

# RADIO DESIGNS MANUAL



26  
N°65

## Pitman's Radio Books

### Radio Service Test Gear

By W. H. Casby. The author has had extensive experience in the construction of test instruments, and his book is an invaluable guide to the principles on which the various types of test gear operate. With numerous diagrams 4/- net.

### Experimental Radio Engineering

By E. T. A. Rapson, M.Sc. (Eng.), A.C.G.I., D.I.C., A.M.I.E.E., etc. Assisted by A. G. Ackermann. Contains a number of experiments and methods of measurement suitable for a 3 or 4 years' course at a technical college. With illustrations and tables. 3rd Edition. 1/6 net.

### The Superheterodyne Receiver

By Alfred T. Wynn, A.M.I.E.E. Provides the essential working knowledge required by every keen amateur constructor, radio student and service engineer. Sixth Edition. 6/- net.



### Modern Radio Communication (2 vols.)

By J. H. Reyster, B.Sc. (Hons.), A.C.G.I., D.I.C., A.M.I.E.E., etc. The two volumes together deal with all branches of modern radio theory, and provide a complete groundwork for the student of radio engineering. Each 7/6 net.

**PITMAN**, Parker Street, Kingsway, London, W.C.2

### AMPLIFIER KITS

of outstanding performance. Using original circuits developed for high fidelity reproduction of records. These kits are only supplied by us and comprise ready drilled chassis complete with all components—down to nuts, bolts and solder.

3 & 7 watt models are available with a special amplifier designed for moving coil pick-ups.

Blue prints are available of each model  
**HFA1:** 7 watt 8 valve Amplifier  
**HFA2:** 3 watt 5 valve Amplifier  
**HFA3:** 7 watt 8 valve Amplifier for Moving Coil pick-up.  
 prints 2/6 each.

Write for our lists of Amplifier Kits, radio receiver kits, loudspeakers, pick-ups and associated equipment.

**CHARLES AMPLIFIERS LTD.**  
 11, Palace Gate, Kensington, London, W.8  
 Phone: WESTern 3350

### The "PADHACKSAW"

NEW!  
 UNIQUE!



PRICE 15/6 POST PAID  
 \*THE TOOL YOU CAN'T AFFORD TO BE WITHOUT

For Metal, Plastic, Paxolin, Bakelite, etc.

An entirely new type of Cutting Tool. Will operate in the most restricted space. Does everything a hacksaw does, and all the jobs in which the hacksaw frame restricts its use. Standard type hacksaw blades are used. Its unique reciprocating action makes sawing a pleasure.

Please send cash with order to:  
**S.P.B.A. SUPPLIES LTD.**  
 Dept. D.46, WIGTON HOUSE, ST. JOHN ST., LONDON, E.C.1.



**BERNARDS (PUBLISHERS) LTD.**  
 LONDON · W. 6

7500

First Published 1948

## CONTENTS

INTRODUCTION ... ..	5
Chapter 1. THE POWER UNIT ... ..	7
Chapter 2. A PRE-SELECTOR UNIT ... ..	14
Chapter 3. A 5 AND 10 METRE CONVERTER UNIT ... ..	17
Chapter 4. A MIXER UNIT FOR BROADCAST RECEPTION ... ..	25
Chapter 5. AN I.F. AND DETECTOR UNIT ... ..	29
Chapter 6. A 3-4 WATT OUTPUT STAGE FOR 4 VOLT OPERATION ONLY ... ..	33
Chapter 7. A REMOTE TONE AND VOLUME CONTROL UNIT ... ..	36
Chapter 8. A SINGLE VALVE OUTPUT UNIT FOR 4 OR 6 VOLT OPERATION ... ..	39
Chapter 9. THE LOUSPEAKER "UNIT" ... ..	41
Chapter 10. AN AMPLIFIER - OUTPUT UNIT FOR 6 VOLT OPERATION ... ..	43
Chapter 11. AN AMPLIFIER - OUTPUT UNIT FOR 4 VOLT OPERATION ... ..	48
Chapter 12. A T.R.F. UNIT FOR QUALITY RECEPTION ... ..	51
Chapter 13. A PICKUP PRE-AMPLIFYING UNIT ... ..	54
Chapter 14. A PAIR OF TEST UNITS FOR THE WORKBENCH ... ..	57
APPENDIX ... ..	63

## INTRODUCTION

The Radio Design Manual is intended to show in diagrams and written text a series of circuits of radio receiver stages and equipment arranged as Units, the units, wherever their uses are complementary, being capable of coupling one to the other to form a complete receiver.

It will also be found possible to couple some of the units to an existing receiver, either to increase its waverange or to give an improvement in selectivity, whilst amplifying and output units are shown which can be used to give a greater output, but it is intended that the units, whilst forming a very complete radio receiver, can also be used for other purposes—for audio amplification and sound reproducing, for example, or, as stand by substitute apparatus on the experimenter's or engineer's bench.

Considerable care has been taken to specify in the construction of the units only those valves and components which are readily available at the time of writing.

The circuits are shown with component values for both 4 and 6 volt valves, and as well as conventional power packs, a 6 volt vibrator pack is shown for the convenience of those workers who may deal with car radio or who need transportable apparatus in an area where the mains supplies are not widely distributed.



## CHAPTER 1.

### THE POWER UNIT

In the majority of cases, constructional radio articles and text books deal with the power supply at the end, but here it has been thought advisable to give the power pack the pride of place. A general purpose power pack, supplied with a 4 or 5 pin output socket into which auxiliary apparatus can be plugged quickly and easily, is a real asset either to the home receiver constructor or to the experimenter and engineer.

Three power pack circuits are shown, for A.C., A.C./D.C. or battery operation.

#### The A.C. Power Pack

For general purposes the usual power supply needed is a smooth current of up to 100 mAs. at 350 volts, with 4 or 6.3 volts from a heater secondary on the mains transformer with an adequate current rating. It is possible to obtain transformers with a double set of heater windings, supplying both 4 and 6.3 volts, and such a unit is of considerable help in many instances. The design of the power pack is not affected, however, so that in the circuit of Fig. 1 a single heater secondary is shown, apart from that feeding the rectifier heater.

The rectifier may be rated, for its heater, for either 4 or 5 volts, depending on whether the unit is to feed 4 or 6.3 volt type valves. The 5 volt rectifier has, in general, a directly heated cathode—i.e., of the filament type, whilst the 4 volt rectifier specified has an indirectly heated cathode connected internally to the heater. This cathode is shown by the broken line in Fig 1, and it is only necessary to ensure that the H.T. line is taken from

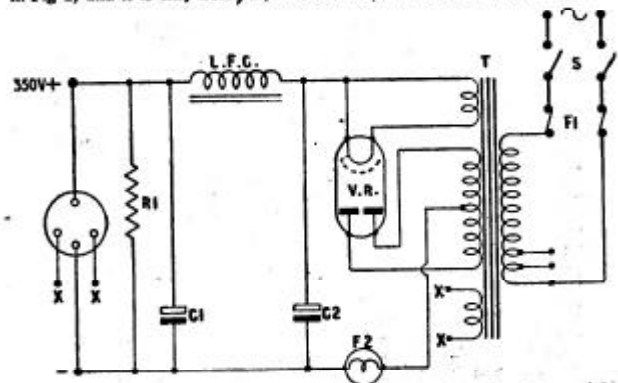


FIG. 1.—The General-Purpose Power Pack, for A.C. mains.

the heater pin to which this connection is made, otherwise the H.T. current will flow through the heater, giving it a degree of overload.

A bleeder resistance is included in this circuit, taking approximately 10 mAs. This current flow gives some assistance to the regulation of the power pack as well as ensuring a discharging path across the condensers so that they cannot remain charged should the load be taken off the power pack before the supply is switched off.

Fuses are provided in the mains and in the H.T. circuits, so that the pack is well protected.

Components List for A.C. Power Pack, Fig. 1.

For Use With 4 Volt Valves.

T,	200-250 volt primary. 350-0-350 volt, 100 mAs. H.T. Secondary.
	4 v. 2 a. Rectifier heater Secondary. 4 v. 6 a. Heater Secondary.
R1,	33,000 ohms, 5 watt.
C1,C2,	8 mfd. 500 v.w. Electrolytic.
L.F.C.	20 Hys. 100 mAs. 425 ohms.
S,	Double Pole ON-OFF switch.
F1,	0.5 amp. fuses.
F2,	200 mAs. fuse bulb, with holder.
VR,	UU6.
	1 Mazda Octal chassis mounting valveholder.
	1 4 pin " " " (as output socket).
	Chassis, aluminum or steel, 7 x 3½ x 2 or 9½ x 4½ x 2.

Components List for A.C. Power Pack, Fig. 1.

For Use with 6 Volt Valves.

T,	200-250 volt primary. 350-0-350 volt, 100 mAs. H.T. Secondary.
	5 v. 2 a. Rectifier heater Secondary. 6 v. 4 a. Heater Secondary.
R1,	33,000 ohms, 5 watt.
C1,C2,	8 mfd. 500 v.w. Electrolytic.
L.F.C.	20 Hys. 100 mAs. 425 ohms.
S,	Double Pole ON-OFF switch.
F1,	0.5 amp. fuses.
F2,	200 mAs. fuse bulb, with holder.
VR,	5Y3C
	1 International Octal chassis mounting valveholder.
	1 4 pin " " " (as output socket).
	Chassis, aluminum or steel, 7 x 3½ x 2 or 9½ x 4½ x 2.

In both cases the final chassis size is determined by the size of the Mains transformer obtained. If several units are to work together it is obviously desirable to keep each unit of the same overall size as far as is

possible, and the 9½ x 4½ x 2 chassis can accommodate quite large circuits and layouts, especially when the power pack is kept separate.

In general it is advised that aluminium chassis are used. The steel chassis gives good screening and is very robust, but the screening is not really suitable for R.F. circuits and aluminium is considerably more simple to work, and requires no finishing in the way of paint or enamel.

The output socket may be mounted either in the top of the chassis, or centrally in one side or one end, and again, the desired arrangement of the units on the bench or in a cabinet must be a factor in determining the choice of position. By placing the socket in the top of the chassis, however, free access is assured, no matter in what position or order the units are grouped.

The A.C./D.C. Power Pack.

The primary disadvantage of the A.C./D.C. power pack is that the H.T. potential is limited, and is of necessity somewhat below the mains voltage—a general figure is an output potential of about 200 volts. The current is limited only by the rating of the rectifier valve and L.F. choke.

As is well known, for A.C./D.C. operation the heaters of all valves used in the apparatus must be connected in series, and must have the same current rating, this rating also applying to the rectifier valve heater and to the barretter, or voltage dropping bulb, B, in Fig. 2.

British A.C./D.C. valves have, in general, a heater current rating of 0.2 amp. so that the rectifier valve and barretter must also be rated at 0.2 amp.

The barretter is chosen to give the correct voltage drop and this is calculated by adding the heater voltages of all the valves in the circuit and subtracting the total from the mains supply voltage. The remainder is the voltage which must be handled by the barretter.

To take a concrete example, consider an ordinary A.C./D.C. receiver, with a valve chain consisting of a TP2620 Mixer, a VP133 I.F. amplifier, an HL133DD double diode triode as detector and first audio amplifier and a Pen 3520 output stage, all fed from a U4020 rectifier. Then, connecting the heaters in series gives a total current of 0.2 amp with a total voltage drop of 26 + 13 + 13 + 35 + 40 = 127 volts.

Subtracting 127 from the usual mains voltage of 240 leaves 113 volts to be dropped across the barretter.

Barretters are rated as giving potential drops over a range, and the Phillips Miniwatt Regulator Lamps are obtainable in a number of ranges. Thus the C2 lamp is rated at 60 to 120 volts, which covers the 113 volt drop required.

An ordinary dropping resistance can be used, but the barretter is much more convenient with its powers of self regulation over wide voltage ranges. To set an ordinary voltage dropping resistance it is necessary to use either an accurate A.C. voltmeter or ammeter in the valve heater circuit, and even then the resistance must be changed for a change in the valve chain.

When the circuit of Fig. 2 is used, therefore, care must be taken to ensure that the barretter B is rated at the range of voltages it is required to drop, but no adjustments are then necessary.

A.C./D.C. valves must be arranged so that the first audio stage in a receiver—i.e., the detector—or the most sensitive valve in an amplifier has one side of its heater connected straight to the negative line, in order that there shall be no heater—cathode leakage with consequent hum. Obviously, in Fig. 2, the valve heater chain is connected between H and the negative line.

It must always be remembered that a direct earth connection must never be made to A.C./D.C. apparatus. The apparatus is in direct connection to the Mains supply on one side, so that under some conditions a direct earth connection would short-circuit the mains.

Any earth connection to A.C./D.C. apparatus must be made through a 0.01 or 0.1 mfd. condenser with a working voltage of at least 400 volts. In an A.C./D.C. receiver it is also wise to isolate the aerial by a similar condenser.

In the case of an A.C./D.C. amplifier, it is possible for gramophone pickups, microphone stands, etc., to become "alive to earth" and a test for this condition may be made with a neon lamp, one side of the lamp being connected to a physical earth, such as a water pipe, with the other side of the lamp connected to the apparatus suspected of being "alive." If the lamp lights, it is possible to obtain a shock from the gear, and if the apparatus is on A.C. mains, the mains plug may be reversed to correct the fault. If the apparatus is on D.C. mains the plug cannot be reversed since the power pack must be connected to the mains in the correct sense, or polarity. With an earthed positive every precaution should be taken against shock, preferably by protecting both the apparatus and the operator by the use of rubber mats.

Components List for A.C./D.C. Power Pack, Fig. 2.  
For Use With 0.2 Amp. Universal Valves.

L.F.C.	20 Hys. 100 mAs. 425 ohms.
C1,	16 mfd. 500 v.w. Electrolytic.
C2,	8 mfd. 500 v.w. Electrolytic.
VR,	U4020 (40 volts, 0.2 amp. heater).
B,	Barretter to suit total valve chain.
	Miniwatt Lamps:—
	60-120 volts, 0.2 amp, Type C2.
	90-230 volts, 0.2 amp, Type C1.
	100-200 volts, 0.2 amp, Type C.3.
	35-100 volts, 0.2 amp, Type C9.

- 1 5 pin chassis mounting valveholder for VR.
- 1 4 " " " " as output socket.
- 1 Holder to suit Barretter make and type chosen.
- S, Double Pole ON-OFF switch.
- F, 0.5 amp. fuses.

Chassis, steel or aluminium, 7 x 3½ x 2 or 9½ x 4½ x 2.

Half wave rectification is used for A.C./D.C. apparatus and the hum level therefore sometimes rises. It is not wise to increase the value of C2

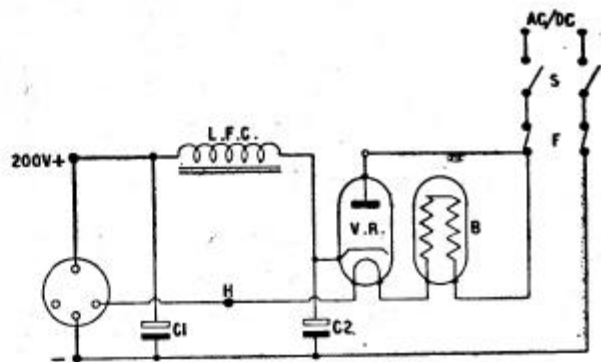


FIG. 2.—A.C./D.C. Power Pack.

over 8 mfd. however, unless it is really necessary, since the smoothing is carried out chiefly by C1. The value of this condenser may be increased to 32 mfd. if necessary.

