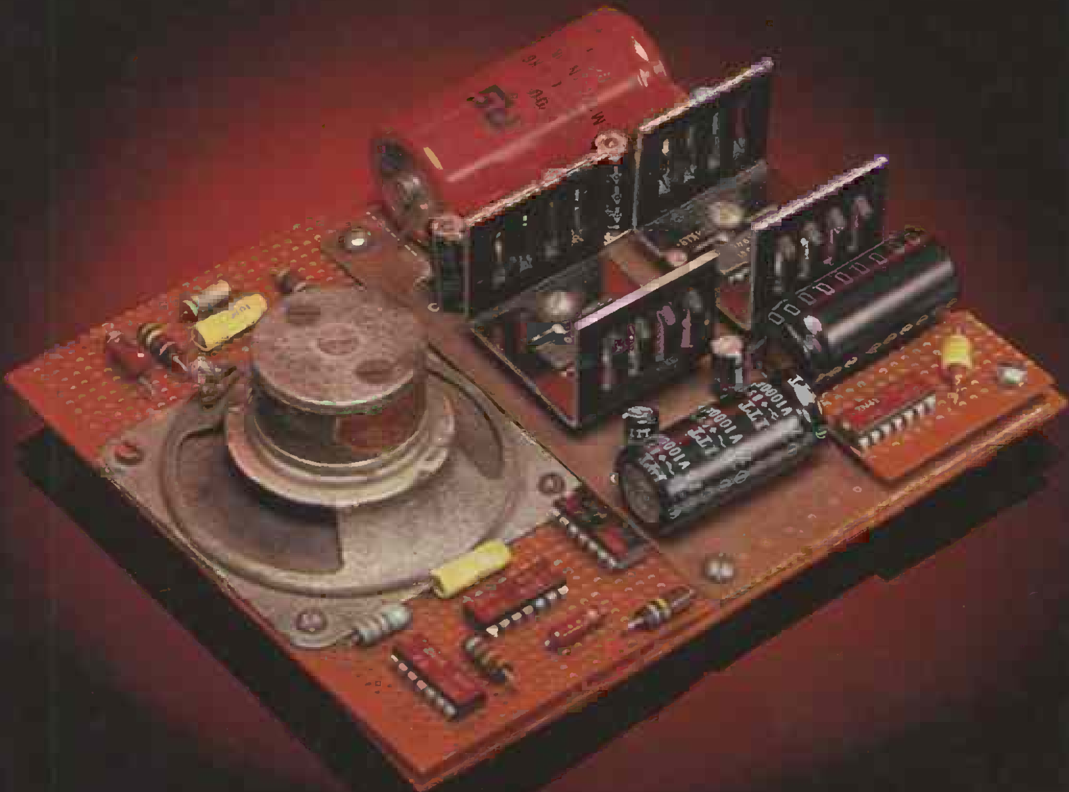
FUN WITH SILICON CHIPS
IN MODERN RADIO



GILBERT DAVEY

EDITED BY JACK COX

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Symbols and Abbreviations

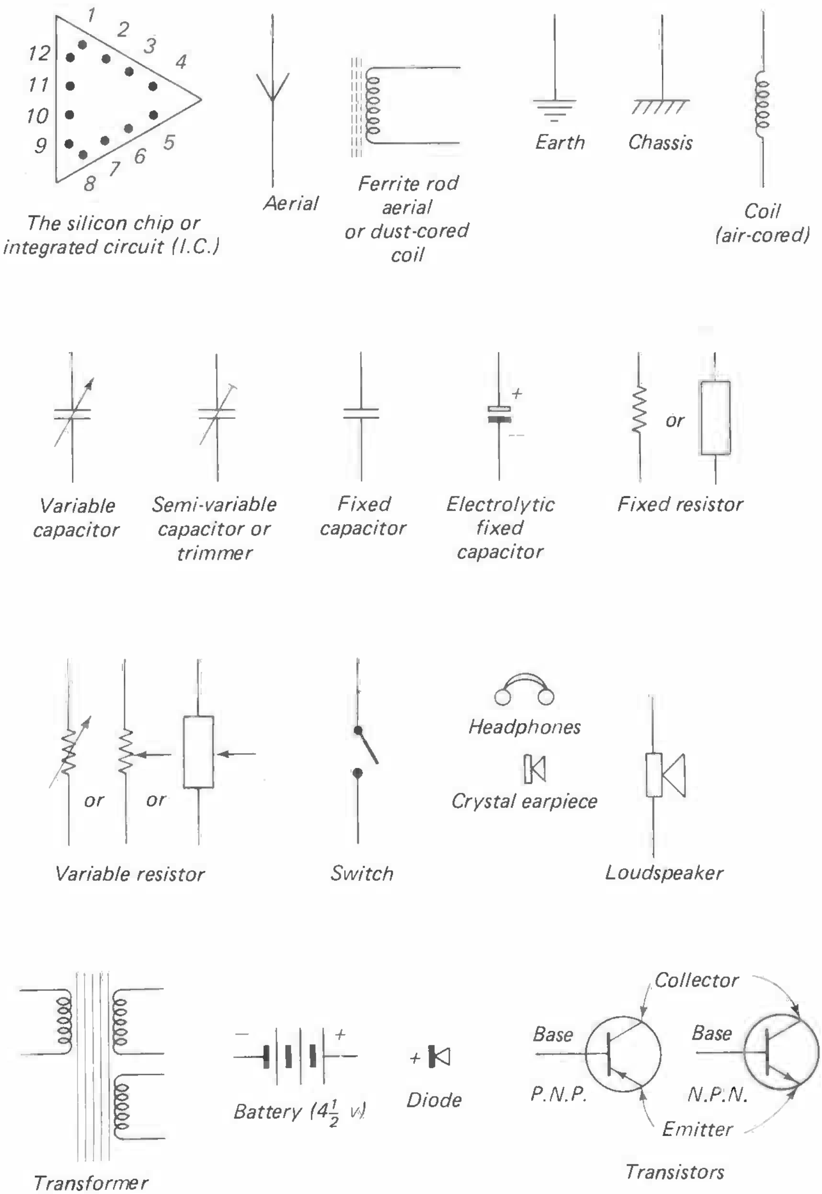


Figure 1.

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

Prefixes for Abbreviations

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

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

The International Code is as follows:

(i) Resistors	*(ii) Capacitors*
6Ω8 = 6.8Ω	*5 p6 = 5.6 pF*
6K8 = 6.8K	*5n6 = 5,600 pF = 0.0056μF*
6M8 = 6.8M	*560n = 560,000 pF = 0.56μF*
	5μ6 = 5.6μF

Figure 1. Continued

Manufacturers and Suppliers

Ambit International,* 200 North Service Road, Brentwood, Essex.
Antex Ltd., Plymouth, PL1 1BR.
Bi-Pak Semiconductors Ltd.,* 3, Baldock St., Ware, Herts. (P.O. Box 6).
Continental Specialities Corporation (U.K.) Ltd.,* Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ.
Denco (Clacton) Ltd.,* 355-7-9 Old Road, Clacton-on-Sea, Essex CO15 3RH.
Ferranti Electronics Ltd., Fields New Road, Chadderton, Oldham, OL9 8NP.
Home Radio (Components) Ltd.,* 240 London Road, Mitcham, Surrey CR4 3HD.
I.L.P. Electronics Ltd.,* Graham Bell House, Roper Close, Canterbury, Kent CT2 7EP.
ITT — Gemini* (Distributors of Mullard Products), Edinburgh Way, Harlow, Essex.
Marshall's,* Kingsgate House, Kingsgate Place, London NW6 4TA (also shops in Cricklewood, London; Glasgow; Bristol — see local directories).
Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.
Science of Cambridge Ltd.,* 6 Kings Parade, Cambridge, CB2 1SN.
Semicomps Ltd.,* (Distributors of Ferranti products), Wellington Road, London Colney, St. Albans, Herts. AL2 1EZ. (also in Kenilworth, Keighley and Kelso — see local directories).
Sinclair Radionics Ltd., London Road, St. Ives, Cambridgeshire PE17 4HJ.
Vero Electronics Ltd., Industrial Estate, Chandler's Ford, Hampshire SO5 3ZR.
Wilmslow Audio,* Swan Works, Bank Square, Wilmslow, Cheshire SK9 1HF.

It should be remembered that local radio shops no longer sell components for the home constructor. They are usually purchased by mail order and such purchases may be made from the firms marked above with an asterisk (*) or through suppliers advertising in the radio periodicals mentioned.

CHAPTER ONE

Silicon Chips and Transistors: their History and uses in Radio

Silicon chips have infiltrated every aspect of life since the mid-1960's. The practical designs in this book require no technical knowledge to interpret them. They will provide normal intelligent boys and girls, and adult readers, with a fascinating practical hobby. For some enthusiasts it may be a gateway to a worthwhile career.

Think of a four-figure number, and double it; now work out the square root of the result to, say, four figures of decimals. It took you quite a time, no doubt, and needed a large sheet of paper. Yet in my pocket there is a small black box on which I press eight keys in sequence and I have the answer in seconds. It is, of course, a pocket calculator which many readers now own and use; it performs seemingly miraculous tasks with the aid of silicon chip circuitry.

Silicon chips have been with us since the mid-1960's and, as the world is at last beginning to realise, have infiltrated into every aspect of life today from calculators to radio and television, to operating robot machinery for manufacturing processes, controlling naval craft, aircraft and modern weapons of war. They are used in exploring Space by means of satellites. Their manufacture and use form a branch of the science we call 'Electronics' and to qualify in this opens up a satisfying future career for boys and girls with ability and talent.

In this book we do not propose to teach you Electronics as, similar to our earlier titles, it provides a set of practical designs which any boy or girl (or adult!) can make up without any technical knowledge at all. If you have some technical knowledge we hope it will make you want to extend it; if you have none perhaps it will stimulate a fascinating hobby or even career. I recall some years ago when I was doing a BBC TV series the cameraman said he had read many of my articles in *Boy's Own Paper* and had, in fact, written to me with a query. This was the start of his interest in television leading to a career.

Our silicon chip designs relate to the use of the chip in radio and audio circuits because here they can be used to make compact and effective designs quite easily and cheaply. At the same time it gives an opportunity to handle the chips and to appreciate what they can do. Details of some operations outside radio are given as a matter of interest in Chapter 13.

Today we take radio and its associated devices for granted, but it is little more than a century since the first ideas of anything like radio waves were born. A Scot named James Clerk Maxwell was an eminent professor at the universities of Aberdeen, London and Cambridge in 1863. It is accepted that he was 'the father of modern physics'. His main researches were in the fields of light, gases and electricity. In 1863 he suggested that the crude electrical apparatus with which he was experimenting seemed to radiate some kind of waves. More than that he does not appear to have discovered other than to say that he thought these waves were related to light in some manner and travelled at the same speed.

There seems to have been no further mention of Professor Maxwell's ideas for twenty-five years; a German scientist named Heinrich Hertz then invented an apparatus which would actually produce these 'electro-magnetic' waves. He found they followed a definite waveform or frequency which could be measured in cycles per second. Today we remember Hertz well; instead of cycles per second, the old term, we now refer to Hertz; our electric mains frequency is 50 Hertz and the BBC Radio 1 programme, for instance, broadcasts on 1053 and 1089 kiloHertz.

While Hertz could produce the waves from his apparatus they could not be of practical use until they had been 'detected' or rectified; a French scientist named Branly invented a gadget called a 'coherer' which would do just this. Sir Oliver Lodge made an improved version of it in England. At this time, late in the nineteenth century, the telephone had already been invented; so had the telegraph, for Morse produced his famous code in 1836.

No doubt many readers will have seen old films where telegraph wires are shown running alongside the railroad while a Morse key operator furiously taps out a wire from one sheriff to the sheriff of the next county telling him to collect a villain off the train. As long as the wires were there it was simple enough. But along came a man with the vision of 'wireless', the idea of sending Morse code messages without the need for wires everywhere. That man was William Marconi. Born in 1874, the son of an Italian father and an Irish mother, Marconi experimented with his ideas and tried to sell them to the Italian Government. They were not interested in Italy so he went to Britain to carry out his experiments.

There is no doubt that inventors in the United States and Europe were working along the same lines but it seems to me that Marconi was the first in the field and ultimately succeeded in transmitting a signal across the Atlantic. In 1897 a company was formed called the Marconi Wireless Telegraph Co. and it sent, not telegrams, but 'Marconigrams'. Apart from the commercial aspect of 'wireless' its importance and value was soon seen in relation to safety at sea where larger and faster vessels were constantly being built. Marconi's apparatus was being installed both in ships of the Royal Navy and in passenger ships. In the United States and in Europe similar action was taken.

At the turn of the century transmission was still effected by practically the same apparatus as Hertz' invention, namely a spark leaping across a gap and produced by a generator. Interruption of the spark by means of a Morse key produced the 'di-da's' of the code. To receive the signals a coherer or a crystal detector was used and both were very unstable; but in 1904 came the beginning of a real break-through. J. A. Fleming (later Sir Ambrose Fleming) was a British scientist whose main concern was the installation of electric lighting in Britain following the invention of the incandescent electric lamp. Fleming found that if a metal plate was inserted in the vacuum of the bulb alongside the filament and a positive charge was placed on that plate, electrons flowed from the filament to that plate (anode). The diode valve was born. Here was a most stable and satisfactory rectifier, far superior to other devices in use.

Two years later Lee de Forest, an American scientist, discovered that if a metal wire grid was placed between the filament and anode of Fleming's diode, by applying a controlling negative potential to that grid the device could be made to amplify. This was the triode valve, or De Forest Audion, as it was known for many years. To my mind this was the beginning of Electronics as we know it to-day. Fessenden, in America, had broadcast speech and music over the 'wireless' still using the spark transmitter, but now, with the valve much simpler and more effective, apparatus was available. Another American, Armstrong, is generally credited with the discovery of 'feedback' in the valve, although in Europe both Meissner and Franklin had similar claims. Armstrong went on to develop and evolve many circuits and is one of the inventors who, it is claimed, gave us the superhet around which most modern technique still revolves.

Broadcasting in Britain, following the earlier start in the U.S.A., began in 1922, first experimentally and then officially with the formation of the British Broadcasting Company in November, 1922. Crystal sets were the accepted type of receiver, very similar to that mentioned in Chapter 4, although valve receivers became more popular as the months went by. But valves required a battery to heat the filament and high voltage to attract the electron flow to the anode. Batteries were cumbersome and heavy, and mains working meant restriction to a source of mains supply, apart from which large installations could give off considerable heat. Already by 1924 the electronic engineers of the day were searching for a 'cold valve' which would not have these disadvantages and a radio periodical dated 29 November 1924 described experiments carried out by a Russian scientist, O. V. Lossev, in an attempt to make crystals oscillate.

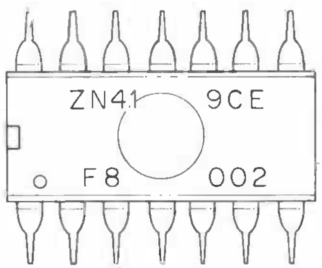
Nothing appears to have resulted from Lossev's work but crystals were not forgotten for during the Second World War (1939-1945) a search was made for a compact rectifier to use in Radar and the crystal was brought to mind! This time, however, instead of leadgalena the metal used was germanium which made a satisfactory and tiny semi-conductor (see Chapter 4). The success of this revived thoughts of the 'cold valve' and in 1948 came the first transistor.

Two scientists, John Bardeen and Walter H. Brittain, working under Research Director William Shockley's guidance, calculated how to produce the transistor. At least, Bardeen did the maths, and Brittain carried out the experiments. The first experiments failed but success came at last and the two scientists were awarded a Nobel Prize. This happened in June 1948 and the transistor was what we call a 'point-contact' transistor. It was difficult to use in practice and is now obsolete but from it William Shockley developed the junction transistor in 1950. Since then millions of these transistors have been produced throughout the world, not least of all in Japan which took to them at once and became a pioneer country in the production of transistor radios and television. In computers the small size and ability of transistors to 'run cold' were ideal, and transistors are used in every facet of our lives today.

The first transistors were what is known as PNP types and used the metal germanium but later models are described as NPN types and based on silicon. If you wish to study more about the technicalities of these types I recommend a book titled *Introduction to Semi-Conductor devices* by Dr. M. J. Morant (Harrap) which, though highly technical in places, has much explanatory matter which is easier to understand. The city of Dallas in Texas, USA, will always be associated with the assassination of President John F. Kennedy, and its preoccupation with the rich world of oil and cattle ranching, but it is also the world headquarters and location of Texas Instruments Incorporated, experts in the field of electronics. They have a very fine modern factory complex at Bedford, England, which I have visited and where I saw some fascinating experiments which I tell you about in Chapter 13. Texas Instruments Inc. were the inventors of the transistor radio before it became a Japanese production!

The greatest interest to my mind about Texas Instruments Inc. is that they were the inventors of the silicon chip, and the remarkable thing is that it occurred in 1965. Only now are we beginning to take seriously the many implications of the silicon chip. Briefly, complete transistor circuits are formed on one chip of silicon; the circuits are so designed that bulky items like resistors and capacitors are avoided by special transistor circuitry. The book by Dr. M. J. Morant gives very full details of the methods involved which are beyond the scope of this book. The end result, however has been the mass production of small cheap integrated circuits which can perform many functions. So small are they that the equivalent of a transistor circuit involving several thousand transistors can be accommodated on a slice of silicon about 25 mm. square. Appropriate thin wires are attached and the device is 'encapsulated' (i.e. put into a little black plastic box) and connecting lugs led out from it. (See Figure 2).

All leading electronics manufacturers now produce 'chips' and we shall be describing the use of several in the following chapters. We hope you will enjoy making up some of the circuits we describe, the beauty of chips being that most of the work is already done inside them and if CSC 'breadboards' are used even soldering is not required! As for personal safety, if you do not wish to use the mains, or if your parents prefer you not to do so, the finest results can be obtained with low-powered batteries. So in the next chapter we tell you something about the basic processes in making your own radio.



Figures 2. An example of a ''silicon chip

CHAPTER TWO

Introduction to Building Radio Receivers

In this chapter we show you the basic processes in making modern radio sets. You must, for instance, be able to read a modern radio circuit and know the simple shorthand of the hobby. Do not be confused by technicalities. What matters is the fun and enjoyment of working with silicon chips; no deep theoretical knowledge is required to enjoy the hobby.

