FUN WITH TRANSISTORS

by GILBERT DAVEY

edited by JACK COX

(EDITOR OF *BOY'S OWN PAPER*)

FULLY ILLUSTRATED

This is an important and natural follow-on to FUN WITH RADIO, FUN WITH SHORT WAVES and FUN WITH ELECTRONICS. Briefly, it explains what transistors are, how they work and how they compare with valves; it details those types of transistor receivers which require aerials and those which do not, giving types, cost, results and difficulties. It then goes on to deal with the construction of transistor sets – from a simple type to more complex ones – and includes the four-transistor-set, transistor-superhets, record amplifiers, short-wave receivers, electronic guitars, etc. It deals also with the various transistor applications in modern life – computers, aircraft, rockets, space travel, and so on.

It is fully illustrated by technical diagrams and photographs.

THIS IS ONE OF THE
WELL-KNOWN
'LEARNING WITH FUN' SERIES,
FOR DETAILS OF WHICH
SEE THE BACK OF
THIS JACKET

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DRAWINGS BY B. GERRY
FROM ORIGINALS SUPPLIED BY THE AUTHOR

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FOREWORD

Gilbert Davey, who combines the rare enthusiasm of the gifted amateur with the precise skill seen in a professional mechanical engineer, is already well-known for his outstanding books, *Fun with Radio*, *Fun with Short Waves* and *Fun with Electronics*. I had the pleasure of helping him to shape their contents from my knowledge of what the modern boy wanted as far as practical radio was concerned, and then the privilege of editing Gilbert Davey's notes and preparing his advice and instructions and designs for publication. Now there is a fourth new volume in this splendid series. Here it is—*Fun with Transistors*—and I am sure it will bring much pleasure and satisfaction to the modern boy whose hobby is amateur radio, and not a few girls who also share that interest, as well as fathers and uncles and other relatives and friends.

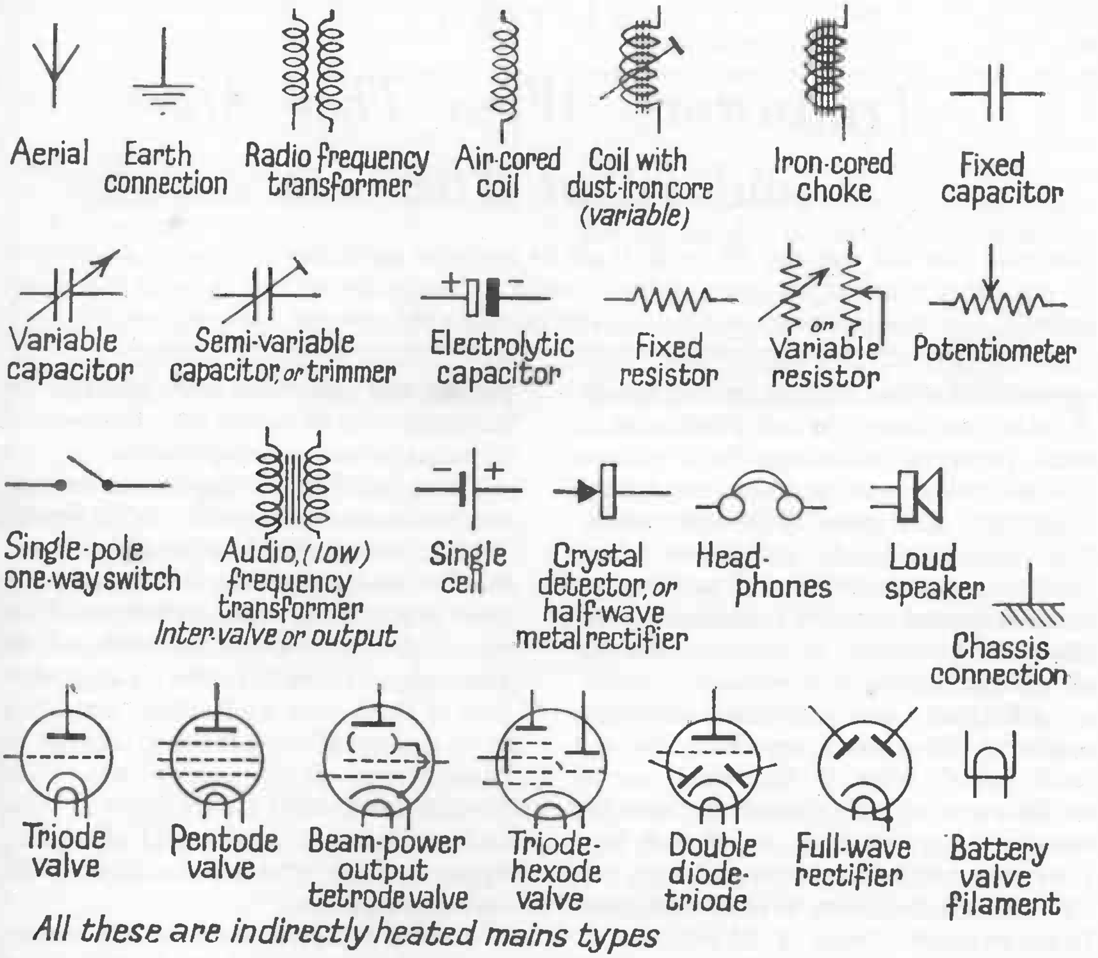
Gilbert Davey shows us how the transistor has replaced the valve in all its practical applications in radio. Yet they are not a very difficult or complicated business for the enthusiast who has built his own receivers and had a good deal of fun from them. In this book you can start with a single transistor receiver, or a pocket transistor receiver with a personal earphone, and then progress with a loudspeaker added to an existing design on to amplifiers, short-wave receivers, oscillators and battery eliminators. Transistors have transformed the world of radio and no enthusiast can be up-to-date without a sound working knowledge of them.

I am sure Gilbert Davey's book meets a real need and that it will be welcomed as an important addition to his lively and practical series. Anyone who has read his previous books, or made up some of his designs from his regular contributions to *Boy's Own Paper*, will know that the name of Gilbert Davey is a guarantee of sound design and practical application. As ever, it will be amateur radio with fun, which has always been our object in preparing these books.

JACK COX

Photographs by courtesy of
Bullock & Turner Ltd (*Figs. 9, 10*)
Murphy Radio Ltd (*Fig. 16*)
Ferranti Radio & Television Ltd (*Fig. 18*)
Ferguson Radio Corporation Ltd (*Figs. 17, 19, 20*)
IBM United Kingdom Ltd (*Figs. 21, 22, 26*)
British Broadcasting Corporation (*Figs. 27, 28, 29, 30, 31*)

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



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 = micro micro = μμ usually known as pico = p = (× 10^{-12})
One millionth = micro = μ = (× 10^{-6})
One thousandth = milli = m = (× 10^{-3})
One thousand times = kilo = k = (× 10^{3})
One million times = mega = M = (× 10^{6})

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

CHAPTER 1

Transistors: What They Are and What They Do

The transistor has replaced the valve in all its practical applications in radio. Progress is so rapid that within a few years domestic radio and television will all be using transistors entirely. Yet transistors are not at all complicated for the amateur radio enthusiast.

FOR most of my lifetime the thermionic valve has been the vital component in radio receivers, television sets, amplifiers and all the associated electronic devices which have been invented to exploit them. The valve, as all radio enthusiasts know, requires power in the form of batteries, or mains-operated battery eliminators, to heat the filaments, or heaters, and to supply the high-tension voltage.

As long as I can remember, electronic engineers have been searching for the 'cold valve', some device which would oscillate and amplify without the need for external power supplies, or, if such supplies were needed, something of such low voltage, and small size, as to be negligible. In my treasured library of old radio books there is a copy of *Popular Wireless*, dated 29 November 1924, which describes experiments to make crystals oscillate carried out by O. V. Lossev, a Russian scientist.

The crystals used by Lossev were of the 'cat's-whisker' variety then in vogue and consisted of minerals or combinations of minerals, which were lightly touched by a contact of springy metal. Lossev discovered that certain types of crystals, combined with certain metals, would oscillate when a voltage was applied to them. The discovery never seemed to be put to any practical use. Perhaps the improvements in valves and development of mains power was responsible.

The possibility of the crystal detector was not forgotten, however. In the Second World War 1939-45 a small compact rectifier was needed in Radar, and this drew attention to the possibilities of the crystal detector. This need produced the germanium 'crystal' rectifier. Large numbers of them were available to the public as 'war-surplus' and became popular in constructing stable crystal sets. The germanium rectifier is now used in radio and television to most useful effect and, in fact, in many other modern applications, such as computers.

Results obtained with the germanium detector or, to give it its correct name, semi-conductor, revived thoughts of the cold-valve and in 1948 came the first transistor. Two scientists, working in the Bell Telephone Laboratories in America, and named John Bardeen and Walter H. Brattain, invented (or was it discovered?) this device. At that time it was a 'point-contact' transistor.

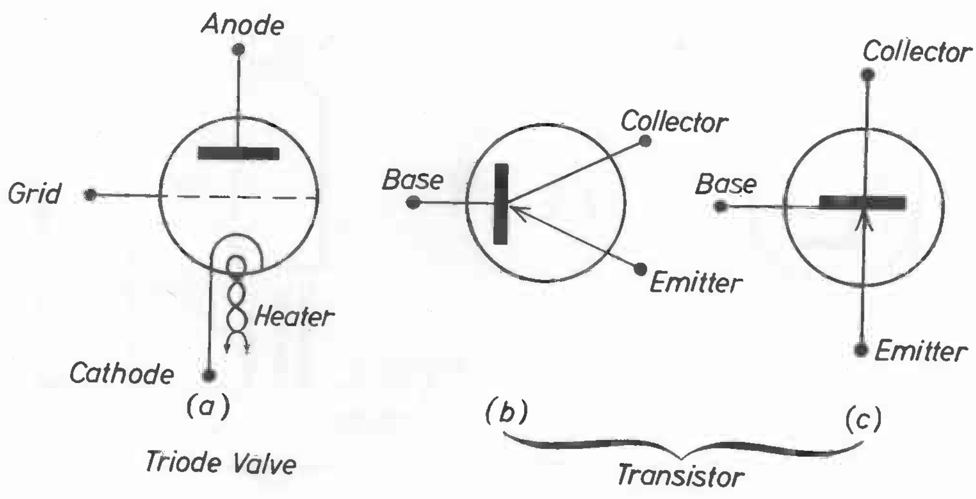
I have read that everything can be forecast and foretold in our modern world by mathematics. Everything which happens is supposed to be calculable by the mathematician; certainly the maths you learn at school today seems far more advanced than anything taught in my day. The transistor was a mathematics 'baby'. John Bardeen calculated in advance what he believed should happen and passed his results to Brattain to carry out the experiments. At first they did not succeed but eventually they were able to introduce to the world the transistor. It earned them a Nobel Prize.

From their early point-contact transistor, which was 'tricky' to use and is now considered obsolete, the junction transistor was developed. It dates from 1950. Millions of them must have been manufactured all over the world since then and not least in Japan which became one of the pioneer countries of transistor radio receivers. Today there is no doubt that the transistor is replacing the valve in all the various applications in which the valve is used and, in particular, in radio receivers; in fact, I believe that within a few years valves will have no place at all in domestic radio and television.

This is a practical book, and yet a simple one, which contains circuits and ideas using transistors which you can easily make up for yourselves. In radio today development has practically standardized all receivers at the one circuit, the supersonic-heterodyne or 'superhet', which forms the basis of our reception, be it medium-wave, VHF or TV. With transistors the most popular set is the superhet using several of them, but there are a number of simple circuits you can make up and these are included.

Although there are some four-electrode transistors now being developed, the component is basically a triode, or three-electrode device, and compares in some ways with the triode, or three-electrode, valve. There are many important differences but we need not trouble unduly about them in this book. The chief points which interest us here are that transistors are very small. A dozen of them will go in a thimble! Their power requirements are likewise small, and, as a result, the heavy items required in a receiver to provide power from the mains are no longer necessary. Consequently, it follows

Fig. 1 Theoretical symbols for triode valve and transistors



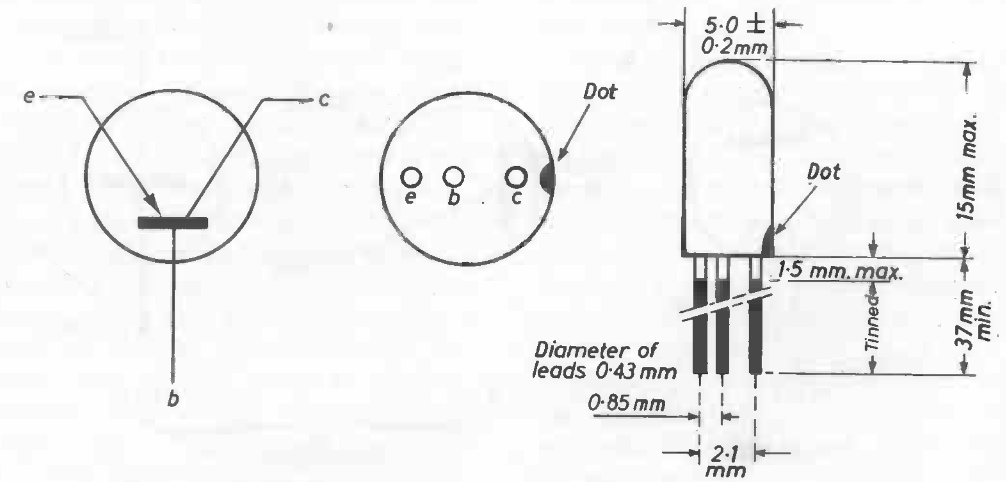
that the heat which results from a concentration of valves in a radio or TV set is absent; transistorized equipment can be much more compact.

Provided they are used correctly, transistors appear to be everlasting and there is no recurring cost of replacement such as there is with valves. Unlike valves, transistors do not have a fragile glass envelope and are consequently very robust which is an important point when they are used in guided missiles or rockets in outer space.

In Fig. 1 I am showing you the symbols for a triode valve at (*a*) and two symbols for a transistor at (*b*) and (*c*). You may find both of these in use. That at (*b*) is probably more usual just at present but the 'preferred' design of (*c*) is likely to be the ultimately used symbol. These symbols relate to junction transistors of the p-n-p variety which are most popular in Britain and which are the ones used in this book. If you have seen transistor symbols in which the arrow on the emitter 'e' line points away from the thick line indicating base 'b' then a n-p-n transistor is indicated. We shall not be using these at all; they are not very common in radio sets built by amateurs but sometimes one can be found in the push-pull output stage of some commercial receivers.

At (*a*) in Fig. 1 I have drawn the theoretical symbol for a triode valve so that you may see the similarity to a transistor. The valve shown is a mains-type but we are only concerned with its three electrodes of anode (at the top), grid (dashed line in the centre) and cathode (hook at the foot). The heater, which causes the cathode to give off electrons, is the small 'hairpin' below the cathode and may be disregarded for our present purpose. You will note that the transistor collector 'c' is similar to the valve's anode, the base 'b' like its grid, whilst the emitter 'e' can be compared to the cathode. One important difference to remember is that, in the valve, anode is positive and cathode is negative, whereas, in the p-n-p transistor with which we are concerned, the reverse applies and the

Fig. 2 Details of transistor connections



emitter goes to the positive side of the battery with the collector negative.

Fig. 2 shows the connections to a typical transistor and also details of the shape and size of the component. You will note that the diagram gives the transistor at double its actual size. Different makes from that shown sometimes have varying shapes but the connections and indicating spot would be the same. The details shown in this figure are reproduced from the diagram supplied by Messrs. Mullard Ltd, who have very kindly allowed me to reproduce it. Mullard have been well-known in radio for some forty years as leading manufacturers of valves. Their enormous present-day contributions to research into, and the supply of, transistors is just one example of how much importance the valve manufacturers place on the new industry centring around the transistor.

I have now told you something about what transistors are and what they do, but it would need the whole of this book to tell you just how they work. There are several very excellent books already available which deal with the subject. The first is a book first published in 1957 and addressed to the beginner. It is Egon Larsen's *Transistors Work Like This*, published by Phoenix House Ltd, which is a sound introduction to the subject. A more recent publication by Iliffe Books Ltd is a fascinating and instructive book by our friend of *Foundations of Wireless* fame, M. G. Scroggie, B.Sc., M.I.E.E., which is entitled *Principles of Semi-conductors*. Transistors are only one part of this book as they are, of course, only one example of semi-conductors but for the reader who wants to delve into technicalities more deeply this is of absorbing interest.

For the serious student who is thinking of taking up electronics as a career, and who knows something of the theory and the advanced maths associated with it, the Mullard *Reference Manual of Transistor Circuits* is of advantage. It was first published in 1960 by Mullard Ltd and has since been brought up to date. These books are useful for future reference. They may be available at your local public library.

We tackle our first constructional design (a simple receiver) in Chapter 3 but in the next chapter I give you some practical details about the types of transistor radio sets which can be made or bought.

