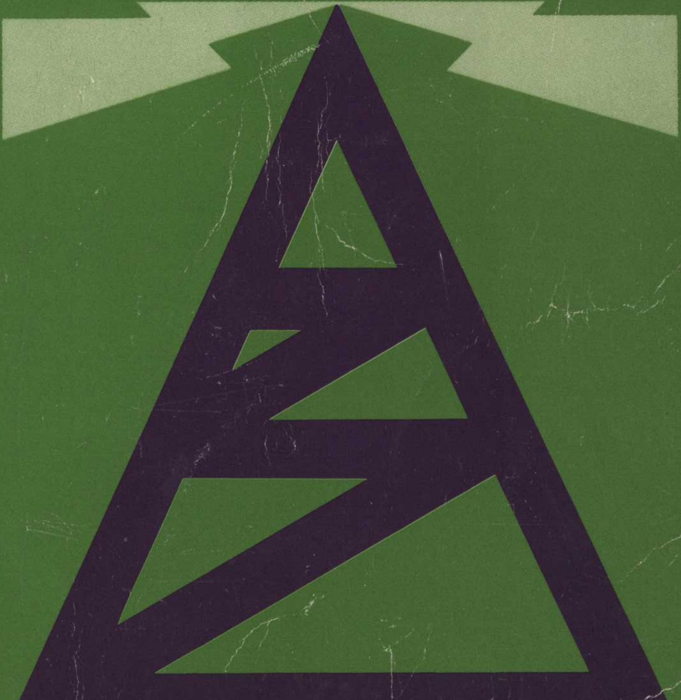
Solid State Short Wave Receivers For Beginners

R. A. PENFOLD



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SOLID STATE SHORT WAVE RECEIVERS FOR BEGINNERS

by

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CHAPTER 1

There is a strange fascination in listening to a broadcast that eminated from a station some thousands of miles away, and this has helped to make short wave listening one of the most popular and interesting branches of electronics. Although most people interested in S.W. reception have aspirations of owning a complicated communications receiver, most start with a far less extravigant set, and almost invariably one that is home constructed.

Fortunately, even using a simple receiver it is possible to receive transmissions from the other side of the world, and usually a greater sense of achievement is experienced when one receives a distant station using a simple home made set, rather than when one has used a sophisticated commercially produced receiver.

Several simple S.W. receiver circuits are described in this book, and these will all give a fairly high level of performance despite the fact that relatively few components are employed in each case. There is no one simple design that will suit all S.W. listeners requirements, and it is because of this that a number of designs have been included. For instance, the Direct Conversion Receiver provides an excellent introduction to amateur band reception if the constructor has space for a good aerial and earth system and requires a fixed installation. On the other hand it is completely useless if the enthusiast is primarily interested in the broadcast bands or in a portable unit that does not require a long aerial and an earth connection.

Prospective constructors are therefore advised to study the various designs and choose for construction only those that really suit their requirements. If there is no preference for either broadcast or amateur bands reception initially, then one of the general purpose circuits would probably be most suitable to start off with. However, most short wave listeners specialise in one type of reception eventually.

Frequency Spectrum

The S.W. frequency spectrum extends from about 1.7 to 30 MHZ, and this is divided into areas which are designated for specific purposes. Those that are of primary interest to the S.W. listener are the six amateur bands and the twelve commercial broadcast bands.

Although one can simply build a receiver and then occasionally tune around the dial to see what can be picked-up, it is a great advantage to have a certain amount of knowledge about the various bands and their characteristics. Armed with this knowledge the S.W. listener stands a much better chance of obtaining good results from his or her receiver. For example, searching the 160 Metre amateur band for distant (DX) stations using a simple receiver would be a waste of time, whereas searching the 20 Metre band for such signals would almost certainly be much more fruitful.

A table giving the frequency limits of the S.W. amateur bands is shown below.

160 Metre Band	1.8 to 2.0 MHZ
80 Metre Band	3.5 to 3.8 MHZ
40 Metre Band	7.0 to 7.1 MHZ
20 Metre Band	14.0 to 14.35 MHZ
15 Metre Band	21.0 to 21.45 MHZ
10 Metre Band	28.0 to 29.7 MHZ

The 160 Metre band is shared with maritime stations, and the maximum permissible transmitter input power for licensed amateur stations is only some 10 Watts in this country. Therefore most of the stations received on this band will be within a radius of about 50 miles from the receiving location. On infrequent evenings conditions are such that reception over distances of a few hundred miles or even more is possible.

80 Metres is suitable for both local and DX reception, the more distant stations being received mainly during the late evening and the small hours of the morning. This makes 80 Metres one of the most interesting of the bands.

The qualities of the 40 Metre band are similar to those of 80 Metres, but theoretically DX reception should be better on 40 Metres. This is probably rarely the case in practice as this band is only 100 kHz wide and has the 41 Metre broadcast band lying just off its high frequency end. This tends to make reception rather difficult on this band, and this is particularly so after dark when the situation is exacerbated by the frequency encroachment of powerful broadcast stations onto the band. This has led to the 40 Metre band being one of the least popular bands among both transmitting amateurs and S.W. listeners.

160, 80 and 40 Metres are collectively known as the 'Low Frequency' (L.F.) bands.

Undoubtedly the best band for amateur DX reception is 20 Metres, and this band can usually be relied upon to provide a number of interesting transmissions. The 10 and 15 Metre bands are also usually associated with DX reception, but these bands, particularly 10 Metres, are greatly affected by propagation conditions that vary considerably with changes in the upper atmosphere.

Propagation

The reasons for the amateur bands having these differing characteristics can best be explained by looking at how radio waves travel. The diagram shown in Fig.1 will help with this explanation.

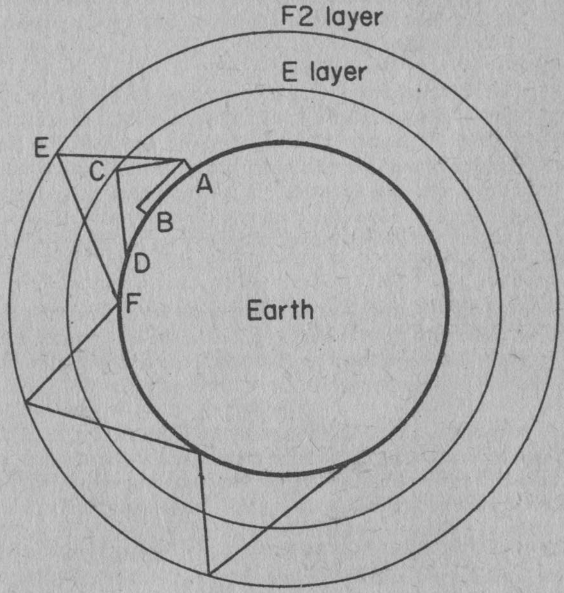


FIG. 1

When the transmitter is close to the receiving station the radio waves can travel direct from the transmitter to the receiver. This is represented by line A–B in the diagram, and is termed the 'ground wave'.

At frequencies of more than a few MHZ the ground wave tends to be absorbed by the earth and cannot be used for reliable communications, except over very short distances.