In this chapter we have assumed that you are a newcomer to radio set building and that you need to know how to set about the job. If you have built radios before then we hope there will be something in the chapter which will help you just a little more. No doubt, a brief mention to a grandfather that you are going to build a radio receiver will provide many details of how he built them in the early days of radio when the best way to obtain a radio set was to build it yourself. The famous Cossor 'Melody Maker' was a great favourite; the coils were wound, and all parts were mounted on the wooden baseboard and so on. Things to-day are very different and components are no longer screwed to wooden baseboards. Those wooden baseboards were very similar to the family breadboard and, in fact, in the United States in those early days they talked about 'building receivers on breadboards'.

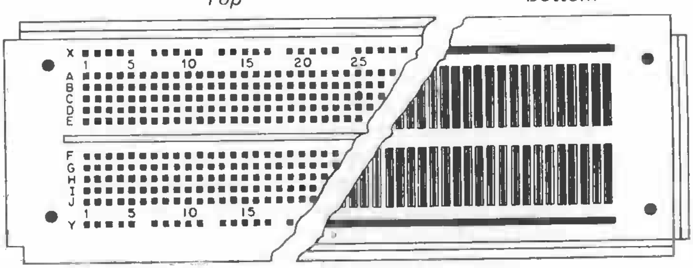


Figure 3. The C S C "breadboard".

To-day they do just the same but the 'breadboards' are quite different. Made in U.S.A the modern 'radio breadboard' is moulded in plastic in varying sizes and is the ideal device for experimental work. Pierced in it are small holes containing springs which grip the wire ends of a component or the tags of a silicon chip very securely. Each set of holes, generally five, are connected together so that the joining together of wires or components is easily achieved. Our artist has drawn an impression of one of the boards in Figure 3. They are sold in Britain by Messrs. Continental Specialities Corporation

(U.K.) Ltd. (address in Appendix). If you are good at soldering, and to solder transistors or 'chips' you must be, you will no doubt use Veroboard which is a laminated plastic board with strips of copper on one side and small holes drilled through the board into the strips. Wire ends can be pushed through the holes in the top of the board into the copper strips underneath and then soldered. The copper strips can be gently cut away so as to make the required connections. Another method of connecting up when using soldered connections is simply to allow the components to be fixed into the wiring but this method is only suitable when making a small receiver. We have wired up in this way for the receiver in Chapter 6.

If you are going to solder you will need the correct form of iron and certainly it will be quite different from the one our enthusiastic grandfathers might have have used many years ago. To-day's irons are electrically heated and quite small, and for the work involved in the designs in this book a suitable iron would be no larger than 25 watt consumption at 230-240 mains voltage. My own iron, in fact, is a 15 watt miniature made by Antex Ltd. and at the time of writing (1980) a similar iron complete with two spare bits, a coil of solder, a heat sink and a booklet on how to solder cost some £6.00.

The solder to use is a type containing its own flux; the best-known is Ersin Multicore which has five cores of flux. The size for transistor work which I find best is the thin 60/40 alloy 18 swg package. The essential point to remember about soldering is that the iron must be clean and hot. I keep mine clean by wiping it on a small piece of felt when it is hot. Never try to solder by holding a warmish iron against a component until the solder runs, for it will only harm the part it is trying to heat up. Make sure your iron is hot enough to make the solder run, and make sure the items to be soldered are clean (a small piece of fine sand- or glass-paper is useful for this). Apply the solder with one hand, with a quick touch of the hot iron in the other. The solder should run and fix the parts concerned. Remove the iron and blow gently on the joint to cool it and all should be well. Beware of 'dry' joints. They look all right on top but below have failed to join securely. They have an unpleasant habit of coming adrift just when it is most inconvenient. The only way to test a joint to find out if it is 'dry' is to give it a sharp tug. If it comes apart, the answer is obvious — start again!

To take a real interest in the hobby of radio set making you must be able to read a circuit, that is to say, to understand the various symbols and what they signify when they are joined together in what is called a schematic, or theoretical, diagram. In modern circuit design using silicon chips, or more properly, integrated circuits (IC's) we do not need to use a great deal of symbols because so many of the component parts are combined in the one small IC. However, in Figure 1 I have set out the symbols you are likely to meet as a certain number of components need to be used externally to the chip in order to make the circuit operate. These are, in the main, resistors and capicitors.

The resistors can be the tiny 1/8th. watt type as they carry only very small currents and the capacitors rarely need to exceed 25 volts working. Certainly those used in the designs in these chapters need not. If you are familiar with any of these symbols already you will note that there are two types shown for fixed resistors. In the past we have always used the zig-zag line for this but the modern idea is the small oblong design also shown. You will need to remember that electrolytic capacitors are 'polarised', that is to say that they have to be connected the correct way round in relation to the battery supply. The symbol indicates this by showing the negative side as a solid black block while the positive is a small oblong showing white.

Germanium transistors are very sensitive to heat and a heat sink must be clipped between the transistor and the soldering iron when soldering to them. The heat sink absorbs the heat before it can reach the transistor. A very useful heat sink forms part of the soldering-iron package by Antex which I mentioned earlier in this chapter.

It is very useful in practice to learn the various abbreviations which are shown in Figure 1 as they are generally used in radio circuit work. It is not possible in this practical book to go fully into the theoretical working and meaning of transistors, and for the reader who wishes to study more about the subject there are two books, both published by Iliffe and sold by Home Radio, which are very helpful. (See Appendix for addresses). These are *Principles of Semi-conductors* by M. G. Scroggie, and *Principles of Transistor Circuits* by S. W. Amos. Both these writers are well-known for their work over many years in *Wireless World*.

However, you will not need to have any great theoretical knowledge to make up the designs in this book. We hope you will enjoy the practical work and in the next chapter discuss those most essential items for radio reception, Coils, and how to make them.

CHAPTER THREE

Coils and Components for A.M. Receivers

If you are a beginner, start building your first crystal set operated most efficiently with thirty feet of aerial in the loft or garden and a proper earth (pay special attention to that!). Learn to make your own coils for simple sets that work well. Soon you will acquire confidence and skill in handling radio components, including silicon chips.

This chapter heading refers to radio sets where A.M. means 'Amplitude Modulation' and F.M. means 'Frequency Modulation'. These are the two modulation types which are in use to-day in radio and television; you will no doubt recall that the high-fidelity broadcast band on VHF (very high frequency) where one can receive stereo sound is FM. The broadcasts which we have been able to receive in Britain since 1922 on long and medium waves are AM and this is a much simpler form of circuitry to deal with than that for FM. As a result almost all our designs are for AM medium-or long wave-reception which is the most generally popular form of broadcast in the world to-day.

Unfortunately manufacturing processes have veered away from the home constructor market and few radio shops are now available where components are for sale. It is generally accepted that purchases are made by mail order and radio periodicals such as *Wireless World* and *Practical Wireless,* both of which include advertisements of mail order firms, do operate safeguards which avoid difficulties which may have arisen in the past with purchases made this way. In the Appendix are given the addresses of some suppliers. Please note that neither the Editor nor I sell radio components, nor do we have a catalogue and we are not connected in any way with any of the companies whose products may be mentioned in these chapters.

The most difficult components to obtain appear to be coils, but fortunately our friends Messrs. Denco (Clacton) Ltd. are still manufacturing their very complete range both for valves and transistors and, they inform us, have every intention of continuing to do so. We will look more closely at their coils when we consider Short Wave reception in Chapter 12. As far as the simple type of receiver which we wish to make is concerned it is easy enough to make the coils for ourselves. For an absolute beginner to radio construction I suggest building a 'crystal' set, although today the crystal is a germanium diode. I give the schematic diagram in Figure 5 and you will see that on the left are shown symbols for aerial and earth; for a crystal set it is also essential to be able to erect a suitable aerial. Thirty feet of wire to a tree in the garden or arranged in the loft should be sufficient if you live within the service area of a transmitter. The earth can be made to the metal pipe of a cold water tap or central heating system. NEVER, AND WE REPEAT, NEVER ATTEMPT TO EARTH TO A GAS PIPE.

In the diagram the aerial is shown connected to the coil and the earth to one end of it. To make the coil you need a piece of tube such as postal tube 1 ½ in. in diameter and about 4 in. long. It is wound with insulated wire of 22 s.w.g. (standard wire gauge) and the insulation can be silk, cotton or enamel. Messrs. Home Radio (Components) Ltd.

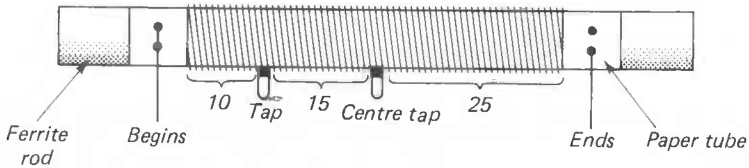


Figure 4. Ferrite Rod aerial coil.

sell 22 s.w.g. enamelled but if you happen to have 24 or 26 s.w.g. try using it; you will probably need to put on an extra number of turns. Using a darning needle pierce two holes about ½ in. from one end of the tube and about 1 in. apart. Push the end of the wire through one hole and up through the other so that it is held securely. Now wind on fifteen turns keeping them close together and tightly on the tube.

Leave about 6 in. of wire at the beginning for connecting up purposes and now at fifteen turns just make a twist in the wire without breaking it; then carry on for another fifteen turns when you make another twist in the wire, once again making sure it does not fracture. You now have thirty turns neatly at one end of the tube. Carry on for another thirty turns (no more twists in it) making sixty turns in all. Carefully holding the wire and tube in one hand take the darning needle and make two more small holes in the tube. Now cut the wire so as to leave about 6 in. once more and slip it down one hole and up the other; pull it tight to keep the coil quite firm. Repeat this process if necessary to keep the wire quite taut.

Now you have a coil of sixty turns with taps at fifteen turns and at the centre. Using a piece of fine sandpaper clean up the two taps by taking off the insulation and revealing the clean copper wire. In the next chapter this coil will be used in the description of some receivers, as will the coil shown in Figure 4. The latter is wound on a ferrite rod and is capable of bringing in signals without an external aerial or earth; the rod is made of conducting material and picks up the signals which are induced into the coil wound round it. This ferrite rod aerial is the type normally used in modern transistor receivers which do not require a separate aerial or earth. However, where it is used in a crystal receiver there is no guarantee that the signals picked up will be strong enough to provide adequate power to operate the headphones so that an aerial and earth might be necessary.

In a book about silicon chips you may wonder why the next chapter is included as it deals with a crystal set and a pocket receiver using germanium transistors! No apologies are necessary, however, as both the diode and the germanium transistor are the ancestors of the silicon chip. A crystal set is a sound form of practical radio construction for a beginner; the small pocket transistor set has been popular for so many years that we have included it from our title *Fun with Transistors* which is being superseded by *Fun with Silicon Chips in Modern Radio*. Apart from this the transistors used in it cost only a few pence each and the set can be made up quite cheaply.

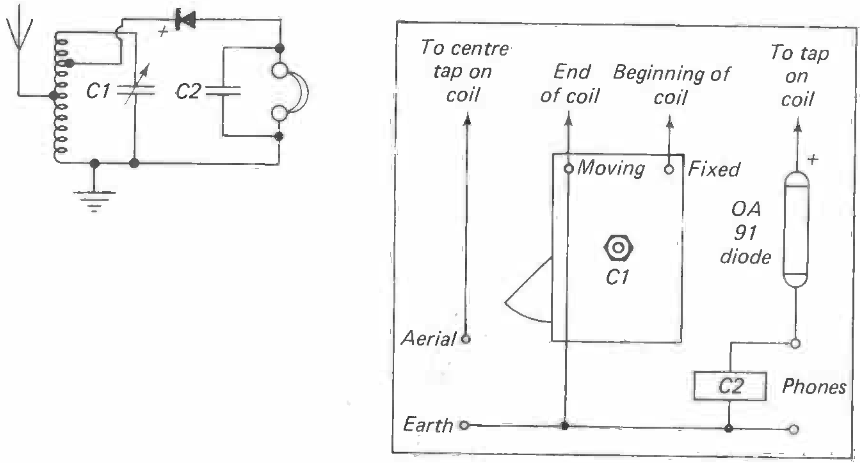


Figure 5. The Crystal Receiver.

Built on 4 in. square piece of plywood or hardboard.
Wire to coil as chosen from Chapter 3.

Components:
C.1. Solid dielectric tuning capacitor 500 pFd.
C.2 Fixed capacitor 0.001 mfd.
Diode 0A 91 or similar.
Two sets of terminal sockets, high resistance (2,000 ohms) phones.

CHAPTER FOUR

Easy-to-make Receivers for Medium Waves

Easy-to-make inexpensive receivers for the medium wave band are immensely popular. Transistors rarely need more than 9 volts to operate them; inexpensive batteries provide cheap, safe and reliable power. But great care must be taken in the practical work to avoid short-circuits.

The simplest receiver to make is the so-called crystal set and a theoretical diagram and layout of one of these is shown in Figure 5. There is a choice of two coils, one which was described in Chapter 3 or the one shown in Figure 4. If you live within a few miles of a transmitter it is worthwhile making up the ferrite rod coil, hoping that the signals will be strong enough without the use of an aerial. If they are not, an aerial and earth will doubtless work wonders! On the other hand if you do have an aerial, or expect to erect one, then use the other coil design and save the cost of a ferrite rod. You can quite well use a commercially-made coil such as the DRR2, but do remember it is no longer manufactured; you may have one or can obtain one but the Denco PCC1 is still available. In fact, Denco (Clacton) Ltd. supply a complete kit of coil, tuning capacitor and diode for about £4 (1980 prices).

Later on in Chapter 9 this crystal set design is used in conjunction with a silicon chip amplifier to provide a complete receiver which works a loudspeaker. I made this without difficulty and it is very successful; do not hesitate to make the crystal receiver because it seems too simple!

The next design is a basic one which has been used since the early days of germanium transistors. It is a useful receiver for personal listening (ideal for the bedroom!) and as the components are quite inexpensive it should not demand too much pocket money. The plastic box may be somewhat difficult to obtain but a visit to a Woolworth's store may solve the problem. Never use metal, for it would prevent signals reaching the ferrite rod aerial and in any case the wires would, no doubt, short-circuit against it. If you build it as specified, you will have a useful pocket receiver which works well. 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, a few 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 1¾ in. × ⅞ in. × ½ in. thick is used and this gives 9 volts and lasts for many months. Exactly how long depends on the amount of use the set receives. I have two receivers similar to that described. One has an Ever Ready PP3 in it and the other the Vidor T6003.

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 4in. × 3in. × 1½ 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 Messrs. Mullard Ltd whose 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 manufacturers and I am sure many overseas readers will know those made by the Japanese who have made transistors and their associated products a speciality. They are of very good quality and many are available in Britain. 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 country 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 most places in the world. These transistor receiver components are very small and light and can 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 Figure 6 (a). You will see that each component has been given a reference letter and number which corresponds with the details in the list. The coil is the same as that used for the crystal receiver described in this chapter but it has one small winding added; this extra winding is for the provision of feedback.

This feedback is controlled by a 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 show 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 Figure 4 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

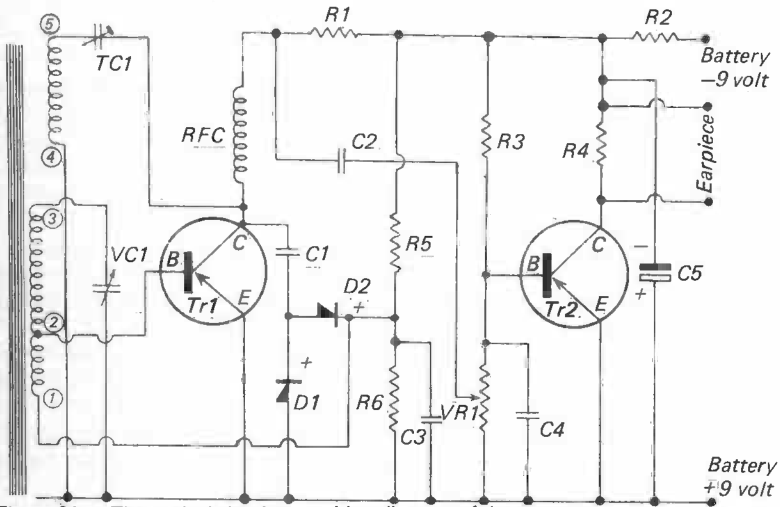


Figure 6A. Theoretical circuit and wiring diagram of the two-transistor pocket receiver.

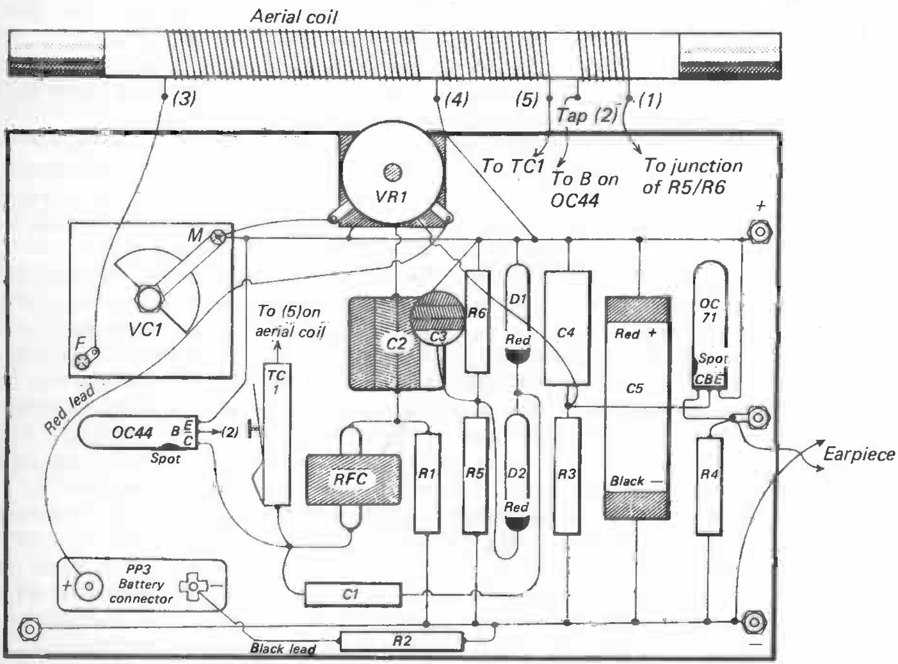


Figure 6B. Wiring diagram of the two-transistor pocket receiver.