CHAPTER 2

Introduction to Transistor Radio Receivers

Aerials and earths, pocket sets, types and cost, results and difficulties. The most effective receivers of vest-pocket size which do not require aerial or earth employ a superhet circuit. Small two-transistor earphone sets are very effective. Gilbert Davey picked up Radio Luxembourg strongly with one when on holiday in North Wales.

IT seems to be the ambition of every young person to own a transistor radio set which can be carried in the pocket, does not require an aerial or earth and will reproduce Radio Luxembourg at full loudspeaker volume! This is not a difficult matter and, later on, I will tell you about sets which can do it. Unfortunately, the cost is often stated to be limited to between 25s. and 30s. I am sorry to say that it just cannot be done at such a low price.

The simplest, and cheapest, transistor receiver consists of a germanium diode detector plus one transistor as an amplifier. This is similar to a crystal set with a one-stage amplifier which was popular in the early days of radio. There is the advantage with this type of receiver that it is simple to make; it is a good introduction to using transistors because cheap 'surplus' types may be used and no great cost is involved if one is damaged. Because of the use of such types a receiver of this design may be built for only a few shillings and, as we are not greatly concerned with 'miniaturization', inexpensive resistors and condensers of normal size may be used.

Now on the debit side the disadvantages are the input and the output for an aerial, and possibly an earth is essential. They, of course, are the input and for the output one must use headphones or, possibly, a small deaf-aid type earpiece, generally called a 'personal phone'.

If you want to try out transistors this is a good way of doing it because both the diode used in the 'crystal set' front end of the receiver and the transistor itself can be used for incorporating in a more advanced receiver as you progress. Most readers can put up a small aerial of some kind, even if it is only a wire around the bedroom; a small aerial is an advantage with this receiver. Since it has only the one tuned circuit it is not very selective and consequently the two 'local' transmitters are likely to interfere with each other.

A small aerial helps to keep this effect as low as possible; with a receiver of this nature you must always accept some compromise in the aerial to get the best length for both maximum reception and selectivity. In Chapter 3 I describe how you can build one of these diode-transistor receivers.

The receiver in Chapter 4 utilizes two transistors and two diodes and is called a reflexed design. This means that the first transistor amplifies the radio signals at high-frequency when they come from the aerial and then again at low-frequency after they have been rectified by a diode. The transistor used to do this must be one of the special high-frequency types which are a little more expensive than the ordinary L.F. pattern.

In this design we use a ferrite-rod aerial. This is a short piece of rod about half an inch in diameter which is made from granulated crystals of iron. The special construction of the rod gives it special properties for use in coils. You cannot use a piece of iron rod or tubing instead! With this ferrite-rod aerial you can receive signals without either aerial or earth but you must use an earpiece. There is no reason why you cannot try a small aerial as well, if you wish, but I think there is likely to be some difficulty in separating stations if you do.

These small two-transistor earphone sets are very effective. I took one on holiday to North Wales in 1963 and Radio Luxembourg came in regularly at fine volume. I expect the signals bounced down from the Heaviside layer conveniently at that point! On the other hand I had great difficulty in picking up the BBC Light programme. There are numbers of these receivers on the market in kit form and I will tell you more about them in Chapter 6. One or two more transistors are sometimes added to enable the output to be fed into a small loudspeaker but naturally all that adds to the cost.

The most effective receivers which do not require either aerial or earth, and can be of vest-pocket size up to full table-model specification, employ a superhet circuit; the type of output circuit, plus the size of loudspeaker used, govern the tone and volume obtained. There have been a number of designs for these in the radio journals in recent years, one of the earliest being the Portable Transistor Receiver described by S. W. Amos in *Wireless World* in 1957. Messrs Mullard give a few theoretical circuits in the reference manual already mentioned and there have been a number of designs in the popular constructors' journals.

Chapter 7 deals with one of these superhet kits for the home constructor while commercial receivers of the ready-made variety are described in Chapter 9. The next chapter is the first of those dealing with a practical design for you to construct and is of a simple receiver using a diode detector with one transistor. Before you begin work with transistors I am going to make one or two suggestions which I hope will assist you, particularly if you have been used to dealing with valves.

The first point to remember is that a transistor circuit seems 'upside-down' from what you have probably been accustomed to, as the negative line is shown at the top of the circuit and 'earth' line at its foot is positive. It is essential to remember the correct way round for transistors for if the voltage is reversed the transistor will be destroyed or severely damaged (we are dealing in this book only with p-n-p transistors). The connecting wires to the transistor should not be bent too close to the body of it. Fig. 2 indicates that 1·5 mm. at least, should be left, otherwise, if the wires snap off to where they are led out, the transistor is useless.

Transistors are sensitive to heat and, when soldering, it is essential (1) not to lean a hot soldering-iron against the body and (2) to make the connections to the wires quickly. Also a 'heat-shunt' should be employed to prevent the heat running up the connecting wire into the transistor. A good method of doing this is to hold the wire between the spot where you are soldering and the transistor body with a pair of pliers. These would absorb the heat and prevent it from running up the wire.

Usually transistor work involves very small components and it is essential to have a good hot soldering-iron so that the solder will run quickly. It is no use trying to make a 'sticky' joint by holding your warm iron against the component until the solder runs. It is far more likely that the small component will be destroyed by the heat. This reminds me that electrolytic condensers will also be destroyed if connected the wrong way round. They are often used in transistor sets as they are an effective means of obtaining a large capacity in a small size, but the positive side must always be connected to the positive side of the battery and likewise with the negative.

The positive side is indicated by a red marking or by a plus (+) sign; the negative is black and/or a minus (–) sign. Resistors have no polarity and may be connected either way round. Try to build one or two of the transistor-set designs; they are very simple and I think you will be surprised at the effective results. The first one, in the following chapter, is the diode and one transistor L.F. amplifier receiver.

CHAPTER 3

A Simple Transistor Receiver

Start with the forerunner of the transistor—the diode. For good results you need an aerial and an earth with this set, as well as some Lady Jayne hair-clips! A small 9-volt battery will last many months as only one transistor is used. This small crystal-type set is simple, and gives excellent quality reproduction.

I MAKE no excuse for introducing a diode into a book about transistors. It is the forerunner of the transistor and is made of the same basic material. In the case of the diodes and transistors dealt with in this book that material is germanium, although, as you will learn if you read M. G. Scroggie's book, there are some which use silicon. Diodes occur in all the transistor designs which we shall be discussing as they have become one of the most useful components in modern radio.

Take a look at Fig. 3 which is the theoretical diagram of a crystal receiver. This is very simple to build and the wiring diagram for it is shown in Fig. 5. The coil is home-made and quite easily wound; we make our own coils in this book because after specifying commercial makes in my earlier books I found that they were not readily obtainable in some parts of Britain or in other countries. In some cases the manufacturer gives up production of a particular coil after a year or so. Fig. 4 gives a diagram of the coil which is wound on a piece of ferrite rod. The latter assists in giving the coil its excellent efficiency.

To make it you need a ferrite rod four inches in length and three-eighths of an inch in diameter. You also require a small quantity of 28 standard wire gauge (s.w.g.) double-cotton-covered (d.c.c.) copper wire. This is the British size designation and if you live outside the United Kingdom you may well find it is called by a different gauge number. This you can check by the diameter of the wire which is 0·0148 in. If it is double-silk instead of double-cotton-covered it is unimportant. I have not tried enamelled wire for this coil but I cannot see that there is any objection to it. Try it if you have some. Nothing is ever lost by experimenting. The coil I am going to describe is for medium waves only but you can try a long wave addition to it if you wish and I tell you how to do this later.

Start by wrapping a thin piece of card or thick piece of paper round the ferrite rod to form a small tube about three inches long. The edge of the card or paper should overlap slightly and can be sealed with a thin piece of cellulose tape. Do not wrap it so tightly that it is prevented from sliding along the rod if required. To anchor the ends of the coil of wire I do not like using cellulose tape as it seems to come adrift after a time; so I make two small holes in the end of the tube and slide it off the ferrite rod. I make two holes with a large darning needle about ¼-inch apart and the same distance from the end of the tube.

Thread the end of the wire through these

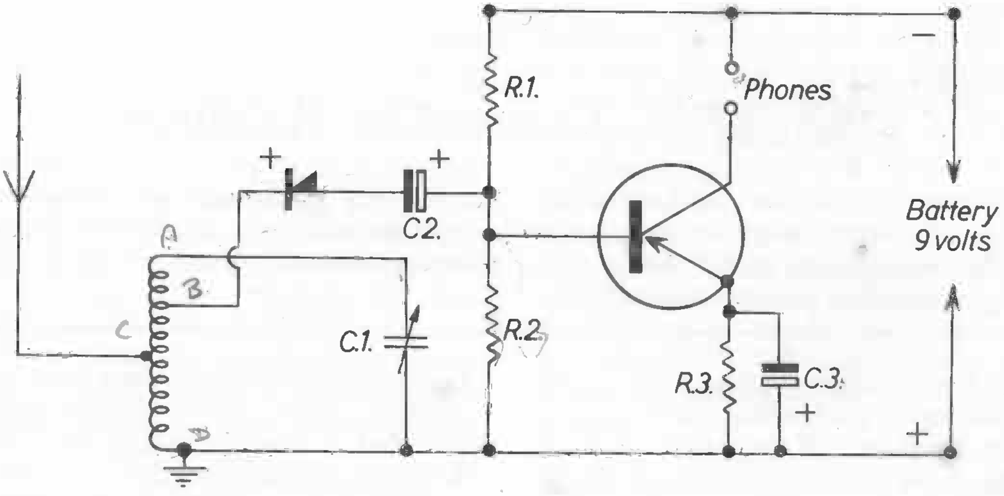


Fig. 3 Theoretical circuit of the diode/transistor receiver

holes so that they hold it tightly and allow about three inches free for connecting-up purposes. Wind ten turns carefully side by side on the tube (you will probably find it helps to insert the ferrite rod inside it again). Having wound on these ten turns, hold them with your thumb tightly and twist the wire once or twice so that it forms a loop. If you scrape the cotton covering off this you will be able to connect to the wire making a tapping point. That, however, comes later so you should now continue winding until you put on another fifteen turns.

Hold the wire with your thumb and twist it to form a second tapping point. This, in fact, will be a centre tap as you have put on a total of twenty-five turns and should now continue for a further twenty-five making fifty in all. The figure fifty is not very critical and if you miss a turn or two, or put on a couple too many, it is not important.

Slide the tube off the ferrite rod so that you can make two more holes with the darning needle close to where the winding finishes. Still holding it carefully with one hand, cut the wire so as to leave about three inches spare for connecting up and thread the three inches through the two holes to fix the end firmly. When doing all this, take care not to flatten the tube or to pull the wire so tightly as to prevent the tube moving along the ferrite rod if necessary.

This is the basic medium-wave coil and the connections to it should be quite clear from the theoretical and wiring diagrams. The aerial is connected to the centre tap and the diode detector to the tenth turn from the beginning. The beginning of the coil goes to fixed-vanes connection on the tuning condenser and the end of the winding, the fiftieth turn, goes to the moving-vanes connection of the tuning condenser and to earth. The complete coil is thus tuned by the tuning condenser. This set, as I told you in the last chapter, requires an aerial and earth, as the amplification given by the transistor is after the

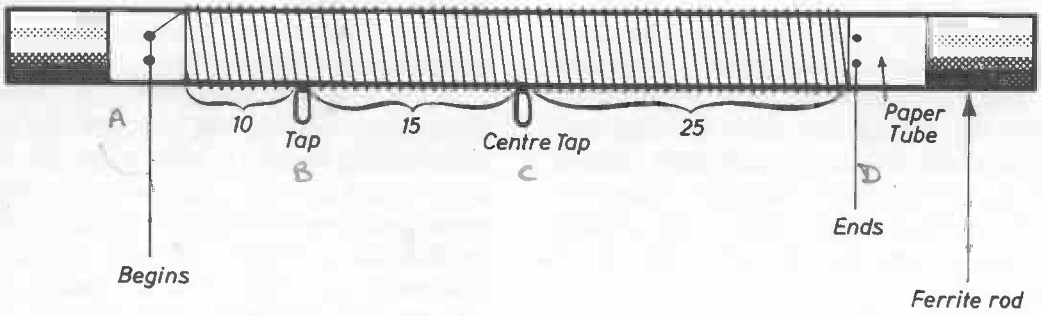


Fig. 4 The special coil for the receivers described in Chapters 3 and 4

diode detector and that cannot amplify but only rectify the signals received by the aerial.

My home is within ten miles of the BBC transmitter and I find that this receiver will bring in the Home programmes at understandable strength without an aerial or earth but it is not really designed to do this. If you want to try to receive long waves you can push the medium-wave coil to one end of the ferrite rod and make another small tube about 1½ in. long at the other end of the rod. Anchoring the ends as before, wind on to it 225 turns of 34 s.w.g. enamelled wire. You will need to obtain a small on-off switch to connect across this coil to short circuit it on medium waves and the two ends of the long wave coil should go between 'Ends' on the medium-wave coil and M on the tuning condenser. I have not tried this arrangement myself so cannot be certain it will work but it may be successful in your locality. In any case, a good aerial is always required for long-wave reception.

The set is built on a small panel of wood, hardboard or, ideally, Paxolin about 3½ in. × 2 in. but size is not very important. As you can see, it is quite small but you could build it in any box you may have to hand. There is just the one control, the tuning condenser, as I have not included any switch for the battery which is included to operate the transistor. There is room to add this, if you so wish, as well as a switch for long waves if you want to include such a coil.

Wiring presents no difficulty and soldering should be carried out quickly and with a hot soldering-iron so that it does not have to press on joints for too long. Look out for, and avoid, dry joints which appear well made but in fact will pull apart quite easily. The components are given in a special list and you will see among them two tag boards, one with five tags and the other with four. These are placed at the bottom and top of the panel respectively and are used largely to anchor the various components which are disposed between them. The second in from the left on the four-tag board is for the aerial connection and the similar tag on the five-tag board below is for the earth. I have not used terminals for these points as I think the aerial and earth wires are best terminated in crocodile clips which can be clipped on to the tags mentioned.

Mentioning clips reminds me to refer you to the last chapter regarding the need for care when soldering the diodes and transistors and the provision of heat shunts. I have found that an excellent way to do this is to use some large hair-clips (trade name, *Lady Jayne!*) which are on sale in most stores and are used by ladies for setting hair after shampooing. These clips are large and have strong springs which grip the fine transistor lead-out wires with their long double prongs. I have found them very useful indeed.

The component list mentions the transistor as being an OC 71 or OC 72 and either of these will work quite satisfactorily. The OC 72 is the slightly more expensive but it gave me slightly preferable results. If you have one or two transistors try them out carefully for best results. The so-called 'surplus' transistors work quite well in this set but I always find them a little more 'mushy' as regards noise than the better types.

When you have completed the connections, your receiver can be tested out and any battery from 1½ volts upwards will do to make it work. I found a somewhat run-down 9-volt PP4 gave me first-class results but a battery in poor condition does tend to make reception noisy. As you are only operating one transistor (the diode takes no battery current) a small 9-volt PP3 battery will last many months and a connector to suit it should be obtained. This is important as such connectors are matched to the battery to prevent the wrong polarity being applied

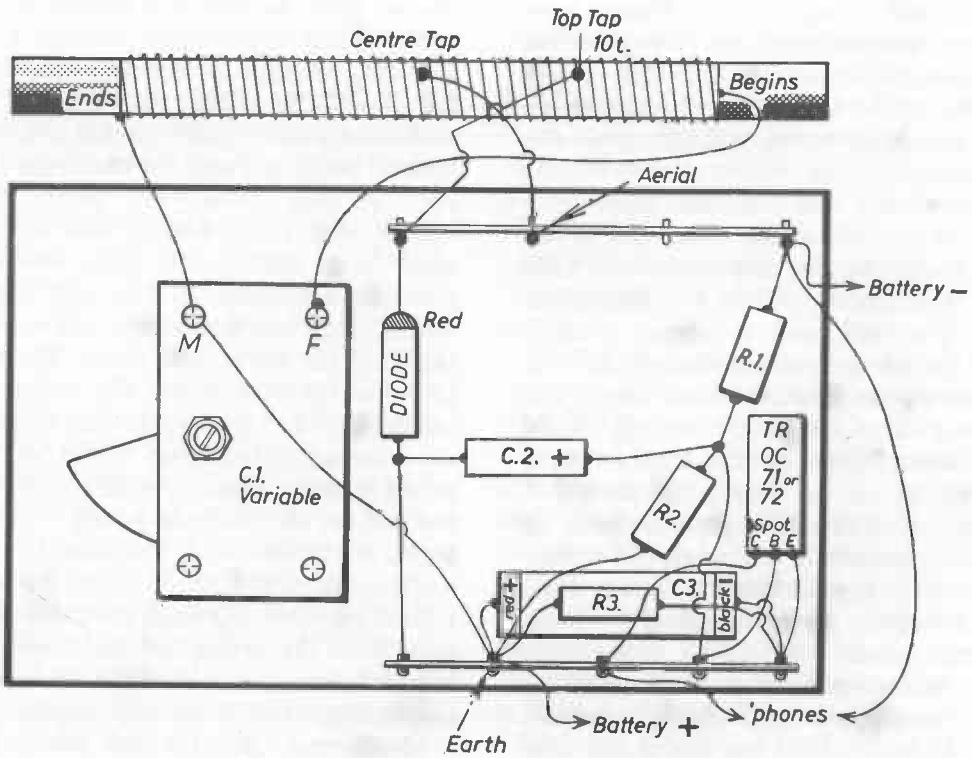


Fig. 5 Wiring diagram of the diode/transistor receiver

to the transistor. If the battery is connected the wrong way round the transistor can be destroyed.