After dark the ionised E layer of the atmosphere will reflect radio waves at low and medium frequencies, except those that hit it at a very high angle. These merely pass straight through and pass on into space. This reflected signal is represented by line A–C–D, and can provide communications over a far greater distance than the ground wave. It is termed the 'sky wave'.

High frequency signals pass straight through the E layer usually, and go on to the F2 layer where they are reflected back to earth. The F2 layer is at a height of about 200 miles as compared to about 70 miles for the E layer. This greater height of the F2 layer causes the reflected high frequency radio waves to be reflected back to the earth's surface at a great distance from the transmitter, and it is partially this factor that makes the H.F. bands (10, 15 and 20 Metres) so good for DX reception. This type of propagation is represented by line A–E–F in the diagram.

Another factor for the good DX reception on the H.F. bands is the absorbtion of the ground wave which prevents local transmitters from blotting out DX signals. When listening on the 20 Metres amateur band it is quite common to hear a relatively local station in contact with one several thousands of miles away. Often the distant station provides a really strong signal whereas the local one is barely perceptible. In fact, when listening on the 20 Metre band only very rarely will a British station be heard at all.

In order for a signal to pass from one side of the earth to the other it has to bounce from the atmosphere to the earth, back up to the atmosphere and then down to earth again for several cycles in order for it to negotiate the curvature of the earth's surface.

How well, or otherwise, the signals are reflected by the F2 layer is largely dependent upon unpredictable events, and the sun is a major factor here as it is it's radiation that ionises the relevant layer of the atmosphere. It is quite possible for an H.F. band to suddenly have a proliferation of DX signals which disappear a few hours later just as fast as they arrived. For quite long periods the H.F. bands can seem to be completely dead, particularly towards the upper end of the S.W. frequency spectrum. Therefore one should not be too perturbed if a newly constructed receiver does not seem to operate as well on the H.F. bands as it does on the L.F. ones. This is probably due to a lull in the propagation conditions on the H.F. bands rather than because of some fault in the receiver.

Broadcast Bands

There are twelve broadcast bands and their frequency limits are shown in the table below. Note however, that broadcast stations tend to sprawl outside these limits, and they are not adhered to as strictly as in the case of the amateur bands.

120 Metres	2.3 to 2.495 MHZ
90 Metres	3.2 to 3.4 MHZ
75 Metres	3.9 to 4.0 MHZ
60 Metres	4.75 to 5.06 MHZ
49 Metres	5.95 to 6.2 MHZ
41 Metres	7.1 to 7.3 MHZ
31 Metres	9.5 to 9.775 MHZ
25 Metres	11.7 to 11.975 MHZ
19 Metres	15.1 to 15.45 MHZ
16 Metres	17.7 to 17.9 MHZ
13 Metres	21.45 to 21.75 MHZ
11 Metres	25.6 to 26.1 MHZ

Of course, what was stated earlier about propagation conditions on the amateur bands also pertains to the broadcast bands. Thus the 49, 41, 31, 25 and 19 Metre bands will provide the most consistent results. 16, 13 and 11 Metres will be far more influenced by prevailing conditions. The four lowest frequency bands are not as popular as the others, particularly if one is using a fairly simple receiver. The only one of these bands that is likely to give good results is the 60 Metre band.

Aerials

Apart from the two sets that are intended for use with an integral telescopic aerial, all the receivers described in this book are designed for use with a longwire aerial. Such an aerial is merely an insulated wire that is as long as can be accommodated and positioned as high up as possible. The aerial should preferably be set up well clear of buildings or other large obstructions. It should also be well insulated from the groundas otherwise some of the signals generated in it will be drained away straight to earth, rather than to earth through the receiver's input coil. A typical method of fixing a longwire aerial is shown in Fig.2.

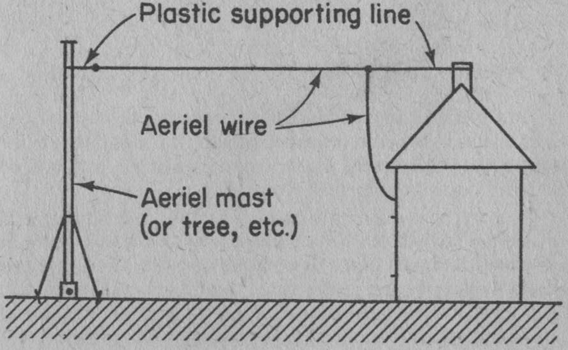


FIG. 2

Ideally the aerial should be some 20 to 40 Metres long overall (i.e. including the lead in wire), but as little as 10 Metres will suffice quite well. Generally speaking the longer the aerial the greater the signal it will provide. Thus when conditions are somewhat mediocre a long aerial will provide a usable signal where a fairly short aerial will not.

If 7/22 s.w.g. aerial wire can be obtained this is the best wire to use in the construction of the aerial. Ordinary 16 s.w.g. enamelled copper wire will also provide good results.

An indoor aerial, mounted in a loft for instance, will give reasonably good results if it is at least 6 Metres long. An aerial any shorter than this will almost cettainly give poor results except when propagation conditions are exceptionally good.

It is perhaps worth mentioning that for reception on the L.F. bands (either the amateur or commercial broadcast ones) the use of a long aerial is of greater importance than it is on the H.F. bands. This is not to say that a fairly short aerial will not give reasonable results on the L.F. bands, but merely that anyone who settles for such an aerial will be at more of a disadvantage on the L.F. bands than on the H.F. ones when compared to someone who has a long outdoor aerial. Anyone who is interested in DX reception on the L.F. bands should, of course, consider a proper outdoor antenna an essential.

It is possible to use an aerial that has been designed to optimise performance on the band or bands that are of primary importance to the operator. However, this is a rather complicated subject, and it is probably better to use a longwire aerial initially. This is probably the most popular type of S.W. receiving aerial anyway, and is usually the most practical.

Earth

In contrast to a good aerial, and contrary to popular belief, an earth connection is by no means essential. It is not likely to be of much benefit to reception on the higher frequency bands, and in fact in most cases it will be of no help whatever.

On the L.F. bands the situation is somewhat different. Here the use of an earth connection will normally provide a very noticeable and worthwhile increase in the strength of received signals. Even on the L.F. bands an earth is far from being a necessity, but is certainly worth adding where it can be accommodated without too much bother.

It is an easy matter to construct an earth connection from a metal pipe, or any other piece of metal that has a fairly large surface area. The larger this surface area the more effective the earth should be. A length of wire is connected to the piece of metal which is then burried in any convenient patch of soil. The earth will be more efficient if the soil is fairly moist and the metal pipe (or whatever) is made from a non-corrosive metal. Also make the lead-in wire to the receiver as short as possible in order to obtain optimum results.

The general arrangement of a simple earth is shown in Fig.3.

