FUN WITH RADIO

by Gilbert Davey
edited by Jack Cox
(EDITOR OF *BOY'S OWN PAPER*)

completely revised edition

FULLY ILLUSTRATED

This is a completely revised and up-to-date version of *Fun With Radio*, which was first published in 1957 and has been in constant demand ever since. It is a book of sound, modern, tested designs for 'home-made' radio sets, written in straightforward, simple language for the modern, practically minded boy—though it is in fact suitable for any age of radio enthusiast.

GILBERT DAVEY has been since 1946 the Radio Correspondent for *Boy's Own Paper*. Year after year he has headed that journal's 'Popularity Poll' of contributors, and the radio sets designed and printed in it rapidly go out of print. Some of the designs are explained here, with other new ones of many different kinds.

Fun With Radio exactly expresses the aim of the book, the putting of brain and hands to active use and purpose, and having fun at the same time. See how to make:

CRYSTAL SETS
A ONE-VALVE SET
A BATTERY TWO-VALVE RECEIVER
A THREE-VALVE RECEIVER FOR BEDSIDE OR CAMP
ALL-MAINS RECEIVERS
A MAINS HT UNIT
A MIDGET TWO-VALVE RECEIVER
A THREE-VALVE TRF RECEIVER
A SIMPLE HF AMPLIFIER
RECEIVERS FOR HOME USE
A FIVE-VALVE SUPERSONIC HETERODYNE RECEIVER
TRANSISTOR RECEIVERS

In this edition there is also a new chapter dealing with amplifiers and record players.

The designs are all planned on a progressive basis of difficulty, starting from the one for the simple crystal receiver which anyone can make; and there are many detailed diagrams and circuit drawings.

This is education the easy way, really learning with fun, whether it is in the classroom or at home, for anyone from age 12 upwards.

'Fills a long-felt need for a down-to-earth book for the radio-minded boy.'

The Times Literary Supplement

NEW EDITION

FUN WITH RADIO

by
GILBERT DAVEY

Edited by JACK COX
(Editor of *Boy's Own Paper*)

Fourth (completely revised) edition

ILLUSTRATED BY R. BARNARD WAY AND B. GERRY
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 B.B.C. and I.T.A. television programmes in which he showed viewers how to build various receivers, Gilbert Davey has worked only for *Boy's Own Paper*, and his record there has been quite outstanding. For many years he headed a Readers' Popularity Poll among regular contributors and his *B.O.P.* designs quickly go out of print. Some of them were reproduced for the first time in book form in this title in 1957, which was also Gilbert Davey's first published work. The series now includes *Fun with Short Waves*, *Fun with Electronics* and *Fun with Transistors*.

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 always been great fun for me to edit his work, both in *B.O.P.* and the excellent series of books (all published by Edmund Ward) which started with *Fun with Radio*.

1964 JACK COX

For the technically minded, and those studying electronics, the following are a selection of symbols and abbreviations used in this science:

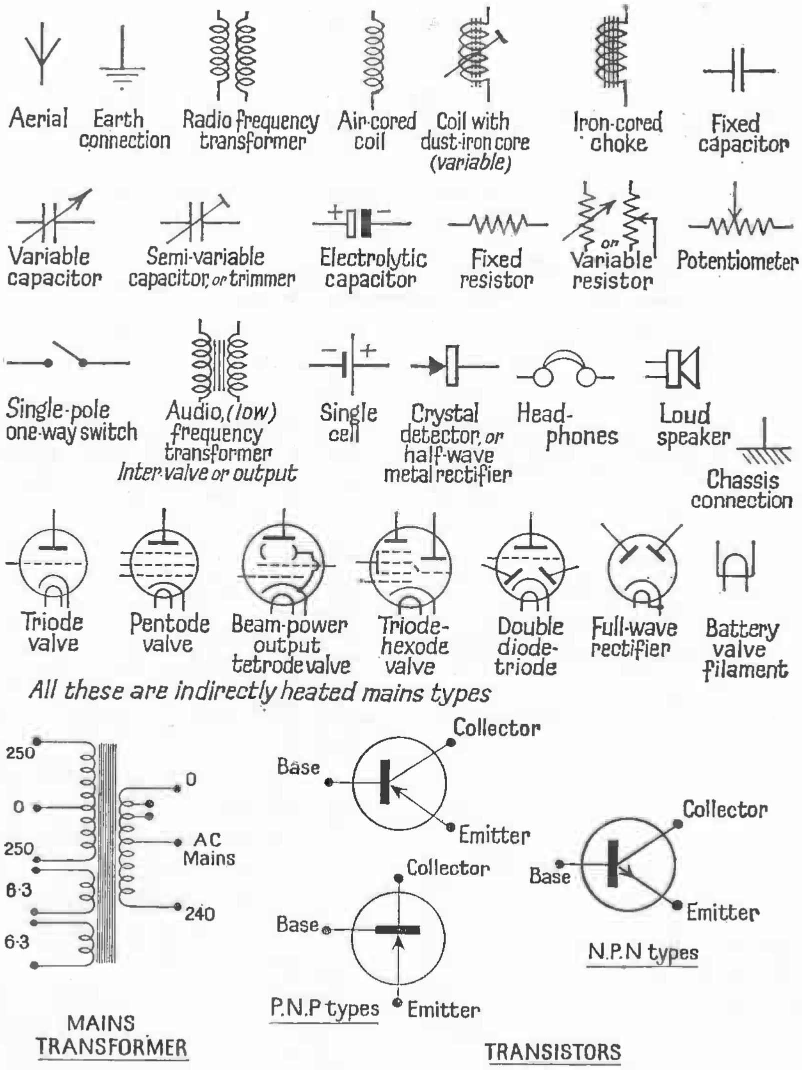


Fig. 1

Wavelength	= λ	metre	= m
Frequency	= f	cycle per second	= c/s
Voltage	= E	volt	= V
Current	= I	ampere	= A
Power	= P	watt	= W
Inductance	= L	henry	= H
Resistance	= R	ohm	= Ω
Impedance	= Z	farad	= F
Capacitance	= C		

Prefixes for Abbreviations

One million millionth = micromicro = $\mu\mu$ usually known as pico = p = $(\times 10^{-12})$

One millionth = micro = μ = $(\times 10^{-6})$

One thousandth = milli = m = $(\times 10^{-3})$

One thousand times = kilo = k = $(\times 10^{3})$

One million times = mega = M = $(\times 10^{6})$

Examples: megohm = MΩ; microfarad (mfd.) = μF; milliamp = mA

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.

THIS IS a completely revised and up-to-date version of *Fun with Radio* which was first published in 1957. Many of the designs in the book were reprints of designs which I had produced for *Boy's Own Paper* during the previous eleven years. That takes us back to the end of the Second World War when home-constructors were striving (with the help of 'war-surplus' valves and components) to overcome the necessary wartime restrictions and get going again.

As most of my readers will know, electronics during the past twenty years has become one of the important features in modern life, industrially, commercially and in the entertainment world. There is no doubt that the periodicals which cater for interested amateurs have done an enormous amount in assisting this advancement by informing them of developments, providing ideas for experiment and generally fostering the curiosity which every good radio amateur has about matters concerning his hobby. I like to think that the Editor of *B.O.P.* and I have helped also by providing for the young beginner advice and encouragement in the radio hobby by means of regular articles and supplements in *B.O.P.* and our radio books in the Edmund Ward series. The interest of readers all over the world has been a great encouragement to us and we are grateful to the many thousands who have expressed pleasure in the books and have made necessary a new version of *Fun with Radio.*

Broadcasting officially started in Britain on 14 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, usually of the crystal variety. In the first year the number of licence-holders reached about 200,000 and it was almost 1925 before the million figure was attained. How many 'unlicensed' listeners there were could not be computed! In 1957 the total of licence-holders was around the 12-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 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 set is a little more complicated and so they progress right through to a five-valve mains-driven superhet receiver. None of them is 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 often 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 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, too, useful correspondence courses, and also 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 used a lot of components which I had on hand, for every good experimenter keeps a 'junk box' of spare parts; but I have taken care to ensure that everything mentioned is available to the modern reader. Valves change, naturally, and I have made provision for differing types. Overseas, those available in the U.K. are often not obtainable. Coils are another difficulty, as most of those specified in earlier editions are out of production now. Unfortunately some manufacturers are no longer catering for the home-constructor market, but Repanco and Weymouth assure me that their designs which are suitable for use in various of our specifications should remain available for some years yet. Our old friends Osmor, also, are continuing production of suitable coils for the superhet in Chapter 13, but it is no longer possible to buy a 'coil-pack'.

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

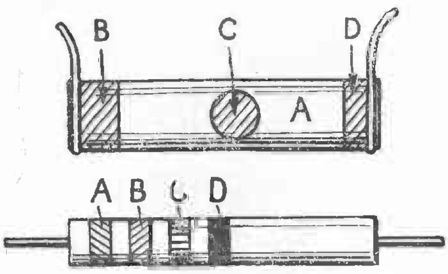


Fig. 2

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

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 such as I have used, firms like Webb's Radio, Stern-Clyne and Home Radio (addresses in Appendix) provide valuable assistance, though any of the advertisers in periodicals such as *Practical Wireless*, *Radio Constructor* or *Wireless World* will be helpful and they give good value for money.

Readers are well aware of the improved quality of reception which is obtainable from frequency-modulated transmissions (FM) and these are broadcast on very high frequency (VHF). Consequently, because of the difference in the type of transmission (those to which we are accustomed on the medium and long waves being amplitude-modulated), and of the lower wavebands used, a special receiver is necessary. I find many requests for such a design in my post, but have to disappoint enquirers, as there is no satisfactory simple design for such a set. FM receivers are superhets and need very careful adjustment and alignment to work properly.

There are some kits for home construction on the market, but very often the constructor is left to arrange his own alignment and without the knowledge and instruments required, this is really impossible. 'Hit-and-miss' methods are no good at all. For this reason I have suggested in the past that you should leave FM alone, but I have recently had the opportunity, thanks to Messrs Jason Electronic Designs Ltd, to make up one of their kits. This was their very successful FMT 1, which was their earliest and cheapest design and which is still a first-class production. It costs around £7 (1964 price) and is simple to construct, a booklet with full instructions and full-size photograph and diagram being supplied. What is of prime importance, however, is that there are no alignment troubles as, provided you make the set in accordance with the instructions and with the specified components, the receiver may be sent to Messrs Jason who will align it, test it and send it back in good working order. This is so very valuable to the younger constructor and I do recommend it to you if you are interested in making an FM receiver. Messrs Jason have been experts in the field for some years now and details of their various kits are given in a 'Data Publications' booklet, No. 12, called *FM Tuners for Manual Operation*, costing 2s. 6d.

This is an appropriate point at which to mention another subject that often crops up in my correspondence, and that is transmitting. The position here is that nobody is allowed to operate a transmitter until he has attained the age of fourteen years and has passed the G.P.O. examination and been allotted a licence to transmit. The examination is a theoretical one at about the City and Guilds standard and there is a Morse Code test in sending and receiving the code at not less than twelve words per minute. So you see that you require a good knowledge of radio, and the best way to obtain it is to study textbooks, experiment and build radio receivers.

Before you start to build, here is some advice on tools. You need two screwdrivers —one of 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 hack-saw, 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 B.B.C. 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. Today 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. A small flake of it is sealed into a tiny glass tube, with its cat's-whisker contact cemented permanently into place (Fig. 3).

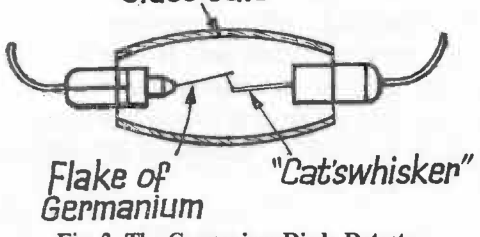


Fig. 3. The Germanium Diode Detector

A crystal set has no power to amplify 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.

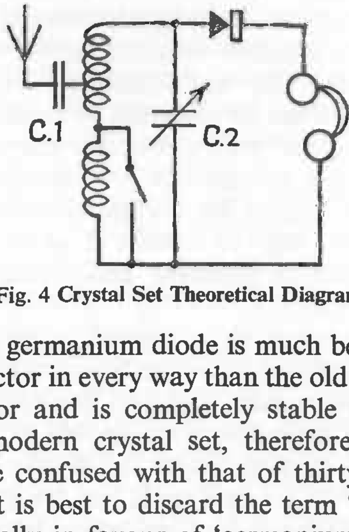


Fig. 4 Crystal Set Theoretical Diagram

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 the 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 B.B.C. (Brookmans Park) transmitters in North London, I can receive both the B.B.C. Home and Light services 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 B.B.C. 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 a more selective set.

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 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.

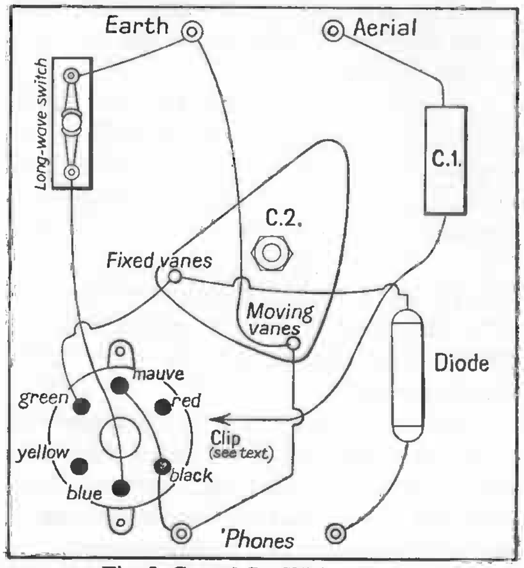


Fig. 5. **Crystal Set Wiring Diagram**

Components required:
·0005 mfd. solid dielectric variable capacitor (C.2)
On-off switch
DRR 2 coil (Repanco)
·0002-mfd. fixed capacitor (C.1.)
Germanium diode (Osram GEX 35 or Mullard OA 81)
4 terminals or 2 double mounts
Crocodile clip
Wood, wire, etc.
Tuning knob

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 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 unsolder 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 coil specified is a Repanco DRR 2 and is really a coil with a reaction winding which is normally used in a one-valve or two-valve receiver. I have specified it for the crystal set because, in accordance with our promise of progressive set-building, it can be used for the receivers described in Chapters 3 and 4. There is no objection to your using a crystal-set coil if you wish, such as the Teletron HAX (if available) or the Repanco DRX 1. In such cases you must wire up the coil in accordance with the details given with it. In the design as given, using the DRR 2 coil, the 'reaction' winding is wired up so that it may be used as an aperiodic aerial winding which will give you a variation in selectivity. For this reason the lead from the aerial (through C.1) terminates in a crocodile clip. This may be attached either to 'yellow' on the coil or 'red', in order to give the best position for the aerial in use. Try also fixing the diode to 'yellow' instead of to 'fixed vanes'.