I hope you enjoy making and using this simple little set which will give such fine quality signals. In the next chapter the set described is a pocket receiver which will operate without any aerial or earth and which can utilise the ferrite-rod aerial and other components of the receiver just described.

Component List

	s.	d.
Piece of Paxolin, thin card, etc., $3\frac{1}{2}$ in. × 2 in.	–	–
Ferrite rod 4 in. long, $\frac{3}{8}$-in. diameter	1	6
Small quantity 28 d.c.c. wire ..	–	–
Solid dielectric variable condenser (between 365 and 500 pF capacity) (C.1.)	4	0
Electrolytic capacitor 8μF 12 volt working (C.2.)	1	0
Electrolytic capacitor 25μF 12 volt working (C.3.)	1	0
Two tag boards, upright type, 1 × 4 and 1 × 5 tags	1	3
Resistors $\frac{1}{8}$- or $\frac{1}{4}$-watt size as follows: R.1. 39K.ohms, R.2. 10K.ohms, R.3. 1K.ohms. 3d. each ..		9
Germanium diode, type OA 81 (Mullard)	2	0
PNP junction transistor, audio type, OC 71 or OC 72 (Mullard)	7	0
Battery connector for battery (PP3 or PP4 as used)		6
Knob		6

Earphones or personal earpiece, nuts, bolts, solder, etc.

Prices quoted are approximate and were checked in late 1963. Alternative diodes and transistors equivalent to the quoted types can be used according to availability.

CHAPTER 4

A Pocket Transistor Receiver for Use with a Personal Earphone

Now you can build a very good pocket set which works well. It is built into a plastic cabinet and operates from a miniature personal earpiece. The ferrite rod aerial means that there is no need to bother about an aerial or an earth. Follow the instructions carefully.

THE small crystal-type receiver described in the last chapter is similar to one which I described in *Boy's Own Paper* in 1963. It follows the standard pattern for this class of receiver. The circuit is a basic one and it is only in variations of layout and coil used that one receiver can be different from the next. One of the reasons for describing the designs in this book is to enable readers to utilize them as a basis for experiment to try out components they may have on hand or to try the effect of using different types or values of components from those I have specified.

Similarly with the design in this chapter, the circuit is a basic one and the layout given here is much the same as the two-transistor receiver described in *B.O.P.* If you build it as specified, you will have a useful pocket receiver which works well, but if you prefer to use the circuit as a basis for experiment, go right ahead and do so secure in the knowledge that you can do no harm and will obtain much useful knowledge from the attempt.

It is useful for young readers to remember (and, perhaps, I may add, some anxious parents!) that transistors rarely need more than 9 volts to operate them. This voltage is obtainable quite easily and cheaply from batteries. Although later in this book I describe mains-operated units for transistor work, these are for the advanced experimenter and are not necessary for successful results with transistors. The 9 volts from the small batteries used can do no harm. In the set about to be described a battery pack which is $1\frac{3}{4}$ in. × $\frac{7}{8}$ in. × $\frac{1}{2}$ in. thick is used and this gives 9 volts and lasts for many months. Exactly how long, of course, depends on the amount of use the set receives. I have two receivers similar to that described. One has an EverReady PP3 in it and the other the Vidor T 6003. Both batteries have been in the receivers and used off and on for well over eighteen months with good service.

This small receiver is built into a plastic cabinet which is 4 in. × 3 in. × $1\frac{1}{2}$ in. deep and operates from a miniature personal earpiece. It employs a ferrite-rod aerial which obviates the need for an aerial and earth. Its extremely good sensitivity is due to a 'reflexed' circuit which uses two transistors and two germanium diodes. The transistors are of differing types, the first being an OC 44 which is called a radio-frequency (or r.f.) transistor and the second is an OC 71 which is an audio (or l.f.) transistor. Both these types are made by Mullard and I always use and specify their transistors; the firm is genuinely interested in the home constructor and the difficulties which he experiences from time to time. Their products are of a uniformly high standard of quality.

There are many other makes of transistor on the market and I suppose that every manufacturer of valves makes transistors as well. There are also foreign makers and I am sure many of my overseas readers will know those made by the Japanese who have made transistors and their associated products a speciality. They seem to be of very good quality and many are available in Britain. In particular, I cannot recollect having seen a personal earpiece of the crystal type which was not made in Japan! If the specified parts are not available in your part of the world exactly in the types described, I am sure you will have no difficulty in obtaining equivalents in other makes.

The transistors *must* be of the differing kinds which I have mentioned and all other parts should be readily available. I have, in any event, given in the Appendix the names and addresses of suppliers whom I have used, and I am sure they will be able to send parts by post to anywhere in the world. These transistor receiver components are very small and light and can, without doubt, be posted anywhere very easily.

The list of parts required for this pocket receiver is given elsewhere in this chapter and how they are combined into a receiver is shown in the theoretical circuit in Fig. 6. You will see that each component has been given a reference

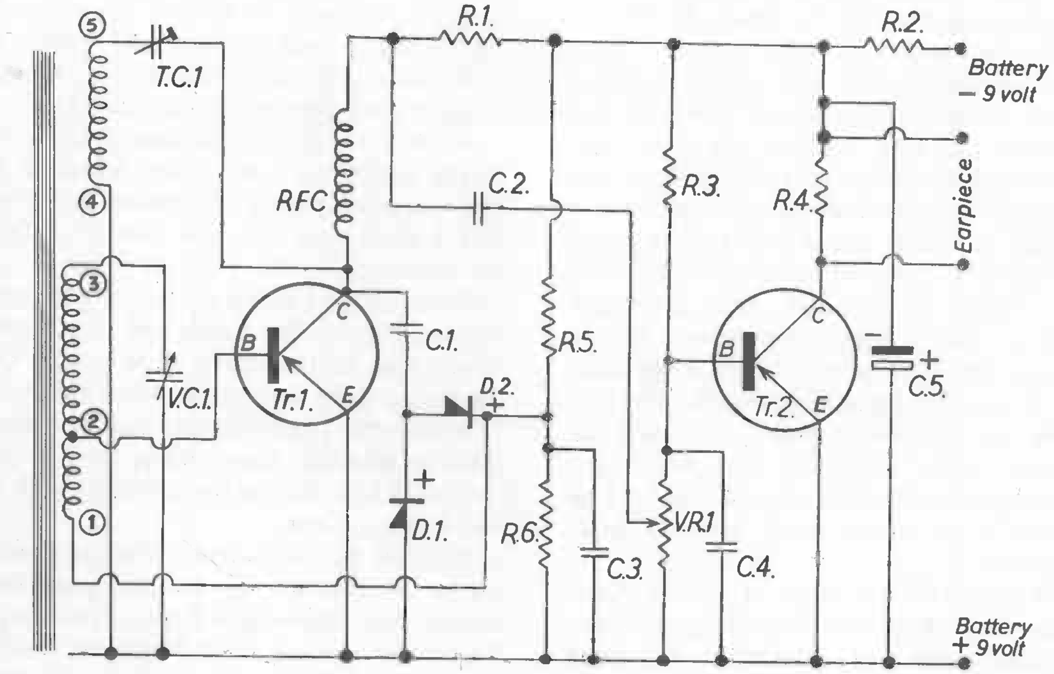


Fig. 6 Theoretical circuit of the two-transistor pocket receiver

letter and number which corresponds with the details in the list. The coil is the same as that used for the crystal diode-transistor receiver described in the last chapter but it has one small winding added; this extra winding is shown between Figs. 4 and 5 on the diagram and is for the provision of feedback.

This feedback is controlled by the small trimmer shown as TC1 and details regarding the adjustment of this are given after the set has been built. To begin with, therefore, I will tell you how to make the coil. If you have not already constructed the crystal set and thus have a coil already available you must refer back to Chapter 2 and make it according to the instructions there with one exception. The centre-tap is not required (this set has no aerial to attach to it) and you can wind straight on forty turns after the ten-turn tapping without bothering about the tapping point at the twenty-fifth turn.

If you are using a crystal-set coil you have already made ignore the tapping point simply by pushing it down as flat against the coil winding as you can. Taking your ferrite rod with its aerial coil in place you must now wrap a small piece of stiff cartridge paper about 1½ in. long round it to form a further small tube on the outside of the coil. One difference here is that it must be wrapped tightly round the d.c.c. wire. There is no need for it to slide up and down like the first tube on the ferrite rod. It should be placed right alongside the tenth-turn tapping point and the edge of it should be sealed down with a small piece of cellulose tape.

Wind on seven turns of the 28 d.c.c. wire starting at the end closest to the tapping point and winding in the same direction as the larger coil. In view of the danger of piercing the cotton covering and short-circuiting the wires there is no need to anchor the ends of this small coil with holes as before, and it can be kept in position with a few small pieces of the cellulose tape.

Now you have a ferrite rod with two coils wound on it, one above the other, and four lengths of wire and a tapping-point which must be identified so that you know how to connect to them. This I will describe to you now. I refer you to the two diagrams in Figs. 6 and 7 and in which you will see the coil has been numbered. The beginning of the larger winding is numbered (1) and the tap at ten turns is (2). The end of that larger winding is (3). The beginning of the smaller winding, i.e., the wire nearest the tapping point, is (5) and the end of that smaller winding is (4). It is difficult to be too hard-and-fast about this smaller winding as if you have trouble in obtaining satisfactory feed-back, described later, it may be necessary to reverse the ends of this winding and connect (4) where I have shown (5) and vice versa. That, however, is a matter for experiment.

As well as giving you theoretical and wiring diagrams, I have also included a point-to-point wiring description in words and I think you will find this simplifies the construction for you. It follows the order in which I wired up the set and you will see it leaves the diodes and transistors to the end, so that there is no danger of damaging them with a hot soldering iron. It is important to remember that heat can quickly damage these items and it is necessary to solder to them quickly with a hot soldering-iron.

NEVER use warm irons which are held on to components for minutes until the solder runs. Damage is done in that way. The solder to use is Ersin Multicore which has cores of flux inside it; the iron I use myself is the Solon 25-watt instrument model. It is a light, neat iron with a

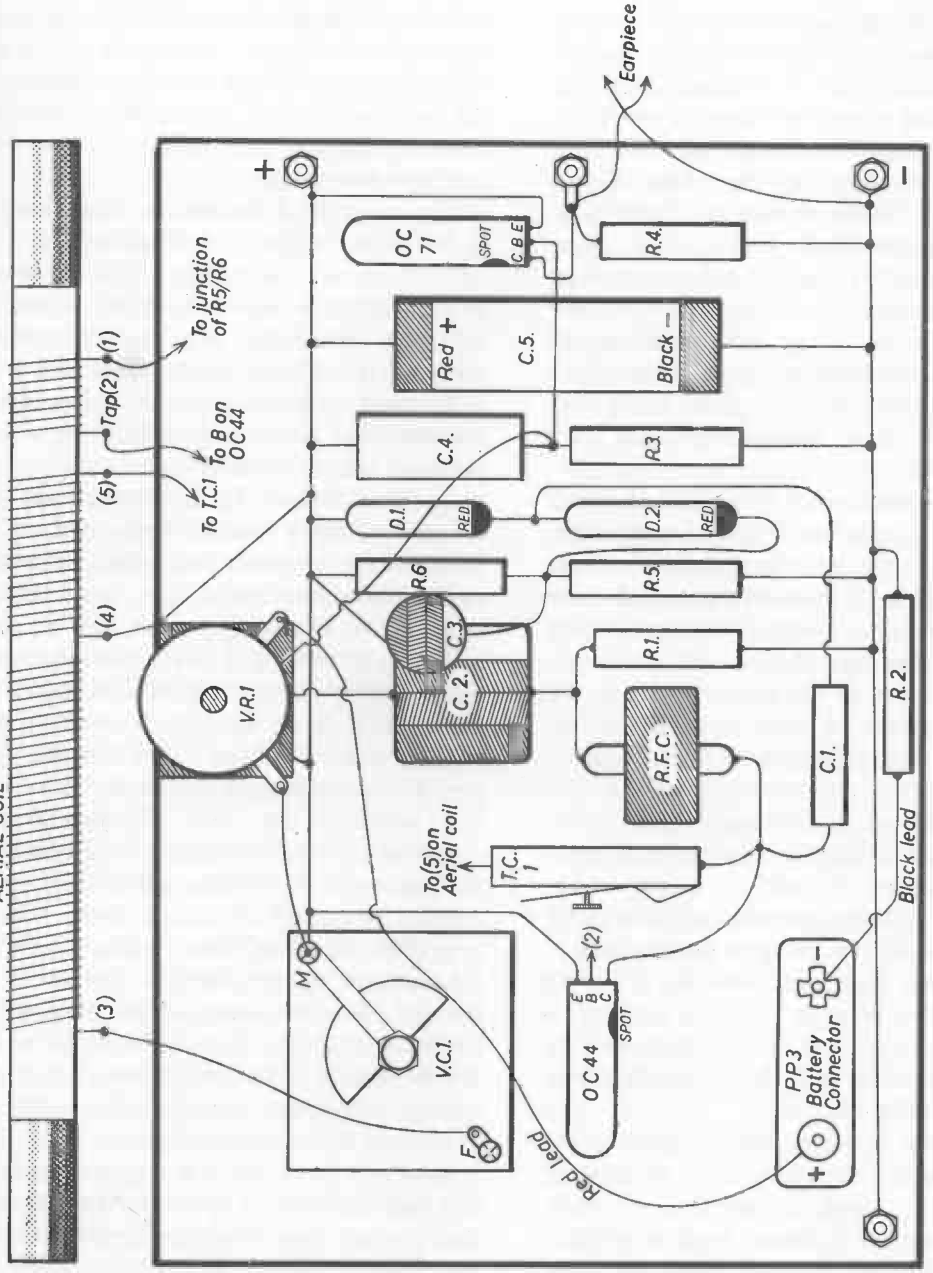


Fig. 7 Wiring diagram of the two-transistor pocket receiver

small bit which heats up quickly. Constant soldering does eat away the copper bit in time but it is replaceable quite cheaply although you may like to try the special 'Savbit' solder which is specially made to avoid burning away the bit too quickly.

You also require a small piece of fine sandpaper to clean up the ends of the components before soldering them, and are almost sure to find that they are a little too long for neat work and require to be cut to size. A handy tool for this, as well as for stripping the insulation off the ends of connecting wire, is the 'Bib' wirecutter and stripper also made by Ersin. It is quite inexpensive and very useful indeed.

I have mentioned overheating and damaging diodes and transistors: too much heat can also harm other components such as condensers and resistors. In particular the latter are very small and easily overheated through an overlong application of the soldering-iron. In regard to values, I have quoted, in the component list, the standard British markings for those resistors painted in the modern manner with rings. You may also find a further ring after the ones indicated either of gold or silver. This additional marking shows the 'tolerance' of the resistor. In modern mass-production methods it is not possible to make every resistor exactly to the resistance which it is supposed to represent and in most radio work a little inexactitude in this way is of no account.

Sometimes, however, as in high-fidelity amplifier work, it is necessary to have a resistance as close as possible to that specified and all resistors have a certain rating off the figure which they are supposed to be. The ordinary unmarked resistor can be as much as 20 per cent above or below the figure it represents. Those marked with a silver ring are only 10 per cent off the true figure and the gold-ringed ones are 5 per cent above or below. It is possible, at extra cost, to buy resistors only 1 per cent off their marked resistance. For the purposes of the designs in this book, however, the ordinary 20 per cent tolerance type will be quite adequate.

The receiver described in this chapter is built on a piece of Paxolin, or thin hardboard, or even thin plywood, such as the side of a tea-chest. It must not be built on metal but any thin insulating material is really suitable. The first task is to mark out this panel by cutting out a small piece in the top centre of it where you can see it is shadowed on the wiring diagram. This is to accommodate the volume control switch and you must judge for yourself, according to the component you have, just how much needs to be cut away.

The position of it also must be considered in relation to the cabinet used and as I cannot know exactly the sizes of the items you are likely to buy, I can only say you will have to manipulate them to find for yourself the best position. The diagram shows the layout according to the parts which I used myself. The volume control switch which I used, and I believe it applies to all of them, certainly to all I have seen, is attached to the panel by two of its outer tags, which have small holes in them to accept 10 B.A. bolts. When you buy the component you must ensure that it has the two nuts and bolts of correct size supplied with it.

