FUN WITH RADIO

by GILBERT DAVEY

edited by JACK COX

FULLY ILLUSTRATED

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GILBERT DAVEY

EDITED AND WITH A FOREWORD BY

JACK COX

(Editor of *Boy's Own Paper*)

ILLUSTRATED BY R. BARNARD WAY
FROM ORIGINALS SUPPLIED BY THE AUTHOR

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Foreword

This is a practical handbook written in simple language for the modern boy, but suitable, indeed, for any radio enthusiast. It is based on the long experience of a skilled home radio constructor who has proved his worth as Radio Correspondent for *Boy's Own Paper* since 1946. Apart from a number of recent Television appearances in which he showed viewers how to build simple receivers, Gilbert Davey has worked only for *Boy's Own Paper*, and his record there has been quite phenomenal. Year after year he has headed a Readers' Popularity Poll among regular contributors and his *BOP* designs quickly go out of print. Some of them are reproduced for the first time in book form here, which is also Gilbert Davey's first published work.

Home Radio Construction is clearly a popular and lasting hobby among intelligent boys with a practical and scientific turn of mind, if the evidence of Gilbert Davey's postbag be accepted—and how can it be denied? *Fun With Radio* expresses perfectly his own interpretation of the approach to the hobby, for the author is still an *amateur* who has raised his standard to a high professional level by keen practical work and by keeping up-to-date in all branches of the science. He understands the amateur's enthusiasm and the amateur's problems so well because he is a skilled amateur himself.

This book will make him many new friends and earn him the gratitude of countless boys who keep asking where can they get 'a Davey design'. It has been great fun for me to edit his work.

JACK COX

CHAPTER 1

Introduction to Radio Set Building

This is not a textbook. It is a book of sound, modern, practical radio designs, all of which work well. You must not copy a design slavishly, though; you need to find out why and how it works, and then you can experiment later on.

BROADCASTING started in Britain on 14th November 1922 when the British Broadcasting Company, forerunner of the present Corporation, opened its London transmitter, '2LO'. On the following day its Birmingham and Manchester stations opened.

At that time there was virtually no supply of ready-made components available and almost everyone used a home-built set mostly of the crystal variety. In the first year the number of licence holders reached about two hundred thousand and it was almost 1925 before the million figure was attained. How many 'unlicenced' listeners there were could not be computed! In 1957 the total of licence holders was around the twelve million mark.

My interest in the hobby started in 1927 when I was a boy. As a result of moving to a new house outside London, my father asked a friend to build us a three-valve set. This was run from batteries and was of the type known as a detector and two LF. The latter were transformer coupled and we had a loud-speaker with an enormous horn curled over the top. The builder of this receiver, seeing my interest, gave me a number of spare components and some old periodicals. I began to experiment!

It was fun in those days to try a new circuit, perhaps to invent something different. We wound our own coils, made a lot of our own component parts, and if a new set worked at the first try-out we were astonished! We had a lot of fun from radio experiments then, and it is the purpose of this book to assist you, perhaps a newcomer to radio, to obtain the same fun with your radio now as we did with much cruder apparatus in the past.

Electronics is a new modern industry, which has rapidly assumed a position of importance in the industrial life of the world. Its development is suffering constantly from a shortage of personnel. Apart, therefore, from the interest in radio as a hobby it may be the passport to a career in electronics in industry, in Government research, in the Services or the Merchant Navy.

This book does not set out to be a textbook teaching theory. It is a book of sound, modern practical designs, all of which work. In the building and operating of them the beginner will learn much. No great attempt has been made to explain theory, and an assumption has been made that some theoretical knowledge is possessed or is being acquired in your own reading. There is not the least need for such knowledge, however, as any design in this book can be built up from the diagrams supplied with each chapter.

In radio you usually find you are not content merely to copy a design slavishly; you want to know *why* and *how* it works, and to experiment with different valves and loud-speakers and values of resistors and so on. There the 'fun' with radio comes in.

My designs have been made on a 'progressive' basis so that the first set is the simplest crystal receiver which anyone could build. The next one is a little more complicated and so they progress right through to a five-valve mains-driven superhet receiver. None of them are hard to build. If you feel like building one go ahead and have a shot at it; if it does not work first time check it over and try again. It is easy to make a wiring mistake and just as easy to rectify it.

I hope your interest is such that you really want to get ahead with this modern boy's hobby. It is most desirable that you should learn the theoretical symbols, the shorthand of radio. Those which you are likely to come across most are shown in Fig. 1. A knowledge of these will help you to understand and assess a circuit, and to check wiring and trace faults. With a fair

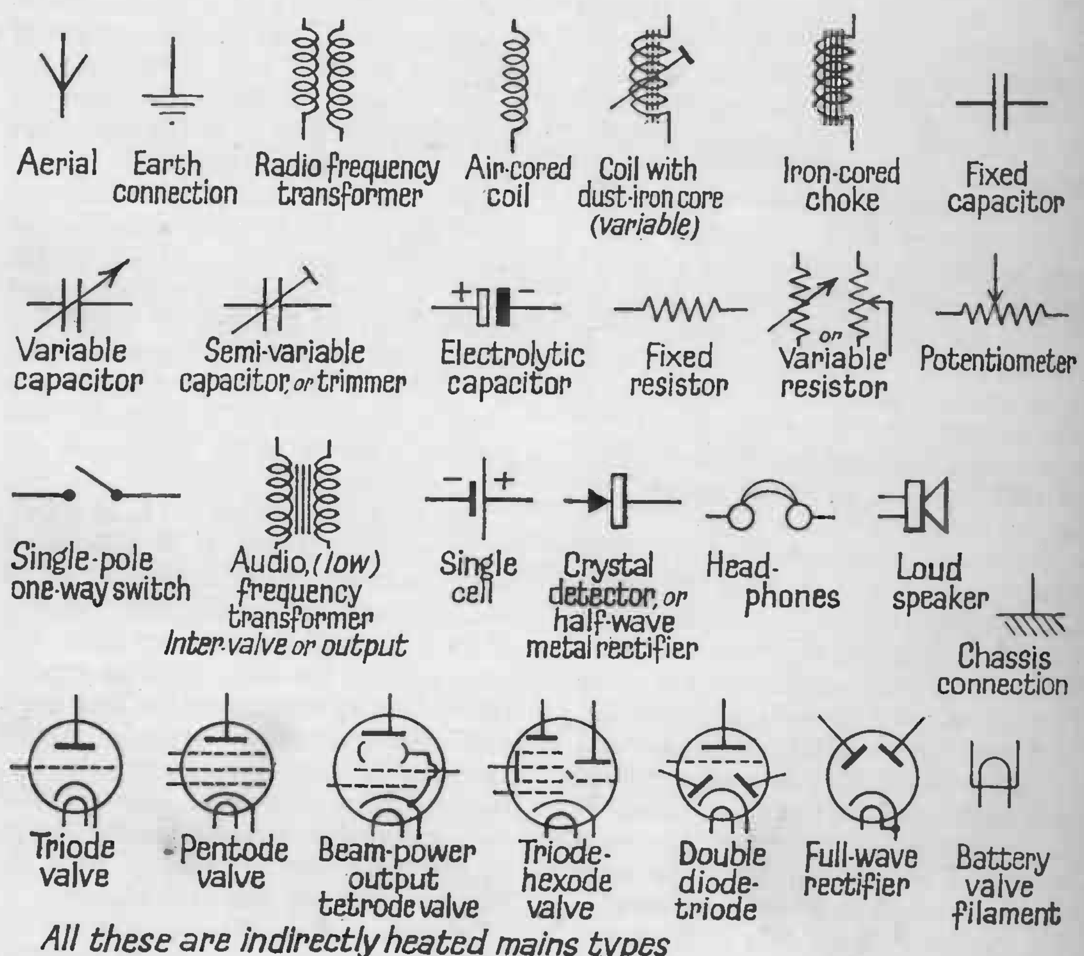


Fig. 1
The above are a selection of the most commonly used symbols in radio theoretical diagrams

knowledge of these you must next read up some theory. Here are details of some sound books which will assist you:

A Beginner's Guide to Radio, F. J. Camm (Newnes)

Radio Servicing—Theory and Practice, Abraham Marcus (Geo. Allen and Unwin)

Foundations of Wireless, M. G. Scroggie, B Sc, AMIEE (Iliffe)

There are also useful correspondence courses run by EMI Institutes of 43 Grove Park Road, W4, as well as evening classes at the local Technical Colleges and Institutes in many parts of Britain. I also suggest that you buy a good radio periodical. (The local public libraries usually have radio periodicals and textbooks available. Some library books on radio are out-of-date and you should ask your local librarian for one of the three books I have suggested.)

The question of components may now be considered. In building the prototypes of these designs I have mainly used components I had on hand and some of these may no longer be manufactured. This is unimportant as long as the electrical features are the same; the same point applies to 'Government Surplus' components and valves. With these some care is needed in purchasing, but new boxed valves are usually satisfactory.

Beware of old capacitors or resistors and if in doubt about any part avoid it. It is unlikely that you will find a radio components shop in your district as these days they are rather rare and most sales are done by Mail Order. One of the radio periodicals may be consulted; reliable firms specializing in sales by post advertise regularly. For the top-class valves and components, not 'surplus', such as I have used, and particularly in the short-wave field, there are two firms of repute in London. These are: Webb's Radio, 14

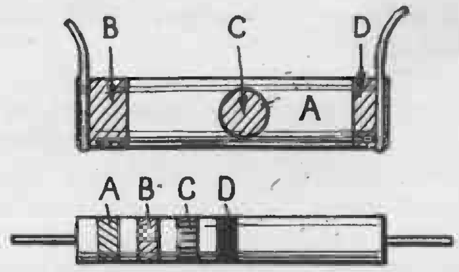


Fig. 2

Resistor Colour Code

Colour	*Figure*
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Purple	7
Grey	8
White	9

Read in the following manner:
A or body—first significant figure
B or end—second significant figure
C or spot—indicates the number of noughts following the figures
D or other end—indicates tolerance of the resistor
Gold ± 5%
Silver ± 10%
Unmarked ± 20%
e.g. A = yellow
B = purple
C = orange
D = silver
= 47,000 ohms at 10% tolerance

Soho Street, London, W1, and Berry's (Short Wave) Ltd, 25 High Holborn, London, WC1.

For short-wave coils used in the short-wave receivers described herein, Messrs Webb's can supply the Eddystone types, while Messrs Berry's deal in the Denco and Raymart types. Either of these firms will give technical assistance to you if you deal with them, as will the two firms, The Teletron Co. Ltd and Mullards Ltd. (I am indebted to these firms for much help in their respective fields of coils and valves and I am sure you will find the same excellent service.) The addresses are: The Teletron Co. Ltd, 266 Nightingale Road, London, N9. Mullard Ltd, Technical

Service Dept, Tottenham Court Road, London, W1.

Mullard Ltd publish literature on all aspects of radio and have available a leaflet on the '3-3' Quality Amplifier Circuit which is particularly good. This is free of charge as are their details of circuits for transistors. These latter are the new 'cold valve' of which you may have read in the press.

I have avoided describing a transistor design in this book for several reasons. Firstly, the application of transistors is limited at present and further research on them is really necessary before they can be used in popular circuits. Secondly, they are expensive at present and rather easy to damage by wrong connexions, both of which reasons, I feel, debar them from being used in circuits for beginners with a restricted amount of money to spend.

* * *

Finally, what can be done with them is covered fully in the Mullard Transistor brochure, and Teletron also have a leaflet on one design. All these leaflets are free. Mullard Ltd publish in book form, obtainable at all booksellers, a design for a High-Fidelity Amplifier giving rather larger output than that described in this book.

The Osram valve people (GEC) have a similar publication and couple with it a book describing a complementary Very High Frequency, Frequency Modulation, tuner for coupling to the amplifier to obtain the highest fidelity. Frequency Modulation or FM, as it is called, is now broadcast by the BBC on Very High Frequencies (VHF) which is the same as saying 'very short wavelengths'. They have the value of being free from interference and of reproducing extremely fine quality sound.

The first requirement is, therefore, a high-fidelity amplifier and loud-speaker. This is preceded by a FM tuner which picks up the signals and deals with them suitably for feeding into the amplifier. This tuner is a superheterodyne receiver of special type but it must be carefully and accurately aligned to receive good quality results from it. This usually requires certain meters and equipment and is tricky to carry out. There are a number of booklets giving FM receiver designs as well as one or two commercial 'kits' available. Usually the suppliers of the kits are willing to assist in alignment of the finished receiver. (*As it is not our policy to describe a design which is difficult to build or which cannot be made to work without much difficult aligning, we have not given such a design here*—Ed.) If, when you have worked through this book, you would like to attempt a VHF FM design I am sure that by then your keenness on the hobby will have led you to find suitable designs elsewhere.

Before you start to build here is some advice on tools. You need two screwdrivers—one normal type and one very small for the grub-screws of knobs, a pair of pliers with wire cutters at the side, and an electric soldering iron. If you are going to buy a soldering iron get one of the special types for radio work. Extra refinements which are of great help, but not strictly necessary, are: A 'Bib' wire stripper and cutter (cost 3s. 6d.), a hacksaw, a drill, a keyhole saw, files, and a gadget for cutting holes in metal. If you have not got any of these available at home do not bother to buy them specially. Carry on with the bare essentials and see how you manage. If you find you want some additional tool then buy it as you require it.

Soldering is done with solder which has its flux built into it and I usually obtain Ersin Multicore. Buy the 'Home Constructors' Pack' which costs 2s. 6d. Soldering is simple. Apply the hot iron and the solder together to the joint to be soldered, let the solder run, take away the iron and solder, blow on the joint to cool it and it should be perfect. Beware of dry joints which look good but are not. A quick tug will usually reveal one. In soldering cleanliness is essential. It is a good idea to keep a piece of fine sandpaper handy to clean up joints to be soldered. For connecting-up I prefer tinned copper wire, about 24 s.w.g. gauge, with insulating sleeving to slip over it. Insulated connecting wire may also be purchased. For connexions to the mains the usual type of PVC or rubber-covered twin flex is used and this is also used, in single flex, for connexions to batteries in sets which use them.

Both the Editor and I wish you lots of fun with radio, both in building and experimenting with receivers, and in using the completed set. If you have any special queries we will be glad to answer them if you write us c/o the publishers and enclose a stamped, addressed envelope for a personal reply.

CHAPTER 2

Crystal Sets

Crystal sets are simple to build and *cheap! With six feet of aerial this set will pick up the BBC programmes at good strength; with fifty feet of aerial the volume is really loud. Build the set with care, remembering that reception depends* entirely *upon aerial and earth.*

THESE Crystal Set designs are chosen as the first in our constructional series because of their simplicity and cheapness. The most popular receiver for years was the 'crystal set', the theoretical design of which was precisely the same, in effect, as that shown in Fig 4, our first design. Those old crystal sets, however, used large coils of thick wire and detectors consisting of a piece of crystalline substance 'tickled' by a small cat's-whisker, which was only a piece of thin wire wound up into a small spring. To-day we use a miniature coil with a dust-iron core and a germanium diode detector.

Germanium is one of the modern metals which have been developed for industrial purposes in recent years, and is actually processed from soot-scrapings obtained from certain factory chimneys! A small flake of it is sealed into a tiny glass tube with its cat's-whisker contact cemented permanently into place (Fig. 3).

A crystal set has no power to amplify

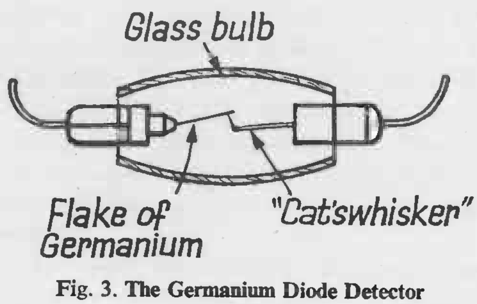


Fig. 3. The Germanium Diode Detector

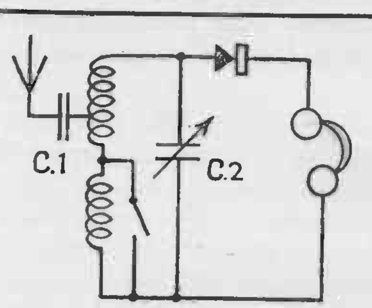


Fig. 4 Crystal Set Theoretical Diagram

the signals which it receives via the aerial and the crystal detector merely converts the radio signals into currents capable of actuating the diaphragms of our headphones and producing sounds thereby.

It follows, therefore, that the strength of the sound we receive in the headphones depends on the size of the aerial we have—a larger aerial picking up 'bigger' signals—and the efficiency of the detector in converting them ('rectifying' them is the proper term) into 'sound' signals.

The germanium diode is much better as a detector in every way than the old crystal detector and is completely stable in use. The modern crystal set, therefore, must not be confused with that of thirty years ago; it is best to discard the term 'crystal set' really in favour of 'germanium diode receiver'. The receiver in Fig. 4 circuit is small and compact and very simple to make. With a good aerial it will give an extremely loud headphone signal from two or, possibly, three stations. It is essential to have a good aerial with a crystal set, and a good earth as well if this is possible. At my own home, which is ten miles from the BBC (Brookmans Park) transmitters in North London, I can receive both the BBC Home and Light service with about 6 feet of wire. With 50 feet of aerial in the loft I can obtain Home, Light and Third, the first two at extremely loud volume. The trouble then is that it is difficult to separate Home from Light, and each programme has a slight background of the other.

* * *

From this you see that on medium and long waves *small aerials mean good selectivity* (*i.e. power to separate stations*) *but small signals*, whereas large aerials give large signals but poor station separation. If you live in a country district a long way from a BBC transmitter, and can erect a large aerial in the open air, you will probably get good results from the simple receiver; but, if, like me, you live under twenty miles from a station, for best results you need the more selective set shown in our second design.

Firstly, then, to build the set shown theoretically in Fig. 4 with a wiring diagram in Fig. 5, you need a piece of three-ply wood about 2½ inches square. If you have a particular box or cabinet to build the set into, and this requires a slightly larger size, it does not matter at all. You must drill holes for those components which are mounted on the panel; and these are the tuning capacitor in the centre, above and below it the 'A/E' and 'Phones' terminals or terminal mounts. If you use the latter the terminals affixed to them must protrude through holes to the other side, but terminals will automatically pass their shanks through the panel. The particular coil specified has a long-wave section and this requires an 'on-off' switch to

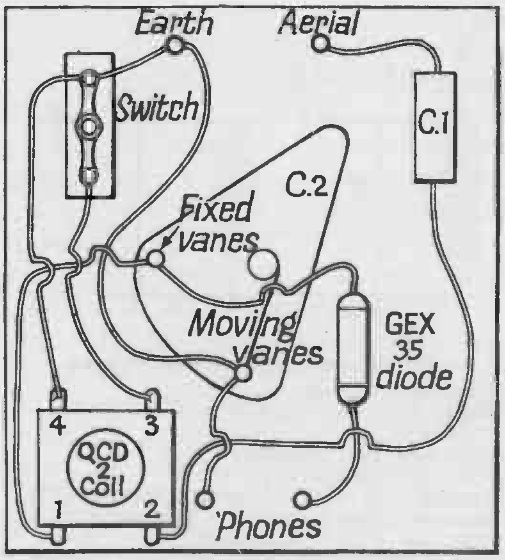


Fig. 5. **Crystal Set Wiring Diagram**
Components required:
·0005 mfd. solid dielectric variable capacitor (C.2)
On-off switch
QCD 2 Coil (Osmor)
·0002 mfd. fixed capacitor (C.1.)
Germanium diode (Osram GEX 35 or Mullard OA 60)
4 terminals or 2 double mounts
Wood, wire, etc.
Tuning knob
For better selectivity Teletron HAX coil can be used. Connections are given with coil.

short-circuit the long-wave section of the coil when medium waves only are required. As some of the holes may be a little larger than the drill you have available an easy way to make them is to drill them out as large as possible and then 'reamer' them to size with the tang of a file or other tool.

After mounting those parts which require fixing to the panel, the soldering-up can be started; it will be found that remaining small items can be soldered into place and held into position by the wiring. Earlier remarks on soldering and wire to use may be referred to here, particularly the importance of clean joints made with a hot iron. Avoid 'dry' joints which look good but can be pulled apart quite easily and beware of applying a hot soldering iron for too long to the tags of components. In particular do not let the iron get too

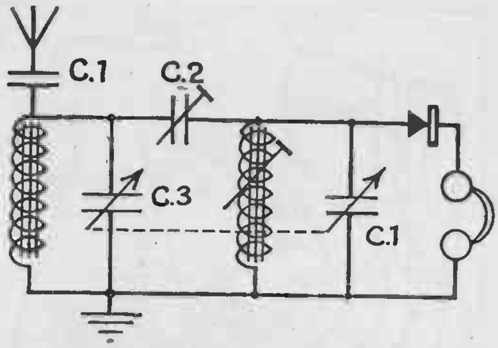


Fig. 6 **Crystal Set Theoretical Diagram**

Components required:

Midget ·0005 mfd. variable capacitor (C.3/4) dual gang
·00005 mfd. fixed capacitor (C.1)
2 Teletron Coils type BA 2
50 mmfd. (i.e., ·00005 mf.) variable trimmer (C.2)
Germanium diode (Osram GEX 35 or Mullard OA 60)
4 terminals or 2 terminal mounts
Knob or small dial

near to the diode or remain too long on its connecting wires.

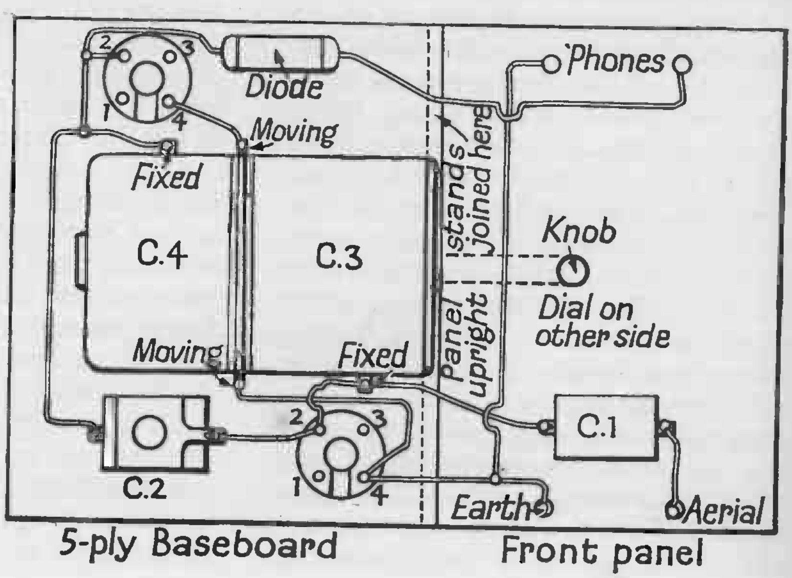
When soldering to the coil be careful that the heat of the iron does not un-solder the wires already connected to the tags. Once the wiring has been completed and checked over, the headphones may be joined to the appropriate terminals, with aerial and earth also connected to their correct points.