The second crystal receiver is very cheap and simple to make and uses the *B.O.P.* coil which I made up for use in two transistor receivers I described in *Boy's Own Paper* in 1963. It is very easily wound on a ferrite rod which is 4 inches long and $\frac{1}{4}$ inch in diameter. At the end of this chapter I repeat the instructions which we gave in *B.O.P.* for winding it. The receiver in Fig. 6 can be put together easily in any handy box and will tune medium waves only, so that if you must get your Light

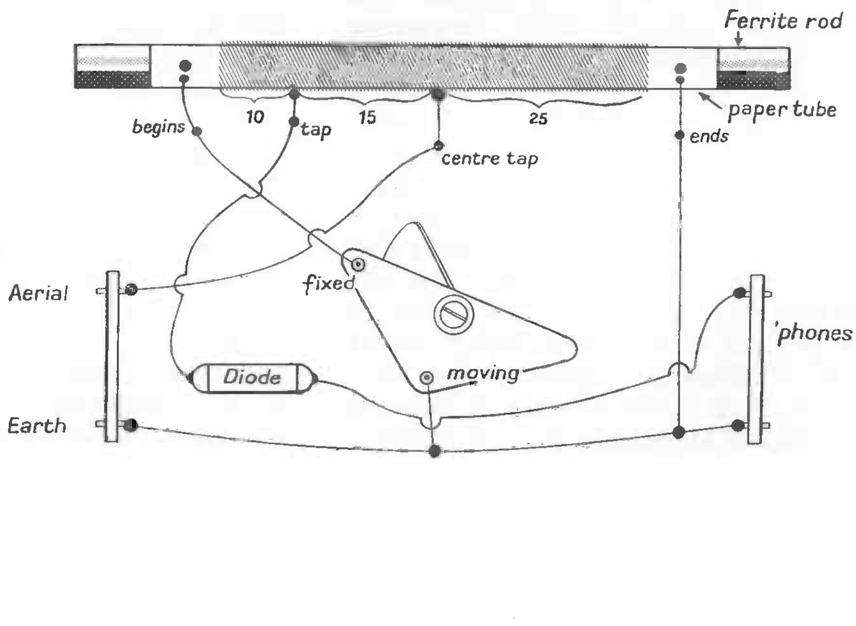


Fig. 6
Crystal Set.
Wiring Diagram
(home-made coil)

programme on long waves, you would do better to make the design in Fig. 5. Components for this ferrite-rod coil design should be the same as those listed below Fig. 5 except for the coil, of course, which will not be required, nor will the on-off wavechange switch or the crocodile clip. The ·0002 mfd. condenser (capacitor) will help selectivity if it is wired between the aerial terminal and centre-tap on coil. By the way, use two thicknesses of good writing paper or very thin card for making the coil. The wire should not be too close to the ferrite rod itself. You can experiment with this coil quite a lot, if you wish, by putting different windings on it. Readers of *B.O.P.* have even been using it for short-wave reception by using fewer turns and adding a reaction winding. For this crystal receiver, it might be found better to use a tuning condenser of only 200 pf (i.e. ·0002 mfd.) instead of the ·0005-mfd. one specified.

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.

Winding the Aerial Coil

This coil is simple to make. It tunes medium waves only; the addition of long waves is a little too complicated to include.

Take the ferrite rod and cut a small piece of thickish paper or thin card about 3 inches long, just enough to wrap round the rod with a small overlap for fixing.

Wrap it round tightly enough to allow it to slide fairly firmly along the rod. The join may then be sealed with a small strip of cellulose tape.

The wire used for the coil is 28-gauge double-cotton-covered (d.c.c.) and very little is required. It is rather a thick wire, but this makes it easier to use and gives an efficient coil.

The ends of the wire must be anchored; to do this, I like to make two small holes in the end of the tube.

Slide it off the rod and pierce two holes in the tube about ¼ inch from one end and about ¼ inch apart. Thread the wire through the two holes, leaving about 3 inches spare for connecting.

Take care *not* to flatten the tube while doing this; now slip the tube back on to the ferrite rod. Begin winding by putting on ten turns of wire neatly side by side, pulling them fairly taut . . . but not so as to distort the tube or to stop it sliding along the rod when the coil is wound.

Having put on ten turns, hold them steady with your thumb. Now make a loop in the wire and twist it so that you can continue winding, but have the loop sticking up as a connecting point.

Continue to wind on another fifteen turns and then make another loop in the wire. Twist this to make the 'centre-tap'. Continue to wind on another twenty-five turns, so that you have fifty turns in all with a tap at the tenth turn.

The figure fifty is not vital, so don't worry if you miscount and have one or two more or less. Hold the fiftieth turn carefully with your thumb and cut the wire so as to leave about 3 inches spare.

Slip the end of the tube off the ferrite rod sufficiently to allow you to make two more holes with your darning-needle close to the end of the winding. Thread the spare end through these holes and pull gently but tightly so as to fix the winding

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 pieces of the same size, but of thinner wood such as three-ply. Now, with a few ½-inch panel pins, join the 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 sides. If you prefer to use a complete panel

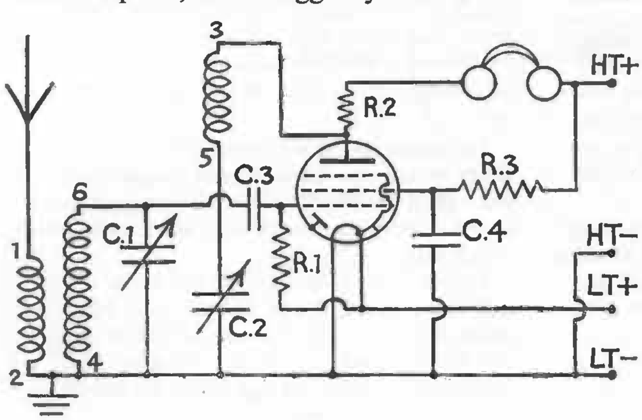


Fig. 7 **One-Valve Set**

Components required:
Wood for baseboard and panel
B7G valveholder
C.1. ·0005-mfd. variable capacitor
Repanco DRR 2 coil (see text)
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.
DAF 91 or 96 valve
On-off switch for wavechange

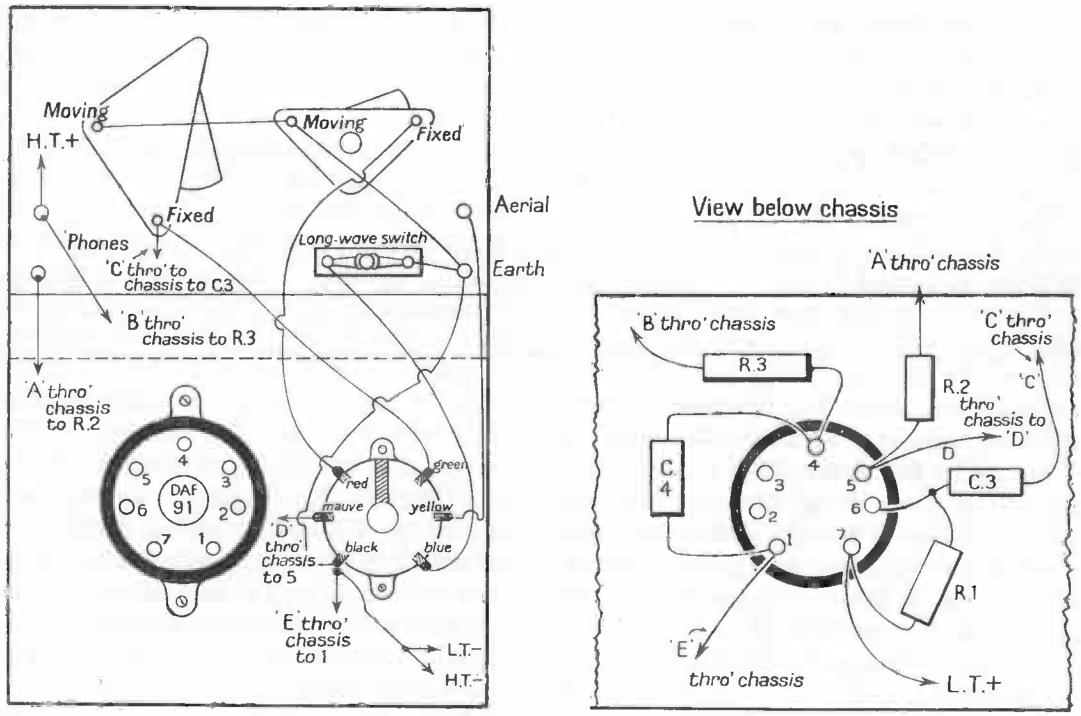


Fig. 8

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 3-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 it 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 gently increasing the capacity (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 P.M.G.'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. 7 that there are three windings on the coil, 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.

This theoretical diagram (Fig. 7) is not exactly correct for the DRR 2 coil used in this design which has no separate aerial winding but which does have a dual-range tuned winding. The actual schematic representation of the DRR 2 coil is shown in Fig. 9 in the next chapter. The principle is the same in every way and it may be instructive for you to compare the two diagrams and see the difference. The wiring diagram in Fig. 8 gives details for the DRR 2 coil, of course. You can use a DF 91 (or 1T4) or a DF 96 (1 F1) instead of the DAF 91 valve specified, if you wish, and by comparing the base connections of the two valves which are given in Fig. 15 should be able to make the correct joins to the valveholders.

Reverting to our one-valve set, reaction having been tested and found 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.

CHAPTER 4

A Battery Two-Valve Receiver

Here's an excellent set which will give good loud-speaker results within the normal range of medium- or long-wave stations. It costs little more than a home-made transistor receiver and will give hours of fun and pleasure.

THIS receiver uses two valves and dry batteries, so that it is a little out-of-date by modern standards where transistors are the order of the day. However, it costs very little more than a home-made transistor receiver, but will give loud-speaker results of a very satisfactory nature anywhere within the service area of a medium- or long-wave station. Using headphones, there are many stations that can be received and only a small aerial and earth are necessary. Two-valve receivers have been popular since radio began, largely because they will work with any valves obtainable without the need for a great deal of low- or high-tension voltage or current. A further point in favour of this design is that it is the next step in set-building from the one-valver in the last chapter and if you built that set you only need the extra components for the LF valve to give you the two-valver.

The first thing to do is to construct the chassis and this is very easily done with two runners of 1-inch-square timber and a couple of pieces of hardboard. For the basic receiver the two pieces of hardboard should each be 7 inches long by 4 inches wide and the two runners each 7 inches long. The two runners are laid on the table and the hardboard laid on top of them so that one runner lies along each edge. The panel is then fixed along one side, upright of course, so that the tuning controls can be mounted on it. It is a good idea, before mounting the front panel, to drill out the holes for two small valveholders. This can be done by drawing the circle to be removed and then either drilling all round it with a drill so that the centre falls out, or taking a hammer and screwdriver and simply tapping all round it until you cut the centre right out. Hardboard is easy to work in this way and holes for fixing components by nuts and bolts can be made. You can either make a nice professional-looking job of fixing the hardboard to the runners by using a few round-headed screws, or you can simply pin the baseboard and the panel in place with ½-inch panel pins. If you are going to use a small loud-speaker, say a 4-inch diameter one, you could mount it above the tuning controls, but this would mean using a front panel about 9 inches high. The extra weight would probably be a little too heavy for the fixing arrangements mentioned, so that additional support should be given between the panel and baseboard at each end of the panel. A small square of wood cut from corner to corner to provide two triangular pieces will give effective supports.

You will see that it is quite easy to build the receiver into a cabinet, if you so wish, by using pieces of hardboard and I have seen some very effective cabinet-work which readers have done from time to time with plywood or hardboard covered with one of the many plastic covering materials now available. However, for a simple battery receiver of this nature, which uses batteries of quite low voltages, a cabinet is not really necessary. Later, when we discuss designs for mains sets, I do suggest that a cabinet is essential for safety's sake.

This two-valve receiver uses the Repanco dual-range coil, type DRR 2, which is and should remain readily available, together with two 'all-dry' valves, types DL 94 and DF 91. The schematic and wiring diagrams are for these valves, but instead of the latter you can use the DAF 91 if you have one or are converting the one-valve receiver. The connexions for it would be the same as given in Fig. 8. Incidentally, the '96' series can be used instead of, or with, the '91' series which I quote. That is to say, you can use a DL 96 and a DF 96 if you wish, as they are interchangeable with the ones quoted. The '96' series takes the same voltage, namely 1·4, as the '91', but only half the current, i.e. 25 milliamps instead of 50, so that the filament battery should last twice as long! If you are buying new valves for the set it would be better, of course, to get the 96's. For overseas readers, the Mullard Overseas series should enable you to use the valves, but if you wish to use the American series the equivalent of the DF 91 is the 1T4 and of the DL 94 the 3V4.

You will note that the DL 94 and 96 have a centre-tapped 2·8-volt filament which means each can be used in series with those volts or, as they are centre-tapped, the two sections can be placed in parallel and operated from 1·4 volts. This, in fact, is the way we use them in the designs in this book and this accounts for the unusual way in which pins 1 and 7 appear to be joined together. This is quite correct when operating in this manner and would seem to be sometimes misunderstood by readers who have written to me suggesting there has been a mistake made. You will note that we bias the output valve automatically by means of a resistor between the HT— and LT—. The current of the set flowing across this resistor causes a voltage drop (remember Ohm's law!) and causes the filament of the output valve to be just that much more positive than the grid, which receives a negative bias by way of R5 which is connected to HT—. This is the modern method of obtaining grid-bias, but a separate battery could be used for the purpose and in fact such a method is shown in Fig. 11 where grid-bias both for the RF pentode and for the output valve is obtained from a battery.

Wiring is best done with some form of insulated wire and I have always found that the plastic-covered wire sold at Woolworths as bell-wire is satisfactory for this purpose. It is sold in a number of colours and if you want to be very professional you could wire up the various circuits, such as HT, LT, etc., in different colours. An alternative to this wire is some plain, tinned copper wire, with sleeving for insulation. I feel that it is important in a battery set of this type to use insulated wire, as the valve filaments are so delicate that a short-circuit could easily burn them out.

This reminds me to mention batteries and you have quite a choice here. The filaments require 1·4 volts, as already mentioned, which could be supplied from one of those large 1·5-volt dry cells called 'bell batteries'. One of these would last ages! The high-tension voltage should not exceed 90 volts, so that you could buy a separate battery of that size. If you want more compactness, though, a complete unit which combines LT and HT for the 1·4-volt valves is available. If you purchase one of these batteries, you will need to wire the leads from the set to a special plug which fits into a socket on the battery. Do be doubly sure that you wire it up correctly; it is so easily mis-wired and then two good valves are ruined.