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 them. This I will now describe. I refer you to the two diagrams in Figure 6(a) and 6(b) 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 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. 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 Antex model described in Chapter 2. It is a light neat iron with a small bit which heats quickly. Constant soldering does eat away the bit in time but it is replaceable quite cheaply although you may like to try the Savbit solder which is especially 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 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 variation 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 see can 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 have 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 start wiring 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 is tightened so 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. The property is useful in assisting to separate two mutually interfering stations, provided that they are not both in the same direction!

Component List (1980 Prices)

	£.p.
VC 1. Transistor tuning condenser solid dielectric about 200 to 365 pF	2.50
TC 1. Trimmer, adjustable, size about 50 to 60 pF	0.26
C.1. 200 pF fixed condenser	
C.2. 0·1 μF fixed condenser	each
C.3. 0·01 μF fixed condenser	0.07
C.4. 0·01 μF fixed condenser	
C.5. 25 μF fixed condenser electrolytic 12 or 25 v.wkg.	0.09
R.1. 3·9 K.ohms resistor: marked: orange/white/red	
R.2. 1 K.ohm resistor: marked: brown/black/red	
R.3. 220 K.ohms resistor: marked: red/red/yellow	each
R.4. 4.7 K.ohms resistor: marked: yellow/purple/red	0.05
R.5. 100 K.ohms resistor: marked: brown/black/yellow	
R.6. 5·6 K.ohms resistor: marked: green/blue/red	
VR1. 5 or 10 K.ohms miniature volume control with switch	0.31
Tr.1. Transistor OC 44 by Mullard Ltd. (AF 127)	0.18
Tr.2. Transistor OC 71 by Mullard Ltd. (AC 128)	0.37
D.1. and D.2. Germanium diodes type OA 81 by Mullard Ltd. each	0.12
RFC Radio frequency choke; medium-wave type	1.05
Ferrite rod and wire 28 s.w.g., d.c.c.	0.60
Earpiece, crystal type	0.50
Cabinet: plastic box	as
Dial, battery connector, solder, battery, etc.	available

Prices given are approximate and are those operating in Britain in 1980. They may vary from place to place and in different countries. They are intended to be a general guide.

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

The OC 44 and OC 71 transistors may be out-of-date and possibly difficult to obtain. If so, use AF 117 or AF 127 and AC 128, respectively, instead.

Point-to-Point Wiring Connections for Receiver described in this Chapter

1. Mark out and cut out Paxolin panel as Fig. 6(b) (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. 6(b).
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. 6(b).
6. Take some bare tinned copper wire and run two lengths as follows:
   (i) between the solder tag connector of moving vanes on VC1 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 nut 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. 6(b) 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 con-nections

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 FIVE

VHF, FM, and Stereo: what they are and why we use them

Our designs are based on the medium and long wave bands with good quality reproduction as the target. But the sheer congestion of stations on, say, the medium wave band means that reproduction is limited. There is no simple circuit we can use for FM but sound kits are available at reasonable prices.

As we concentrate our designs on simpler practical receivers which can be made by beginners, and which will work, it is essential for such designs to be based on what are known as medium and long wavebands. We also touch on short waveband sets but these are dealt with in detail in our title *Fun with Short Wave Radio*.

Modern developments in radio and audio technology permit extremely good quality reproduction approaching equality with the original performance. This is called 'high-fidelity' or 'hi-fi'. To obtain such results on radio it is necessary for an extremely wide band of frequencies to be reproduced from the low ones of the bass to the highest notes with all their attendant harmonics. The reasons why the use of medium waves will not allow this and the practical difficulties surrounding it, are matters which you will learn if you study electronics.

Briefly, due to the congestion of radio stations on this band there has to be a rigid separation of them and this has been set at 9 kH (kiloHertz). You will see, therefore, that this imposes a limitation on the higher levels of top-note, or frequency, reproduction which the station can transmit. There is much interference between stations, particularly at night, and this causes a 'splatter' very often on the station one is trying to hear! No doubt you are familiar with it.

In the early days of television it moved away from the old 30-line transmissions of the early Baird experiments, which took place on medium waves, and began to use the higher definition of 405 lines. It was found that the only way to accommodate the band-width required was to use the VHF (very high frequency) bands where separation between stations could be obtained with a large enough frequency between them. So these began on a wavelength equal to around 7 metres in Band I. When high-fidelity transmissions were proposed Band II was brought into use for the same reason of band-width availability. It was also decided that better reception free of interference would be obtained if FM (frequency modulation) was used.

This again is something to learn from theoretical and practical work, but it relates to the method in which the sound signal is projected from the transmitter. The normal form to which we are accustomed on medium waves is AM (amplitude modulation). FM is much more complicated and involves special circuitry. For this reason there is no simple circuit which we can suggest you can use but there are several sound kits available. Among a number of catalogues I enjoyed reading those from Ambit

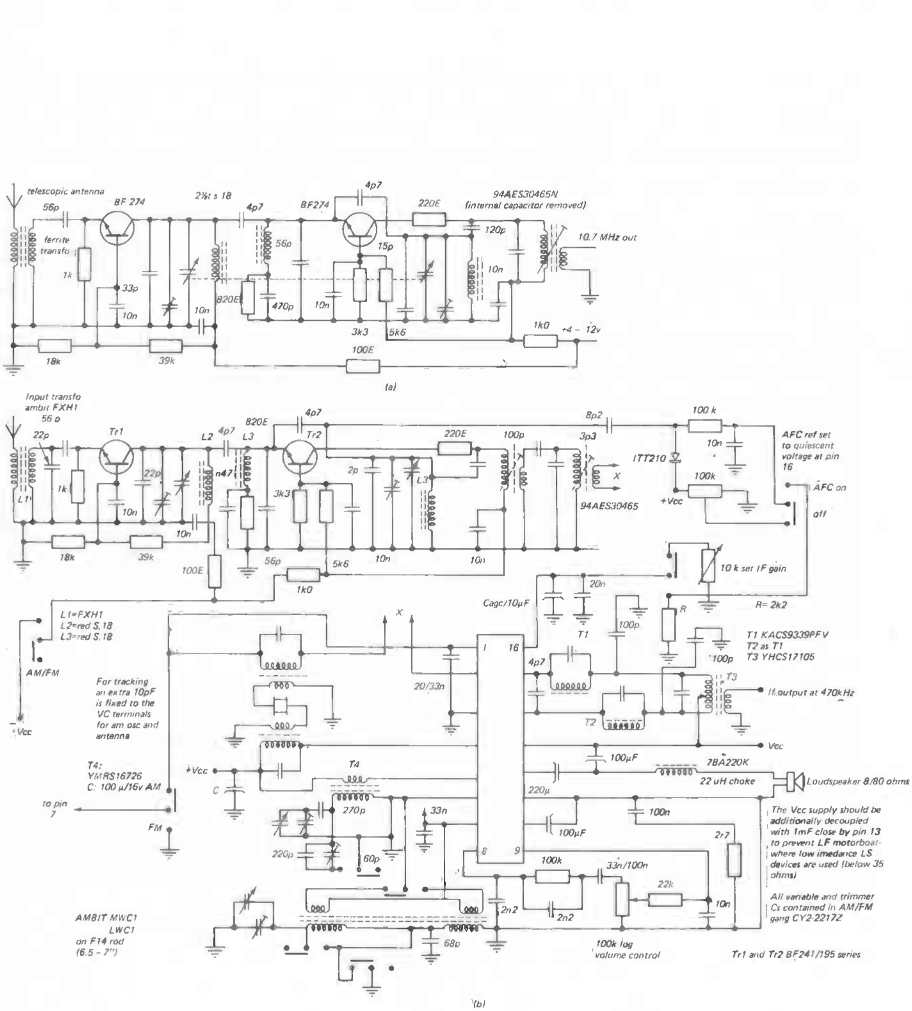


Figure 13. Receivers embodying FM reception.
(Reproduced by courtesy of Ambit International)

At (a) is a simple low current two stage tunerhead for Band II (VHF). Tuning capacitor is 3.5 to 20pF per section (or varicap).

At (b) is a complete broad-cast receiver for MW/LW and FM which embodies the tunerhead shown at (a). More complete details are available from AMBIT.

International (address in Appendix). They are well written, very amusing at times, yet all the time the reader finds sound information. They are intended for the more advanced radio enthusiast but they do give details of ready-made items at reasonable prices. Each part of the three-part Ambit International catalogue (by the time you read this there may be more parts) cost 60 pence in 1980, but they are well worth adding to a radio library.

I am indebted to Ambit International for allowing me to reproduce diagrams from their catalogues and in Figure 13(a) there is a 'tunerhead' for Band II, i.e. the VHF band for FM, which uses two transistors. These feed into the I.F. (intermediate frequency) amplifier and then into the audio amplifier, thence into the loudspeaker. A complete receiver for FM, medium waves and long waves using this 'front end' is shown in Figure 13(b). The integrated circuit is shown in the centre of the diagram and contains all the necessary transistors apart from the two in the tunerhead. The Ambit International catalogue gives a layout which shows that this complicated receiver can be built in an area some five inches square. Using a printed circuit board it should present no difficulties to construct. If you are interested please write to Ambit International direct (do not forget the return postage for reply) and not to the Editor or myself.

With silicon chips the provision of stereo is relatively simple. Stereo is the practice of duplicating amplifiers and loudspeakers so that what is played on the left-hand side of the broadcasting, or recording, studio comes out of the left-hand loudspeaker and, conversely, what is played on the right-hand side is played on the right-hand loudspeaker. In audio work this is arranged by having the grooves in the records (discs) so arranged that they activate the stylus in a special form of pick-up head. In other words two signals, left and right, are picked up at source (the disc).

In radio there is only one signal being transmitted from the station and this has to be split, in some way, between the left and right sources of sound. This is done by a device called a 'decoder' which is interposed between the output from the receiver's I.F. stages and the two amplifiers. Ambit International help here with kits for decoders or complete tunerheads embodying them. I must mention, however, that, in these realms of radio, circuits are becoming quite complicated and, unfortunately, expensive. In the next chapter we return to simpler and less expensive devices with the description of a receiver built round a remarkable chip which is smaller than the average single transistor.

CHAPTER SIX

A One-chip Receiver for Medium Waves

Complicated and expensive circuits can be avoided by simpler devices which cost but little. This receiver is based on a remarkable chip smaller in fact than the average transistor! Only six components and a 5in. ferrite rod aerial are needed to achieve really excellent results.

The design in Chapter 4 is a very simple receiver which is based on a 'crystal set' plus an amplifier and it has the inherent shortcomings of a crystal set not least of which is the need for an aerial and earth. It is still an easy and useful set for a beginner to make. The receiver in this Chapter 6 uses six components and gives most remarkable results using only a ferrite rod aerial 5 in. long. My home is in East Anglia, about eighty miles north of London, yet a station in the Republic of Ireland comes in clearly in daylight; apart from the home stations in Britain there are plenty of 'continentals' as well. Performance is all due to a small 'chip' which looks like a small transistor but which is, in effect, a series of

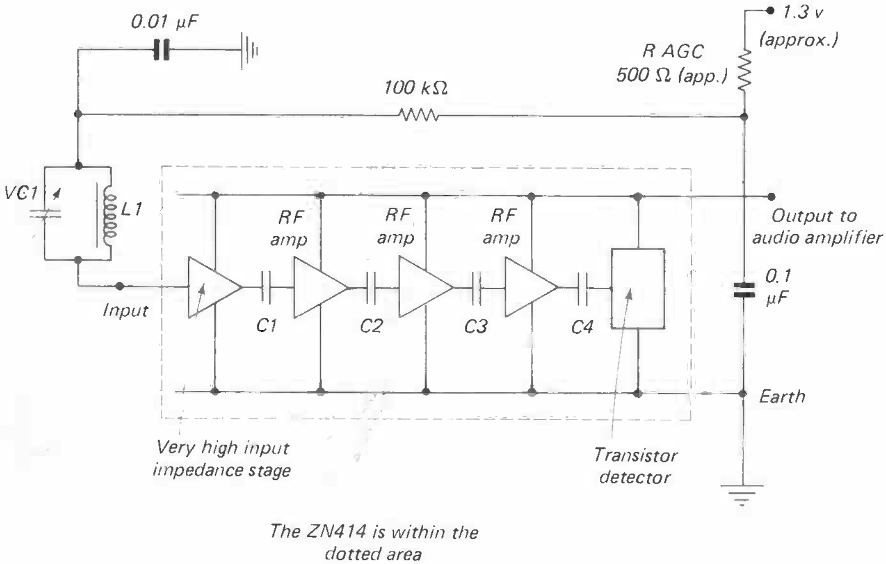


Figure 7. Block diagram of Ferranti ZN 414 ten-transistor TRF tuner.
(Reproduced by courtesy of Ferranti Ltd.)

ten transistors thanks to the modern manufacturing process discussed in an earlier chapter. The device is called ZN 414 and is manufactured by Ferranti Electronics Ltd. The name Ferranti is one of the most famous and respected in the British electrical engineering field and in the early days of radio their name was synonymous with the highest quality. Readers who possess our other titles in the Fun with Radio series (and we hope this includes you all!) will have read of my particular regard for the AF3 and AF5 audio transformers which Ferranti once produced. I am indebted to the company for providing me with data, circuits and other details and for allowing me to reproduce some information for you to use.

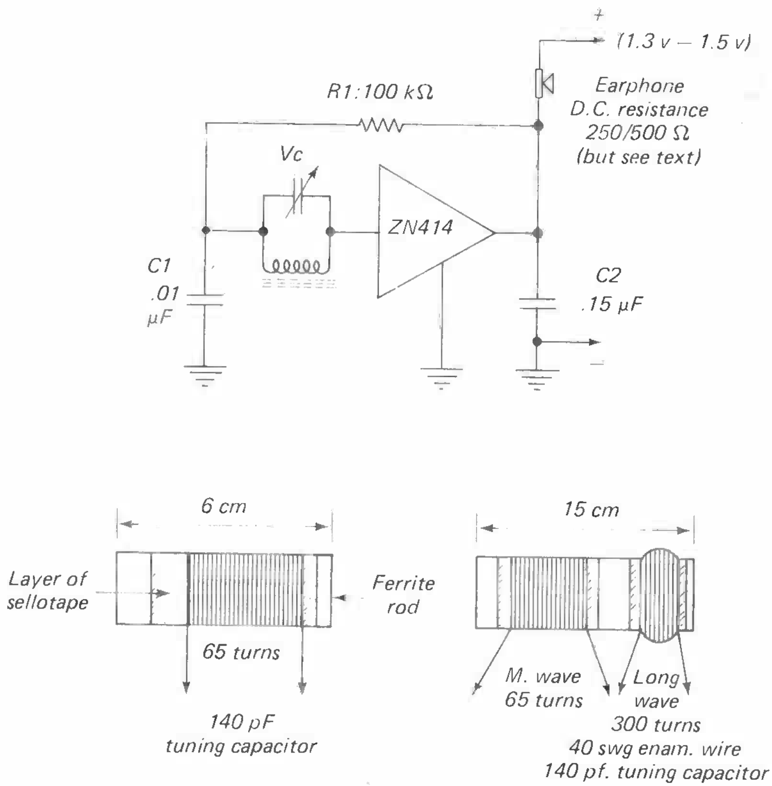
When you study electronics you will soon know that, and I put it quite simply, there are three types of amplification which we can use. The first is Radio Frequency (RF) which amplifies all signals before they reach the rectifier, or detector. The second is Intermediate Frequency (IF), amplification which works at one fixed frequency (generally 465 or 470 kHz) and is used to amplify the 'middle' stages of a super-het. The final third type is Audio Amplification (AF) which is fed the detected signals and makes them loud enough to operate a loudspeaker.

The ZN 414 is a ten-transistor tuned radio frequency (TRF) circuit which accepts the incoming signals from a ferrite-rod aerial (tuned by a variable capacitor) and amplifies them by a series of RF amplifiers before they are detected by a transistor detector. The system is indicated in Figure 7 which is the Ferranti diagram showing how it works. You will see that to operate the device we only require a voltage of 1.3 volts which is the voltage given by a small mercury cell, but as these tend to be expensive, though long-lasting, it is quite possible to use a small 1.5 volt battery of normal type. The current taken does not exceed half a milliamp.

The detector will operate a small earpiece and that is the arrangement used in the receiver described in this chapter. The theoretical diagram is shown in Figure 8 and you will see it uses five small components apart from the ZN 414. The first item to deal with is the making of the coil. For medium waves the details are much the same as given in Chapter 4 for the ferrite rod coil used in the crystal receiver. The ferrite rod which I used is five inches long and $^5/_{16}$ths of an inch in diameter but any other you may have available about this size will be adequate.

Prepare the rod with the card or paper former and make the holes for anchoring the wire. Now for the wire almost any type of coil-winding wire will be suitable. I pulled an old coil to pieces and found it was wound with 32 gauge enamelled which I have used very successfully. Note that gauge is about 0.3 mm diameter. If your wire is a little thicker it will not matter but it *must* be insulated, that is to say, covered with cotton, silk or enamel. Wind on to the ferrite rod former 80 turns of the wire carefully ensuring that they lie closely together but do not overlap; finish off as shown in Chapter 4. The number of turns is not vital and you can put on more turns than 80 and pull some off if it seems there are too many. How many will be decided by the capacity of the tuning capacitor.

Ferranti suggest 80 turns tuned by a 150 pF capacitor but with that number of turns I found I had to use a 500 pF (.0005) capacitor. Much will depend on the 'fatness' of the ferrite rod, and if you have a 150 or 200 pF capacitor handy try it and see if it tunes across the medium wave adequately. I have specified (and if you are buying one it is my recommendation) the .0005 size. If it seems too large a few turns are easily removed from the coil.