The Vibrator Power Pack.

The Vibrator Power Pack supplies a high tension supply from a 6 or 12 volt accumulator battery by switching the low tension supply across a centre tapped primary winding on a specially designed transformer, giving the effect in the primary of an angularly shaped A.C. waveform. If the transformer is wound to give a step-up ratio, there will thus be induced in the secondary a high voltage—low current. This, of course, requires rectification, which can be performed either by a valve or by the vibrator itself, through a second pair of contacts. The synchronous, or self-rectifying vibrator, switches the ends of the secondary winding into the load in time with the switching on the primary, the switching occurring as the secondary undergoes the polarity change.

For real efficiency it is advisable to purchase a commercially made vibrator Pack, such as those produced by Messrs. Masteradio, but the pack can be built by the home constructor if a suitable transformer is obtained. One such transformer is the Bulgin M.T.5, wound to give 250 volts. A special transformer is necessary since it should be "tuned" to the frequency of the vibrator, usually of the order of 115 cycles, and suited to the peculiar wave form of the current.

The vibrator must be carefully by-passed, as shown in the circuit of Fig. 3, the small condensers acting as anti-sparking buffers. The values shown are those usual, but any circuit details supplied with the vibrator itself should be adopted, since different makes of vibrator occasionally require different treatment.

The vibrator has a driving coil which is usually shunted across one half of the primary winding, and since the contacts inside the vibrator unit are delicately adjusted, no attempt should be made to re-adjust them in the case of trouble. Vibrator sticking or bad sparking or arcing indicates that the contacts are ageing, or that the component has been misused or damaged, and repair, at least in the home workshop, is impossible.

Great care must be taken to ensure thorough filtering in both the input and output circuits of the vibrator pack, since there is a radio frequency type of interference transmitted by the sparking contacts as well as low frequency interference, and both R.F. and L.F. interference can be fed back to the battery and thus into the associated apparatus, as well as through the H.T. output lines.

For this reason a Hash Choke, H.C. in Fig. 3, is incorporated in the battery lead, wound with thick wire since it must carry a heavy current, a bypassing condenser C4 completing the filter circuit.

Both the output filter condensers, C6 and C8, must remain out of circuit until the transformer secondary connections to the rectifying contacts are corrected for polarity. Obviously the switching must occur in the correct sequence, so that the output circuit must be tested with a voltmeter and the connections reversed if a reversed output is indicated. The electrolytic condensers may then be connected in circuit to provide filtering.

The whole of the vibrator pack must be screened. The vibrator itself is supplied with a built-on screening can, but the whole unit should be built either in a metal box with good electrical connections between sides, top and bottom, or, if chassis construction is preferred, unscreened components should be built in below the chassis wherever possible and the top of the chassis screened by a shaped and bolted down cover of sheet metal, with ventilation holes drilled in the top.

The negative side of the power pack, to which all screening must be firmly connected, should then be taken by as short and direct a route as possible to a good earth, such as a main water pipe.

The fuse F must be included in the circuit, a usual rating being 10 amps. Should the primary contacts of the vibrator stick, for any reason, the resistance of the circuit will be very low and a heavy current will flow, possibly fusing the transformer winding and damaging the battery.

The high voltage ratings of the condensers must also be observed, for the peak Back-E.M.F.s are very high, and a broken down condenser across either primary or secondary will also cause serious damage.

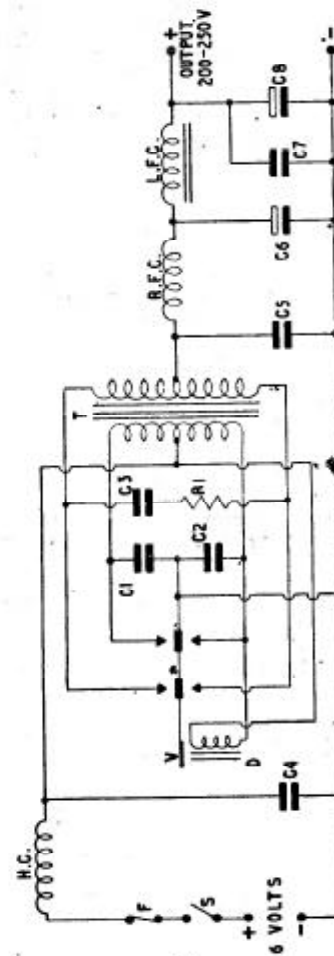
#### Components List for Vibrator Power Pack, Fig. 3.

For Use With 6 Volt Valves and Vibrator.

V,	6 volt Vibrator. (D, driving coil).
C1, C2	0.1 mfd. 500 v.w. Non-inductive.
C3,	0.01 mfd. 1,500 v.w. "
C4,	0.5 mfd. 500 v.w. "
C5,	0.01 mfd. 750 v.w. "
C6,	8 mfd. 500 v.w. Electrolytic.
C7,	0.0005 mfd. Mica.
C8,	16 mfd. 350 v.w. Electrolytic.

12

C



13

FIG. 3.—Vibrator Pack, with Synchronous Vibrator.

E

R.F.C.	R.F. Choke (To suit waverange of apparatus. Capable of carrying up to 100 mAs. For sound equipment, use all wave choke).
L.F.C., I.L.C.	20 Hys. 100 mAs. 425 ohms. Hash Filter. Wind on 1in. diameter wooden rod, using 14 S.W.G. enamelled copper wire. 50 to 75 turns.
S.	Single Pole On-Off switch, heavy duty Q.M.B. type, to carry 10 amps.
F.	10 amp fuse.
RI,	4,700 ohms, 1 watt.
T.	Vibrator type power transformer, 6-0-6 volt primary.
	Chassis, or metal case, steel, aluminium or copper.
	Chassis size, 7 x 3½ x 2 or 9½ x 4½ x 2.

Since every effort must be made to ensure smooth working and the least possible sparking of the vibrator, some further additions or slight changes to the buffering circuits may be tested. The condensers, C1 and C2, may be shunted each by a 100 or 220 ohm resistance, and the combination of C3 and RI, shown shunted directly across the whole secondary winding, may be taken instead from one side of the secondary to the negative or earth line, an exactly similar combination of 0.01 mfd. and 4,700 ohms being taken from the other side of the secondary to earth, thus maintaining the balance of the circuit.

If the vibrator power pack is used to supply H.T. to 4 volt heater valves, it is wise to provide a separate 4 volt battery for the valve heaters. Tapping off 4 volts from the 6 volt battery supplying the vibrator will result in uneven discharge of the cells, and in any case a separate battery for the heaters will assist in the prevention of vibrator interference.

#### CHAPTER 2. A PRE-SELECTOR UNIT.

A pre-selector is a radio frequency amplifying stage usually connected between the aerial and input circuit of a short wave or communications receiver to improve sensitivity and selectivity, but there is no reason why such a stage should not precede an ordinary broadcast receiver in areas where reception is poor or where it is desirable to improve the receiver for any reason.

The pre-selector must have its own tuning condenser, and cannot be ganged in with the tuning of the main receiver, which is a disadvantage, but with practise it is a simple matter to keep both pre-selector and main tuning in gang, whilst the pre-selector tuning is sufficiently broad to allow stations to be tuned first on the main set, and then finally tuned on the pre-selector to bring up volume and increase selectivity, so long as the two sets of tuned circuits are kept roughly in step.

The pre-selector may have its own power supply or may be supplied from the receiver with which it is operating, but in the latter case full precautions must be taken against feedback. The pre-selector may be supplied with a manual volume control, if variable mu valves are used, but whilst the circuit could easily be adapted to work with A.V.C. it is best not to make this coupling between the receiver and the pre-selector.

Where it is desirable to have a very selective circuit as the additional R.F. stage, both anode and grid circuits may be tuned, but in general it is sufficient to tune the grid circuit in the usual manner, coupling the anode to the first tuned circuit of the receiver.

The pre-selector must be well shielded, the coils being mounted below the chassis for preference and grouped round the wave-range switch to give short and direct leads. When using the P type coils as specified, they should be mounted so that the windings are at least a half-inch from the chassis or other earthed metal part.

The tuning condenser may be mounted above the chassis, or, if a small component is obtained, below the chassis, using the front edge of the chassis as a panel. Slow motion tuning is advisable, however, and the dial used may require the tuning condenser to be mounted above the chassis. A sheet aluminium panel will then be useful to provide a base for the dial and condenser as well as shielding the unit. Further shielding can be provided by the cover for the pre-selector, made from sheet metal or metal gauze or perforated sheet metal, cut and soldered to shape and held to the chassis and panel by 6 or 8 B.A. nuts and bolts.

In the event of instability a valve screen may be used to give additional shielding to the valve. The coupling leads between the pre-selector and receiver, whatever type of coupling is used, should be short and direct, screened leads being used.

Separate trimmers for the coils are not used since the tuning is not ganged and there is therefore no need for correction of stray capacities, these being made automatically in the tuning.

The simple aerial coupling coil is generally found only in the communications type of receiver, and an input circuit of the type shown in Fig. 4 will usually be found in the ordinary broadcast receiver.

In this case the capacitive coupling is simpler to arrange, but even better results may be obtained if the output of the pre-selector is fed directly through a small capacitance to the tuned grid circuit of the first receiver stage, the connection being shown by the dotted line in Fig. 4.

In the diagram, the gain control in the pre-selector is R3, the usual variable bias resistance.

The coils for the pre-selector are specified to cover the bands 16-47 metres, 200-557 metres and 700-2,000 metres, but further coils may be switched in to cover a wider short wave band if required.

#### Components List for Pre-selector Unit, Fig. 4. For Use With 4 or 6 Volt Valves.

L1,	Wearite PAS.	16-47	metres
L2,	"	PA2.	200-557 "
L3,	"	PAL.	700-2,000 "

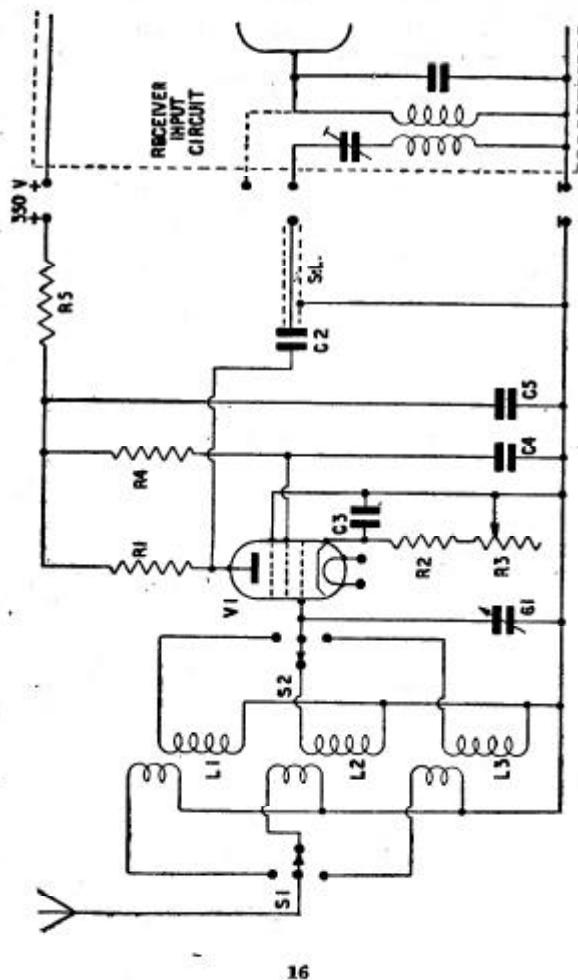


FIG. 4.—Pre-selector with Capacitive Coupling.

- C1, 0.0005 mfd. Variable Tuner.  
 C2, C3, C4, C5, 0.1 mfd. 350 v.w. Non-inductive.
- Note.—In Fig. 4, if C2 is to be connected to the following grid circuit, as shown by the dotted line connection, the value of C2 must then be reduced to 0.0003 or 0.0005 mfd.
- R1, 100,000 ohms, 1 watt.  
 R2, 150 " ½ "  
 R3, 10,000 " variable.  
 R4, 33,000 " ½ watt.  
 R5, 10,000 " 1 "  
 S1, S2, 2 pole 3 way Yaxley type switch.  
 S.L., Screened lead to sult circuit.  
 V1, 6K7 for 6 volt operation.  
 VP4B for 4 volt operation.

- 1 International Octal chassis mounting valveholder  
 or 7 pin British " " "  
 Chassis, aluminium, 9½ x 4½ x 2.  
 Control knob for R3 and slow motion drive for C1.

The unit is shown as being fed from the receiver, when the heater leads would be taken to the heater secondary of the receiver mains transformer. If, however, the unit is fed from a separate power supply the earthed or negative line, i.e., the chassis of both receiver and pre-selector must be connected.

If the pre-selector is supplied from a separate A.C./D.C. power pack, the neon lamp test should be made between the two chassis before they are connected together. If the lamp lights, the mains connection to the pre-selector power pack must be reversed.

### CHAPTER 3.

#### A 5 AND 10 METRE CONVERTER UNIT.

Many communications receivers, as well as most broadcast receivers, are unable to tune to frequencies above 20 Mcs. or so—that is, below 15 metres. A variety of stations operate at frequencies above this, however, including the Television Station at Alexandra Palace, with a frequency of 41.5 Mcs., 7.23 metres approximately, whilst the "Ten Metre" amateur band, from 28 to 30 Mcs. is one of the most used bands and gives opportunities for world wide signal reception.

The Five Metre band does not contain so much activity, but is again well worth exploring.

One difficulty which prevents these bands from being included in the tuning ranges of the broadcast and simpler communications receivers is the high Intermediate Frequency which is necessary to prevent image reception. Using an I.F. of 460 kcs. means that the oscillator must work 460 kcs.

As already mentioned the oscillator may be lower or higher in frequency than the signal, and in the tests with this unit a higher frequency was used. Thus, when receiving a signal on 30 Mcs. the oscillator must be tuned to 35 Mcs., for a signal on 41.5 Mcs. the oscillator must be tuned to 46.5 Mcs. and so on.

This means that the mixer must have an oscillator section capable of working at high frequencies, and the oscillating circuit is arranged as a Colpitt's oscillator. The efficiency of the circuit overcomes the disadvantage that neither rotor nor stator of the oscillator tuning condenser is earthed, so that the condenser must be mounted on an insulating bracket. An extension spindle is necessary, however, to overcome hand-capacity effects, so that the condenser mounting, the insulated bracket, is a necessity in any case.

The tuning is fine, and a good slow motion drive must be used with C7. C1, however, is directly driven, as is C6 if a variable condenser is used here, although once again a variable condenser for C6 must be mounted on an insulating bracket. In the original converter a trimmer condenser was mounted directly across C7 to perform the function of C6.

The coil sizes given in the components list are subject to variation. Small changes in stray-capacities, circuit layout and similar variables will have disproportionately large effects on the tuning of the oscillator.

Details of construction and lining up are given after the components list.

Components List for the 5 and 10 Metre Converter Unit, Fig. 5.  
For Use With 4 or 6 Volt Valves.

Coils: See table at end.