Headphones must be of the 'high resistance' type, i.e. 2000 or 4000 ohms impedance. If you have bought a pair of Government surplus 'phones which are low-resistance type, or yours are marked LR or 120 ohms, you can use them by interposing a special transformer (obtainable quite cheaply) between the set and the 'phones. Most dealers have these transformers.

After connecting the external apparatus, make sure the switch indicates the waveband required, that is, points *short-circuited*, cutting out the long waveband, if you want to receive on medium waves, and *open* if you want the whole coil in circuit for long-wave reception. Turn the knob slowly and you should pick up the stations available.

The selective receiver in my next design is shown theoretically in Fig. 6, and fully wired in Fig. 7. It costs a little more than the set just described, but if a large aerial is available is well worth having because of the large signal the aerial brings in, which

Fig. 7
Crystal Set Wiring Diagram



allows splendid reception. This set is built on a baseboard with a front panel; a piece of five-ply wood about 3 inches square will serve for the baseboard with a similar-sized piece of three-ply for the panel. Again the sizes are not critical if you have any particular cabinet in mind. The panel stands upright along the edge of the base-board to which it is fixed by two or three round-headed wood screws.

* * *

The dual capacitor used must be a type with feet which can be screwed to the baseboard, and if there are connexions underneath it which will be difficult to reach with a soldering iron, once it is fixed to the board, short lengths of wire should be soldered to them before fixing. A hole at suitable height must be made in the panel to allow the spindle of the capacitor to protrude through for sufficient length to fix on the knob or dial. The 'A/E' and 'Phones' tags (or terminals) must be fixed on either side of the panel.

Wiring-up is quite simple and the diagram explains it clearly. Once it is completed the 'phones and aerial and earth may be connected up. The thirty pf. trimmer should be open (i.e. unscrewed) about half-way and the capacitor dial slowly rotated. A station should be received and the cores of the coils may be adjusted for maximum volume. It is best not to use a screwdriver for this but a special trimming tool or a piece of wood suitably sharpened to a chisel-point. A large plastic knitting-needle rubbed to a suitable shape on a piece of glasspaper makes a very useful tool for trimming. If there is difficulty in finding a station, the aerial wire may be connected temporarily to the fixed vanes of the gang capacitor where they are connected to the diode, when both stations will probably be heard together. It should be easy to resolve the tuning point of one or other, when the aerial may be put back on its correct terminal. Leaving the set so tuned, adjustment of the cores may now be carried out until the station comes in at maximum volume. Careful manipulation of them together with any slight tuning adjustment necessary should bring in both stations separately and clearly.

If you build these crystal sets remember that reception is *entirely* dependent upon the aerial and earth in use. If these are poor, good signals cannot be expected. *Poor signals cannot be amplified or adjusted to make them louder*. A crystal set connected to an amplifier such as the 'Small High Fidelity' described later makes a very satisfactory arrangement for local station reception. For 'reaching out' and for louder signals a valve detector is required. A simple one-valve battery set is my next design.

CHAPTER 3

A Beginner's One-Valve Set

Leave your crystal set intact and build this excellent One-Valve Set on a panel and baseboard. You don't need a cabinet for it. Pay special attention to the wiring-up and don't forget to disconnect the LT when you finish listening!

THIS small and useful set is designed to give you an idea of the working of a valve-set and is a logical 'follow-on' from your crystal receiver. You can either pull this to pieces and use most of the parts to build this one-valver or you can purchase a completely new set of components. The latter is the better idea as it is practicable to have a crystal set on hand constantly (it is particularly useful for testing amplifiers).

The one valve set is built as a 'hook-up', that is to say, it is just laid out on a panel and baseboard and wired up without a great deal of attention to super-efficiency, or to building it into a cabinet. You can take these liberties with a small set of this kind for medium waves, but do not try to do it on short waves or with a more complicated set as trouble will result.

You need a small shallow chassis 4 or 5 inches square and I suggest you make a kind of box out of some odd bits of wood. Take two fairly thick pieces of wood, say five-ply or similar, about 5 inches long by 1½ inches wide, and two more of the same size only of thinner wood such as three-ply. Now with a few ½-inch panel pins join the four ends together so that the four sides form a kind of box without top or bottom. Then obtain a piece of three-ply or other thin wood 5 inches square and fix that on to form the top of the chassis. It will overlap at one end but this does not matter.

For a more complicated set it is necessary to cover the chassis with metal foil, or to buy or make it of metal. Two more strips of thin wood are required for mounting the capacitors, say two pieces 6 inches by 2 inches, and these can be screwed at one end to one of the thicker

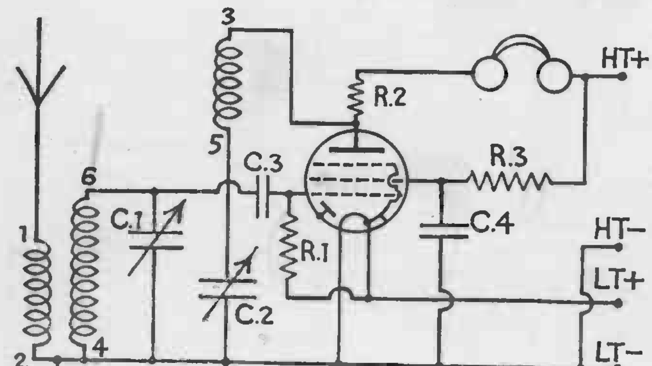


Fig. 8 One-Valve Set

Components required:
Wood for baseboard and panel
B7G valveholder
C.1. ·0005 mfd. variable capacitor
Teletron type D/R coil
C.2. ·0001 mfd. variable capacitor
C.3. ·0002 mfd. fixed capacitor
C.4. ·1 mfd. bypass capacitor
R.1. 2·2 megohm grid leak
R.2. 10,000 ohm fixed resistor
R.3. ·5 megohm resistor
Headphones, wire, terminals, etc.

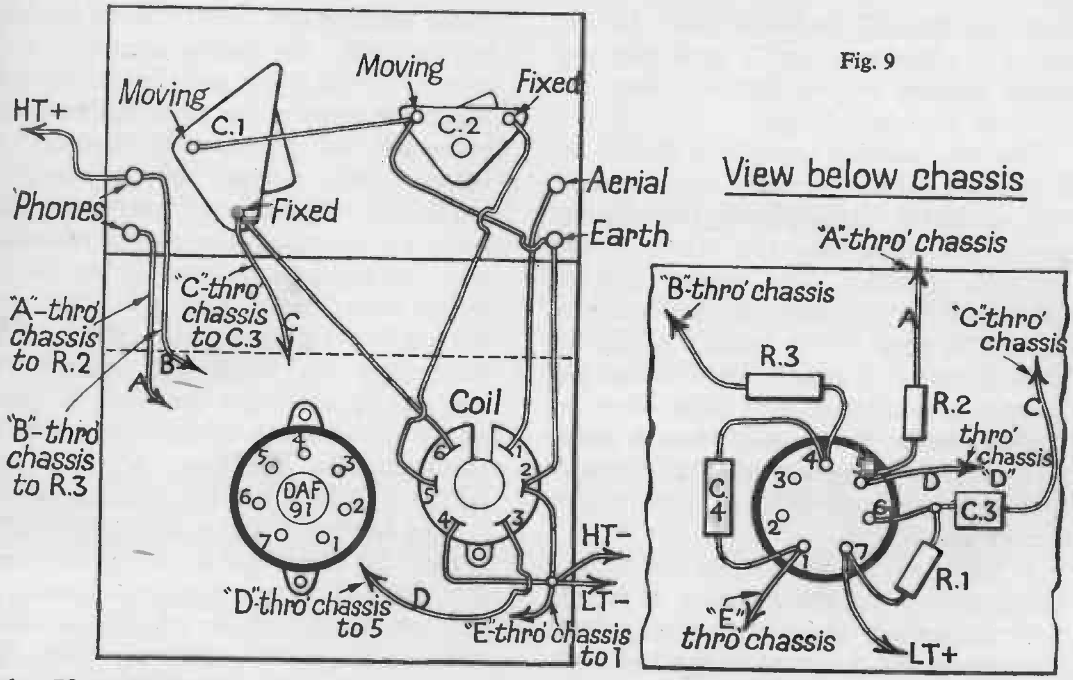


Fig. 9

sides. If you prefer to use a complete panel here, say 6 inches by 5 inches, there is no objection. Each of these pieces requires suitable holes in it at about 1½ inches above the top of the chassis to accommodate in one case the ·0005 mfd. variable capacitor, and in the other the one of ·0001 mfd.

The chassis needs a hole near the back for the small valveholder. (For method see Chap. 4.) If you use the solid dielectric capacitor from, or similar to that in, the crystal receiver, you will see that it is quite compact. You can put your valveholder somewhere in the centre of the chassis. With a ·0005 mfd. air-dielectric type, however, you need more room and have to put the valveholder more to the rear.

The diagram makes it clear how the chassis is constructed and also how the set is wired up. *Be very careful over the wiring-up as an error can put the high tension voltage on to the valve filament, destroying it completely.* After wiring-up it is a good idea, before inserting the valve, to connect up both HT and LT batteries and to place a three-volt flashlamp bulb across the LT tags on the valveholder. If it lights up all is well. If it fails to do so or 'blows' a careful check is needed.

You can obtain a special battery which incorporates LT of 1½ volts and HT in one unit. If you use this you need the special plug which goes with it, but I think you will find it an expensive way of buying batteries. For general experimental work buy a fairly good-sized 1½-volt dry cell and a standard-size HT battery of say 45 volts. For headphone work this should be an adequate voltage and furthermore is a perfectly safe voltage for you to use. The wiring checked, the valve can be inserted and aerial, earth and 'phones connected up. A large aerial is not really necessary—try out whatever you have available or 20 feet of wire round the picture rail or thrown from an upstairs window.

Do not worry if you cannot make an earth; the set should work without it. For economy's sake there is no switch on this hook-up. When you connect up the 1½ volts and the HT the set is 'ON'. *Do not forget to disconnect the LT each time you finish listening or you will run down the batteries very quickly.*

The two variable capacitors should be fully open, which normally means turned fully to the left. Try increasing the capacity gently (i.e. enmeshing the vanes) of the reaction capacitor (the smaller one of ·0001 mfd.) by turning the knob to the right. The noise in the 'phones builds up until a 'howl' is heard. That means the receiver is oscillating, and must never be left or used in that condition as it interferes with the reception of other listeners and is an infringement of the PMG's licence conditions.

If the receiver fails to oscillate at any point even with the reaction capacitor fully enmeshed, there is a wiring fault somewhere and this must be checked over. It could be a 'dry' soldered joint or wiring which is too long and rambling, or even insufficient HT voltage. It is essential for correct operation of the receiver that smooth reaction is obtained which builds up gradually to an oscillation howl at its peak. Reaction is a feature of a number of sets in this book and it is a good idea to become familiar with it at the outset.

If you can now read theoretical diagrams you will see from Fig. 8 that there are three windings on the Teletron D/R coil specified, one an aerial winding, the next the grid winding which is tuned by the ·0005 mfd. capacitor to the frequency of the required station, and thirdly a reaction winding. This last is connected to the anode but coupled to the grid winding so that energy from the anode is fed back into the grid circuit. The amount of the feedback is controlled by the ·0001 mfd. reaction capacitor. Reaction secures an enormous increase in amplification—a great advantage over the crystal detector.

Reverting to our one-valve set, having tested reaction and found it to be working satisfactorily, the tuning capacitor may now be moved slowly and stations brought in. As the vanes of the tuner become more enmeshed, so it becomes necessary to increase the capacity of the reaction capacitor. Normally you search for stations by operating the tuning capacitor with the right hand, maintaining the reaction control in the correct position with the left. For a beginner it is a good idea to disconnect the aerial and operate the controls so as to get the 'feel' of them, and to be able to maintain the set in its most sensitive condition, which is just before it 'spills over' into oscillation.

This one-valve design is a very suitable subject for experimenting with, and much fun with radio arises from experiments. In this set another make of coil could be substituted for that originally used—this sort of coil costs only 3s. or 4s.—any difference in results being noted. The ·0001 mfd. fixed grid capacitor could be varied and any different values up to, say, ·0005 mfd. tried out. Similarly, the 2·2 megohm grid leak might be changed and any values between ·47 meg. and as high as 10 meg. substituted. The ·5 meg. resistor between the screen of the valve and HT + may be varied and different values up or down tried out. A good way of doing this is to remove the ·5 meg. resistor altogether. Then connect the two ends of a 1 meg. potentiometer across HT from + to −, and connect the slider of the potentiometer to the screen of the valve. Leave the ·1 mfd. by-pass capacitor connected between screen and earth.

The spindle of the potentiometer can be rotated to obtain varying voltages on the screen thus varying results. It will possibly act as a supplementary reaction control. Having mastered your one-valve set you can use all the components in a two-valve portable, my next design.

CHAPTER 4

Two Portable Receivers

You can take your choice or build both receivers. A Two-Valve 'All-Dry' Set or a Four-Valve Superhet Portable are offered. Try out different aerials, and use the metal spring of a bed if you like! Use small components, and large batteries for economy of use in home listening.

THE first portable design is for a **Two-Valve 'All-Dry' Receiver** using 1·4 volt valves and the types suggested are the Mullard DAF 91 and DL 94. You may use similar types in other makes if you wish, and your dealer will have details of

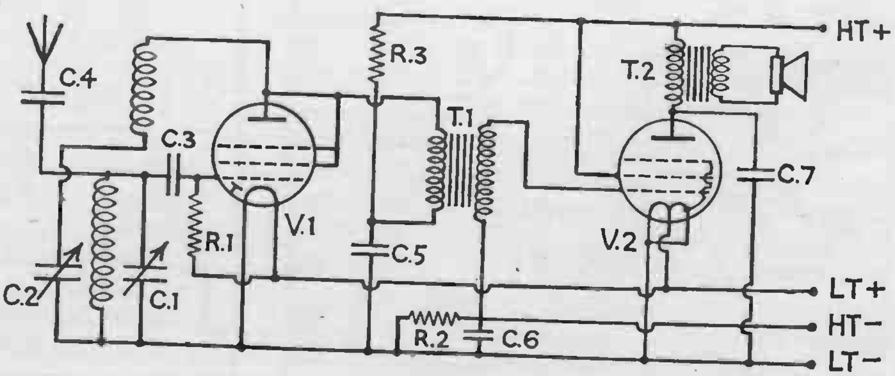


Fig. 10 Two-Valve Portable Set

Components required:

	Component	*Make*
	1 2½-in. loud-speaker	Celestion
T.2.	1 Miniature output transformer	(any)
C.1.	1 ·0005 mfd. variable capacitor	(any)
C.2.	1 ·0001 mfd. variable capacitor	(any)
	1 PA coil type 'range 7'	Wearite
	2 Valveholders B7G	McMurdo
C.3.	1 ·0003 capacitor	(any)
R.1.	1 2 megohm resistor	(any)
C.4	1 ·0002 mfd. capacitor	(any)
C.5/6	2 2 mfd. miniature capacitors	T.C.C.
R.2	400 ohms resistor	(any)
R.3.	1 47,000 ohms resistor	(any)

	Component	*Make*
T.1.	Intervalve transformer	See text
C.7.	1 ·002 mfd. capacitor	(any)
	1 On-Off switch	(any)
	Wire (Insulated connecting)	
	Multicore solder	Ersin
	2 Knobs	
	Wood, screws, leatherette or other covering	
V.1.	1 Valve DAF 91	Mullard
V.2.	1 Valve DL 94	Mullard
	1 1·5 volt cell	Ever-Ready
	1 90 volt H.T. battery B.126	Ever-Ready

substitution types. The first is 'a single diode AF pentode' which means it is a dual valve combining a diode and a pentode. It is primarily designed for use in a portable super-heterodyne type of receiver in which the diode would be used for detection and the pentode section for audio-frequency amplification feeding into an output valve such as the DL 94 pentode.

In this first two-valve set we use only the pentode section of the DAF 91 ignoring the diode. A diode cannot provide reaction which we require in this simple set to give us range and volume. As

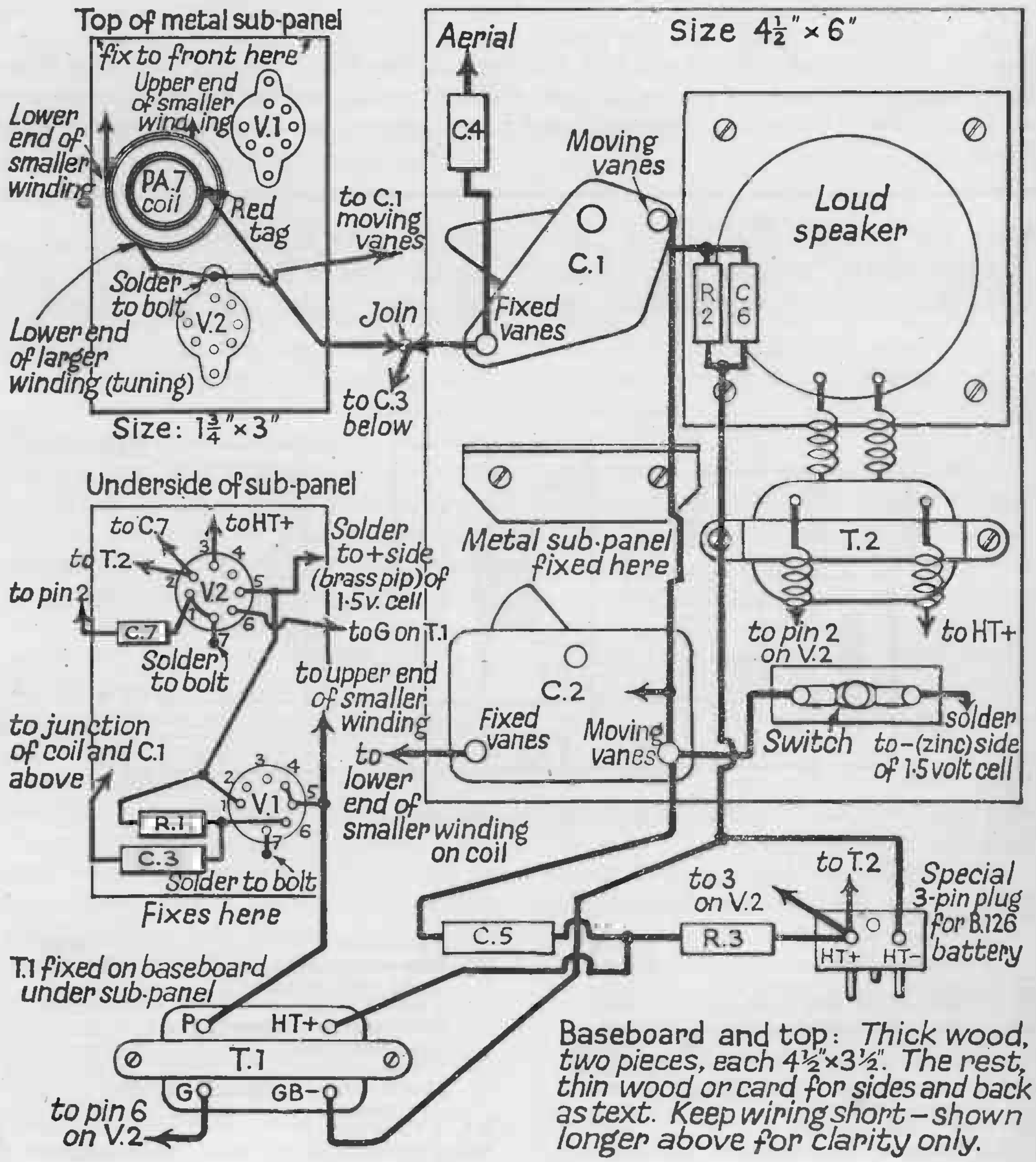


Fig. 11 Two-Valve Portable Wiring Diagram

a result we use the pentode as detector with reaction, and feed its output into the DL 94 thence to the small loud-speaker. This enables us to build an extremely compact receiver which only suffers from the disadvantage that it needs a good aerial for best results.

Trying out different aerials, however, is part of the interest of using a set like this one. At home an aerial in the loft with a water-pipe earth will give extremely loud signals but such an aerial might be a little difficult to erect. Try two dozen feet of wire round the picture rail or, perhaps, if you are using the set in an upstairs room, simply thrown out of the window.

Have you a metal spring to your bed? If so, try that as an aerial! A yard or so of wire with a crocodile clip on the end is connected to the aerial terminal of the set. The clip then goes on to the bed-spring. (Many soldiers in the Second World War, or boys on National Service since 1945, found that Army cots used in this way made effective aerials.)

But I am discussing the operation of the set before its construction! The first stage is to obtain the components. If you are converting the one-valve set described in the previous chapter you will only need the parts which are additional to those in that set. As the 'Cabinet' forms the framework on which the set is built, it is essential first to have ready the wood from which this is to be made up. When I built this set I used pieces of wood from an old orange box, quite firm but light, of about three-ply thickness, for most of the set with a couple of thicker pieces from the end of the box to form the top and bottom.

All dimensions are given in the diagram and as we are going to cover the wood when the set is finished it need not be in first-class condition. If it is rough sand-paper it down to a fairly smooth condition after cutting. It is pleasant to work with it like this and you avoid splinters. Start by taking one of the larger pieces of thin wood which is to form the front of the set and drill in it the large hole for the loud-speaker, the four holes for the fixing bolts for the speaker and the other three for two capacitors and a switch.

I suggest elsewhere in this book various methods of making these holes, and the holes required for the valveholders in the small chassis which we use in this set. This chassis is just a piece of aluminium or tin of the dimensions shown and has the valveholders and coil affixed to it. These may now all be fixed to this chassis and the transformer screwed to the wooden base of the set underneath the spot where the chassis will be fixed. It may be a good idea to do as much as possible of the wiring under the chassis to the valve-holders before it is fixed to the front panel above the transformer. The front panel is screwed or fixed with panel pins to the thicker baseboard which is already carrying the transformer. This operation enables the whole set to stand up by itself and the wiring can be started.

* * *

It is a good idea to leave the fixing of the loud-speaker and its associated output transformer until last. The loud-speaker is very delicate and care must be taken not to damage the small paper cone. Wiring should present no difficulties. Use tinned copper wire and sleeving or ready-made connecting wire. Take care to avoid short-circuits and test the LT circuit with a 3-volt bulb, as described in Chapter 3, before connecting full HT with the valves in place.

As you will wish to use this set as a portable model, you require the small portable batteries specially designed for such sets. The HT is a midget 90-volt battery which fits snugly in the case behind the loud-speaker. The LT can be a small $1\frac{1}{2}$-volt flashlamp cell. Solder the leads to it, the brass 'pip' being positive and the zinc case negative. Use thick solid wires (insulated) for this and you will find they hold the cell in place above the loud-speaker. If you are making this set for the dual purpose of using it in your room, perhaps beside a bed, for most of the time, with occasional trips out-of-doors for camping or holidays, I strongly advise you to get two sets of batteries.