I do not think there is anything more I can usefully tell you apart from suggesting that you are now ready to proceed to wire up the set. Wire used where necessary should be insulated and I have found that the small lengths of insulation which you pull off to bare the ends for connecting purposes are very useful for insulating the wire ends of transistors or resistors.

The components must *not* come higher than the tops of the three bolts (if you are going to put the set in the cabinet specified) but there should be no trouble on this account. I found they fitted in quite flat and close to the panel. The transistors can be wired in an upright position and afterwards bent over gently so that they come within the height limit prescribed.

The PP3 battery stands on edge at the bottom left-hand corner so care must be taken to leave room here for it. Great care must be taken to avoid short-circuits and in particular the ferrite rod must be so positioned that neither it nor its connections make contact elsewhere.

The ferrite rod is metal so will naturally 'short out' any points it is allowed to contact; you may like to adopt my plan and cut out a strip of thin plastic (cut from a food bag) to lay under it to keep it insulated from the surrounding parts. The connections to the ferrite-rod aerial coil should be fairly short and taut, to keep the whole arrangement in place lying above VR1.

When the wiring is finished, the set is ready for testing and the battery can be connected to its special connector. You will observe that each terminal is different to prevent a mistake in connection. As you know, transistors can be destroyed if the battery is applied to them incorrectly. Place the earpiece comfortably in your ear and switch on, turning up the volume about halfway.

The condenser (VC 1) may be turned slowly and possibly a station will be heard. If nothing is heard but a loud whistle, the set is oscillating and the control screw in the centre of TC 1 should be slackened off so that the plates open; the oscillation should then cease. The screw should be so tightened up that there is no oscillation anywhere when the tuning dial is turned, but volume should be increased greatly when it is correctly set.

A certain amount of adjustment will help you to get the best results out of the receiver. If you can obtain no oscillation whatever it is possible that the connections to (4) and (5) on the small coil should be reversed and you can try unsoldering them and changing them round. You will notice that the aerial is directional and works best when it is pointing toward the transmitter. This property is useful in assisting to separate two mutually interfering stations, provided that they are not both in the same direction!

I hope your receiver works well. If you find it does not, check very carefully with the wiring instructions and diagram until the fault is apparent. I use this same set as a basis for the one described in the next chapter which has an additional transistor and which will work a small loudspeaker.

Component List

	s.	d.
VC 1. Transistor tuning condenser solid dielectric about 200 to 365 pF	3	6
TC 1. Trimmer, adjustable, size about 50 to 60 pF	1	0
C.1. 200 pF fixed condenser ..		3
C.2. 0.1 μF „ „ ..	1	0
C.3. 0.01μF „ „ ..		6
C.4. 0.01μF „ „ ..		6
C.5. 25 μF „ „ electrolytic 12 or 25 v.wkg.	1	6
R.1. 3.9 K.ohms resistor: marked: orange/white/red		3
R.2. 1 K.ohm resistor: marked: brown/black/red		3
R.3. 220 K.ohms resistor: marked: red/red/yellow		3
R.4. 4·7 K.ohms resistor: marked: yellow/purple/red		3

R.5. 100 K.ohms resistor: marked: brown/black/yellow		3
R.6. 5.6 K.ohms resistor: marked: green/blue/red		3
VR1. 5 or 10 K.ohms miniature volume control with switch ..	3	6
Tr.1. Transistor OC 44 by Mullard Ltd	9	3
Tr.2. Transistor OC 71 by Mullard Ltd	8	0
D.1. / D.2. Germanium diodes type OA81 by Mullard Ltd., each	1	6
RFC Radio frequency choke; medium-wave type	1	0
Ferrite rod and wire 28 s.w.g., d.c.c.	1	3
Earpiece, crystal type	5	0
Cabinet: Ranger III plastic box by Henry's Radio	3	0
Dial, battery connector, solder, battery, etc.	3	6

Prices given are approximate and are those operating in late 1963. They may vary from place to place and in different countries.

Note that K = kilo = 1000: thus 3·9 K.ohms = 3900 ohms.

Point-to-point wiring connections for Receiver described in this chapter

1. Mark out and cut out Paxolin panel as Fig. 7 (see text).
2. Mount the volume control/switch VR 1.
3. Mount the tuning condenser VC 1.
4. Fix three 1⅜-in. long 4- or 6-b.a. brass bolts at top right, bottom left and bottom right corners of the panel looking at it from the rear, i.e., in accordance with Fig. 7.
5. Fix solder tag by means of a small 6-b.a. bolt centrally between the two long bolts on the right of the panel (see Fig. 7).
6. Take some bare tinned copper wire and run two lengths as follows:
   (i) between the solder tag connector of moving vanes on VC 1 and the bolt at top right of board.
   (ii) between the two bolts at the bottom edge of the panel.
   The end of the top wire is soldered to the tag on VC 1 but all connections to bolts are made by making a small loop in the end of the wire around the bolt and then running on a washer and another bolt which is tightened up.
   The top line as at (i) above is positive and the top right bolt should be marked + with a nail or screwdriver. Similarly that at the bottom right should be marked — as the lower line is negative. (Fig. 7 will make this clear).

The soldering iron is now required to make the following connections using Multicore solder. So solder as follows, ticking off each item as it is completed:

7. M (moving vanes) on VC 1 to the left-hand tag of VR 1. This is the tag nearest to VC 1 and is the tag bolted to the panel.
8. The next tag on VR 1 (i.e., second from left) to positive line.
9. One end of R.4 to negative line.
10. Other end of R.4 to solder tag between the two right-hand bolts.
11. Black end (or end marked —) of C.5 to negative line.
12. Red end (or end marked +) of C.5 to positive line.
13. One end of R.3 to negative line.
14. One end of C.4 to positive line (+ end if electrolytic condenser).
15. Other end of R.3 to free end of C.4.
16. One end of R.5 to negative line.
17. One end of R.6 to positive line.
18. Other end of R.5 to free end of R.6.
19. One side of C.3 to + line end of R.6.
20. Other end of C.3 to junction of R.5/R.6.
21. One end of R.1 to negative line.
22. One end of C.2 to centre tag on VR 1.
23. Free end of R.1 to free end of C.2.
24. One end of RFC to junction of R.1 and C.2.
25. Free end of RFC to one end of C.1.
26. Moving plate of trimmer TC1 to junction of RFC and C.1.
27. Fourth tag on left on VR 1 (only free tag) to junction of R.3/C.4.
28. Red wire (Positive +) on battery connector to right-hand tag on VR 1 (i.e., tag bolted to panel).

29. Black wire (negative —) on battery connector to one end of R.2.
30. Free end of R.2 to negative line.
31. One end of earpiece lead to one side of R.4.
32. Other end of earpiece lead to other side of R.4.
33. Plain end of D.1 to positive line.
34. Red end of D.2 to junction of R.5 and R.6.
35. Plain end of D.2 to Red end of D.1
36. Free end of C.1 to junction of D.1 and D.2.

Use heat-shunts on all diode connections (items 33–36)

37. Join (3) on ferrite rod aerial winding to F (fixed tag on VC 1.
38. Join (4) on ferrite rod aerial winding to positive line.
39. Join (5) on ferrite rod aerial winding to fixed plate on TC 1.
40. Join (1) on ferrite rod aerial winding to junction of R.5 and R.6.

We are now concerned with completing the receiver by soldering the transistors in place. The iron must be hot and applied quickly and heat-shunts must be used on all transistor-connecting wires. A small piece of insulating sleeving should also be placed on each such wire but not of such length as to impede the effectiveness of the heat-shunt.

Carefully and quickly solder:

41. 'E' on OC 44 to positive line.
42. 'B' on OC 44 to (2) on ferrite rod aerial winding.
43. 'C' on OC 44 to junction of C.1, TC 1 and RFC.
44. 'E' on OC 71 to positive line.
45. 'B' on OC 71 to junction of C.4 and R.3.
46. 'C' on OC 71 to central soldering tag at end of R.4.

The battery may be connected to the connector, making sure it is the correct way round and the receiver is ready for testing.

CHAPTER 5

How a Loudspeaker Can Be Added to Earlier Designs

We show you how the reflex circuit can be built into a receiver for loudspeaker reception in two ways. Then outstanding loudspeaker results can be obtained in several ways. As you gain in experience you can experiment for yourself—it's fun finding out!

As we have already seen, the difficulty you are most likely to encounter with the simpler type of receiver is the selectivity problem, the power to separate one station from another. If this difficulty is met in one of the less powerful receivers, it will only be magnified if amplification is added to a receiver in order to work a loudspeaker.

Improving the selectivity often means cutting down the signal fed into the receiver and also cutting down the output. In the crystal receiver described in Chapter 3 this can be done by pruning the size of the aerial used, though this often results in considerable loss of signal. The same effect can be produced artificially by adding a variable condenser in the aerial circuit. It should be of about ·0002μF capacity and can be a compact, solid, dielectric type.

In the circuit given in Fig. 3 the condenser goes between aerial and centre-tap by connecting the aerial to its 'fixed' terminal and a short piece of wire from its 'moving' terminal to the tap. Variation of the condenser will sharpen the selectivity but also reduce the volume.

A very successful design for a small loudspeaker transistor receiver was the *Three Dee*, published by Repanco Ltd. This consisted of a germanium-diode detector coupled to a transistor amplifier. The selectivity problem was very well overcome by use of a 'band-pass' arrangement using two of Repanco's DRR 2 coils. I show you this circuit in Fig. 8. This could be made into a very useful receiver provided there was no objection to erecting some form of aerial and earth. The two DRR 2 coils are tuned for the sake of simplicity and maximum efficiency by two separate tuning condensers rather than by a ganged-condenser. Solid dielectric types would be in order and the capacity of each should be ·0005μF.

The output from the diode could be fed into the amplifier described in Chapter 8 and would result in a first-class radio receiver. The *Three Dee* kit was very popular and may still be available. The diode was followed by three transistors in a simple circuit, and a single transistor output stage was used. This did not give as great a volume as the push-pull arrangement in the amplifier described later, but was quite useful for listening in a quiet room or a bedroom.

The reflex circuit described in the last chapter has generally assumed the popular lead among simple receivers, mainly, I suppose, because the special R.F. transistors required are now available at reasonable cost and also because there is no need for an aerial and earth. This form of circuit can be built into a receiver for loudspeaker reception in two ways.

Firstly, the basic circuit of Fig. 6 can have another transistor added to it and this should be an OC 72. The method of adding this is to disconnect the earpiece leads from the two sides of R.4 and take the output from R.4 into a further stage similar to that which provides the amplifier for the crystal set in Fig. 3. Connect the junction of the collector lead on Tr.2 and R.4 (in Fig. 6) to the negative side of an 8μF electrolytic condenser (12 v. wkg.). Join one end of a 39 K.ohms resistor to the negative line and join its other end to a 10 K.ohms resistor. The other end of the latter resistor goes to the positive line.

The positive end of the 8μF condenser is now soldered to the junction of the two resistors and the base connection of the OC 72 transistor also goes to the same point. The emitter lead of the transistor goes to one end of a 1 K.ohms resistor and also joins the negative side of a 25μF electrolytic condenser (12 v. wkg.) to the same point. The other end of the 1 K.ohm resistor and the positive side of the electrolytic condenser both join to the positive line. All that is needed is to wire either a suitable output transformer between the collector of the transistor and the negative line or a special transistor speaker which has a high impedance.

The highest impedance types I have seen among transistor speakers have one of 75 ohms and this should work satis-

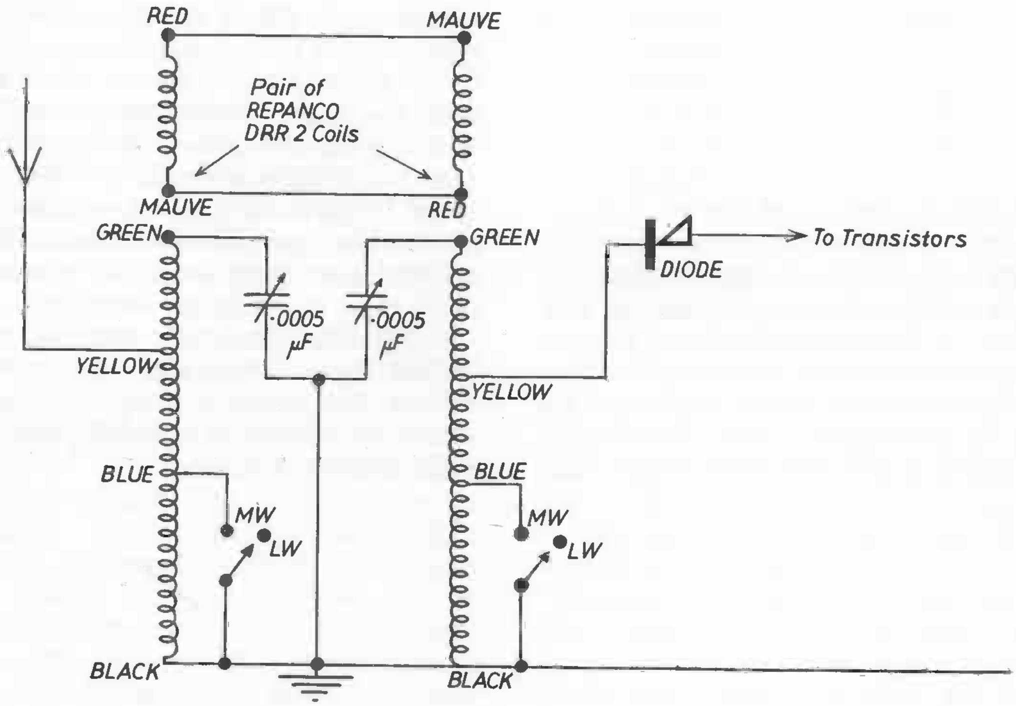


Fig. 8 **Bandpass tuning arrangements of *Three-Dee* transistor receiver designed by Repanco**

factorily, although the ideal impedance for proper matching is 120/140 ohms. The transformer should be purchased with a correct ratio to match any loudspeaker which you have. The addition of this stage should provide good loudspeaker results from the set described and using the home-made coil but, as suggested, the selectivity may be rather less, in some localities, than one would like.

I have found the coil for the ferrite rod aerial which is used in the Henry's Radio *Ranger III* to be a very selective one and you may like to buy one to try. The complete ferrite rod assembly costs 6s. (December 1963). You may find its extra selectivity causes a slight drop in signal strength. The Henry's coil has coloured ends which compare with the home-made coil numbers as follows:

Home-made coil No.	**Henry's coil colour**
1	White
2	Brown
3	Green
4	Red
5	Yellow

As far as reversing the connections to (4) and (5) is concerned, in the event of no oscillation at first, the same conditions would apply to changing round Red and Yellow on the other coil.

Another method of obtaining first-class loudspeaker results would be to use Tr.1 and the two diodes of the reflex receiver as in Fig. 6 and feed their output into the amplifier in Chapter 8. Build the receiver as far as C.2/VR1/C.4 with C.2 connected to the slider of VR1 and C.4 across VR1, the lower end of them both being connected to the positive line.

Now look at Fig. 14 and disregard R.1, RV.2, C.1, and R.4. By disregard I mean disconnect them if you are working on an amplifier you have already built; do not obtain them at all if you are building a complete receiver. Connect the top end of VR1/C.4 to the base of the OC 71 in Fig. 14 in place of R.4 which is shown there. You now have signals led through C.2 of Fig. 6 into VR1 which will control the volume and will feed the signal into the base of the first transistor in the amplifier. From there on the amplifier is as shown in the diagram.

This should make a very effective receiver but you need a certain amount of experience to put it together. For this reason I have given a suggested combination of the schematic diagrams which will help the more experienced readers to carry out their own ideas and experiments with the circuits concerned. Never be afraid to experiment. That is where so much of the interest in home-construction is found apart from the immense educational value of finding out for yourself.

In the next chapter we continue with further ideas. There are, for instance, one or two receivers using transistors which you can buy as complete ready-to-make kits if you wish.

CHAPTER 6

Commercial Transistor Kits

If you buy a kit, make absolutely sure that it will do what you expect of it at the place where it is going to operate. Value for money is the only way to judge a commercial kit.

In Chapter 2 I told you something about the different types of transistor receivers available. In this chapter I am going to mention a few kits which are available in the radio shops today and which I have tried out for myself. If any kit I mention is not readily available at the time you read this, there is no doubt that the firms mentioned will have something to supply which is as good or possibly even better. The progress of transistor radio is very rapid!

I am indebted to suppliers who have gladly helped me with the loan of kits which I have made up and tested. Their names are included here and I have quoted full names and addresses in the Appendix so that you can write to any whose products interest you.

In preparing this book I had an interesting correspondence with Mr John Bull, a well-known radio dealer who is now Managing Director of Messrs Electronic Precision Equipment Ltd. This firm is well-known and their products are of excellent quality. Mr Bull sent me lists of a whole range of receivers from solderless ones at 37s. 6d. to full-scale kits for eight-transistor sets costing around £10. I am sure you would be interested in these lists and I suggest you write for details direct to Electronic Precision Equipment Ltd. (Please do *not* write to me for literature!)