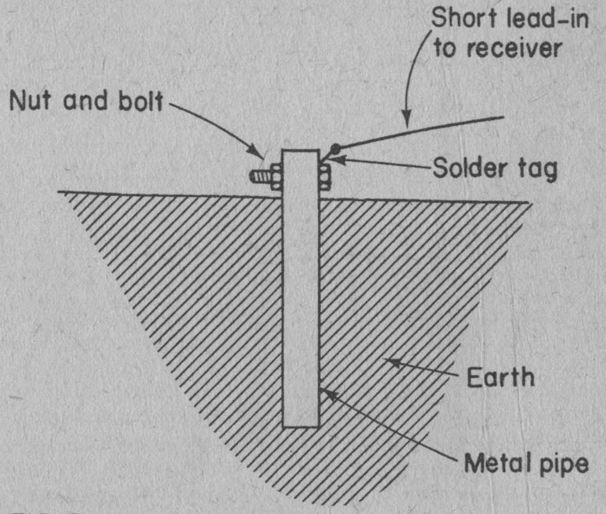


FIG. 3

CHAPTER 2

Ultra Simple Receivers

Crystal Set

A good starting point for anyone interested in building receivers is to build a crystal set. The main advantage of this type of set is its extreme simplicity. Another very important one is that they require no power supply and have no running costs. This tends to give crystal sets an added fascination over other types of receiver as it is actually the power of the received transmission that provides the energy that drives the diaphragm of the headphones or earpiece. It may seem impossible that the energy radiated from a transmitter some hundreds or even thousands of miles away can provide sufficient power to produce an acceptable volume at the transducer of the receiver, but indeed it can.

Before considering a practical crystal set circuit it is a good idea to look at what the received signal is actually like.

High frequency A.C. signals at the transmitter are radiated as a form of electro-magnetic signal which is usually termed radio waves. These travel out from the transmitter at the speed of light (186,000 miles per second) and when they reach a receiving aerial they generate minute electrical signals in that aerial. These signals are identical to the original high frequency A.C. signal produced at the transmitter, but are of course at a very much lower power level.

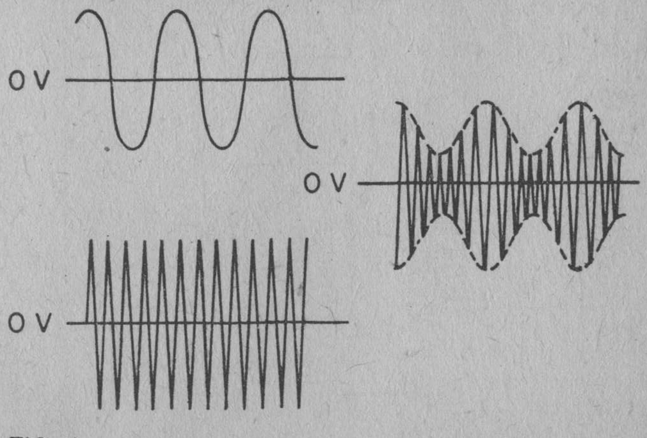


FIG. 4

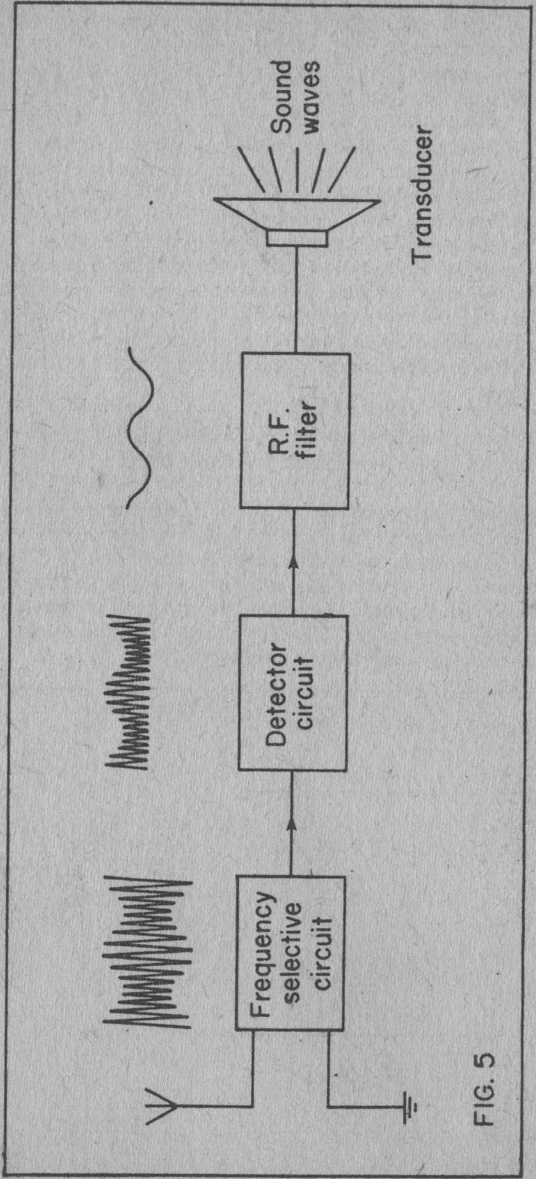


FIG. 5

The signal can be considered as consisting of two parts, the carrier wave and the modulating signal. The carrier wave is the high frequency signal that carries the audio signal modulated onto it between the transmitting and receiving aerials, and it is from this that it derives its name. Fig.4 shows how the audio signal is amplitude modulated onto a carrier wave. Amplitude modulation (A.M.) is the form of modulation used by all commercial broadcast stations on the Long, Medium and Short Wave Bands.

The receiver must carry out several basic functions in order to produce an audio output from a radio signal. These basic requirements are shown in block diagram form in Fig.5. The first thing that the receiver must accomplish is to sort out the desired signal from the many thousands picked up by the aerial. As each of these signals will be on a different frequency the input circuitry of the receiver must be designed to respond to only a very narrow range of frequencies with all others being rejected. This ability is termed selectivity.

The second function is that of detection, and this merely consists of removing one or other of the sets of half cycles of the signal, as shown in the diagram. The carrier signal provides no useful function beyond the detection stage, and is therefore filtered out. This leaves the final stage of the receiver which is the transducer. The purpose of this is to convert the audio frequency electrical signals into sound waves.

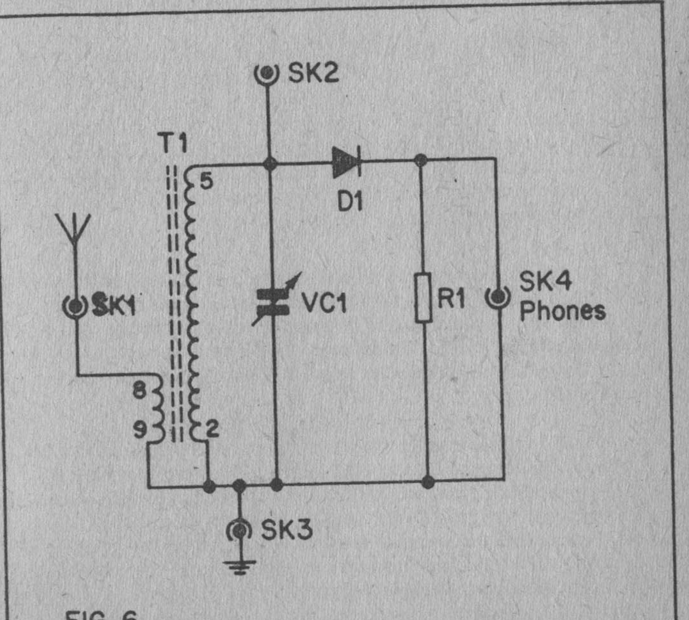


FIG. 6

Components List for Fig.6

T1	Denco Green Range 4 Dual Purpose Coil.
VC1	365pf air spaced (Jackson type '0').
D1	OA90 or OA91.
R1	100k ¼ watt 10%.