The midget 90-volt battery will not last long if it is used continuously—it is designed for intermittent use as in a portable—so I suggest you have a larger capacity 90-volt battery for use at home. You need longer leads from the set but will save a great deal in HT costs. Similarly you can use a larger battery for LT although the few pence these units cost is not so important.

* * *

The same details regarding correct reaction apply as set out in the chapter on the one-valve set and if you get that going properly you should find your set works well. Note that the filament connexions of the DL 94 are slightly different from those of the DAF 91. The DL 94 has a centre-tapped 2·8-volt filament and the connexions shown join the two halves of the filament in 'parallel' so that they work on 1·4 volts, the same as that required for the filament of the DAF 91. The voltage applied to the grid of the output valve—the DL 94—is called the grid-bias and is usually obtained in a battery set from a 9-volt grid-bias battery. In this set it is 'automatic' and is given by the voltage drop which is obtained from the current flowing through the 400-ohms resistor in the HT-lead.

When the set is all wired up and has been tested and found satisfactory the cabinet can be completed. Another piece of thick wood may be screwed (or nailed with panel pins) to the top of the front panel. Two further pieces of thin wood may be fixed to form the sides. Do not fix anything on the back at this stage but prepare a piece of thin wood of the same size as the front panel. The cabinet may be covered with Rexine or other suitable material. A very useful material for cabinet covering is wallpaper which has an imitation wood-grain design. After fixing it should be varnished with a clear varnish to protect it. The back should also be covered with the same material and two or three holes made at each top and bottom edge for screws to be inserted to fix it to the cabinet. Do not forget to put some covering over the loudspeaker cut-out.

A small piece of curtain-net or butter-muslin can be stuck to the wood first before the cabinet is covered. The covering can then have a small hole made in it to allow the speaker to operate. A piece of leather strap can be fixed to the top of the set for a carrying handle, or a plastic handle fitted.

A similar cabinet can be made for the next set shown which is a **Four-Valve Superhet Portable**. I do not suggest this rather more complicated set should be made by the reader at this stage. The description is inserted here to keep it in its right place among battery portables, but you may like to refer back to the design later on when you have more experience in radio set construction. The actual building of the set is extremely simple; the components start at one end of the chassis and go in order to the other end! At the beginning there is a Ferrite rod aerial which must be mounted horizontally along the back of the chassis, and the signals which it picks up proceed through the four valves, undergoing the various processes of conversion into a sound which you can hear through the loud-speaker.

This receiver uses four valves and is on the superheterodyne principle, which

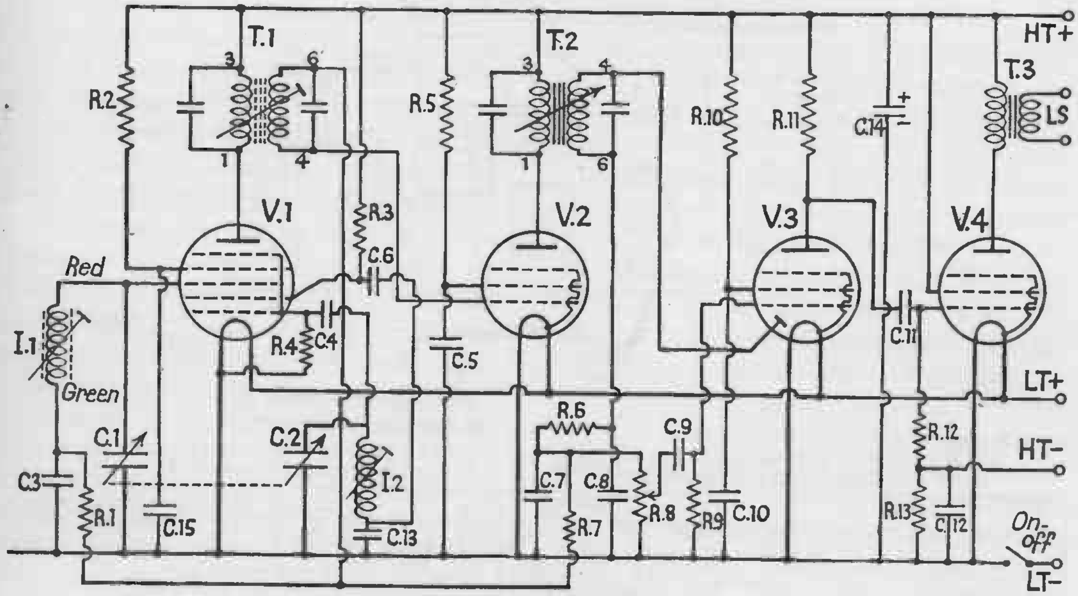


Fig. 12 Four-Valve Portable

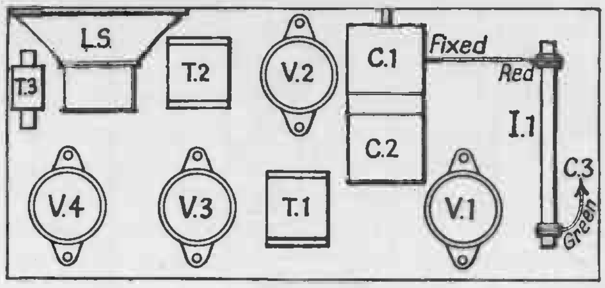
I.1 Teletron Ferrite rod aerial
I.2 Teletron BO.2 Osc. coil
C.1., C.2. ·0005 mfd. dual gang capacitor
C.3. ·05 mfd. capacitor
C.4. 100 pf. capacitor
C.5, C.10, C.15. ·1 mfd. capacitor
C.6 100 pf. capacitor.
C.7, C.8. ditto
C.9, C.11. ·005 mfd. capacitor
C.12, 20 mfd. 12 v. miniature electrolytic.
C.13. 600 pf. mica padder
C.14. 8 mfd. miniature electrolytic capacitor
T.1, T.2. Teletron miniature 465 kc. intermediate freq. transformers
T.3 Miniature output transformer.
All capacitors etc. to be miniature types
Resistors: all ¼ watt miniature types
R.1, R. 7. 1 meg.

R.2.	220 k. ohms
R.3.	20 k. ohms
R.4.	47 k. ohms
R.5.	22 k. ohms
R.6.	47 k. ohms
R.9.	2·2 megohms
R.10.	1 megohm
R.11.	·27 megohm
R.12.	·47 megohm
R.13.	400 ohms
R.8.	·5 megohm potentiometer combined with on-off switch

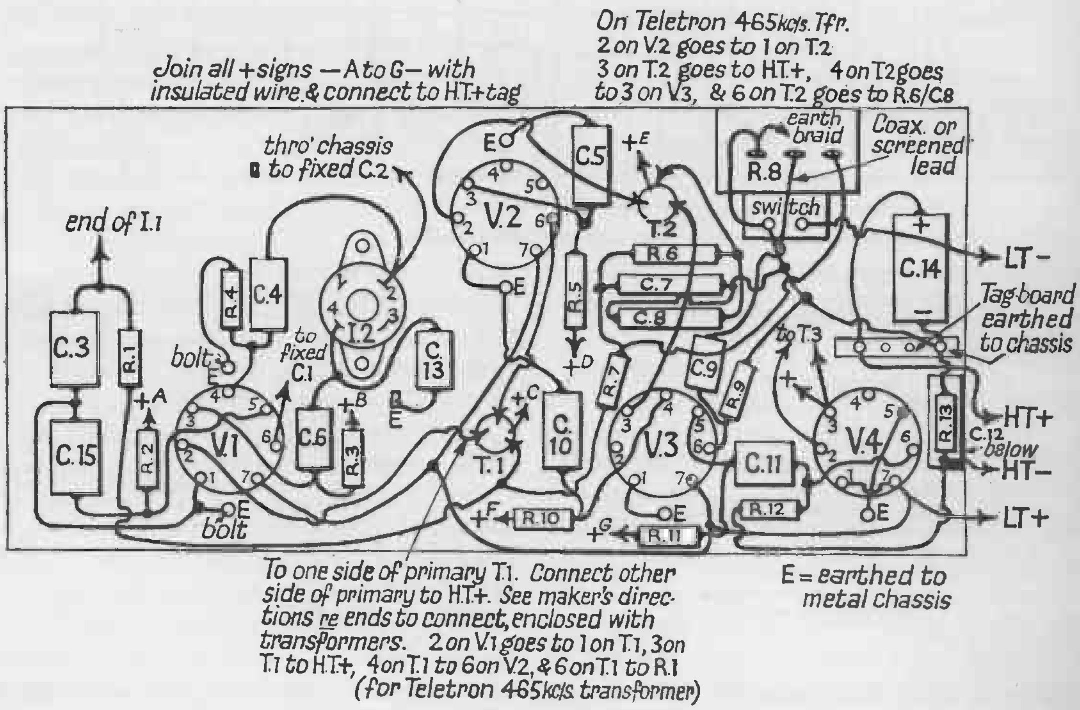
V.1.DK 92, V.2. DF 91, V.3. DAF 91, V.4. DL 94. All by Mullard—or equivalent types in other makes
4 B7G valveholders. Knobs.
Batteries for HT and LT

makes it much more sensitive and selective than the two-valver just described, but also rather more difficult to adjust. You will notice that whereas for the two-valve set we need a fairly good aerial for a really loud signal, in the superhet the ferrite rod is adequate for picking up many stations on the speaker.

At the same time the set is very compact and uses as two of its four valves similar types to those in the two-valve portable, namely DAF 91 and DL 94, so that you can in due time convert the small set into the superhet. As for the adjustment required to make the set work properly, you will find this outlined in Chapter 13 which deals with the mains superhet. An outdoor aerial must be pressed into service temporarily for use on this set during the aligning process. Some brief notes on the way a superhet works are also given in Chapter 13 and I suggest you read them before attempting the construction of this portable. As before, it should be easy to make up a small cabinet, although there is no reason why it could not be built into



Top of Chassis



Underside of Chassis
Size is not important. This one is 8 by 3½ inches.

Keep all components close to and below each relative valveholder, and keep all wiring as short and direct as possible.

Fig. 13 Four-Valve Portable Wiring Diagram

one of the ready-made small portable cabinets on the market. The set is constructed round a front panel on which a small strip of metal is mounted as a chassis, and you should cut out the holes for the valveholders before mounting the chassis to the panel.

Drill two holes in appropriate places for the two spindles to protrude through the front panel. It is impossible for me to give the measurements for these in detail as different sizes of tuning capacitor may be used, thus giving a higher or lower position for the spindle hole. I suggest that the volume control (which also combines the on-off switch) be mounted at such a height as to give a symmetrical layout. Components may be mounted and wired up and for smallness and lightness the smallest midget sizes may be utilized. Keep the components associated with each valve under the appropriate valveholder; do not allow them to be mixed with those of other valves.

For the loud-speaker a 5-inch diameter model would be much preferable from the point of view of tone, but the tiny one used in the previous set would be quite suitable. Incidentally, on the question of tone and volume it must be realized that small portables cannot, and are not intended to, give the same output as one expects from a large-size mains receiver. The limitations of battery supplies are chiefly responsible, as well as the small size of the valves. They do give adequate volume for what is called 'personal listening'. In bed, at school or home, at camp or by the sea they are very useful. Certain low notes must be absent from the response but the distortion is rarely discernible to the human ear and the output is pleasant enough for listening.

* * *

For the superhet portable the same comments regarding batteries apply as I made about the two-valver. The midget batteries are intended for short-period listening when the set is carried about. They will not last very long if subjected to use for long periods and should, therefore, be confined to use when the set is 'out and about'. Use larger batteries for home listening if you want economy of use. Regarding these sets it should be made clear that the smallest components available should be used. Tiny resistors are on the market and a very small output transformer is also available. The two-valve portable uses an intervalve transformer and these are somewhat difficult to obtain these days. You need the tiniest one obtainable. It must be a type with four leads having a separate primary winding. Do not use a transformer made for parallel-feeding only. If you have difficulty in buying a suitable component, write to Stern's Radio Ltd, Fleet Street, London, EC4. This firm has them in stock.

CHAPTER 5

A Three-Valve Receiver for Bedside or Camp

Here is a grand battery design using three pentode valves. The set can be taken quite easily from room to room, and is most useful at boarding school. Its widest use is probably in camp for it works anywhere from a small aerial slung over a tree limb. For reliability this set wants some beating.

IN 1950 I designed a **Camper's Receiver** for readers of *Boy's Own Paper* which proved immensely popular. This new receiver, which I have called a Bedside Portable, might well be a more up-to-date version of that earlier design for it will work just as well beside your sleeping-bag as it does at home. The set is a battery design for economy's sake and employs three pentode valves.

In the original set I used 2-volt battery valves—two of W21 and one PM22A. If you have a small 2-volt accumulator, such as are obtainable very cheaply as Government surplus, you can run these 2-volt valves from it without any resistance in circuit. If, however, you do as I did and run the set from a 3-volt bell dry battery, you need a small 3-ohm resistance in the filament circuit.

You can see this quite clearly in the diagrams, and 3 ohms are correct for two HF pentodes taking ·1 amp. each as do the W21's, plus an output pentode taking ·15 amp., as does the PM22A. If you use another type of output pentode, which would probably take ·2 amp., you can drop the value of this resistor to 2½ ohms.

The set should work quite happily with any type of pentodes and you might find

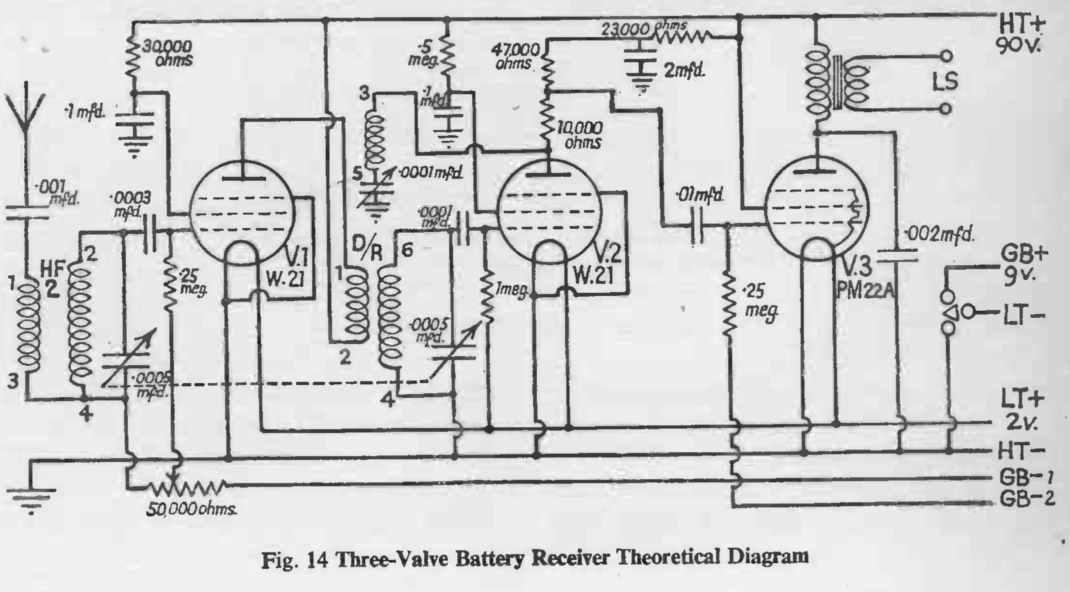


Fig. 14 Three-Valve Battery Receiver Theoretical Diagram

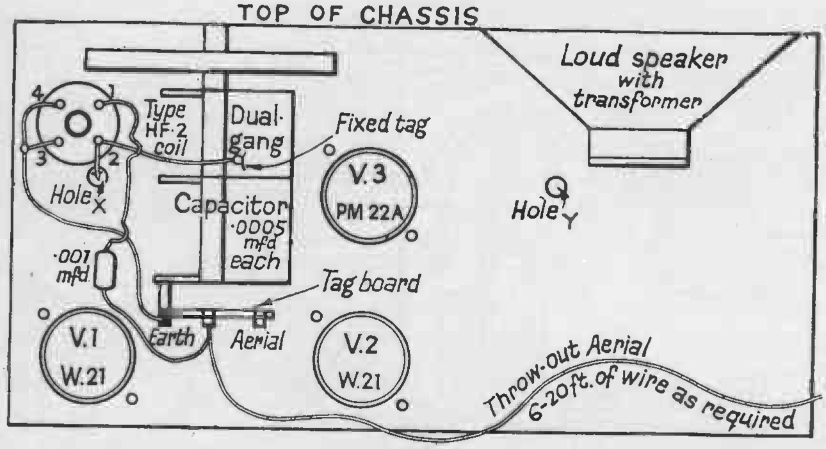


Fig. 15A

it worth while to look round your local radio shop for some suitable valves. I have seen HF pentodes of a suitable type advertised in shop windows at 1s. 9d. They were actually brand-new surplus valves!

The first item to be prepared is the chassis, which is 10½ in. long by 5½ in. wide and has a depth of about 1½ in. In other words it is a shallow tray and I made the original one of plywood. The simplest way to do this is to cut out a piece of three-ply wood or 'hard-board' 10½ in. by 5½ in. for the top piece, and cut or punch the holes in it for the valveholders.

If you have a suitable tool this will be easy. If you have to improvise you can draw the outlines of the holes and punch round with an old screwdriver—tapping it gently with a hammer—until you are able to tap the centre of the holes right out. This method does not leave a very clean edge but it will not show when you have fixed the valveholder in position.

Now you will need two pieces of five-ply wood, size 5½ in. by 1½ in. each, which will be fixed by screws, or panel pins, at each end of the larger sheet. Finally two long pieces, each 10½ in. by 1½ in., which will be fixed along the front and back. These, by the way, should be three-ply wood or 'hard-board', as with the top of the chassis.

If you build your own chassis you will eventually have to make a cabinet for the receiver, but this should be quite easy to construct out of thin wood. If you do not want to make your own chassis and cabinet, you can buy both these items, plus a suitable dial mechanism, for about 22s. 6d. I have purposely designed the set to the size stated to enable you to use one of these cabinet kits which make available white or brown bakelite cabinets or polished wood ones. Details are given with the plans, but the home-made chassis will do just as well if you feel you do not want the additional expense.

* * *

After making the chassis (or purchasing a metal one) you can now mount the components. On the top there are the three valveholders, the two-gang condenser and the type A coil. The loud-speaker also has to be fixed, but I advise you to leave this until last. It is delicate, and you must be careful not to disturb or tear the paper cone.

Underneath the chassis you fix the Type D coil (on the rear runner so that it is at right angles to the A coil above, to minimize interaction between them) and the

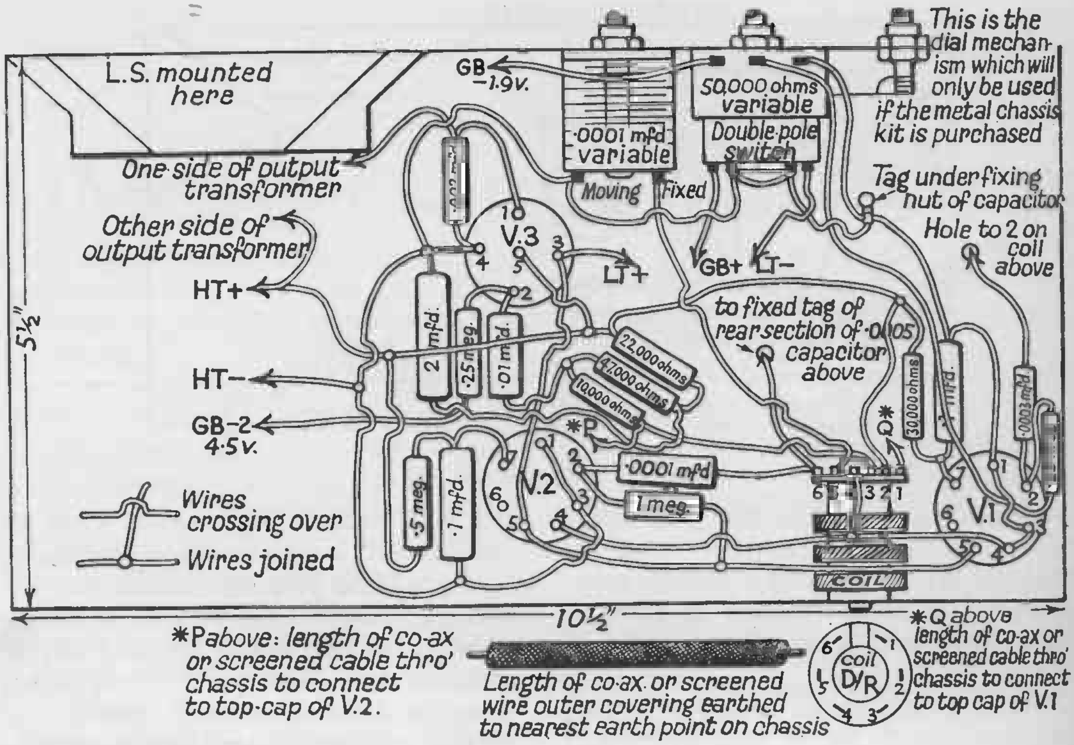


Fig. 15B Three-Valve Battery Set

Components required:
1 wooden chassis (see text)—or bakelite, or wooden cabinet with metal chassis and dial.
1 home-made cabinet (see text)
1 coil type HF2 (Teletron)
1 coil type D/R (Teletron)
1 50,000 ohms potentiometer with d.p. switch (midget type)
3 valveholders (2 at 7-pin, 1 at 5-pin)
1 dual-gang capacitor ·0005 mfd. each section (with trimmers) to fit the above chassis
2 valves—HF pentodes (type W21 in the original set)
1 valve—output pentode (type PM22A in the original set)
Capacitors:
  1 each of the following:
  ·001 mfd., ·0003 mfd., ·0001 mfd., ·01 mfd., ·002 mfd.
  2 at ·1 mfd., 1 at 2 mfd.
Resistors:
  1 each of the following:
  30,000 ohms, ·5 meg., 1 meg., 10,000 ohms, 47,000 ohms, 22,000 ohms
  2 at ·25 meg.
5-inch loud-speaker with transformer (or smaller if desired)
·0001 mfd. variable reaction capacitor (midget type)
About 18 inches of co-ax cable or screened wire
Insulated connecting wire, multicore solder, knobs, red and black flex, and wander plugs
HT Battery 90 volts, GB Battery 9 volts, 2-volt accumulator or 3-volt cycle battery with resistor (see text)
Small tag-board for aerial fixing (1 earth tag and 2 other tags)

volume control, and reaction capacitor on the front runner. You can use small wood-screws for fixing on the wooden chassis but you need a small supply of 6 BA nuts and bolts for the metal chassis.

The loud-speaker, which should have the output transformer fixed to it, can now be added. If you have the metal chassis it is quite easily bolted to the front where a place for it is cut away. With the home-made chassis the easiest method is to cut out a small baffle-board a little larger than the speaker, say 5 inches square, then cut a circular hole in it for the speaker aperture, and then mount it on the front of the chassis and fix the speaker to it. A U-shaped piece would do just as well and be easier to cut out and handle.