An interesting kit which I made up came from Messrs Clyne Radio Ltd and was called the *Courtesan*. It consisted of a three-transistor set, plus two diodes, and operated a small loudspeaker. This was a reflexed circuit, not a superhet, and it covered both medium and long waves using a ferrite rod aerial. It is not exactly built up on a printed circuit board but on a special Paxolin board which has rivets and solder tags already fixed in place. These are in the correct positions for soldering in the components; full details are given in a very comprehensive booklet of diagrams and connections. Components are fixed to both sides of the board and the whole receiver, including the small 2½-in. loudspeaker, fits into a compact pocket-sized case which has a metal carrying handle across the top.

If the components are purchased separately, the cost works out at less than £5, but if the whole kit is purchased at one time Messrs Clyne Radio Ltd offer a special inclusive price of £3 3s. This kit is very good value at that price, which applied in December 1963.

Another kit I have tried is the *Ranger III*, which is one of the well-known Ranger series supplied by Messrs Henry's Radio Ltd. This is a small set in a plastic case, 4 in. × 3 in., which is supplied with a small personal earpiece. This will drive a loudspeaker very well. Instructions are, in fact, given in the constructional leaflet advising on how an external loudspeaker may be added.

I found that the aerial assembly (which is for medium waves only) has been designed carefully for selectivity, and separates the local stations well. This is important in an earphone receiver as a background of another station can be most annoying. There is no doubt that this selectivity is assisted by the fact that an air-dielectric tuning condenser is used in this receiver though this does add to the cost somewhat.

This receiver also employs three transistors and two diodes and is very simple to assemble. A Paxolin board is supplied with tags riveted into it and connections are made on one side only in accordance with fifteen steps listed in the instruction sheet. A special feature is the employment of transistor holders so that no direct soldering is done to the transistors and there is thus no chance of damaging them. This well-designed little set is very good value for an outlay of less than £4.

One of the best kits I made up and tested was a very inexpensive one costing £1 1s. and supplied by Messrs Lasky's Radio Ltd. It is called the *Beta II* but if this design is not available, there are other designs equally good and as reasonable in price in Messrs Lasky's list. This small set employs a ferrite rod aerial which

Fig. 9 **The *Murphy* B 812, a seven-transistor portable receiver with two crystal diodes**

Fig. 10 Attractive Claire Tarrant tries out her *Bush* seven-transistor TR.106

you make yourself (all wire supplied) and it utilizes a printed circuit which makes construction easy. Although it only has two transistors with two diodes it is remarkably sensitive and brought in Luxembourg with remarkable consistency when used in North Wales.

The receiver is built into a small plastic case shaped like a suitcase with a handle on top and is switched on by inserting the plug attached to the earpiece provided into the jack-socket. The PP3 battery in my own version of this set remained unchanged for well over a year despite frequent use. This is a very good and cheap little receiver.

These are just a few of the simpler and cheaper kits which are available and which I can recommend personally. There are others of which I have no personal knowledge but I can only repeat what I said in an earlier chapter. If you are thinking of buying a kit be sure it will do just what you want at the place where you want it to operate. See that you get value for your money. As far as the larger and more expensive kits are concerned, I have given details of the *Osmor* superhet in Chapter 7; a number of these larger kits are also available from dealers who advertise in the radio journals.

A notable one which I had the pleasure of testing was supplied by Messrs Daystrom Ltd. This kit was supplied complete with a leather case; it looked excellent when made up, and its sound matched this appearance. It cost, as a kit, about £12. If you are interested in buying a kit to make up, I suggest you study the advertisements in *Wireless World.*

CHAPTER 7

Transistor Superhetrodyne Receivers

If you intend to build a superhet transistor receiver, you must have it aligned properly or selectivity will suffer. One firm will test your receiver for you and align it, correcting all faults for a nominal charge.

MOST readers will know that receivers in use today, whether used for normal broadcasting, television, VHF or short-wave reception, employ what is called a supersonic-heterodyne (superhet) circuit. I am referring now to receivers which are commercially available. We who experiment with radio use other designs, usually simpler ones such as those described in earlier chapters of this book. Now these simpler circuits have both a particular advantage and disadvantage which, from the amateur's point are view, are exactly reversed in the superhet type of design.

On the great majority of wavebands in use the main problem is that of selectivity. There are so many powerful transmitters pouring out information, entertainment and propaganda into the ether that they tend to interfere with one another and create all kinds of reception difficulties. The simpler receiver has just one, or perhaps two, tuned circuits. If it is at all sensitive, it is quite unable to cope with the problem of separating the transmitting stations.

The difficulty is overwhelming where two powerful local stations are concerned as they are both liable to be received together. That is the disadvantage of the non-superhet receiver and, conversely, the advantage of the superhet, which can be made much more selective. The disadvantage of the superhet form of receiver is that to take full advantage of its powers—indeed, often to get it to work at all!—it is necessary to have it aligned properly. This means a good deal of apparatus and knowledge of technique which makes the novice and average experimenter fight shy of building superhets.

On the other hand the simpler set will work very well without any complicated trimming and 'lining-up'. The manufacturer of ready-made sets can line up his sets before they leave the factory and fix the alignment in place by suitable means, which is a great advantage.

All this means that if you are going to buy a superhet transistor radio kit you must ensure that the finished receiver is lined-up properly. It is no use thinking you can do it yourself by trial-and-error methods. I find that system quite unsatisfactory. The use of a signal generator is necessary. There are a few of these kits on sale at varying prices. All are based on the same superhet circuit which has been developed for transistor use.

Prices of these kits vary from around £6 to £12 for the kit, including the case, if any. When made up and properly aligned, the resultant receiver is as good as, or even better, than its commercial counterpart, mainly because these kits employ printed circuit boards. These

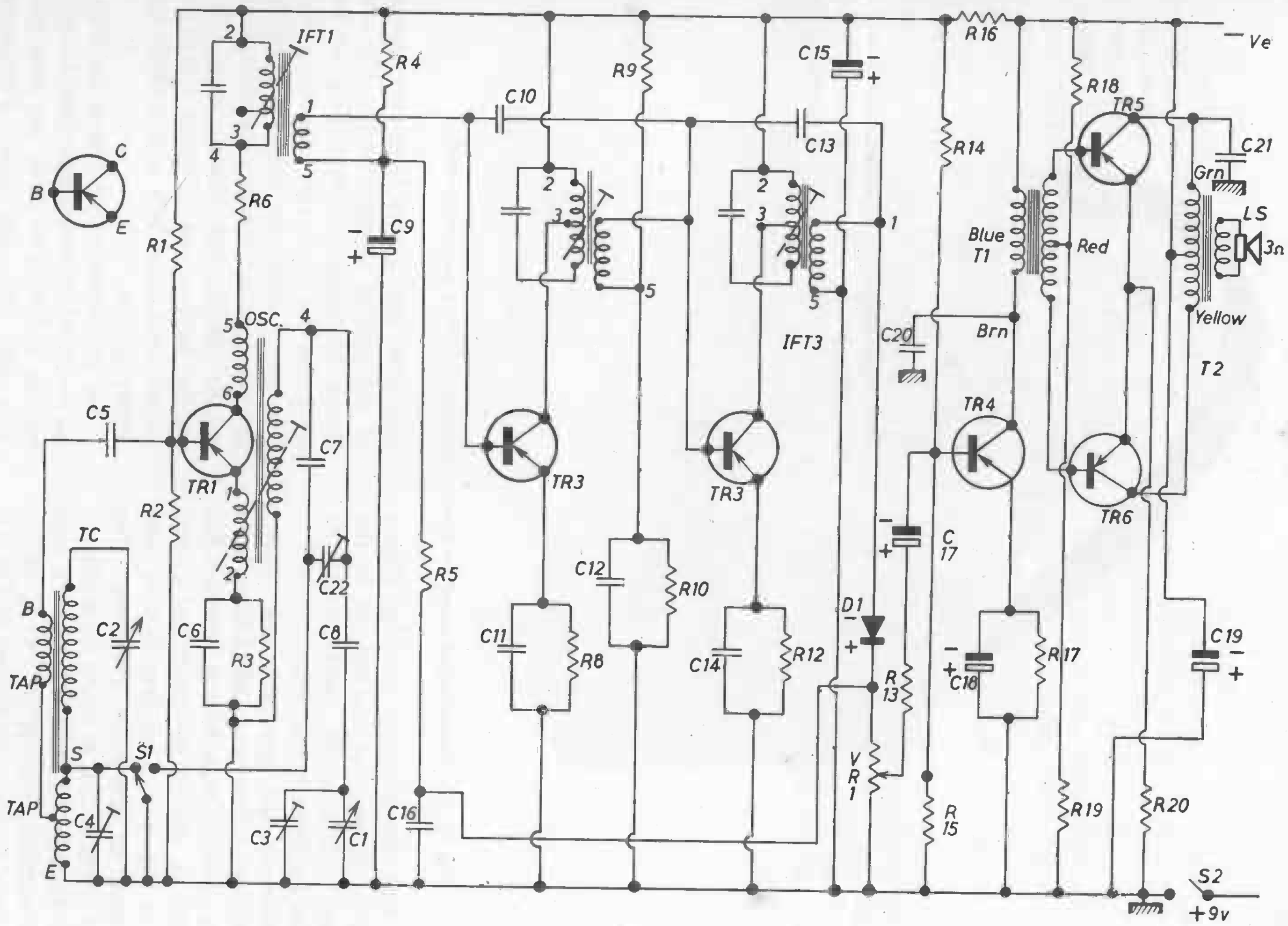


Fig. 11 Theoretical circuit of the *Osmor* transistor superhet receiver

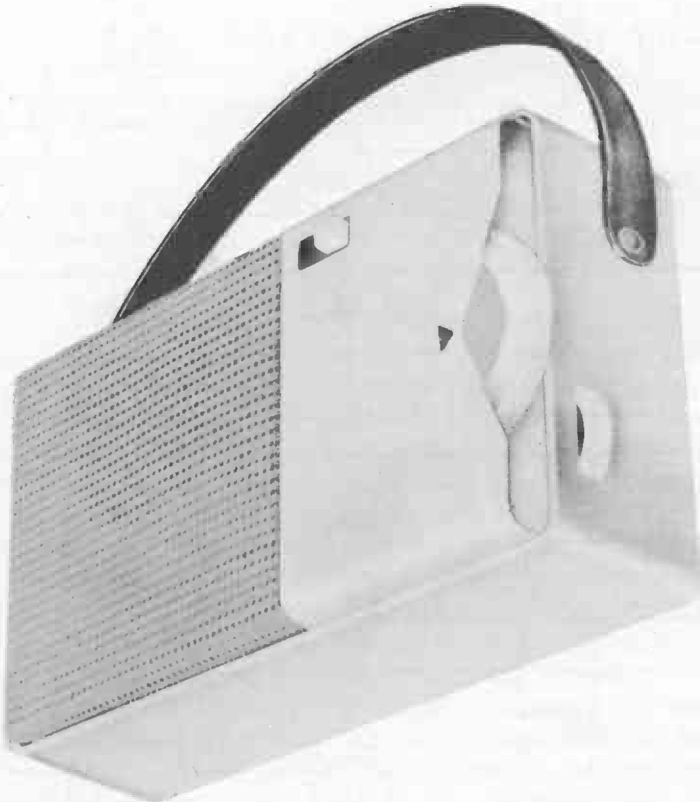


Fig. 12 The *Osmor* pocket transistor superhet receiver built into a neat plastic cabinet

mean that components can be placed exactly in the position worked out by the designer. Interaction and instability troubles are thereby avoided.

Thanks to the generosity of Messrs Osmor Radio Products Ltd, I have been able to make up their Pocket Superhet Kit and this is shown in theoretical circuit form in Fig. 11. This firm is now concentrating on transistor receivers. The Pocket Superhet kit is based on a printed circuit board and built into a very neat plastic cabinet, size $5\frac{3}{4}$ in. × $3\frac{1}{2}$ in. × 2 in. deep, which is illustrated in Fig. 12. The kit includes a word-by-word instruction sheet and a very large reproduction of the printed circuit board. The sheet shows 95 items of connection or construction—so you can see it is quite detailed. I made the set up myself in a few evenings but I must emphasize that it entails careful and delicate work. It is useless buying one of these kits if you cannot solder carefully with a fairly small soldering-iron.

An important point about the Osmor kit to my mind, however, is that Osmor are willing and able to assist the constructor who gets into difficulties. Furthermore the firm will undertake to align and test the set. Faults will be found and corrected and only nominal charges made. This is a valuable facility for constructors and I sent my own set to them for alignment. It is a tremendous help to the amateur to be able to do this.

Incidentally, Osmor call this *The P.W. Transistorized Pocket Superhet* since it follows to a large extent, having certain Osmor modifications, a design which was originally published by *Practical Wireless*. This valuable periodical has published a number of transistor-set designs in recent years and it is a useful source of information about trends and ideas. It also has a valuable advertisement section which helps readers to find out where components are obtainable. This monthly journal is available in many public libraries, or can be obtained through any newsagent.

I do not intend to describe the building of a superhet transistor receiver in this book because of the difficulty that would probably arise for many readers about the question of alignment. However, I have introduced the Osmor kit to you and I could not describe anything more efficient. This kit is readily available and if you have any trouble in obtaining it, please write to Osmor whose address is in the Appendix.

We now consider the question of the reproduction of records (discs) through a transistor amplifier and, in Chapter 8, you will find you have a choice of two suitable instruments which you can build.

CHAPTER 8

Transistor Audio Amplifiers

Here are two amplifiers which use transistors. You can use them for playing records with the aid of a pick-up or as the audio section of a complete receiver. You can make an electronic guitar with an amplifier fitted in it, if you wish!

Two words which have become commonplace in electronic language in recent years are 'audio' and 'video', both of which have a Latin derivation, the first relating to hearing and the second to seeing. From these two words we classify amplifiers into audio amplifiers and video amplifiers, meaning that one amplifies sound and the other amplifies pictures. Neither of them does exactly that as they carry out their amplifying before the signals are actually turned into sound, by the loudspeaker, or pictures, by the cathode-ray tube.

In the early days of radio we spoke of low-frequency, or L.F., amplifiers but some of the low-frequencies our high-fidelity apparatus can amplify today are very high, so it is better to use the term audio-amplifier. In this chapter I am introducing you to two such amplifiers, both of which utilize transistors and which you can use very satisfactorily for playing records with the aid of a pick-up or as the audio section of a complete receiver.

The first of these two amplifiers is a remarkable piece of equipment. The complete amplifier measures $\frac{3}{4}$ in. $\times$ $\frac{3}{8}$ in. and stands on a halfpenny in front of me as I write, leaving much of the coin visible! This is the *Micro-amp* put up in kit form by Messrs Sinclair Radionics Ltd, to whom I am indebted for supplying me with a kit which I made up and tested thoroughly. I show you the theoretical circuit of this miniature amplifier in Fig. 13 and must admit that my fingers, brought up on large transformers and equally large condensers, found the construction of this midget a little difficult.

It is built upon a tiny printed circuit board supplied with the kit and I found it was delicate work. No doubt the sharp eyes and nimble fingers of boys can cope with this work much more easily than mine. It needs very careful and quick soldering with the smallest possible soldering iron, but it is a most interesting item to have when the work is completed.

The kit costs about £1 8s. and is supplied with nine diagrams showing how it can be used. You will see from our diagram that few components are used, as the amplifier uses direct-connection between the transistors. The latter are micro-alloy types for which is claimed a very high gain and especially good frequency responses.

The second amplifier is a basic design of its type and is taken, thanks to Messrs Mullard Ltd, from their excellent *Reference Manual of Transistor Circuits*. The theoretical circuit is given in Fig. 14 and I have translated it into a more practical layout in Fig. 15.

If you study these together, you will see how easy it is to translate a transistor circuit into a practical piece of equipment. The components fall quite easily into place between two 'lines', one negative and the other positive. In the case of this amplifier, the signal is fed into one end and out of the other duly amplified.

The amplifier is rather more expensive to make than the Sinclair type already mentioned but it does give a larger output. Messrs Mullard rate it at 200 mW (milliwatts) or one-fifth of a watt. That would be about as much as we used to get from our battery sets in the days of 2-volt battery valve radios. It is perfectly adequate for normal room listening and, having the advantage of negative feedback, the amplifier gives very good quality.

The feedback resistor's value and the turns ratio of the output transformer depend on the impedance of the loudspeaker used. This would, no doubt, be one of 5 to 8 inches and not one of the midget types whose impedance is frequently in the region of 35 or 75 ohms, as the amplifier is quite capable of working a good type of larger speaker (even 10-inch, if you have one).