The set is wired both above and below the baseboard, the wires being run through holes in the top board as necessary. Although this also gives a neater appearance, it is really done in this manner so as to keep the components as near the valve-holders as possible. Short, neat wiring makes for efficiency, avoids losses and instability due to feedback. You will note that a spot is marked out on the wiring diagram as being a suitable position for an output transformer if a loud-speaker is used. Headphones are normally—and if you are buying any, ensure that they are—of a 'high resistance' and can be used directly in the anode circuit of the output valve, as it needs a high resistance to match its own impedance. Loud-speakers of the moving-coil variety, as normally used these days, have a low resistance of the order of 3 to 15 ohms and this will not match the output valve. The small loud-speaker such as you will probably be using with a set of this nature would have an impedance of 3 ohms and must match the output impedance of the DL 94 valve, which is 10,000 ohms, or the DL 96, which is 13,000 ohms. There is a formula

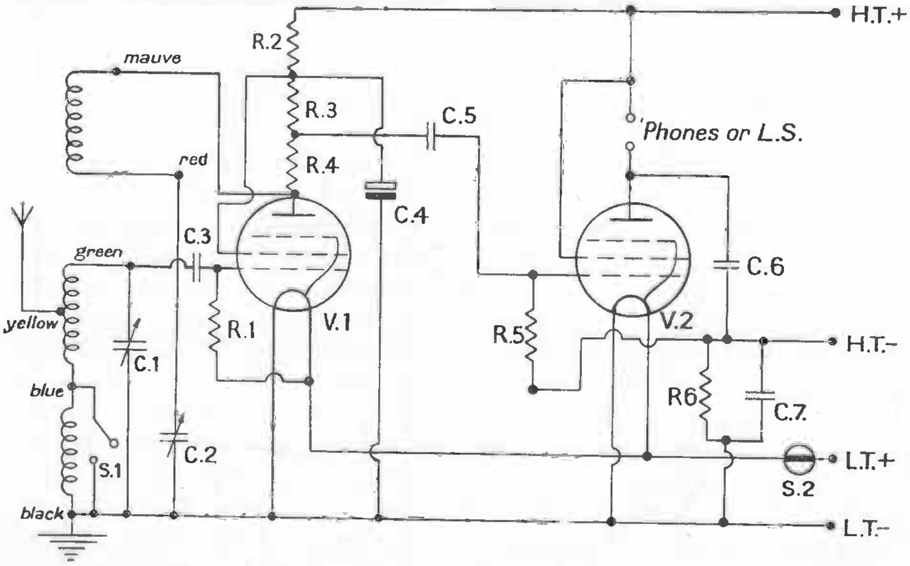


Fig. 9 **Battery Two-valve Receiver Theoretical Diagram**

Components Required:

C.1. variable condenser, ·0005 mfd., small air, or solid, dielectric
C.2. variable condenser, ·0003 mfd., small air, or solid, dielectric
C.3. fixed mica condenser, ·0003 mfd.
C.4. fixed paper condenser, 2 mfd. }
C.5. fixed paper condenser, ·01 mfd. } 150 or more volts working
C.6. fixed paper condenser, ·005 mfd. }
C.7. fixed electrolytic condenser, 25 mfd., 12 volts or more working (note negative (−) side goes to HT−)

R.1. fixed resistor, 2·2 megohms }
R.2. fixed resistor, 25 kohms }
R.3. fixed resistor, 100 kohms } all ¼-watt
R.4. fixed resistor, 10 kohms }
R.5. fixed resistor, 0·25 megohms }
R.6. fixed resistor, 470 ohms }
Coil: Repanco DRR 2
On-off switch for wavechange and also for battery
Phones or loud-speaker (also transformer for LS)
Terminal blocks, wood, wire, valveholders (two B7G)
Valves: DF 91 or DF 96 (V.1.) and DL 94 or DL 96 (V.2.) (Mullard)
Batteries (see text)

for calculating the turns ratio which the output transformer must have to provide such a match, but it is much easier to look it up in tables which are readily available. From these you see that a 3-ohm speaker requires an output transformer of 60 : 1 ratio to match a DL 94 and of 70 : 1 ratio to match a DL 96. The first should carry 10 milliamps of current but, as the DL 96 is more economical, its output transformer needs only a 5-milliamp carrying capacity. You will find a suitable transformer easily available whichever valve you use.

The main problem with this type of simple receiver which has only one tuned circuit is that of selectivity—the power, that is, to separate stations from one another. In most of London this is a real difficulty, as the Home and Light programmes which are transmitted from the powerful B.B.C. transmitters just outside the city to the north present a special problem of separation. This is particularly so with a simple set, as a good aerial and earth are then needed for the maximum signal pick-up. In general, the problem is solved by the use of a superheterodyne receiver which provides selectivity by means of a number of tuned circuits. But a simple receiver with only two tuned circuits can be very effective, as we see in the design in the following chapter.

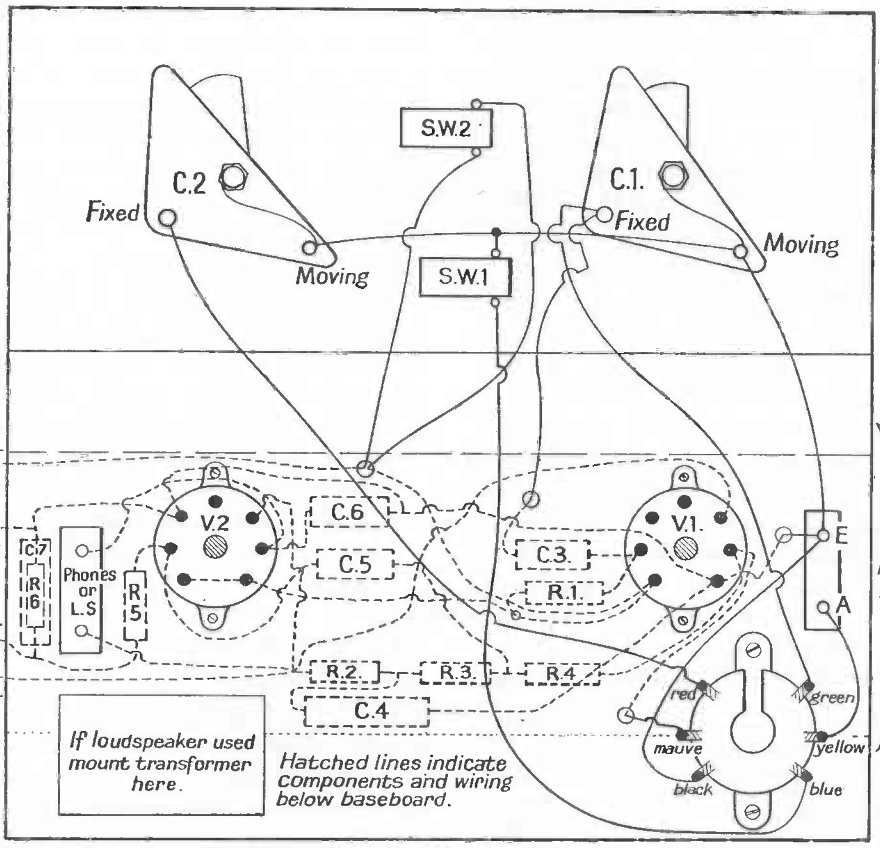


Fig. 10 Battery Two-valve Receiver Wiring Diagram

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. Such valves are now quite obsolete and the 1·4-volt series are used wherever a battery valve is required. I have written a good deal about this type of valve in the last chapter where we used two pentodes, one an HF type, DF 91, and the other an output pentode, a DL 94. In this set we now use three pentodes, two HF (or RF) types and the same type output pentode. Both the RF pentodes are DL 91's, but one is used for RF amplification and the second as a sensitive detector. You will see that we are thus using two circuits, each of which is tuned, and to make operation easier a dual-gang condenser is used.

The set should work quite happily with any type of pentodes and you might find it worth while to look round your local radio shop for some such 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 inches long by 5½ inches wide and has a depth of about 1½ inches. In other words, it is a shallow tray and I made the original one of plywood. The simplest way to make it is to cut out a piece of three-ply wood or hardboard, 10½ inches by 5½ inches, 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 inches by 1½ inches each, which will be fixed by screws, or panel pins, at each end of the larger sheet; and finally two long pieces, each 10½ inches by 1½ inches, which will be fixed along the front and back. These, by the way, should be three-ply wood or hardboard, as for 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

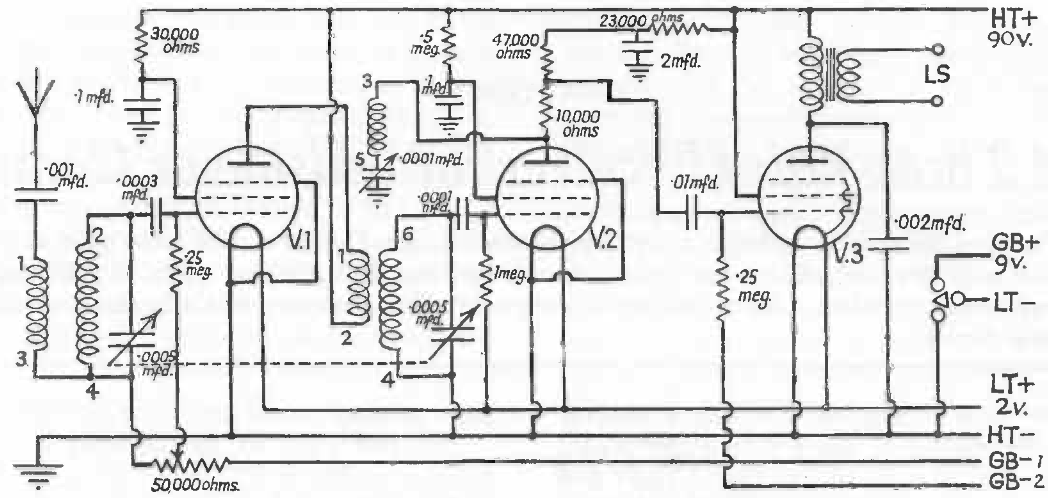


Fig. 11 **Three-Valve Battery Receiver. Theoretical Diagram**

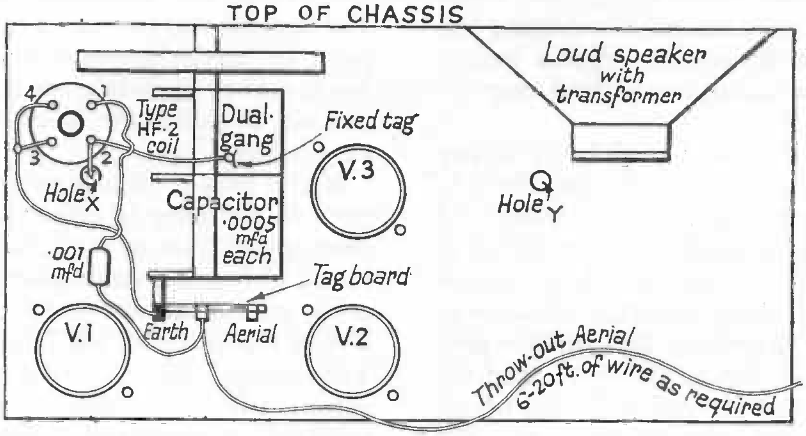


Fig. 12

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 aerial 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 inter-valve coil (on the rear runner so that it is at right angles to the A coil above, to minimize interaction between them) and the

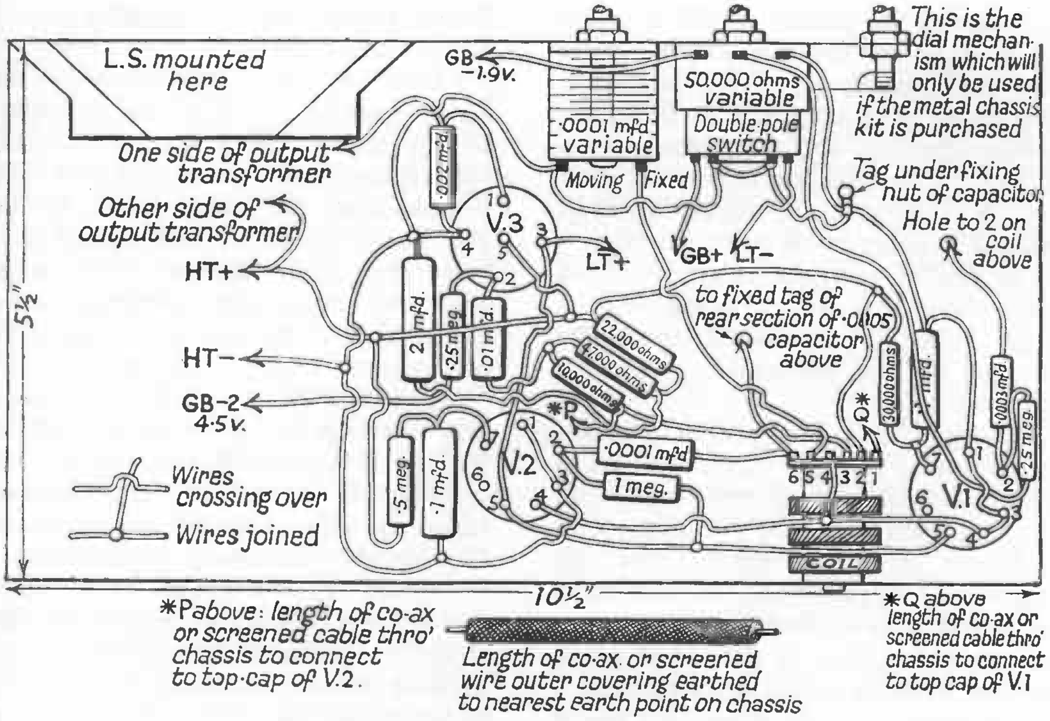


Fig. 13 **Three-valve Battery Set**

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 (aerial) } see text
1 coil (intervalve) } see text
1 50,000 ohms potentiometer with d.p. switch (midget type)
3 valveholders to suit valves used
1 dual-gang capacitor, ·0005 mfd. each section (with trimmers), to fit the above chassis
2 valves—HF pentodes } see text
1 valve—output pentode } see text
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 the 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 to 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 multicored 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 one component, or one 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 multicored 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 rechecked.

I have used three batteries in this set: for filament heating a $1\frac{1}{2}$-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.

This set can be converted to automatic-bias like that in Fig. 9 quite easily. In Fig. 11 disregard GB+ altogether. Join together GB — 1 and GB — 2 and connect them to HT—. Instead of connecting LT— to HT— as shown, connect between LT— and HT— a resistor of 470 ohms and connect across that resistor an electrolytic condenser of 25-mfd. capacity and at least 12 volts working. The negative (— or black) side of this condenser *must* go to the HT—. Connect a fixed paper condenser of 0·1 mfd. between the slider of the 50,000 ohms variable potentiometer and earth (or HT—).

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—recheck 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.

Before concluding this chapter I must say something about two matters which cause some difficulty these days, particularly in writing a book which goes all over the world, and they are valves and coils. There are many types of the first and few of the second. I always use Mullard valves and they are an international series which should be obtainable anywhere; even so, the American types are also very popular and many readers also like to use older types which have been given to them, or are from an old set. I quite appreciate that—as I told you in an earlier chapter, I began my own interest in radio in exactly that way.

Insofar as coils are concerned, the difficulty is that manufacturers are tending to concentrate their efforts on making them for set-manufacturers rather than for the home-constructor trade. This is understandable, since they must concentrate their efforts and tool up their machines to provide the products which will pay them best. There are thus only one or two coils which I can suggest you use. I have, for the reasons mentioned, left unaltered the theoretical and wiring diagrams given in Figs. 11, 12 and 13 which related to the 2-volt battery valves and Teletron coils originally specified, because it is very likely that a reader somewhere in the world has just such components available and would like to use them in this receiver. A very fine receiver they make, too, and I know that in some of the more remote parts of the Commonwealth, the use of 2-volt battery valves is still necessary, due to conditions.

As far as the theoretical diagram is concerned, the details apply whatever coils or valves are used and the layout as given in Fig. 12 will also be the same. If you use DF 91 and DL 94 valves, however, some reconsideration of the underside of the chassis will be required. I will give you the details of the pin connexions of the W21 and PM22A and by looking at Fig. 15 you will be able to make the correct connexions to 1·4-volt-type valves. Remember, by the way, if you have American-type valves, that the connexions for 1T4 are exactly as for the DF 91, and for the 3V4 they are as for the DL 94. On the W21:

1 = screening join to f—, g3 on DF 91
2 = g1
3 = g3, join as f—, g3
4 = f—, join as f—, g3
5 = f+
6 = blank, same as IC which is always left unconnected
7 = g2
Top cap = a

and on the PM22A:

1 = a
2 = g1
3 = f+
4 = f— (g3 is already joined here internally)
5 = g2

To use the 1·4-volt valves in this set, all you have to do is to take the various wires shown on the wiring diagram to the appropriate pins in accordance with the above details. Do not forget that the DL 94 and DL 96 having centre-tapped 2·8-volt filaments are, in fact, used for 1·4 volts by joining f— and f+ of pins 1 and 7 together and taking them to LT+ whilst pin 5, fct, g3, goes to LT—.