C1,	100 mmfd. Tuning condenser. Raymart VC100X.
C2,C8,	0.1 mfd. 500 v.w. Non-inductive.
C3,C4,C9,	0.01 mfd. 500 v.w. "
C5,	100 mmfd. Silver-mica. "
C6,C10,	30 mmfd. Trimmer, with screw adjustment.
C7,	15 mmfd. Tuning condenser. Raymart MC15DX.
R1,	68,000 ohms. 1 watt.
R2,	22,000 " 1 "
R3,	100,000 " 1 "
R4,	51,000 " $\frac{1}{2}$ "
R5,	220 " $\frac{1}{2}$ "
R6,	33,000 " 1 "

Note.—For 6 volt operation with the 6K6, R1 should be 43,000 ohms, 2 watt, and R5 should be 300 ohms,  $\frac{1}{2}$  watt.

V1, AC/TH1 for 4 volt operation.  
6K6 for 6 volt operation.

1 7-pin British chassis mounting valveholder, or  
International Octal chassis mounting valveholder.

1 Extension spindle for C7, Eddystone No. 1008.

1 Insulating bracket, Eddystone No. 1007.

Chassis, aluminium,  $9\frac{1}{2} \times 4\frac{1}{2} \times 2$ .

Panel, aluminium,  $9\frac{1}{2} \times 6$ .

Slow motion drive for C7, Jackson Epicyclic.

Control knobs for C1 and drive of C7.

Input and Output sockets for A1, 2, 3 and A, E.

Coil Table.

For I.F. of 5 Mcs.

10 metre band.

L1, 2 turns 16 S.W.G. enamelled, spaced own diam.  $\frac{1}{8}$ " diameter.

L2, 10 " " " " spaced  $\frac{1}{8}$ " " "

L3, 20 " " " " closewound, " "

5 metre band.

L1, 1 $\frac{1}{2}$  turns 16 S.W.G. enamelled, spaced own diam.  $\frac{1}{8}$ " diameter.

L2, 6 turns 16 S.W.G. enamelled, spaced  $\frac{1}{8}$ "  $\frac{1}{8}$ " diameter.

L3, 8 " " " " spaced  $\frac{1}{8}$ " " "

The coils are wound with ends left protruding 1" for plugging into coil holders which are cylindrical legged soldering tags sweated directly on to the condenser tags, the coils thus being self supporting.

Where L1 is used a small terminal block must be provided to support the coil in close proximity to the grid end of L2, but unless a dipole aerial with twin feeders is used, it is advised that the aerial coupling be as shown by the dotted line in Fig. 5 where the aerial is run via a condenser directly to the grid of V1, from the point A3. The condenser should be about 5 or 10 mmfd., but it is preferable to use a variable condenser with a maximum capacity of 30 mmfd., and find the optimum value by experiment. This condenser may be of the preset type.

Coils L4, L5 for First I.F. of 5 Mcs.

The output transformer L4, L5, is obtained ready made, since a Wearite PHF6 coil is used. The main winding forms L4, the trimmer C10 being sweated directly across the two upstanding coil tags, whilst the twin feeder from L5 is made of ordinary twin flex, as short a length as possible, soldered to the two smaller side tags on the coil former, the feeder running to the Aerial-Earth sockets of the broadcast receiver as shown by the symbols A, E, in Fig. 5.

Construction.

The layout of the converter chassis is shown in Figs. 6a and 6b. It will be seen that since the tuning condensers are mounted above the chassis the leads from the tuned circuits to the valveholder connecting tags must pass through the chassis, but if the leads are taken by as direct a route as possible little loss appears to be introduced.

All the by-passing and earth connections should be taken to the same earthed point, except for the earthed connection of C1-L2 which will automatically be made to the panel.

No especial screening need be given to any part of the converter unit, and whilst it may be covered by a metal screen or built into a metal box, this is not essential.

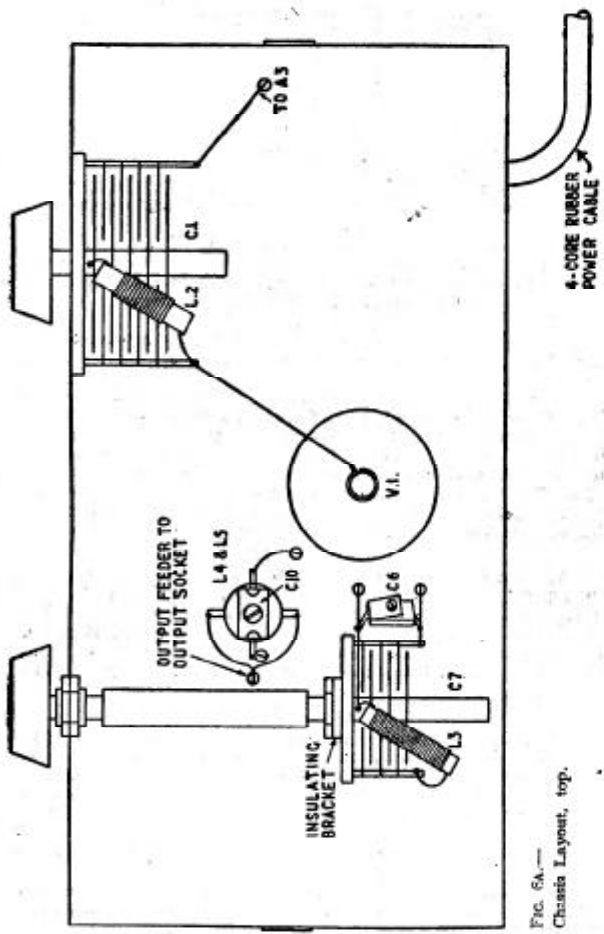


FIG. 6A.—  
Chassis Layout, top.

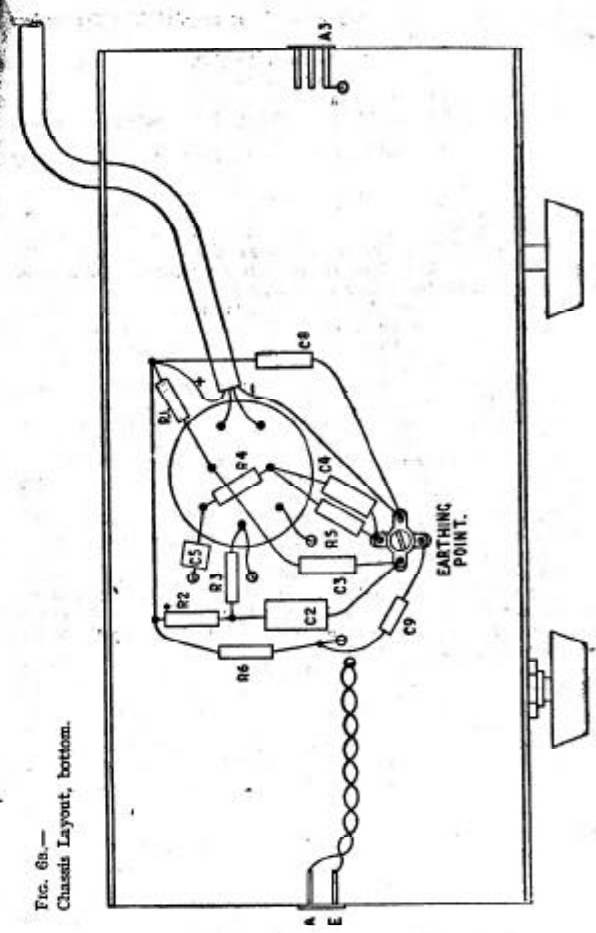


FIG. 6B.—  
Chassis Layout, bottom.



The unit may be separately powered, or supplied from the receiver with which it is to work.

#### Aligning the Converter Unit.

Plug in the coil set for 10 metre operation.

Set C1, C6 and C7 to half capacity.

Connect A and E of L5 to the Aerial and Earth sockets of the main receiver.

Switch on receiver and converter and allow them to reach operating temperature.

Tune the main receiver to 5 Mcs., 60 metres.

The first step is to trim C10-L4 to 5 Mcs. most conveniently performed by coupling a signal generator tuned to 5 Mcs. into the control grid of V1, trimming C10 for maximum response in the loudspeaker of the main receiver, but if a signal generator is not available C10 must be trimmed to tune the transformer on circuit noise.

Adjust C10 until valve hiss is heard in the main receiver, or, if the noise level is low, the anode connection of L4 may be tapped with a screw-driver to supply a noise source in the shape of clicks. The trimming can be completed on a signal.

With L4 and C10 tuned to 5 Mcs. it is now necessary to set C6 so that, for the 10 metre band, the centre of the amateur band is tuned with C7 at rather less than half full capacity. The oscillator, therefore, must be set to work at 34 Mcs. with C7 at half capacity and the simplest method once again is to use the signal generator. Couple the generator into L2 and tune the generator to 29 Mcs. Leaving C7 at half capacity, or slightly less, adjust C6 until the generator signal is heard in the loudspeaker reducing generator output as the oscillator comes into tune. If it is found that two settings of C6 bring in the generator signal, choose the setting which gives the maximum response.

The generator may then be removed, the aerial connected in and the converter used to tune a received signal. If conditions and the time are suitable a signal should be found almost immediately since the unit is already set centrally in the amateur band. Search the band with C7, and bring up station volume with C1.

If a generator is not available a station signal must be used. With C1 at half capacity or slightly less, and C7 in a similar position, adjust C6 to bring in an amateur station, or a station whose wavelength is known. The 10 metre band should be discovered easily, and the original converter was aligned without the use of a signal generator using the overseas broadcast on 11 metres. This station was found and identified, and then C7 was meshed to two-thirds of full capacity, C6 being slackened off a little to bring in the station once more. This placed the 10 metre band almost centrally on the condenser's tuning range.

With the coils as listed and using a straight wire aerial 20' long, omitting the aerial condenser, several American amateurs were received ten minutes after first switching on the converter.

It was found that the 10 metre coils covered the amateur band and up to the first programme stations on the 13 metre band, whilst the 5 metre coils covered the amateur band and the television station.

It must be repeated here, however, that the constructor must be prepared to experiment with the coil sizes to suit his own layout and wiring of the converter unit, opening or squeezing the coils as necessary to decrease or increase the inductance by small amounts.

If it is desired to use an I.F. into the receiver of 10 Mcs. it is necessary to use a different combination for L4, L5. A Wearite PHF5 coil is substituted for the type PHF6, and the unit is tuned as before, using 10 Mcs. instead of 5 Mcs. for the first I.F. The oscillator handset condenser will then be set to give an oscillator frequency of 39 Mcs. to receive signals at the centre of the 10 metre band.

When tuning the receiver to the first I.F. of either 5 or 10 Mcs., it may be found that a local or strong shortwave signal is breaking through at that frequency. It is only necessary to tune the receiver away from this interfering signal, thus changing the I.F. by a few kcs. The setting of C6 will compensate for the change.

## CHAPTER 4.

### A MIXER UNIT FOR BROADCAST RECEPTION.

For the experimenter and engineer whose main interests lie in the reception of broadcast signals on the short, medium and long wavebands, a complete receiver assembled in units has much to recommend it, either for experimental or demonstration purposes, since the unit method of construction allows work to be carried out on one section of the receiver at a time, the remaining sections being undisturbed. For example, it may be required to test a series of I.F. coils for gain and efficiency characteristics, when an I.F. amplifier separate from the rest of the receiver will be of great value, or a receiver with interchangeable output stages may be required, to give a relatively small audio output for home use and a large output for use in a hall or shop.

Accordingly a complete receiver has been designed, for construction on the unit principle, the stages consisting of the tuner and mixer, the I.F. amplifier and detector with A.V.C. and the output stage with provision for gramophone work.

The tuner and mixer circuit is seen in Fig. 7, and is fairly conventional. No A.V.C. is applied to this stage since it has been found unnecessary, although little ingenuity would be required to bring an A.V.C. line from the following I.F. and detector unit to the control grid of the mixer valve, providing that the line was well screened throughout its length.

As with the pre-selector of Chapter 2, three wavebands are provided, and the pre-selector unit can be connected before the mixer unit if desired, using the Fig. 4 type of coupling.

Further wavebands may be added to the mixer unit by providing a further set of coils in both control grid and oscillator circuits, together with larger wave change switches. Further coils added in this manner to the oscillator section must be trimmed and padded, of course, so that details are given after the components list for suitable trimming and padding condensers for the Wearite P type coils which may be added.

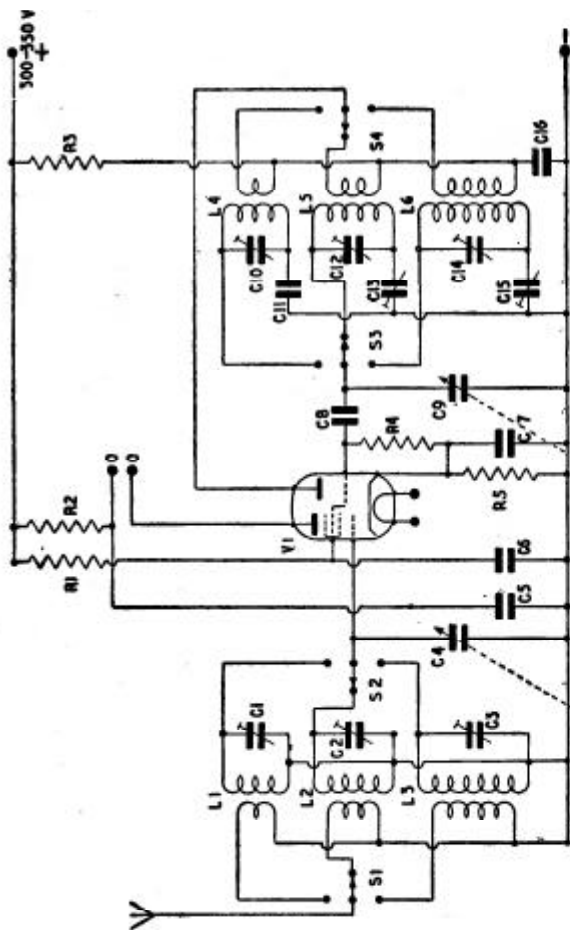


FIG. 7.—A. Mixer Unit for Broadcast Reception.

The layout and construction of the mixer is conventional and needs no especial mention since it follows normal receiver practice. An advantage of the unit method of receiver construction is that inter-stage shielding is far more efficient than is generally the case and each chassis, being given over to one particular purpose or stage, has more space for the components.

In the mixer unit, the coils should be grouped around the switch, a 2" chassis depth allowing them to be mounted below the chassis providing that small postage stamp trimmers are used and the long upright coil tags are bent down or cut to reduce the overall height of coil and trimmer to just under 2".

The trimmers may be mounted beside the coils if the based type of trimmers are used, these being provided with fixing holes, but sweating the trimmers directly across the coil tags is a neater and more efficient method of mounting the condensers.

The oscillator padding condensers should be mounted on the underside of the chassis and coded for future reference. The shortwave padder, which is a fixed condenser, may be suspended in the wiring.

The only point in the mixer unit requiring special attention is the arrangement of the I.F. output from the mixer valve. Experiment has shown that the I.F. transformers should both be mounted on the I.F.-Detector chassis, so that a double lead must be taken from the mixer via output and input sockets to the primary of the first I.F. transformer on the following unit chassis. These leads must obviously be as short as possible, not only to avoid interference or feedback effects but also to keep the lead capacity low, for any stray capacity here will be added to the tuning capacity across the I.F. transformer winding.