High impedance headphones or earpiece. Control knob.
Two wander sockets, one 3.5m.m. jack socket.
Aluminium, B9A valveholder, wire, etc.

Practical Circuit

Fig.6 shows the circuit diagram of a practical crystal set. The aerial is coupled to the primary of R.F. transformer T1, and this causes signals to be induced into the secondary winding. This secondary winding, together with VC1, forms a tuned circuit. This type of circuit exhibits a high impedance at 'resonance', but this impedance falls to a low level above and below the resonant frequency. Thus only signals at or close to the resonant frequency will be permitted to pass on to subsequent stages, and all others will be shorted to earth through the tuned circuit. This part of the circuit therefore provides the frequency discriminating part of the unit. Adjusting VC1 allows the resonant frequency of the tuned circuit to be varied over a wide range of frequencies, and this is in fact an ordinary tuning control.

Diode D1 acts as the detector, and a diode is a simple semiconductor which has the property of allowing a current to flow through it in one direction only. It is a sort of electronic valve. With D1 connected with the polarity shown in the diagram only the positive going half cycles are able to pass, and the negative going ones are blocked. In actual fact it does not matter which polarity of the signal is allowed to pass and which is blocked, and the circuit will function properly with D1 connected either way round.

The transducer for the receiver is a pair of crystal headphones or a crystal earpiece. Some capacitance is required across the output to smooth the carrier signal to a D.C., and the self capacitance of the headphones is sufficient for this purpose. There is no need to block this D.C. signal from the phones as it is too small to have an adverse effect on the circuit.

For all practical purposes the resistance across a pair of crystal headphones can be regarded as being infinite. This can prevent the circuit from operating properly as the capacitance across the output can charge up to the peak level of the signal fed to it, and then of course the required audio signal is not produced across the headphones. R1 is a bleeder resistor and this prevents such a charge from building up by providing a D.C. path across the output.

It is also possible to use the circuit with a pair of high impedance magnetic (sometimes called moving coil) headphones. These must be high impedance (4,000 ohms or more) phones or satisfactory results will not be obtained. These do provide a D.C. path across the output and so R1 can be omitted if magnetic headphones are used. As far as results are concerned, in the authors experience crystal and magnetic headphones provide about the same volume level, and either will work well. A crystal earphone (or two connected in parallel) is a cheaper alternative, but some of these are not very sensitive and could give disappointing results.

When signals seem to be low in strength, or if a short aerial is being used, the alternative aerial connection point at SK2 can be used. This will provide a greater output volume, but this will be at the expense of selectivity. This will be discussed more fully later.

An earth can be used with the receiver and can be plugged into SK3. Using an earth will not greatly improve performance, but bearing in mind that a really strong signal is needed to provide an audible output from the set, one must strive to obtain the strongest possible input signal for the set. It is therefore worthwhile using an earth if possible.

Coil Units

As is the case with all the receiver circuits described in this book, the coils used are all ready made. Ready made coil units have the advantage of being made to very close tolerances and this gives the circuits reliable and repeatable results. Home wound coils tend to be far less consistant, and are not as easy for the amateur to wind as one might think. This tends to outweigh the economic advantage that home made coils have over the ready made variety.

The Denco coils specified cover the complete S.W. frequency spectrum in three ranges. Therefore three coils are required to cover all the S.W. bands. The coils have nine pin bases which plug into a standard B9A valveholder. There are two main reasons for using this arrangement. One is that the coils are wound on polystyrene formers which tend to melt if the pins are soldered to direct. Making the soldered joints to the holder avoids this problem.

The other advantage is that this enables a very simple method of bandchanging to be used. The required band is selected by simply plugging in the appropriate coil. Admittedly this method is less convenient than using a wavechange switch, but it makes receiver construction very much more simple by considerable reducing the complexity of the wiring. It is also less expensive than employing a wavechange switch, and enables a neater and more compact receiver to be built as space for only one coil has to be found on the receiver's chassis.

To those unfamiliar with this method of band changing it may seem to be a little unusual, but in fact, it is almost universally used in simple S.W. receiver designs, and is even employed in a few highly sophisticated sets. One thing it is, is very practical,and this accounts for its widespread adoption, and its recommended use with the receiver circuits described here.

When using the specified 365 pF tuning capacitor the three ranges have the approximate frequency coverage shown below:–

Range 3	1.5 to 5.5 MHZ
Range 4	5.0 to 17.0 MHZ
Range 5	10.0 to 35.5 MHZ

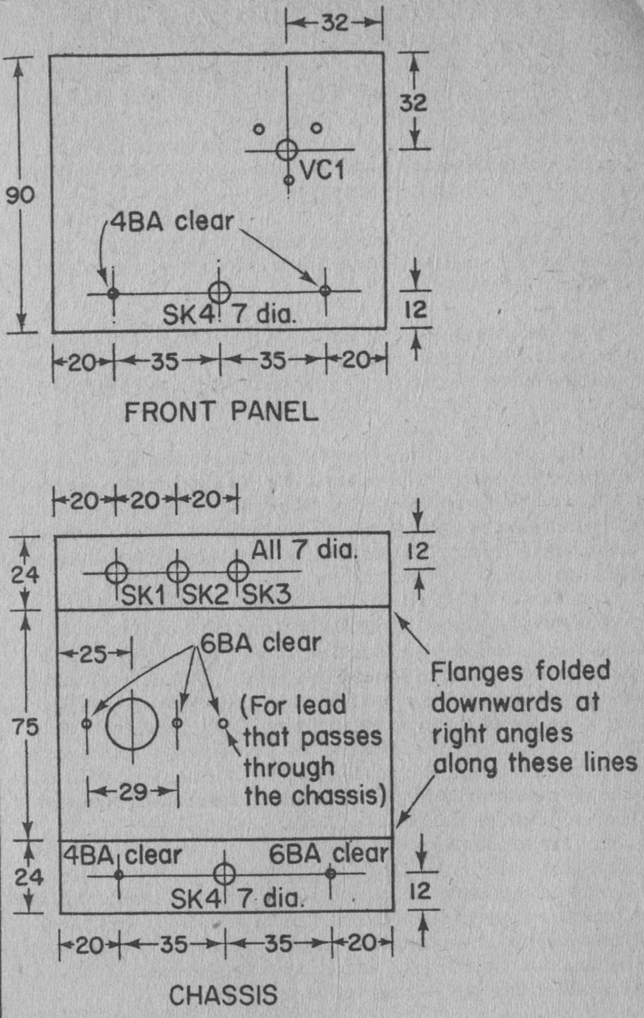
Note that these are only approximate, and the exact frequency coverage of a receiver is influenced to some extent by the tolerances of the components used and by stray capacitances present in the circuit. It is also affected, and to a far greater extent, by the setting of the adjustable core of each coil.