Some suggestions for coil winding
(but see text for more details)

Figure 8. The ZN 414 one-chip receiver. *(Reproduced by courtesy of Ferranti Ltd.)*

The next point requiring consideration is the earpiece. In the original design a sensitive magnetic earpiece is suggested with a resistance of around 250 ohms and this is how the output arrangement has been shown in Figure 8. These earpieces are not very easily available and the Japanese crystal type is much more common. It is possible to use the latter in this circuit. All that is required is a small 500 ohm resistor. This is connected across the earphone output jack. When making the receiver I found a magnetic type earpiece (made in England!) which appeared from its marking to have a resistance of 100 ohms. I found a series resistor of 200 ohms was required between it and the battery. Better still was a variable resistor of 1,000 ohms which could be altered to give some variation in sensitivity. If you have one it could be tried in place of the 500 ohm resistor mentioned above.

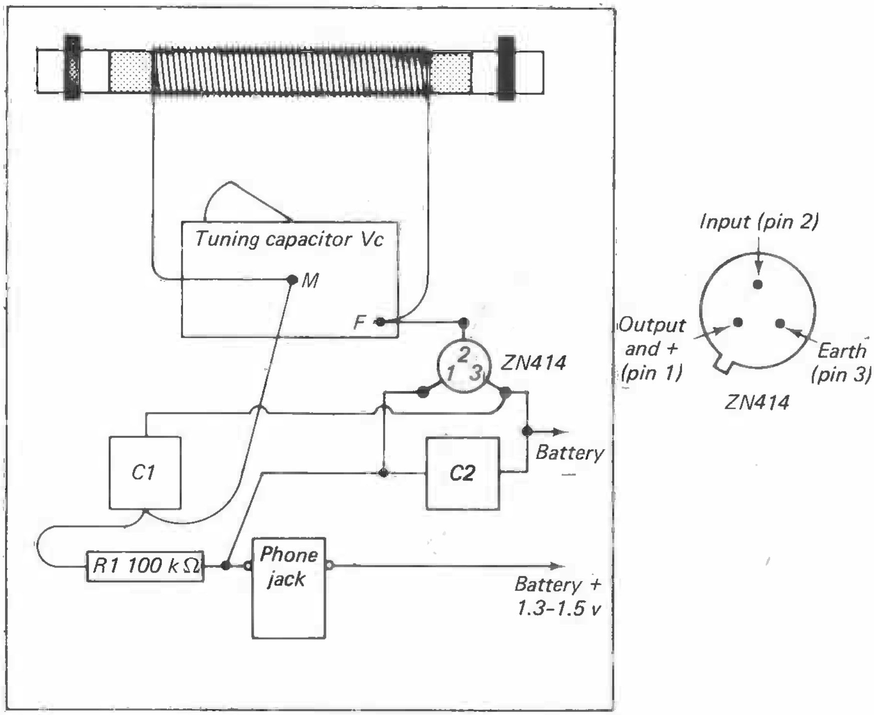


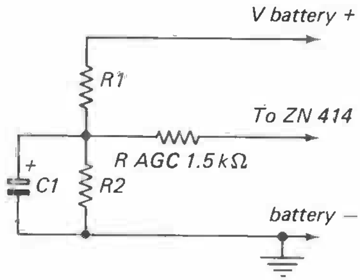
Figure 9. Wiring diagram of one-chip receiver.

Components required:
Ferrite rod — 5 ins. or 13 cm. long
Wire — see text
Tuning capacitor Vc — solid dielectric 500 pF variable (but see text)
C.1. 0.01 mfd. capacitor (fixed)
C.2. 0.15 mfd. capacitor (fixed)
R.1. 100 kilo-ohm resistor (fixed)
ZN 414 Ferranti single-chip integrated circuit
Phone jack or two terminals
Earphone (see text)

The receiver can be built up in a number of ways and the one I have used is shown in Figure 9. I simply took a piece of 3-ply wood (or hardboard) which was 5 in. square and mounted the variable capacitor in the centre. Above it (far enough away not to foul the moving vanes) I mounted the ferrite rod by taking two pieces of carpet tape (because it is thicker than Sellotape), simply looping it around each end of the ferrite rod and leaving a piece sticking up at the top. Using two small nuts and bolts these ends can be bolted to the top of the square of wood.

The former carrying the coil of wire should still be able to move freely along the rod. At the bottom of the square the small jack for the earpiece can be fixed. Now all that remains to be done is to wire up the few components with quick and careful soldering. When I am soldering, in order to keep the iron hot, I usually leave it connected to the mains. *In the case of soldering to the ZN 414, however, Ferranti recommend that the iron should be disconnected from the mains when doing so.* When you need to solder to this item, therefore, make sure that your iron is hot so that you can make the three connections required as speedily as possible with it disconnected from the mains.

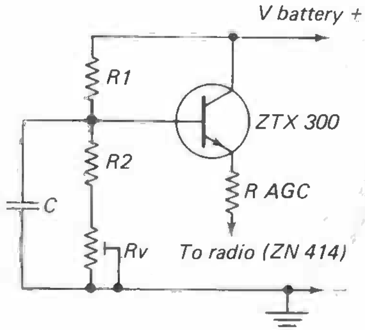
The next problem is that of batteries; as already mentioned, only 1.3 to 1.5 volts is required by the ZN 414, at a very small current. In my experiments I have used an HP2 battery which is a high-power torch battery. I quickly soldered a negative lead to its base and a positive lead to the brass pin at its top. It is easily done. Simply scrape a spot clean, apply a dab of resin-cored solder and then solder on the appropriate leads. You can purchase holders for batteries, however, and Home Radio (Components) Ltd supply a very suitable one made by Bulgin if you prefer not to solder onto the battery itself.



Values to use

V battery	R1	R2	C1
1.3 v cell	Run ZN 414 direct		470 Ω AGC
1.5 v cell	Run ZN 414 direct		470 Ω AGC
3 v	820 Ω	1.0 kΩ	⩾ 4.7 μF
4.5 v	1.5 kΩ	1.0 kΩ	⩾ 3.3 μF
6 v	2.2 kΩ	1.0 kΩ	⩾ 2.2 μF
9 v	3.9 kΩ	1.0 kΩ	⩾ 1 μF
12 v	5.6 kΩ	1.0 kΩ	⩾ 1 μF

(a) Potential divider



Values to use

V battery	R1	R2	Rv	C
1.3 v	Run ZN 414 direct			
1.5 v	Run ZN 414 direct			
3 v	39 kΩ	68 kΩ	25 kΩ preset	0.1 μF
4.5 v	100 kΩ	68 kΩ		
6 v	150 kΩ	56 kΩ		
9 v	220 kΩ	56 kΩ		
12 v	330 kΩ	56 kΩ		

(b) Transistor drive

Figure 10. Voltage applications for ZN 414. *(Reproduced by courtesy of Ferranti Ltd.)*

It is possible to drive the ZN 414 from a higher voltage source likely, say, where the output is fed into an amplifier which we describe in Chapter 9. The amplifier will require at least 12 volts so that some means of reducing the voltage for the ZN 414 is needed. Our good friends Ferranti realise this and supply tables showing how this may be achieved. I have shown two methods in Figure 10, one being a potential divider and the other by means of a transistor. In the former case the circuit consumes more current than the ZN 414 but as this is only 2 mA. it does not seem too serious a matter. The transistor drive, say Ferranti, is 'the most elegant drive circuit' and the current consumed is tiny. You will no doubt enjoy experimenting with both circuits.

Earlier I mentioned earpieces and how I used a magnetic type which was very sensitive. I have also used a crystal type but the sensitivity does fall off a little. If, therefore, you are going to use a crystal one and find that you need a little more volume the addition of a small transistor amplifier will assist without much additional cost. Ferranti show how this can be done and I include their circuit in Figure 11. Here you see a volume control has been added, and the volume could be stepped up even more by connecting a 200 mfd. capacitor (6.volt type) across the 270 ohm resistor. The amplifying transistor used is a ZTX 300 but you could try the well-known BC 108 shown in Figure 12(a). Both these are NPN transistors but if you have a PNP type such as the OC 71 or OC 72 or AC 128 you could try the effect of adding this. The circuit suggested is in Figure 12(b). Remember that PNP types have the positive battery connected to the emitter while it is reversed on NPN types; these are positive to collector, and negative to emitter.

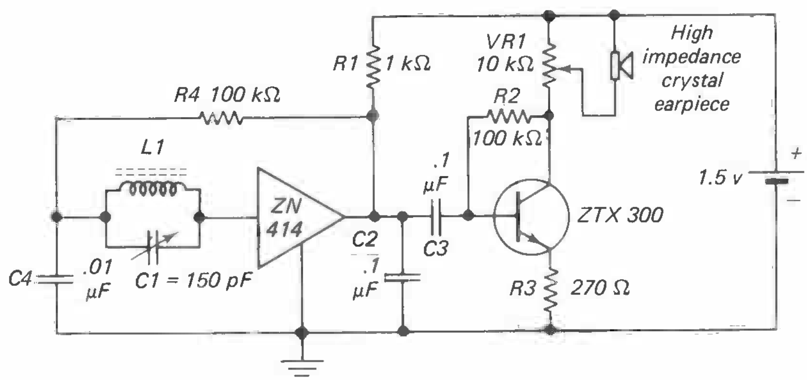


Figure 11. Adding a Transistor Amplifier to circuits in Figures 9 & 10. *(Reproduced by courtesy of Ferranti Ltd.)*

Additional Components requred:
R.1. Resistor 1,000 ohms
R.2. Resistor 100,000 ohms
R.3. Resistor 270 ohms
VR1. Variable resistor 10,000 ohms
C.3. Fixed capacitor 0.1 mfd
Transistor ZTX 300
Crystal earphone

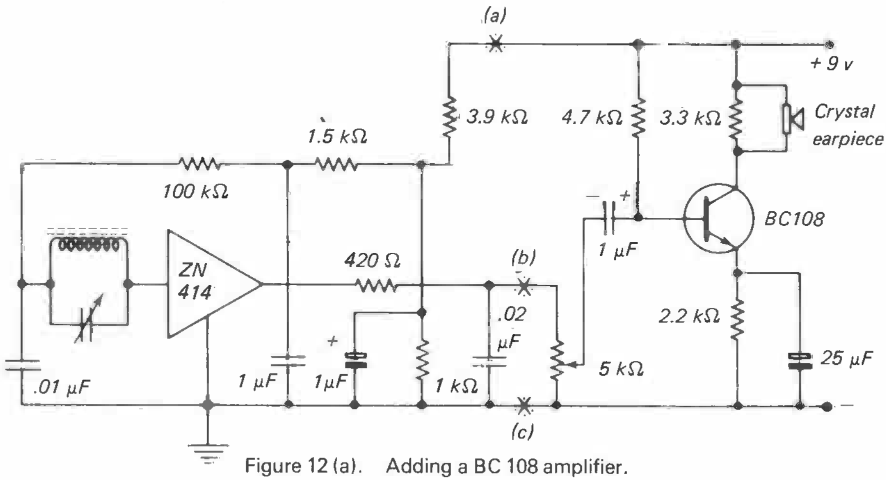


Figure 12 (a). Adding a BC 108 amplifier.

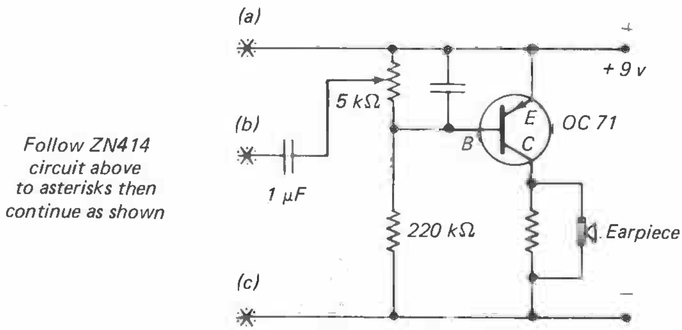


Figure 12 (b). Adding an OC 71 amplifier.

At the time of writing (1981) the ZN 414 cost less than £1 in the UK. The other components are quite inexpensive so we hope you make and enjoy using this little receiver. It can also be built on Veroboard or on the CSC 'breadboards', both of which are described in Chapter 2. For its size the ZN 414 is a remarkably powerful device and we shall mention it in later chapters where we suggest its use with an audio chip to make a more powerful receiver, and also as an IF amplifier in a superhet receiver.

Ferranti operate as a company all over the world so that you should always be able to obtain the ZN 414. Ferranti do not deal direct with the public but supply their products through their various distributors, some of whose addresses are given in the Appendix. The ZN 414 is generally available from Home Radio (Components) Ltd., as well as Marshall's and other retail component suppliers.

CHAPTER SEVEN

Audio Amplifiers Employing Chips

Chip amplifiers weigh hardly anything at all and can be carried around in the trouser pocket! The amplifier suggested will perform well using a 9-volt PP3 battery. If mains power is used then do ensure the chip is not running too hot. If it is, you will have to fit in a reliable and suitable heat-sink.

In our title *Fun with Hi-Fi* we described, by kind permission of Mullard Ltd., some of their amplifier designs which we felt should not be lost to students of electronics. The '5-10' amplifier measured 14 in. long, was 7 ins. deep and 7 in. high; it needed some strength to carry it around! The chip amplifiers described in this chapter with about the same output power are 4 in. × 2 in., weigh almost nothing at all and can be carried in a trouser pocket! Such is the progress made in 25 years, thanks first of all to the transistor and then the silicon chip. In construction, the work involved is minimal in comparison, as most of it is done inside the chip itself. All that is needed are a few capacitors for decoupling and by-passing. A number of manufacturers (British, American, Japanese and European) make these audio integrated circuits so that there is a wide choice, although not a great number, of differing types.

A very popular one is TBA 810 S which is readily available from Ambit International, Bi-Pak Semi Conductors Ltd. and other suppliers. The first design in Figure 14 uses one of these chips and others are shown later on in the chapter. I suggest you build it using a piece of 5-ply or blockboard about 4 × 3 in. On one of the longer sides fix a small piece of ply-wood (3-ply) or hardboard, again 4 × 3 in. In the centre of this drill a hole and fix the 100 k. variable resistor. At one end mount a two-hole socket strip for input with a similar one at the other end for output. Alternatively you can use terminals or a DIN socket or a 'phono' socket according to what is available where you happen to live. I have shown the small socket strip but adapting for anything else would present no difficulty.

The next item to be prepared is the mounting for the components, in particular the IC (this abbreviation is the common one for Integrated Circuit, which, as you know, is a silicon chip). Some points should be mentioned right away. It follows the pattern shown in Figure 2 except that the connecting lugs are 'staggered'. I found it difficult to fit them into the CSC 'breadboard'. If you want to use a 'breadboard' it would be a good idea to obtain an IC holder into which the IC can be fitted and then clipped into the 'breadboard'. I have also used Veroboard which I have discussed in other titles in this series, but it may be new to some readers. I cannot do better than quote Home Radio (Components) Ltd. They say 'Veroboard consists of a bakelite panel to which is bonded a series of copper strips with holes located at 0.15 in. or 0.10 in. pitch along the centre of the copper strips...' The size which fits our IC has the holes located at 0.10 in. (i.e. one-tenth of an inch) apart. The piece I used had thirty-six copper strips along it and was thus 3¾ in. wide and 2½ in. long.

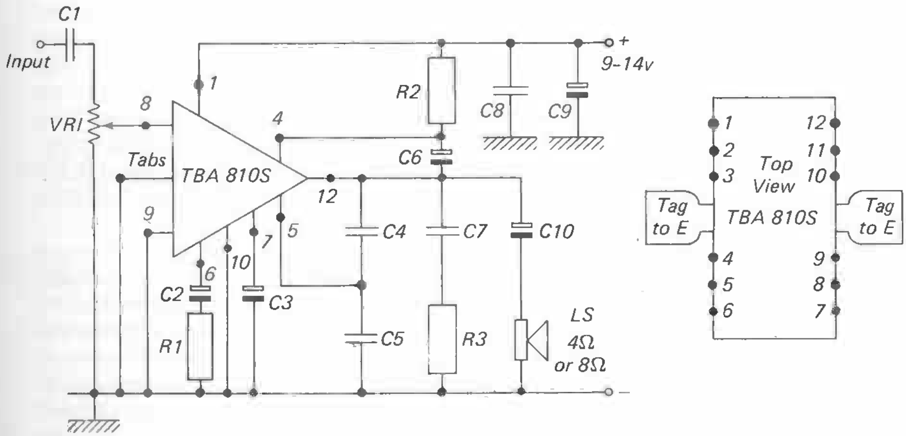


Figure 14. Audio Amplifier using TBA 810 S.

Components required:
TBA 810 S integrated circuit
VR1. Variable resistor 100 k.ohms.
R.1. Fixed resistor 56 ohms.
R. 2. Fixed resistor 100 ohms.
R. 3. Fixed resistor 1 ohm.
C.1. Fixed capacitor 0.1 mfd.
C.2. Fixed capacitor 100 mfd. electrolytic 25v. wkg.
C.3. Fixed capacitor 100 mfd. electrolytic 25v. wkg.
C.4. Fixed capacitor 1.5 nF.
C.5. Fixed capacitor 5.6 nF.
C.6. Fixed capacitor 100 mfd. electrolytic 25v. wkg.
C.7. Fixed capaçitor 0.1 mfd.
C.8. Fixed capacitor 0.1 mfd.
C.9. Fixed capacitor 100 mfd. electrolytic 25v. wkg.
C.10. Fixed capacitor 1000 mfd. electrolytic 25v. wkg.

I mounted the IC in the centre of the Veroboard, carefully pushing the connecting pins into the holes. At once I can hear readers protesting that all those on the outer line will be short-circuited together as will those on the inner ones; this is quite correct and means we must turn our IC round the other way. Before doing so, however, take a file and remove one line of holes at about the centre of the Veroboard. For best results mark out the line first using a felt pen or pencil; then carefully file down it so that the contact is broken between the strips on the left and the strips on the right. Do it very gently so that the copper does not curl up off the board but make quite sure the two sides are disconnected electrically. Run a screwdriver down the groove you have made to be certain it is clear. Now you can mount the chip across the groove with legs 1 to 6 on one side of it and 7 to 12 on the other. You put it, naturally, on the 'non-copper' side of the board so that the lugs pierce through into a copper strip each.