This lead is kept short by mounting V1 at the right hand end of the chassis, with the output socket immediately beside it, mounted in the end of the chassis so that the lead from the valveholder to the socket is only an inch or so in length. A similar arrangement in the I.F. chassis, with the signal input socket mounted in the left hand end of the chassis carrying the second unit, the first I.F. transformer being mounted close to the left hand end reduces the length of the lead in the I.F.-Detector unit, and the two units may be connected by a very short cable, an inch or so in length.

For the cables connecting valveholder to output socket, output socket to input socket and input socket to first I.F. transformer, short pieces of co-axial cable may be used, providing the outer conductor is rubber sheathed. The outer conductor should be connected to the junction of C5 and R2 since this point of the circuit is at earth potential so far as R.F. is concerned, the inner conductor then running from the anode pin of the valveholder to the output socket.

If co-axial cable cannot be obtained, screened two core cable must be used, the screen being earthed.

Whatever cable is used as a coupling between the two chassis, it must be remembered that after the whole receiver is aligned and ganged the same length of cable must be used from then on, for a different coupling cable will introduce a slightly different self capacity with consequent de-tuning of the I.F. transformer primary.

H.T. and heater power supplies are carried through the whole receiver by a system of 4 pin plugs and sockets, the sockets as usual being chassis mounting 4 pin valveholders and the plugs being made from old 4 pin valve bases. After wiring the plugs by heating the pins and cleaning out old wire and then sweating the new cable cores into the plug legs, the plugs should be filled with pitch or Chatterton's compound or cobbler's wax.

The output stages are provided with the master 4 pin plug which is inserted into the power pack socket, and the cables from this plug, beside supplying the output stage, also supply a second output socket mounted on the rear of the output stage chassis. A 4 pin plug and cable from the I.F.-Detector unit is fed from this socket, supplying the unit and yet a third socket into which the 4 pin cable from the mixed unit is plugged.

The chassis are thus connected together, but the negative or earth line may require to be made more direct by strapping the chassis together by short links bolted down from chassis to chassis. To prevent any chance of feedback such direct earthing connections are highly desirable.

#### Components List for the Broadcast Mixer Unit, Fig. 7.

For Use With 4 or 6 Volt Valves.

L1,	Wearite PA3.	16-47	metres
L2,	" PA2.	200-557	"
L3,	" PA1.	700-2,000	"
L4,	" PO3.	Shortwave	oscillator.
L5,	" PO2.	Mediumwave	"
L6,	" PO1.	Longwave	"
C1,C2,C10	60 mmfd.	Trimmer.	
C3,C12,	75 mmfd.	Trimmer.	
C4,C9,	0.0005 mfd.	Two-gang tuning condenser.	
C5,C6,C7,C16,	0.1 mfd.	350 v.v. Non-inductive.	
C8,	0.0001 mfd.	Mica.	
C11,	0.005 mfd.	Mica or Non-inductive.	
C13,	500 mmfd.	Padder.	
C14,	100 mmfd.	Trimmer.	
C15,	150 mmfd.	Padder.	
R1, (for 4 volt working).	51,000	ohms.	1 watt.
R2,	33,000	"	1 "
R3,	56,000	"	1 "
R4,	51,000	"	½ "
R5,	470	"	½ "
R1, (For 6 volt working).	33,000	"	1 "
R2,	43,000	"	1 "
R3,	62,000	"	1 "
R4,	51,000	"	½ "
R5,	390	"	½ "
S1,S2,S3,S4,	4 pole	3 way	Yaxley type wave change switch, with ganged leaves.

V1, AC/TH1 for 4 volt operation.  
6K8 for 6 volt operation.

1 British 7 pin chassis mounting valveholder  
or International Octal chassis mounting valveholder.

Slow motion drive for C4, C9.

Chassis, aluminium, 9½ x 4½ x 2.

Input socket, aerial.

Double output socket, O-O.

Cable, etc.

Further coils which may be used are the Wearite PAA, 12-35 metres, and PA5, 34-100 metres, in the S2, C4 circuit.

Oscillator coils for use on these two extra bands are the PO4 and the PO5.

Trim PA4 and PA5 with a 60 mmfd. Trimmer each.

Trim PO4 and PO5 with a 60 mmfd. Trimmer each.

Pad PO4 with a 0.005 mfd. Mica or Noninductive condenser.

Pad PO5 with a 0.002 mfd. and a 0.0004 mfd. condensers connected in parallel to give a total padding capacity of 0.0024 mfd.

Details for trimming, padding and general alignment are given in the following chapter.

## CHAPTER 5.

### AN I.F. AND DETECTOR UNIT.

The input circuit of the I.F. amplifier has already been discussed, and here again the layout is purely conventional apart from the fact that T1 must be close to the input sockets mounted on the left hand side of the chassis.

Iron cored I.F. transformers are used, the tuning being carried out by core adjustment or by condenser adjustment, according to the type obtainable.

The I.F. transformers and valves should be mounted in line along the central axis of the chassis, the transformer cans thus assisting valve screening, and the lead from T1 to the top grid of V1 must, of course, be screened.

All grid and anode leads must be short and direct, since instability and parasitic oscillation in I.F. amplifiers can generally be traced to the grid and anode wiring of the I.F. amplifier valve, in this case V1 of Fig. 8.

The power input socket, of the four-pin type, should be mounted in the rear of the chassis, towards the left hand side, the four core power supply cable entering at the rear towards the right hand side.

A single wire output circuit is shown, and here again the lead should be as short as possible and shielded to prevent hum pickup, the condenser C9 being included in the shielding by wrapping this component in a turn of copper foil, the foil being connected electrically to earth or the wire screening.

Straightforward A.V.C. is applied to the I.F. amplifier, no delay being given since this is the only valve with A.V.C., so that full control must be exercised.

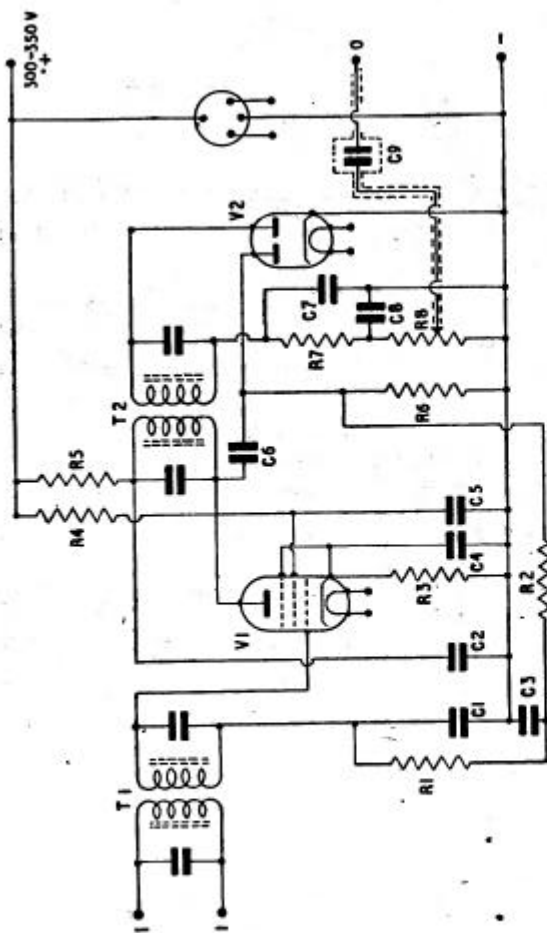


FIG. 8.—The I.F. and R.I. Detector Unit.

If desired a Magic Eye tuning indicator could also be fed from the A.V.C. line.

Components List for the I.F.-Detector Unit, Fig. 8.

C1,	0.01 mfd. 350 v.w. Non-inductive.
C2,C3,C4,C5,	0.1 mfd. 350 v.w. Non-inductive.
C6,	0.0001 mfd. Mica.
C7,C8,	0.0002 mfd. Mica.
C9,	0.02 mfd. 350 v.w. Non-inductive.
R1,	100,000 ohms, $\frac{1}{2}$ watt.
R2,R6,	1 megohm $\frac{1}{2}$ "
R3,	150 ohms, $\frac{1}{2}$ "
R4,	68,000 " 1 "
R5,	10,000 " 1 "
R7,	33,000 " $\frac{1}{2}$ "
R8,	0.5 megohm volume control.
T1,T2,	Iron cored I.F. transformers, for I.F. of 465 kcs.

V1, VP4B for 4 volt operation,

6K7G for 6 volt operation.

V2, 2D4A for 4 volt operation,

6H6 for 6 volt operation.

1 British 7 pin chassis mounting valveholder

1 " 5 " " " " " " "

or 2 International Octal chassis mounting valveholders.

Chassis, aluminium,  $9\frac{1}{2} \times 4\frac{1}{2} \times 2$ .

Input socket, I-I.

Output socket, O.

Cable, wire screening, etc.

1 British 4 pin chassis mounting valveholder as power output socket.

The two units, mixer and I.F. amplifier and detector make up the tuned portion of a superhet receiver, and may be aligned and trimmed as they stand, or preferably, with an output stage added. Whatever the output stage used, the circuits should be adjusted with an output meter connected to the final stage, rather than using the loudspeaker volume as a check, since after a short time the single audio note given by a signal generator has a deadening effect upon the ear and judgment is poor.

To align the receiver, set all trimmers and variable padders to the half-way position. Switch to the medium wave position, and switch on the receiver and signal generator and allow them to reach a steady working temperature before use—at least ten minutes should elapse.

Ascertain that the mixer and I.F.-detector units are correctly coupled by the chosen coupling cable, and that the chassis are strapped.

Couple the signal generator to the control grid of the mixer and earth, i.e., the mixer chassis. Tune the signal generator to 465 kcs.

Trim the two I.F. transformers for maximum response at 465 kcs. with the receiver volume control at full and the generator output control at full, reducing the generator output as the volume increases and the I.F. circuits come into tune. Trim from the detector back towards the mixer.

With the I.F.'s trimmed for full response at 465kcs. they should not be touched further.

It is common practice to prevent the oscillator section of the mixer from working whilst trimming the I.F. transformers, but the operation can be performed with the oscillator functioning. The amateur, however, is advised to stop the triode section oscillating, and this is carried out most simply by shorting the triode grid to earth for R.F. by connecting a 0.1 mfd. condenser between the mixer oscillator grid and earth.

With the I.F. transformers trimmed, remove this condenser if used, to allow the oscillator to operate.

Remove the signal generator lead from the control grid of the mixer, and connect it instead to the aerial input socket.

Tune the signal generator to 250 metres, 1,200 kcs, and tune the receiver, on a calibrated dial, to the same frequency.

Open C12 to the minimum capacity, and then slowly trim towards full capacity, stopping at the first response peak.

Tune the signal generator and receiver to 600 kcs, 500 metres, and pad C13 for maximum response.

Retune the signal generator and receiver to 1,200 kcs. It will be found that the padding operation has unbalanced the trimming so that the circuit must again be trimmed for maximum response by a slight adjustment of C12.

Retune the generator and receiver to 600 kcs and correct the padding adjustment of C13.

Repeat these last two operations as often as is required until the trimming and padding are balanced to give correct tracking over the tuning dial.

Finally, at 1,200 kcs., trim the first tuned circuit, C2, to maximum response.

Remember to keep the signal generator output as low as possible as soon as the circuits are roughly in tune.

The medium waveband is now adjusted, and the operations of trimming and padding the oscillator and trimming the first tuned circuit of the long waveband must be carried out. The I.F. transformers, of course, are set, and must not be re-adjusted.

Trim and pad the long waveband circuits with the receiver switched to Long, and using the two wavelengths 900 metres, 333.33 kcs. for trimming and 1,500 metres, 200 kcs., for padding. (C14, C15, C3.)

The short waveband padder is set, so the oscillator must be trimmed, by C10, to correct for wavelength at 30 metres, 10 Mcs., and then the first tuned circuit trimmed to maximum response at the same wavelength by C1. The shortwave band should then be checked for tracking at several points throughout the band. Any serious error will be due to C11, the fixed padder, and may be corrected experimentally either by inserting a slightly smaller capacitance or by increasing C11 by parallel connected condensers.

## CHAPTER 6.

### A 3-4 WATT OUTPUT STAGE FOR 4 VOLT OPERATION ONLY.

The output stage described in this chapter is a very simple two-valve amplifier for 4 volt operation. A PX4 triode is used as the output valve, and since there is no similar valve in either the British or American 6 volt valve ranges, this unit is limited to 4 volt working only.

The units shown and described so far have been designed to operate with the heater line not connected to earth, so that in their 4 volt versions they might be suitable for use with this output stage. It will be seen from Fig. 9 that the PX4 is a directly heated triode and that its bias must therefore be applied via the heater. If it is desirable to avoid the use of a second heater winding given over to the PX4 the heater line must be earthed only through the PX4 biasing resistor, R9 and R7 and R8 in Fig. 9, for earthing the heater line at any other point would short-circuit the output valve's biasing circuit.

When 6 volt valves are used, or when 4 volt cathode type output valves are used, the heater line may have one side earthed as a precaution against hum.

A selector switch in the first stage of the simple output unit allows either the output from the superhet units or from a gramophone pickup, the unit having sufficient gain to provide full output from an input of approximately 0.6 volt input. The diode detector of the superhet will, therefore, provide ample input, as will practically any moving-iron type of pickup, the first valve of the unit being protected from overloading by a volume control in either case.

A crystal pickup provides a very large output, and if such an instrument is to be used the valve type AC2HL used for V1 can be replaced by a 354V in the majority of cases. Here again, however, R1, the pickup volume control, protects the unit from overloading and the valve, with a higher amplification factor, makes the unit as a whole more versatile.

When switching the inputs both volume controls should be reduced to the lowest position, but even so, the grid of the valve is left open as the moving contact crosses from pickup to radio positions, so that unless a switch is obtained where contact with the second position is made before contact with the first position is broken, there will be a clicking or "crashing" as the switch is operated. By connecting R2 to the grid of the valve this may be avoided to some extent, but then R2 is shunted permanently across R1, and in some cases R1 may be specially chosen to suit the pickup. In the majority of cases, however, R2 may be connected to the grid of V1 rather than to the switch position without ill-effect, if the open grid effect causes annoyance.

The quality obtained from a two-triode amplifier such as that shown in the diagram is excellent, the PX4 in particular assisting with its high damping factor.

The output is sufficient for all home uses, and should be fed to a 10" speaker, of the permanent magnet type. (An energised magnet speaker must have its own field power supply, since no provision is made in the power packs described earlier for field energisation.)

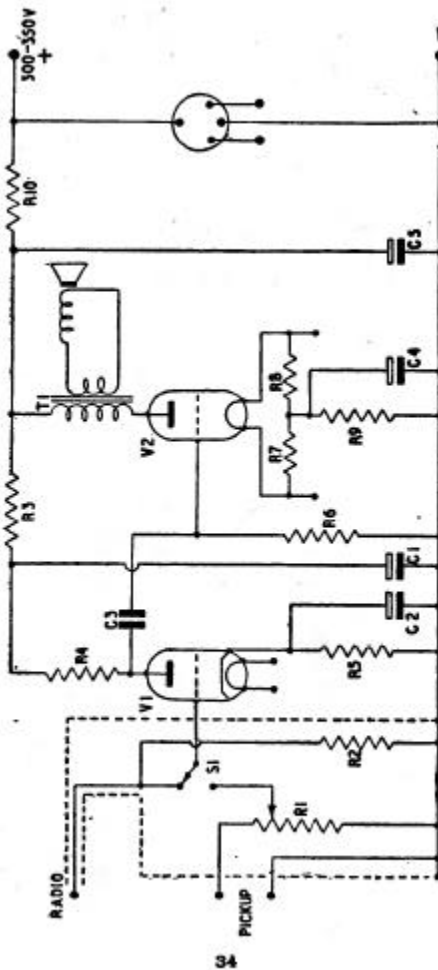


FIG. 9.—3-4 watt Output Stage—4 volt operation.