Coils are the next point to be considered and if you are buying them for this set, I suggest that you should buy Repanco type DRM 3. They come in matched pairs, so are very suitable for such a receiver as this which uses a ganged tuner. These coils are dual-range, whereas this receiver is for medium waves only and if you are proposing to confine its use to medium waves, you must take a short piece of wire and solder 'blue' to 'black' on each coil, thus shorting out the long-wave winding on each coil. Now here are the relationships between the numbers shown on the diagrams 11, 12 and 13 and the colours on the DRM 3 coils. There are two coils, one aerial coil and the other the intervalve coil with reaction. If you buy them separately, those are the coils you want. You will find a diagram in each coil-box which will show these details:

	No. on diagram	*Colour of coil-tag*
Aerial coil	1	Yellow
(above chassis)	2	Green
	3, 4	Black
Intervalve coil	1	Red
(below chassis)	2	Mauve
	3	Yellow
	4	Black
	5	White
	6	Green

Now if you want to use long waves, instead of shorting out the coil permanently, you need a switch to permit you to do it as required and the first possibility is to mount two on-off switches on the front (or back if you wish) of the set, connecting one switch to each coil between the blue tag and the black instead of the shorting wire. You now have to operate the two switches, both 'open' for long waves or both 'closed' for medium waves. A better idea is, of course, to have a ganged arrangement so that one knob will operate both switches. This is easily obtainable, but a little more expensive. This is the last chapter dealing with battery receivers, as the next commences to deal with mains-operated ones.

CHAPTER 6

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 7!

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 were 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, these were of 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. 14 gives you an idea of how these valves are arranged. A sturdy wire is formed into a

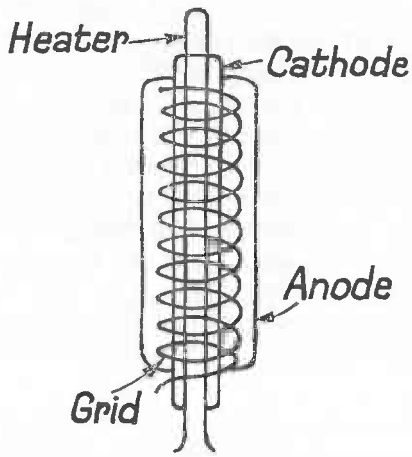


Fig. 14 An Indirectly Heated Triode

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, since 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 standby or as extra receivers. Four volts had become established as the normal heater for most AC valves in Great Britain and on 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 U.S.A., indirectly heated valves developed around a heater voltage of 6·3 as opposed to Europe's 4, and the normal American heater current was ·3 amp. Prewar 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 U.S.A. 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 U.S. designations and what is now known as the 'international octal base', became standard.

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 today ousting the larger types. Although varying voltages for heaters are now commonly used, the general voltage today for AC mains radio receivers is 6·3 volts.

In addition to becoming smaller, valves are now 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 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.

Many 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, though 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, so that attention to the question of loud-speakers is needed. 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.

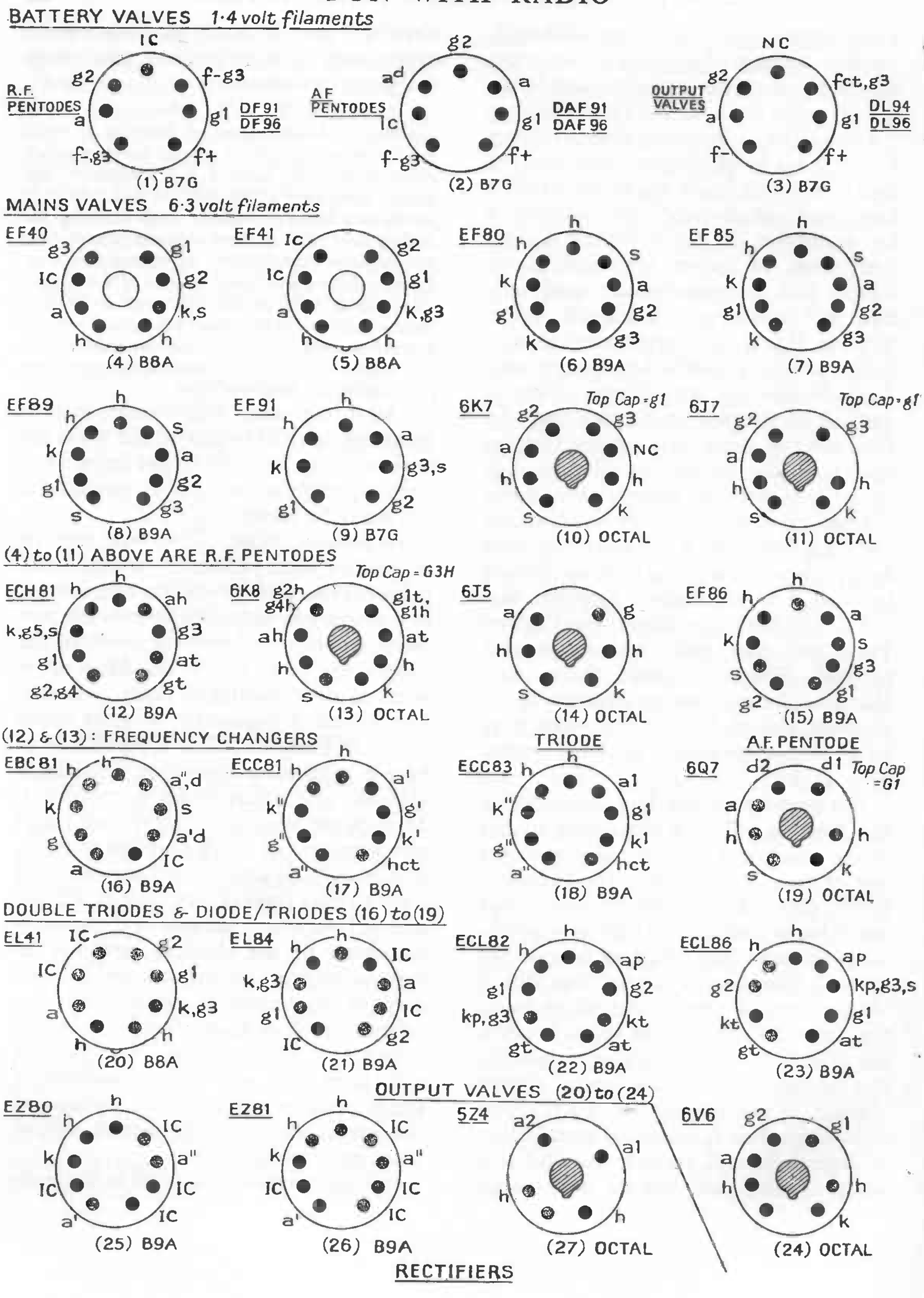
* * *

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 and have it in mind. After many 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 be taken to ensure that these sets 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-


BATTERY VALVES 1·4 volt filaments
R.F. PENTODES
IC g2 f-g3 a g1 f-g3 f+
DF91 DF96
(1) B7G
AF PENTODES
g2 ad a IC g1 f-g3 f+
DAF91 DAF96
(2) B7G
OUTPUT VALVES
NC g2 fct,g3 a g1 f- f+
DL94 DL96
(3) B7G
MAINS VALVES 6·3 volt filaments
EF40
g3 g1 IC g2 a k,s h h
(4) B8A
EF41
IC g2 IC g1 a K,g3 h h
(5) B8A
EF80
h h s k a g1 g2 k g3
(6) B9A
EF85
h h s k a g1 g2 k g3
(7) B9A
EF89
h h s k a g1 g2 s g3
(8) B9A
EF91
h h a k g3,s g1 g2
(9) B7G
6K7
Top Cap = g1
g2 g3 a NC h h s k
(10) OCTAL
6J7
Top Cap = g1
g2 g3 a h h s k
(11) OCTAL
(4) to (11) ABOVE ARE R.F. PENTODES
ECH81
h h ah k,g5,s g3 g1 at g2,g4 gt
(12) B9A
6K8
Top Cap = G3H
g2h g4h g1t, g1h ah at h h s k
(13) OCTAL
6J5
a g h h s k
(14) OCTAL
TRIODE
EF86
h h a k s s g3 g2 g1
(15) B9A
A.F. PENTODE
(12) & (13): FREQUENCY CHANGERS
EBC81
h h a",d k s g a'd a IC
(16) B9A
ECC81
h h a' k" g' g" k' a" hct
(17) B9A
ECC83
h h a1 k" g1 g" k1 a" hct
(18) B9A
6Q7
Top Cap = G1
d2 d1 a h h s k
(19) OCTAL
DOUBLE TRIODES & DIODE/TRIODES (16) to (19)
EL41
IC g2 IC g1 a k,g3 h h
(20) B8A
EL84
h h IC k,g3 a g1 IC IC g2
(21) B9A
ECL82
h h ap g1 g2 kp,g3 kt gt at
(22) B9A
ECL86
h h ap g2 kp,g3,s kt g1 gt at
(23) B9A
OUTPUT VALVES (20) to (24)
EZ80
h h IC k a" IC IC a' IC
(25) B9A
EZ81
h h IC k a" IC IC a' IC
(26) B9A
5Z4
a2 a1 h h
(27) OCTAL
6V6
g2 g1 a h h k
(24) OCTAL
RECTIFIERS

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 today 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 bolts 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 of 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. Otherwise 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.

Fig. 15 (see opposite)

This is a comprehensive glossary of the connexions to the pins or valveholders of most of the valves popularly used for home-constructed receivers today. Note that they are given when looking at the valve, or valveholder, *from the underside*. Having these details, it should be a simple matter to translate the valveholder connexions given in a diagram in this book to those of a similar suitable valve which it is proposed to use instead. The following are the meanings of the abbreviations used:

a: anode
f: filament, + plus or − negative as may be
fct: filament centre-tap
g: grid, 1 being first or control grid and 2 and 3 the screen or suppressor grids
h: heater
hct: heater centre-tap
k: cathode
m: external metallizing (screening)
s: internal screening
IC, NC, NP: No connexion to these points at all
t: triode
p: pentode

CHAPTER 7

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 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 battery costs but a shilling or so.

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 is 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 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 a 2-amp. one 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; this acts on a half-wave principle. As a reservoir capacitor use an 8-mfd. electrolytic type; smoothing is

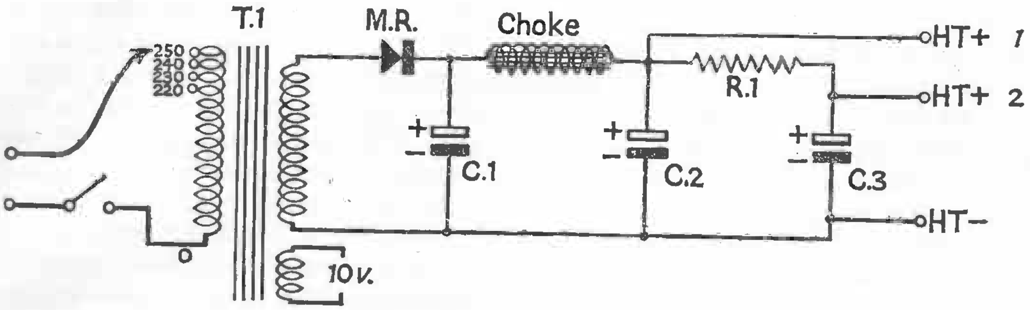


Fig. 16 **Mains HT Unit. Theoretical Circuit**

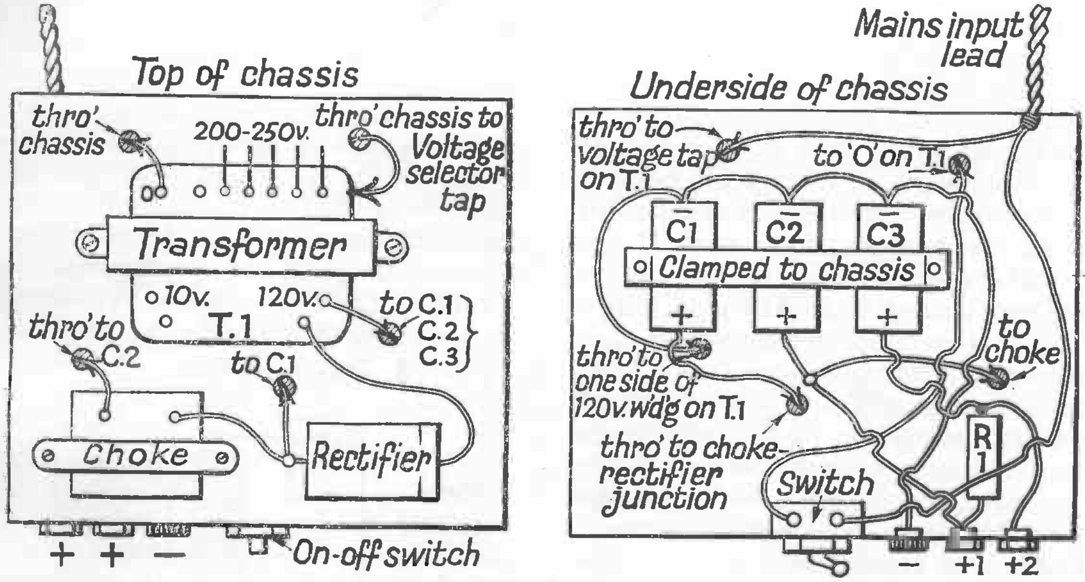


Fig. 17 **Wiring Diagram**

Components required:

T: unit transformer, 120 volts 40 m/a (RSC (M/Cr) Ltd, Leeds)
Metal rectifier, 125 volts 40 m/a (Brimar SB 2 or any suitable type)
Small smoothing choke, 10 henry 60 m/a (RSC (M/Cr) Ltd, 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.

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 bypassed 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 such available, but I should not use lower-rated ones).

The components are mounted on a small chassis which you can make 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 bypass 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 that 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 was usually obtained from an inexpensive grid-bias battery of 9- or 18-volt rating. Nowadays, 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.