Here is the Mullard table giving the variation in values:

Speaker load (ohms)	**Value of R.13 (K.ohms)**	**T.2 Turns ratio to 1**
3.0	56	9·8
5·0	68	7·6
15·0	120	4·4

From this table you will see that it is essential, for best results, to have your values correct. Naturally, the better (and often, therefore, the more expensive) the components you buy the better the results obtained. Particularly does this apply where transformers are concerned. The specifications given by Messrs Mullard would imply a carefully-made and expensive component for both the driver

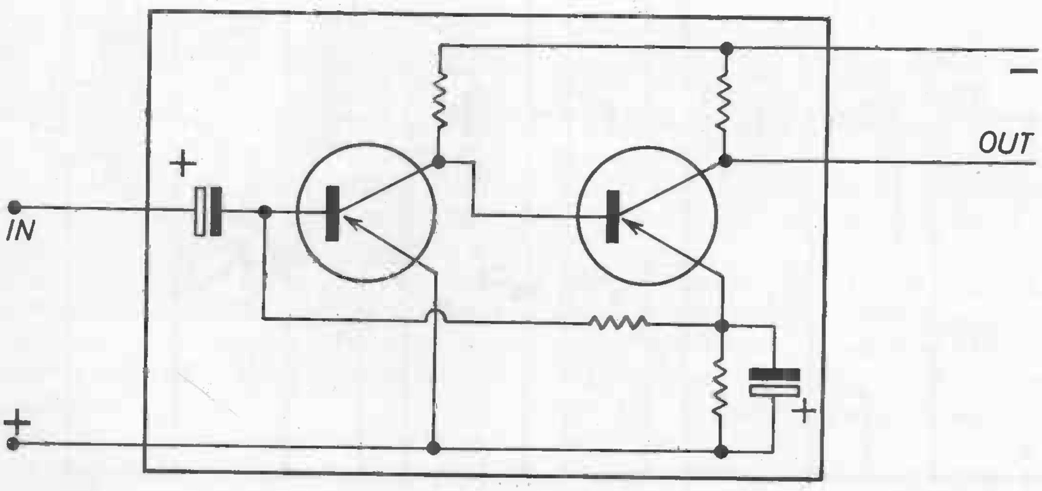


Fig. 13 Theoretical circuit of the *Sinclair Radionics* midget amplifier

transformer (T.1) and the output transformer (T.2).

The book in which we find this design is addressed to constructors of more advanced knowledge than we who get a great deal of fun from running together a few experimental circuits. I do not think that you need to buy items other than those you find available in the usual dealers' lists. There are some made by Messrs Osmor or Messrs Repanco, also some extremely inexpensive ones called Rex which are sold by Messrs Eagle Products.

Messrs Mullard specify a turns ratio of 3·5 to 1 for the driver transformer but you may find this is not exactly obtainable. The nearest to this will be quite suitable. In the Rex range the LT 44 would seem to be suitable and if you have a 3-ohm speaker (the majority are) the LT 700 seems about right. The resistance of the windings on all these transformers are somewhat higher than those specified by Messrs Mullard but their design is rated for a voltage of six. You could try the usual 9-volt battery which should overcome the effect of the higher resistances. A suitable size would be PP6 but PP4 would suffice if you do not wish to pay the higher price.

The resistance of RV 11 is adjustable as it is a pre-set control and should be adjusted to give a quiescent current (i.e., the current when there is no signal being received) of 1·2 mA in the output stage. If you have no meter whereby you can measure this current, I suggest you simply

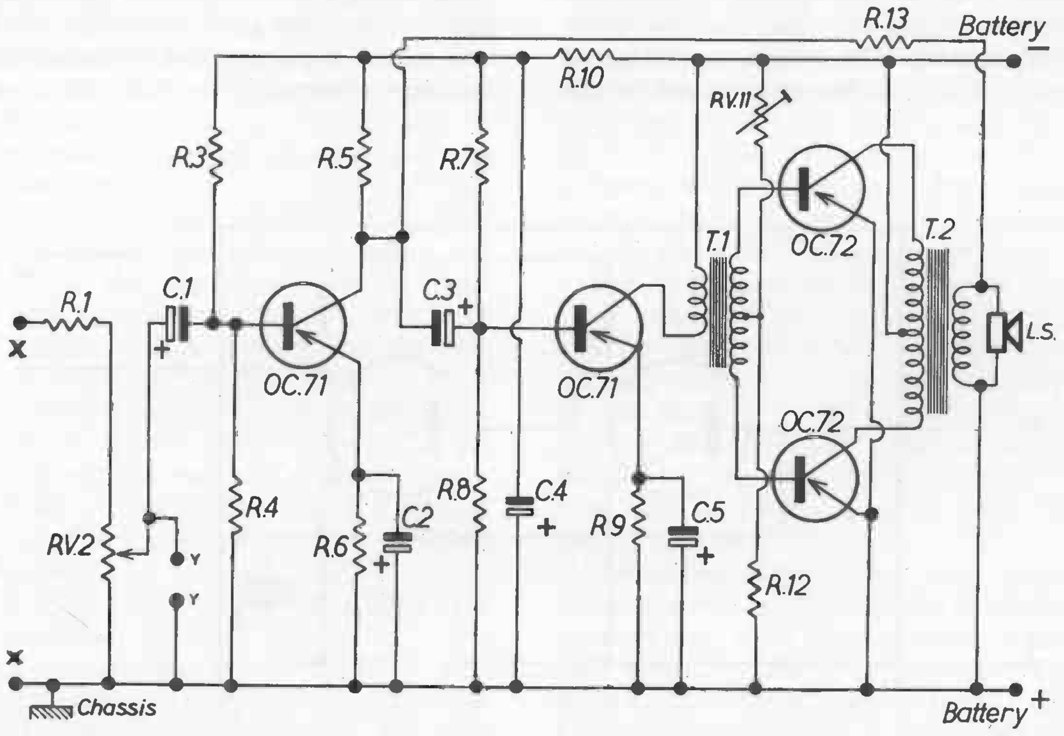


Fig. 14 **An audio-amplifier with push-pull transistor output**

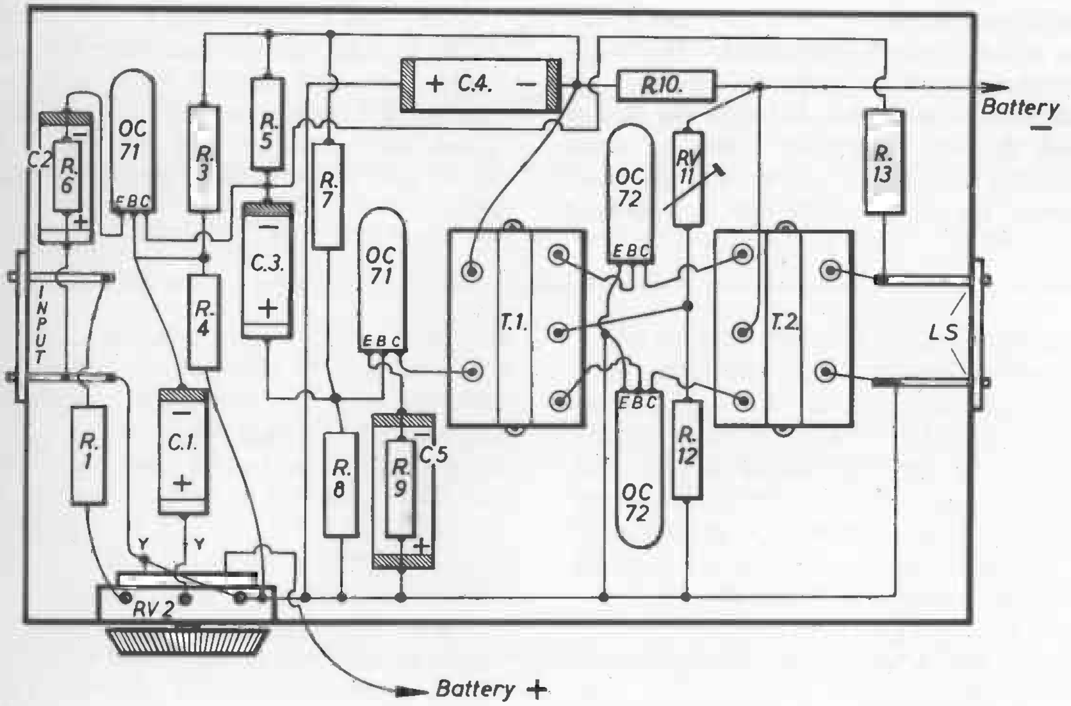


Fig. 15 **Wiring diagram of the transistor *audio*-amplifier**

use a fixed one of about 10 K.ohms instead, or fit the pre-set one and adjust it gently for best results.

The input terminals have been marked 'x-x' and this point is suitable for plugging in a crystal pick-up which needs a high input impedance for proper matching. When using a radio feeder, whether a 'crystal' or transistor input, you may find it preferable to feed in at points 'y-y'. Here is the list of components which you require if you wish to make an amplifier on these lines:

Resistors: ±5 per cent tolerance types (gold ring), type recommended. $\frac{1}{8}$ or $\frac{1}{4}$ sizes.

All sizes stated are in kilo-ohms (except R.10 and R.12). R.1:330; R.3:56; R.4: 10; R.5:3·9; R.6:1·2; R.7:22; R.8:10; R.9:1; R.10:470 ohms; R.12: 180 ohms. RV2 1 megohm volume control with switch; RV11 pre-set 20 K.ohms.

Condensers: All electrolytic; working voltage 6, 12, 15 according to voltage of battery used. All values in microfarads. C.1.:10; C.2.:100; C.3.:10; C.4.:100; C.5.: 100.

Transformers: T.1. Driver and T.2. Output: both centre-tapped for push-pull; details as per text.

Transistors: Two type OC71 and two type OC 72 (latter a matched pair). All by Mullard.

Chassis size as required: input and output 2-hole socket strips; loudspeaker and battery as text.

Readers of *Fun With Electronics* will recall that I showed in that book how an electronic guitar may be made. I would also suggest that one of these transistor amplifiers could be built into the guitar to make a novel instrument. The loudspeaker could be mounted so that its mouth pointed upwards under the strings and the small amplifier could be fitted into the body of the instrument. My latest design for an electronic guitar appeared as an eight-page supplement in *Boy's Own Paper* for April 1964.

Many home constructors are often consulted by their non-technical friends about radio. The next chapter gives some information about commercial receivers which use transistors and will keep you up to date with details of sets now available.

CHAPTER 9

Commercial Receivers using Transistors

Every home-constructor has a keen and lively interest in the commercial transistor receivers on sale. They vary greatly in size, appearance, price and performance. If you buy one don't be in a hurry. Take your time! See all, hear all and make up your mind slowly.

THE transistor, as we know, is rapidly replacing the valve in a great many electronic applications; in no place is this seen more clearly than in the domestic radio receiver. In fact within a few years I do not suppose our radio or TV sets will contain any valves at all. When we planned this book we asked some forty manufacturers of radio receivers for details of their transistor radio receivers. Most of them sent us voluminous details and we are grateful to them for the valuable assistance they have given us.

It is clear, however, that every responsible manufacturer of radio equipment is producing a transistor radio set and I do not want to bore you with a mere catalogue of names. If you want to buy a ready-made receiver you can go to the dealer of your choice and be sure that he will supply you with the set you need. We include in this book some photos of reliable makes.

You must remember, incidentally, that in these days of mergers and trading groups many radio set manufacturers, as in the car industry, produce basically the same model under a different name and in a slightly different case.

Another point to remember is that all transistor receivers are not necessarily of a small pocket size. Many are now full-size table models though somewhat smaller and lighter than a similar valve set due to the absence of heavy mains equipment. This small size must not be carried to excess, however, if you are buying a receiver for permanent listening in the home. For high-fidelity reproduction a good size of speaker is essential and due regard must be given to this if you wish to listen to well-reproduced music.

Battery size and cost is also an important item to study; nothing could be more annoying after purchasing a fine receiver than to discover it contains one or two costly batteries which need replacing every week or so. Most transistor sets operate on the basis that the louder the volume they are asked to give, the greater their current consumption! If you can, therefore, keep the sound within reasonable limits the less your battery replacements will cost you.

Many of the larger sets which one would use normally in the home can be run off the mains at very little cost and I have made this clear in Chapter 13. Some receiver manufacturers make a suitable battery eliminator available for their particular product at small extra cost which will fit into the case in place of the battery.

Some of the receivers on sale have special features of interest and I must make it clear that, apart from sets which the manufacturers have been kind enough to allow me to test, I cannot say, from my own personal knowledge just how efficient such receivers are. However, they are all from manufacturers of first-class repute. They are not excluded from this book for any reason other than our wish not to bore you with a mere catalogue of names.

There are many unknown makes of transistor radios on sale, often at low prices. Some of these are Japanese and some from Hong-Kong. It is as well to ascertain before buying, that service facilities and replacement components are available. Transistor receivers are noted for reliability but they do break down sometimes. The miniature resistors and condensers are particularly vulnerable, and it is essential to know that repairs are easily and economically possible.

Many radio enthusiasts consider that the material of which the case is made should be chosen with care. A wooden case, they say, is preferable to plastic. I cannot agree entirely with this and believe that modern plastics produce some extremely attractive receivers. Lovers of classical music invariably say that a wooden case and chassis makes for better tone and clarity. It is a matter for personal choice.

Other features worth considering include the availability of sockets to take a car aerial for better 'pick-up' in a car, and also for the attachment of a 'personal earpiece' when one wishes to listen without interfering with other people's comfort and convenience. A suitable carrying-case may be looked for where it is desired to take the set out-of-doors—or a strap can be clipped on for carrying. Sometimes a telescopic aerial is desirable, especially if the receiver is designed to receive short waves or the BBC's VHF programme, Size of speaker and good tone quality are important to enable the best advantage to be taken of the very high quality of the FM broadcasts.

The smallest receiver I had an opportunity of using was the Ferranti *Pixie*, which is about the size of a packet of twenty cigarettes. With six transistors and a printed circuit the set gives remarkably

Fig. 16 The *Murphy* B 605 transistor receiver

Fig. 17 The *Ferguson* 358 BT transistor receiver

good results on its 2-inch speaker. A small carrying case embodies a pocket into which a personal earpiece can be fitted. Very handy for listening to the Test Match scores in school!

The Light programme is fixed-tuned on the long waves but medium waves are fully tunable and the indispensable Radio Luxembourg comes in well. I enjoy using this handy little set on holiday; the cost (1963) was £11 11s. (see Fig. 18). Ferranti make a variety of transistor receivers at all sizes and prices.

Writing of prices reminds me that £11 11s. seems to be the cost of quite a number of transistor receivers on sale. One of the larger 11-guinea types I had the pleasure of trying was the Fidelity *Floret*. Tuning over both wavebands, I decided this 7-transistor portable was notable for its sensitivity, as it brought in a remarkable number of stations using its internal ferrite-rod aerial, plus, on occasion, the telescopic pull-out one. The case is of unbreakable plastic and it has a 3-inch speaker. A protective carrying-case is supplied and included in the price. In the car the pull-out aerial ensured good reception, although a car-aerial socket is fitted. This is an attractive set for home or outdoor use.

The third 11-guinea receiver which I had an opportunity of using was made by Messrs Ferguson, a branch of one of the giants of radio and electronics. Ferguson make a whole galaxy of transistor sets and the one I tested extensively is shown in Fig. 19. This is quite a small receiver, tunable over both wavebands, but, in my opinion, having a most remarkable quality of tone in relation to its size. This may be due, in part, to the fact that the plastic-covered case is softly padded all over. The speaker is large for such a small set.

Fig. 18 **The *Ferranti* "Pixie", with six transistors**

Fig. 19 The *Ferguson* 3110 model

Two carrying handles clip on, one short, as in the illustration, the other for shoulder carrying. There is no car aerial socket. Nevertheless, the set works well in a car without an external aerial. There is no output socket for an earphone, but the excellent sound-quality is the real feature of this set.

Another Ferguson receiver, Model 3102, combines a jewelled watch movement and 'wake-up' alarm which can be set to switch on the radio and wake the owner up to music! Their Model 3112 is a smart modern receiver embodying VHF for FM reception. It costs (with a service charge and 'free' batteries included) 21 guineas (1963) and is also available on rental terms as are many other receivers.

The tendency to use transistor receivers in the home does mean that a number of them now allow VHF stations to be tuned in and trouble-free FM quality to be enjoyed. Most of those available are larger sets in the over £20 class like the Ferguson mentioned. Other makes in this range are Decca and Stella. G.E.C. have a smart new design at 18½ guineas. More expensive still is the Blue-Spot Lido at 32 guineas (1963), a very elegant-looking receiver made in Western Germany and carrying a well-known trade-mark which has been known in Britain since the early days of radio.

From Germany comes the Grundig series which have ranges on normal wave-bands plus short waves and VHF. The price category is, however, from 37 up to 77 guineas which is the cost of the intricate Transistor 17. This is a portable receiver that does *anything* and has two loud-speakers plus 1·5 watts output. All the Grundig sets have a mains-power insert available at extra cost.

Ultra, who already have a transistor

Fig. 20 The *Ferguson* 3112 model—nine transistors, two germanium diodes and an impressive power output of 800 mW class B push-pull

portable covering VHF in their list at a little over £20, introduced a new model in 1963 at 15½ guineas. It has a small-size case but it is stated that the speaker is large enough to do full justice to the VHF transmissions. Many readers are interested in short-wave transmissions, as opposed to VHF, and most manufacturers have receivers available which include these wave-bands. My overseas readers find the short-wave bands invaluable for receiving programmes, possibly even their 'local' one, so they require their transistor receivers to cover the higher frequencies.

