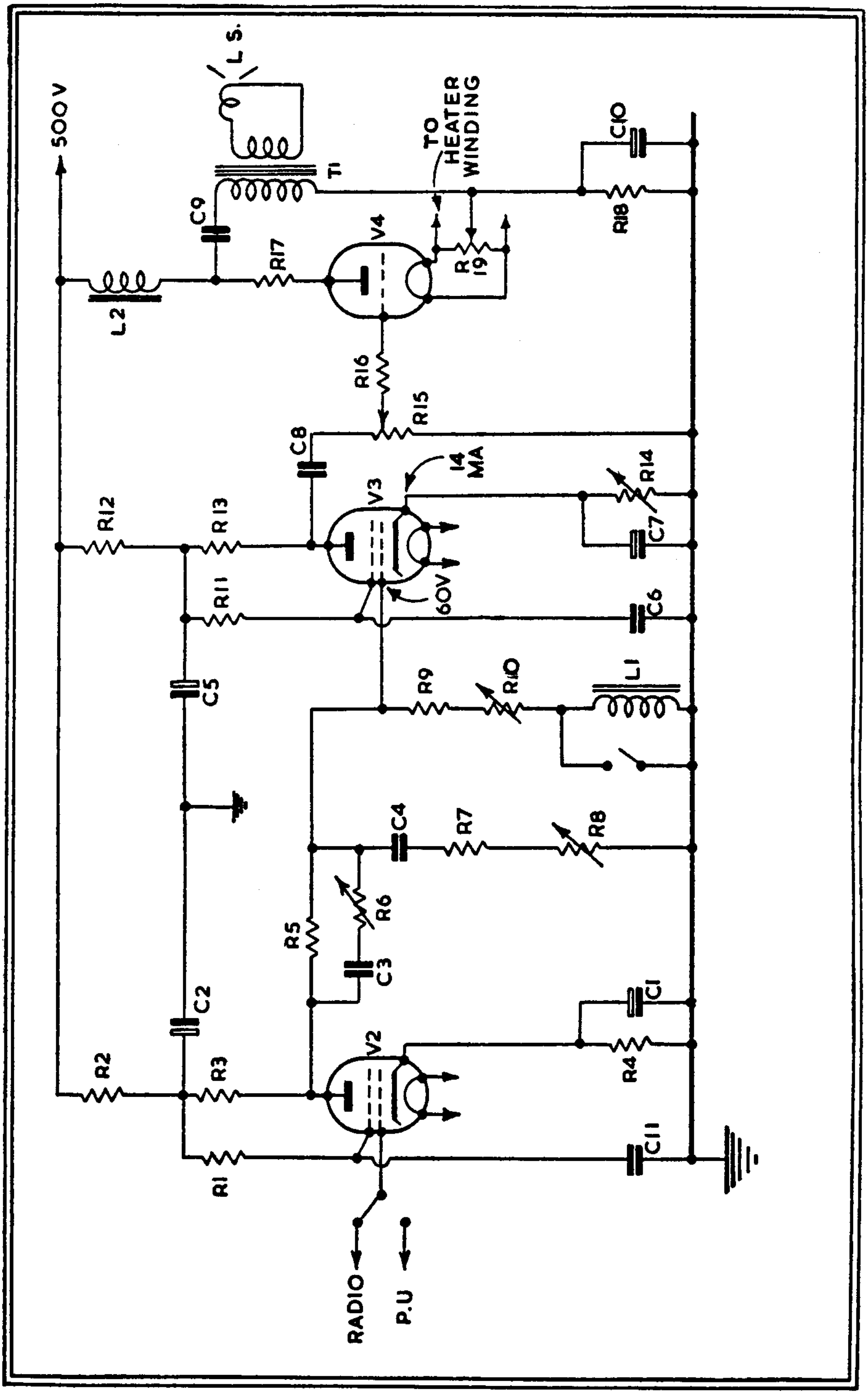

FIG. 5.—*A Modified Version of Direct Coupled Amplifier.*

In this circuit arrangement the valve is operated at an anode-cathode potential of 400 volts, the required negative grid bias of 85 volts is obtained automatically across R18. An output power of 7 watts may be obtained. Normal R.C. coupling is used between V3 and V4 mainly to permit a lower voltage supply to be used, which of course is cheaper to construct.