There are two cooling fins attached to the IC and on mine these were bent down so that the connecting pins would not pierce the Veroboard. This problem was soon solved by bending them up level with the top of the IC using a pair of small pliers. This was done very, very gently indeed. When run at high power these IC's can become very hot, but it is unlikely you will want to use enough power to cause this; so the fins fitted should be adequate. There is a slightly higher-powered version of the TBA 810 S known as TBA 810 AS which you can use in exactly the same circuit. The fins on the latter IC, however, have holes drilled in them and this allows the fitting of a heat-sink for better dissipation of any heat.

The fixing of components to Veroboard must be done by soldering and this means a small soldering-iron such as the 15 watt type already recommended. As you can see, the strips of copper are quite close together and it is obviously essential that blobs of solder must not be allowed to wander across and short-circuit one strip to its neighbour. *This soldering requires a hot iron and fine resin-cored solder.* If you have an odd piece of Veroboard it is worthwhile to practise a little beforehand. Once again I must emphasise that the iron must be hot; it is quite useless holding a warm iron against a component hoping it will eventually heat up enough to make the solder run. That is the swift way to damage the components and, what is more, to make poor 'dry' soldered joints. Be patient! Wait until the iron is properly heated before you start to solder. You are now ready to solder the IC into its appropriate strips of copper into which you have inserted the soldering lugs.

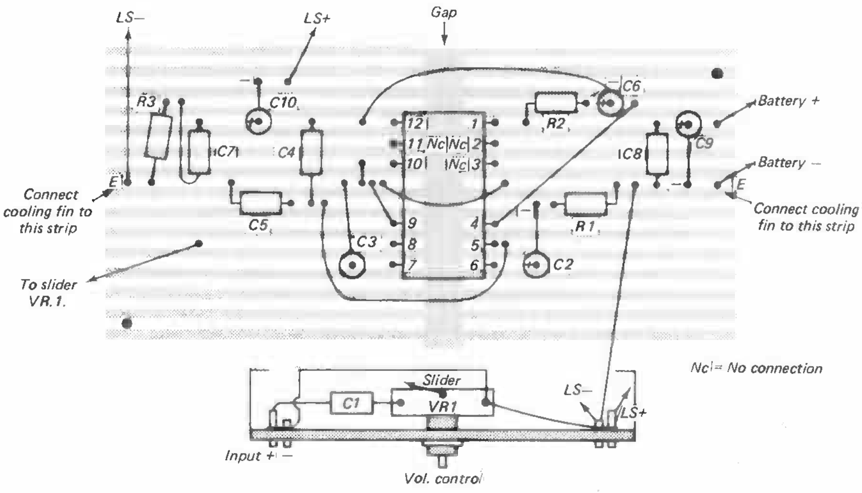


Figure 15. Veroboard mounting for Amplifier shown in Fig. 14.

Components are mounted on the upper side which is clear of copper strips, and lugs, wire ends etc. are passed through the holes.

Make a careful note of the numbering files from Figure 15. It goes down one side and up the other; do not forget that you are working with the solder on the underside of the chip so that you must check very carefully when adding the other components that they go to the correct positions. Note that there are no connections whatever to pins 2, 3 and 11 and, while they will appear on the underside of the Veroboard through their copper strips, no connections are to be made to them or to the strips through which they peep. Now all that remains to be done is to connect the other items, i.e. capacitors and resistors, to their appropriate strips remembering that larger capacitors are polarised and must be connected the correct way round. It is usual for these larger capacitors to be soldered in 'standing up' rather than in a horizontal position, as shown in the diagram. It is *not* important that this should be done but it *does* save space.

Resistor R is shown with a value of 1 ohm and resistors of this size are available both in carbon film or wire-wound. You need only the smallest you can find in this size. If you are using some components already to hand, or have difficulty in obtaining the specified sizes, you may like to know that I found I could vary some of the sizes without causing any trouble. For instance, instead of 100μF for C2 I used 50μF which I had available and 64μF for C3 instead of 100. I only used 25μF for C6 but instead of 200μF for C9 I had a 250. Try and use the specified sizes if you can get them but do not hesitate to try other values, as I did, if you have to do so. The two cooling tabs are connected to negative and earth; they solder very easily if you clean a spot with fine sandpaper and quickly apply the soldering iron and solder to it. The best way to solder in the capacitors in the upright position is to push the wire from the correct end through the appropriate hole in the Veroboard. Then snip off the surplus wire above the copper, apply the solder and hot iron and fix it. The wire at the other end is then bent down over the capacitor into the correct hole for it. An old pair of nail-scissors is very useful for cutting the wire ends of these small components. Make sure it is an old pair. Do not borrow your mother's best scissors, since wire is a sure way to ruin them!

You can mount a small switch on the panel if you wish, and, if you do so, connect the positive flex connector to the switch. Then connect from the switch to the Veroboard. I have not shown a switch but have used a small connector to the battery and disconnected this when I have wished to switch off. It must be remembered if you do the same, that you must unplug the battery to avoid wasting it. A loudspeaker of 4 or 8 ohms plugs into the output sockets. The usual small speaker is 3 or 4 ohms and will be quite satisfactory. The input is across the 100k. variable resistor which acts as a volume control. Unlike a valve amplifier no heat should be found troublesome if the amplifier is run within the power limits which I expect most of our readers will require. It will, therefore, be quite in order for the front panel and base to be used as two sides of a simple box. I am sure you will have no difficulty in doing this carpentry. If you are using battery power, perhaps 9 volts from a PP3, there is absolutely no danger; you need not enclose the amplifier if you want to leave it on a shelf as it is.

If you want to run the amplifier from the mains the voltage would be 14 or 15. You would obtain a higher power output but you must then check that the chip is not running too hot. It has protective circuits in it which prevent it becoming damaged from overheating but you would not find it operating properly if overheating was occurring. Watch this, therefore, and if the IC seems to be running hot (take care if you touch it, for it may be hot enough to cause a burn) you will have to fit a suitable heat sink. Alternatively, if you must operate at such a volume that it causes the IC to run hot, it would probably be preferable to use the TCA 940. Details are given in the next chapter.

CHAPTER EIGHT

More Audio Amplifiers using IC's

A substantial output is obtained by using a higher-powered chip with a simple heat-sink. The practical work involving circuits and 'breadboards' is fascinating; soldering is avoided and we can make very good use of instant hook-ups. Reception on AM receivers is versatile and there is a wide variety of stations.

A higher-powered relative of the TBA 810 S chip is the TCA 940 which will work with a maximum voltage of 24 and provide quite a substantial output. If run at high volume, it becomes too hot and requires the addition of a heat sink. These are obtainable quite easily and are nothing more than U-shaped pieces of metal, cut away to help dissipate the heat. They bolt onto the tabs on the silicon chip. In the TCA 940 holes have been drilled in the tabs to enable this to be done. Figure 16 gives the theoretical circuit of an amplifier using the TCA 940 and you will see that it is very similar to the less powerful relation.

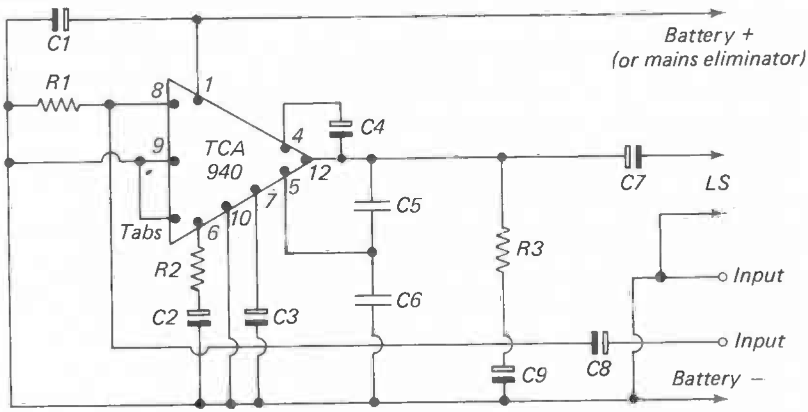


Figure 16. Schematic Diagram of TCA 940 amplifier.

Components required:
TCA 940 — silicon chip integrated circuit.
R.1. — 100 K.ohm resistor (may be variable for volume control).
R.2. — 56 ohms.
R. 3. — 1 ohm.
Electrolytic capacitors, 25 volt working.
C.1. — 1 mfd; C.2. — 100 mfd; C.3. — 33 mfd; C.4. — 22 mfd; C.7. — 1,000 mfd;
C.8. — 1 mfd; C.9. — 1 mfd;
C.5. — capacitor 1n; C.6. — capacitor 4n7.
Heat-sink, Veroboard, wire and terminal blocks or plugs and sockets for input and output.

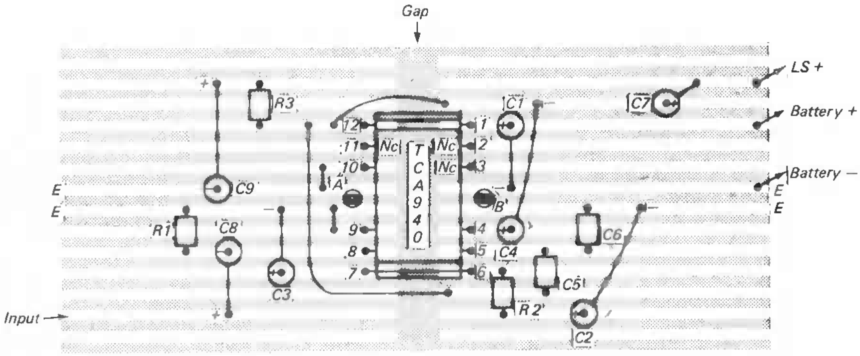


Figure 17. Veroboard layout of TCA 940 amplifier.

Components are mounted on the non-copper side and a heat-sink must be bolted on below the IC. In the diagram "A" and "B" are nuts bolting heat-sink and IC to the board. Washers must be used on each bolt so that the strips marked "E" on each side make good electrical contact with the heat-sink. This will then link the four "E" strips together.

In Figure 17 a layout is given which is almost the same as that in Figure 15; all the points mentioned in relation to the construction of that amplifier apply to this one. The output from both these amplifiers is 'mono' which is usually understood to mean 'monaural'. As Mullard pointed out some years ago 'monaural' means listening with one ear while really we are listening to one sound source with two ears. Correctly, 'mono' should mean 'monophonic', say Mullard, and maybe to-day it does, since no-one seems ever to extend the word beyond 'mono'. There has never been any doubt about 'stereo' which has always meant 'stereophonic', intended to spread the sound source about the listening room in the same manner as it is played in a studio or concert hall. It requires a doubling of equipment, i.e. two amplifiers and two loudspeakers.

Some years ago Sinclair Radionics Ltd. produced a stereo amplifier using the TCA 940 which would rest quite easily on the palm of one hand. Sinclair Radionics Ltd., I regret to write, no longer cater for the radio home constructor. I am indebted to them for allowing me to reproduce the circuit diagram of their stereo amplifier and this is shown in Figure 18. You will note that it is a combination of the two TCA 940 amplifiers shown earlier. Originally the Sinclair design had part of the power supply included and they supplied a printed circuit board which made construction very easy. I have planned a layout for you using Veroboard which is in Figure 19. May I stress that you should not write to Sinclair Radionics Ltd. about any of these items. They cannot assist in any way.

Let us now turn to the products supplied by Ambit International. Referring to the TBA 810 and the TCA 940 in one of their publications Ambit International write: 'The TBA 810 AS and TCA 940 are interchangeable audio power IC's — the only differences being the increased supply voltage capability of the TCA 940 coupled with the increased output power of the TCA 940. These IC's represent the 'standards' of both amateur and industry, and are now manufactured by more sources than almost any other consumer

1 DC power −VE (earth)
2 DC power +VE
3 Signal earth
4 Signal input right
5 Output earth
6 Output right
7 Output left
8 Alternative output earth
9 Signal input left
10 Alternative signal earth

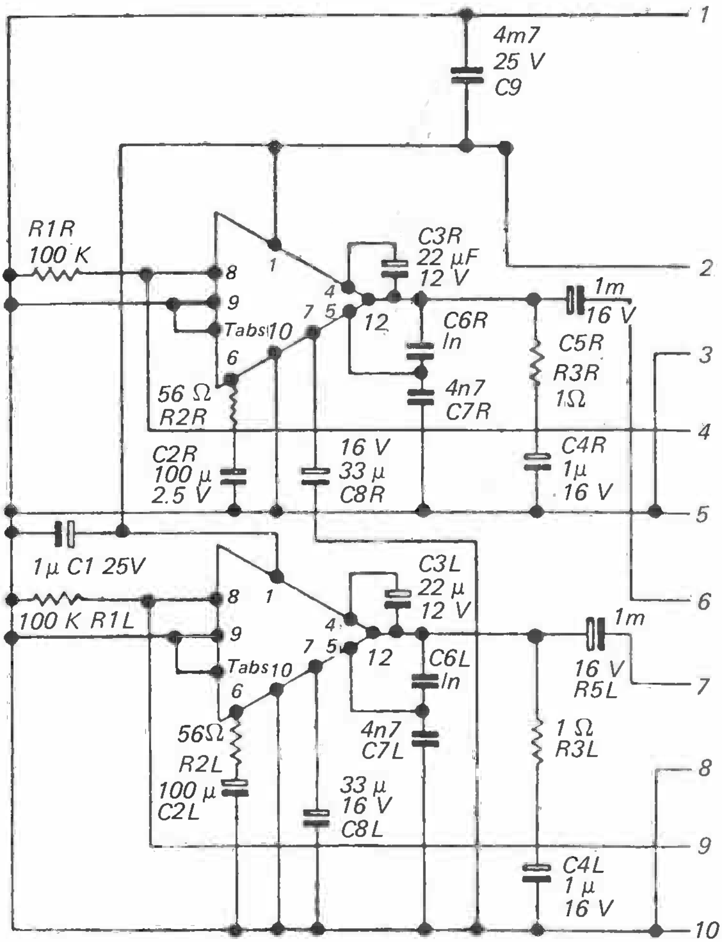


Figure 18. Stereo amplifier using IC's TCA 940

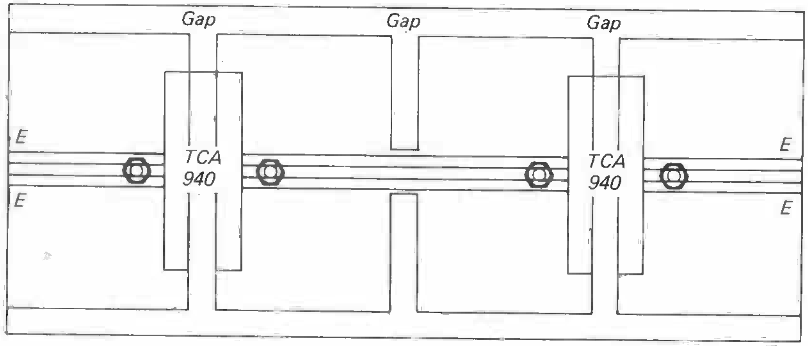


Figure 19. Layout for stereo amplifier.

On a piece of Veroboard are mounted two TCA 940 IC's as shown in Fig. 17. Make a gap between the two sides but allow "earth" strips to run right across and form common earth line between the two sections.

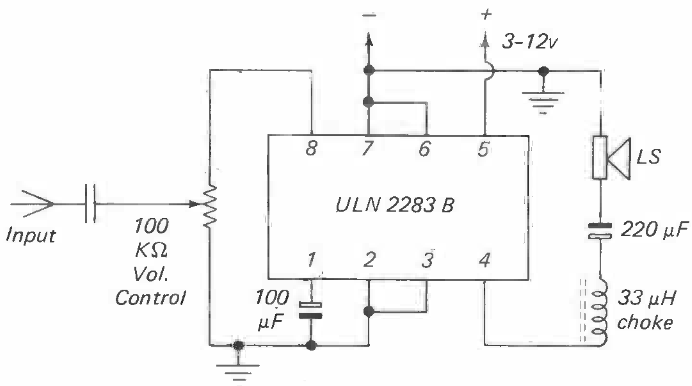


Figure 20. Schematic diagram of amplifier using ULN 2283 B.
(Reproduced by courtesy of Ambit International)

linear IC. They are both short-circuit protected outputs, operating from wide supply voltages, and consuming a minimal quiscent current under no-signal conditions'.

It would seem from this statement that there should be no difficulty in obtaining these IC's; there is certainly no difficulty in adding the few extra components to make up a satisfactory amplifier. They both appear in Ambit's own catalogue as does the very versatile audio chip shown in Figure 20. This is the ULN 2283 B which provides practically all the components required within itself. The input is by means of a variable resistor which is used as a volume control. There are two low voltage electrolytic capacitors, one of 100 μF for decoupling and a larger one of 220 μF for the loudspeaker, also fed via a small AF choke of 33 μH. The voltage required is between 3 and 12 and at the maximum of 12 volts the output into a 16 ohm loudspeaker is 875 milliwatts — not very large but perfectly adequate for a portable or personal receiver, say, for a bedroom.

For approximately sixty years the name Mullard has been synonymous with progress in the electronics industry and, in particular, with 'wireless' as we called it when Mullard first began producing valves in the early days of broadcasting. They have manufactured many other radio products and Mullard transistors, for instance, became as famous as their valves. Mullard have always been very helpful to amateurs in supplying details of their products, and we are indebted to them for allowing us to reproduce some of their circuits. The first one is very interesting as it shows the complex circuitry which can be

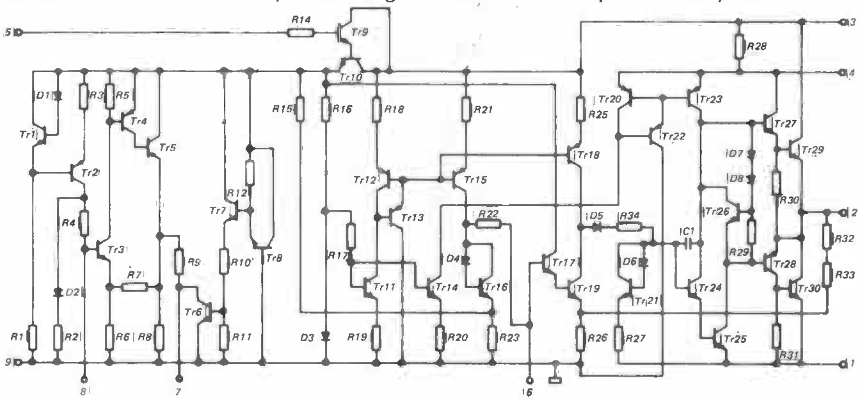


Figure 21. Internal connections of Mullard TDA 1010 chip.
(Reproduced by courtesy of Mullard Ltd.)