Some readers may be confused by the fact that some receiver circuits shown in these pages use coils intended for valve circuits (the D.P. coils) and some use coils intended for transistor circuits (those that have a letter T after the range number), whereas all the designs are solid state ones. This is because many of the designs use field effect transistors (FETS) and these are very different to ordinary bipolar transistors. The primary difference is that FETs have extremely high input impedances and so do valves, but dipolar transistors have comparatively low input impedances. Thus coils that are intended for valved circuits can be easily and well adapted to FET circuits, whereas coils that are intended for bipolar transistor circuits cannot.

The crystal set is really only designed to operate with a Range 4 coil, and this has the 49, 41, 31, 25 and 19 Metre broadcast bands within its coverage. These provide the most prolific selection of stations when using a very simple set such as this.

It is possible to use the Range 3 and Range 5 coils, and the set will function just as well on these ranges, but good results are not likely to be obtained as there are not such a large number of stations providing suitable signals on these ranges. Reception of the ordinary M.W. broadcast band can be provided by using a Range 2 coil.

A crystal set is not really suitable for amateur band reception as amateur transmitters are restricted to a relatively low output power, and this means that few, if any, signals of sufficient strength can be received on these bands. Anyway, these days the majority of amateurs use modes of transmission that cannot be resolved by a crystal set even if a signal of adequate strength is received.



All dimensions in mm (for 4BA clearance use No. 24 drill, for 6BA clearance use No. 31 drill)

FIG. 7

Construction

The crystal set can be inexpensively constructed on a home made chassis and panel having the dimensions shown in Fig.7. This also gives details of the drilling and folding of the chassis and panel. They are constructed from aluminium, and a relatively thin gauge, say about 20 s.w.g. will provide a structure of adequate rigidity and strength. A thicker gauge could be used, but would be more difficult to work and fold.

3 or 4 mm wander sockets are the most suitable type to use for the aerial and earth sockets, and a 3.5 mm jack socket makes a suitable outlet to the headphones.

The $\frac{3}{4}$ in. diameter cutout for the B9A coilholder is made using a chassis punch. If a suitable punch is not available, it is possible to cut this using a miniature round file or a fretsaw fitted with a fine toothed blade.

If the specified Jackson type 'O' tuning capacitor is used, a total of four mounting holes will be required for this component. A central $\frac{3}{8}$ in.)(10 mm) diameter hole is required for its spindle and three 4BA clearance holes are required for the mounting bolts. These are short 4BA countersunk types and, incidentally, these are not usually supplied with the capacitor.

Probably the easiest method of locating the positions of the three small mounting holes is to make a paper template. To do this simply take a small piece of paper (about 40 to 50 mm square) and make a 7 mm diameter hole in its centre. Then thread this over the spindle of the tuning capacitor and press it up against the front plate of this component. It should then be possible to punch three holes in the paper with the point of a pencil above the positions of the three holes in the capacitors front plate. This completes the template.

The three mounting bolts pass through the panel and into the threaded screw holes in the front of VC1, but a few words of warning are in order here. The mounting bolts must not be allowed to protrude more than 1 or 2 mm through the front plate of VC1. If they should do so they may well come into contact with one of the capacitors sets of vanes and this could jam the unit, or in extreme cases it could possibly even irreparably damage the capacitor.

It is unlikely that the constructor will be able to obtain suitably short mounting bolts, and it will almost certainly be necessary to use spacers over these bolts, between the front plate of VC1 and the front panel of the receiver, in order to reduce the penetration of the screws to an acceptable level. Some 4BA washers or three 2BA nuts are usually sufficient for this purpose.

The completed chassis and panel are held together using a couple of 4BA nuts and bolts.

Wiring

There are very few connections to be made in this simple receiver, and a straight forward point to point wiring system is the most practical method of wiring up the set. A complete wiring diagram of the unit is shown in Fig.8.

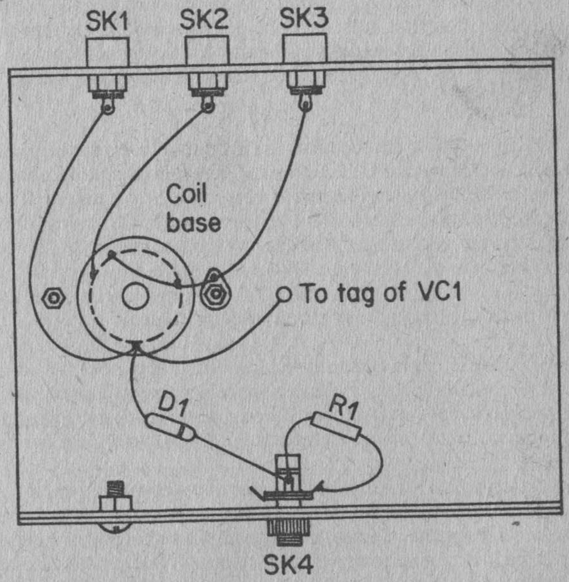


FIG. 8

Modern components have leads that do not easily oxidize as they have been developed for modern automatic production methods. This simplifies soldering and it is not necessary to clean the component lead out wires unless they are obviously very heavily oxidized. Once the component leads have been cut to length their ends should be tinned with solder, and the tags of sockets, etc. should be similarly tinned before attempting to complete a soldered joint. Use a multi-core solder and use plenty of solder on each joint. Try not to move the components while they are being connected. Keep to these guide lines and good soldered joints should be obtained.

Do not keep the iron on any joint any longer than is absolutely necessary. All components can be damaged by excessive heat, and semiconductor devices are especially vulnerable. Germanium devices such as diode D1 are very easily harmed by excessive heat, and it is advisable to use a heatshunt on each lead as it is connected. Heatshunts are available, but it is not really necessary to use a proper headshunt, and gripping the wire with a pair of long nose pliers, between the body of the component and the joint, should be equally effective.

Note that the earth connections to VC1 and SK3 are made via the chassis, and for this reason only one lead connects to each. SK3 must obviously be an ordinary jack socket of the open construction variety, and not an insulated type. Conversely, the aerial and earth sockets should be of an insulated type as otherwise the aerial connections will be shorted to earth. This obviously would not matter in the case of the earth socket which is connected to the chassis anyway, but for the sake of a neat appearance this socket should match the aerial ones.

The Denco coils are supplied in an aluminium container which can be used as a screening can. Screening of the coils is not necessary in any of the simple designs described here, and these cans are discarded. The adjustable core of each coil is always screwed right down when the coils are received, so that they will fit into their containers. The cores should be unscrewed slightly so that about 5 to 10 mm of screwthread protrudes from the top of each coil. This applies to all the circuits described in this book, and not just to the crystal set.

If a suitable signal generator is available it is possible to adjust the cores to give the correct frequency coverage on each band. However, as it is unlikely that the majority of readers will have access to such equipment, such precise setting up is not really feasible.