There is a third type of amplifier which can give excellent results. Its principal feature is the novel method of coupling the output stage to the loudspeaker. Instead of feeding the latter from the anode of the output valve, the coupling is taken from the *cathode* of this valve; in other words, the valve is employed as a " cathode follower." The advantages from the high quality aspect of a low impedance output stage have already been indicated, and here we have an instance of a valve functioning as a carrier rather than as an amplifier of the speech frequencies. Distortion due to non-linear amplification at this particular stage is thus minimised. The circuit of this amplifier is given in Fig. 6. There are only two stages and the driver stage is responsible for the amplification of rectified signals as well as for loading the output valve. The latter must, of course, be able to handle the input without excessive harmonic distortion, therefore two PX4 type valves in parallel are chosen. The first L.F. valve must obviously have a higher amplification factor than the power tetrode, and a suitable valve for this purpose is the EF37A pentode (or its equivalent). The value of the anode load resistor has been most carefully chosen to suit the amplifying characteristics of this particular valve, so that its output may be linear up to at least 20 kc.s as indicated on an oscilloscope. Further explanation of the circuit is unnecessary, since the diagram and components list provide all the data required for making the amplifier.

COMPONENTS LIST, FIG. 5

R1	150 kΩ	C1	50 μF 12 v. electrolytic
R2-3	15 kΩ	C2-5	32 μF 450 v. electrolytic
R4	560 Ω	C3	1,000 pF mica
R5-11	100 kΩ	C4	0.02 μF
R6	1 MΩ pot.	C6-8	1 μF
R7	10 kΩ	C7	32 μF 100 v. electrolytic
R8	10 kΩ pot.	C9	8 μF 600 v.
R9	39 kΩ	C10	32 μF 100 v. electrolytic
R10-15	50 kΩ pot.	L1	200 Henry 1 mA
R12-13	10 kΩ 1 w.	L2	40 Henry 50 mA (D.C. resistance 500 Ω)
R14	5 kΩ pot.		
R16	4.7 kΩ	V2-3	KT41, MKT4, Osram, etc.
R17	100 Ω		
R18	1.7 kΩ 5 w.	V4	V503 Mazda, DA30 Osram
T1	To match speech coil to 2,000 Ω load		

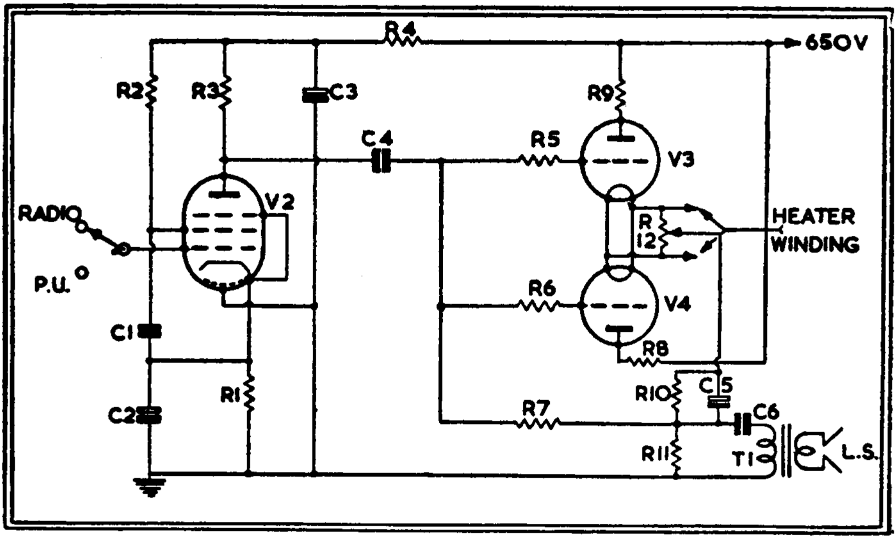

FIG. 6.—*Amplifier With Cathode-Follower Output.*

COMPONENTS LIST, FIG. 6

R1	390 Ω	C1	4 μF 250 v.
R2	820 kΩ	C2	25 μF 12 v. electrolytic
R3	150 kΩ	C3	4 μF 600 v. electrolytic
R4	10 kΩ	C4	1 μF
R5-6	4.7 kΩ	C5	50 μF 50 v. electrolytic
R7	120 kΩ	C6	8 μF 600 v.
R8-9	100 Ω	T1	To match speech coil to 6,000 Ω load
R10	500 Ω 5 w.		
R11	3 kΩ 50 w.	V2	EF37A Mullard
R12	100 Ω pot.	V3-4	PX4 Osram
2	B4 valve-holders	1	I.O. valve-holder