A small output stage may be built onto the same chassis as the power pack, since the two valves (or, in some cases, a single valve) take up very little room and require little shielding from mains transformers and L.F. chokes, but this rather reduces the versatility of the power pack which may be required to supply apparatus which has no need of an output stage. In general, therefore, the separate output unit is to be preferred.

Components List for the Output Stage Unit, Fig. 9.

For Use with 4 Volt Valves Only.

R1,	0.25 megohm volume control, or as specified for pickup.
R2,	1 megohm $\frac{1}{2}$ watt.
R3,	33,000 ohms, 1 watt.
R4,	51,000 " 1 "
R5,	680 " $\frac{1}{2}$ "
R6,	220,000 " $\frac{1}{2}$ "
R7,R8,	68 " 1 "
R9,	820 " 2 "
R10,	1,000 " 3 "
C1,C5,	8 mfd. 500 v.w. Electrolytic.
C2,C4,	25 mfd. 50 v.w. "
C3,	0.1 mfd. 500 v.w. Non-inductive.
S1,	2 way selector switch.
V1,	AC2HL.
V2	PX4.

- 1 5 pin British chassis mounting valveholder.
  - 2 4 " " " " " " " "
  - (1 to act as 4 pin power output socket).
  - T1, Output transformer, to match speaker into 4,000 ohms anode load.
  - Chassis, aluminium, 7 x 3 $\frac{1}{4}$  x 2 or 9 $\frac{1}{2}$  x 4 $\frac{1}{4}$  x 2.
- Note that the input circuit for both radio and gramophone is screened to prevent hum pickup. The simplest method of screening the circuit is to mount the switch and other components in a group, making a small cover of sheet copper or metal gauze cut and sweated to shape, fixing this cover over the input circuit components by bolting it to the chassis.
- The required output transformer ratio is found in the usual manner by the formula

$$R = \sqrt{\frac{\text{Anode load}}{\text{Voice Coil impedance}}}$$

Since the anode load is 4,000 ohms, the ratio of T1 for use with a 3 ohm speaker would therefore be

$$R = \sqrt{\frac{4,000}{3}} = 31.6.$$

The transformer ratio thus requires to be 31.6 : 1 and the component must be capable of handling 3.5 or 4 watts.



CHAPTER 7.

A REMOTE TONE AND VOLUME CONTROL UNIT.

The output unit of Fig. 9 is shown with no provision for tone control. Volume is controlled, for radio reception, in the output circuit of the diode detector, and for gramophone pickup work, by an input volume control, but it is possible to equip any amplifier containing two or more stages with a master control unit which not only gives volume control but also two tone controls, one working in the treble and one in the bass frequencies.

There are many types of tone control, some containing tuned circuits which actually give true "boost" over a rather restricted frequency range, but the majority of tone controls operate by attenuation—that is, if a greater response in the bass frequencies is required the treble and some of the middle frequencies are attenuated or reduced, and *vice versa*. Thus the frequencies whose level is to rise are left at their original level, but the attenuation of other frequencies gives to the ear the desired result.

The simplest method of attenuating frequencies is to bypass a percentage of the chosen frequencies to earth, as in the combination C3-R1 of Fig. 10, or to pass them through a filter as in the combination C2-R2 of Fig. 10.

The impedance presented by a capacitance to currents at various frequencies varies depending on the order of the capacitance. Thus the impedance of an 0.1 mfd. capacitance at 100 cycles per second is approximately 16,000 ohms, but at 5,000 cycles per second the same capacitance presents an impedance of approximately 325 ohms. By choosing a suitable

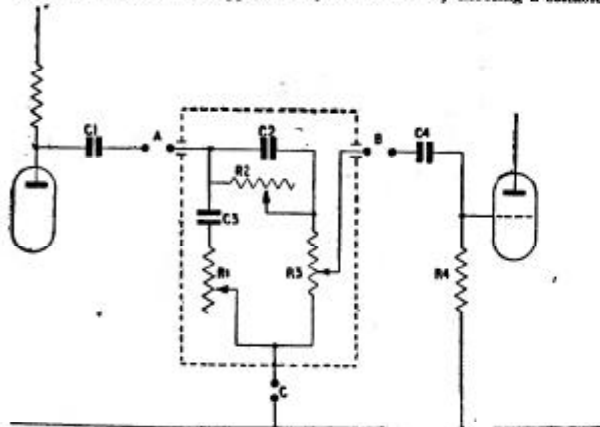


FIG. 10.—A Remote Tone Control and Volume Control Unit.

condenser, therefore, attenuation over a band of frequencies can be made automatic, the degree of attenuation being under control by including a variable resistance in the circuit.

In Fig. 10 the combination C3-R1 is the treble attenuator, bypassing a proportion of the higher frequencies to earth, whilst the combination C2-R2 is the bass attenuator. C2 is kept fairly small in capacitance, so that whilst R2 impedance to the higher frequencies is not great the impedance rises quickly as the frequency falls. The capacitance therefore blocks the passage of lower or bass frequencies, which are allowed to pass to the volume control through R2. As the resistance of R2 is increased, therefore, a smaller proportion of these lower frequencies is passed to the following circuits.

By including a volume control in the unit, R3, the whole system is complete in itself as a master control, but there is an added advantage in that it will feed not only into an ordinary valve stage but also into a phase-splitter stage to give control over a large paraphase amplifier. Isolating the following stage by C4-R4 allows the following valve to have any type of input circuit, thus covering the requirements for a phase splitter where the grid leak, R4, is connected, not to earth, but to a point on the cathode load resistance.

Another advantage of the unit is that the overall loss of gain introduced by its use is small. Many types of tone control cause a serious loss in the overall amplification of the stages into which they are incorporated, but by keeping the attenuation to the upper and lower frequencies the middle frequencies suffer little loss, and since these are the frequencies which contribute most to apparent volume, tone correction by the unit is satisfactory whilst the apparent volume drop is small.

The unit's chief advantage, however, lies in the fact that it may be built either directly into an amplifier, the controls then appearing on the panel, or in a remote control box. For both home and public address work the remote master control has many uses, especially for the music lover, since it gives him control over the gramophone output from his armchair.

For remote control, the unit must be built into a shielded box, either of metal or of wood lined with metal gauze. Care should be taken to see that the spindles of the variable resistances are insulated from the moving arms by making a simple continuity test. In composition track potentiometers the spindle is almost invariably insulated from the circuit, but in some wirewound potentiometers the moving arm and spindle are sometimes connected electrically. Mounting such a component in a metal or shielded box without insulating the mountings means that the moving arm of the component is short circuited to earth.

The control box can add much to the appearance of the apparatus, especially if a good wooden casket is used and the controls are mounted in line along the central axis.

The shielding inside such a casket must be thorough, extending over top, sides and bottom, each screen being sweated to its neighbours and the top screen, in the lid of the box, connected to the remainder of the screening by a flexible lead, so that the box lid can be opened.

A light cable, up to 4 yards in length, may be used to couple the box into the main amplifier, the cable having twin cores in a screened metal sheath, rubber covered overall.

The twin cores connect the "live" sides of the unit into the main amplifier, one extending between the two points at A, the other extending between the two points at B, the two points at C being coupled by the screen of the cable which thus acts as both screen and earth return.

With a well screened box and a good cable the hum pickup of the unit is reduced to nil.

A slight loss in the treble due to the self-capacitance of the cable is entirely swamped by the treble control.

**Components List for the Remote Tone and Volume Control Unit, Fig. 10.**

C2,	0.001 mfd. Mica or Non-inductive.
C3,	0.005 mfd. Mica or Non-inductive.
R1,R2,	0.25 megohm potentiometers.
R3,	0.5 megohm volume control.

It will be seen that C1, C4 and R4 are not included in the unit. Their values should be as follows,

C1, 0.1 mfd., 500 v.w.

C4, 0.02 mfd., 500 v.w.

R4, to suit following valve. For most output valves, 0.22 megohm, but for a phase splitting stage, 1 megohm or even higher.

The unit may be inserted between any two stages of a straight amplifier, but the best position is between the output valve and the penultimate stage. In this position any valve noise or distortion which has been introduced by the preceding stages is reduced, by the volume control, along with the signal, so that the percentage of noise or distortion cannot rise as the signal falls. In a paraphase or push-pull amplifier, however, the master control unit must be inserted into circuit immediately before the phase splitter.

With the master volume control near the output stage, in a straight amplifier, it is wise to retain a volume control in the input circuit, so that the first stage may be protected against overloading.

This control is not suitable for connecting into circuit between the diode detector of a radio receiver and the output valve, however. Diode detectors should be shunted by as high a resistance as possible to keep tone and reproduction good, and the shunting introduced by this unit would be of too low a resistance.

Tone control, in any case, is difficult when a receiver has an output stage following the diode with no intermediate stage, and the usual method of controlling tone is to shunt a treble attenuator across the primary winding of the output transformer. A combination of a 0.05 mfd. capacitance with a 0.1 megohm variable resistance is suitable for use in this circuit position, bypassing a proportion of the higher frequencies across the output transformer.

**CHAPTER 8.  
A SINGLE VALVE OUTPUT UNIT.  
FOR 4 OR 6 VOLT OPERATION.**

Where the main point of interest in a receiver lies in the tuned stages, it will be required that the output stage should be as simple as possible, so that a single valve stage will be all that is necessary. The small physical size of such a stage hardly warrants the provision of a separate chassis, and where the single output valve is used it may be built onto the end of the I.F.-Detector unit, onto the power pack chassis or even into the loudspeaker cabinet.

In the circuit, shown in Fig. 11, is included the treble attenuator mentioned in Chapter 7, connected across the primary of the output transformer.

For 4 volt operation a beam power tetrode is used, with beam forming screens internally connected. In this case, therefore, the connection to the earthed screen of the valve, shown in the diagram, should be disregarded, since this applies only to the 6 volt valve.

An advantage of both valves specified, either for 4 or 6 volt operation, is that a quite small input voltage is required to give full output.

The rated output for the 4 volt valve is over 4 watts, for the 6 volt valve, approximately 3½ watts. In either case the output is perfectly

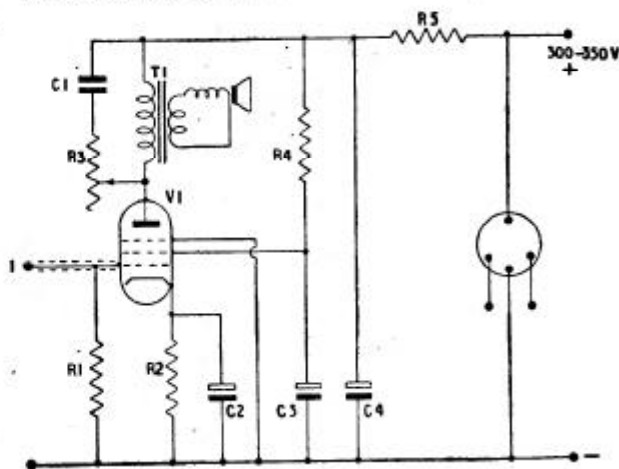


FIG. 11.—A Single Valve Output Unit.



sufficient for home use, and the local stations will give sufficient signal strength fully to load the valve.

No volume control is shown in the grid circuit for the reason that the stage or unit is intended to work from the I.F.-Detector unit, which contains an output volume control, but in some cases it may be desired to use a gramophone pickup with this stage. A further stage of amplification is definitely necessary between a pickup and the output valve, even with the sensitive valves specified, but a crystal pickup will give sufficient output to load the stage up to an output of 1 or 2 watts, so that in a case of emergency, or breakdown of the gramophone amplifier, this unit could be used to give results of a sort.

The crystal pickup should be connected into the grid of the valve by a volume control and filter network, the circuit and details of which are supplied with any good crystal pickup to suit the instrument's characteristics.

If a screened lead, as shown, is used in the input circuit and the anode leads and circuits are kept well clear of the grid lead, the unit may be built on any chassis without trouble, and takes very little space. Note the resistance wattage ratings, however, and mount these components clear of the chassis so that they may obtain some ventilation.

#### Components List for Single Valve Output Unit, Fig. 11.

For 4 or 6 Volt Operation.

R1,	220,000 ohms, $\frac{1}{2}$ watt.
R2, (For 4 Volt working)	180 ohms, 1 watt.
R2, (For 6 Volt working)	91 ohms, 1 watt.
R3,	100,000 ohms potentiometer.
R4, (For 4 Volt working)	22,000 ohms, 2 watt.
R4, (For 6 Volt working)	68,000 ohms, 2 watt.
R5,	1,200 ohms, 3 watt.
C1,	0.05 mfd. 350 v.w. Non-inductive.
C2,	25 mfd. 25 v.w. Electrolytic.
C3,C4,	8 mfd. 350 v.w. "
T1,	Output transformer.
	Anode load for 4 Volt Working, 5,200 ohms.
	Anode load for 6 Volt working, 6,000 ohms.
V1, Pen.45.	for 4 Volt Working.
KT61.	for 6 Volt Working.
3 Mazda Octal chassis mounting valveholder or International Octal chassis mounting valveholder.	
1 British 4 pin chassis mounting valveholder (as Power output socket).	
Chassis (if used) aluminium, 7 x 3 $\frac{1}{2}$ x 2.	
Input socket, 1.	

The stage and loudspeaker voice coil are matched by calculating the transformer ratio by the formula already given. T1 must be capable of handling 4-5 watts.

## CHAPTER 9.

### THE LOUDSPEAKER "UNIT."

It may be argued that the loudspeaker cannot be called a unit in the manner in which various radio and valve circuits have so far been treated as units, but the fact remains that when unit construction is used the loudspeaker no longer has a radio receiver cabinet for its mounting and baffle, and must therefore be treated individually.

There are advantages in this, for the ordinary radio receiver cabinet is far from satisfactory speaker mounting. At the time of writing one manufacturer has designed a receiver in such a manner that the speaker is supplied with a true baffle board, but in general a great deal of realism and truth is lost by placing the speaker in a small, light cabinet, the interior of which is filled with reflective surfaces and resonant objects.

The workshop can usually give room sufficient for a large baffle board to be stood or hung in some corner, but the construction of a bass reflex chamber causes little extra work, gives mechanical protection to the loudspeaker (often highly important in a workshop where metal filings and dust are present) and also assists the speaker to give true and beautiful reproduction. The bass reflex chamber, moreover, can be used in the living room when, for obvious reasons, the baffle board is banned.

The object of any baffle is to prevent air vibrations from the rear of the speaker cone mixing with those from the front of the cone. If, however, the vibrations from the rear of the cone could be added in phase to those from the front of the cone, the output would be increased. This can be done with the low frequencies, which are those chiefly requiring reinforcement, and the bass reflex chamber performs this work by absorbing the high frequencies from the rear of the cone, reflecting the low frequencies from the same source out through an aperture below the speaker opening.

The chamber is seen in diagram form in Fig. 12, and the dimensions for a 12" speaker are as follows.

30" high, 22" wide, 12" deep.