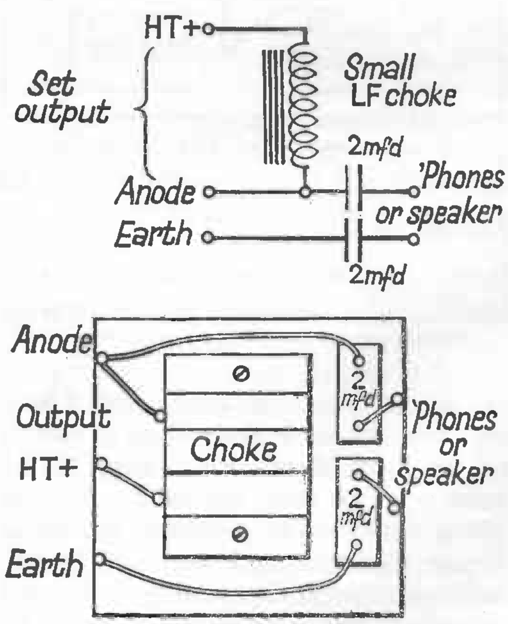


Fig. 18 Output Filter Circuit

CHAPTER 8

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 when 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

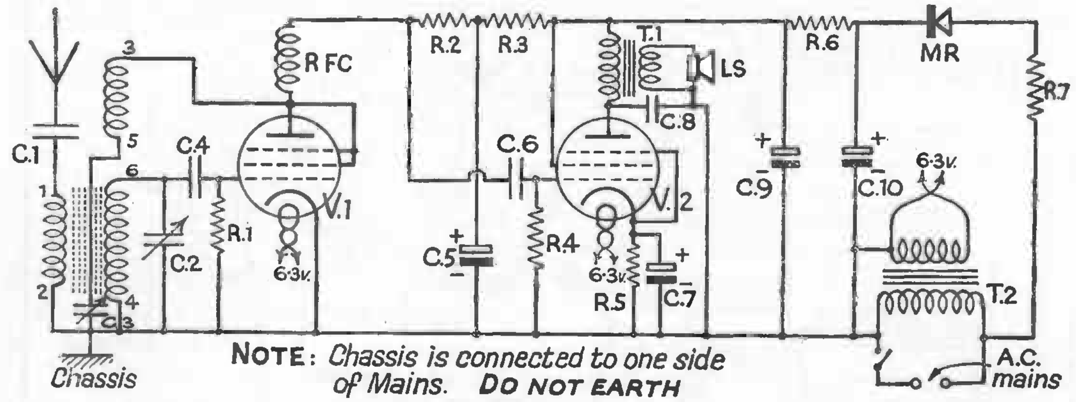


Fig. 19 Theoretical Diagram
Midget AC Mains Two-Valve Set

Components required:

V.1. } 2 EF 50 valves
V.2. } 2 B9G valveholders (and clips)
Coil: see text
RFC or 10-kohm resistor
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. } Each 8-mfd. electrolytic capacitor (3 in all,
C.9. } or 1 double, 8 × 8, and one single, 8 mfd.)
C.10. }
C.6. ·005-mfd. fixed capacitor
C.7. 50-mfd. electrolytic capacitor, 12-volt working
C.8. ·002-mfd. fixed capacitor
MR metal rectifier, selenium type, 230 volts, 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 megohms, ¼ watt
R.2. 100,000 ohms, ¼ watt
R.3. 22,000 ohms, ¼ watt
R.4. 1 megohm, ¼ watt
R.5. 150 ohms, ¼ watt
R.6. 5,000 ohms, 1 watt
R.7. 100 ohms, 1 watt
Metal chassis (or foil-covered wood): front panel
Midget 2½-inch loud-speaker
Wire, solder, flex as required, knobs, on-off switch (250-volt 1-amp. type)

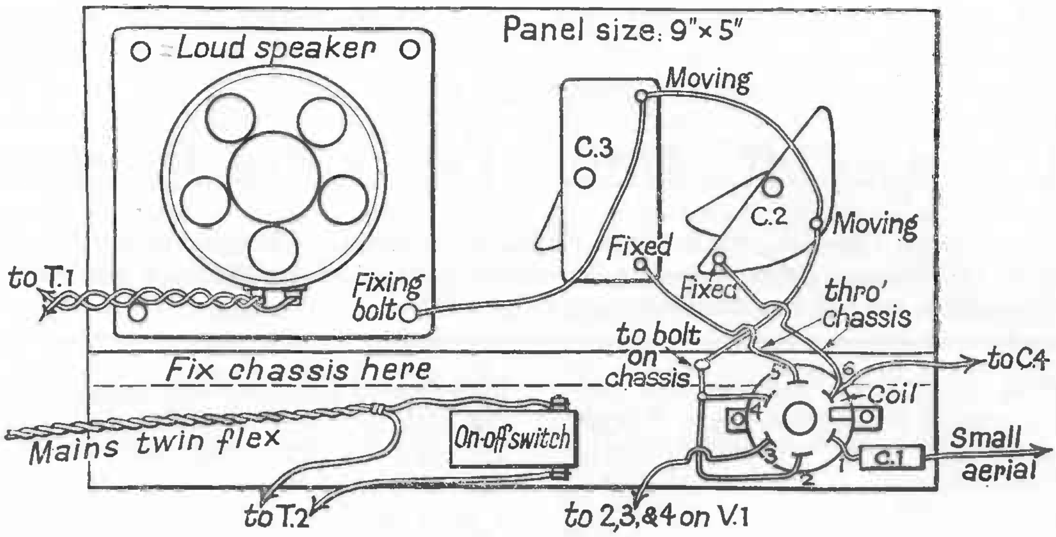


Fig. 20A **Wiring Diagram Panel**

Top of Chassis Carries Filament Transformer and Valveholders

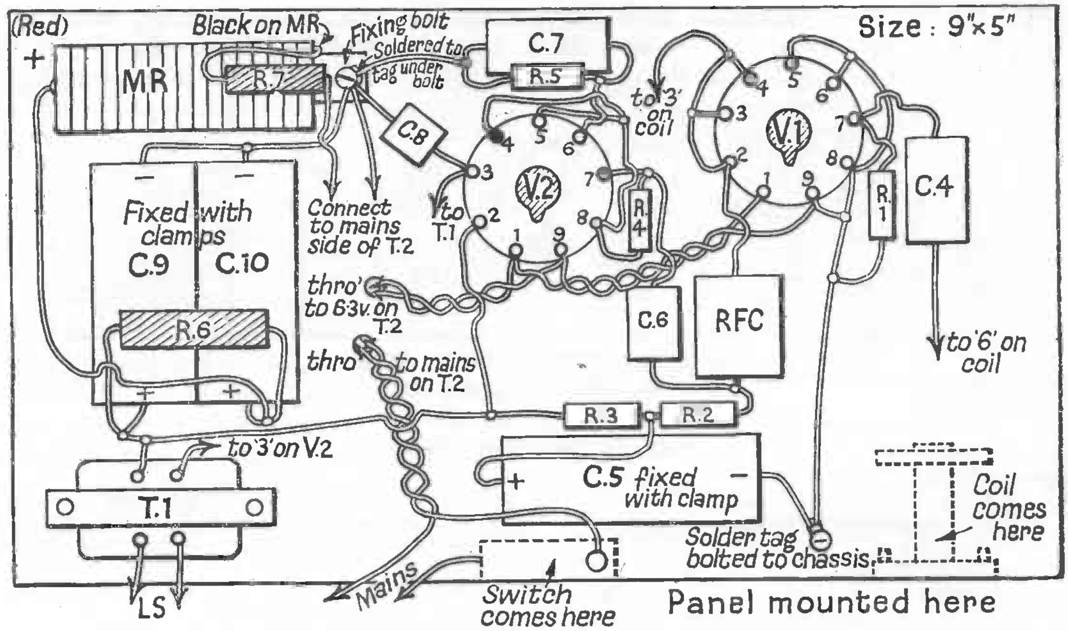


Fig. 20B **Wiring Diagram**

known as EF 50, 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 VR 91 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 SP 61, 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. 19 gives the theoretical diagram and the wiring is given in Fig. 20. As has been mentioned in earlier chapters, coils are difficult to specify these days and I have therefore left both the theoretical and the wiring diagrams unaltered as regards the coil which I originally used and specified for this receiver and which was the Teletron type DR. Unfortunately, I do not suppose you will be able to buy this coil now, as Teletron concentrate on transistor coils and coils for manufacturers' receivers, so I suggest that you should use a Repanco DRR 2. This is a high-efficiency coil, not iron-cored, and details of it have been given in several earlier chapters. However, I will repeat them here in relation to the numbers given in Figs. 19 and 20. No. 1 goes to the yellow tag on the DRR 2 and 2 and 4 are joined and are 'black'. No. 6 would be the green tag and on the 'reaction' winding 3 is 'mauve' and 5 is 'red'. This leaves one tag on the coil coloured 'blue' and if you are not going to use long waves (for the DRR 2 is a dual-range coil), this blue tag should be connected to black.

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 a pencil or large nail and then cut round the marks with an old chisel.

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 EF 50 valves—ceramic and paxolin. Either type can be used in the set, but the paxolin are cheaper and quite suitable.

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 ventilationt The electrolytic condensers used can consis. 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.

For absolute safety, 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 danger in it so long as care 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.

CHAPTER 9

A Three-Valve TRF 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

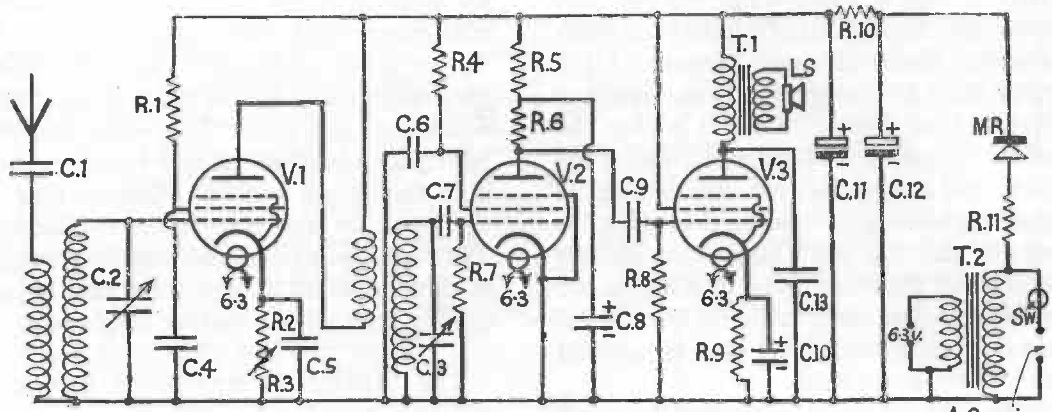


Fig. 21 **Three-Valve Portable Receiver for AC Mains**

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. electrolytic—may be a double capacity
C.13. ·005 fixed (but see text re variable tone control)
Resistors: (all ½-watt types)
values in ohms (k = kilo = thousand)
R.1. 47 k. (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 EL 41 to 3 ohms (midget size)
Tr. 2. filament transformer, 6·3 volt 1·5 amp.
M.R. selenium metal rectifier, 250 volt. 50 m/a.
Valves: V.1. EF 41, V.2. EF 40, V.3. EL 41 (Mullard); but see text
Valveholders: 3 type B8A
Coils
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 should be considered at this early stage and that relates to the valves to be used. The original set was built around three Mullard valves, EF 41, EF 40 and EL 41, which use the B8A bases and which are still listed at the time of writing (Summer 1964) in the Mullard data book as being current types. For this reason I have not seen any reason to alter either the schematic or the wiring diagrams which are given in Figs. 21 and 22. But this set will work quite happily with any three similar pentode valves and if you have three available, you may wish to use them. You could use, for instance, 6K7, 6J7 and 6V6 in the international octal series. In the modern B9A types, you could line up the EF 89, EF 86 and EL 84. Or, again, there is no objection to a combination of all three types! This is where the details I have given in Fig. 15 will prove useful to you. When you come to the wiring-up of the set with the three valves you decide to use, you can easily find the correct connexions for them by comparing those given in Fig. 22 which relate to EF 41, EF 40 and EL 41 with the appropriate underside of the valveholder wiring given in Fig. 15. It might be as well before commencing the work of wiring-up to sketch the correct details on a piece of paper. Incidentally, remember that different output valves will take different currents and differing values of grid-bias. For a 6V6 resistor, R.9. must be raised to 250 ohms and for an EL 84 it goes up again to 270 ohms. Consult valve tables or the slip given usually in the valve-box. All these mains output valves will give a much larger sound output than the battery ones you may have been used to previously, actually something in the region of 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, it is preferable to use as large as possible a speaker in the mains receiver, since it will be more robust and will handle a larger output more satisfactorily. The large speaker will give rather better quality of output than a 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 the volume being turned up 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

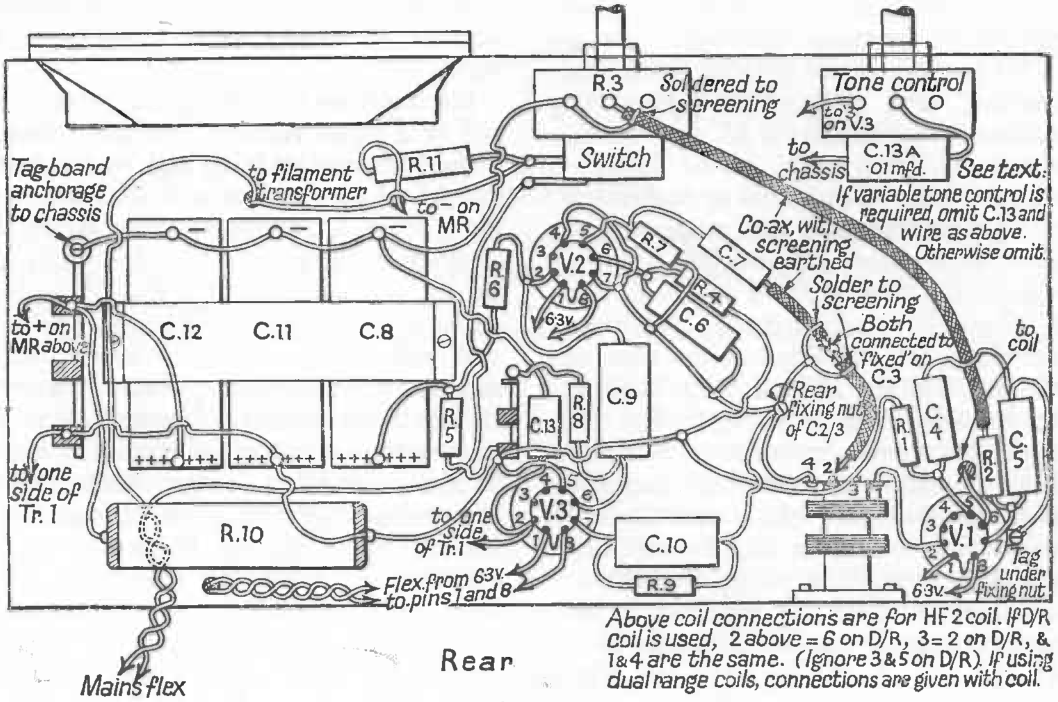


Fig. 22A Underside of Chassis

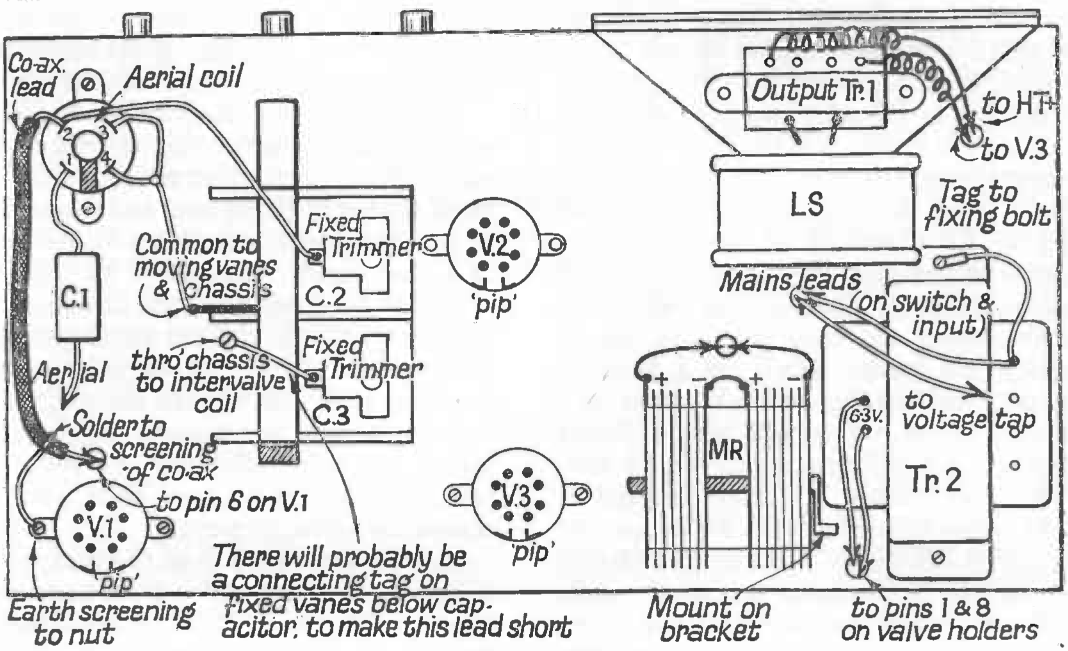


Fig. 22B Top of Chassis

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 and lay the foil on it, gently rubbing the foil flat and turning it down over the edges. Snip 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 to read 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 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 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 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 dual-range coils with a 2-pole, 2-way wavechange switch. This switch will then occupy the spare hole and complete the three. 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. However, I have written in earlier chapters of the types of coils available to home-constructors and I suggest you should read again the concluding paragraphs of Chapter 5 on this subject. The same coils as are used in that receiver would be very suitable for this one, namely Repanco DRM 3 and, of course, they can be used for medium waves only, as indicated, or, by using a double switch, for both wavebands. The switch might well be placed at the rear of the chassis shown in Fig. 22, possibly alongside the coil under R.9./C.10. Connexions would be :

	No. on diagram	*Colour of coil tag*
Aerial coil	1	Yellow
(above chassis)	2	Green
	3, 4	Black
Intervalve coil	1	Red
(below chassis)	2	Green
	3	Mauve
	4	Black

Both coils blue to switch for long waves (see Chapter 5).