The smaller components are not fixed to the chassis, but are held in place by the actual soldered joints which make the electrical contacts between them and the fixed points.

This brings me to the question of soldering, which is a 'must' in modern radio work. Fortunately it is very simple with an electric soldering iron (which must be *hot*!) and multi-cored solder. You also need a piece of glass-paper to put a shine on the wire ends of components. Soldering tags on such things as the valveholders, and the variable capacitor, also need a light rub over with the glass-paper before soldering.

To fix a component, or a piece of wire, to another, just wrap the wire-end round the tag of the other component (or the other wire-end) so that they are lightly fixed together, leaving both your hands free. Then apply the end of a coil of multi-cored solder to the join with one hand and apply the hot soldering iron with the other. The solder will run and, provided the points to be soldered are clean, will quickly join them together.

Remove iron and solder—I usually blow gently on the joint to cool it—a slight tug to test it, and there is your joint! Beware of 'dry joints'. They look all right but are not really, hence the 'tug test' which will soon expose them.

It is best to use insulated wire for wiring-up. The filaments of battery valves are very delicate and crossed wires, or a wrong connexion, can easily apply high tension to them and possibly ruin all three valves in the set. For this reason the wiring must be checked and re-checked.

I have used three batteries in this set. For filament heating the 3-volt dry battery already referred to, a small 90-volt HT battery, and a grid-bias battery of 9 volts. I have used the latter purely on the grounds of simplicity and cheapness. I know that the modern practice is to get 'free' grid-bias by means of a resistor and condenser, but the battery arrangement is just as good, and much cheaper.

* * *

The battery connexions are made with little lengths of flex, generally red flex for positive leads and black for the negative. Similarly coloured plugs can be used on the ends for connexion purposes. There should be room on top of the chassis, behind the speaker, for the HT and LT batteries, but it is as well to test the set before it is put into the cabinet.

After completing all the wiring-up, and seeing it is checked with the diagram, insert the valves in the appropriate sockets. The LT battery may then be connected up. See if the valves are alight. If you cannot check this connect up all three batteries before inserting the valves and apply a flashlamp bulb across the appropriate sockets of each valveholder. If it 'blows' the answer is obvious—re-check the wiring. If it lights up all is well and you can put the valves in.

Unscrew the trimmers on the top of the capacitor and tune in a station at one end of the band. Then gently screw down the trimmers one at a time for maximum volume. Tune in another station at the other end of the scale and gently 'waggle' the trimmers to see if any further adjustment is required. Leave them set at a compromise position to give best volume at each end of the scale.

CHAPTER 6

A Portable Cycle Radio Set

This set can be made cheaply and fitted to any standard British cycle. It was designed for boys who wanted to hear Test Match commentaries while at camp! For cycle-campers who are out regularly at weekends or holiday times, this set has an instant appeal. **Do not operate it at any time while cycling.**

HERE is a light and simple radio receiver which can be made up easily and cheaply and fitted to a standard bicycle. It can be considered in three sections—receiver, loud-speaker and batteries.

The receiver is a three-valver of the detector and two low-frequency stages type with a pentode output, designed for operation from a very small aerial. It has no high-frequency stages, the first valve being used as a detector with reaction and thus is only for local station reception. In some areas, it will receive both Home and Light programmes at full volume on its short aerial, but in others it is probable that only one station might be received. This is thought to be quite adequate for this particular purpose.

The aerial is connected to a small home-made coil which feeds a triode leaky-grid detector with a reaction coil in its anode circuit to increase its sensitivity. This valve

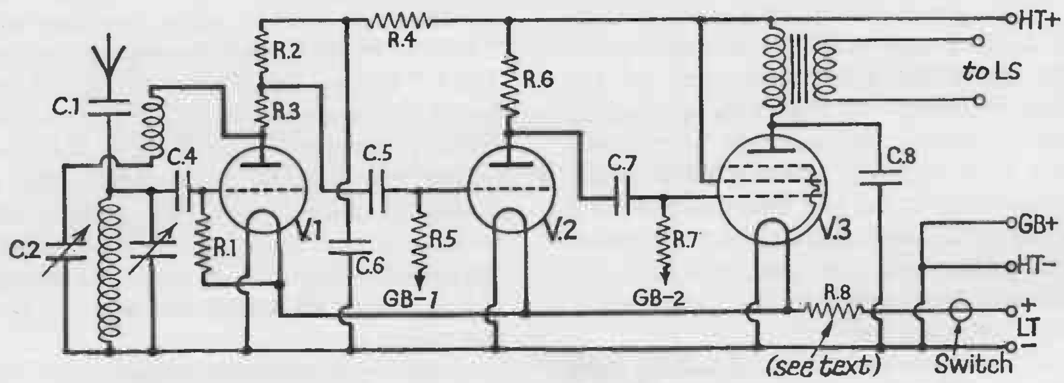


Fig. 16 Bicycle Receiver All parts to be smallest obtainable (except where indicated)

C.1. ·0005 mfd. fixed capacitor
C.2. ·0001 mfd. variable capacitor
C.3. ·0005 mfd. miniature variable capacitor
C.4. ·0001 mfd. fixed capacitor
C.5. ·005 mfd. fixed capacitor
C.6. 2 mfd. miniature 150 v. electrolytic
C.7. ·005 mfd. fixed capacitor
C.8. ·002 mfd. fixed capacitor
R.1. 2 megohm resistor
R.2. 47,000 ohm resistor
R.3. 10,000 ,, ,,
R.4. 22,000 ,, ,,
R.5. ·5 megohm ,,
R.6. 47,000 ohm resistor
R.7. ·25 megohm ,,
R.8. 3 ohms to carry ·5 amp. (see text)
V.1. HL2K (Osram)
V.2. PM2HL
V.3. PM22A (Mullard) or equivalent types
3 × 5-pin valveholders
Output transformer
On-off switch
Wire, Terminals, Wander-plugs
HT Battery 90 volt, GB Battery 9 volt
LT Battery or accumulator
Miniature loud-speaker, knobs

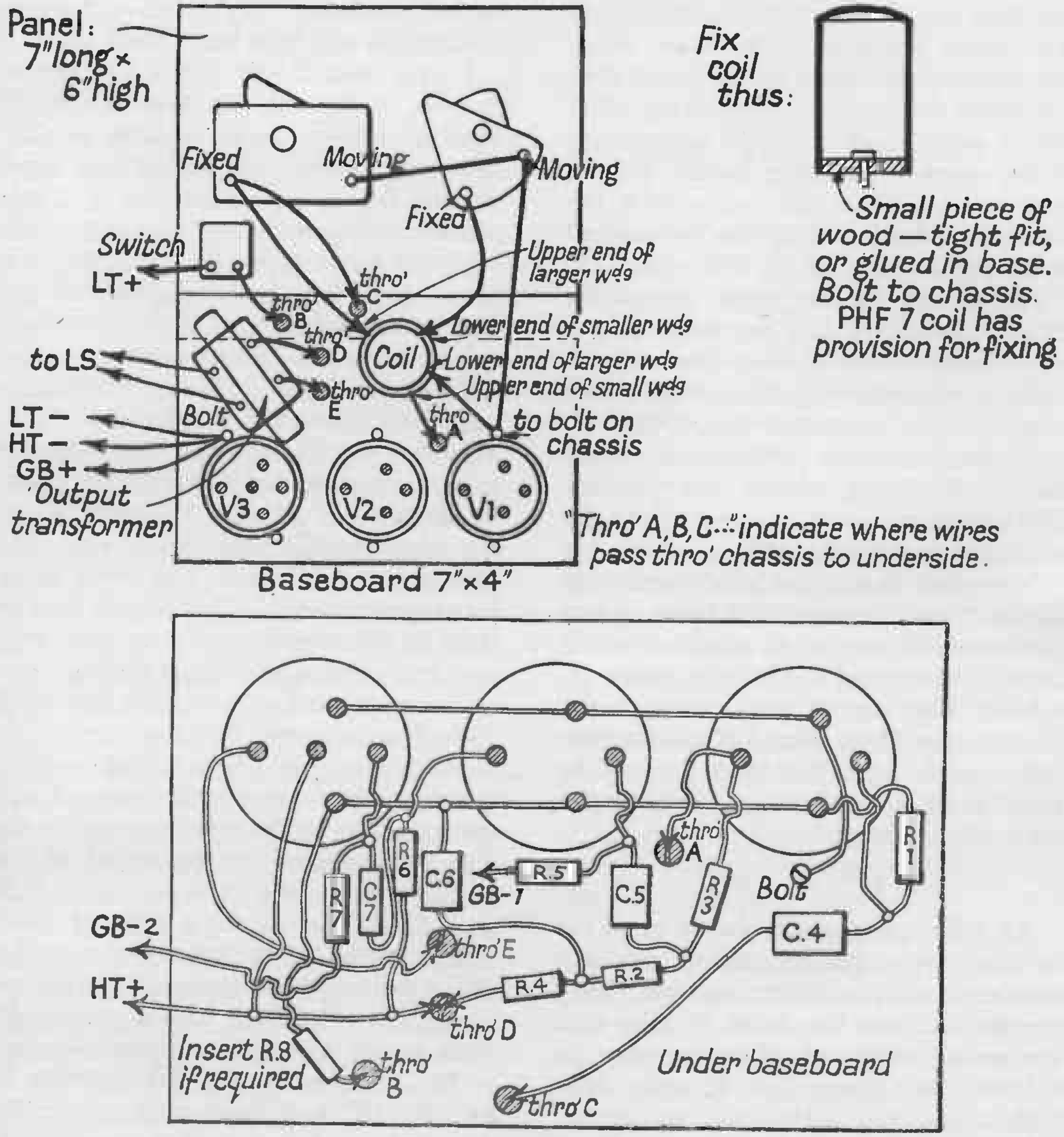


Fig. 17 Bicycle Receiver. Wiring Diagram

is resistance-capacity-coupled to another triode which is again resistance-capacity-coupled to a high-slope pentode which drives the loud-speaker. The small currents picked up by the tiny aerial are thus detected and amplified by the first valve and then further amplified by the two following valves into a powerful signal.

The small chassis is of thin aluminium, brass or even tin. Cut it to the size shown on the diagram and bend down the flanges at the front and back. These are for fixing purposes, that along the front having a small panel to which the variable condensers and switch are fitted. The valve-holders are the chassis type and the holes for these are best made before the flanges are turned down as it is easier. Mark the circles for the holes on the metal, then cut round the marks by hammering either with a small chisel or an old screwdriver. If the edges of the holes buckle a little, you can tap them flat again with the hammer, and should they be a little ragged at the edges, tidy them up with a file.

Having cut out the holes, mount the three valveholders and the small output transformer on the chassis. The compact variable condensers are then fixed on the panel making sure that the ·0005 mfd. condenser is used for tuning purposes and that of ·0001 mfd. capacity for reaction. The switch, too, may be mounted on the panel. Also make the coil—the turns are 'pile-wound': that is, just 'piled' one on top of the other—the tuned coil being in two sections of 45 turns each, a total of ninety turns. The reaction coil is sixty turns pile-wound. You can, if you wish, use the Wearite-type P coil instead of making your own, and the type PHF range 7 should be suitable. In this coil the red tag denotes the grid connexion.

* * *

All other components should be of the 'midget' type—¼-watt resistors and the smallest sized condensers are used. They are all fixed into the circuit by their own connecting wires and, of course, must be soldered into place. This is easily done with resin-cored solder and an electric soldering iron. Use a heavy-gauge tinned copper wire for connecting up. No. 16 or 18 s.w.g. is suitable and a length of sleeving will be needed so that wires which cross or are liable to touch one another, or the chassis, may be insulated. Make all the connexions as short as possible so that the components are held rigidly. There must be no 'sloppiness' or else short circuits are likely to arise. Soldered joints must also be well made—no 'dry' joints—otherwise, the first jolt will quite likely break them.

I have used 2-volt valves for several reasons. Valves of this type are easily obtainable from 'ex-government surplus' stores. They are quite robust and small enough for our purpose and a 2-volt pentode will give a larger output than the midget 1·4-volt type. If, of course, you have valves of the latter type on hand you can try them out, with a single 1·5-volt cell omitting the 2-ohms resistor.

When the set is built and working to your satisfaction make a small box for it. The back should be a piece the same size as the front panel and four small pieces can be cut to fill in the sides, top and bottom. Fix them with small panel pins and then cover the whole box with some waterproof material. The set can then be fixed to the cross-bar of your cycle with two small straps or strips of metal.

The loud-speaker for the set is a small 2½-inch component. Make a box to enclose it completely, with a hole in the front which can be covered with a piece of wire gauze. Cover in the same way as the set. The loud-speaker can be bolted to the handlebars of your cycle so that it faces you, fixing the box to a strip of metal clipped to the handlebars. Use the type for fixing electrolytic condensers. This clamps round the handlebars with a washer cut from an old inner-tube to prevent slipping.

The batteries required are a midget 99 volt for HT and 3-volt cycle battery for LT, and they are carried in a saddlebag. You might care to buy a small ex-Army 2-volt unspillable accumulator for LT in place of the 3-volt battery. If you use this, you will not need the 2-ohm resistor.

In the interests of road safety it is certainly not intended to use this set while you are riding, but as soon as you halt for a meal, or rest, or camp overnight, you have the opportunity to listen to the radio if you wish.

CHAPTER 7

Constructing All-Mains Receivers

First we tell you something about the valves used in Mains Receivers. That is most important. Then we stress the constant need for care when handling electricity from the mains. Follow the Davey Drill and you will never have trouble. Read this chapter many times slowly until you have grasped the essentials. Then we are ready for Chapter 8!

APART from the crystal set designs the receivers described so far have used batteries. They have suffered from the limitations of all such receivers. In the case of 1·4-volt filament valves, *relative inefficiency*, which means a lack of sensitivity to weak signals, and restricted output power. Two-volt valves are better in these respects but all battery valves suffer from the fact that both filament current and high-tension current and voltage must be limited. In the early days of radio and radio valves, the latter took from 4 to 6 volts at possibly 1 ampere of current each and a three- or four-valve set had to be run from a 6-volt accumulator.

On the high-tension side accumulators also were used and these, on the score of expense, restricted both the milliamperes of current and the voltage obtainable. Batteries improved in performance as did valves, so that by the late 'twenties we had 2-volt valves which only took ·25 amp. or ·18 amp. each, and dry HT batteries of 108 or 120 volts at fairly reasonable prices.

Valves soon dropped to a requirement of only ·1 amp. or less at 2 volts and quite small accumulators could be used, but even so the cost of running a radio set from batteries was obviously quite expensive. The development of electricity throughout Britain resulted in a device known as a 'mains unit' or 'HT battery eliminator' coming on the market. This enabled radio sets to be run from the electric light mains, thus 'eliminating' the battery, although the accumulator was still necessary for heating the filaments of the valves. Some HT mains units had an additional 'trickle charger' by means of which a small charge could be put into the accumulator overnight in order to keep the voltage up. It was not possible to heat the filaments direct from the mains because the mains voltage is never entirely steady and the filament would vibrate slightly in sympathy with the fluctuations. This would induce hum into the valve which would amplify it and pass it through the set, obliterating the signal!

* * *

Osram introduced the KL1 type of indirectly heated valve in 1926, and this was followed by improved valves made by most manufacturers, in 1929. The battery-valve filament is a length of wire as thin as a hair which discharges electrons when it is heated by means of the filament current. In the early valves they were tungsten wire but in time were coated or compounded with various mixtures to give an improved electron discharge. This discharge is called the emission from the filament, and when a valve is old, although the filament may not be burnt out or broken, it may become useless because the emission is low due to the supply of electron-discharge material being exhausted.

Now, as you know, the alternating current mains are in a constant state of change from positive to negative—this occurs so many times per second (generally 50, hence 50-cycle mains). If this AC voltage is applied to the thin filament of a battery valve, as mentioned above, it causes a hum. The detector is particularly sensitive in this respect and it was therefore found necessary to introduce some means of overcoming this disadvantage. Hence the KL1 referred to above, and the later types of 'indirectly-heated' valves. Fig. 18 gives you an idea of how these valves are arranged. A sturdy wire is formed into a

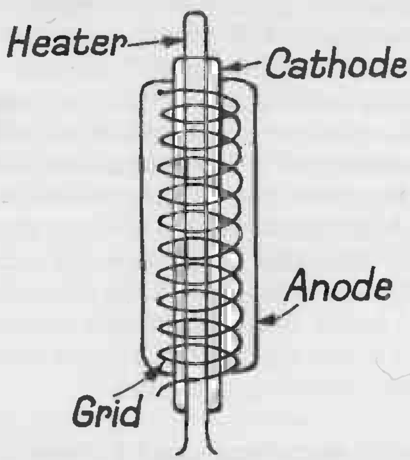


Fig. 18 An Indirectly Heated Triode

V-shaped loop and this is the filament, or, as it is now called, the heater. Around this, and very close to it, is fixed a cylinder which is coated with the electron-emitting material. Sometimes this device consists of a narrow porcelain cylinder pierced with two holes through which the heater is threaded, lengthwise.

Either way the intention is for the heater indirectly to heat the cathode, as the coated cylinder is called, and cause a discharge of electrons. These are then dealt with by the grid (or grids) and ultimately reach the anode. We thus have now a valve with an extra connexion compared with those we have been accustomed to in battery valves, and thus a somewhat different operating technique has to be evolved. The additional connexion is to the cathode, as in the battery valve the filament is both heater and cathode, but in the mains valve the heater simply has the requisite voltage applied to it and acts solely as a means of heating the cathode. Exceptions to this are large directly-heated AC mains power and pentode output valves where the filament performs the dual function as in a battery valve.

The indirectly heated valve became firmly established before the last war and with the extension of AC mains, most people owned AC mains receivers. Battery receivers were used as a stand-by or as extra receivers. Four volts had become established as normal heater for most AC valves in Great Britain and the Continent of Europe, and the heater current was, in general, 1 ampere. Phenomenally efficient valves were evolved, particularly certain output valves, pentodes, which could deliver huge outputs from relatively tiny signals delivered to their grids. In the USA indirectly heated valves developed around a heater voltage of 6·3 as opposed to Europe's four, and the normal American heater current was ·3 amp. Pre-war American valves were considered to be less efficient than British or European types, but tended more to standardization.

Standardization of radio between Great Britain, the USA and their Allies was necessary in the war. As a result the American 6·3-volt ·3-amp. type of valve came into general use. After 1945 this type of valve with US designations and what is now known as the 'international octal' base became standard.

It appears likely that it will be so for many years to come. This kind of valve has the advantage of being instantly recognizable by type whatever the make. The growing need for compactness in multi-valve apparatus has popularized miniature valves which are to-day ousting the larger types. Although varying voltages for heaters are now commonly used due to the inclusion of these heaters in a 'series chain' rather than across a transformer winding, the general voltage to-day for AC mains radio and car receivers is 6·3 volts.

In addition to becoming smaller, valves are being made of all-glass construction, thus eliminating losses due to the bakelite base, and single-ended, i.e. without a top connexion. In the following designs both types of valves are specified. It follows that the transformers used with them will subscribe to a 6·3-volt heater winding. If you enjoy experimenting with radio, therefore, and have available 4-volt valves with 4-volt heaters and transformers, there is nothing to prevent your using them in these designs. I cannot guarantee that the results will be entirely satisfactory, but the basis of fun with radio is experiment.

Most valve-makers supply lists of valves and equivalents which will show you what 4-volt valves you may use in place of those specified. I would suggest, however, that you should not try to obtain 4-volt valves. These are now quite out-of-date and probably difficult to obtain, those available being for replacement purposes in old receivers. I know that many boys have old components, sets and valves given to them.

The purpose of this long introduction has been to tell you something of the valves which you use in mains receivers and of their development. The technique is very different from that involved in the use of battery valves, and I feel it is worthwhile to know something of how it has evolved. Using mains valves brings with it the problem of overcoming mains hum; the higher efficiency of the valves involves the difficulties which arise due to instability; larger output valves mean greater volume which needs attention to the question of loud-speakers. Higher fidelity of reproduction is possible and this is a study in itself and has its own special circuits. There is much to study, much opportunity of experimenting and many designs to be worked out. Those given here are a few of the simpler ones available.

Over the whole aspect of this side of radio work I must now give a special word to safety precautions. The more I use electricity, the more I am aware of its dangers, and I do urge you to be careful constantly when handling the mains, and the higher voltages which you obtain from transformers connected to them. These voltages are lethal. They CAN kill you. Bear this in mind all the time, and do nothing foolish such as poking about haphazardly inside a receiver with the mains plug connected. It is not sufficient merely to switch off—pull the plug out of the socket always.

I know that some adjustments such as trimming have to be carried out while the set is working, but they do not require any handling of the set and proper precautions can easily be taken.

To reassure those of you who may be worried by these cautionary words, I will point out that all these designs and, indeed, any others you may come across are *perfectly* safe provided you are aware of the danger in mind. After twenty-five years of experimenting in radio even now I remember it constantly. A great safety factor in using electrical apparatus is to have a good earth connexion, and this is valuable also where radio is concerned. Most power points nowadays have three-pin plugs, one of which provides an earth, and this may be used to earth the chassis of a set. Certain types of sets, such as AC/DC and AC sets where one side of the mains is connected to the chassis, must not be earthed on any account and aerials must only be connected to them through a safety capacitor. Care must always be taken to ensure that they are always used with a cabinet, and the grub-screws of knobs must be well below the surfaces of the knobs so that your fingers cannot make contact with them.

It is often a good idea to fill in the grub-screw holes with a little wax or plastic wood to complete the insulation. When using mains sets the voltages are very much higher than those to which one is accustomed from batteries, and the usual transformer used to-day is a 250–0–250 type. This is for connexion to a full-wave rectifying valve and is really the same as a centre-tapped 500 volts winding. The two ends of it are connected to the rectifying valve anodes and the centre-tap goes to earth. This winding when it has no valves taking current from it, if connected to the mains, will give something around 700 volts or 350 volts per winding. The rectifying valve is designed to stand these voltages and the rectified voltage which it gives may be in the region of 280 volts. This will be dropped down by the resistance of the smoothing choke or resistor to about 260 volts, which is the normal maximum voltage of most valves we use.

You must, therefore, be careful to obtain capacitors which will stand up to these higher voltages and usually in a receiver working at these volts we use capacitors rated for 350 volts working. It is useless to try and use old capacitors from a battery set as they are usually rated to stand only about 150 volts and would quickly break down and cause a short-circuit across the HT supply. Similarly with resistors: battery valves are rated at a maximum HT voltage of 150 volts or lower, and unless a mains unit is being used, the actual voltage used from batteries is usually in the 90–120 volts range. At these voltages the current taken by the valves is only a few milliamps, batteries are not cheap compared with mains electricity and the current drain has to be as small as possible. As a result, battery sets are restricted in the output which they can give. However, this low current combined with a moderate voltage means that the wattage of resistors used can be the lowest made—usually ¼ watt.