Fortunately it is not really necessary anyway, and even if the adjustment of the cores is considerably out, the frequency coverage will not be so seriously affected that any of the broadcast or amateur bands will be lost from any receiver's coverage. Neither will there be any gaps in the coverage of multiband receivers as there is a considerable overlap in the coverage of each coil range. Also, the upper and lower limits of the coverage obtained with the coils and the specified tuning capacitor, extend well above and below the limits of the S.W. frequency spectrum. Therefore, in the circuits described here anyway, the settings of the cores should not be considered too critical.

Using the Set

Operating the crystal set is really very straightforward. There is only one control and that is a conventional tuning control. The tuning will be fairly broad and it must be admitted that the selectivity of a

crystal set is not very high. This is particularly so when the aerial is plugged into SK2, as the aerial then has a strongloading effect on the tuned circuit, and its efficiency is severely reduced. Thus even though stronger signals will be produced by plugging the aerial into SK2, and there is a strong temptation to simply ignore SK1, the greater selectivity obtained with the aerial connected to SK1 makes this the better of the two most of the time. Only use SK2 when conditions are such that only very weak signals are obtained when using SK1.

A degree of patience is required in order to obtain good results from any S.W. Receiver, but this is especially so in the case of a S.W. set. Stations temporarily fading out completely is one problem, and another is that one station on the band can suddenly become exceptionally strong, and blot out reception of the desired transmission, even though it is at a good strength.

Despite its deficiencies, a lot of fun can be had from a crystal set, and stations some thousands of miles away can be received if one perseveres.

Regenerative Receiver

Unlike the crystal set, most receivers have a large amount of gain. This enables very weak signals to be boosted to a level that produces a good level of volume from the transducer. It also enables the selectivity of the receiver to be greatly improved, and this is just as important as the increased sensitivity.

One of the most widely used types of detector in simple S.W. receivers is the regenerative detector. Basically this just consists of a transistor (or other active device) in one of its normal amplifying modes. A capacitor is connected across the output, as it is in the case of a diode detector, to remove the R.F. content at the output of the detector.

It may not be immediately obvious how this arrangement provides rectification, and in fact this type of detector may seem to be a little unusual to those who are not familiar with the technique employed. It relies upon the fact that no contemporary amplifying devices are completely linear in operation, and the gain of an ordinary transistor for instance, tends to rise with increasing collector current.

If it is used to amplify an R.F. signal it will therefore tend to amplify one set of half cycles more than the other set. It will amplify the positive input half cycles more than the negative ones. This provides a very crude and inefficient form of rectification, and of course, it is rectification that the detector must provide.

Regeneration is applied to the circuit in order to greatly increase the detection efficiency of the circuit. Regeneration is merely positive feedback, or sending some of the signal back from the output to the input of the circuit so that it is amplified for a second time. This is sometimes given its alternative term, 'reaction'.

One effect of regeneration is to increase the gain of the circuit, but the important feature is that it will not increase it by an equal amount on all signals, or even on all parts of each signal.

For instance, the positive input half cycles are at a greater amplitude at the output than are the negative ones, and therefore a larger amount of feedback is produced on the positive input half cycles. This causes a larger increase in gain on the positive input half cycles than on the negative ones, and regeneration thus increases the detection efficiency of the circuit. This is illustrated in Fig.9 which shows the input, output, and output after regeneration waveforms of typical regenerative detector, with an unmodulated R.F. input.

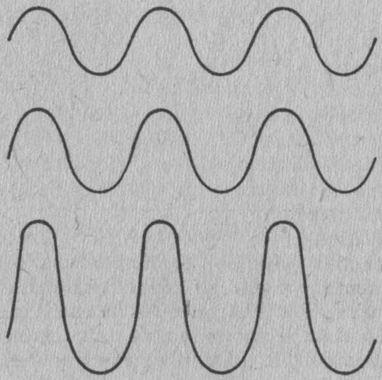


FIG. 9

A regenerative detector has a considerable level of gain, and it is far more sensitive than a simple diode detector of the type used in the crystal set.

Increased Selectivity

Using regeneration also greatly boosts the selectivity of a receiver. If a graph showing frequency versus sensitivity for a crystal set was plotted it would look something like the graph shown inFig.10(a). The peak occurs at the resonant frequency of the tuned circuit, and the response only falls away gradually either side of this. As a result, the receiver has only a very limited degree of selectivity, and when a transmission is present within a few tens of KHZ of the desired one, both signals will fall within the receiver's passband, and it will not be possible to tune to only one or other of them.

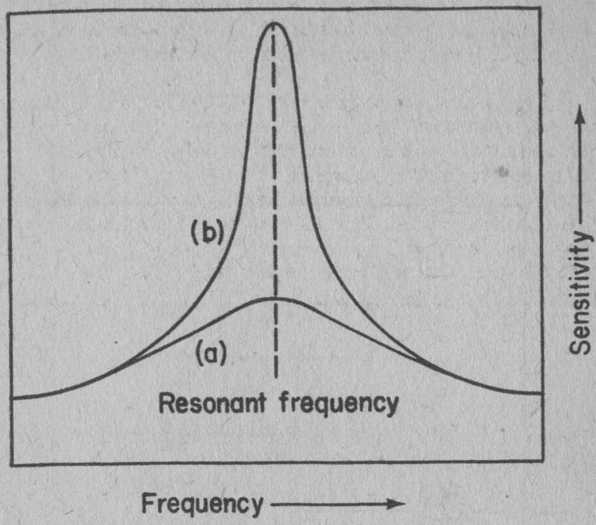


FIG. 10

Regeneration will boost signals at or near the centre of the receiver's response by a far larger amount than it will boost signals towards the edges of the response. It does this in just the same way as it boosted positive input signals more than negative ones. This gives the receiver a passband something like that shown in Fig.10(b). The 'bandwidth' as it is termed, is greatly reduced, and the receiver is capable of accepting only one of two closely spaced signals.

This feature is very important for any S.W. receiver, because a large number of S.W. stations tend to be crammed into each band, and a sensitive receiver with poor selectivity would simply receive a jumble of signals and would not be able to produce a coherent output.