The speaker opening is cut in the upper half of the front of the chamber, the reflex opening, about 7" x 3" being below the speaker opening.

The chamber must be built of heavy wood, at least  $\frac{1}{2}$ " and preferably 1" thick, heavy ply being ideal, and the speaker is mounted, not on the wood, but on a square of thick fibrous material such as wall board or building board, this being mounted in turn to the wood of the chamber front. The speaker mount should be 14" square.

The absorbing of the high frequency sound waves from the rear of the cone is performed by thick felt. Really heavy material must be used, positioned on the back of the chamber so that it is directly opposite the loudspeaker, the felt running from side to side of the chamber and being, like the speaker mounting, 14" deep.

The interior of the chamber should be left empty, apart from the output transformer if this can be mounted on the rear of the speaker, but it is advisable to position the transformer on the output stage chassis, leaving the chamber clear for the speaker.

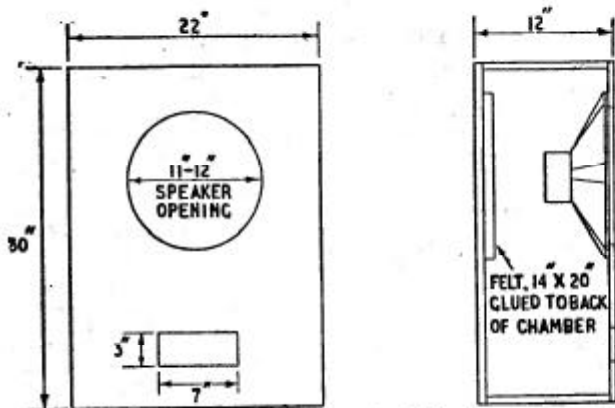


FIG. 12.—Bass Reflex Speaker Cabinet.

If a speaker with an energised field must be used, the field supply unit should be mounted at the rear of the chamber, or chassis built and mounted on the bench. A metal rectifier can be used where A.C. mains supply the field current, halfwave rectification being all that is necessary, since the field acts as its own high inductance smoothing choke.

A large speaker should have a field capable of carrying 100 mAs., but any good speaker has the field current requirements marked on the identification label. The field supply may therefore be adjusted to give the correct

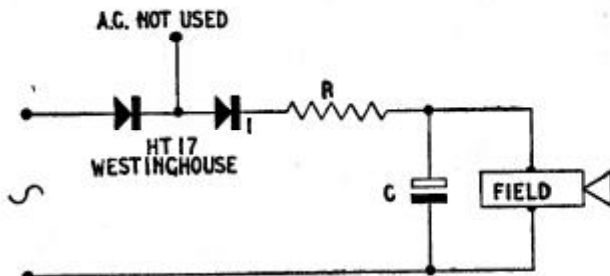


FIG. 13.—Speaker Field Energising Power Supply.

42

C

current by including a series resistance in the field circuit, the resistance being calculated by the use of Ohm's Law.

The power pack circuit is shown in Fig. 13.

Supposing that a field whose resistance is marked as 1,000 ohms requires a current of 100 mAs. The metal rectifier, connected as a half-wave rectifier, will probably give an output of about 200 volts when connected to the usual A.C. mains supply.

Thus, a circuit to pass 100 mAs—that is, 0.1 amp.—at 200 volts must have a total resistance of

$$R = \frac{200}{0.1} \text{ ohms, or} \\ = 2,000 \text{ ohms.}$$

The speaker field, therefore, makes up half of the total resistance needed, so that the series resistance must be 1,000 ohms also.

The watts rating of the resistance is the voltage dropped across the resistance multiplied by the current passing. The potential drop is, of course, 100 volts, so that the watts dissipated in the component are given by

$$W = 100 \times 0.1 \\ = 10 \text{ watts.}$$

A small wirewound resistance must be used, therefore, mounted so that it has good air ventilation.

The condenser across the speaker should be found by experiment, an electrolytic condenser being suitable since the current is rectified, the polarity being ascertained from the connections of the metal rectifier. An 8 mfd. condenser may be tried as a start.

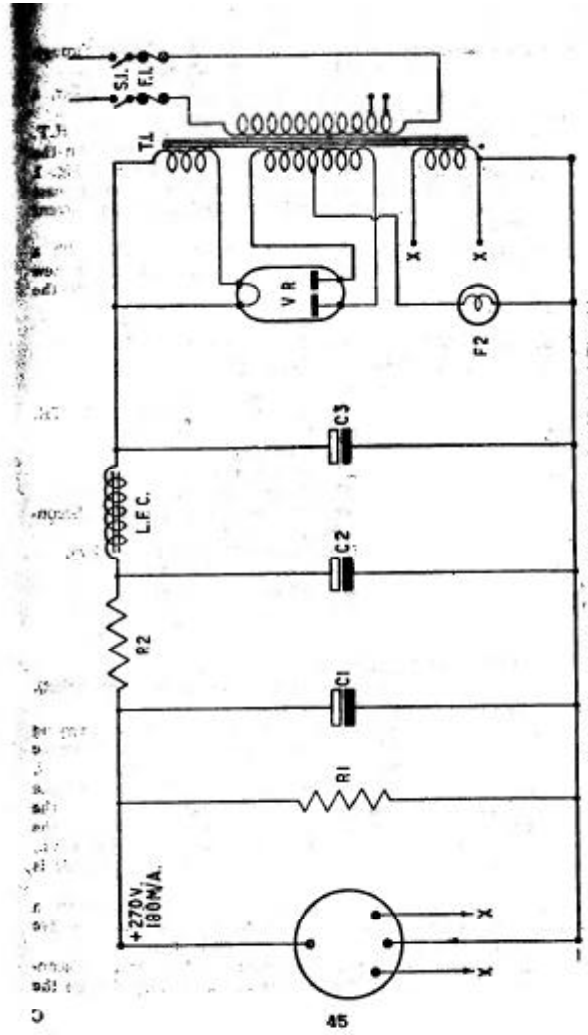
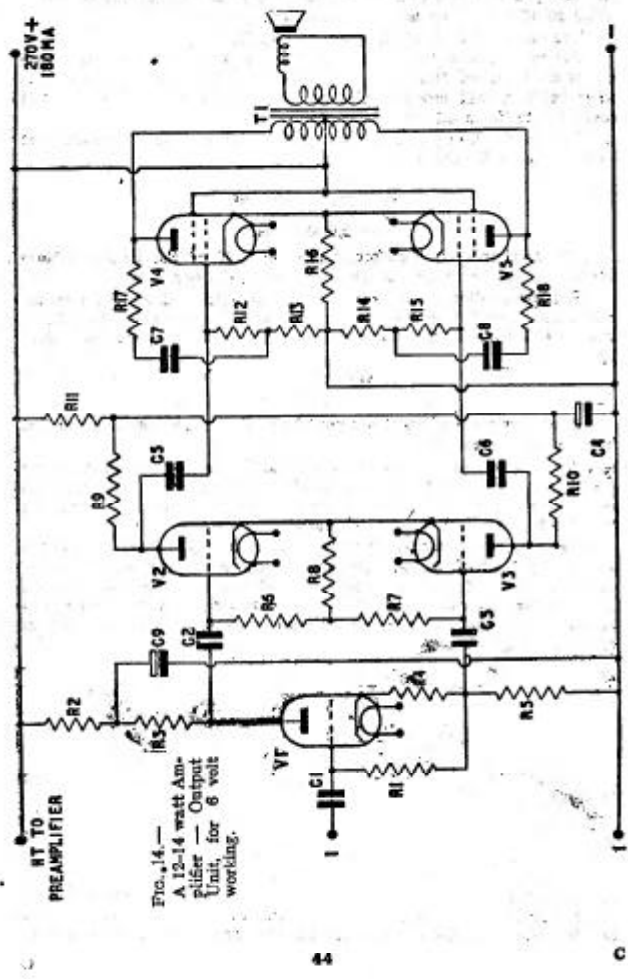
The bass reflex chamber may be finished in any manner to suit the surroundings, whilst the speaker opening should be covered with cloth gauze, as should the reflex opening. Metal gauze may be used to give greater protection and strength, but in this case every care must be taken to keep the gauze taut and well clamped round each edge, so that no vibration or chatter may arise.

#### CHAPTER 10. AN AMPLIFIER-OUTPUT UNIT FOR 6 VOLT OPERATION.

The unit to be described in this chapter, and whose circuit is shown in Fig. 14, is a complete amplifier from the phase splitter to the paraphase output stage, using 6 volt valves with the beam tetrode 6L6 type in the final stage. Negative feedback is applied over this stage to improve the quality of the output. The over-all gain of the unit is such that an output of 12 to 14 watts can be obtained with an input to the phase splitter of between 1 and 2 volts, so that if desired a crystal pickup can be fed directly into the phase splitter to give very good output. In general, however, the unit is intended for use either as the amplifier and output stage of a radio

43

C



receiver or as a gramophone amplifier with a further stage feeding through the master tone and volume control into the phase splitter.

Since a feeding stage requires only small gain to load the amplifier, a bass boosting triode circuit may be used.

It must be noted, however, that the current demand from the H.T. line is heavier than 100 mAs., so that this circuit cannot be fed from the power packs described in Chapter 1. The same circuit as shown in Fig. 1 may be used, but the power supply must be capable of giving at least 180 mAs., including the feed to a preamplifying stage, with a heater current of 3 amps at 6.3 volts.

A transformer with a higher current winding, and a rectifier with a greater current capacity must therefore be used, and accordingly a new component table has been drawn up, the component code referring to the circuit of Fig. 15.

#### Components List for Heavy Duty Power Pack, Fig. 15.

##### To supply Amplifier Unit of Fig. 14.

R1,	15,000 ohms, 6 watts.
R2,	650 ohms approx. 30 watts. SEE NOTE.
C1,C2,	8 mfd. 500 v.w. Electrolytic.
C3,	8 mfd. 750 v.w. "
L.F.C.	20 Hys., 200 mAs., 150 ohms.
T1,	200-250 volt primary.
	425-0-425 volt, 200 mAs. H.T. Secondary.
	5 v. 3 a. Rectifier heater Secondary.
	6 v. 3 a. Heater Secondary.
S1,	Double Pole ON-OFF Switch.
F1,	1 amp fuses.
F2,	250 mAs. Fusebulb with holder.
VR,	5U4

1 International Octal chassis mounting valveholder.

1 British 4 pin chassis mounting valveholder (to act as output socket).  
Chassis, aluminium or steel, 9½ x 4½ x 2.

Note.—To provide a resistance of 650-700 ohms, capable of carrying 200 mAs., a 0.2 amp heater dropping resistance is used. This resistance is mounted vertically on the top of the chassis so that it is well ventilated, and the output taken from the adjustable tap. Starting with the resistance fully in circuit, and a 250 mA. meter in the positive supply line to the amplifying unit, reduce the resistance until the H.T. current drawn by the unit and its preamplifying stage, if working on the pickup, is 180 mAs., or, without a preamplifying stage, until the current drawn by the unit is 170 mAs.

If no ammeter is available, adjust the resistance of R2 by connecting a D.C. voltmeter across the unit supply lines, setting the resistance to give a potential of 270 volts across the positive and earth lines.

Remember that switching on the power pack whilst the unit is disconnected will cause the voltage to rise to a degree which may damage the

electrolytic condensers. Always connect the amplifier to the power pack before switching on.

Although the amplifier contains five valves, it is easily accommodated on a 9½ x 4½ x 2 chassis, and there is room left to build in the master tone and volume control, if desired, or to include a simple triode stage of first amplification for a pickup. A suitable pickup preamplifying unit is described in a later chapter.

The output transformer may be mounted on the chassis, in which case the spare room will be taken by the component which must be of a size capable of handling 15 watts, or the transformer may be mounted on the loudspeaker.

Conventionally the phase splitter or phase splitter and pre-amplifier will be at the left hand end of the chassis, the rest of the stages being mounted with the valves side by side in chain towards the right hand end of the chassis, the input sockets being set on the left hand side of the chassis remote from the power input cable and audio output cable, which should both be at the right hand side of the chassis. So long as the input and output sockets are well separated, however, the layout of the amplifier may take any form convenient to the constructor.

The heater of the phase splitter, V1, is at a potential above earth due to the voltage drop across the cathode load resistance, so that the difference in potential appears between the heater and the cathode. If the mains transformer has a spare heater winding, this can be used to supply the heater of the phase splitter, the winding being bypassed to earth by a 0.1 mfd. condenser connected between its centre tap and earth, or a 33,000 ohm. resistor may be connected in the same position, but if there is no spare heater winding, the phase splitter heater must be supplied in parallel with the heaters of the following valves in the usual manner.

The input to the phase splitter is shown ready for connecting to the master tone and volume control unit, either direct or with remote control.

#### Components List for the Amplifier-Output Unit, Fig. 14.

##### For 6 Volt Operation Only.

R1,	1.2 megohm, ½ watt.
R2,R11,	22,000 ohms, 1 "
R3,R5,	33,000 " 1 "
R4,	1,500 " ½ "
R6,R7,	470,000 " ½ "
R8,	510 " 1 "
R9,R10,	43,000 " 1 "
R12,R15,R17,R18,	100,000 " ½ "
R13,R14,	10,000 " ½ "
R16,	120 " 3 "
C1,	0.02 mfd. 350 v.w. Non-Inductive.
C2,C3,C5,C6,	0.1 mfd. 500 v.w. "
C4,C9,	8 mfd. 350 v.w. Electrolytic.
C7,C8,	0.05 mfd. 500 v.w. Non-Inductive.
V1,V2,V3,	6C5
V4,V5,	6L6

5 International Octal chassis mounting valveholders.

T1, Output transformer to match voice coil into 5,000 ohms anode to anode load. To handle 15 watts.

Chassis, aluminum, 9½ x 4½ x 2, or larger if required.

Input socket, I-I.

3 pin output socket, if T1 is mounted on speaker.

2 pin output socket if T1 is mounted on chassis.

When constructing amplifiers, coupling condensers of proved quality should be used, to avoid any chance of leakage. The condensers are connected directly between anodes and the grids of the following valves, so that any leakage at this point would result in the cancellation of grid bias, the grid possibly running into heavy grid currents, with damage to the valve at worst, and distortion and poor working at best.

Group board construction is very useful when several resistances are in circuit, and in a main amplifier such as that in Fig. 14 may have all resistances and condensers mounted on one large group board.

Where pre-amplifiers are mounted on the same chassis, however, the pre-amplifier should have its own group board so that the components of this stage are isolated from those of the main amplifier.

#### CHAPTER 11.

#### AN AMPLIFIER-OUTPUT UNIT. FOR 4 VOLT OPERATION.

An Amplifier-Output Unit to use 4 volt valves follows much the same general outline as the amplifier of the previous chapter, but triodes are used throughout, so that excellent quality is obtained without the use of negative feedback.

The power pack, once again, however, must have a greater output than those shown in the first chapter, and follows the same circuit shown in Fig. 15, the component values being changed to suit the new conditions. Note that in place of R2 a second L.F. choke is used, whilst the mains transformer has a rather larger H.T. secondary voltage, and a 4 volt rectifier is used.

The power pack must also have a spare heater winding, with a centre tap, to accommodate the bias arrangements for the two PX25's in the output stage. The bias resistance connections are shown in the diagram of Fig. 17.

Components List for Heavy Duty Power Pack, Fig. 15.