Mains valves, as mentioned before, do not need to be restricted either in voltage or current and are generally constructed to work at 250 volts HT. At this voltage 10 milliamps is quite a common current for a valve of any type to take, and an output valve will take 40 to 50 milliamps. You see, therefore, that the resistors must be capable of carrying much heavier currents, and also special care has to be taken to ensure proper ventilation of mains receivers. Mains valves run very hot, especially the rectifier and output valves, and designers usually arrange that such valves are at the back of the receiver so that a flow of air can get to them through the perforated back of the set. Radio set cabinets, you will notice, have perforated backs for the dual purpose of ventilation, and for avoiding a 'boom' tone which would result if the cabinet were closed completely. A radio set, therefore, must *not* be pushed back against a wall, nor may curtains be allowed to drape over its back, otherwise the whole point of these perforations is lost, and damage is likely to occur to the set. The question is of greater importance still where television sets are concerned as these use around twenty valves generating considerable heat.

I do insist that you must build some sort of cabinet or cover for every mains set or amplifier you build. The danger of accidental shock to yourself is too great, apart from the risk to younger children or pets getting among dangerous voltages.

The first mains design is dealt with in the next chapter.

CHAPTER 8

A Mains HT Unit for AC Mains

Now you can supply High Tension Voltage for some of your battery sets by building a Mains HT Unit. Components are few in number and cheap to buy. Running costs are very low. Go to it!

THIS unit is designed to supply high-tension voltage for battery sets such as those already described which are designed to run from batteries and which use battery-type valves. This means that the dry battery or accumulator which is used for supplying the filament heating must still be used, but this is not a very expensive item and occasional replacement of a dry battery or recharging of a 2-volt accumulator costs but a few pence.

The advantages of a mains HT unit (and it is only for AC mains, by the way) are the continuous supply of a relatively high voltage compared with a battery; the fact that the voltage does not gradually deteriorate as does that of a battery, and the very low running cost.

Components are few and quite cheap. First of all a transformer which has three windings, the primary tapped for varying mains voltages between 200 and 250 and two secondaries, one giving 120 volts at a current of 40 milliamps, and another which is a centre-tapped 10-volt winding (at 1 amp.). This last winding we disregard in our present design; it is for use with a half-wave rectifier for trickle-charging accumulators, but as it requires a couple of meters to set it up properly, it is felt it is outside the scope of the designs presented in this book.

When you have more experience and more equipment you can try out a trickle-charger using this 10-volt winding. However, I must return to the two windings which I intend to use. The primary is connected so that one side of the mains is connected to the 'O' end of the winding and the other side of the mains to the correct tapping on the winding according to the mains voltage. You will note a switch for 'On-Off' purposes is interposed in one lead. If the mains voltage does not

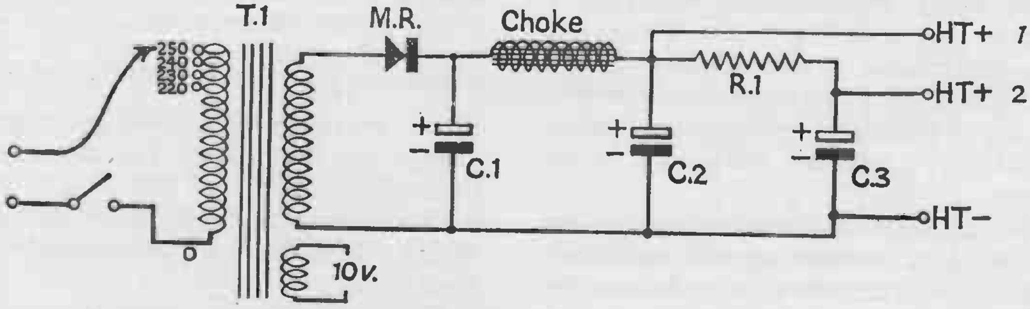


Fig. 19 Mains HT Unit. Theoretical Circuit

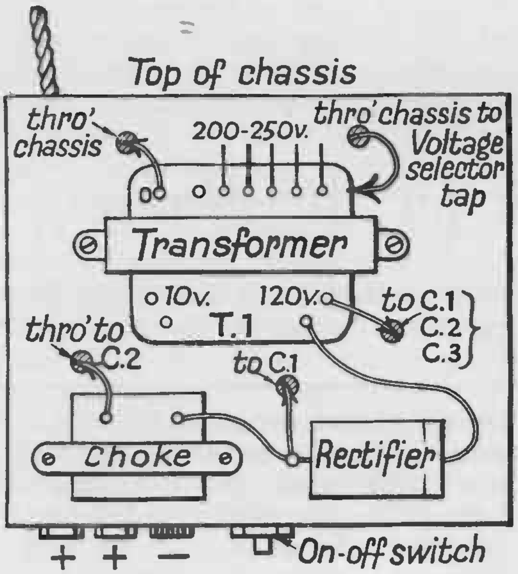


Fig. 20A

Wiring Diagram

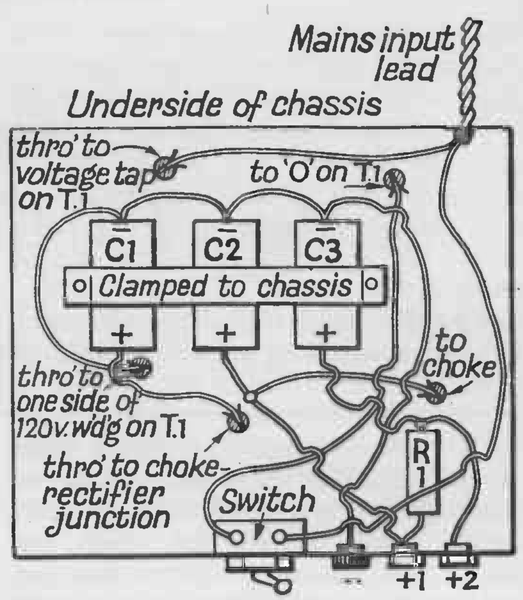


Fig. 20B

Components required:

HT Unit transformer 120 v. 40 m/a (Radio Supply Co., Leeds)
Metal rectifier 125 volts 40 m/a. Brimar SB 2 or any suitable type
Small smoothing choke. 10 henry 60 m/a (RSC Leeds as above)
3 capacitors, 8 mfd. electrolytic each 200 or 250 volt wkg.
Resistor 2,500 ohms, 1 watt type.
1 black 2 red sockets, wire, chassis, etc.

correspond exactly with one of the marked tappings, the connexion should be made to that which is marked for a voltage immediately higher. For instance if the mains are 240 volts and the tappings are 210, 230 and 250, connect the mains input to 0 and 250. If you do not know the mains voltage it will be marked on the electricity meter, or the local Electricity Board showroom will tell you. If you like, a fuse can be connected in the input lead for extra safety, and a suitable holder for a 1-amp. fuse is on the market. I have not specified this for the sake of simplicity and cheapness, but a fuse may be incorporated in any of the mains set designs, a 1-amp. fuse in the smaller sets and 2-amp. for the larger.

Having wired up the primary side of the transformer, connect up the secondary which gives 120 volts at 40 milliamps. To rectify this alternating current use a selenium rectifier and this acts on a half-wave principle. As a reservoir capacitor use an 8-mfd. electrolytic type; smoothing is carried out by a choke and another 8-mfd. capacitor. It is unlikely that a battery set will take 40 milliamps. even at 135 volts, and as a result the voltage will rise above the 120-volts output of the transformer. Consequently I include a 'tapping' which is obtained by passing the current through a 2500-ohms resistor by-passed by another 8-mfd. capacitor. If the set takes a total of 10 milliamps. the voltage drop will be $\frac{10 \times 2500}{1000} = 25$ volts and this should be sufficient to avoid too high a voltage on the valves. The capacitors, incidentally, can be of 200 or 250 volt working voltage ratings (higher, if you have them available, but I should not use lower rated ones).

The components are mounted on a small

chassis which you can make up of wood if you do not want to buy and work on a metal one. It is much better to use a chassis as so many of the components can be mounted under it safely out of harm's way. The rectifier must be mounted on top as it must have sufficient ventilation, but in view of the low rating we are using, it should run cool. Because of the HT on this rectifier I made a cover to prevent hands from brushing against it when the HT Unit is in use. A simple cover made from perforated zinc or expanded metal, as used for loud-speaker frets, is adequate. One of the bolts connecting the cover to the chassis, if this is of wood, should be connected to earth so that the cover is automatically earthed by it. It would rather defeat the purpose of the cover if this should accidentally touch the high tension line and become 'live'! The output from the unit is connected to three sockets only; one for negative which can have a black 'collar' and two positives with red 'collars'. One of the positive outputs will be the maximum voltage direct from the smoothing choke, and the other will be through the 2500-ohms resistor already discussed. For normal battery sets I use this latter tapping-point and avoid too high an HT voltage on the valves. Only one output point is given as it is modern practice to provide the intermediate points for those valves, other than the output (which takes the maximum HT), by means of resistors incorporated in the set itself. These are linked to by-pass capacitors of suitable size and give each valve its appropriate voltage plus stability and extra smoothing.

* * *

If you look at the circuit of the Three-Valve Set in Chapter 5 you will see that resistors are used for dropping the voltage to the HF pentode, and the detector valves. The larger the resistor, the lower the voltage which it will allow to reach the valve. Also in each case where we use a resistor in this way we use a large 'by-pass' capacitor. In HF circuits (i.e. before the detector) we can use small paper capacitors of ·01 to ·1 mfd. capacity. After the detector, in AF circuits, we must use larger sizes between 2 and 8 mfd. The latter size is a useful one and electrolytic capacities of this capacity are readily available. Do not forget with electrolytics the negative (marked '—' or black) must always go to the negative HT line.

Valves require a grid-bias voltage for the output valve and for any intermediate low-frequency valve which there may be, as well as for a variable-mu pentode if this is fitted on the HF side. In battery sets this is usually obtained from an inexpensive grid-bias battery of 9 or 18 volt rating. Sometimes, again, as in the set described in Chapter 4, this bias is obtained by inserting a resistor in the HT negative lead and obtaining 'free' grid bias. It is not free really, it must be deducted from the

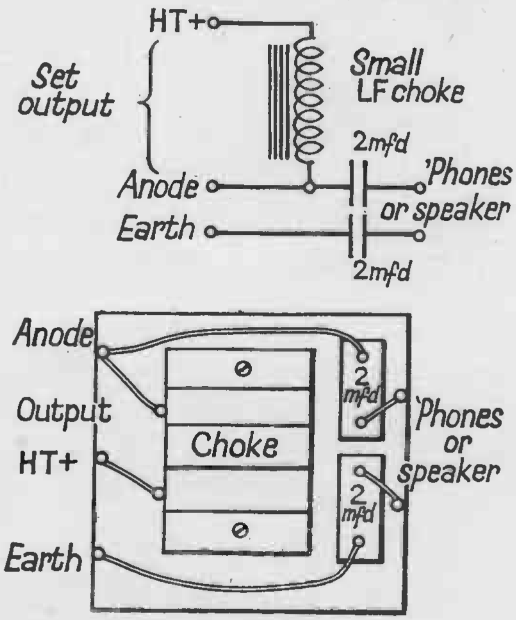


Fig. 21 Output Filter Circuit

total HT voltage. In the case of a small battery output pentode the 5 to 7 volts required is not an important deduction from the HT. A large mains power output valve, however, may require 40–50 volts bias, and this has to be remembered when working out the HT volts to be supplied.

After completing the mains supply unit we can connect up the set to it, place the mains power supply plug in its socket and switch on. The higher voltage and plentiful supply of current should be apparent in better results at once. If you have a one- or two-valve set which uses earphones only, be very careful not to use them when HT is supplied from the mains unless you use a choke or resistor filter output or a 1 : 1 transformer. The simplest and cheapest to arrange is probably the former, as 1 : 1 transformers are not easy to obtain these days. The circuit is given in Fig. 21.

The next design is our first All-Mains Receiver in this book. It is given as an AC mains design, as these mains are now more general in this country than the antiquated DC type.

CHAPTER 9

A Midget AC Mains Two-Valve Receiver

Here's a midget Two-Valve Mains Set with a fine performance. With 50 feet of aerial in the loft you can pick up a dozen stations at loud-speaker strength without difficulty. Don't use a large aerial or you will have trouble in separating stations.

THIS small set is compact and self-contained in all respects and is operated from AC mains. It is ideal for use as a bedside receiver, or at school, because it operates well from only a few feet of aerial. It is not designed for use from a large aerial but I received a dozen stations at loud-speaker strength trying the set out with 50 feet of aerial housed in the loft. As it is so small, with only one tuned circuit, it is not suitable for use with such a large aerial as it becomes unselective and it is difficult to separate the stations.

The two valves used are of the type

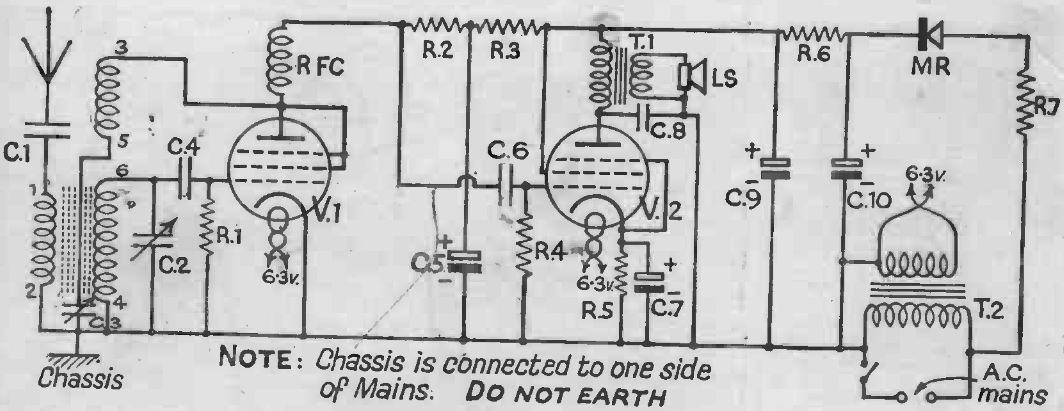


Fig. 22 Theoretical Diagram
Midget AC Mains Two-Valve Set

Components required:

V1/V2. 2 EF. 50 valves
2 B9G valveholders (and clips)
Coil. 1 Teletron. D/R coil
RFC. 1 Teletron RFC 4 HF. Choke
C.1. ·001 mfd. fixed capacitor
C.2. ·0005 mfd. midget solid dielectric capacitor (variable)
C.3. ·0001 mfd. midget solid dielectric capacitor (variable)
C.4. ·0001 mfd. fixed capacitor
C.5. C.9. C.10. Each 8 mfd. electrolytic capacitor (3 in all or 1 double 8 × 8 and one single 8 mfd.)
C.6. ·005 mfd. fixed capacitor
C.7. 50 mfd. electrolytic capacitor 12 volt working
C.8. ·002 mfd. fixed capacitor
M.R. Metal rectifier. Selenium type 230 v. 30 m/amps.
T.1. Small output transformer: highest ratio obtainable
T.2. Heater transformer: output 6·3 volts 1 amp. Input to match mains
R.1. ·25 megohm, ¼ watt
R.2. 100,000 ohms, ¼ watt
R.3. 22,000 " " "
R.4. 1 megohm, " "
R.5. 150 ohms, " "
R.6. 5,000 ohms, 1 "
R.7. 100 ohms, " "
Metal chassis (or foil-covered wood): front panel
Midget 2½-inch loud-speaker
Wire, solder, flex as required, knobs, on-off switch (250 v. 1 amp. type)

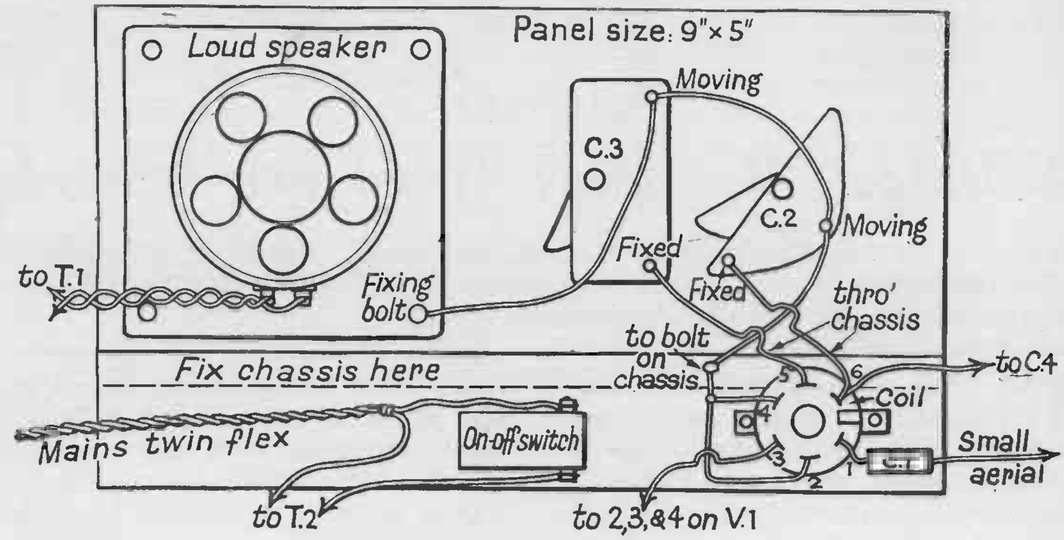


Fig. 23A Wiring Diagram Panel

Top of Chassis Carries Filament Transformer and Valveholders

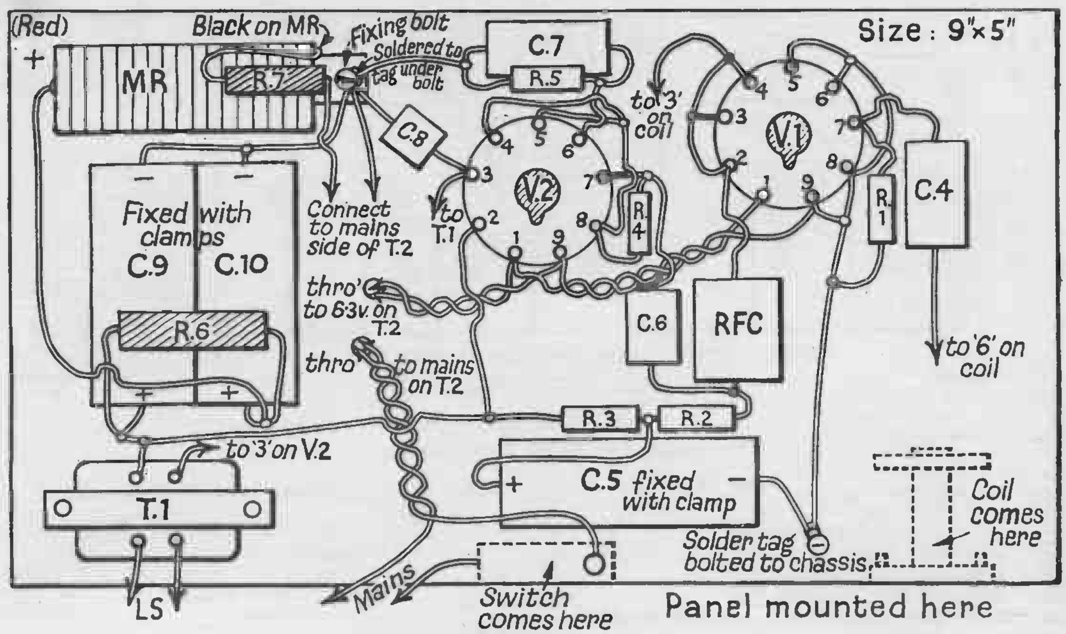


Fig. 23B Wiring Diagram

known as EF50, which is described as a high-frequency pentode and is especially used in television receivers or short-wave sets. These valves are available very cheaply as 'government surplus' under the designation VR91 and they require a heater voltage of 6·3 volts at a current of 0·3 amp. These are the only valves which can be used in the set. There are similar types of 6·3-volt valves available that are known as SP61 but these are not suitable as they consume 1 amp. of current each and this is too heavy for the midget type of mains transformer used.

Fig. 22 gives the theoretical diagram and the wiring is given in Fig. 23.

Aluminium Chassis

The first job is to make up the small chassis and panel on which the set is built. I have used this method of construction as it is the simplest form for beginners and obviates a lot of metal-work which all-chassis construction would entail. The small chassis used is made of a piece of aluminium. Thin copper or brass could be used if either is available.

A flange has to be made along the front of the chassis to attach it to the panel but before this is done the two holes for the valveholders should be cut. The easiest way to do this is to mark them out with pencil or a large nail and then to cut round the marks with an old chisel, or screwdriver and hammer. Lay the metal on a block of wood on the floor to do this, as mother will not be pleased if you do it on the kitchen- or dining-room table!

Having cut round the marks which you have drawn, knock out the centres and, if necessary, clean up the inside edges with a file. If this work has buckled the metal a little it can be gently hammered flat again. The flange can be made by bending the metal down with pliers and finally tapping it out at right angles along the edge of the bench, or even the back-door step. There are two types of valveholders for EF50 valves—ceramic and paxolin. Either type can be used in the set but the paxolin are cheaper and quite suitable. They have the advantage of a centre clip which fits into an indentation in the spigot of the valve and holds it firmly in place. This is an advantage because EF50 valves have a habit of springing out of their valve-holders. In the original set I used clips which fitted over the tops of the valves and, for the sake of the low cost, these clips are well worth while.

The front panel of thin plywood needs a hole in it for the speaker and this can be cut in the same way as those for the valve-holders. Two small holes will also have to be made in it for mounting the variable condensers and there will have to be further holes made in the chassis for fixing the components. This is accomplished with 6 BA nuts and bolts. The metal rectifier is provided with a nut and bolt for fixing it in an upright position. Keep it near to the back of the chassis for ventilation purposes. The electrolytic condensers used can consist of three separate condensers or may be one double type, plus a further single one.

The HT circuit employs a half-wave selenium rectifier and no transformer is used between it and the mains. This means that one side of the mains is connected to the chassis, so it is important that the set should not be handled or adjusted while it is switched on.

To be absolutely safe, a cabinet should be used. An earth must not be connected to the receiver for the same reason. This method of obtaining HT is fully in accord with modern practice and there is no particular danger in it so long as the care, already outlined, is taken. The grub-screws of the knobs must also be sunk well below the level of the knob so that the fingers do not come into contact with them.

A small cabinet can easily be constructed from odd scraps of wood to enclose the set completely. If you cannot carry out the carpentry sufficiently well to justify painting, or staining and polishing, the cabinet can easily be covered with leatherette or plastic material afterwards.

CHAPTER 10

A Three-Valve Portable Receiver for AC Mains

A small, light Portable Mains Set is clearly very useful in the home. It can be moved around from room to room with a short 'throw-out' aerial. Use a midget 5-inch speaker and follow the instructions carefully.