3. *Power Supplies.*—The power pack or power supply, as it is sometimes called, has considerable bearing on the ultimate performance of the equipment. Not only must it be able to supply potentials of a given value, but the rectified outputs must be ripple free and the regulation beyond reproach. Provided good quality components are used throughout, no trouble should be experienced from the regulation or from ripple, with any of the designs described in this book. A suitable power supply for the push-pull amplifier (Fig. 2) is shown in Fig. 7; electrolytic capacitors are used throughout since the voltages required are not very high. Direct coupled designs such as those of Figs. 3A and 4 require a rather more elaborate design, as a glance at Fig. 8 will show.

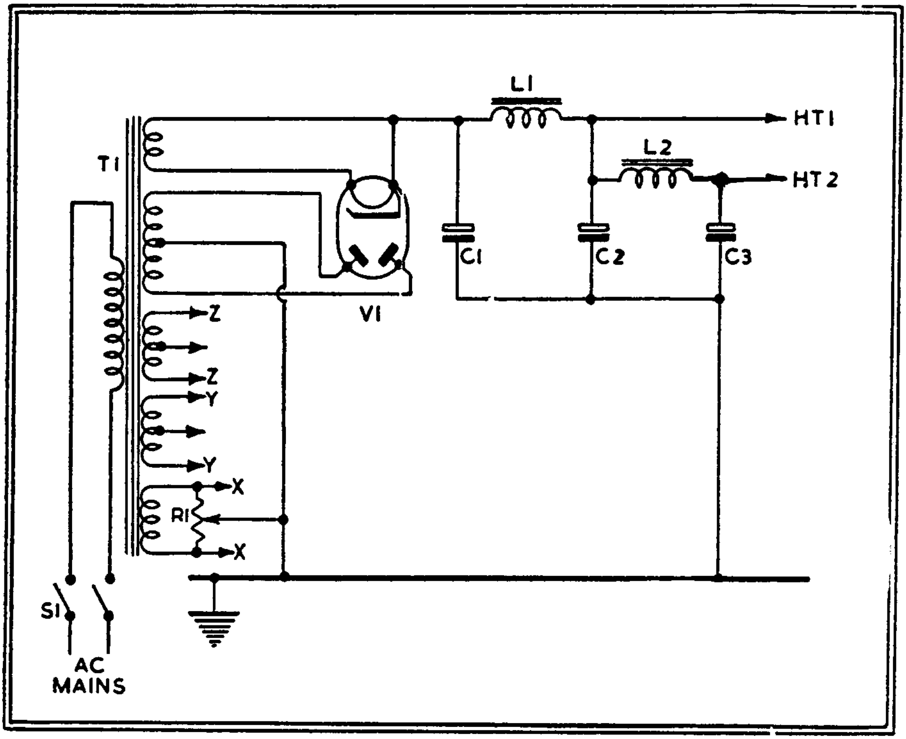

FIG. 7.—*A Power Pack for Fig. 2.*

COMPONENTS LIST, FIG. 7

C1-2	16 μF 450 v. electrolytic	T1	Pri. to suit mains
C3	32 μF 450 v. electrolytic		Sec. 350-0-350 v. 120 mA
L1	10 H 120 mA		4 v. 1 A (Y)
L2	40 H 60 mA		4 v. 1 A (Z)
R1	100 Ω pot.		6.3 v. 2 A (X)
1	International Octal valve-holder		5 v. 2 A (Rec)
S1	D.P.S.T. Switch	V1	GZ 32 Mullard

In order to prevent instability due to cross-coupling, it is desirable to use a separate rectified source for the output stage. Ideally, with this class of amplifier each stage should be fed from a separate supply; but this is a standard of perfection not easily attainable due to considerations of cost and space. Fortunately it is not difficult to provide two sources of supply, as in Fig. 8, and this type of power pack will be found perfectly satisfactory under any conditions. It will be observed that from a voltage supply angle, the only difference between Figs. 3A and 4 lies in the voltage applied to the DA30 anodes, and therefore it is only necessary to change the specification of the H.T. secondary on T1 to render the design suitable for use