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 three 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 incorporates 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 were discussed in Chapter 6. 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 the loud-speaker 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 halfway.

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 prevent 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 10

Amplifiers, Record-Players and High Fidelity

THE HEADING of this chapter is, I must admit, a somewhat absurd one, because it could easily form the title of a book! There is so much that could be said about the equipment mentioned, but nevertheless I am going to try and touch briefly on each of the items and leave you to delve deeper into the subject with your own experimenting. I am going to say something about the reproducer first of all, the actual instrument which is the means of allowing you to hear the speech or music being passed into it as alternating currents. It follows naturally that a poor loud-speaker cannot improve on what is fed into it and, therefore, it must be the best you can afford. It will, without doubt, be a moving-coil loud-speaker as, regrettably, the electrostatic type, although a fine loud-speaker, is more expensive than most of us can afford. However, there are some very good m/coil types available at reasonable prices and I will tell you about three which I use.

Firstly, for general listening I have a Wharfedale 10-inch, bronze FSB unit mounted in a suitable Record Housing cabinet. This has foam surround, bass resonance around 30 cycles, and costs (October 1964) about £5. 10s.—an outstanding unit which can easily have a 'tweeter' unit added for better top-note reproduction. For general experimental work (because it has an arrangement allowing the speech-coil impedance to be altered) I use a Whiteley 'WB' Stentorian 10-inch type, HF 1012. This is a first-class unit at a reasonable price and costs just under £5. The same manufacturers have recently brought out a model with a more powerful magnet, known as the HF 1016, and I have one of these mounted in a large open cabinet for general high-fidelity work. This unit is more expensive, costing around £8, but it is a high-quality loud-speaker giving really beautiful results.

Both these manufacturers have a full range of differing types of loud-speakers and they will send details if you send them a stamped, addressed foolscap envelope, (addresses are in the Appendix). There are today some very sound speakers made by them in the 8-inch size range, these being especially in demand now because of the smaller rooms of modern houses and flats.

To feed the loud-speaker an amplifier is needed and a number of kits are available for sale in the advertisement pages of the radio periodicals. I have two main amplifiers which are not included in the many experimental ones I make up and both of them are Mullard designs from the book published by them entitled *Circuits for Audio Amplifiers*. These are the ten-watt amplifier and the three-watt amplifier, both of which are high-fidelity designs, the former being particularly fine. This book, which has been prepared by the Mullard Technical Service Department and costs 8s. 6d., is invaluable to anyone interested in sound reproduction. The designs in it are not cheap to build, as the components required are of top-quality manufacture, but kits for these amplifiers are available at reasonable prices from advertisers in the technical journals. Another item which is desirable with a high-fidelity amplifier of the ten-watt type is a pre-amplifier and there are two designs in the book mentioned. The three-watt design is a very sensitive amplifier, however, and I find gives full output from the most insensitive gramophone pick-up.

I have given details in Fig. 23 of another three-watt amplifier which is also a Mullard design and I am grateful to the manufacturers for allowing me to reproduce it. Since the publication of their book mentioned above, they have introduced a new audio triode-pentode, the ECL 86, which you will observe is two valves in one envelope, and the output valve is a very steep-slope pentode. You will probably know of the ECL 82 which is also a triode and pentode in one envelope, but here the pentode is of a rather insensitive type and a satisfactory amplifier using it really needs an additional valve as a pre-amplifier. The ECL 86, however, is sensitive enough to be used alone as a three-watt amplifier and to exploit its virtues Mullard have published a very useful leaflet (No. TP 456) which has two designs for a ten-watt and a three-watt stereophonic amplifier. If you are interested, I suggest you write to Messrs Mullard for the leaflet but, in the meantime, you may consider the circuit given in Fig. 23 which can be built up as a single amplifier or, as in the Mullard leaflet, doubled for stereo use.

I am not including any wiring diagram for this, as I feel that if you are competent enough to built it you could experiment yourself with the layout to suit your purpose. I will warn you that the high-voltage gain of the pentode section of the ECL 86 makes it imperative to avoid interaction and feedback between the two sections of the valve. Mullard themselves say the 'wiring of the 3W amplifier is critical' and they advise the use of printed-circuit boards. Suitable kits are available from advertisers if you are attracted by this interesting and economical amplifier which, thanks to negative feedback, has a low distortion level up to 2 watts output.

I have given in Fig. 24 the outline of a circuit for a three-valve amplifier which can be built up as it stands to give a large output from quite a small input, but which, as it has no negative feedback, will have a higher than usual level of distortion. In this form it is very useful as an amplifier to build into a case with a turntable unit, to make up a complete record-player. Suitable valves would be an audio or RF pentode plus an output pentode, together with a rectifier for the HT. An EF 86 with an EL 84 would make a good pair and so would an EF 40 and EL 41. In fact, there are quite a number of combinations you can try, including 6J7 and 6V6 when you will find you have a design much like that in Fig. 25.

You can also try the addition of negative feedback to any of the combinations mentioned above and the method would be as in Fig. 25. Values would be much the same, namely 100 ohms as the feedback resistor in the cathode circuit of the audio pentode and 4·7 kohms as the feedback resistor from the output transformer. I have not given you any values for resistors and condensers in Fig. 24, as these are something you must work out yourselves according to the valves used. Fig. 25 can be used as a good general guide for values of voltage-dropping resistors and electrolytic condensers. For R.3., 100 kohms would be a useful figure and ·22 meg. for R.6., while C.8. would be all right at 0·1 mfd.

Choke condenser smoothing has been dropped in this circuit in favour of the more modern resistance-capacity variety and R.9. would be about 330 ohms, 2 watt, wirewound. Its associated condensers, C.7. and C.8., can be as large as 50 mfd. as long as an EZ 80 or 81 is used. For the 5Z4 or similar types, not more than 16 mfd. should be used for C.7. The EZ series require 6·3 volts on the heater, but the '5' series take 5 volts. The advantage of the EZ series is that only one 6·3-volt winding is required on the transformer in order to serve all three valves.

An important point to remember about amplifiers such as this one is that the valves dissipate a great deal of heat, particularly the output valve, and it is essential to ensure that there is adequate ventilation for the amplifier. It should be placed in such a position that air can come in from below it, pass over it and out above the top of it. These currents are called convection currents and provide the best way of cooling apparatus, as the hot air rising will draw colder air in from below.

I had the opportunity recently of looking at one of the amplifier banks used at one of Messrs Butlin's holiday camps for announcements and for playing music throughout the camp and in the various theatres. The weather was very hot at the time and the heat in the small glass-enclosed room which contains the amplifying equipment was unbearable. This was due to the enormous heat given out by the valves in the amplifier racks, mainly by the output valves which are standard KT 88 types and, I understand, are rarely known to fail although they are at work some sixteen hours a day.

You may spend a lifetime of experiment with amplifiers and high-fidelity reproduction, as I have done myself. I think the important point to remember, however, is that the primary reason for having the equipment is to listen to music, speech, plays, etc., and not to spend one's time worrying about the quality of the reproduction. It is an excellent idea to determine to make one good amplifier, one good radio feeder unit to be used with one good loud-speaker and record-player and then *to leave them alone*! Experiment then as much as you like with all sorts of other pieces of equipment, but keep the one set-up, the best you can possibly afford, for listening.

The next item to discuss in the reproduction chain is the radio feeder unit and for serious listening this can only be an FM unit, working on VHF and receiving the three B.B.C. stations. I have already mentioned the Jason FMT 1 unit which I made recently and which I sent to Messrs Jason for alignment. I still have it working at my home in Middlesex. The alignment cost £1 and was well worth it, for the results are really superb. The quiet background and wide frequency response which FM gives must be heard to be believed, particularly when the unit is used with the Mullard ten-watt high-fidelity amplifier. To all readers who want a simple, inexpensive but absolutely effective FM unit, I recommend the Jason FMT 1. A special aerial is not really necessary, for my set works well with a piece of split flex laid on the table and I am about 20 miles from the VHF broadcasting station. A proper high aerial of correct length will give improved results.

I am not going to say a great deal about units for the broadcast band, as I have mentioned such an arrangement elsewhere. Personally I would not bother with such a feeder when I can have an FM type, but I know my younger readers like the music from Radio Luxembourg which broadcasts on 208 metres and, of course, requires a tuner for the medium waveband. Also overseas readers may very well not have VHF broadcasting and must receive on the medium or short waves. For all such cases a tuner unit can be built, using a superhet circuit built round coils by Repanco or Weymouth. I know that Messrs Repanco publish a leaflet showing how to do this and no doubt you can obtain similar details from Weymouth for their coils. Write direct to either of them (addresses are included in the Appendix).

Finally, we must consider the record-player, as every young person today is anxious to play records. These, as you will know, are plastic and made normally in two speeds of 45 revolutions per minute or 33⅓ r.p.m. The first type are the single or extended-play recordings of 7 inches diameter and the slower ones are the larger 12-inch 'long-players' or 'LPs'. There are also available some even slower LPs which revolve at 16⅔ r.p.m. and, of course, most people still have a supply of the old and obsolete shellac discs which were 10 inches or 12 inches in diameter and revolved at 78 r.p.m. Because of this, it is customary for the pick-up to be fitted with interchangeable heads, or a fixed head which incorporates a turn-over cartridge. This usually takes the form of a crystal cartridge one side of which plays the microgroove type of disc used for LPs and 45's while the other, by means of a turn-over device, can play 78's.

The reason for having the two types is that the microgroove requires a stylus tip of something less than 0·001 inch and the 78 record's stylus must measure about 0·002 inch to 0·0025 inch. Damage would be done to either type of record by the use of the wrong type of stylus. There is some interesting information on recording techniques in the Mullard book already mentioned, *Circuits for Audio Ampliers*. Messrs Cosmochord Ltd also publish an extremely useful leaflet on styli. The latter usually have sapphire tips for both LP and 78 sides and such tips should not be used for a total playing time of more than 25–30 hours. Sapphire styli are relatively cheap, but it is more economical to purchase a diamond-tipped stylus which can be used for 500 to 600 hours at only three or four times the cost of the sapphire.

One of the features of replacing the stylus which I once found irritating was that I had to replace the LP stylus when it wore down, while the 78 stylus on its other side was quite unworn. Messrs Cosmochord helped me here, however, as they now supply, at very reasonable cost, a stylus which has a diamond for LP's and 45's but, on the other side for 78's, a sapphire stylus. This is an excellent idea, because now I have the advantage of a diamond for the side which receives all the wear, yet am able to use the 78 side occasionally if necessary.

The next item to consider is the record-playing unit, the actual motor and turntable which carries the discs and rotates them, allowing the pick-up to traverse the grooves impressed upon them and to convey the currents so created into the amplifier for amplification. This item, like the pick-up which very often forms part of it, must be bought as a ready-made unit and is generally mounted in some form of cabinet. In choosing a record-playing unit it is probably true to say, as one can of so many things, that the more one pays, the better the unit one obtains. It is normal to choose a unit with four speeds, viz. 78, 45, 33⅓ or 16⅔ revolutions per minute, and most purchasers these days require a record-changing type, so that a number of sides can be played automatically.

The most expensive transcription-type playing units do not normally incorporate record-changing facilities, but their prices are probably outside the range of those which most of my readers will want to pay. My own two units are in differing price ranges but very satisfactory in every way, being of somewhat different types. In the normal record-playing equipment fitted in the living-room, I have the Collaro 'Studio' record-playing unit which is fitted with the Cosmochord 'AcoStereo' 73 pick-up. This unit costs about £12 complete and is a four-speed auto-changer which is most reliable.

For general experimental work and for taking out and about for small public-address use, I have a Garrard Laboratory series Auto Turntable type A, which has the Garrard GC 8 plug-in pick-up head. This unit has quite a number of special refinements and costs over £20 complete. It is a record-changing unit of a different type from those normally seen; in the form in which I originally used it, it was necessary for the centres of the 45 r.p.m. records to be removed, as the records had to fit on a large central pillar. Messrs Garrard were showing at the last Audio Fair in London a useful little spring gadget which fits on to the record platform and allows 7-inch records to be played on the long central spindle without the need of removing the 'spider' in the middle. These small items are available quite cheaply if you have a turntable of this type. This is a quality turntable in the forefront of its class.

I hope this chapter has helped you on the question of high-fidelity, but as I said at the beginning, it only scratches the surface of the subject. There are so many books you can read, including a series of interesting and helpful ones by Mr G. A. Briggs of Messrs Wharfedale Wireless Ltd who also publish them. If you are going to construct an amplifier, do not overlook the Mullard book mentioned earlier. Above all, remember that radio and records are for listening—and not merely for testing amplifiers! I have not mentioned the specialized subject of tape-recorders, for they would require a book in themselves. In fact there is one—an excellent book by Ken Peters entitled *Modern Tape Recording and Hi-Fi*, published by Faber. Our next chapter still deals with amplifiers and is a practical design for simple hi-fi which has been very popular with our readers for several years now.