THIS is called a portable receiver because it is small and light and can be moved around from room to room as required. It cannot be used out-of-doors because it is designed to be used on an AC mains supply, but as long as it can be plugged into such a supply the short 'throw-out' aerial will give good signals anywhere. This is a mains version of the battery set described in Chapter 5 and uses the same

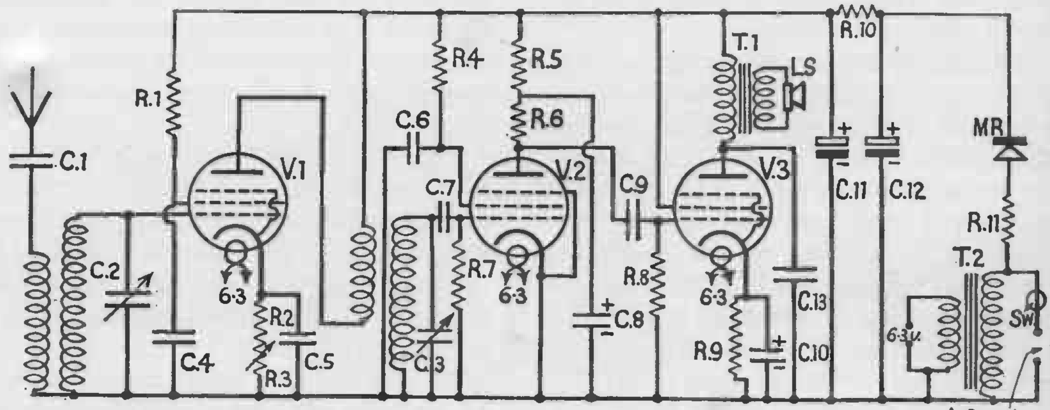


Fig. 24 Three-Valve Portable Receiver for AC Mains

Components required:

Chassis—see text
Cabinet—see text
Capacitors: (values in mfd.) all 350 volt
C.1. ·001 fixed
C.2/C.3 dual-gang variable ·0005
C.4. ·1 fixed
C.5. ·1 fixed
C.6. ·1 fixed
C.7. ·0001 fixed
C.8. 8 mfd. electrolytic
C.9. ·1 fixed
C.10 25 mfd. 25 volt electrolytic
C.11. 8 mfd. electrolytic—may be a double capacity
C.12. 8 mfd. „ —
C.13. ·005 fixed (but see text re. variable tone control)
Resistors: (All ½ watt types)
values in ohms (k=kilo=thousand)
R.1. 47k. (i.e. 47 thousand)
R.2. 100 ohms
R.3. 10 k. variable (with switch)
R.4. ·5 meg.
R.5. 47 k.
R.6. 100 k.
R.7. ·5 meg.
R.8. ·5 meg.
R.9. 200 ohms
R.10. 2 k. wirewound 6 watt
R.11. 100 ohms
Tr.1. Output transformer to match EL41 to 3 ohms (midget size)
Tr.2. Filament transformer 6·3 volt 1·5 amp.
MR. Selenium metal rectifier 250 volt. 50 m/a.
Valves: V.1. EF41, V.2, EF40, V.3. EL41 (Mullard or equivalent)
Valveholders: 3 type B 8A
Coils, Aerial HF2. Intervalve HF2. If battery set is being converted the D/R coil may be used as Intervalve coil. If long waves wanted (see text) use A/D and A/HF.
5-inch loud-speaker

basic components plus additional ones required for the mains operation.

This means that you are able by merely obtaining new mains valves plus the additional components for AC conversion to make up a very useful AC set. There is one point here which is fairly important. For the description of the battery receiver in Chapter 5, a midget 2½-inch speaker is specified. Such a speaker can be used in a battery set which has a comparatively small output (about ·5 watt at maximum HT) but is too small for a mains output pentode which will give an output of over 4 watts.

Naturally we cannot use this large output in a small receiver, but the volume might be turned up fairly high by accident, and would destroy such a small speaker as that shown. So, whilst its power-handling capacity is not 4 watts either, it is preferable to use a 5-inch speaker in the mains receiver as it is more robust and will handle a larger output more satisfactorily. The larger speaker will give rather better quality of output than the midget. On the subject of quality it must be remembered that these small sets cannot be expected to give a 'high fidelity' output. Broadly speaking the larger the loud-speaker and associated equipment, the better the reproduction. These small sets are extremely sensitive and receive signals on only a few feet of aerial wire. They are light and portable and as long as the loud-speaker is not overloaded by turning up the volume too high, they will, thanks to the modern valves and straightforward design, give extremely pleasant results from a number of stations.

The design for a battery version shows a wooden chassis which could be made up in accordance with the instructions given. A metal chassis could be used and this could be purchased with the cabinet kit referred to in the chapter. The cabinet kit consists of the cabinet, tuning dial and components associated with it and the metal chassis. In the case of the present design for mains working, whilst the wooden chassis in the battery version is adequate for battery valves, the higher efficiency of the mains valves means that we must have a metal chassis for better screening.

So, unless you want to go to the expense of buying one, the wooden chassis must be covered with metal foil. There are aluminium foils on the market which are sold for cooking purposes. The one I used was obtained at a stationers' shop and is called 'Mirap'. A half-crown packet will give enough foil to cover several chassis. Simply make the wooden chassis as described in the earlier chapter and then stick the metal foil all over the topside of it. It is quite simple to cut a piece of foil roughly to size for top and sides with a pair of sharp scissors, coat the chassis top and sides with liquid glue, lay the foil on it gently rubbing it flat and turning it down over the edges, snipping out the corners, as necessary, with the scissors. Trim away unrequired overlap and allow to dry. You will find it quicker and easier to cover it than reading here how it is done.

Mount the components on top of the chassis in the positions shown, and also those which are fixed below the chassis. The coil type D/R is mounted on the rear runner so that in this way the two coils have their axes at right angles. Note that in the mains version we do not use the reaction winding and ·0001 mfd. reaction capacitor. The higher efficiency of the mains valves provides adequate volume and sensitivity without reaction.

If you have purchased the cabinet kit with a metal chassis you will find there are three holes in the front runner which have to be used in some way otherwise the appearance of the set will be spoiled. Looking at the front of the set, the hole

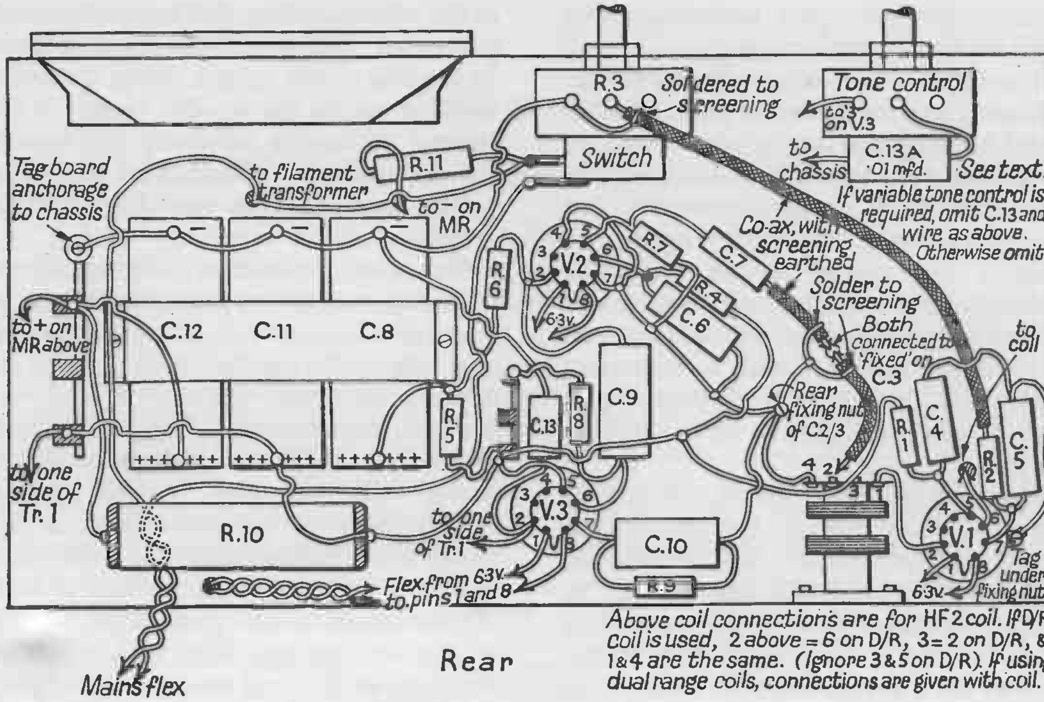


Fig. 25A **Underside of Chassis**

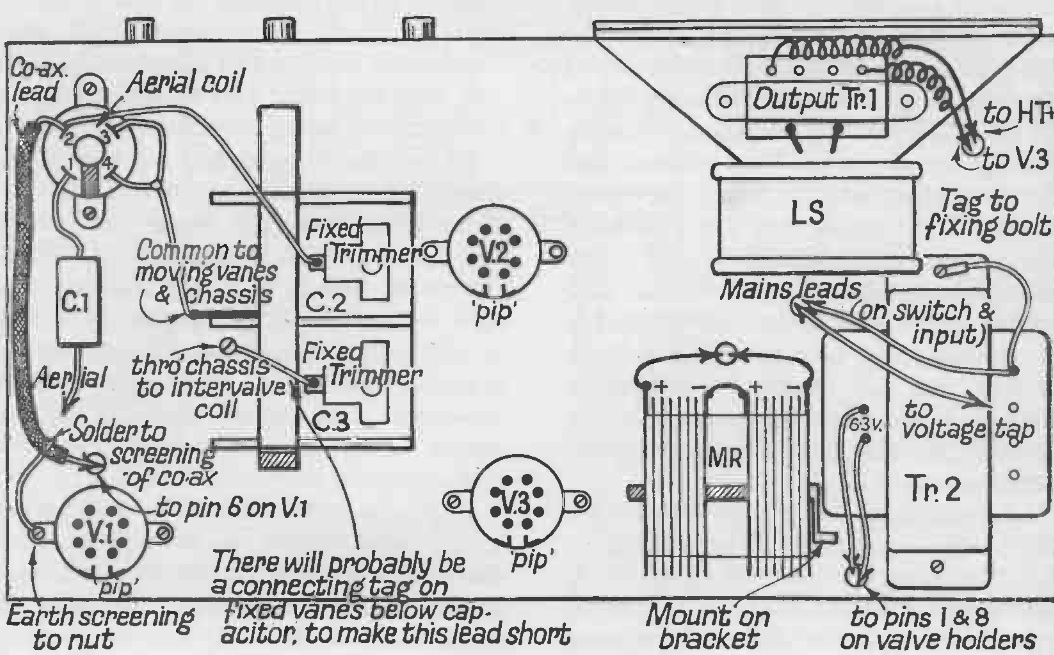


Fig. 25B **Top of Chassis**

on the right will be occupied by the tuning mechanism and the centre one by the volume-control plus switch combination. For the other there are two alternatives; you can either use dual-range coils type A/HF which give both medium and long waves, or you can have the variable tone control which is shown. The set as described is for medium wavebands only and it is my usual practice only to design and build sets for this waveband.

As I live in the Outer London area, I find that an excellent service is provided by the medium wave stations and I *never* use the long waveband. I know that in some areas of Britain it is difficult to receive the Light programme on other than the long waveband, and if this is normal where you live, it would be better for you to buy A/HF dual-range coils with a 2-pole-2-way wavechange switch. This switch will then occupy the spare hole and complete the three. The inset diagram shows the wiring for this. In my set, of which the main diagram shows the wiring, the coils are for medium waves only. I have used a variable tone control of which the wiring is shown. In my set I used a tuning mechanism which I had on hand and this made the tuning knob come in the centre instead of to one side. I have, therefore, placed the other two components on either side of it to make a symmetrical layout. This is a minor point, though, and you can do the same if you use a different dial mechanism.

Below the chassis it is advisable to anchor the large electrolytic capacitors to the chassis and not to trust to the wiring to hold them in place. Suitable clamps for this can be purchased for a few pence or can easily be made from odd scraps of metal. In my own case, it being a wooden chassis which I have used, I have simply held the electrolytics to it by a strip of wood placed across the four of them with a long screw at each end clamping them tightly in place. A rubber 'grommet' placed in each hole is a nice refinement with a metal chassis, where wires have to pass from the top of the chassis to the underside and also prevents the chafing of the wire against the edge of the metal with resultant damage to the insulation and consequent short-circuit. With the wooden chassis the grommets are not needed.

* * *

The small transformer on the top of the chassis supplies 6·3 volts for the heaters of the three valves. If the particular dial you use incorporated a dial light, the bulb for it can also be run off this supply. There is a dial light tapping at 4 volts on many transformers. On the HT side the metal rectifier is connected directly to one side of the mains, the other side of the mains being connected to chassis. After rectification, the metal rectifier delivers the positive voltage and the chassis is negative. As mentioned elsewhere the fact that the chassis is in direct contact with the mains makes care in handling the set essential and you must use a cabinet for it.

If you do not obtain a bakelite one, it is easy to make one up from odd pieces of wood and cover it with leatherette or decorative paper. If paper is used it should be varnished for protection. The question of cabinets, knobs, and grub screws for sets of this type was discussed in Chapter 7. Wiring-up must be done carefully; soldered joints with insulated connecting wire are essential.

When the set is completed check over again before inserting the valves. Incidentally, the loud-speaker may cause a little difficulty in mounting. With the metal chassis it is easy—there is a metal cut-out to which it must be bolted. On the wooden chassis it is necessary to make a bracket or brackets to mount it just at the edge of the chassis. When the chassis is inserted into the cabinet, the loud-speaker must gently touch the front of it. If you have made a cabinet with a rigid front you can, if you wish, bolt the loud-speaker to that and connect up two wires from it just before putting the chassis into the cabinet. However you do it the loud-speaker must not be allowed to vibrate or shake otherwise there will be a nasty buzz and rattle when the receiver is operated. Reverting now to the question of operation; after the valves are inserted the coils should be inspected and the cores arranged so that they are about central in the coil former, and in the same relative position in each coil. The trimmers on the top of the two-gang capacitor must each be open about half-way.

Now you must switch on the set and tune in, say, the Home programme at about the centre of the dial. With a proper trimming tool or a piece of rod sharpened to a chisel point gently move the cores of the top coil in and out to find a position of maximum volume. Little, if any, movement should be required, then turn to the two trimmers on top of the tuner and carefully adjust one trimmer at a time, trying it gently either way—in or out—until maximum volume is obtainable. Then tune in the Light or other programme at the lower end of the scale and just gently try the trimmers to see if any adjustment is required to them for best volume. What is required is to find a setting which is a compromise for the best volume from both Home and Light stations. It is best to carry out this trimming process with the volume at a fairly low level as this will enable you to detect alterations in volume fairly easily.

It is also necessary to do it with the chassis out of the cabinet so that care will have to be taken not to touch any 'live' parts or to touch the chassis. Some experimenters always keep one hand in a pocket when adjusting a working receiver, so that a shock cannot be obtained across the body from one hand to the other. It is good practice always to do this.

Another idea is to obtain a neon lamp or tester and touch it to the chassis when it is switched on; if it lights it means that the 'live' side of the mains is connected to the chassis. If the mains plug is reversed, or the wires on it reversed if it is a three pin type, the chassis will be connected to the neutral lead and safe enough to touch.

I still suggest that great care should be taken with it, however. A cardboard box could be arranged over the HT end of the receiver to avoid contact with it while you adjust the trimmers. I hope all these precautions do not alarm you as the danger, if adequate care is taken, is very small. I emphasize them to boys, however, to get you into the habit of taking care when handling electricity so that it becomes second nature to you.

Three or 4 feet of wire should be affixed permanently to the set to form the aerial. You can get adequate reception on this but if you need more aerial attach a longer length either permanently by soldering or by twisting the wires together for a temporary join. Do not omit the ·001 mfd. capacitor in the aerial lead—it is there as a safety precaution to isolate the aerial. An earth is not necessary and must not be connected to the chassis in any circumstances. I hope you have great success with this splendid little receiver. It is a very attractive and useful set and should give you much pleasure.

CHAPTER 11

A Simple High-Fidelity Amplifier

An amplifier is a standard piece of equipment for the Home Constructor. The Davey Amplifier is a high-fidelity job which can be built at very reasonable cost. The design is straightforward and absolutely safe in every way.

APART from its obvious use for reproduction of gramophone records with the aid of a 'Pick-up', an amplifier is a standard piece of equipment to which a detector stage or radio-frequency amplifier and detector may be attached to form a complete radio set. Radio 'fans' will have noticed that the low-frequency amplifying

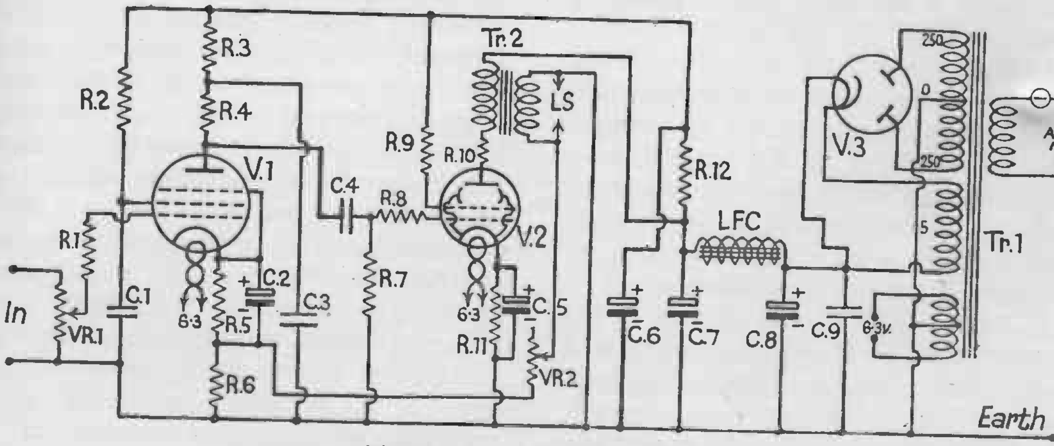


Fig. 26 A Simple Fidelity Amplifier

Components required:

RESISTORS:

V.R.1.	·5 megohm variable
R.1.	10,000 ohms (¼ watt)
R.2.	1 megohm (½ watt)
R.3.	5,000 ohms (½ watt)
R.4.	·25 megohm (½ watt)
R.5.	1,000 ohms (¼ watt)
R.6	100 ohms (¼ ,,)
R.7	·22 megohm (¼ ,,)
R.8.	10,000 ohms (¼ ,,)
R.9.	100 ohms (1 ,,)
R.10.	100 ohms (1 ,,)
R.11.	250 ohms (1 ,,)
R.12.	1,000 ohms (3 ,,)
V.R.2.	5,000 ohms variable

3 Octal valveholders
2 double socket-mounts
LFC. 10/30 henry LF choke to carry 100 m/amps.
Chassis } see text
Loud-speaker }

CAPACITORS:

C.1.	·1 mfd. fixed
C.2.	50 mfd. 25 volt electrolytic
C.3.	·5 mfd. fixed
C.4.	·1 mfd. fixed
C.5.	50 mfd. 25 volt electrolytic
C.6.	8 mfd. 350 ,, ,,
C.7.	8 mfd. 350 ,, ,,
C.8.	16 mfd. 450 ,, ,,
C.9.	·02 mfd. 450 volt fixed

VALVES:

V.1: 6J7G, V.2: 6V6G, V.3: 5Z4G

Tr.1: Mains transformer 250-0-250 volt. 5 volt 1 amp. 6·3 volt 2 amp.

Tr.2: Output transformer to match 6V6 valve and loud-speaker (but see text)

On-off switch (separate switch used to avoid running mains wiring among components)

Octal screened top-cap connector

Flex, wire, etc., knobs

sections of radio sets are nearly always the same—so one might have this section as a 'constant' and then add on other stages.

Since broadcasting began the aim of radio set designers and constructors has been to obtain fidelity of reproduction. At one time to do this required lots of HT volts, many big valves and possibly two or three loud-speakers. To-day, however, loud-speakers are extraordinarily good, and valves have improved so much that high volume and fidelity are obtained more easily.

* * *

Of recent years a further advance has been made by introducing 'negative feedback'. Briefly, part of the amplifier's output signal is fed back into it again 'in opposite phase' and this has the effect of reducing harmonic distortion, increasing efficiency of the output valve and straightening out the response curve. It is impossible to say more in the space I have available, but I would strongly advise those readers who are interested in the theory to read it up in a good textbook such as Scroggie's *Foundations of Wireless*.

In this amplifier I have decided to use 'negative feedback' and the result is a high-fidelity, economical piece of apparatus which can be built at reasonable cost. The design is perfectly straightforward and safe as all wiring is below the chassis.

Three valves in all are used. One, of course, is the rectifier for the HT voltage and the other two are the LF amplifier and output pentode. For the latter I have used the popular high-power output pentode, the 6V6, which, by the way, gives the large output of 4·25 watts. I have used it because it can be easily and cheaply obtained as an ex-government valve. The other two valves will probably be obtainable in this way.

If you look at the theoretical diagram you will see that a resistance network is inserted in the cathode circuit of the 6J7, and that a tapping is taken from it to one side of the low-resistance winding of the output transformer (that is the winding to which the speech-coil is connected) and the other side of that winding is taken to earth. This is effected by a flex lead which is taken direct to the output transformer. If your output transformer is separate from the loud-speaker you can mount it on the chassis and take your lead direct to it.

If it is mounted on the loud-speaker itself you will have to have a fairly long lead which you can connect to it. The best way would be to fix a 'crocodile clip' to each free end of the flex and you can easily clip one on each side of the low-resistance winding. If you do this the first time and get a loud howl it is because you are obtaining 'positive' instead of 'negative' feedback due to the leads being connected the wrong way round on the transformer. Change them over and all should be well.

The chassis size is 11 inches by 7½ inches but it may be either slightly smaller or larger than this size. This chassis will need to be cut out in the appropriate places for the three valveholders and the mains transformer. The electrolytic condenser will also require a fairly large hole. I have used one can-type electrolytic which requires such a hole and one double-type cardboard-cased condenser which is bolted to the chassis.

The type of electrolytic is not important. It is probable that the kind you buy will not require mounting on top of the chassis, in which case you will mount them below it with clips. Use single or double types.

All the electrolytics may be of the can-type if you wish, and if you use them you must drill two more holes for them just in front of the LF choke. Do not forget the holes which require to be drilled in the front of the chassis for the on-off switch and the volume control. At the sides you have to cut out small spaces for the socket panels and you will need two holes in suitable positions for the 'feedback' flex to the loud-speaker and for the mains lead. The hole for the latter should have a small rubber grommet to avoid chafing the flex.

Having mounted all the components, the wiring may now be easily and quickly carried out—general hints for doing this have been given elsewhere. The 5-volt winding is connected to the rectifier valve-holder with a small piece of flex and a similar piece runs from the 6·3-volt winding to the 6V6 valveholder. Between this valveholder and that for the 6J7 there is no need to use flex for the heater winding; ordinary wiring is used here. Note that a bare piece of thick wire is taken the length of the chassis from the earth terminal to the connecting bolt on the LS socket panel. This makes a very useful point to which most of the earth return connexions may conveniently be made.