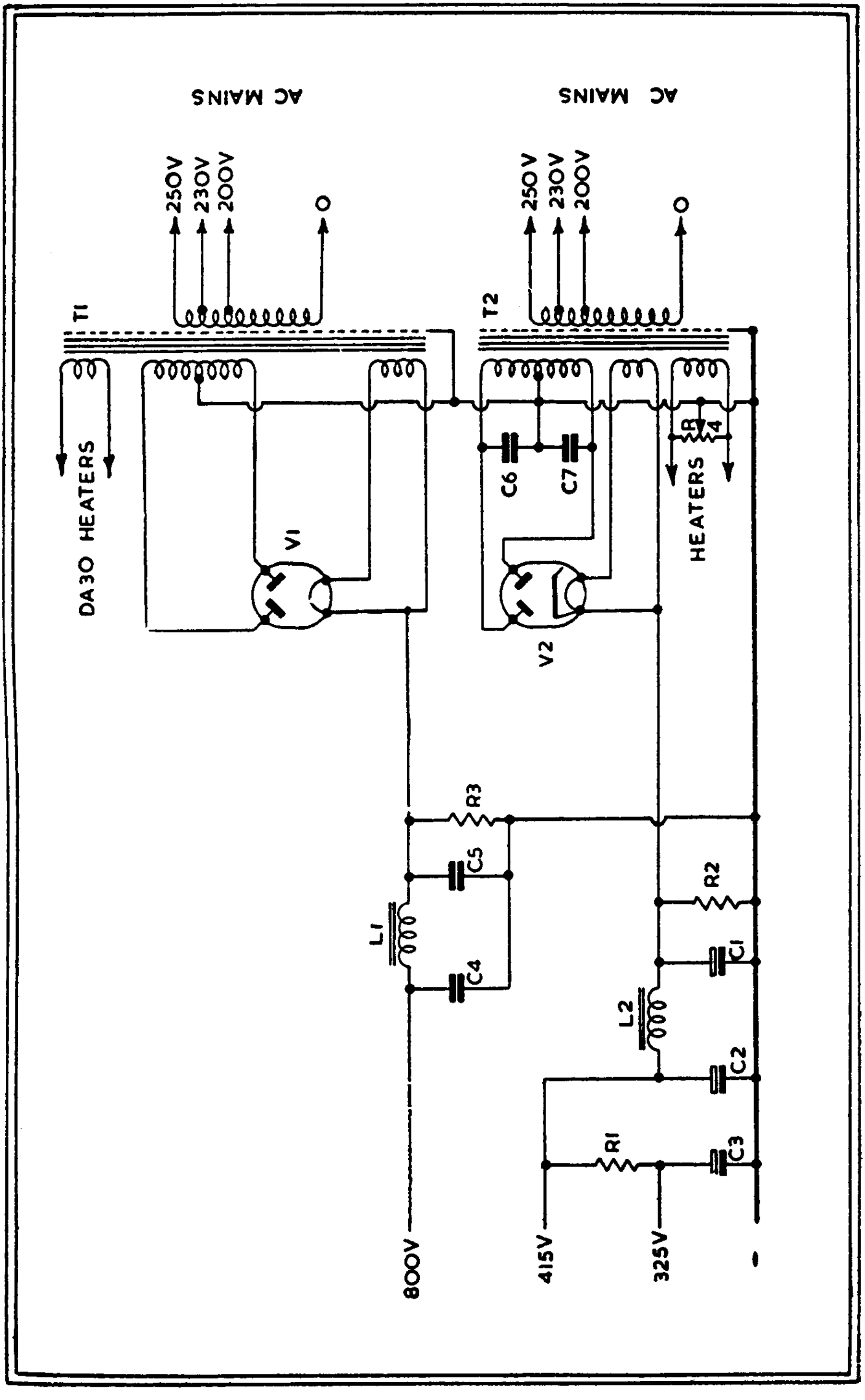

FIG. 8.—*A Power Pack for Figs. 3a and 4.*

COMPONENTS LIST, FIG. 8

T1	Pri. to suit mains H.T. Sec. See Text L.T. Sec. 4 v. 3 A (Rec) 4 v. 4 A (Heaters)	R2-3	220 kΩ ½ w.
		R4	100 Ω pot.
		V1	U 18/20 Osram
		V2	52 KU Cossor
		L1	10 Henry 120 mA
T2	Pri. to suit mains H.T. Sec. 325-0-325 v. 60 mA L.T. Sec. 5 v. 2 A (Rec) 4 v. 3 A (Heaters)	L2	40 Henry 60 mA
		C1	8 μF 450 v. electrolytic
		C2	16 μF 450 v. electrolytic
		C3	16 μF 350 v. electrolytic
		C4-5	8 μF 1,200 v.
		C6-7	0.01 μF 1,000 v.
R1	12 kΩ 1 w.		

with either amplifier. For use with Fig. 3A the winding should be 650-0-650 v. at 120 mA., but with Fig. 4 this must be increased to 800-0-800 v. at 120 mA.

If PX4 valves are used in conjunction with Fig. 3A the H.T. winding must be reduced to 550-0-550 v. at 120 mA. It should be noted that these voltage ratings for T1 assume the use of an Osram U18/20 and a reservoir capacitor of 8 μF. In the high voltage section of Fig. 8 constructors are advised to adhere to this specification. The low voltage rectifier V2, Fig. 8, is an indirectly heated type and it is essential that such a valve is used, otherwise the output valves may be permanently damaged. Conversely V1 is directly heated and should not be replaced with an indirectly heated pattern, since, as the output valves are directly heated, the cathode might easily become stripped during the warming-up process.

Fig. 9 is similar in many respects to Fig. 7 and is primarily intended for use with Fig. 6. By using a smaller rectifier and inserting anode stoppers at the points marked "X" (Fig. 9), the voltage can be reduced to the requirements of Fig. 6. The precise value of such series resistors can only be found by actual trial after the apparatus is completed, since much depends on the design of L1 and T1. From this the reader will appreciate that it is impossible to state accurately what voltage may be expected from a given power supply. It is invariably necessary to make practical tests on completion and to adjust the output on load to the required value. Fortunately series anode stoppers provide a simple way of losing any excess volts. The value will usually lay between 15 and 100 Ω and is best found by the experimental use of two variable wire-wound resistors. Every care must be observed when making adjustments, since the contacts will be some hundreds of volts above the chassis potential; no adjustments should be made without first SWITCHING OFF. One point which often escapes consideration is that the rating of any resistors used in the anode circuit of a rectifier should not be less than 5 watts.

This is due to the peak current handled by this circuit.

Although not shown, fuses should be included in the primary circuit of the mains transformers. A cartridge fuse twin holder is available, which makes a very neat fitting on the rear apron of the power pack. 2 amp fuses should be used.