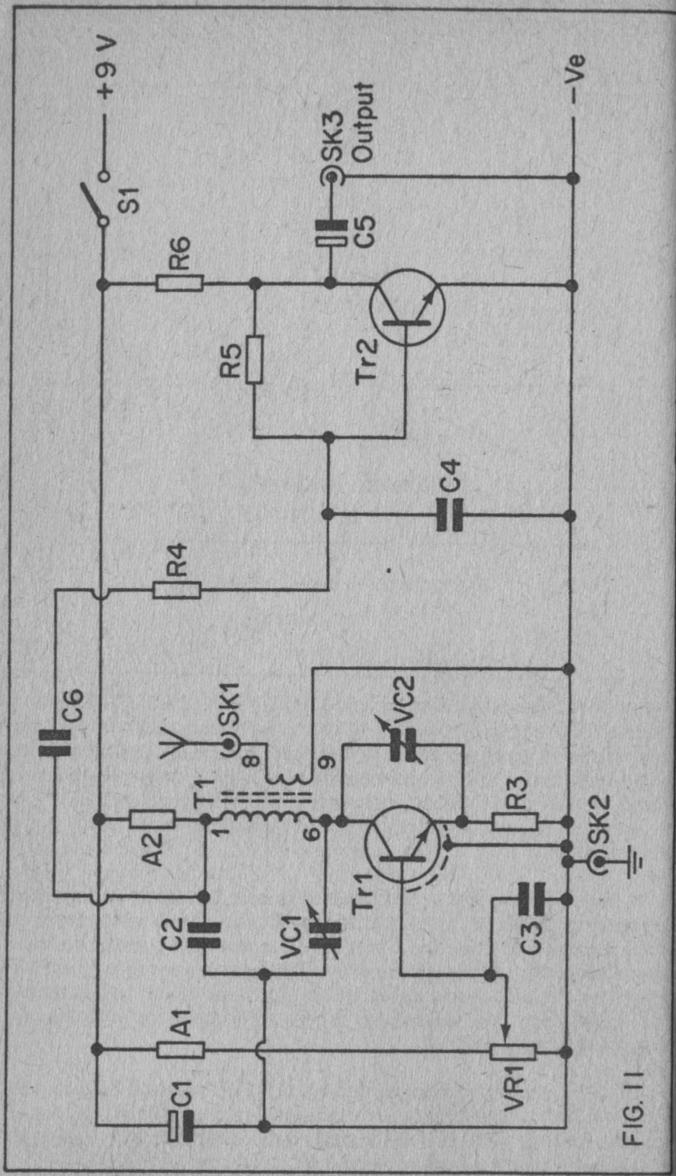


FIG. 11

Components List for Fig.11

Resistors, all ¼ watt 10%.

R1	18k	R4	680 ohms.
R2	3.3k	R5	2.2 Meg.
R3	1.8k	R6	5.6k.
VR1	10k 1in. carbon.		

Capacitors.

C1	100mfd. 10v.w.
C2	6.8nf polystyrene.
C3	10nf plastic foil or ceramic.
C4	5.6nf polystyrene.
C5	4mfd. 10v.w.
C6	100nf plastic foil.
VC1	365pf air spaced (Jackson Type '0').
VC2	50pf air spaced (Jackson Type C804).

Semiconductors.

Tr1	BF115.
Tr2	BC109.

Inductor.

T1	Denco Transistor Useage coils Ranges 3T, 4T, and 5T, Yellow.

Switch.

S1	S.P.S.T. toggle switch.

Miscellaneous.

B9A valveholder, PP3 battery and clips to suit.
Two wander sockets and one 3.5m.m. jack socket.
Aluminium, control knobs, wire, etc.

Circuit Operation

The circuit diagram of the regenerative receiver appears in Fig.11. Looking at this in very broad terms, Tr1 is the regenerative detector and Tr2 is a high gain audio amplifier.

Tr1 is used in the common base mode and is biased by R1 and VR1. C3 couples Tr1 base to earth at R.F. The tuned winding of T1 provides the R.F. collector load for Tr1, and VC1 is the tuning capacitor. The collector and emitter of Tr1 are in phase, and so in order to provide the required positive feedback it is only necessary to couple these two points by way of a variable capacitor. This is VC2 and it is the regeneration control. VR1 also acts as a sort of regeneration control, and the use of these two controls will be fully dealt with later.

The aerial signal is coupled to the detector via the primary winding of T1. The audio output is developed across R2 and C2 is the R.F. filter capacitor. C6 provides D.C. blocking between the detector and audio stages of the receiver.

This capacitor may seem to have rather a low value for the impedance into which it is working. By the standards of entertainment receivers it does have too low a value, but in entertainment equipment one is aiming for the widest possible frequency response, whereas in communications equipment the aim is to obtain a signal that has the highest possible intelligibility. The low value of C6 produces a considerable attenuation of bass and low middle frequencies, but this actually makes received signals easier to understand.

It is also an advantage to roll off the upper audio frequencies above about 2.5 to 3.5 kHz, as this not only increases the intelligibility of the signal, but it also greatly reduces the background noise level. R4 and C4 form a simple low pass filter which fulfils this requirement.

This network also provides additional R.F. filtering. It is absolutely essential to ensure that no R.F. signal finds its way into the audio circuitry, as an audio amplifier employing a silicon transistor has a frequency response that extends well into the S.W. frequency spectrum, and even beyond this into the V.H.F. range. Silicon transistors can provide high gains and low noise levels, and large use is made of them in the audio stages of the receivers described here.

There are two main problems that are likely to result from insufficient R.F. filtering. One, and usually the lesser of the two, is the breakthrough of unwanted signals, and these signals are often well away from the actual band being tuned in terms of frequency. They are actually picked up in the wiring at the input to the audio amplifier, and not by the aerial.

The second problem, and by far the most troublesome, is that of the signal being greatly amplified by the audio amplifier, and then fed back to the R.F. section of the circuit through stray circuit capacitances This can manifest itself in either of two ways. If the stray feedback is positive, the circuit will oscillate uncontrollably and proper reception will not be possible. If the feedback is mainly negative it will severely reduce the sensitivity of the receiver, and could render the regeneration control almost totally ineffective.

Efficient and effective R.F. filtering is therefore absolutely essential with this type of receiver, and very simple methods of the type used with the crystal set are simply not good enough.

The audio stage of the receiver is a conventional high gain common emitter amplifier using an inexpensive BC109 transistor or one of its many equivalents. R6 is the collector load resistor and R5 is the base bias resistor. R5 introduces a certain amount of negative feedback over the audio amplifier and this does reduce the gain of the stage by a small degree. However, it is still a good idea to use this method as the feedback gives a very stable biasing system that only requires a single resistor. Also, the use of some negative feedback gives improved quality to the audio output.

The slight loss of gain is not really important since the circuit still has more than adequate output to drive virtually any medium to high impedance headphones. The audio output is fed to the output socket via D.C. blocking capacitor C5.

C1 is a supply decoupling capacitor and is required in order to prevent feedback between the two amplifying stages through the supply lines. S1 is an ordinary on/off switch.

As the set consumes only about 2.5 to 3 mA from a 9 volt supply, a small battery such as a PP3 will provide very economical operation of the receiver. In fact even with frequent use, the battery will probably have virtually its shelf life.

Transistors

The BC109 transistor sometimes has a letter added at the end of its type number (e.g. BC109B). This is the gain grouping of the transistor, and there are three groups for most audio transistors. Group 'A' is the lowest gain, group 'B' is the medium gain one, and group 'C' is the highest gain grouping. The BC109 being a high gain device is only available with a B or a C suffix.

Any BC109 can be used in this circuit, or any of the circuits in this book where a BC109 is specified, and whether it has a B or a C suffix, or none at all, the level of performance will not be significantly affected.

The BF115 transistor is a little unusual in that it has four leadouts rather than the usual three. The additional leadout wire is a shield (s) connection, and this merely connects to the metal case of the device.