Take particular care with the connexions to the 6V6 valve. The resistor used for auto-bias has the special value of 240 ohms, and the grid of the valve is joined to the junction of the coupling condenser and grid-leak (C4/R7). The R7 end of the grid-leak is connected to the adjacent earth wire.

The wiring diagram shows the output transformer mounted on the top of the chassis, but it can be on the speaker itself. This, as already mentioned, is unimportant; if you are buying both, I recommend buying a separate transformer and mounting it on the chassis. Buy as good a one as you can afford. The same applies to the loud-speaker. This amplifier deserves a really good reproducer; these are expensive but it is worthwhile to pay £5 or £6 for one such as the WB 'Stentorian' or Goodmans types.

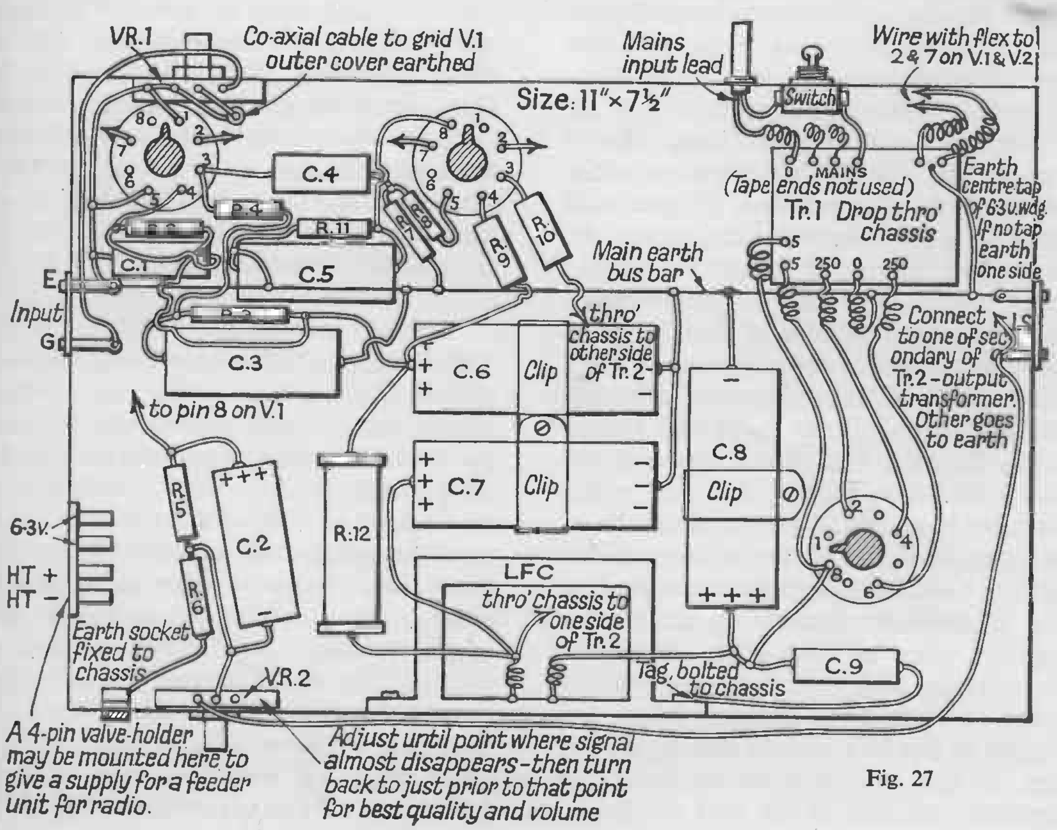


Fig. 27

CHAPTER 12

Building Receivers for Home Use

Sooner or later you will want to build a set for the lounge. Here is some really practical and sound advice, whether you aim at a Table Model or a Radiogram.

THIS is a brief chapter suggesting one or two methods of building a radio set of normal size for home use, either as a table model or as a radiogram. There are a number of cabinets available for both these types as the advertisements in the radio periodicals will show you. The same advertisements also indicate some useful record-playing units with three-speed control and, normally, crystal pick-ups. These can be incorporated in one of the larger cabinets to make a radiogram.

If this is your own particular idea, I suggest you should build the amplifier described in the previous chapter and make up a feeder-unit for the radio side. There are a number of designs for these in leaflet form, and with FM transmitters now covering so much of Britain, it is useful to get one of these units.

Denco of Clacton publish a kit design you can make up easily, as do Messrs Osmor Radio Products Ltd, 418 Brighton Road, South Croydon, Surrey. Teletron would probably have details of a simple medium-wave feeder if you prefer to keep to this band. A 6K7 variable-mu valve feeding into a germanium diode is all that is required. Any of these ideas should be adequate for really excellent high-quality reception from local stations unless you happen to live in a remote reception position. In that case, you should build the superhet described in the next chapter.

So much depends on the loud-speaker for the best reproduction and if you are going in for high-fidelity you must be prepared to spend a few pounds on a good one. Most speakers to-day need some sort of 'reflex cabinet' for best results and one of these can be more expensive to buy, at times, than the speaker itself. However, they are quite easy to make if you are handy with a saw and hammer. Details often appear in the radio periodicals. There are at least two loud-speaker manufacturers who publish details of cabinets to match their own speakers and these are Goodmans and Whiteley. If you buy one of their speakers you will no doubt obtain these details from them.

* * *

If you buy a table-top cabinet you lose a little of the extreme bass that a reflex cabinet can give you but will still get very good results. Make sure there is room in the cabinet for both your amplifier and feeder unit. In most of the cabinets of this type the speaker is mounted above the chassis and it may be that your cabinet is a little too small to accommodate the amplifier which is on a fairly large chassis. If this is the case, I suggest you build the chassis shown in Chapter 10. This unit is extremely sensitive and powerful, and will easily drive an 8-inch or even 10-inch speaker, but if you are restricted for space make up the 8-inch. This, with the chassis suggested, will give a very satisfactory result, with volume and, especially, quality, rather better than with the 5-inch speaker specified for the midget portable. When purchasing components, simply omit the 5-inch speaker specified, and obtain the larger one of whatever size is needed. Also buy an output transformer of larger size than the specified midget component. Mount the loud-speaker over the cut-out space for it in the cabinet you have, and the output transformer can then be fixed to the chassis at about the spot where the speaker would have been fixed in the midget set. Keep the iron core of the output transformer at right angles to that of the filament transformer. The two secondary terminals can then be connected to the speech coil terminals on the loud-speaker with two pieces of flex.

This particular set, you will see from Fig. 22, has a metal rectifier connected direct to one side of the mains and you should carefully note the precautions referred to in the text regarding this set. If by any chance you live in one of the few remaining direct current (DC) areas still left in Britain, you will not require either a transformer or a rectifier and can use an AC/DC or 'Universal' design.

These sets are made to operate with a resistor in circuit to drop the mains voltage to that required by the valve heaters, instead of using a transformer, as in our design. A metal rectifier is incorporated in them (but does not function on DC) so that the set may be used equally well on AC mains should its owner move to an AC district or the current be changed. If you require an AC/DC design, I suggest you study the radio periodicals closely for an advertisement for a kit of parts for such a receiver and purchase that. The need for sets for use on DC to-day is so relatively small that I do not feel that the inclusion of a special design in this book is warranted. For AC use only I think the design given is the better by far as it avoids entirely troubles caused by dissipation of heat or breakdown of the dropping resistor.

* * *

A very good and economical high-quality receiver can be built up by anyone living in the service area of a BBC station by using the quality amplifier described in the last chapter and feeding it on the radio side by the selective crystal receiver shown in Chapter 2. There is no doubt that in an area of sufficiently good reception to work this scheme the single-tuned circuit crystal set would not be selective enough, but you can try it if you have one at hand. Pass the output from the crystal set into the amplifier, making sure the leads are the correct way round, that is to say the lead connected to the earth side of the crystal set must go to the earth side of the amplifier. The lead from the diode goes to the grid side of the amplifier.

At a distance of seven miles from the BBC Brookmans Park transmitters, I use, at my own home, a combination of this nature with more than adequate volume and beautiful quality.

My next design is the largest set in this book and is a simple all-mains superhet receiver which will give results equal to any similar commercial receiver on the market and yet is cheap to build and very economical to run.

CHAPTER 13

Five-valve Supersonic Heterodyne Receiver

All the Davey designs so far described are 'straight sets'. Here is the only Mains 'Superhet' design in the book. It is a Five-Valve Set of fine performance, although construction is by no means difficult. Wiring-up is simple but keep it really short.

At the beginning of *Fun With Radio* I pointed out that it is not strictly a technical textbook, and that these designs are presented in the assumption that you have enough elementary technical knowledge to understand radio diagrams. The diagrams and details I have given are sufficiently clear to enable anyone who can handle a soldering iron to make up the set of his choice.

A slight technical digression is necessary here, for we are passing from 'straight receivers' to the 'supersonic heterodyne' types, or 'superhets'. All the designs so far except for the four-valve portable have been 'straight sets'. This five-valve set is the only mains 'superhet' in the book.

The 'straight receiver' receives signals from the aerial which are tuned in each according to its wavelength, or, more correctly, the *frequency* at which it is sent out by the transmitter. These signals are amplified by the high-frequency amplifier, and rectified by the rectifier, or detector.

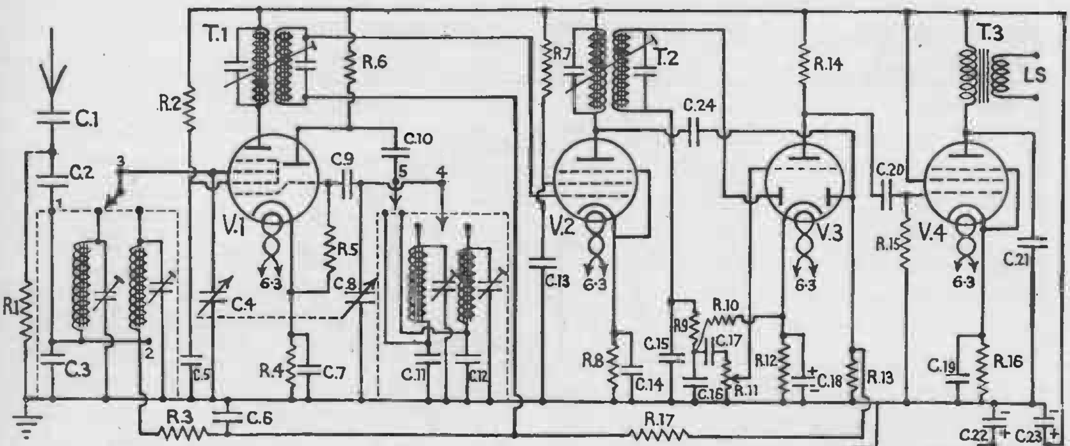
In the three-valve midget receiver the first valve, the EF 41, is the high-frequency amplifier whilst the EF 40 is the detector. In cases of 'straight' sets the signal which reaches the detector is at 'signal frequency'—*the actual frequency at which the signal is being transmitted and received.*

In the case of the superheterodyne receiver the signal is received by the aerial at signal frequency, and passed into the first valve which, in this design, is a 6K8 mixer valve. This valve is really two interconnected valves of special design in one envelope, and if you study its theoretical symbol, you will see that on the left it has a hexode (rather like an HF pentode with an extra electrode) and on the right a triode section.

The triode portion of the valve is connected as an oscillator and adjusted in such a way that it heterodynes the signal frequency, passing through the hexode from the aerial, and produces at the anode of the hexode a fixed frequency (irrespective of what the signal frequency may be) which is generally 465 kilocycles.

This is called the intermediate frequency (IF) and the coils and tuned circuits of both aerial and oscillator sides of the valve are so adjusted that whatever the frequency of the signal tuned in, the intermediate frequency appearing on the 6K8 anode is always 465 kilocycles. *It is this adjustment which makes the superhet difficult for the inexperienced constructor to get going properly without the use of meters or signal generators.*

However, in my design I have used coils and IF transformers which the makers have pre-adjusted to match each other so that, provided the wiring is kept short and direct, the set should operate at once. The present design is one of the simplest forms of superhet in that the signal from the



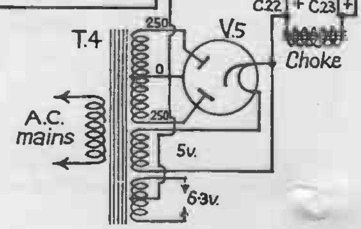


Fig. 28 Supersonic Heterodyne Receiver

Components required:

CAPACITORS:
C.1, C.2, C.17, C.20—·01 mfd.
C.4, C.8—·0005 mfd. variable.
C.5, C.7, C.6, C.13, C.14—·1 mfd.
C.9, 100 pfd.
C.10, 150 pfd. C.24, 100 pfd.
C.15, C.16, 100 pfd.
C.18, 25 mfd. 25 volt electrolytic
C.19, 50 mfd. 25 volt electrolytic
C.21, ·005 mfd.
C.22, 8 mfd. 350 volt electrolytic
C.23, 16 mfd. „ „ „
C.3, C.11, C.12, and unmarked trimmers all in coil-pack
V.1, 6K8; V.2, 6K7, 697; V.4, 6V6; V.5, 5Z4
Coils = Osmor B.2 (L and M Coilpack), pre-aligned
T1 and T2 = Osmor 465K/C I.F. transformers, pre-aligned
T3 = Output transformer to match LS & 6V6
T4 = Mains transformer, 250-0-250 volt, 5 volt and 6·3 volt, 2 amp.
LF Choke: 10-30 henries
Loud-speaker (8 in. or 10 in.) (with output Trans. T.3 attd.): Chassis: 5 Octal valve-holders, wire etc., Dial assembly

RESISTORS:
R.1, 10 k.
R.2, R.6, R.7, R.5, R.9, 47 k
R.3, 100 k.
R.4, 300 ohms
R.8, 300 ohms
R.10, 1 meg.
R.11, ·5 meg. variable (with switch)
R.12, 3 k.
R.13, R.17, 1 meg.
R.14, ·25 meg.
R.15, ·5 meg.
R.16, 240 ohms.

Coils can be obtained from Osmor Radio Products Ltd, S. Croydon, Surrey; pre-alignment must be requested. Osmor can supply chassis and many other components.

aerial is fed straight into the 6K8 mixer valve. In some the signal is amplified at signal frequency by one or two high-frequency stages before conversion into the IF by the frequency-changer valve.

These signal frequency circuits have to be tuned, and their initial adjustment can be very complicated. The actual building of a superhet as described here is very straightforward as the valves follow each other in logical sequence round the chassis. This must be prepared first and there is no objection to a wooden one covered with foil, if preferred. The holes for the valve-holders *must* be drilled out and if you use a metal chassis the proper chassis-cutting tool would be a useful acquisition. Otherwise you can probably arrange for the retailer to drill it to your specification.

The wooden one is cut out easily with a fretsaw, or by drilling round the edges of the holes with a hand drill, knocking out the centre-pieces and cleaning up the edges with a file or sandpaper. If you fit the

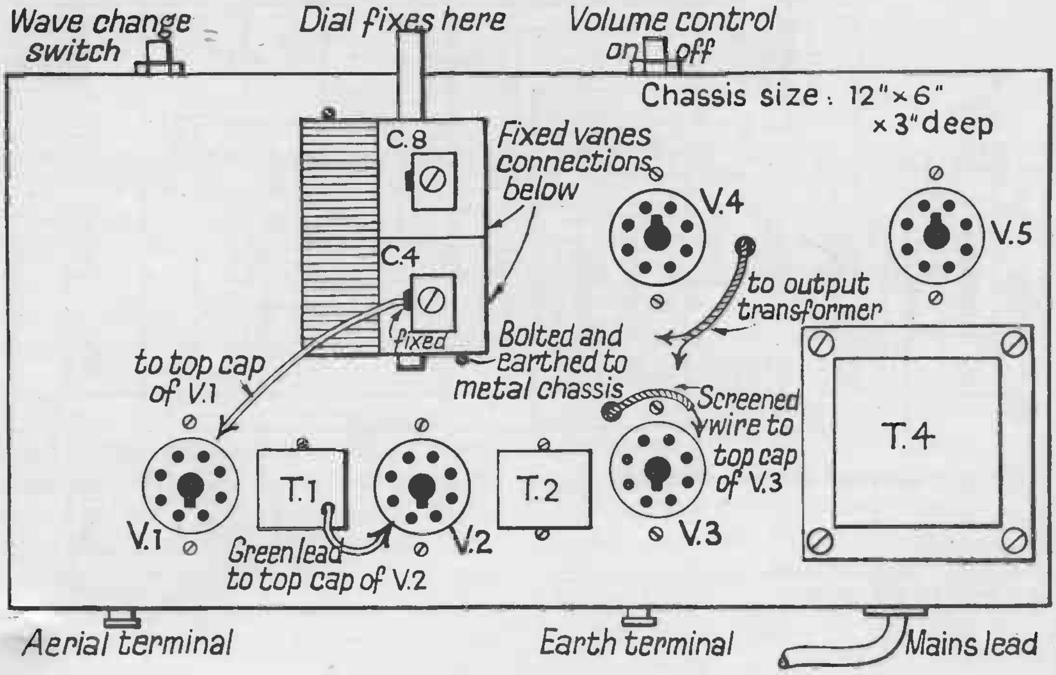


Fig. 29A Superhet Wiring. Top of Chassis

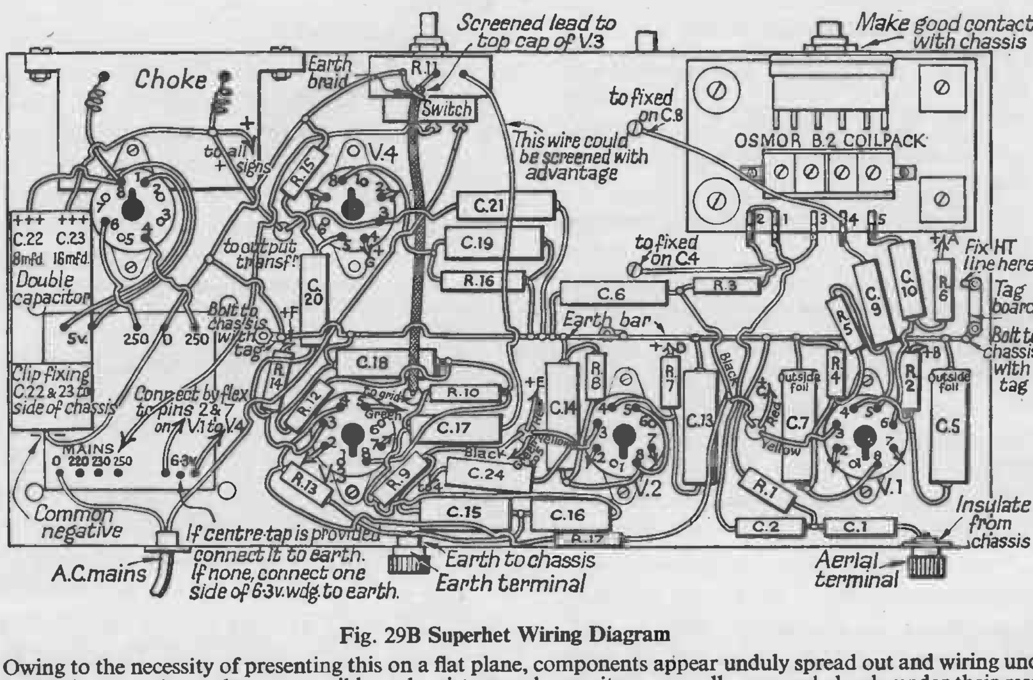


Fig. 29B Superhet Wiring Diagram

Owing to the necessity of presenting this on a flat plane, components appear unduly spread out and wiring unduly long. Wiring must be as short as possible and resistors and capacitors generally grouped closely under their respective valveholders. An HT positive busbar must be run across the chassis from choke to tag-board at the other end of the chassis. All components marked + (from 'A' to 'G') must be connected to it. It should be insulated wire.

valveholders over the top of the holes the edges, if untidy, will not show. Normally, where holes are specially cut for them in a metal chassis, valveholders are fitted below the chassis. The valveholders and mains transformer can be fitted on top with the variable capacitor and IF transformers.

Below the chassis on the front runner is fitted the volume control which combines the switch with it. The dial assembly can be fitted last so as to avoid any damage to it. Symmetrically on the other side of the front runner from the volume control the coil-pack is fixed, and beneath the chassis the only large items requiring to be anchored are the electrolytic capacitors. I have assumed that the output transformer is purchased already fixed to the speaker.

All that remains to be done now is the wiring-up. The first job to do then is to fix the earth 'busbar' of thick plain tinned copper wire which goes round the set. All connexions to earth go to this, rather than to the chassis, and this avoids any chance of instability being set up by HF currents running around the chassis. A similar 'busbar' is run round the set on the HT side. HT to the various valves is thus fed through the various decoupling resistors.

Some set builders like to put all resistors and capacitors on little tag-boards which are fixed around the chassis and from which connexions are made to the various valves and other components as required. I think this method allows too much stray wiring and I prefer direct connexion of the smaller components between the two 'busbars' and their other associated parts.

Wiring is simple enough and I advise you to keep it short and avoid short-circuits between adjacent wires. Use insulated connecting wire or tinned copper wire with insulated sleeving. Do make really good soldered joints and after wiring, check all connexions very carefully.

Once you are satisfied that the set is in order it may be plugged into the power and the switch operated. Turn to medium waves (the coil pack tunes to medium and long wavebands) and tune to the BBC Light Programme. If your dial is one marked in stations you should hear this programme easily at the correct spot.

The medium wave trimmers may be adjusted very gently for maximum volume and if the stations are well off the markings on a marked dial the core of the aerial coil may be adjusted gently. On an unmarked dial this is not so important. Do not, however, go over the set moving or adjusting any other cores or trimmers. Again, when tuned to the long waves, the two trimmers may be tried gently for maximum volume and the aerial coil core, if need be, to move to the correct dial marking. *On either band, I emphasize you must not touch anything but the two trimmers and, maybe, the aerial cores. All these must be treated very gently.*

The makers of the coils are, like most manufacturers of products for the home radio constructor, very helpful to you. If you have trouble with the tuning coils or IF transformers, write to Messrs Osmor Radio Products Ltd, 418 Brighton Road, South Croydon, Surrey. (They are not the only makers whose pre-aligned coil-packs are available, but I recommend them.)

Make sure that the pack is pre-aligned and buy the same maker's IF transformers so that all the items match each other. The Osmor pack I used does not embody Short Waves as it is essential to employ apparatus to align it properly. If you have this, and can use it, there is no reason why you should not use the Three-Wave Coil-Pack. Short Waves are a special branch of Radio Construction and the next chapter tells you something about them.

CHAPTER 14

Short Waves and Short-Wave Sets

Short Waves can only be described as 'thrilling'. A One-Valve Battery Set which will bring in North America, Africa and Australia is very attractive, especially when it is easy and cheap to build. After building this set your ambition will be to own your own transmitter!

By now you have a good deal of experience of how receivers work on the medium-wave and long-wave bands and can extend your activities into the most interesting sphere of Short Waves. I can only touch the fringe of Short-Wave work here as it needs a book to itself, which I hope to write as a sequel to *Fun With Radio*.