Adapted for Use with 4 Volt Amplifier-Output Unit, Fig. 16.

R1,	24,000 ohms, 10 watts.
R2, —	Replaced by L.F.C.2.
C1,C2,	8 mfd. 500 v.w. Electrolytic.
C3,	8 mfd. 750 v.w. " "
L.F.C.1.	20 Hys. 200 mA. 150 ohms.
L.F.C.2,	

48

C

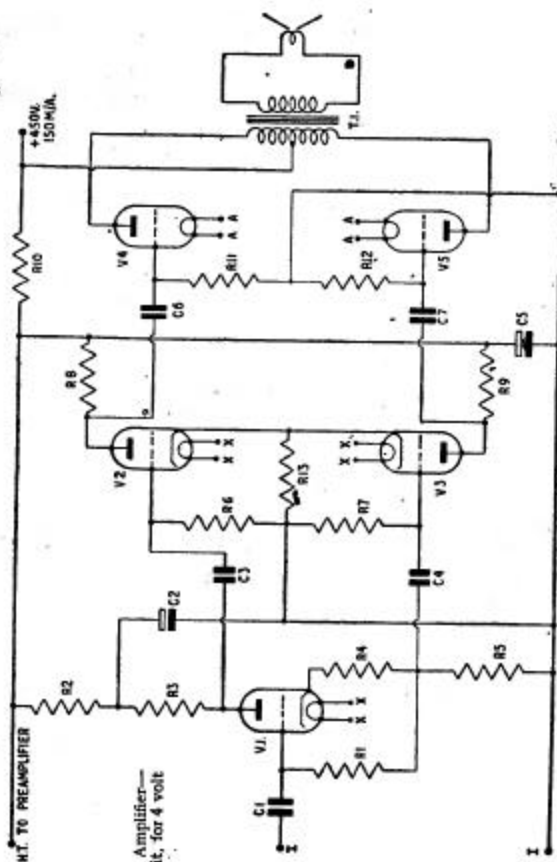


FIG. 16.—  
10-12 watt Amplifier—  
Output Unit, for 4 volt  
working.

49

C

T1, 200-250 volt primary.  
450-0-450 volts, 200 mA. H.T. Secondary.

4v. 3a. Rectifier heater Secondary.  
4v. 4a. Centre tapped heater Secondary for output stage.  
4v. 4a. Heater Secondary.  
Double Pole ON-OFF Switch.  
1 amp. fuses.  
250 mA. Fusebulb with holder.

S1,  
F1,  
F2,  
VR, FW4/500

2 British 4 pin chassis mounting valveholders.  
Chassis, aluminium or steel,  $9\frac{1}{2} \times 4\frac{1}{2} \times 2$ .

Again the power pack must not be switched on without the amplifier load connected in, since a voltage rise will result. The remarks concerning the construction of the 6 volt amplifier refer also to the construction of the 4 volt version.

#### Components List for the Amplifier-Output Unit, Fig. 16.

##### For 4 Volt Operation.

R1,	1.2 megohm,	$\frac{1}{2}$ watt.
R2,	22,000 ohms	1 "
R3,R5,	33,000 "	1 "
R4,	1,500 "	$\frac{1}{2}$ "
R6,R7,	470,000 "	$\frac{1}{2}$ "
R8,R9,	47,000 "	1 "
R10,	4,700 "	5 "
R11,R12,	330,000 "	$\frac{1}{2}$ "
R13,	330 "	1 "
R14 (in Fig. 17),	250 "	$\frac{1}{2}$ "

(two resistances in series may be used, 100 and 150 ohms).

C1,  
C2,C5,  
C3,C4,C6,C7,  
T1,

V1, V2, V3, 354V  
V4, V5, PX25

3 British 5 pin chassis mounting valveholders.  
2 British 4 pin chassis mounting valveholders.  
Chassis, aluminium,  $9\frac{1}{2} \times 4\frac{1}{2} \times 2$ , or larger to accommodate pre-amplifier, etc., if desired.  
Input sockets H.  
2 or 3 pin Output Sockets.

50

C

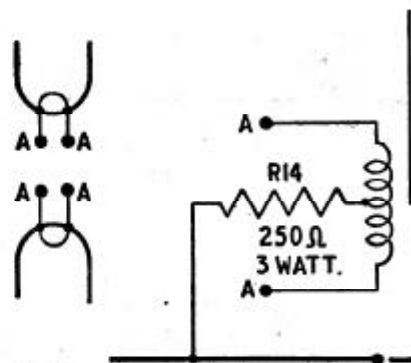


FIG. 17.—Bias arrangement for the Output Stage of Fig. 16.

The overall gain of the amplifier is such that a full output is obtained with approximately 1 volt input to the grid of the phase splitter.

As before, however, for gramophone reproduction it is more satisfactory to use a preamplifying stage with bass boost coupled into the main amplifier via the master tone and volume control unit.

## CHAPTER 12.

### A T.R.F. UNIT FOR QUALITY RECEPTION.

The superhet circuit, given in unit form in previous chapters, is probably more comprehensive a circuit than is required by many constructors. For quality reception, also, a simpler circuit has much to recommend its use, since the sharp selectivity curve of the superhet gives a degree of sideband cutting, thus causing audio bandwidth cutting. At the same time, quality reception usually relies upon the local station so that high sensitivity in the receiver is not required, and accordingly a two-stage tuning unit, with a triode detector without reaction gives satisfactory results in good and fair reception areas, although rather more gain is needed in a poor reception area.

The unit shown in the circuit of Fig. 18 tunes over the medium and long wavebands, transformer coupling between the stages being used. As in the previous receivers, Wearite P type coils are used, each coil being fitted with its own trimmer, and again the coils may be mounted vertically below the chassis if the long connecting tags are shortened and the trimmers are mounted well down on the coil former.

51

C

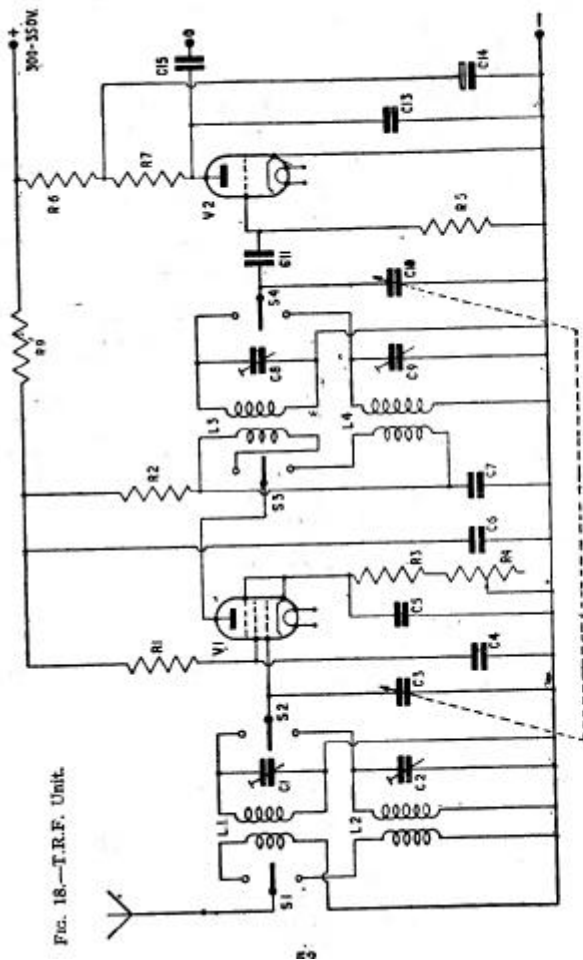


FIG. 18.—T.R.F. Unit.

The coils should be mounted in two groups of two beside their respective switch leaves, and whilst there should be no trouble with feedback any instability can be cured by fastening a small screen of metal foil or sheet aluminium between the two sets of coils, whilst V1 may be shielded by a valve screen.

Tuning is carried out by a double-ganged condenser driven through a slow motion drive.

The layout of the unit is simple, the tuning condenser being mounted centrally on the long side of the chassis with the R.F. stage to the left and the detector stage to the right.

The volume control, R4, and the wavechange switch S1-S4 are mounted on the front edge of the chassis.

Components List for the T.R.F. Unit, Fig. 18.

For 4 or 6 Volt Operation.

- |                 |  |
|-----------------|--|
| L1,             | Wearite PA2. 200-557 metres.                               |
| L2,             | " PA1 700-2,000 "  |
| L3,             | " PHF2.  |
| L4,             | " PHF1.  |
| C1,C2,C3,C8,C9, | 75 mmfd. Trimmer.  |
| C10,            | 0.0005 mfd. Two-gang tuning condenser.                     |
| C4,C5,C6,       | 0.1 mfd. 350 v.w.  |
| C7,C15,         | 0.0001 mfd. Mica.  |
| C11,C13,        | 8 mfd. 350 v.w. Electrolytic.                              |
| C14,            | 8 mfd. 350 v.w. Electrolytic.                              |
| R1,R6,          | 33,000 ohms, $\frac{1}{2}$ watt.                           |
| R2,R9,          | 10,000 " 1 "   |
| R3,             | 150 " $\frac{1}{2}$ "                                      |
| R4,             | 10,000 " variable  |
| R5,             | 330,000 " $\frac{1}{2}$ watt.                              |
| R7,             | 47,000 " 1 "   |
| S1,S2,S3,S4,    | 4 pole 2 way Yaxley type switch.                           |
| V1,             | VP4B for 4 Volt Operation.                                 |
|                 | 6K7 for 6 Volt Operation.                                  |
| V2,             | 354V for 4 Volt Operation.                                 |
|                 | 6C5 for 6 Volt Operation.                                  |
| 1               | British 7 pin chassis mounting valveholder.                |
| 1               | " 5 " " " " "  |
|                 | or 2 International Octal chassis mounting valveholders.    |
|                 | Chassis, aluminium, 9 $\frac{1}{2}$ x 4 $\frac{1}{2}$ x 2. |
|                 | Control knobs for S1-4, and R4.                            |
|                 | Slow motion drive for C3, C10.                             |
|                 | Aerial, Earth and Output sockets.                          |

To trim the receiver, set all trimmers to the half-capacity position, and connect a signal generator to the aerial input socket, and earth. Switch on receiver and generator and allow them to reach working temperature.



Tune both the receiver, switched to the medium waveband, and the generator to 250 metres, 1,200 kcs. and trim the medium waveband circuits to maximum response, trimming first C8 then C1, reducing the generator output as the volume increases, keeping the receiver volume control well advanced.

With the two medium waveband trimmers set, switch the receiver to the long waveband, tuning both receiver and generator to 1,000 metres, 300 kcs., and trim again for maximum response, by adjusting first C9 then C2.

Using the signal generator it is simple to calibrate the receiver if a calibrated dial is not obtainable. It is only necessary to mark the cardinal points on the dial by setting the generator successively to, say, 250, 300, 350, etc., metres, subdividing between these points to 5 or 10 equal parts.

Since a triode detector, which is also an amplifier, is used it may be coupled to the chosen output stage via the master tone and volume control.

Experiment shows that with some valves in the position V2 a fairly large resistance for the grid leak causes hum. It is possible to reduce the specified value of R5, 330,000, to a much lower figure if necessary, but first, if the circuit of the output stage allows, one side of the heater supply line may be earthed to test the effect on any hum which may be present.

The most troublesome type of hum is "modulation hum" which appears only when a station is tuned. It is most likely to appear on a receiver whose power supply is derived from the mains either by a halfwave rectifier or a metal rectifier, but another likely cause is heater-cathode leakage in the R.F. amplifying valve. If modulation hum appears, the R.F. valve should first be suspect and if found to be in good condition, the effect of a small condenser, say, .01 mfd., tried between one side of the mains and chassis. However, it is unlikely that trouble will be experienced if the mains transformer has a screened primary and this screen is properly earthed.

## CHAPTER 13.

### A PICKUP PRE-AMPLIFYING UNIT.

It is generally understood that, in the recording of gramophone discs there is a reduction in the lower frequencies, the reduction increasing as the frequency drops. This is made necessary by the increasing amplitude of the swing of the recording stylus at the lower frequencies, and thus to reproduce the bass the record must be played back using apparatus which has a response curve rising in the bass by the same degree as the recording apparatus introduces the fall.

We have already seen that to give bass boost in as simple a manner as possible, it is only necessary to introduce middle and top frequency attenuation, and this method is introduced into the anode circuit of the pickup pre-amplifier shown in Fig. 19.

Across anode and earth is connected a frequency discriminating network, designed to give attenuation to all but the bass or low frequencies from approximately 250 cycles down, and the following stages are coupled in by a tap on this network which has the effect of a potentiometer coupling.

The gain of the stage is small, as might be expected, but since the output and amplifying stages already shown require but small inputs to fully load them to capacity, any ordinary pickup, preamplified by this stage, will give more than sufficient input voltage to any of the amplifying units shown.

The stage takes up very little chassis space, and may be built either on its own chassis or on the chassis of a main amplifier in line with the phase splitter. Coupling between the stage and the phase splitter (or into the first stage of a straightforward amplifier) may be either direct or through the master tone and volume control. It may seem pointless to increase the bass characteristic only to couple the units through an attenuating control, but in practice it will be found that a degree of control over the bass will be required more than ever.

A 4 or 6 volt valve may be used as the pre-amplifier, although there is a discrepancy in the gain of the stage under the two conditions. The 4 volt valve specified will give a stage gain of approximately 10; whilst the 6 volt valve will give a stage gain of only 5 or 6. Even so, the output will be sufficient to drive the main amplifier shown in Fig. 14.

#### Components List for Bass Boosting Pre-Amplifier, Fig. 19.

##### For 4 Or 6 Volt Operation.

R1,	0.25 Megohm volume control, or to suit pickup.
R2,	33,000 ohms, 1 watt.
R3,	43,000 " 1 "
R4, (For 4 Volt working)	680 " 1 "
R4, (For 6 Volt working)	1,000 " 1 "
R5,	68,000 " 1 "
R6,	22,000 " 1 "
C1,	25 mfd. 32 v.w. Electrolytic.
C2,	8 mfd. 350 v.w. "
	0.05 mfd. 350 v.w. Non-inductive.
C4,	0.1 mfd. 350 v.w. "

V1, 354V, for 4 Volt Operation.

6C5 for 6 Volt Operation.

1 British 5 pin chassis mounting valveholder  
or International Octal chassis mounting valveholder.

Control knob for R1.

Chassis (if required) aluminium, 7 x 3½ x 2, or build on main amplifier chassis.

Pickup input socket.



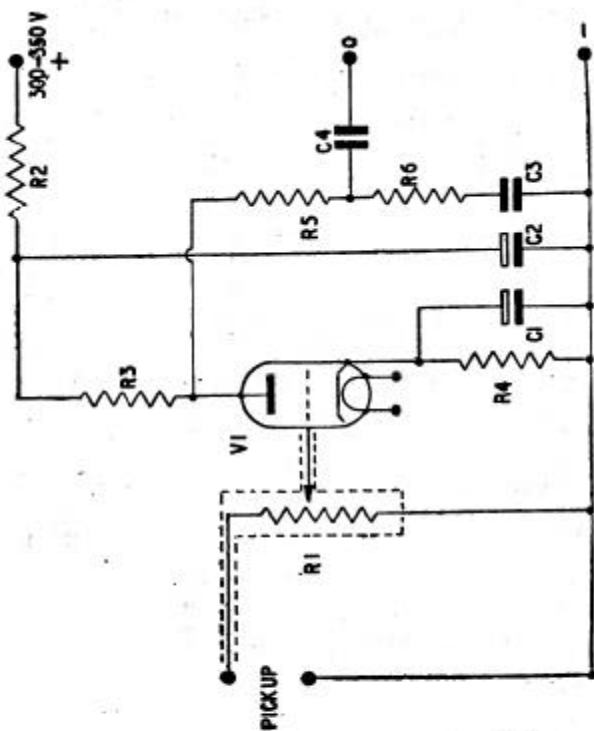


FIG. 19.—100-Hertz Boosting Pickup Pre-amplifying Unit.