A recent receiver at only 13 guineas has been made by Sobell and this covers long, medium and short wave bands. An important addition is the inclusion of thermistors into the output circuit to avoid the effects which temperature variations can have on the performance of transistors.

If, like me, you remain a home-constructor I hope you will still find some interest in the various commercial receivers which I have mentioned. On the other hand, if you are thinking of buying a transistor set I hope this chapter will be helpful. The best thing you can do is to visit a dealer with a variety of receivers available and make sure you like the look of, and enjoy listening to, the set you buy. Don't be in a hurry about it either. There are many types. It is worthwhile getting just the one you want.

In the next chapter I am turning again to home-construction problems and the question of building a receiver for short-wave reception.

CHAPTER 10

Transistor Short-wave Receivers

We show you how to build a very successful experimental short-wave receiver, and give you much practical advice on using it. It may well set you on the road to an amateur transmitting licence. But remember, you cannot use a transmitter of any kind without a GPO licence and the standards required for that are very high.

I WANT to say something in this chapter about the reception of short waves on transistor receivers as this subject is largely neglected in the technical press. It is, without doubt, a difficult subject for the non-technical constructor. You can buy without any difficulty and at no very great cost, ready-made transistor receivers which will work very successfully on the higher frequencies. An example of this type of receiver is the Sobell S 314 which tunes from 18·8 metres to 52·7 metres and costs only 13 guineas. It gives full medium- and long-wave coverage as well. There are other commercial sets on the market and they all employ superhet circuits which are carefully adjusted by the makers before the receivers are despatched from the factories.

The ordinary R.F. transistor, such as the OC 44 and OC 45, which are used in the normal form of transistor receiver, is limited in the frequency up to which it will operate, or in the wavelength down to which it will work, as you prefer. For radio frequency amplification on the higher frequencies (the short waves) special transistors, called alloy diffused junction types, are used.

In the Mullard range, the OC 170 and OC 171 will work down to 70 megacycles (about 4 metres) and the AF 114 (which is used as oscillator/mixer in the Sobell set mentioned) will operate down to 100 megs. (about 3 metres). These transistors are more expensive than the ordinary types. If you would like to try some experiments on short waves and can obtain the OC 170 or OC 171, go ahead and get one. Provided you remember the basic transistor rules of (1) care in soldering, (2) the use of a heat-shunt, and (3) never applying the battery voltage the wrong way round, your transistor can come to no harm.

I suggest that you build your experimental short-wave receiver on the lines of Fig. 6. This is a reflex circuit with regeneration and should work satisfactorily. You will need to use a small 100 pF (or thereabouts) air-spaced short-wave tuning condenser and preferably this should be fitted with a slow-motion dial. This would be VC 1 of the diagram. The trimmer shown as TCL should be a small variable type condenser of about 50 or 60 pF and need not be air-spaced. It should be mounted alongside the tuning condenser for easy adjustment.

Make your coil in exactly the same manner as that described but with many fewer turns. This is where much of your experimenting comes in as you must try out the various turns ratios for yourself. It is easy, though, to make up differing coils and to slip them on the ferrite rod.

Fig. 21 The IBM 1620 Data Processing System

Try at first putting on eight turns for the tuned coil (1) to (3) with a tapping point (2) at two turns. The feedback coil (4) to (5) could be two or three turns. You could also try a centre-tap, as in the crystal set coil, to which the aerial can be fed, either direct or through a small condenser, say, 100 pF. Do not forget, if you have trouble in obtaining feedback, to try the effect of reversing the connections to the feedback coil (4) and (5). Earth would go to the positive line.

The second transistor should be exactly as in Fig. 6. So, in fact, should the rest of the circuit, except for the radio-frequency choke which should be designed especially for short-wave work. Tr.1 must be one of the special short-wave transistors already mentioned. I must emphasize that this is purely an experimental idea which I put forward to interest the more advanced radio experimenters among my readers. Please do not write and ask me for details of how to make a transistor short-wave superhet! As far as I know, the necessary coils are not available in radio shops selling kits and equipment for the constructor; if they were, the precise alignment needed for successful operation of a superhet on short waves could be carried out only with intricate instruments not available to young enthusiasts.

If you would like to try a short-wave receiver which is partially 'transistorized' I can recommend the *Mini-Clipper* made by the Codar Radio Company, Southwick, Sussex. This receiver is a detector and two-transistor low-frequency stages type. The detector is a small battery valve. Operation is thus quite simple, reception of the short-wave stations being made by the regenerative detector valve and amplified by the transistor stages. Plug-in coils are used and battery consumption is especially low, ensuring long life for the battery. This receiver costs £1 16s. 6d. as a one-valve set; the transistor L.F. stage can be added to it at an additional cost of 15s. 6d.

A similar receiver is the Codar *Clipper* which is a de-luxe version of the same circuit with one transistor stage. It costs £3 19s. 6d. The Super *Clipper* costs £4 8s. 6d. and has an extra transistor stage. Batteries are said to last twelve months so running costs are very low. These are first-class short-wave kits for readers who wish to take the initial steps, possibly, towards their amateur transmitting licence.

This reminds me to tell you, since I receive so many letters on the subject, that *you positively cannot use a transmitter of any type unless you have been granted a GPO licence to do so.* To get this you must pass a technical examination in radio receiving and transmitting which is conducted by the GPO. The standard required is very high. You must also pass a test in sending and receiving Morse code at a speed of not less than 12 words a minute. I mention this because many books and periodicals give descriptions of simple transmitters built around transistors. If you build one of these you *must* have the licence (and call-sign) from the GPO before you operate it. I advise you, therefore, to play safe and leave such circuits alone! Keep up your experimenting, and study of theoretical radio. One day you may well find that you can pass the GPO examinations with ease. Then transmitting will open the exciting world of 'ham radio' to you.

Fig. 22 A new automatic system for assembling computer transistors at the rate of 1,800 an hour—developed by IBM

To help you in your studies of Morse code the next chapter deals with the use of transistors in making an oscillator.

CHAPTER 11

A Transistor Oscillator for Practising Morse Code

This is only a short chapter but an important one, for buzzers are unreliable and a transistor oscillator is a much better proposition. Three designs are available.

THIS is only a short chapter because it deals with a limited interest as far as the majority of readers are concerned. Many radio enthusiasts are members of the Scout movement and want to learn Morse, as well as others who wish one day to own and operate amateur transmitters. One way in which a suitable note is obtained is to use a buzzer in series with a Morse key and a battery. Unfortunately, buzzers are not very reliable and it is more like 'the real thing' to have an electronic device which gives a reliable note. The correct term for what we require is a thousand-cycle audio oscillator! One can be made easily with a transistor.

I have seen three designs for this device, the basic one being produced by Messrs Mullard some years ago. The *Wireless World* described one in its November 1959 issue based on the Mullard circuit but which meant obtaining the material to construct the special transformer required. If you are interested in actually making components and want such details,

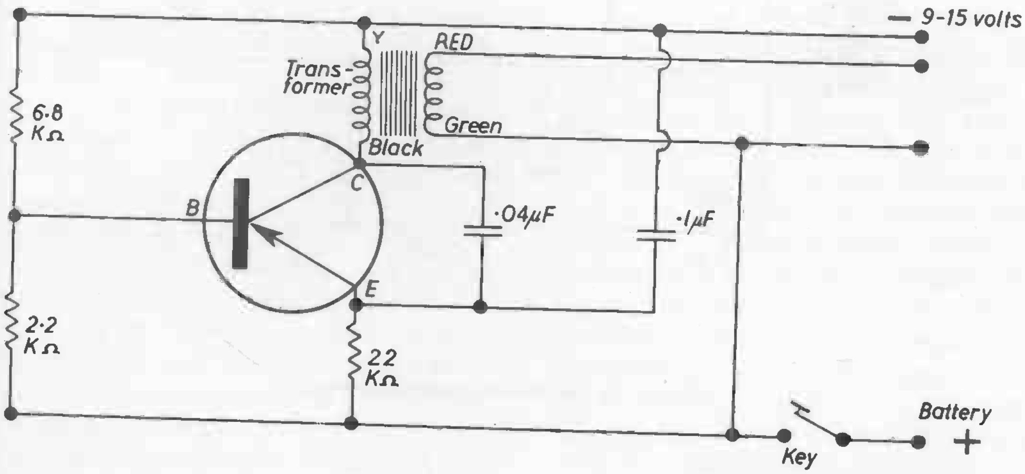


Fig. 23 An oscillator for Morse Code practice

please write to The Editor of *Wireless World*. They are also given in the *Wireless World Diary*.

The third design is contained in an excellent booklet published by Messrs Henry's Radio Ltd and entitled *Practical Transistor Circuits*. This contains all kinds of unusual applications of transistors and one of them is the circuit given in Fig. 23. I am grateful to Mr D. J. French of Messrs Henry's Radio Ltd for allowing me to reproduce the circuit for you here. The device is produced by them as a kit at £1 4s. which includes a chassis tagged ready for the components to be soldered in place. A switch is included but this, for Morse practice, would have to be omitted and a Morse key wired in its place. Earphones would be needed to connect to the point marked 'output' but if a number want to listen this could be fed into an amplifier and a loudspeaker signal obtained.

Our next chapter deals with the mains operation of transistors which is quite unnecessary for the simple designs used in this book. But it is easy to do and does save money, so I have included some details about it for you.

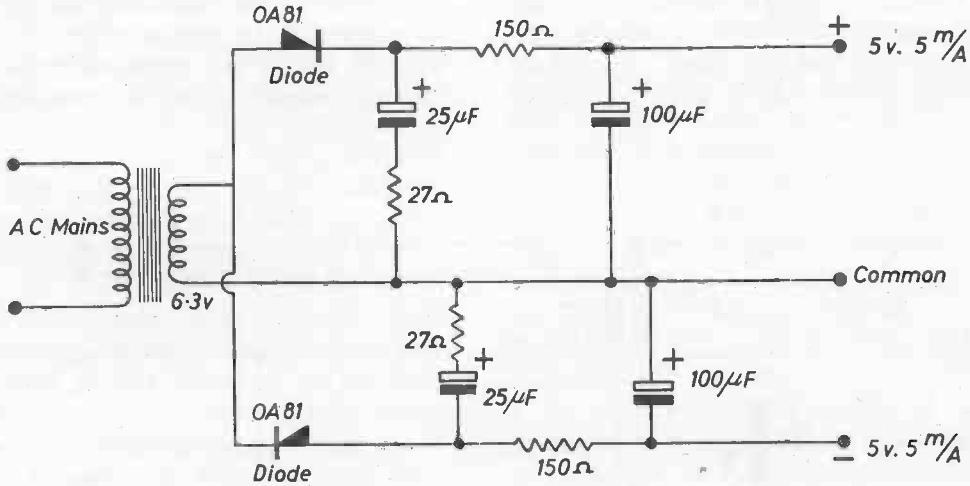


Fig. 24 **An experimental mains supply unit**

CHAPTER 12

Battery Eliminators for Operating Transistor Receivers from the Electricity Mains

This chapter is for the enthusiast who has done some experimental work and wants to try out a new circuit. We do not recommend anyone to use earphones or earpieces with any mains-operated device. Stick to receivers operating loudspeakers only. In this way there will be no trouble or accidents. Common sense is a virtue in amateur radio.

In an earlier chapter I wrote that transistor receivers work from a small 9-volt battery and are perfectly safe, therefore, for the youngest beginner to operate. *They can always be operated from batteries and do not need mains operation at all.* This chapter therefore is for the reader who is more advanced in his experimental work and would like to try out a new circuit.

The circuit given in Fig. 24 only involves an output of a few volts but it does mean a connection to the mains and unless you have sufficient experience to do this, or can get someone experienced to check what you are doing, do not try to build it. On the mains input side it is always wise to incorporate a small fuse-box so that a couple of 1-amp fuses can be included in the circuit and the main fuses will not be blown if anything goes wrong. But if your house is a modern one, with a 13-amp. ring main, you will find that the 13-amp. plugs have fuses incorporated in them and thus will give adequate protection.

The circuit given is run from a 6·3-volt mains transformer which is obtainable quite cheaply, as 1-amp current is enough. Details come again from Messrs Mullard Ltd who have allowed me to reprint it from a leaflet no longer in print and which was produced as long ago as 1955. The germanium diodes originally specified were type OA 71 which are obsolete, but their replacement, type OA 81, will work just as well. You will see that two outputs are given, one positive with respect to earth and the other negative, in each case the output being 5 volts at 5 milliamps.

The original note said that various outputs can be obtained by varying the values of the 150-ohm smoothing resistors. For improved hum reduction you may use choke smoothing; but I advise you to see that the resistance of the chokes is kept as low as possible, otherwise the output voltage will suffer a drop. Most L.F. chokes, such as are required here, are of higher resistance than 100 to 150 ohms and chokes of that order of resistance are somewhat expensive. The condensers are electrolytic types and can be of relatively low voltage; for the outputs shown 6-volt working types would be adequate.

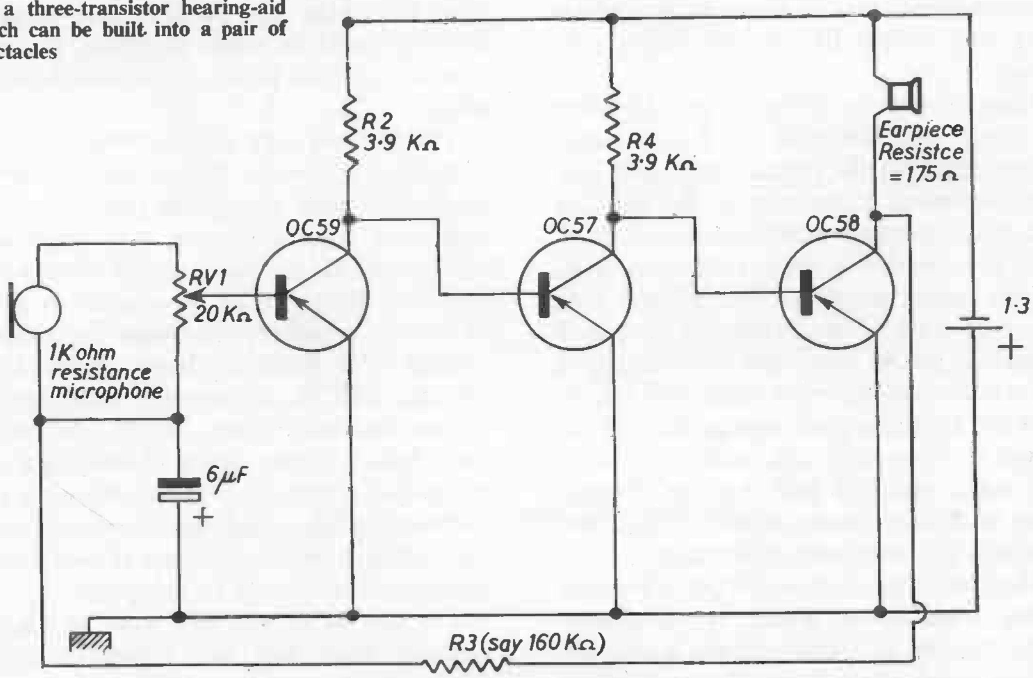
The OA 81 diodes will work at higher voltages than five but transistor work rarely needs more than twelve. I suggest that you could try a 12·6-volt input from a transformer having such a winding (or two 6·3-volt inputs connected in series). This should give you some 10 volts output. The voltage could be reduced slightly by increasing the value of the 150 ohm resistances. If you wanted to use choke smoothing, there would be no objection to 300 or 400 ohms resistance such as the cheaper L.F. chokes usually have.

The circuit in Fig. 24 is put in for the experimenters, but for readers who would like to operate their transistor radios, when at home, from the mains and save the rather more expensive battery, I would commend to their notice a device sold by Messrs Eagle Products. This is described as an A.C. eliminator and battery charger which enables portable transistor radios to operate direct from the mains. It is also claimed that it recharges 9-volt batteries, thus prolonging their life five to eight times. The cost of this device at the time of writing (late 1963) is only £1 4s. 6d. so that it seems a very reasonable proposition. (The address is given in the Appendix.)

Now I would like to repeat a warning to young readers about the electricity mains. Remember that they are *deadly* if not handled with care. Electricity rarely gives anyone a second chance. *I do not recommend that earphones or earpieces are ever used with any device which is mains-operated.* I know that in this chapter we have only discussed low-voltage devices; but should such an arrangement break down and allow the mains voltage to wander about where it is not intended, the headphone wearer is very vulnerable. *You must confine your experimental work with mains operation to receivers operating loudspeakers only.*

So we come to the final chapter which tells you of one or two devices and other uses for transistors in our everyday life.

Fig. 25 **An experimental circuit for a three-transistor hearing-aid which can be built into a pair of spectacles**



CHAPTER 13

Modern Applications of Transistors

Transistors have opened a new world of opportunity to deaf people. The small size and compact nature of transistors also makes them invaluable in the building of computers for industry, commerce and research purposes. There are also exciting developments in the field of radio microphones.