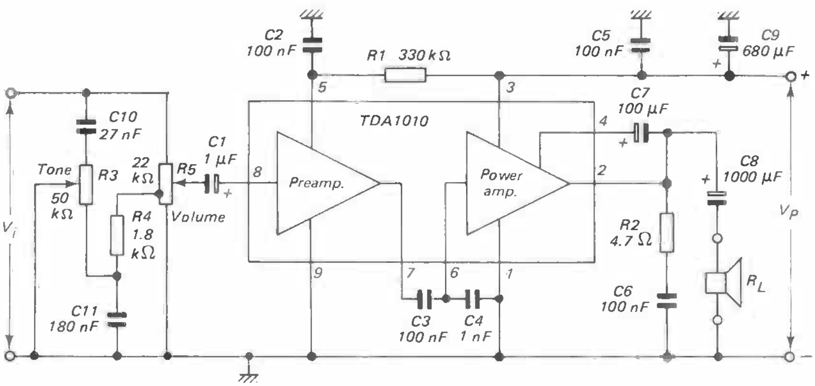
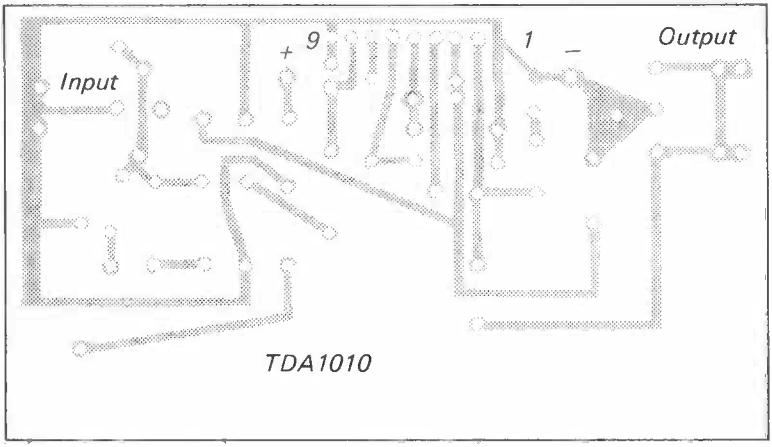


Figure 22. Complete mono audio amplifier using Mullard TDA 1010.
(Reproduced by courtesy of Mullard Ltd.)



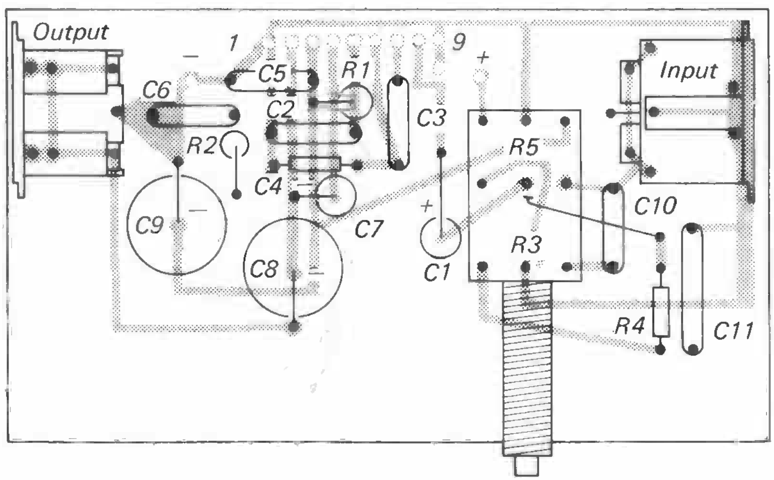


Figure 23. Track side (above) and component side (below) of layout of amplifier shown in Fig. 22. *(Reproduced by courtesy of Mullard Ltd.)*

contained in the tiny chip; it is illustrated in Figure 21. You can see the equivalent of thirty transistors, eight diodes and thirty-three resistors all contained in a package 22 mm. long by 3.55 mm. wide!

The Mullard IC's are sometimes based on a 9-lead single in line formation as shown in this particular one, the TDA 1010 audio amplifier. A heat sink is mounted along the top of the chip. In Figure 22 is shown the schematic diagram of a mono amplifier designed for use in a car radio but equally useful for other audio purposes. In Figure 23 is seen Mullard's layout on a printed circuit board. If you wish to make this there should be no difficulty in translating it to a Veroboard or to a CSC 'breadboard'. You will see that all connections are on parallel lines for the most part. Where lines are cross-joined small links of wire can be soldered in to complete the circuit. For absolute safety to avoid short-circuits it is preferable for these wires to be insulated. Note that the track, or underside, of the board is a mirror image of the component side, or top, so be extremely careful to ensure components are the correct way round, in particular, the IC.

The capacitors are shown in the upright position, as mentioned earlier, and the grey line below is the connection to the lower end of the capacitor. The black line with the + or — symbol indicates the top wire which is led down through the board to its connecting point. The tone and volume controls indicated in the plan are shown by R3 and R5 and take the form of a special type used in car radios where one spindle is hollow and the other runs inside it. It also incorporates a switch, generally on the volume control potentiometer. You may not be able to obtain a device of this type, and, if you can buy one, it will almost certainly be expensive. A better idea is to use separate controls, the 50 k.ohm for tone and the 22 k.ohm for volume with a switch incorporated. Mount these side by side on a small panel and simply connect up to them with a few pieces of insulated wire.

As you look at the track side of the diagram you will see that, if Veroboard is used, certain copper strips would run into one another so that breaks must be made in them. The diagram quite clearly illustrates this by using white patches between the grey lines, and it is easily effected by means of a sharp knife, such as a penknife. It has to be done delicately so as not to remove too much of the copper. Simply cut across the strip at the point where you wish it to end and cut again a few holes lower where it may begin again. Then gently tease off with the knife the unwanted portion between the cuts. Make sure the gap is quite clean. That would be a good time to solder in the bridging wires to connect up any linked strips.

With the 'breadboard' you will work on the top of the board all the time. The holes marked X at the top and Y at the bottom are each interconnected in one long strip and could serve as negative and earth in one case, or could both be joined with a small piece of wire to form an earth line all round the board. The other holes are in strips of five all interconnected. In the centre of the board is a gap and in some boards this is narrow enough to allow a silicon chip to 'sit' over it with the connecting pins in the holes on each side of it. If you study the diagram Figure 3 you will see this clearly. The five-hole sets are marked A, B, C, D, E on one side of the gap and on the other side continue down F, G, H, I, J. Across the top every fifth hole is noted at 5, 10, 15, 20 and so on, according to the size of the 'breadboard'. Thus any particular hole can be identified at once if required e.g. C 12 can be found instantly in the centre of the top bank. If you experiment with radio these boards are very useful indeed, avoiding soldering and allowing instant 'hook-ups'.

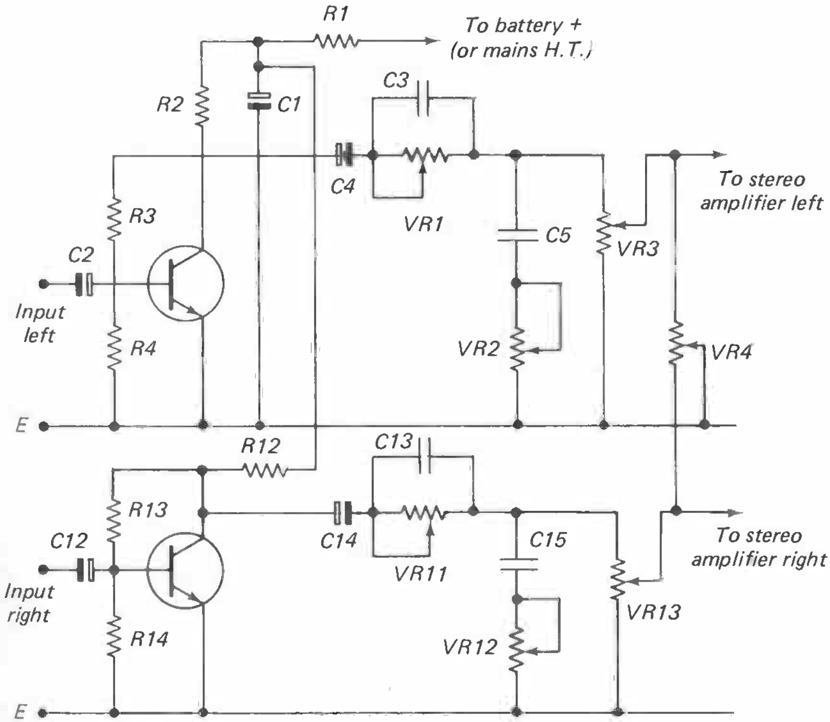


Figure 24. Pre-amplifier for stereo amplifier.

Components required:

Resistors (smallest wattage available).

R.1. — 1 k.ohm; R.2. & R.12. — 57 k.ohms; R.3. & R.13. — 2.7 Megohms;
R.4. & R.14. — 270 k.ohms.

VR.1. & VR.11. — 1 megohm lin. dual gang potentiometer: Bass control.
VR.2. & VR.12. — 1 megohm lin. dual gang potentiometer: Treble control.
VR.3. & VR.13. — 1 megohm log. dual potentiometer: Volume control.
VR.4. — 1 megohm lin. single potentiometer: Balance control.

Capacitors:

Electrolytic, 25 volts. wkg.

C.1. — 220 mfd; C.2., C.4., C.12., C.14. — each 6 mfd.
C.3., C.5., C.13. and C.15. — each 1,000 or 1,200 pF.

As we shall see in the next chapter these audio IC's can be used to form part of a complete radio receiver but the amplifiers described can be fed directly from crystal or ceramic pick-ups in order to play gramophone records (discs). In the case of the stereo amplifier it is probable that a pre-amplifier will be necessary. A suitable simple circuit using two transistors is shown in Figure 24. Connections for tone, volume and balance controls are also given.

As we discussed in Chapter 5 it is not possible in a book dealing with simple radio apparatus to describe FM receivers which operate on VHF and it is therefore necessary to confine our designs to AM types. The reception which can be obtained on AM receivers is more versatile than the three or four stations broadcast on FM, so according to very many of our readers it is the more interesting of the two; the broadcasts of BBC Radio 1, Radio Luxemburg and other popular stations are obtained easily. In the next chapter we combine one or two of the designs already shown to make up a complete receiver.

CHAPTER NINE

Assembling Complete Radio Receivers

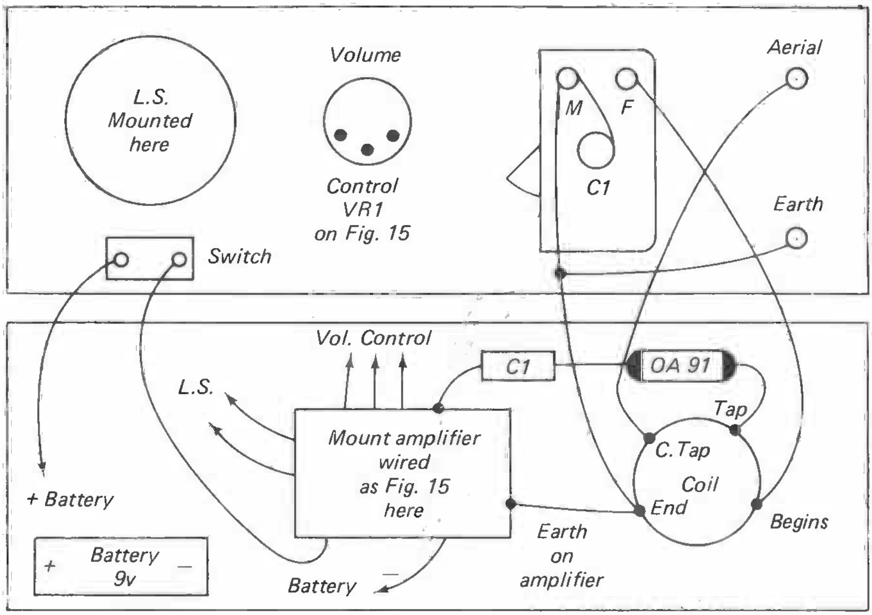
We now combine the designs already described in detail to make up a complete and impressive receiver. For a start we combine a detector, amplifier, aerial and a completely safe earth. This excellent receiver is very sensitive so wiring-up must be neat and direct, the hallmark of all practical radio work.

As you will know by now the use of silicon chips has taken most of the practical work out of making your own radio set and for manufacturers, or the more advanced radio constructor, two or three IC's of differing type can be used to build up a compact and efficient receiver. In this chapter, however, we shall continue our plan of describing receivers which are a little simpler, just as efficient and still easy to build.

The first one is merely a detector and an amplifier and will need, unless you are very close to the station, an aerial and earth. Nothing elaborate is required for an aerial, and usually about thirty feet of wire round the room will do, better still if it is an upstairs room. The earth can be a clip to the bare metal of a radiator or to the cold water main. NEVER TRY EARTHING, OR IN FACT CONNECTING ANYTHING, TO A GAS PIPE OR OTHER GAS APPARATUS FOR IT IS BOTH ILLEGAL AND DANGEROUS.

Where a receiver is mains-operated the connection to the power point will be by means of a three-pin plug. The earth pin on the plug will be automatically connected to the mains earth. This pin will be connected to the chassis of the receiver so that earthing is performed automatically. I do not recommend that you should use mains apparatus other than by means of a three-pin plug which has an earthing point. The exception is a TV set which only operates on the two main pins.

Let us assume that you can erect an aerial and have a wash-basin or radiator in your room for an earth point. You have decided to make the receiver shown in Figure 25 and the first thing to settle is how you are going to house it. The simplest idea is to build it on a panel and baseboard and then to build up the sides and back from them. A simple construction of blockboard nailed with panel pins is sufficient and the whole cabinet can be covered with 'Contact' or a similar adhesive-backed plastic material. First, though, you must decide what you are going to do about a loudspeaker. If you already have one of 4 or 8 ohms impedance all you will need is to make a small radio to stand on top of it. If, like the one I used, yours is a small chassis taken out of an old TV set or radio then you can build it into the complete receiver. Again if you wish to build a complete receiver you can buy a four or five-inch speaker and bolt it to the front panel alongside the controls. This is the design I suggest in Figure 25; as the front panel will probably be 3-ply wood or hardboard it would vibrate a little more than is desirable when the speaker is working. To overcome this it is a good idea to mount the speaker on a sub-panel of blockboard and then to screw this to the panel; this means two holes to cut out instead of one but they are quite easy to do.



Cut out corner of back to allow insertion of battery.
Make leads long enough to connect up to battery before insertion.

Figure 25. Wiring diagram of a "crystal diode and chip" receiver.

For a four-inch speaker a piece of blockboard 5 in. square with a 3½ in. hole in the centre is needed. For a five-inch speaker make the sizes 1 in. larger all round. To cut the circular hole in the centre you will need a keyhole saw or padsaw, and if the square is to be cut out of a larger piece of blockboard it will be easier if you cut out your hole first before sawing off the 5 or 6 in. square. It is easier to operate with a larger piece of wood to hold on to for support.

If you do not have a suitable saw a longwinded but effective way to make the circular hole is to mark it out in pencil and then to take a drill and drill holes all round the mark as close together as possible. Kitchen tables are *not* suitable places on which to do this! Try a concrete path with a thick piece of old timber underneath the work. After drilling all the holes the centre will drop out if given a smart tap with a light hammer. Clean the rough circular edge with an old file, and mark the places to drill the fixing holes for the speaker. When you fit it use countersunk bolts so that the heads do not stand proud and prevent the speaker from fitting close up against the panel. Screw it to the panel, using countersunk screws, and stick a small piece of cloth over the hole to protect the speaker. You can buy special material from suppliers like Home Radio (Components) Ltd. the smallest piece being about a foot square, but your mother probably has something suitable. The test is to hold the material up to the light; if it is porous and lets light through it is usually adequate. You can buy plastic grilles which are fitted after the cabinet is covered. When handling the speaker before fitting do be very careful. In these small speakers, the paper cone is very thin and tears easily. Any damage causes a nasty buzz.

We have dealt fully with fitting a speaker. Now let us turn to the radio set itself; constructional details have been given already. In the first receiver we are using a 'crystal' set front end coupled to a silicon chip audio amplifier. Coils for this type of receiver are discussed in Chapter 3 and as there is room on the baseboard I suggest you make up the coil described in that chapter. It is mounted on the baseboard by cutting a strip of wood, such as 5-ply, about ½ in. wide and sufficiently long to be a tight fit in the coil former. This strip is screwed to the base with a screw in the centre and the coil, when wound, pushed onto it. If it is not tight enough a spot of adhesive on each end of the wood will hold things fast.

Now you must mount the components on the panel. These are the tuning capacitor, two sockets or a double socket strip for aerial and earth and a switch. The switch is needed because the battery for the audio chip will be inside the case. So that you can change the battery easily I show in the diagram a small corner cut out through which the battery can be slid out and a new one put in. Under normal circumstances the battery should last a long time. The audio side is built on a piece of Veroboard and at each end where there are no components a small hole is drilled. The board can then be screwed to the baseboard with a few washers between it and the base. If you use the CSC 'breadboard' holes for fixing are already drilled in it.

If you are in a good reception area and want to use the ferrite rod aerial type coil shown in Chapter 3, building the receiver will follow much the same pattern except that the coil will need fixing in some manner instead of being screwed to the baseboard. In the description of the crystal receiver in an earlier chapter I suggested you obtained two strips of carpet tape or insulating tape and gently looped it round each end of the ferrite rod. Leave two flaps sticking upwards and with small nuts and bolts fix them to the panel. If you make sure that the vanes of the capacitor do not touch it, the best position would be above the capacitor.