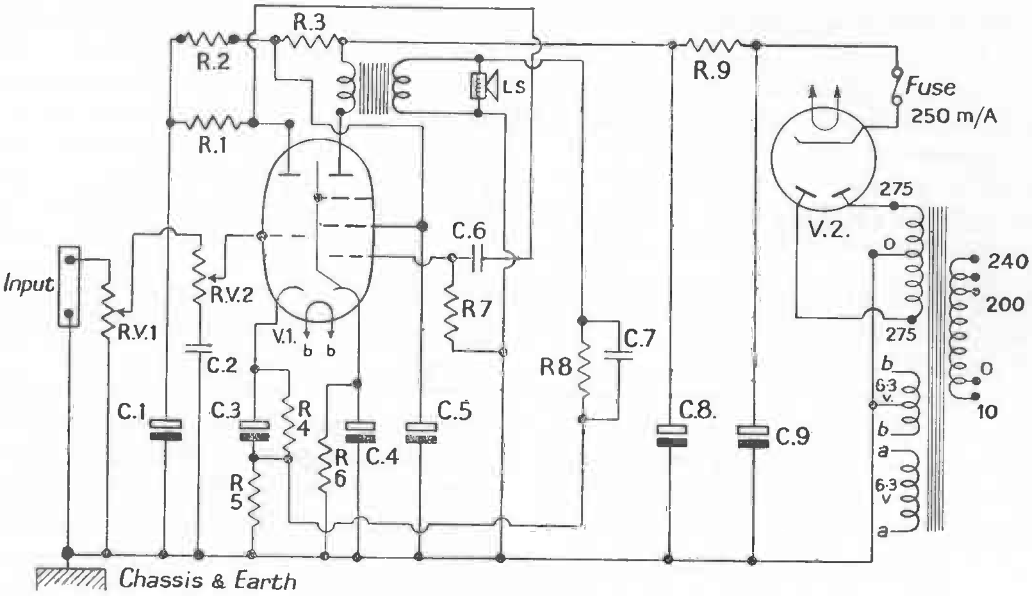


Fig. 23 Basic Diagram for 2-valve amplifier

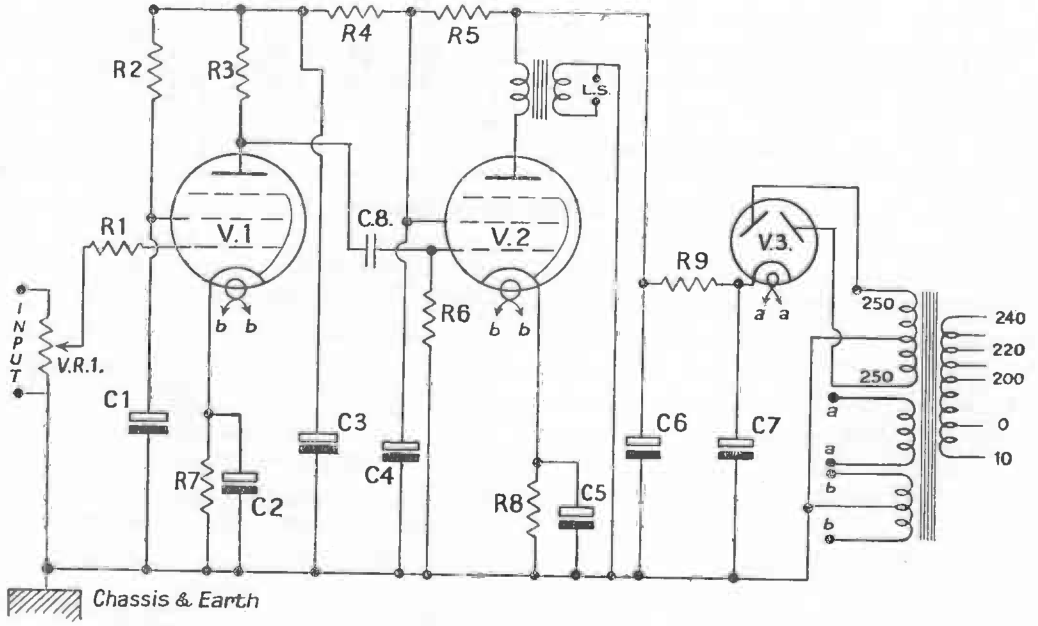


Fig. 24 Basic Diagram for 3-valve amplifier

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

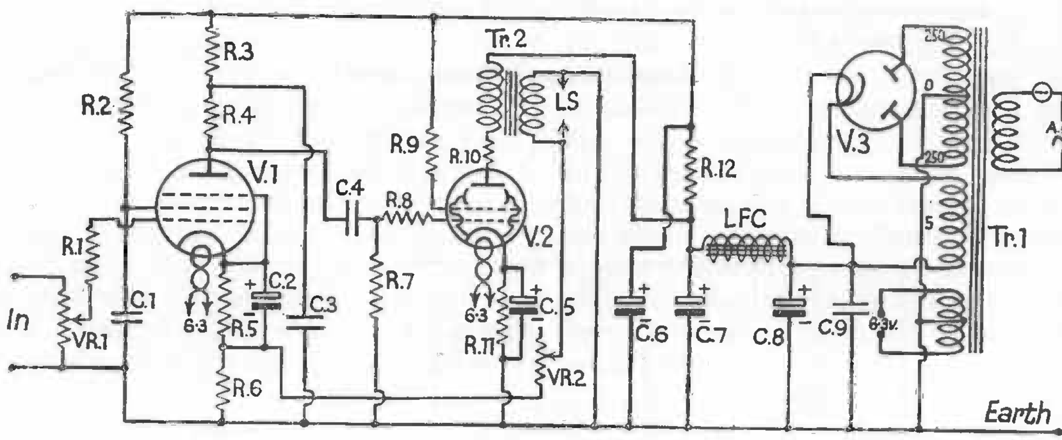


Fig. 25 A Simple Fidelity Amplifier

Components required:

Resistors:
VR.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 watt)
R.7. ·22 megohm (¼ watt)
R.8. 10,000 ohms (¼ watt)
R.9. 100 ohms (1 watt)
R.10. 100 ohms (1 watt)
R.11. 250 ohms (1 watt)
R.12. 1,000 ohms (3 watt)
VR.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 } see text

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 volt electrolytic
C.7. 8 mfd. 350 volt electrolytic
C.8. 16 mfd. 450 volt electrolytic
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. Today, 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 the introduction of '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 sound 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), while 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 $7\frac{1}{2}$ 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 these 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.

All the components having been mounted, 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 valveholder 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 forms 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 (C.4./R.7.). The R.7. end of the grid leak is connected to the adjacent earth wire.

There is one point in connexion with Fig. 26 which I feel should be explained. At the top left-hand corner of the diagram is V.R.1 and it is noted that connected to it is co-axial cable to the grid of V.1. This type of cable you will probably know (it is usually used for connecting aerials to television sets) and it consists of an inner cable covered with polythene insulation and inserted within a braided metal

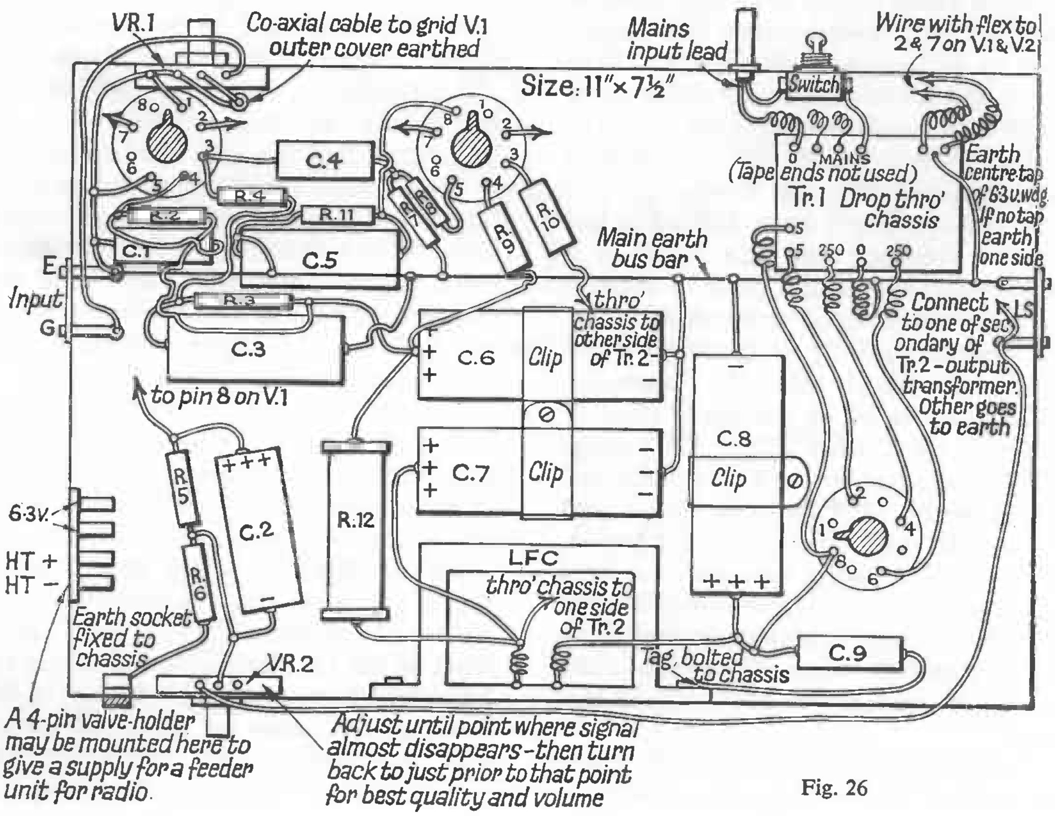


Fig. 26

covering, then a final outer covering of plastic. The outer covering must be removed for an inch or two to reveal the metal braiding; this must be gently slit down and twisted round to enable it to be soldered. The white insulation containing the inner cable is now visible. Gently remove the insulation to within about $\frac{1}{8}$ inch of the braided metal covering and reveal the inner wire.

Reverting to Fig. 26, you will see that the inner cable is soldered to the centre connexion of V.R.1 and the outer braided cable is earthed by soldering it to the earthed side of that component. The whole cable is taken through the chassis and must be of sufficient length to reach to the grid, which is the top cap, of V.1., the 6J7. This end is bared in exactly the same way as the other, except that the braided metal should be connected to the screening cover of the top-cap connector in order to earth it. The inner wire does not go directly on the top cap but to the end of a 10-kohm resistor (R.1.) which has its other end connected to the small spring connector which fits on the top cap. The schematic diagram in Fig. 25 makes all clear.

* * *

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 Wharfedale.

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. Mention has been made earlier of the Jason FM units. They are for VHF. Repanco have a leaflet on a feeder unit giving high quality on medium waves. For more stations and better selectivity a superhet tuner would be ideal. A suitable design has been published in Collins' *Radio Diary*.

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 today 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 some loud-speaker manufacturers who publish details of cabinets to match their own speakers. If you buy one of their speakers you will no doubt obtain these details from them, or, of course, you can buy suitable cabinets ready-made.

* * *

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 your 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 9. This unit is extremely sensitive and powerful, and will easily drive an 8-inch or even a 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. 21, 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 of a kit of parts for such a receiver and purchase that. The need for sets for use on DC today is so relatively small that I do not feel 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 entirely avoids 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 B.B.C. station, by using the quality amplifier described in the last chapter and feeding it on the radio side by the crystal receiver shown in Chapter 2. There is no doubt, however, 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 B.B.C. 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, 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 aerial is fed straight into the 6K8 mixer valve. In some sets, 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.

In Chapter 9 I referred to the various types of valves which are available to readers and which will no doubt be used by readers in many different parts of the world. In the same way, a similar position

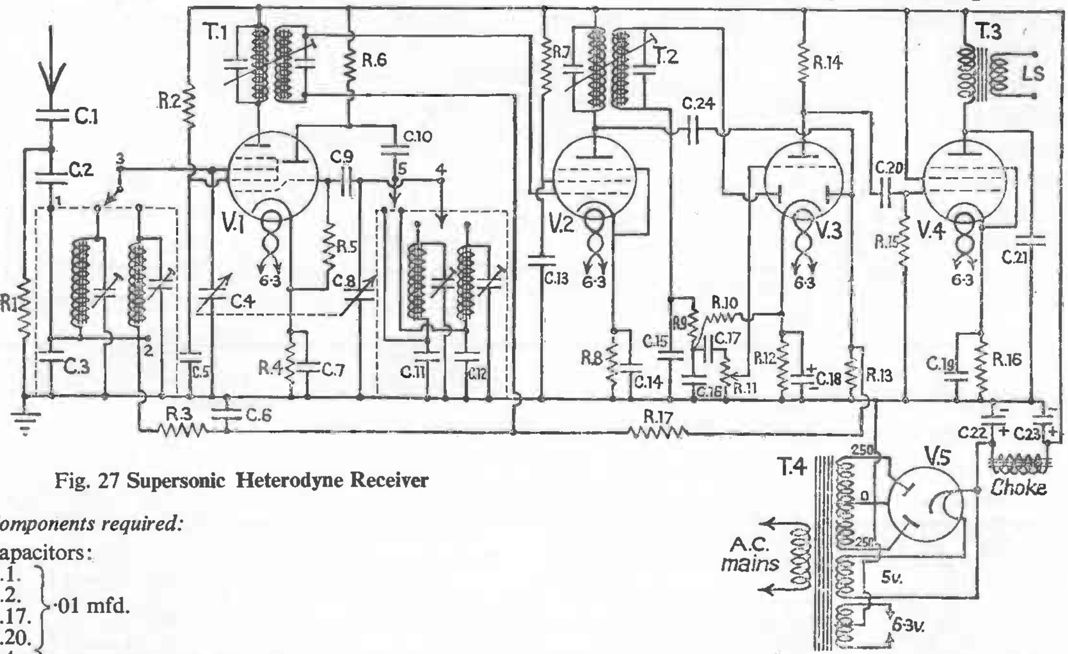


Fig. 27 **Supersonic Heterodyne Receiver**

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. 350 volt electrolytic
C.3., C.11., C.12. and unmarked trimmers all in coil-pack
V.1. 6K8, V.2. 6K7, V.3. 6Q7, V.4. 6V6, V.5. 5Z4
Coils: Osmor, pre-aligned
T.1., T.2. } Osmor 465K/C IF transformers, pre-aligned (but see text)
T.3. output transformer to match LS and 6V6
T.4. 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 transformer T.3. attd.
Chassis, 5 octal valveholders, wire etc.
Dial assembly
Switch as required (see text)
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

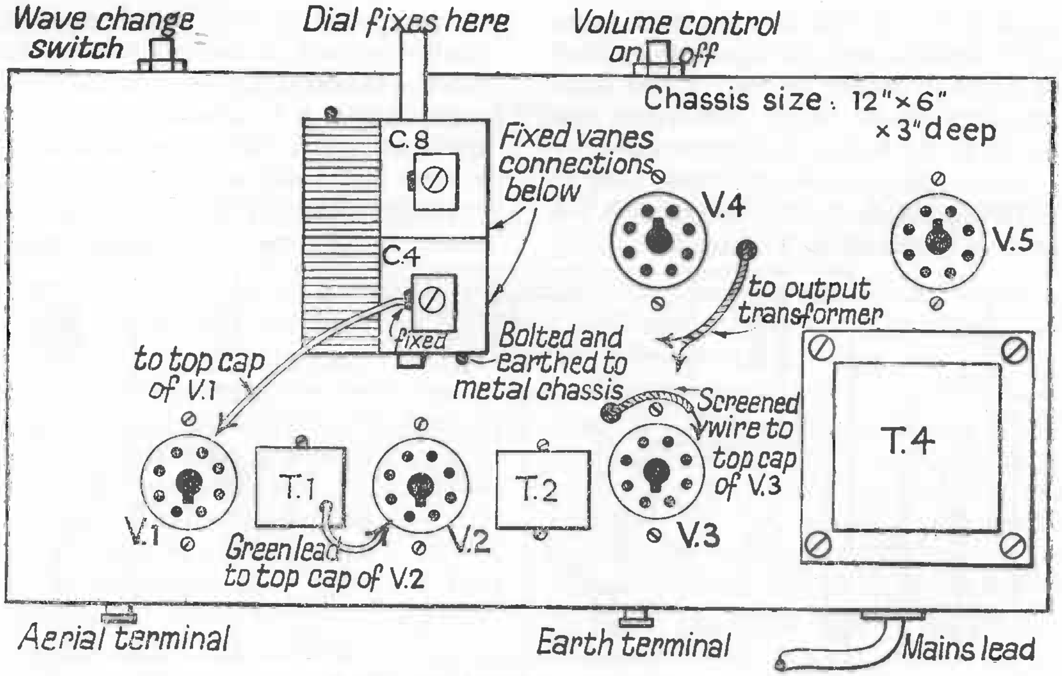


Fig. 28A Superhet Wiring. Top of Chassis

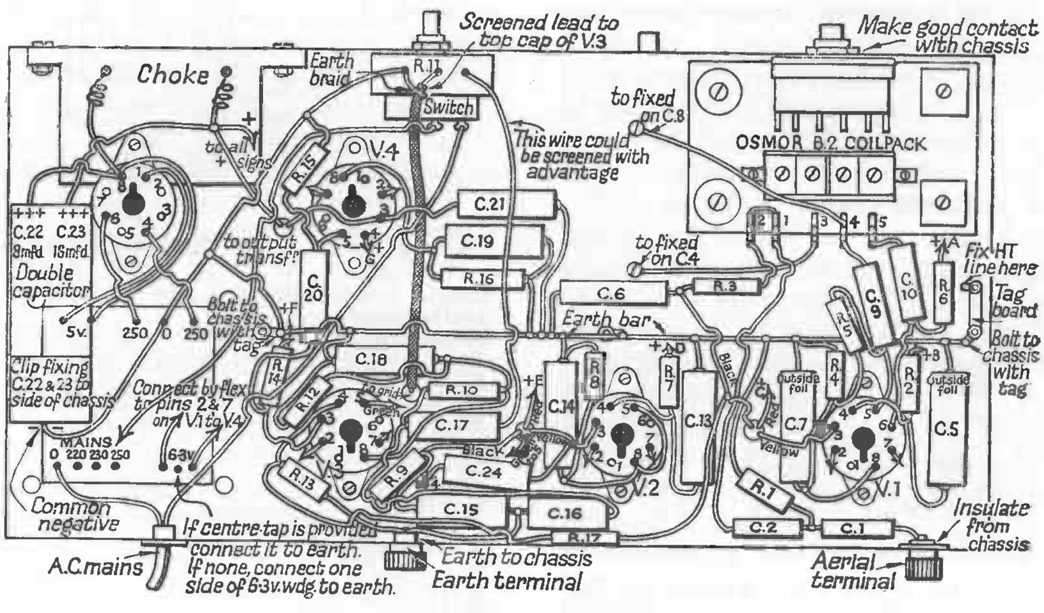


Fig. 28B Superhet Wiring Diagram

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.

can arise with the valves used in this receiver and I have not altered the theoretical and wiring diagrams (Figs. 27 and 28). You will be able to use the American-type valves (or 'international octal' is probably more correct now), or any other valves of your choice. A suitable combination would be ECH 81, EF 89, EBC 81, EL 84 and EZ 80. Referring to the last one first, it is a 6·3-volt valve and your transformer would not need a 5-volt winding but two 6·3-volt ones. Alternatively, as the cathode of the EZ 80 is not joined to heater, a single 6·3-volt winding giving 2 amps. would be adequate.