Note that a volume control input is used to the unit, so that a high output pickup, such as the crystal type, can be prevented from overloading the stage. Screened input leads are necessary.

C4, the output coupling condenser, should be connected into a stage with a high resistance grid leak, whenever possible, the resistance being of the order of a megohm.

#### CHAPTER 14.

##### A PAIR OF TEST UNITS FOR THE WORKBENCH.

Probably the most used and most needed piece of apparatus on the engineer's or amateur's workbench, after the circuit analyser or measuring instruments, is a signal generator, and, so that the generator may be used to the best advantage, an output meter.

Generators, however, are expensive to buy and difficult to build, since not only must extreme rigidity be ensured in their construction, but their calibration presents real difficulty and frequency stability is not easy to achieve.

The chief need for a signal generator, however, is to set the I.F. transformers of a superheterodyne, very often to a frequency of 465 kcs. The trimming and padding of the receiver can be carried out on broadcast signals so long as stations are chosen near the required checking points—approximately 250 metres, or below, and 500 metres on the medium waveband, and 900 and 1,500 metres approximately on the long waveband.

A small generator to give 465 kcs. therefore, can be of great assistance, for once the I.F. of the receiver is adjusted the back of the work is broken.

All that is required is a carrier wave at 465 kcs. modulated by an audio frequency, preferably at about 400 cycles, and such an output can be given by a single triode which, moreover, can be battery driven.

Using a small button valve of the 1C4 type, powered by a 45 volt battery for H.T. and a single 1.5 volt cell for L.T., since the filament consumption is only 50 mAs., a very small and compact portable I.F. generator can be built into a handy case. A type 30 valve will also serve, although its filament is rated at 2 volts, 60 mAs., or the same circuit can be used with 4 or 6 volt mains valves.

The 465 kcs. signal generator circuit is shown in Fig. 20, a form of the Hartley oscillator circuit being used for the R.F. oscillator and a grid-anode coupled transformer supplies the audio modulation. Since the R.F. coil has a tapped connection it must be hand wound, but this presents no difficulty. The tap is determined by experiment to give a good and steady output, so that in the winding of the coil a series of taps are brought out at ten turn intervals, the H.T. feed being attached to each in turn to discover the best working position.

Since the mains version will probably be run from the general purpose power pack, high resistances are used to give a low anode voltage on the valve.

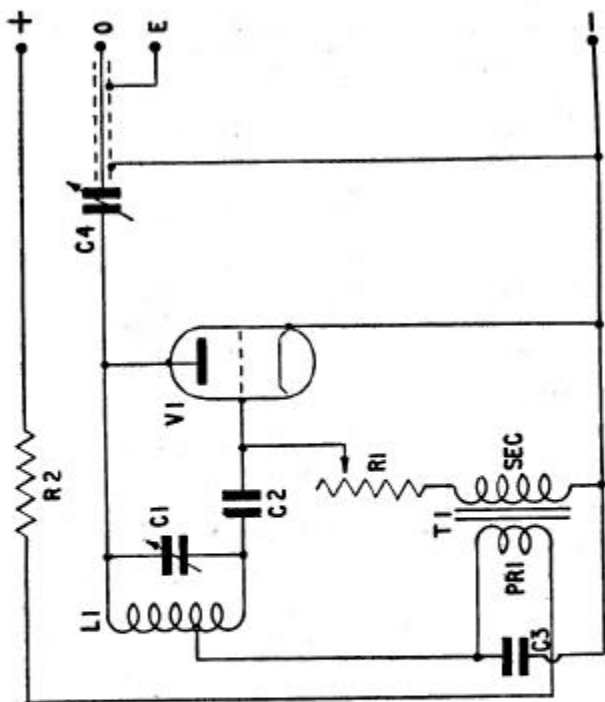


FIG. 20.—An I.F. Signal Generator Unit.

58

C

The connections to the audio transformer are also determined experimentally. If there is no audio oscillation, the connections to either the primary or secondary should be reversed.

The output from the generator is led away via a screened single core cable. The screen is connected to the negative side of the unit, the cable core being fed from the valve anode via a small trimmer type condenser which is set, again by trial, for suitable output. A variable grid resistance gives output control.

The unit should, of course, be built into a screened or metal box so that no field exists around it and the output comes solely from the cable. The unit must be calibrated, but since there is a single working frequency, controlled by the variable condenser across the tuning coil, this is a simple matter so long as a signal generator can be borrowed. The output from the signal generator and the output from the unit should both be fed to a triode acting as a small detector, with a coil and condenser across its grid circuit similar to L1 and C1 of the unit.

The main signal generator is then tuned to 465 kcs. and the triode detector tuned until the signal is heard, and sharply tuned by reducing the coupling between the generator and the detector. Usually no direct connection need be made, since it is sufficient to place the generator's output lead in proximity to the detector tuned circuit.

With the detector tuned to 465 kcs. then, switch off the borrowed signal generator, switch on the unit, allow it to reach working temperature and then tune C1 until the signal is again heard in the triode detector circuit. The unit is then tuned to the required I.F.

The unit may be made rather more versatile if the tuning condenser C1 is brought out to a good slow motion drive. It can then be calibrated in the various I.F.'s used by different commercial receivers, say from 460 to 475 kcs. in steps as close as can be accommodated by the drive.

If a signal generator cannot be borrowed, the unit must be calibrated against a new receiver which is specified, on the service sheet, to have the desired I.F. This is hardly a satisfactory method, however, and a signal generator should be used whenever possible.

#### Components List for the I.F. Generator, Fig. 20.

Note.—For battery valves, treat the heater symbol as filament, with one side earthed as shown and the other to 1.5 volts positive, via an on-off switch.

For mains valves, treat the heater symbol as the cathode, directly earthed. The heater will then be led to a 4 or 6 volt supply.

- |     |  |
|-----|--|
| L1, | 150 turns 30 S.W.G. enamelled, on 1½ in. diameter former, cardboard or paxolin. Close wound, with taps brought out at 40, 50, 60, 70, 80, turns. |
| C1, | 500 mmfd. Trimmer, mounted across L1, or 0.0005 variable tuning condenser.   |

59

C

- C2, 0.0001 mfd. Mica.  
 C3, 0.002 mfd. 350 v.v. Non-inductive.  
 C4, 30 mmfd. Trimmer.  
 R1, 1 megohm volume control.  
 R2, Not used with battery valves.  
 100,000 ohms, 1 watt, for mains valves.  
 3:1 Intervalve transformer.  
 T1, 3:1 Intervalve transformer.

V1, 1G4, 30, for battery, with suitable holder.

AC2HL for mains working, 4 volt operation, with British 5 pin chassis mounting holder.

6C5 for mains working, 6 volt operation, with International Octal chassis mounting valveholder.

Metal or shielded case, etc.

Supply, 1.5 volts, 45 volts H.T. for Battery Operation. 4 volts, 350 volts H.T., or 6 volts, 350 volts H.T. for Mains Operation.

It has already been said that the use of an output meter is advisable when trimming and aligning a receiver with the signal generator. Several makes of circuit analyser include an output meter connection, but when, as is often the case, the analyser is being used to take other measurements, this output meter cannot be used. A Magic Eye tuning indicator can, however, be used in a simple circuit not only as an output meter but also as a test unit for checking condensers. Two pairs of output sockets take test prods or connecting clips which are attached either to the condenser under test or to the output stage, across the primary or secondary of the output transformer.

The condenser test is a leakage or breakdown test. The resistance, R1, is adjusted with the test clips or prods inserted in the "C.T." sockets, the clips or prods being short-circuited together. R1 is adjusted until the Magic Eye closes under these conditions, and then the short-circuit broken to open the Eye. When the clips are connected across a broken down condenser, the Eye again closes, whilst a leaking condenser will cause the Eye partially to close. Intermittent condenser leakages or shorts will give a fluttering effect.

As an output meter, with the test clips or prods inserted into socket "O O," R2 acts as a control. The clips are connected to the output stage under test and, if a steady audio signal is applied, as from a signal generator, the Eye will close as R2 is advanced.

Setting the Eye to a half closed position, therefore, and watching the shadow as further work proceeds, will show whether the Eye closes further or opens. A closing Eye indicates a rise in output, whilst an opening Eye indicates a drop.

The unit may be used for 4 volt or 6 volt valves without change in circuit characteristics.

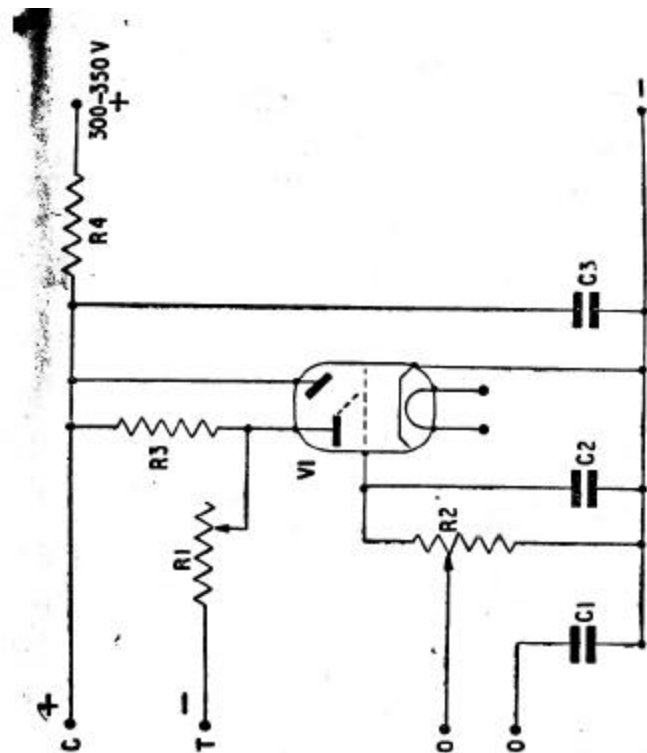


FIG. 21.—A Magic Eye Output Meter — Condenser Testing Unit.

Components List for Output Meter-Condenser Checker, Fig. 21.

R1,	50,000 ohms variable.
R2,	0.25 megohm variable.
R3,	1 megohm, $\frac{1}{2}$ watt.
R4,	22,000 ohms, 1 watt.
C1, C2,	0.01 mfd. 350 v.w. Non-inductive.
C3,	0.1 mfd. 350 v.w. "
V1,	AC/ME or VME4 for 4 Volt Operation. Y63 for 6 Volt Operation.

Note, that when testing condensers on sockets "C.T." the polarity must be observed for polarised (electrolytic) condensers.

## APPENDIX

The circuits in this Manual have been shown with 4 and 6 volt valves. To use them with Universal valves, of the 0.2 amp heater type is, in some cases, impossible. One disadvantage of such valves, for example, is that they are not suitable for use in amplifier output stages, such as the 12 and 14 watt units described, and so are limited to a single valve output stage.

This, however, may be modelled on the stage shown in Chapter 8, and a Pen 3520 is a suitable valve for such use, given a bias resistance of 680 ohms.

A substitute for the VP4B is the VP133 H.F. Pentode, whilst to substitute the AC/TH1 frequency changer or mixer a TH2320 is very suitable.

The DD620 replaces the Double diode detector of the L.F.-Detector Unit, and triodes may be replaced by the HL133.

Further details may be obtained from any valve data sheets.

The drop in H.T. supply voltage may be partially remedied by decreasing the decoupling resistances when A.C./D.C. valves are used, but in general the circuits as shown will work on lower voltages with but little drop in output or efficiency.

## BERNARD'S RADIO BOOKS FOR THE HOME & AMATEUR CONSTRUCTOR

3. SERVICES SIGNALLING MANUAL ... ..	1/-
4. RADIO POCKET BOOK ... ..	1/-
6. ELECTRICAL ENGINEERS HANDBOOK ... ..	1/-
22. MANUAL OF RADIO CIRCUITS ... ..	2/-
30. RADIO VALVE MANUAL ... ..	3/6
37. MANUAL OF DIRECT DISC RECORDING ... ..	2/-
41. WIRELESS AMPLIFIER MANUAL ... ..	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/-
50. INTERNATIONAL SHORTWAVE RADIO STATION LIST ... ..	1/-
51. CATHODE RAY OSCILLOSCOPE MANUAL ... ..	2/-
52. RADIO TUNER UNIT MANUAL ... ..	2/6
53. RADIO CONSTRUCTORS' MANUAL ... ..	3/-
54. RADIO RESISTOR CHART ... ..	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
70. LOUDSPEAKER MANUAL ... ..	2/6
<i>Other Titles in Preparation</i>	
69. RADIO INDUCTANCE MANUAL (Coil and Transformer Construction)	
71. MODERN BATTERY RECEIVERS' MANUAL	
72. EXPERIMENTAL CIRCUITS MANUAL	
73. RADIO TEST EQUIPMENT MANUAL	
74. RADIO VALVE APPLICATIONS MANUAL	
75. RADIO ANTI-INTERFERENCE MANUAL	

## SOCIAL!

Introductions given  
and Partners  
arranged for  
Theatres, Dinners,  
Dances, Sports.

Phone, Write or Call

REGENT INTRODUCTION BUREAU

8 Charing Cross Road, W.C.2

Telephone Bar 1075/1127.

## POPULAR PHOTOGRAPHY, FLYING, PLASTICS, and the new PHOTOGRAPHY

From the publishers of RADIO NEWS come these four superb magazines, each completely fulfilling, in its own sphere, the same essential purpose as RADIO NEWS. Informative to the highly skilled operator or technician, yet understandable and interesting to the amateur; intensely practical, yet never dry or stodge. Brilliantly written, copiously illustrated and beautifully produced, each magazine maintains the highest standards for which American magazines are famous.

Particulars of subscription rates and facilities on request.

ZIFF DAVIS LIMITED,

GRAMPIANS BUILDING,  
WESTERN GATE, LONDON, W.6  
Telephone: SHEPHERDS BUSH 4794.

## RADIO NEWS

foremost American Radio magazine, obtainable direct by post from America; the only sure way of receiving copies regularly.

RADIO NEWS unfolds, month by month, the complete story of radio research and development. Editorially and in presentation, printing and production, it maintains the highest American standards. Each issue contains from 136 to 160 pages of news, articles, pictures and advertisements, brilliantly written and illustrated.

Radio technicians, dealers, business and factory executives, radio specialists in the services, amateurs, "hams," officials, research specialists, constructors, all are fully catered for. The scope of RADIO NEWS, in all that matters, is complete.

For a modest sum, payable in advance, the postman will deliver a copy at the door every month.

Subscription orders may be placed through your Radio dealer or newsagent or, in case of difficulty, posted to us at the address below.

ZIFF DAVIS LIMITED,

GRAMPIANS BUILDING,  
WESTERN GATE, LONDON, W.6  
Telephone: SHEPHERDS BUSH 4794.