That would also be the best position for the coil in the next receiver which is described in Figure 26. This is a much more sophisticated set and uses the Ferranti ZN 414 chip described in Chapter 6. Exactly as in the previous receiver this one consists of the ZN414 'front end' coupled to the IC audio amplifier. The particular one I have specified uses the TBA810S but you can use any of the others mentioned or ready-manufactured devices such as the ILP range mentioned in Chapter 13. This receiver would be a very good type with which to use a small mains battery eliminator and there is plenty of room in the cabinet for it.

I stress that if you use the electricity mains you must arrange for a cabinet to enclose the receiver. Certainly the voltage used for operating a receiver rarely exceeds 24 but a mains transformer is required and on one side of this there are usually exposed tags to which the 240 volts mains input is attached. **Small brothers and sisters, and family pets, tend to be very inquisitive, and it is vital that they cannot put fingers, or paws, on this mains input, apart from your own risk of accidentally touching it. A cover, therefore, is essential!**

This receiver is much more sensitive than the crystal set type so that it is necessary to ensure that wiring-up is neat and direct. No stray wires should be seen across the board and all wires should be as short as possible. With careful wiring you will have an excellent little receiver.

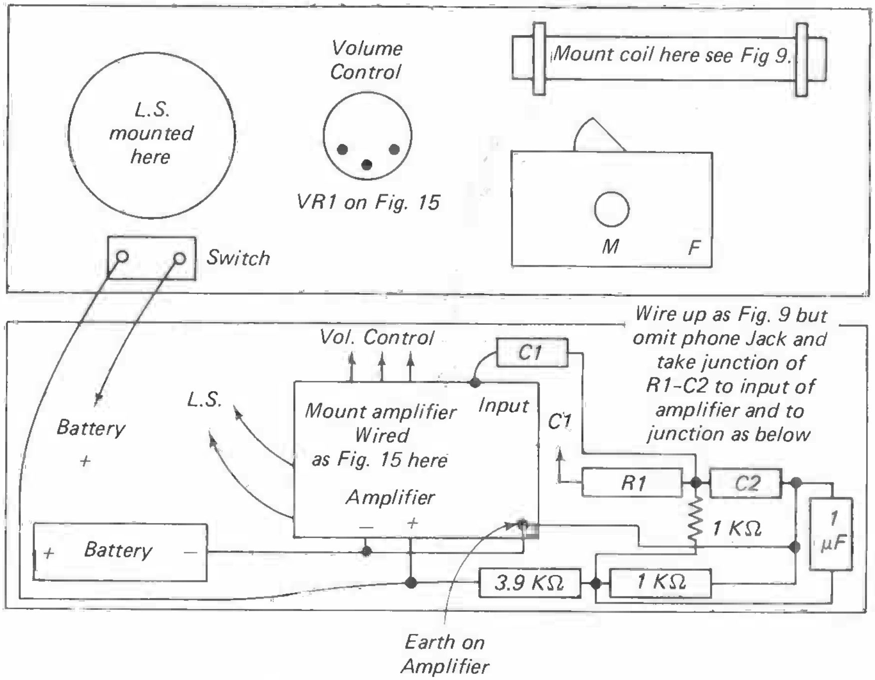


Figure 26. Wiring diagram of a one-chip and amplifier receiver.

In the above diagram R.a. and C.2. shown without values are the equivalent of R.1. and C.2. in Fig. 9. R.1. should be 1.5 kilo-ohms and the arrowed end goes to C.1. of Fig. 9. The capacitor shown as C.1. joined to INPUT in the diagram above is C.1. in Figs. 14 and 15 and will thus not need to be repeated.

CHAPTER TEN

Loudspeakers to Build or Kits to Buy

The cabinet plays a large part in the quality and performance of reproduction of the high-fidelity loud speaker. There is no need to pay a mint of money for new speakers if required since Scout and Guide Jumble Sales or the small advertisements in local or even national weekly papers may well yield perfectly good ones taken from old radio and TV sets. We show you how to set about making a suitable cabinet.

At one time there were plenty of loudspeaker chassis available and it was a simple matter to build one's own very satisfactory reproducer. Most manufacturers have now decided to concentrate on the high-fidelity market and market their loudspeakers already built into a cabinet. As the cabinet does play a large part in the reproduction capabilities of the speaker this is readily understood. Another factor is that present living conditions means houses, flats and apartments with much smaller rooms. So loudspeakers must be smaller too and yet sacrifice nothing in the way of tonal quality. The large floor-standing cabinets with 10 in. or 12 in. chassis in them seem to be used mainly for pop groups, hotels, restaurants, halls and other places with plenty of room. The prices also seem to match the size.

If you have a suitable chassis and wish to build a speaker cabinet there are some very useful thoughts, views, figures and designs in *The Cabinet Handbook* by G. A. Briggs (published by Rank-Wharfedale). Mr. Briggs was founder of the Wharfedale speakers firm which was later absorbed in the Rank Organisation; their loudspeakers, in my opinion, have always been, and still are, quite outstanding. All books written by G. A. Briggs are well worth reading. They combine instruction and advice in a readable, entertaining and commonsense style. Unfortunately many are now out of print but some are still available in local libraries, while secondhand copies are offered from time to time in the weekly Exchange & Mart.

One firm who specialises in loudspeakers is Wilmslow Audio Ltd. and the price of a small chassis suitable for our use was around £5 to £10 in 1980. They also market complete kits for construction of cabinet loudspeakers by manufacturers such as Wharfedale and Richard Allen but these ranged in price from £30 to £60 in 1980. While reproduction from the receivers we describe is very good I do not feel it is worthwhile paying all that money for a 'hi-fi' speaker. No doubt you will be able to find a suitable 4 in. or 5 in. speaker in a local shop, perhaps, or possibly an old valve radio set or TV set in which the loudspeaker is perfectly sound. Scout and Guide Jumble Sales produce some astonishing bargains! The cabinet shown in Figure 27 is one of a pair of speakers I use with a stereo record player giving remarkable results. I regard them as remarkable because the speakers in them are simple ones from an old radio in one case and a TV set in the other. One is an oval shape 5 in. long by 4 in. at the widest point. The other is also oval 6 in. long by 3½ in. You may find something suitable in secondhand shops, market stalls or local jumble sales. Small speakers are usually the correct impedance of 3 or 4

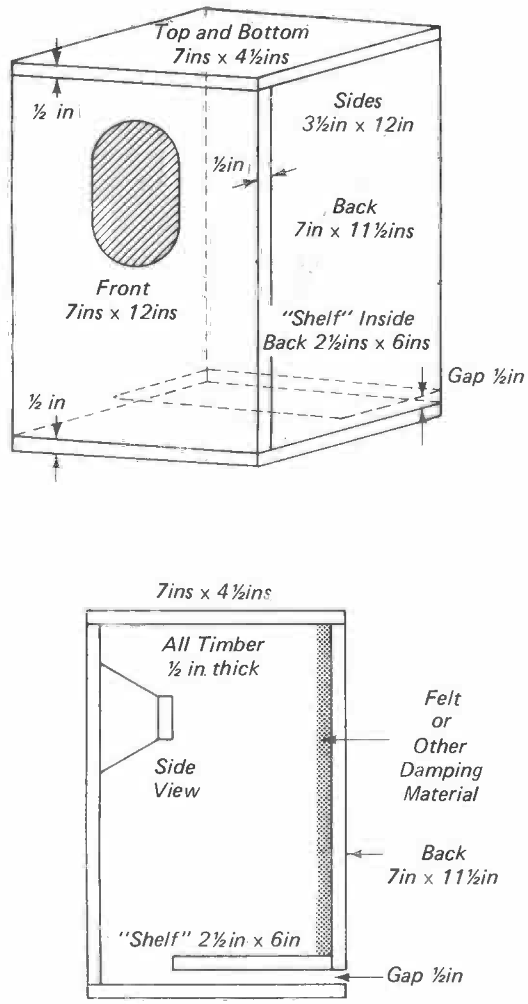


Figure 27. Cabinet for small bookshelf type speaker.

ohms. It is not absolutely necessary to use oval ones for the round variety will be perfectly suitable. The pages of the weekly *Exchange & Mart* often yield some real bargains.

To consider the design in Figure 27, you will only need to make up one speaker unless you are building the stereo amplifier. If you decide to take up stereo later you can always add the other speaker to the same design. It does not matter if you have to use a different speaker chassis. The variations in the speakers themselves, the rooms in which they are used, and where they are placed in the room easily override the need for the speakers to be exactly the same. The advertisements of speaker manufacturers do say they should be, but many authorities agree that, due to the variations mentioned, different speakers are quite acceptable.

For the small loudspeaker shown you will require some half-inch blockboard, but not a lot as you can see; off-cuts are often cheaply available from local do-it-yourself stores. The half-inch thickness is important, however, as that controls the internal dimensions which, in turn, react with the speaker to provide good reproduction. Other timber will do, naturally, but it must be half-inch or 13 mm. thick. On the largest piece a hole for the speaker must be cut out and methods of doing this were discussed in Chapter 9. On the section behind the speaker a piece of damping material must be fixed and this can be carpet felt, foam or fibreglass. It needs to be fairly thick. For instance, carpet felt should be double thickness. It can be just tacked on at top and bottom, one layer on top of the other.

The 'shelf' inside must be fixed before that and I recommend you glue as well as screw it to the foot of the panel. The outlet which is left at the rear end of the cabinet controls the bass and the sound from the back of the speaker cone, so it is essential to allow an inch or so behind the speaker and not push it hard against the wall. When the pieces of timber are glued and screwed together (there is a proprietary resin glue for timber which suits the task excellently) you will be astonished to find that, despite the enormous care you took to cut them straight, there are gaps here and there!

We require the inside of the cabinet to be airtight so we cannot take the risk that air might escape through these gaps. In all my speakers I have filled the edges with plastic wood and made sure they are airtight. I recommend this precaution. A tube of plastic wood is inexpensive and should be adequate. Afterwards the whole cabinet can be covered with Storey's 'Contact', not forgetting first of all to glue a protective grille of some kind over the speaker opening. To finish off I like to screw plastic edging strip round the front. I use the half-inch kind which is angled. Do not forget to solder connecting leads to the loudspeaker tags before building the cabinet around it for it will be impossible to do so afterwards!

If you are lucky enough to obtain a good 8 in. speaker chassis there is a design in G. A. Briggs' book for a 1¼ cub. ft. cabinet to suit it. This is also built of half-inch blockboard. The two ends are 16½ in. by 8½ in. and these are fixed to four pieces so that the total length from end to end is 21 in. It makes a reasonably large cabinet but it will stand on a shelf quite well; to enable it to do so and be close to the wall the tuning slot is in the top, assuming that the speaker chassis is fitted to one side as the front. For an 8 in. speaker the slot should be 12 in. long by ½ in. wide and about 1½ in. in from the rear of the cabinet. Three sides of it should be covered in a good thickness of damping material such as thick felt.

While the speaker cabinet designs we have discussed in this chapter give most satisfactory results, there is no need to have doubts if you propose to mount your speaker in the same cabinet as the receiver. With a loudspeaker chassis some form of 'baffle' is required in which it can be mounted in such a way as to prevent sound waves from the rear of the diaphragm coming round and cancelling out those emanating from the front of the diaphragm. A large square of timber about 2 ft. square with the speaker in the middle would do very well but it is too unwieldy for general use. So a folded baffle in the form of a cabinet serves our purpose. Thus as long as your speaker is mounted in a cabinet of some kind all should be well.

In the next chapter we discuss the question of obtaining our power supplies from the mains.

CHAPTER ELEVEN

Battery Eliminators for Mains Operation

The utmost care must be observed at all times in dealing with power from the mains. The power unit MUST be covered by a box or cabinet. Follow the instructions given in this chapter with every confidence to ensure a satisfying, and above all, safe result.

There is no great difficulty in operating transistor or silicon chip equipment from the electricity mains as the small power requirements mean that only a few components are required. The designs in these chapters do not require more than about 14 volts and, in the case of the ZN 414, a mere 1.5 volts is adequate. You can purchase ready-made devices quite cheaply to give 12 volts for transistor radios. If you have one of these it can be used to operate the IC circuits. The output from these is not very high, though, and if you are going to do some experimenting of your own it is a good plan to make up a power supply which you can use for that purpose.

First of all the safety factor must be stressed again. The power unit must be covered by a box or cabinet. If you are not building it into a set make sure that it is contained in a box of some kind to prevent contact with the live mains terminals.

You will need to contact to the mains by means of a three-pin plug. Make sure you know the correct way to wire that up. The brown lead goes to Live or 'L' (on a 13 amp. plug this is the one with the fuse attached to it). The blue lead is connected to the adjacent short pin and the green and yellow wire connects to the earth pin which is the bigger, thicker pin on its own at the front of the plug.

Whenever you carry out any work on a power unit or mains-operated receiver always pull out the plug. Do not rely on the switch.

The first requirement is a transformer to reduce the mains voltage of 240 down to 12 or 24. In the United Kingdom 240 volts is the standard grid voltage but it may be different where you live. The standard grid voltage is, I know, 120 volts in some countries. The primary of the transformer must be obtained to match whatever the input may be. For general work with IC's it will be adequate to have a 12 volt output but if you are going to make up a stereo outfit like that in Figures 18 and 19 the correct voltage would be a maximum of 24.

This does not mean that the secondary of the transformer has to be 24 as the voltage when rectified tends to rise somewhat, particularly if the transformer is not being asked to give all the current output of which it is capable. So for 24 volts you will require a secondary winding giving 18 volts and half this for 12 volts. As we shall be using what is called a 'bridge rectifier' a single winding only is necessary. I suggest you obtain a centre-tapped winding of 18 volts. This is known as 9-0-9 and thus between 0 and 9 you will obtain the required 9 volts, leaving the other end unconnected. If later on you need the higher potential you can leave 0 unconnected and use 9 and 9 which will give 18 volts. In addition I suggest the transformer should be one which gives a 1 amp. output rather than the smaller type which only provides about 100 m/amp. In 1980 this 1 amp. type cost about £2.50.

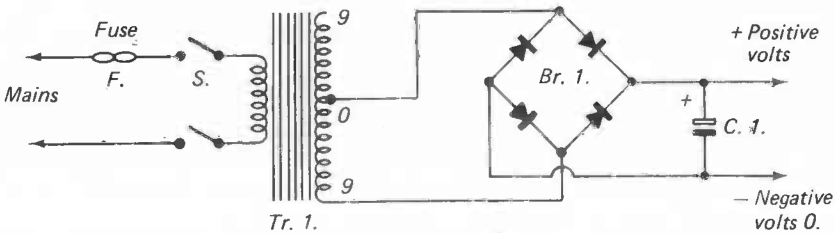


Figure 28. A mains unit for power supply.

Components required:
F — 1 to 3 amp. fuse.
S — Double-pole mains switch.
Tr.1. — Mains transformer 9-0-9 volts 1 amp.
Br.1. — Bridge rectifier 1 or 2 amp. 100 volt p.i.v.
C.1. — Electrolytic capacitor 4,700 mfd. 25v. wkg.

Apart from the transformer a rectifier will be needed to convert the alternating current from the mains to direct current. A 50 volt type will be adequate. Bi-Pak Semi Conductors Ltd. supply a silicon bridge rectifier taking 50 volts input and supplying up to 1 amp. for about 25 pence (1980). You can use this for either the 9 volt or the 18 volt input mentioned above. For smoothing a large capacitor is needed and the size to use is 4,700 μF with a working voltage of 25.

You will need to mount the components on a base of some kind and if you are building the unit into a receiver it can stand on a corner of its baseboard and the switch will be mounted on the front panel. In the same way, if it is to be an independent unit for general use you will be building a small cabinet with the switch on one of the sides. The transformer must be bolted to the baseboard, using bolts with countersunk heads so that they will not stand proud, the heads being on the underside of the base. The bolts then appear through the flanges of the transformer. On one of them add a large soldering tag. Then place the nuts on the bolts and screw down tightly. The rectifier can be suspended on the transformer lugs and the capacitor wired between the positive output from the rectifier and earth.

As for the earth, the earth wire from the mains cable (the green and yellow wire) is soldered to the tag which you fixed under the transformer foot; this point forms the main earth for the receiver in a complete set, or for any other set with which the unit is used. The negative side of the capacitor (watch this point when wiring up — the capacitor is 'polarised') will be soldered to the earthed tag. A connection will also go from there to the earth line of the receiver or amplifier. I recommend that the mains input switch should be a double pole one to disconnect both lines from the mains. A fuse (say the 3 amp. type) on one side of the input is a worthwhile addition.

CHAPTER TWELVE

Short-Waves and Silicon Chips

We like to include a chapter in all our radio books to encourage experimental designs. There is great opportunity, for instance, on the short-wave bands. Experimenting with ideas outside the scope of handbooks gives lots of fun to the enthusiast. Silicon chips are the key to these experiments....

As we have concentrated on such marvellous modern devices as silicon chips it would seem more correct to head this chapter 'High Frequencies and Silicon Chips'. The modern trend is to refer to high frequency rather than short-wave but as VHF in the minds of most readers will relate to FM broadcasting, and UHF to TV colour bands, we are sure that readers will know what is intended by 'short-waves'. As one who has spent

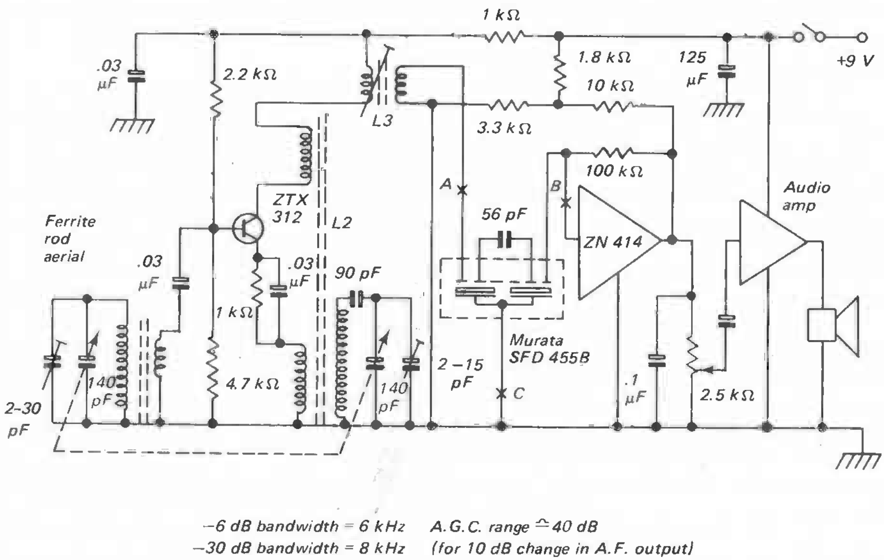


Figure 29. Super-het for medium waves using ZN 414.
(Reproduced by courtesy of Ferranti Ltd.)