Next the output valve would need a cathode resistor of 270 ohms, instead of 240 shown. That for an EF 89, R.8., could be dropped to 160 ohms. Most care would be needed in changing over from a 6K8 valve, which operates a little differently from most frequency changers and needs different from normal connexions. If an ECH 81 is used, therefore, the connexion shown as 'top cap' on the 6K8 would, in fact, go to gl on the ECH 81. The pin to g3 on the ECH 81 has to be connected to gt, which will then carry the pin 5 connexions of the 6K8. I hope this is clear, as all it means is that connexions from the coil and C4 go to gl on the ECH 81 instead of g3, as in the 6K8; and gt instead of being connected internally to gl, as in the 6K8, must be connected externally to g3 of the ECH 81. Other valve combinations can be used, of course, but the peculiarity of the 6K8 has to be taken into account when connecting to another frequency changer.

The chassis must be prepared first and there is no objection to a wooden one covered with foil, if preferred. The holes for the valveholders *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, or maybe Osmor can supply it.

The wooden one is easily cut out 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 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 again I must write specially about coils, although you have a somewhat wider choice available. A special coil-pack, the Osmor B2, is shown in the diagrams (27 and 28); but coil-packs for one or two reasons are no longer available and you must either make one up for yourselves or use four separate coils grouped round the switch. Messrs Osmor very kindly supply a special leaflet which shows how to make up a suitable coil-pack from their coils and you should write and ask them for it. You have a choice of coils also from Repanco and from Weyrad, made by the Weymouth Radio Manufacturing Co. Ltd. The small-size Repanco 'R' coils would be very suitable, as would the Weyrad 'H' types. Both these manufacturers have told me that they expect their coils of these types to remain in production for some time. A circuit diagram is supplied with the Repanco coils and details of the trimmer and padder condenser sizes are given in it. These latter are shown as C.3., C.11. and C.12. within the coil-packs in Fig. 27 and the trimmers therein are unmarked. Remember when obtaining separate coils that they will have to be obtained as required and wired in place.

Messrs Weymouth also supply a leaflet giving details of the connexions and circuits for use with their 'H' coils of which there are twenty-one types, covering aerial, HF and oscillator positions for seven wavebands from 12 to 2000 metres. They also make matching IF transformers, so that you can build a powerful all-wave superhet if you so wish. May I emphasize that this is a job which an experienced constructor could carry out without difficulty from Messrs Weymouth's diagrams, but unless you are experienced I do not recommend that you should attempt it. I regret that I cannot arrange to supply any diagrams for this purpose and suggest that the details given in this chapter are adequate for most of my readers.

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 B.B.C. 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, moved to the correct dial marking. *On either band, I emphasize that you must not touch anything but the two trimmers and, maybe, the aerial cores.*

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 one of the coil manufacturers (addresses in the Appendix).

Make sure that the IFT's are pre-aligned and buy the same maker's IF transformers and coils, so that all the items match each other. The 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 a three-wave coil-pack.

CHAPTER 14

Transistors and Transistor Receivers

Transistors are a modern scientific wonder and have revolutionized amateur radio. The receiver described can be a pocket set using a 'deaf-aid' type earpiece, or you can build it in a large box with a loud-speaker added.

THE FIRST edition of this book ended with a chapter about short waves and short-wave receivers. When the publishers decided the book should be completely revised, that chapter had become obsolete because the valves and coils mentioned in it had gone out of production and, in any event, we had by then produced our book, *Fun with Short Waves*. As we work on this chapter in 1964, our fourth title in the series, *Fun with Transistors*, has been published; but we are not deleting from this book the chapter headed as above which replaced the last chapter of this book when it was last reprinted. I hope it will serve as an introduction to transistors, which are going to be so all-important in the future, and will also make you want to continue to learn more about, and experiment with them by reading *Fun with Transistors*. One small point I should make clear refers to the coil used in the set design. That excellent coil for diodes, the Teletron HAX, is in short supply, if not unobtainable. Its manufacturers tell me they, too, are concentrating on coils for manufacturers of sets these days. You can use instead the Repanco DRR 2 connected in accordance with the details of the first crystal set in Chapter 2.

If your dictionary or encyclopaedia is more than, say, five years old, it is doubtful if the word 'transistor' appears in it, for the component to which it is applied was not invented until 1948. Briefly, it is what is known as a semi-conductor and was developed from that other semi-conductor, the germanium diode, such as was used in the crystal-set designs in Chapter 2. At the end of that chapter we said that the diode detector cannot amplify poor signals, and nor can it still; but it has been discovered that by the addition of a third contact to the 'crystal', it acquires the power to amplify.

When you consider that a dozen transistors can easily be contained in an ordinary thimble, you can imagine the great advantage their use could be in such items of equipment as electronic computers, TV cameras, aircraft radios etc., and in home radio and TV sets. In all these applications many valves have to be used; and although modern valves are small, the even smaller size and absence of heat dissipation and heavy power requirements of the transistor make it invaluable. Transistors are still not yet as useful as the valve in many applications, but are able to form a small amplifier for audio purposes and thereby enable us to build a simple radio receiver.

The receiver described consists of a diode 'crystal' detector feeding into an amplifier using two transistors. If more volume is desired, three transistors could be used but, in view of the simplicity of the design, selectivity is limited by that given by the coil used. The HAX coil is very good in this respect, although a large aerial may mean some overlap of the stations received. The layout of the set is very easy and I have made no attempt to suggest how you should do this. You can build the whole receiver into a fairly large box with the loud-speaker included, or you can make a small pocket set incorporating a 'deaf-aid' type earpiece. Incidentally, either low- or high-resistance headphones work quite well with transistors. In the same way, you can use a normal output transformer for feeding the loud-speaker,

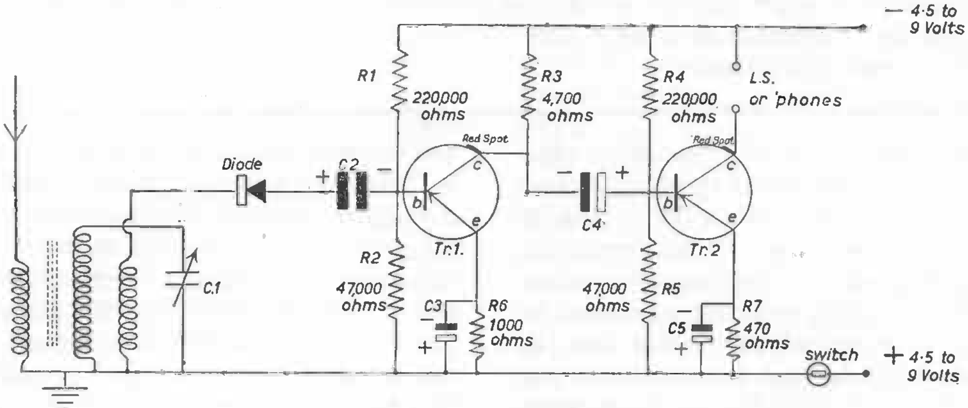


Fig. 29 **Theoretical Diagram**

Components required:

Coil: Teletron HAX
C.1. ·0005 mfd. (500 pf) variable (air or solid)
C.2. } 2 mfd. fixed electrolytic capacitors { working voltage need not exceed 15 volts
C.4. }
C.3. } 8 mfd. fixed electrolytic capacitors
C.5. }
R.1. } 220,000-ohm ¼-watt resistors
R.4. }
R.2. } 47,000-ohm ¼-watt resistors
R.5. }
R.3. 4,700-ohm ¼-watt resistor
R.6. 1,000-ohm ¼-watt resistor
R.7. 470-ohm ¼-watt resistor
Germanium diode such as OA 70 (Mullard)
Two transistors: audio type such as OC 71 (Mullard)
Battery: 4·5 to 9 volts (see text) Ever-Ready
Small switch, aerial, earth, phones, sockets, tag-boards, knob
Suitable cabinet; also phones or LS. (see text)

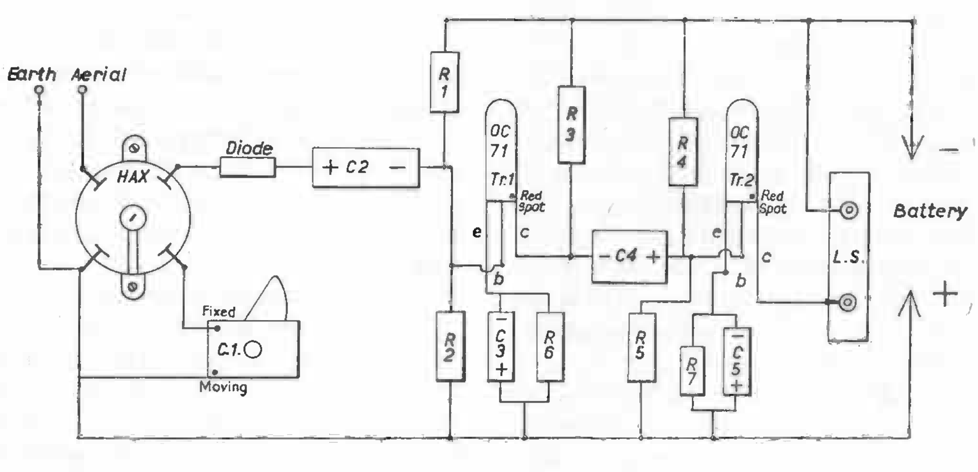


Fig. 30 **Wiring Diagram**

or a special transistor output transformer, or can buy a special loud-speaker wound with a few hundred ohms impedance specially for use with transistors.

The easiest way of making up the set is to use one or two tag-boards, obtainable for a few pence from most component dealers. It is essential to make good soldered joints and when soldering the wires of the transistors a 'heat-shunt' must be used. This is to prevent the heat from the soldering iron from running up the wire lead into the transistor and destroying it. This is very important and the best way of doing it is to grip with a pair of pliers (or get somebody else to do it) the lead of the transistor at a point between the soldering iron and the transistor. Any heat from the soldering iron will run up the lead, but will be dissipated by the pliers and so will not enter and damage the transistor. Wrong 'polarity' connexion of the battery can also destroy the transistor—that means, do not reverse your plus and minus connexions of the battery at any time. You will see that the circuit diagram of the transistor set has the battery connexions reversed when compared with what you expect as regards a valve set. The HT negative line is at the top of the diagram, and at the bottom, which is, as usual, the earth line, the HT positive is connected. Our set needs between 4½ and 9 volts and you can use either a flashlamp battery or the special PP4 transistor 9-volt battery, which is very small and made by Ever-Ready specially for transistor receivers. There is no need to use what are called 'miniaturized' components for this receiver unless you are attempting something extra small; normal battery-set types will be adequate and are cheaper than the tiny types.

Purchasing transistor components has been discussed in Chapter 1 and addresses are given there of firms supplying them and literature to assist you in further experiments with these fascinating little items. Prices of very reliable types are lower now than in earlier days and there is no doubt a very wide field open for a great deal of experimental fun to be obtained from them. In this connexion there are two further points I should mention. Firstly, do not bend the connexion leads of the transistor too near to its seal—not less than $\frac{1}{16}$ inch is a good rule to follow. Secondly, if you want to try three transistors in the set described here, try repeating the first stage after the diode detector. That is to say, make all component values the same as those surrounding Tr.1. The volume then may justify the use of a larger output transistor such as the OC 72, though at the time of writing these tend to be expensive.

I should like to conclude by reminding you of one or two matters, the first being that I shall be glad to help you with any difficulties you may encounter in connexion with the designs in this book. Write to me c/o the publishers, and please enclose a stamped, addressed, foolscap envelope or international or Commonwealth reply coupon. Remember, however, that difficulties over coils, valves, components and the like should go direct to the suppliers or manufacturers whose address will, no doubt, be found in the appendix which follows.

Thirdly, it is important to realize that components for home construction are usually difficult to purchase locally. It is customary to obtain them by mail order from one of the suppliers who advertise in the technical journals (or who are mentioned in the Appendix). Lastly, do not overlook the other radio books in this series which are listed on the outer cover and the fact that up-to-date radio designs and ideas are published in *Boy's Own Paper*, often in special supplements.

Appendix

Books and Periodicals

Practical Wireless (monthly, Newnes)

Wireless World (monthly, Iliffe)

Boy's Own Paper (monthly, Purnell, now published by the British Printing Corporation Ltd)

Radio Constructor (monthly, Data Publications)

FM Tuners for Manual Operation, G. Blundell (Data Publications)

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

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

Foundations of Wireless, M. G. Scroggie (Iliffe)

Audio and Acoustics, and other books by G. A. Briggs (Wharfedale)

Collins' Radio Diary (Collins)

Modern Tape-recording and Hi-Fi, Ken Peters (Faber)

Circuits for Audio Amplifiers, Mullard Technical Service Department (Mullard)

Manufacturers and Suppliers

Brimar Valves, Thorn-AEI Publicity Dept, 155 Charing Cross Road, London W.C.2

Collaro Ltd, Ripple Works, By-pass Road, Barking, Essex

Cosmochord Ltd (Acos), Eleanor Cross Road, Waltham Cross, Hertfordshire

Ersin Multicore Solder Ltd, Multicore Works, Hemel Hempstead, Hertfordshire

Garrard Engineering and Manufacturing Co. Ltd, Swindon, Wiltshire

Home Radio Ltd, 187 London Road, Mitcham, Surrey

Jason Electronic Designs Ltd, 23 Wardour Street, London W.1

Mullard Ltd, Mullard House, Torrington Place, London W.C.1

Osmor Ltd, 540 Purley Way, Croydon, Surrey

Osram—The M–O Valve Co. Ltd, Brook Green Works, Hammersmith, London W.6

Record Housing, Brook Road, London N.22

Repanco Ltd, 203–269 Foleshill Road, Coventry, Warwickshire

R.S.C. (Manchester) Ltd, 54 Wellington Street, Leeds 1

Stern-Clyne Ltd, 3/5 Eden Grove, Holloway, London N.7

Teletron Co. Ltd, 112b Station Road, London E.4

Webbs Radio, 14 Soho Street, London W.1

Weymouth Radio Manufacturing Co. Ltd, Regent Factory, School Street, Weymouth, Dorset

Whiteley Electrical Radio Co. Ltd, Victoria Street, Mansfield, Nottinghamshire

Wharfedale Wireless Works Ltd, Idle, Bradford, Yorkshire

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