I WONDER if you ever knew a deaf person who used a deaf-aid before the days of transistors? You may recall that deaf people carried with them two boxes of equipment, each about the size of two twenty packets of cigarettes stuck together. One box contained the amplifier, which was operated by miniature valves, and the other the batteries, or combined LT/HT battery—for, of course, the valves needed high as well as low tension to make them work.

All that is changed today, thanks to transistors. Even a hearing-aid using the normal transistors, such as the OC 70 or OC 71, could be built into one small container with a self-contained battery, the battery requirement being negligible.

Then a smaller pair of transistors replaced, for hearing-aid work, the two already mentioned; these were the OC 65 and OC 66. Further development has given us the OC 57, 58, 59 and 60 called the 'OC 57 series'. Cylindrical in shape, they are only 4 mm. long and 3 mm. in diameter.

Take your ruler and look on the metric scale to see how small these new transistors really are. Thus there can now be produced a hearing-aid within the frame of a pair of spectacles. The deaf can be assisted to hear with no more difficulty than is involved in wearing glasses. Other uses of transistors are being discovered in the field of medicine to add further to their many blessings for mankind.

Another important way in which transistors are assisting our life today is in the field of computers, which are taking over so many of the more complicated and tedious jobs in industry and commerce. Fig. 26 shows the involved wiring inside a high-speed accounting machine which is one of the specialities of IBM United Kingdom Ltd. There are two important reasons why transistors are so valuable in this class of equipment. Firstly, the question of size. If valves had to be used in these machines they could never be so compact, and this compactness is an important consideration when high rents have to be paid for office accommodation.

Apart from the intrinsic smallness of the transistor itself, compactness is aided by the fact that the heat which would be given off by valves is absent from 'transistorized' apparatus. Components can be placed closer together without any danger of damage or breakdown due to the heat dissipated. This is important in other items such as television cameras and associated equipment. The Electronics Division of the Ferguson Radio Corporation Ltd publish an excellent booklet about equipment which they are producing in 'transistorized' form. It makes absorbing

Fig. 26 **Miles of complicated wiring go into a high-speed IBM accounting machine, here shown being assembled at their Greenock factory**

reading, even to anyone not interested in radio.

Such matters are outside the scope of this book, but I have no doubt you will be interested to know that Messrs Perdio have on sale a transistor television receiver which is fully portable as it operates, naturally enough, from batteries. It has an arrangement, however, which allows it to be worked from the normal AC mains if wished. The screen size is 8½ in. and gives a very clear, sharp picture. So, if you cannot bear to be separated from your favourite TV programmes in the bath or in the garden, 59 guineas will buy you the Perdio *Portarama*.

Overseas readers (and some in Britain too!) may not realize that the BBC have always maintained a most lively, industrious and well-informed Engineering Department which is second to none in the world for the research and development work which it has produced over the years. They also have an Engineering Information Department which is most helpful to radio enthusiasts. I asked them to tell me something about the radio microphone and other applications of transistors in their TV and radio work. You are almost sure to have seen on television how compères of shows, or speakers in interviews, wear round their necks a microphone which has no wires attached and which allows them to move about the stage, or to turn their heads to address other speakers without being lost to sound because they have moved their mouth away from the microphone. This is a radio microphone which, by means of a small transmitter carried on the speaker's person, enables his speech to be picked up by a complementary receiver a short distance away.

Let me quote you some extracts from a letter which the BBC Engineering Department sent to me as I was preparing this book. They wrote: 'We use transistors extensively in all branches of our engineering activities, but in most cases the developments are probably not of the type to interest your readers. No doubt you will mention the advantages resulting from the use of transistors: the saving of space, of power and of ventilation, and the increased reliability which it is hoped to achieve. As far as our particular operations are concerned we think that the increased reliability will be the most important, but the more spectacular applications of transistors are in such things as the radio microphone.

'As you probably know, the radio microphone is a frequency-modulated transmitter operating in Band 1. The first model was designed some years ago and used valves, which necessitated the use of two units, one containing the transmitter and the other the batteries. The latest, 'transistorized', model contains the transmitter and battery in one metal case, $5\frac{1}{2}$ in. $\times$ $3\frac{1}{2}$ in. $\times$ $\frac{7}{8}$ in., and shaped like a hip flask. The microphone lead is used as the transmitting aerial.'

A photo of this radio microphone is seen in Figs. 27 and 28. Fig. 30 shows the well-known commentator, Brian Johnston, often 'out and about', using the Suitcase Outside Broadcasts Outfit about which

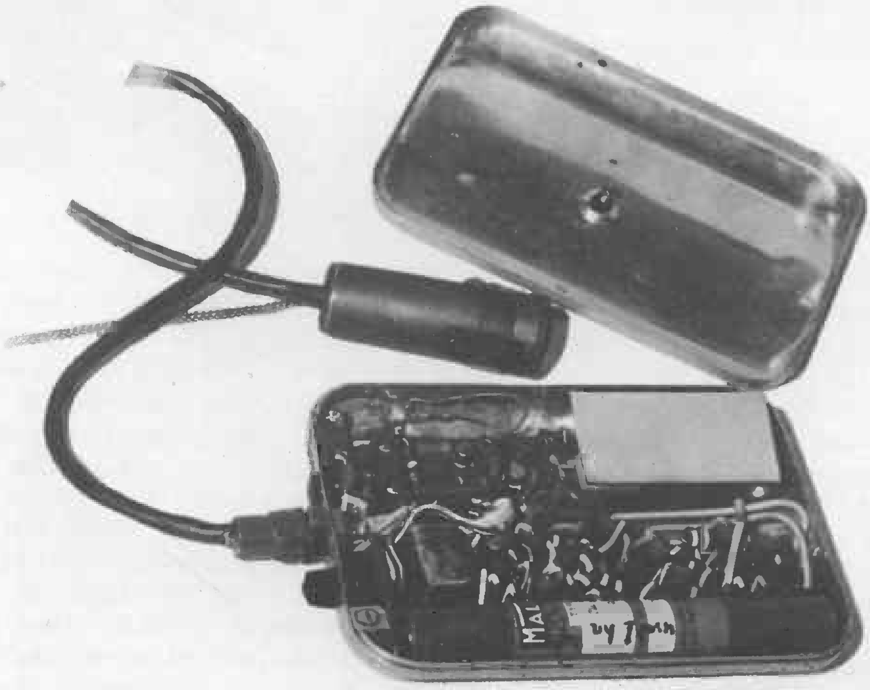


Fig. 27 **BBC radio microphone using semi-conductors**

Fig. 28 **Showing how easily the BBC radio microphone can be slipped into the pocket**

the BBC Engineering Department says:

'. . . our Suitcase Outside Broadcasts Outfit. This is a small leather suitcase containing all the equipment, microphone, microphone amplifier, radio receiver, telephone calling and answering equipment, and 12-volt battery, needed to carry out a simple outside broadcast without the attendance of an engineer. At the outside-broadcast site the commentator or reporter connects the outfit to pre-arranged lines and is able to communicate with the nearest BBC control room and to send his commentary for immediate use or for recording. The receiver is for cueing purposes. The complete outfit measures 16 in. × 10 in. × 5½ in., weighs 15 lb. and is completely "transistorized". It is very unlikely that such a unit, and the programme facility which has grown up around it, could have been achieved before transistors became available.'

I am asked to mention that both the Radio Microphone and the Suitcase Outside Broadcasts Outfit (Fig. 29) are BBC designs. I am grateful to the BBC for such interesting information and the use of these photos. Fig. 31 shows the BBC TV-service radio camera. This item, which has been bought by the BBC from Radio France, is a complete one-man mobile Outside Broadcast Unit in miniature.

Your own knowledge and imagination

will tell you of the enormous field available now, and opening up in the future, for these remarkable transistors. Their compactness and frugality in use of operating power have been mentioned time and time again in this book. Rockets and other devices used in space exploration need such qualities and thus employ transistors. All other kinds of apparatus which have become essential to our modern life use them. Here are just a few from a batch of reports on my desk:

- Transistorized Pulser Units (Thorn Electrical Industries Ltd)
- Transistorized D.C. Supply (Thorn Electrical Industries Ltd)
- Photo Transistor Switch (Thorn Electrical Industries Ltd)
- British Non-Ferrous Metals Coulometric Thickness meter for measuring plating thickness (Nash and Thompson Ltd)
- Stabilized D.C. Supply (Nash and Thompson Ltd)
- Tape Recorders and Dictating Machines by Uher. Supplied by Bosch Ltd.

The list could continue but this is a simple book and the various apparatus mentioned are complicated for intricate uses and outside our scope. As this is the last chapter in the book I hope that it has been of interest and use to you. You are probably in your early or late teens and transistors are going to play a large and vital part in your future life without question. Larger, I would hazard a guess, than valves have done in the last thirty years! If you are interested in transistors I would also suggest that they could open up a wide field of careers to you. If

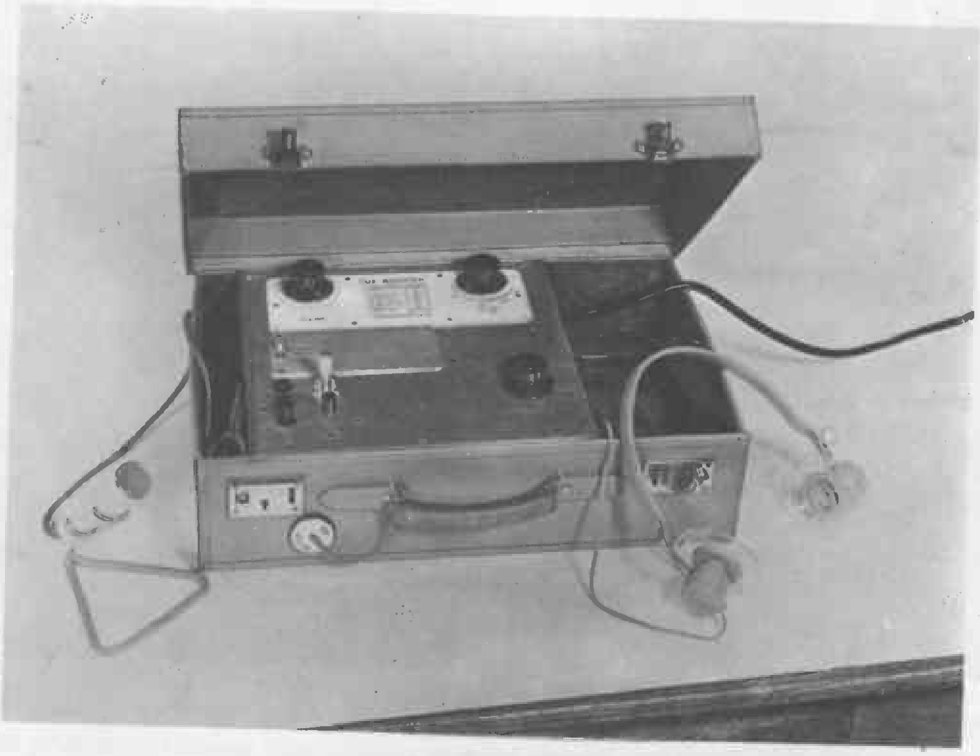


Fig. 29 BBC Outside Broadcast suitcase apparatus

you are keen on mathematics they could offer many lines of interest. The radio industry has a Careers Advisory Service to give advice to those wishing to enter the industry and your Careers Master at school will be able to assist in giving any help you may wish in this direction.

I conclude with an Appendix of names and addresses of firms mentioned in this book, or to whom I am indebted for practical assistance. If you have any queries in regard to their products, please write direct to them and not to me. If you wish for help concerning any point which I have written about in this book, I shall be glad to hear from you, but please enclose a stamped, addressed envelope for a reply. Write to me c/o The Editor, *Boy's Own Paper*, Gulf House, 2 Portman Street, London, W1.

If you experience trouble with a component, or piece of apparatus, or equipment which you have purchased from a dealer, then you should take it back at once, to the dealer from whom it was bought, or advise him of your difficulties in writing. It has been fun to write this book for you and I thank you for reading through it. I hope now that you will be able to put transistors into practice and to have fun with them for yourself and your friends.

Left: **Fig. 30 BBC Commentator Brian Johnston testing the portable Outside Broadcast amplifying equipment**
Right: **Fig. 31 BBC TV-service radio camera**

APPENDIX

If any difficulty arises with a component or piece of equipment which you have purchased, the correct procedure is for you to take it back to the dealer from whom you purchased it. He will know the way in which to make good your complaint. If you have any query regarding some matter which I have discussed in this book, I shall be glad to assist you in any way I can; please write to me c/o The Editor, *Boy's Own Paper*, Gulf House, 2 Portman Street, London, W1 enclosing a stamped, addressed envelope for a reply.

If you wish to purchase a kit set which I have mentioned or would like some further details about a product, you should write direct to the appropriate firm. To help you in this I include names and addresses below of all those mentioned.

Also included in the list are a number whom I have not mentioned in the book because I am indebted both to them, and to those about whose products I have been able to say something, for much help with information, photographs and equipment for test.

BOOKS AND PERIODICALS

Popular Wireless. This has ceased publication but copies are still to be found in second-hand bookshops, and elsewhere

Transistors Work Like This, Egon Larsen (Phoenix House Ltd)

Principles of Semi-Conductors, M. G. Scroggie, B.Sc., A.M.I.E.E. (Iliffe & Sons Ltd)

Reference Manual of Transistor Circuits (Mullard Ltd)

Wireless World (monthly, Iliffe & Sons Ltd)

Practical Wireless (monthly, George Newnes Ltd)

Boy's Own Paper (monthly, Purnell & Sons Ltd)

MANUFACTURERS

Alba (Radio and Television) Ltd, Tabernacle Street, London, EC2

Bosch Ltd (Blue-Spot and Uher), 205 Great Portland Street, London, W1

British Broadcasting Corporation, Broadcasting House, London, W1

British Radio Corporation Ltd (H.M.V. and Marconiphone), 2-5 Upper St Martin's Lane, London, WC2

Bush Radio Ltd, Power Road, Chiswick, London, W4

Clyne Radio Ltd (now Stern-Clyne Ltd), 162 Holloway Road, London, N7

Codar Radio Company, Colebrook Road, Southwick, Sussex.

Cossor Radio and TV Ltd, 233 Tottenham Court Road, London, W1

Daystrom Ltd, Gloucester, England

Decca Radio and TV, 15 Ingate Place, London, SW8

Eagle Products Ltd (Rex and Adler), 32a Coptic Street, London, WC1

Ekco Radio and Television Ltd, Ekco Works, Southend-on-Sea, Essex

Electric Audio Reproducers Ltd, The Square, Isleworth, Middlesex

Electronic Precision Eqpt Ltd (Elpreq), 66 Grove Road, Eastbourne, Sussex

Ersin Multicore Solder Ltd, Multicore Works, Hemel Hempstead, Herts.

Ever Ready Co. (Gt Britain) Ltd, Hercules Place, Holloway, London, N7

Ferguson (Thorn Electrical Industries Ltd), Thorn House, Upper St Martin's Lane, London, WC2

Ferranti Radio and Television Ltd, 41-47 Old Street, London, EC1

Fidelity Radio Ltd, 11-13 Blechynden Street, London, W11

General Electric Co. Ltd, Slough, Bucks.

Grundig (Gt Britain) Ltd, Newlands Park, Sydenham, London, SE26

Hacker Radio Ltd, Norreys Drive, Cox Green, Maidenhead, Berkshire

Henry's Radio Ltd, 303 Edgware Road, London, W2

Kolster-Brandes Ltd (and R.G.D. and Regentone), Footscray, Kent

Lasky's Radio Ltd, 207 Edgware Road, London, W2

McMichael Radio Ltd, Langley Park, Slough, Buckinghamshire

Mullard Ltd, Mullard House, Torrington Place, London, W1

Murphy Radio Ltd, Welwyn Garden City, Hertfordshire

Nash and Thompson Ltd, Tolworth, Surrey

Osmor Radio Products Ltd, 418 Brighton Road, South Croydon, Surrey

Pam (Radio and Television) Ltd, 295 Regent Street, London, W1

Perdio Electronics Ltd, Perdio House, Bonhill Street, London, EC2

Pye Group of Companies, Cambridge, England

Radio and Television Retailers Association Ltd, 19 Conway Street, London, W1

Repanco Ltd, 203-269 Foleshill Road, Coventry

Roberts Radio Co. Ltd, Molesey Avenue, West Molesey, Surrey

Sinclair Radionics Ltd, 69 Histon Road, Cambridge, England

Sobell (Radio and Allied Holdings Ltd), Langley Park, Slough, Buckinghamshire

Stella Radio and TV Co. Ltd, Astra House, 121-3 Shaftesbury Avenue, London, WC2

Thorn Electrical Industries Ltd, 105-109 Judd Street, London, WC1

Ultra Radio and Television Ltd, Television House, Eastcote, Ruislip, Middlesex

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

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