You may have observed that on Medium Waves you can receive longer distances at night after darkness has fallen. This is due to layers of electrical conducting material which are formed by the ionizing action of the sun on the gases which exist in the earth's outer atmosphere. Variation of the effect of these invisible layers occurs according to whether it is day or night, or what the season of the year is, or it may even depend on the sunspots on the surface of the sun itself.

You may have read from time to time of the effect these have on the Short-Wave radio telephones of the world. These layers, called the E and F layers, or more popularly the Heaviside and Appleton layers, reflect to a greater or lesser degree the radio signals transmitted on the earth. These degrees of reflection vary according to the wavelength of the transmission, being negligible at long waves, variable at medium waves, important and useful at short waves, and again of no use at very short or VHF wavelengths.

We can, therefore, on short waves utilize the reflecting powers of the E and F layers to enable us to send Short-Wave transmissions all round the world. By varying

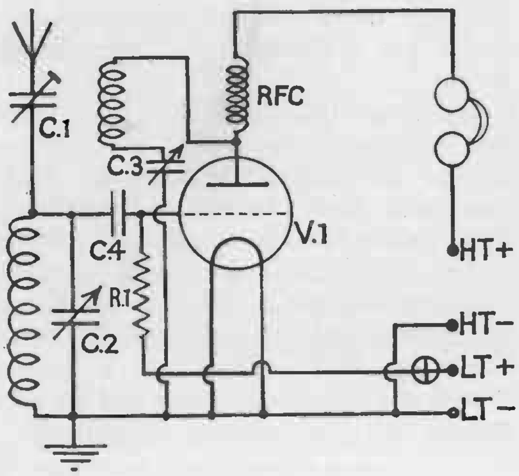


Fig. 30 One-Valve Short-Wave Set
Theoretical Diagram

C.1. 30 pfd. trimmer.
C.2. ·00014 mfd. variable short-wave capacitor
C.3. ·0001 mfd. variable reaction capacitor
C.4. ·0001 mfd. fixed mica capacitor
R.1 3 megohm grid-leak
RFC Short-wave high-frequency choke
V.1. HL2K Valve (Osram) or other similar 2-volt valve
Headphones, batteries, terminals, on-off switch, slow-motion dial, knob, valveholder (4 pin—preferably ceramic)

Coils—plug-in types are used; three types are available—Raymart, Denco and Eddystone. Obtain base to match coil and wire it up accordingly. Denco and Eddystone have coupling winding for aerial which may be brought into use.

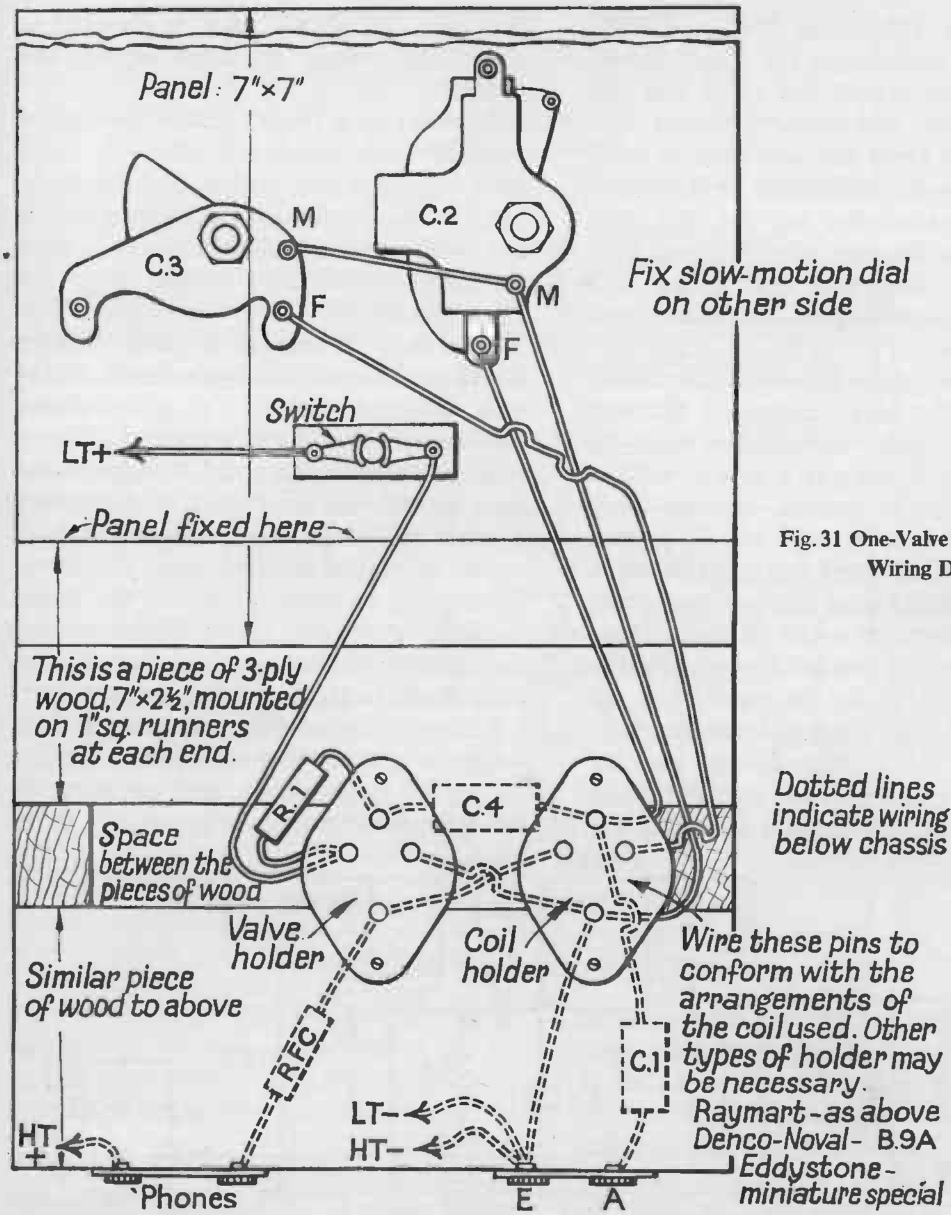


Fig. 31 One-Valve Short-Wave Set. Wiring Diagram

the wavelength in use according to the time of year and time of day we can maintain a constant coverage of the world's surface. This is why, when you operate a Short Wave set, you must choose the band on which you propose to listen according to the factors mentioned above. It is often likely that the Short Waves will be 'dead', careful listening bringing in no stations at all. A few hours later it can be quite different and all the countries in the world seem to come pouring into the receiver!

That is the fascination of Short Waves, the mere fact that a simple One-Valve Battery Set can bring in stations from North America, Africa, or even Australia at as loud a volume as the local BBC station. The first design for Short Waves is a One-Valve Battery Set which you can build very easily and cheaply. Plug-in coils are used and these are available in such brands as Denco, Eddystone or Raymart. I used Raymart coils, and the coil connexions in my diagram refer to them. You will have to vary your coil holder and connexions according to the brand you decide to use.

The set is run from a 2-volt accumulator and this is the best method of filament heating for 2-volt valves when used on Short Waves. It ensures a steady voltage free from crackles due to running-down batteries. HT from a small 45-volt battery is adequate. This small but effective set is easily built, and I used two runners raised up on two pieces of wood. Between these runners I fixed the two holders, one for the coil and the other for the valve. A small panel on the front carries the two capacitors and the switch. Wire up and your set is complete. One important item for Short Wave sets is a slow-motion dial. Buy the best you can afford, as it is essential to move the tuning capacitor slowly and gently.

My next set is similar to this one but has another valve which will give you just a little bit more and enables stations to be put on the loud-speaker. Incidentally, it can, with suitable coils, be made to operate on all wave-bands, so we call it an *All-Wave Receiver*.

This is a design for a radio receiver which can be used on all wavebands, and so it is designed primarily as a short-wave receiver and adapted by the use of different coils for working on the broadcast and long waves. The chief point to emphasize again is that in making a receiver for short waves all wiring must be short and direct from point to point. If this is not done, 'capacity' and other losses will be caused, the receiver will not oscillate, and will not tune down to the short wavelengths.

I have designed the receiver as a two-valver because in that way it can be made simple for the beginner, and yet be versatile enough for experimenting with by those

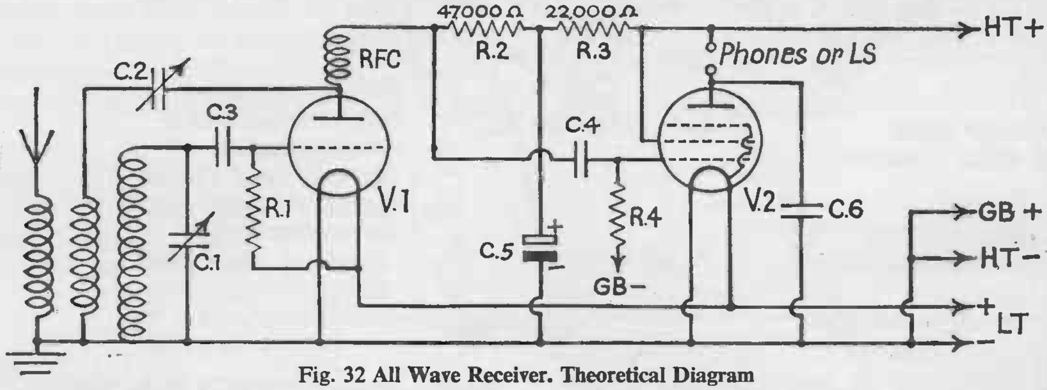


Fig. 32 All Wave Receiver. Theoretical Diagram

Components required:
C.1. ·00014 variable short-wave capacitor
C.2. ·00015 variable reaction capacitor
C.3. ·0001 mfd. fixed mica capacitor
C.4. ·01 mfd. fixed capacitor
C.5. 8 mfd. 200 volt working electrolytic capacitor
C.6. ·002 mfd. fixed capacitor
R.1. 3 megohm grid-leak
R.2. 47,000 ohm resistor ½ watt
R.3. 22,000 „ „ „
R.4. ·5 megohm „ ¼ „
V.1. HL2K valve } or equivalents
V.2. PM22A valve } or equivalents
RFC. All wave R.F. choke
2 valveholders—1-4 pin, 1-5 pin, 4 pin preferably Ceramic
1 Eddystone No. 707 4 pin, short-wave coil socket
Eddystone 706 plug-in coils (pink = medium-wave, Brown = long-wave, Blue-red-yellow-white = short-waves). Equivalent in Denco, Raymart or other makes
Batteries, plugs, chassis, phones or LS etc.

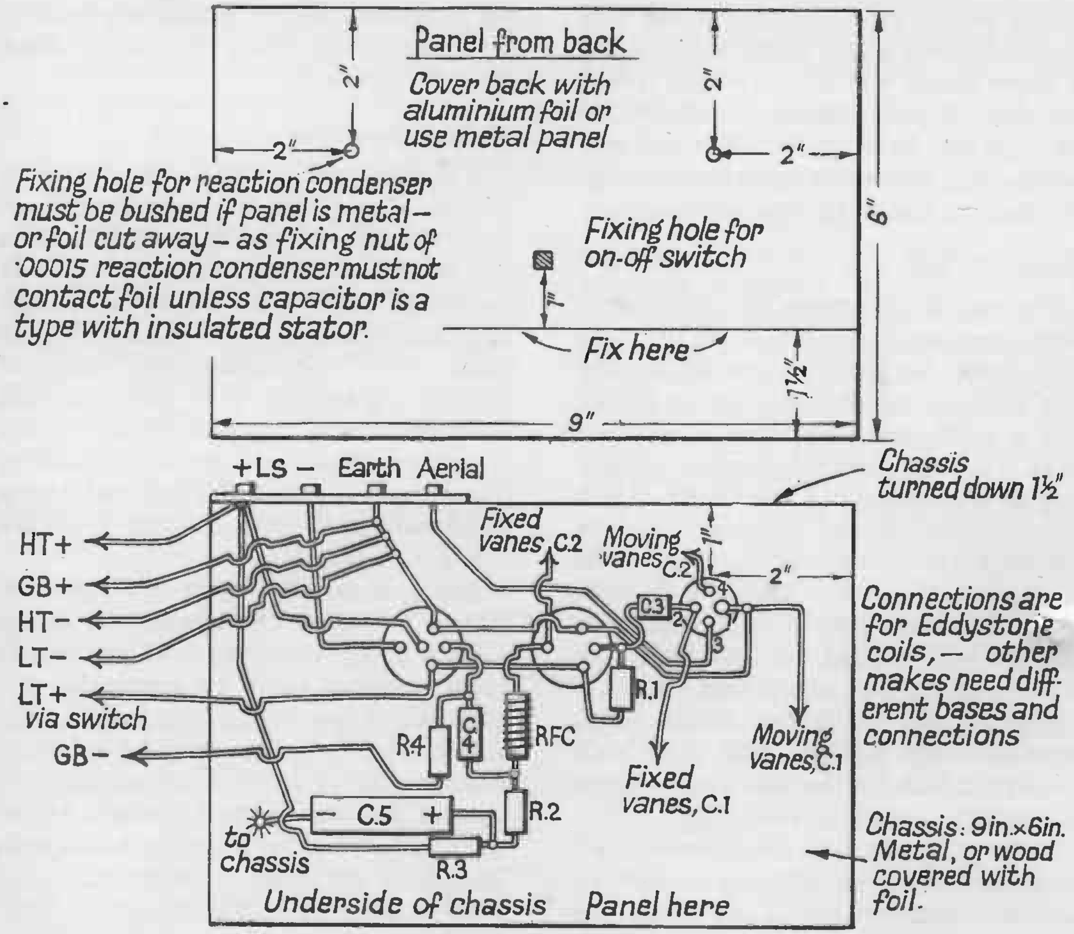


Fig. 33 All-Wave Receiver. Wiring Diagram

who have more experience. Also, it is inexpensive to build, economical in its current requirements, and the components are easily obtainable at any local radio shop.

The theoretical circuit diagram has been drawn for you in Fig. 32. The wiring diagrams are of the battery set only, as the mains set would have exactly the same layout, and those readers who are sufficiently advanced to try all-mains working, should find it quite easy to wire up and add the additional components from the details given in the theoretical diagram.

A compromise has been made between panel and baseboard and chassis construction. A panel is used but the baseboard is raised about 3 inches by means of a runner at the rear. The necessary holes for valve-holders and coil holders are cut with a pad-saw or fret-saw. If you have neither of these you can make large holes quite successfully by marking the circles you wish to remove and then drilling a series of holes all round them. You then remove the centre piece by knocking it out with a light hammer and finish by cleaning up with a file or sandpaper.

The baseboard is covered with copper or aluminium foil or thin sheet metal. If you cannot obtain these, a piece of the very close-mesh wire gauze which is obtainable at some stores will do very well. Make sure that adequate clearance is obtained at the holes you have cut for valves and coil-holders, and also where wires pass through the baseboard, so as to avoid short circuits.

Choice of Coils

The only items among the components which need especial mention are the coils. I have used the four-pin type which plug into ordinary valveholders, and a similar type is sold under the name of Raymart RD4. You can, however, use any suitable type of short-wave coil obtainable. There are, I believe, six-pin patterns (made by Eddystone) and octal-base (eight-pin) types or you could use the Denco coils with rather a different type of base. Whichever you use will depend on the amount of money you have to spend, and the availability in your particular district. You must take care, however, that you obtain the correct base for the coils you purchase and that you wire it up correctly.

Take particular note that the wiring I have shown in the diagram is for the particular four-pin coils I am using. The four-pin coils you obtain may need different connexions, and, of course, six-pin or other type bases will have to be wired according to the directions given with them. If there is no diagram sold with the coils, ask the shop at which you buy them to let you have the details. Incidentally, these short-wave coils cost about 4s. each, and probably four will be required to cover the short-wave bands, and another one for each of the medium- and long-wave bands. It is not necessary to buy them all at once—you may prefer to buy one from time to time as your pocket money permits. The coils are the most important part of the set and if you get into difficulties over them write to us c/o the publishers and we will do our best to help you obtain them, or even to make them for yourself.

Making Your Own Coils

It is quite probable that you will not be able to obtain broadcast and long-wave-band coils in the type you require. If so you must make them for yourselves, and the easiest way to do this is to buy midget coils and wire them up to the appropriate bases. You will require two bases of correct pin-spacing (for 'four-pin' old valve-bases will do) and these, if you cannot purchase them, are easily made by mounting coil pins (Clix, 4d. each) on a small piece of bakelite, ebonite, or similar insulating material.

Buy two coils (such as Wearite PHF Range 7, 250 to 750 metres, and Range 1700 to 2000 metres, 3s. each) and mount these on your bases by connecting the appropriate points on the coil to the correct pins on your bases by soldering with lengths of stiff (16 s.w.g.) wire. So long as you use stiff wire the coils will be quite firm and self-supporting. As the coils mentioned are made for ·0005 mfd. variable condensers, with the ·0001 mfd. condenser specified the range may be restricted, and you should obtain, if you can, coils designed for this size condenser.

'Wandering' Aerial Lead

The lead from the aerial terminal is a piece of thin flex which terminates in a 'crocodile' clip. This is clipped on to the bared wire of the coil about a third of the way up from the 'earthed' end of the winding. If your coils have insulated wire windings you will have to bare a small section (scraping with a penknife is probably the best way). If the windings are bare wire you must be careful that the clip does not touch two or three turns and so short-circuit them.

As the tuning condenser must be turned very slowly on short waves it is essential to have a good slow-motion dial. These are usually expensive items but it should be possible to find one, perhaps of older pattern or ex-Government, which would be suitable. Do not forget that the dial must be of correct size to fit the spindle of the variable condenser you are using. The reaction condenser does not need a slow-motion dial, but it is an added aid to careful handling of this control, which must be brought carefully up to oscillation point and held there as the tuning dial is slowly rotated. You will soon find the knack of using the receiver and must not be disappointed if you cannot at first find any short-wave stations. Short-wave conditions are very variable and change almost from hour to hour, but once you have mastered the art of handling the set, and given good conditions, the stations should roll in.

An Additional Valve

You can make this into a three-valve set later, if you wish, by adding another LF stage of exactly the same pattern as the present one. There is room on the baseboard for it. The pentode output valve would move up into the third position remaining as output valve, and an HL2 valve would be required for the middle position.

If you build this as a mains receiver, take especial care with the wiring-up and connexions. Remember you must NOT use

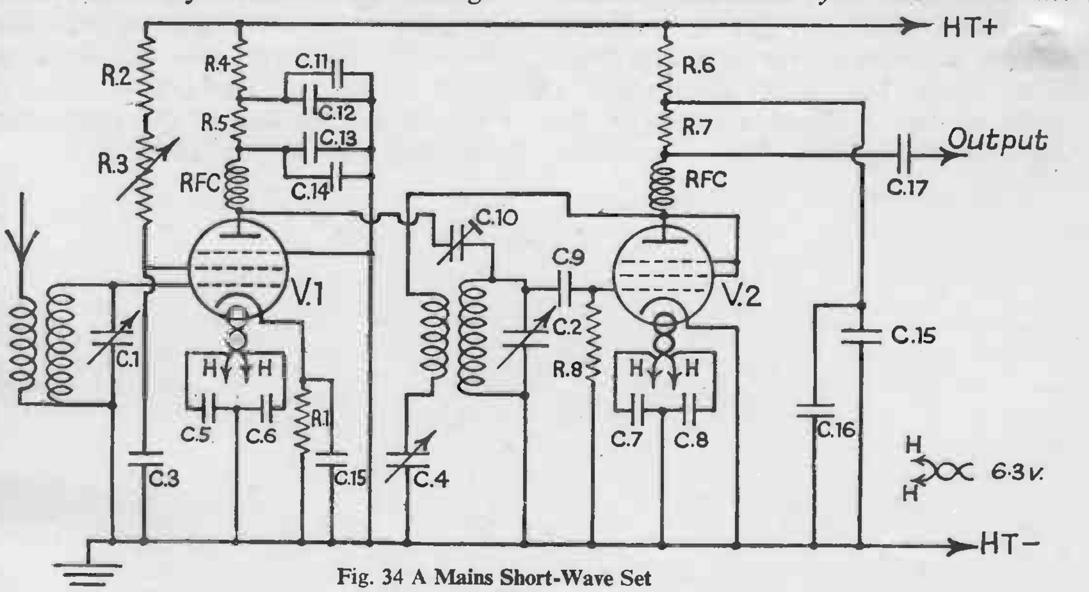


Fig. 34 A Mains Short-Wave Set

C.1, C.2. ·00015 variable two-gang capacitor
Bandspread Capacitor 15/20 mmfd. may be fitted across C.2
C.5, C.6, C.7, C.8. ·001 mfd. decoupling capacitor
C.3. ·1 mfd. decoupling capacitor
C.4 ·0001 mfd. reaction variable capacitor
C.9 ·0001 mfd. grid condenser.
C.10. 30 mmfd. trimmer.
C.11, C.14, C.16, ·001 mfd. decoupling capacitor
C.12, C.13.·1 mfd. decoupling capacitor
C.15. 8 „ „ „
C.17. ·01 „ output capacitor

R.1. 33 to 150 ohms
R.2. 47,000 ohms
R.3. 50,000 „
R.4. 10,000 „
R.5. 10,000 „
R.6. 22,000 „
R.7. 47 kilo-ohms (47,000)
R.8. 2·2 megohms

Coils may be plug-in types by Eddystone, Denco or Raymart *headphones with a mains receiver without a transformer or choke-filter output.*

The last diagram is a theoretical one only of a RF plus detector Short-Wave design which can be used for feeding into an amplifier. If you have progressed sufficiently to the stage of making up sets such as this one you will have no difficulty in translating this diagram into a complete set.

As always in Short-Wave work the essentials are good-class components, first-class 'short-as-possible' wiring, and careful tuning.

If you want to know more about Short-Wave radio I suggest you write to the Radio Society of Great Britain at 28/30, Little Russell Street, London, WC1, and ask for literature. The Amateur Radio Handbook which the Society publishes cheaply is a mine of information on Short Wave topics. The Society also publish a leaflet entitled *A Simple Receiver for the Beginner* which deals with a four–five-valve superhet receiver for Short Waves which is a first-class design for the Short-Wave operator whether he wishes to listen to regular broadcasting stations, or transmissions on the amateur bands.

As for amateur bands, to own and operate his own Short-Wave transmitter is the aim of every boy who becomes a Short-Wave enthusiast. Listening, experimenting and study is the way to do this. No one may operate a Short-Wave transmitter in Britain until he has passed a stiff theoretical and practical examination in radio set by the Postmaster General. In addition, the ability to send and receive Morse Code at a minimum of 12 words per minute is required.

Your ambition may be to have your own transmitter, or to adopt radio as a career, or just to enjoy 'messing about' with radio receivers. We hope that this book has done something to start you on your way, and in the language of the transmitting amateur, we wish you '73's O M'.