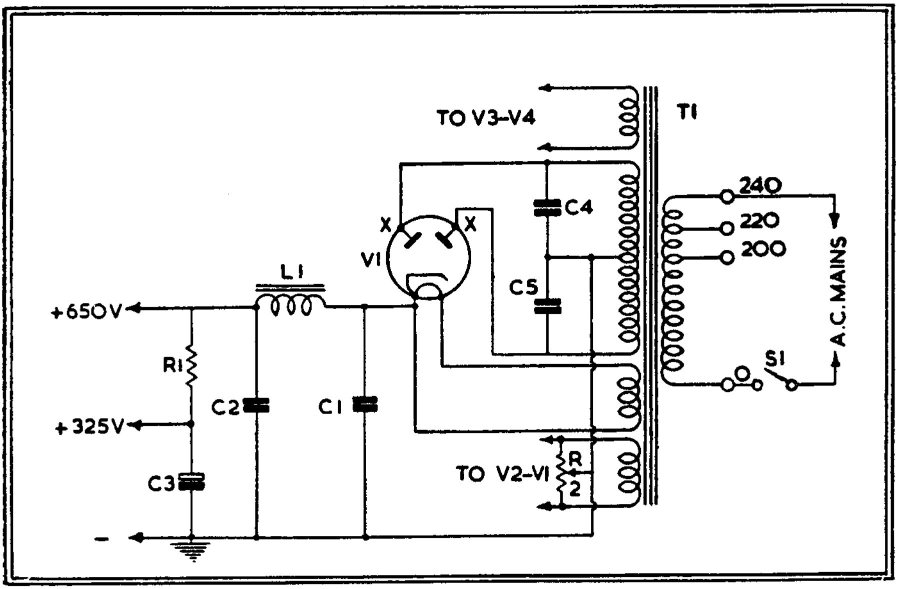

FIG. 9.—*A Power Pack for Figs. 5 and 6.*

COMPONENTS LIST, FIG. 9

T1	Pri. to suit mains	V1	54 KU Cossor (Fig 6)
	H.T. Sec. 500-0-500 v.		or
	120 mA (Fig. 6)		52 KU Cossor (Fig. 5)
	or	L1	20 Henry 120 mA
	80 mA (Fig. 5)	C1-2	8 μF 750 v.
	L.T. Sec. 4 v. 2 A	C3	16 μF 350 v. electrolytic
	5 v. 2 A	C4-5	0.01 μF 1,000 v.
	6.3 v. 2 A	R1	39 kΩ 3 w.
		R2	100 Ω pot.
		S1	S.P.S.T. Switch

4. *Battery Power.*—There are those whose only source of high tension power supply is the dry battery. Lest these listeners should feel left out in the cold, I am adding a special circuit diagram for their benefit. The valves specified are typical only. Quite excellent quality can be expected from this reproducer. The diagram and components list, Fig. 10, will provide all the necessary information for the home constructor. In order to obtain the maximum effect, two

Appendix IV

SUITABLE VALVE TYPES

Fig. 1a.	V1	AC/VP1	(Mazda)	VMP4G	(Osram)
		VP4B	(Mullard)	EF39*	(Mullard
Fig. 2.	V2-3	6SN7GT	(Brimar)	B65	(Osram)
	V4-5	PX4	(Osram)	PP3/250	(Mazda)
		2A3†	(Brimar)	6A3*	(Brimar)
Fig. 3a.	V3-4	MKT4	(Osram)	Pen4VA	(Mullard
		AC/Pen	(Mazda)	MP/Pen	(Cossor)
		KT63*	(Osram)	6F6G*	(Brimar)
	V4-5	DA30	(Osram)	V503	(Mazda)
		PX4	(Osram)	AC044	(Mullard)
		2A3†	(Brimar)	6A3*	(Brimar)
Fig. 3b.	V2	AC/HL	(Mazda)	MH4	(Osram)
		354V	(Mullard)	41MHL	(Cossor)
		EBC33*	(Mullard)	OM4*	(Cossor)
	V3	MKT4	(Osram)	Pen 4VA	(Mullard
		AC/Pen	(Mazda)	MP/Pen	(Cossor)
		KT63*	(Osram)	6F6G*	(Brimar)
Fig. 4.	V2	AC/HL	(Mazda)	MH4	(Osram)
		354V	(Mullard)	41MHL	(Cossor)
		EBC33*	(Mullard)	OM4*	(Cossor)
	V3	MKT4	(Osram)	Pen 4VA	(Mullard
		AC/Pen	(Mazda)	MP/Pen	(Cossor)
		KT63*	(Osram)	6F6G*	(Brimar)
	V4-5	DA30	(Osram)	V503	(Mazda)
Fig. 5.	V2-3	MKT4	(Osram)	AC/Pen	(Mazda)
		Pen4VA	(Mullard)	MP/Pen	(Cossor)
	V4	V503	(Mazda)	DA30	(Osram)
Fig. 6.	V2	EF37A	(Mullard)	EF40	(Mullard)
	V3-4	PX4	(Osram)	ACO44	(Mullard)
		PP3/250	(Mazda)	2A3†	(Brimar)
		6A3*	(Brimar)		
Fig. 7.	V1	5Z4G	(Brimar)	52KU	(Cossor)
		GZ32	(Mullard)	5V4G	(Brimar)
Fig. 8.	V1	U18/20	(Osram)		
	V2	52KU	(Cossor)	5Z4G	(Brimar)
Fig. 9.	V1	52KU	(Cossor)	GZ32	(Mullard)
		54 KU	(Cossor) (For Fig. 6.)		(For Fig. 5.)
Fig. 10.	V1	W21	(Osram)	VP210	(Mazda)
	V2	Z22	(Osram)	SP2	(Mullard)
	V3	Pen220	(Mazda)		

* 6 volt heater.

† 2 volt heater.