The ZN 414 gives excellent results as an I.F. amplifier working at 450-470 kHz. A ceramic resonator is recommended. The audio amp. in the diagram would be another IC similar to those described in earlier chapters.

most of his life 'messing about with radio' I know that experimenting with things which are not set out in books is where so much of the fun lies. The Editor and I have always recognised this in our series of radio books published by Kaye & Ward Ltd.

We like to include a chapter of suggested ideas which I have not built up myself but which are suitable designs for experiments. It is on the short-wave bands that the best opportunity lies for such experimenting. A handbook published by the Radio Society of Great Britain entitled *A Guide to Amateur Radio* by Pat Hawker (G3 VA) contains an easy-to-build, low-cost, short wave superhet design using four transistors. Two of these are on the audio side so that if you built this receiver you could substitute an IC for them without much difficulty.

If you possess one of the remarkable little chips by Ferranti which we discussed in Chapter 6, the ZN 414, you could try this in a simple short-waver. The frequency range of the ZN 414 is given by Ferranti as 150 kHz to 3 MHz, which can be translated into metres as 2000 to 100, so that a certain amount of the shorter waves should be covered by it, especially the interesting 160 metre amateur band. It may also provide some results on the 80 metre amateur band. I suggest you can try 20 turns of wire on a ferrite rod tuned by a 150 pF capacitor. An aerial connection to the fixed vanes of the tuning capacitor may increase reception. It does not need to be a long wire, indeed twelve feet or so round the room should be adequate. It must be emphasised that this circuit is only put forward as a suggestion. It is not a Ferranti design, but you may find it interesting to try out.

The ZN 414 can be used as the intermediate frequency (I.F.) amplifier in a superhet receiver and Ferranti have kindly allowed me to reproduce their schematic diagram showing how this can be done. Figure 29 shows a broadcast band superhet using two I.C.'s, the ZN 414 and an audio amplifier chip such as we used in designs in Chapters 7 and 8. The ZN 414 provides four stages of I.F. amplification at the chosen frequency of 450 to 470, kHz, many coils being wound for a set frequency of 465 kHz. The I.F. frequency is obtained by tuning the oscillator circuits of the RF transistor shown as a ZTX 312. This fixed frequency is fed into the tuned I.F. transformer L3.

There is only this one tuned stage in the I.F.circuits so that selectivity might suffer but this is aided by inserting a crystal filter after it. This filter is tuned to pass only the frequency of the IF. In the diagram the ceramic filter is shown as made by Murata and is type SFD 455 B; this indicates it is 'tuned' to a frequency of 455 kHz whilst the 'B' suffix shows the response characteristic. From the ZN 414 the signal is fed into the audio amplifier chip and on to the loudspeaker.

In Figure 30 I have adapted the aerial and oscillator coil circuits of this superhet to show the use of Denco coils in the transistor input, the appropriate ones being the blue series for aerial and red for oscillator. These coils plug into a noval 9-pin holder and range from the long wave band to 10 metres in the shorter waves. It could be an interesting circuit for experiments. Availability of and assistance with the ceramic filter can be obtained from Ambit International. If you cannot obtain the ZTX 312 transistor the Mullard BF 195 will do. Ambit International describe a 'one-chip' communications receiver in their catalogue which would interest the more advanced reader; alas, the sheer cost of hobby materials makes many designs beyond the range of average pocket money.

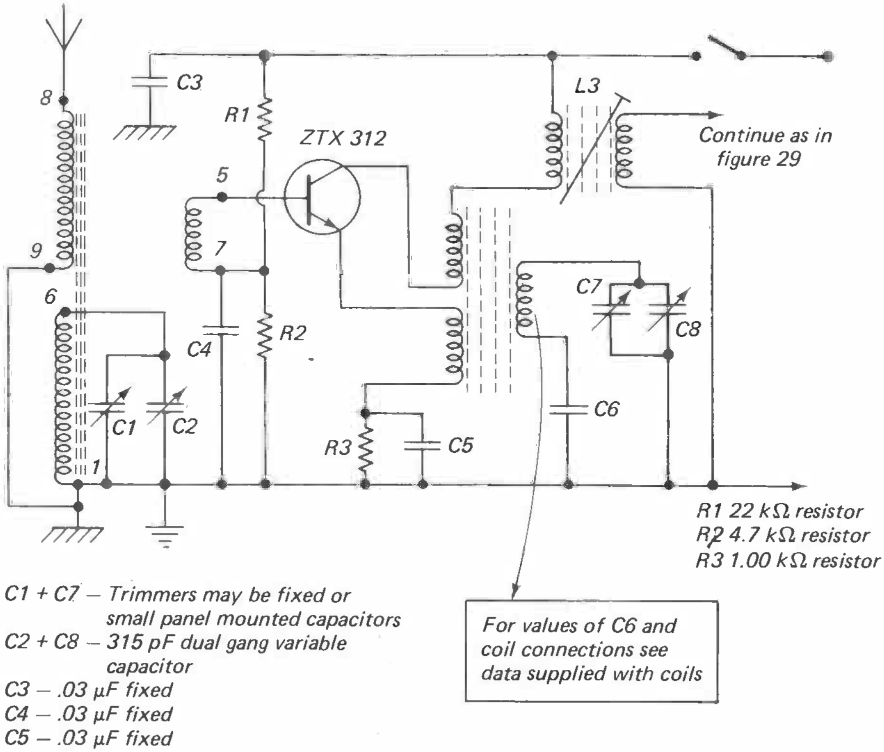


Figure 30. Denco short-wave coils for super-het "front end".
(Reproduced by courtesy of Denco [Clacton] Ltd.)

CHAPTER THIRTEEN

Kits Available, and Applications of Silicon Chips

We suggest a kit which will enable you to build your own computer! That may surprise you but it is built around silicon chips integrated circuits. Chips can be used for controlling model aircraft, model boats and cars, and even for making amusing noises in children's toys! Would you care for a Kojak siren, the unmistakable noise of farm tractors or aircraft, the eerie sounds of a space ship or just a gong?

In discussing silicon chips for use in modern radio and audio projects we have only dealt with the fringe of the variety and quantity of chips available in the world of electronics today. Mullard, which is only one of the firms producing chips, publish a guide listing their varied devices which is over half an inch thick! Mostly these I.C.'s are used for

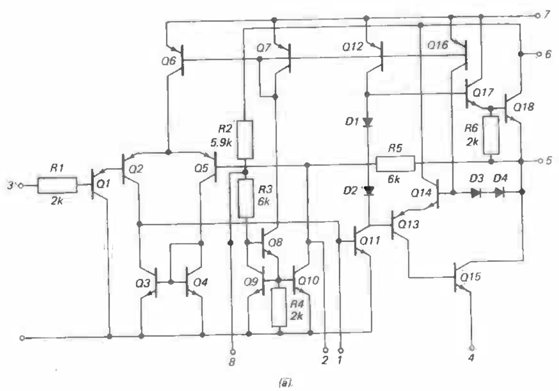


Figure 31. TBA 820 M Chip. *(above and next page)*
(Reproduced by courtesy of Ambit International)
(a) Internal connections.

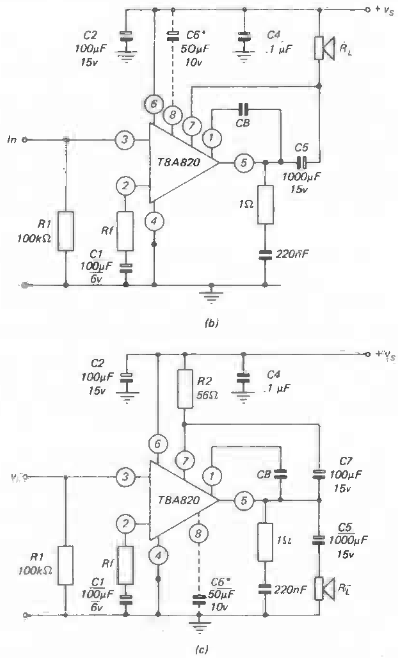


Figure 31. TBA 820 M Chip. *(see also previous page)*
(Reproduced by courtesy of Ambit International)

(b) Loudspeaker connected to supply.
(c) Loudspeaker connected to ground (earth).

Inclusion of C.6. is recommended for best supply ripple rejection.

computers which is the modern generic term for almost any kind of calculating machine. In this final chapter we look at one or two other ideas which are not strictly radio but which can be bought, or built, by the enthusiastic and interested reader.

Computers have already been mentioned so the first kit we suggest is one with which you can build your own computer! It is produced by Science of Cambridge Ltd. and is called the Sinclair ZX 80 Personal Computer. The kit was priced in 1980 at just under £100 including a mains adaptor. No doubt you cannot afford it yourself but a relative in business might well consider it. The kit is also available ready-assembled for £20 extra and is built around the silicon chip integrated circuits.

Mention has already been made of units produced by I.L.P. Electronics Ltd. These are very simple to use where it is desired to avoid too much construction work as they are ready-assembled complete with heat-sink where necessary. For readers interested in public address work for Scout and Guide occasions or a 'pop' group ILP make an amplifier which gives a hefty 240 watts output. Their modules use silicon chips IC's but not solely, and additional transistors are used, the power input required is a 'split' one so that they can only be used with the special power unit available or one similarly designed.

Ambit International's catalogues are highly recommended. Even if much of the information in them is too technical for boys and girls there is much to learn from them apart from the amusing way they are written. Silicon chips form a very large part of the radio material marketed by Ambit and Figure 31 shows another of their audio chips. This is a low-power unit very suitable for making up to follow the crystal detector unit or the ZN 414 tuner. On the left of the diagram is the internal make-up of the chip, another example of the sheer compactness of these midgets; this one is 9.6 mm. long by 6.2 mm. wide.

Radio-controlled models are outside the scope of this book but a number of instructional details are available. There is some connection with radio in that the control of the aircraft or boat operates via radio transmitters and receivers working in the 27 MHz band. The Ferranti ZN 414 can be used in the I.F. stages of a crystal-controlled receiver working in that band. Ferranti also make a chip ZN 419 CE which is designed, they write, 'particularly for pulse-width position servo mechanisms used in all types of control applications'. The small size and low power consumption make this chip ideal for use in model aircraft, boats and cars.

The manufacturer who invented the silicon chip in 1965, whose work I mentioned in the first chapter, is Texas Instruments Ltd. I visited their Bedford factory complex and met a number of their technicians. In particular, I met Mr. Michael Williams a young scientist who was obviously doing a job which he enjoyed, working out uses for some of the Texas silicon chips. He handed me a number of schematic diagrams he had formulated for producing noises which might be used in toy production! Texas Instruments Ltd. have kindly allowed us to reproduce one of these in Figure 32. This chip with the few extra components round it will simulate the noise of 'bleep bleep' when fed into an amplifier and then to a loudspeaker. If you prefer the sound of a machine gun then wire up according to Figure 33. Other sounds which this chip will produce are a gong, a kojak siren, a tractor, various types of aircraft, missiles, guns and a space ship!

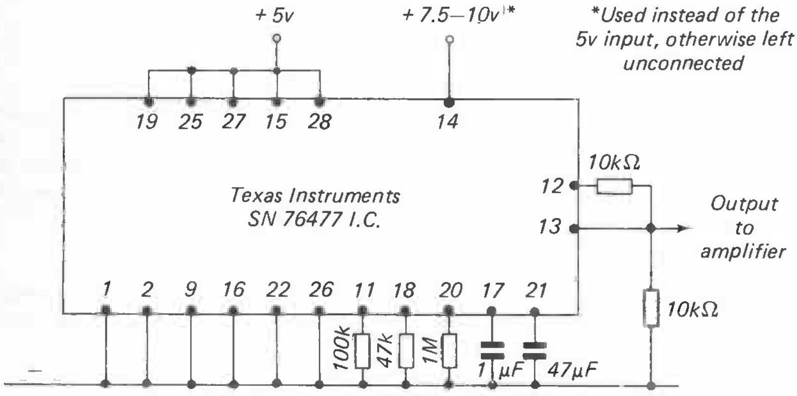


Figure 32. Texas design for "bleep-bleep" noise producer.
(Reproduced by courtesy of Texas Instruments Ltd.)

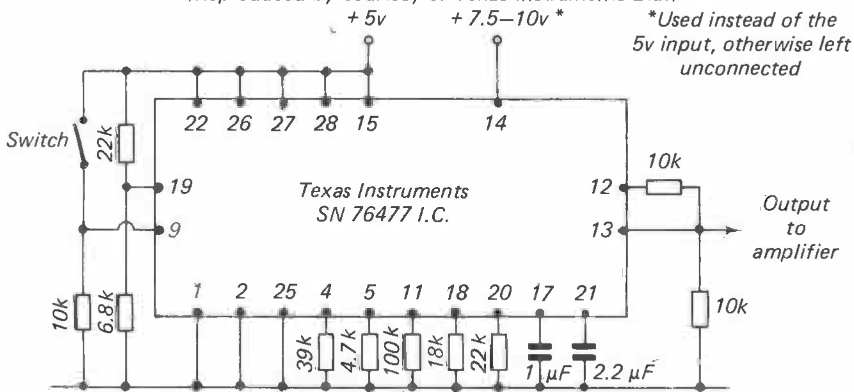


Figure 33. Texas design for "machine gun" noise producer.
(Reproduced by courtesy of Texas Instruments Ltd.)

All these designs are the copyright of Michael Williams and Texas Instruments Ltd. and I am grateful for the opportunity to reproduce them here. Our indebtedness is also due to Mullard Ltd., Ferranti Electronics Ltd., Ambit International, I.L.P. Electronics Ltd., Continental Specialities Corporation (U.K.) Ltd., Denco (Clacton) Ltd. and Sinclair Radionics Ltd., for their assistance in allowing us to use diagrams and for advice and help freely given. The electronics industry is a friendly, and an important world-wide concern today. The coming of the silicon chip made many opportunities for intelligent and qualified technicians. We hope that the information given in these chapters may well encourage some of our readers to take a more extended view of silicon chips and to study for a career in a really modern industry. On the other hand your interest may develop into a worthwhile hobby only. In any event, we hope you have enjoyed reading the book and have built some of the designs we have prepared for you to produce lasting pleasure. The Editor and I send you greetings and good wishes wherever you may be, and wish you every success with your interest in modern radio, and especially the silicon chip.

APPENDIX

If you wish to write to me I shall be glad to help you with any difficulties you may encounter *but only in connection with the designs in this book.* Write c/o the Publishers; please enclose a stamped addressed envelope or International or Commonwealth reply coupon. It is regretted that no reply can be given without the S.A.E. in the U.K. or I.R.C. outside it. It is meaningless if you live outside the U.K. to send me an envelope bearing your country's stamp. Difficulties with components or manufactured products should be referred in the first instance to the supplier from whom the article was purchased. Below are given a list of books and periodicals we have suggested together with names and addresses of manufacturers and suppliers of the products we have mentioned.

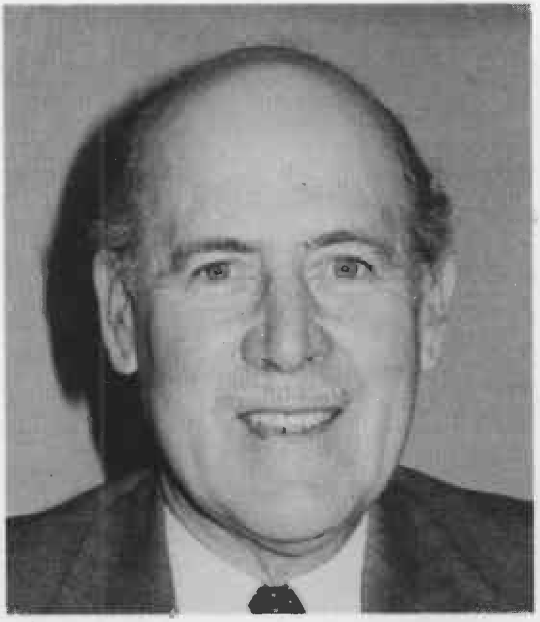
Books and Periodicals

Books:

Introduction to Semi-conductor Devices	M. J. Morant (Harrap)
Principles of Semi-conductors	M. G. Scroggie (Iliffe)
Principles of Transistor Circuits	S. W. Amos (Iliffe)
The Cabinet Handbook	G. A. Briggs (Rank/Wharfedale)
Guide to Amateur Radio	Pat Hawker (R.S.G.B.)
Fun with Short-Wave Radio	Gilbert Davey (Kaye & Ward) (Edited by Jack Cox)
Fun with Hi-Fi	Gilbert Davey (Kaye & Ward) (Edited by Jack Cox)

Periodicals:

Wireless World	published monthly by IPC Electrical-Electronic Press Ltd.
Practical Wireless	published monthly by IPC Magazines Ltd.
Exchange & Mart	published weekly by The Link House Group, Robert Rogers House, New Orchard, Poole, Dorset BH15 1LU.



A practical handbook written in simple, straightforward English for the practical boy or girl whose hobby is amateur radio construction. Although it deals with a highly technical aspect of modern radio which has only existed since the mid-1960's the approach is simple and direct, demanding no technical or theoretical knowledge on the reader's part.

Gilbert Davey was born in 1913, became interested in radio as a boy of fourteen and has followed it as a hobby ever since. He has written for radio journals, radio and television since 1933 and one of his books in this series 'Fun with Radio' has been in continuous publication for twenty years. The following titles by the same author had their origins in the pages of Boy's Own Paper.

Fun with Radio
Fun with Short Wave Radio,
Fun with Electronics,
Fun with Transistors
Fun with Hi-Fi

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