Usually this lead is connected to earth, but in this circuit it is simply ignored.

Construction

The receiver can be conveniently constructed on a chassis add panel of the same basic type as those used for the crystal set. In order to obtain sufficient space for all the components without undue crowding they really need to be somewhat larger. A 152 x 102 x 63 mm chassis and a 152 x 102 mm panel should be adequate. Suitable ready made 18 s.w.g. aluminium chassis are available if the constructor does not wish to build his or her own.

It is probably better to use an S.R.B.P. panel (or one made from a similar insulative material) rather than use an aluminium one. This is because the moving vanes of VC2 are in electrical contact with the components mounting bush. Mounting VC2 on a metal panel causes it to have one connection earthed. In most circuits the variable capacitors have one set of vanes connected to earth anyway, and so this is usually an advantage as it saves having to use a lead to earth one side of each variable capacitor.

VC2 of this circuit is an exception though, and neither of its connections should connect to earth. Therefore, if a metal panel is used some way of mounting VC2 without it being electrically connected to the panel must be found.

In all the other circuits in this book each variable capacitor has one connection earthed, and so this problem does not arise.

Much of what was stated earlier about the mechanical construction of the crystal set also applies to the regenerative receiver, and will not be repeated.

A complete wiring diagram of the receiver is shown in Fig.12. In this it has been assumed that both VC1 and VC2 are mounted above chassis and that a front panel made from an insulative material has been used.

A simple point to point wiring system is used in the construction of the detector circuitry, and again, what was stated earlier about wiring up the crystal set also pertains to this wiring, and will not be repeated.

The A.F. circuitry is constructed on a 0.15 in. pitch Veroboard which has 11 × 12 holes. The copper strips run across the width of the panel. The board is not sold in pieces of this size, and the panel mus be carefully cut down from a larger piece using a hacksaw. The mountin holes can be drilled for either 6BA mounting bolts (No.31 twist drill) or for metric M3 mounting bolts (3.3 mm diameter twist drill).

Soldering components onto a Veroboard panel is easier than the point to point wiring. Good soldered joints should result provided plenty of solder is used on each joint, and the leadout wires are cut to length before they are connected. Cutting them to length afterwards could break the copper strips away from the backing material, and will not give such a neat finish. Incidentally, there are no breaks in any of the copper backing strips with this particular design.

Always leave semiconductor devices until last when wiring up a Veroboard, or any panel of a similar type for that matter. This reduces the risk of damaging any of the semiconductors through overheating. Make sure that all electrolytic capacitors are connected with the correct polarity. The polarity is usually marked on the body of the component, or the positive (+) connection is indicated by an indentation around the body of the capacitor towards the appropriate end of the component.

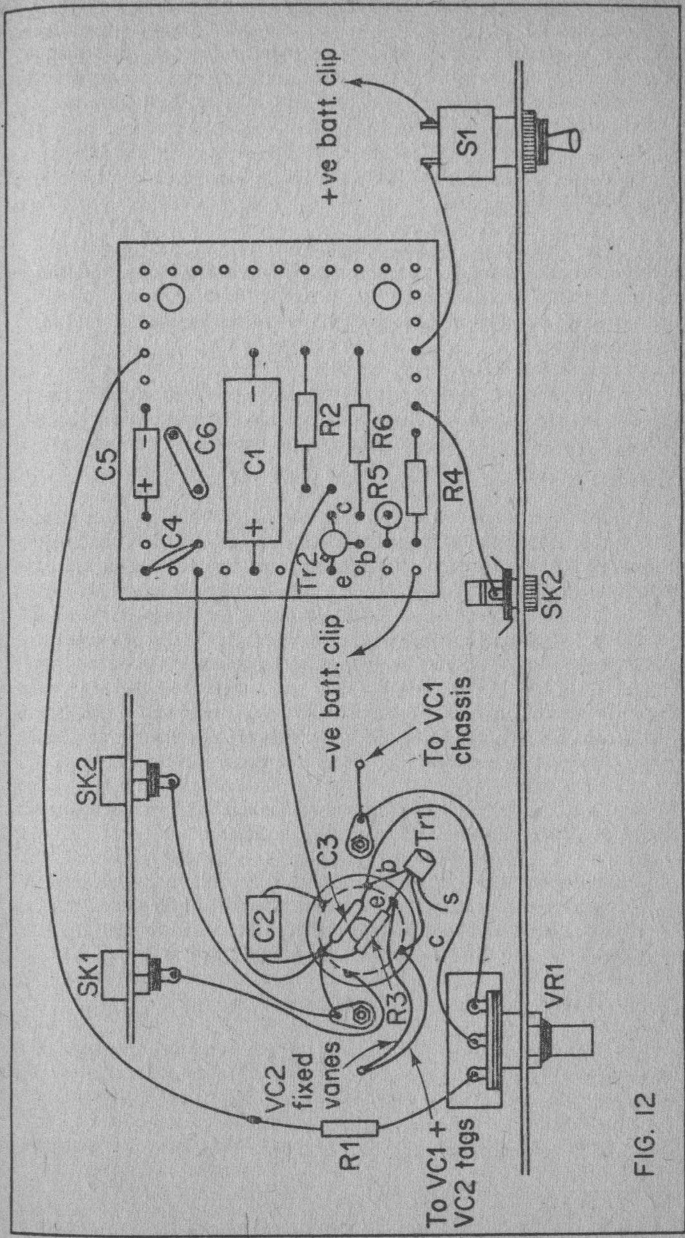


FIG. 12

Wire the completed Veroboard panel to the rest of the circuit using ordinary multistand P.V.C. insulated connecting, and then mount it on the underside of the chassis. Some spacers or extra nuts must be used to space the panel well clear of the metal chassis, as otherwise the connections on the reverse side of the panel will be short circuited through the chassis.

Using the Receiver

This receiver is primarily intended for use on the broadcast bands using the Range 4T and 5T coils. It will not work very efficiently using a Range 3T coil, except towards the high frequency end of the band where a number of stations on the 60 Metre broadcast band can be received.

The tuning on on/off controls are quite conventional, but the reaction controls are not volume controls, and they require very careful adjustment if really good results are to be obtained from the receiver.

The detector will operate most efficiently with VR1 turned well back (i.e. adjusted almost fully anticlockwise), as it is then that the difference in the levels of amplification given to each set of half cycles is most unequal. Therefore VR1 should be kept well backed off and VC2 is advanced to just below the threshold of oscillation. It should perhaps be explained that by advancing VC2, it is meant that the two sets of vanes should be more fully meshed together.

It is with the detector set just below the threshold of oscillation that the set has the highest degree of sensitivity and selectivity. Adjusting VC2 too far will result in the receiver breaking into oscillation, and the practical result of this will be that a whistle of varying pitch will be heard as the receiver is tuned across a station, and proper reception will not be possible with the receiver in this condition.

Fine adjustment of the reaction level is probably best carried out using VR1. This does not control the amount of feedback, but affects the gain of Tr1, and this permits it to be used as a reaction control. It will not provide anything like the degree of control that is available using VC2, but it is this that makes it so much better for making the fine adjustments of the regeneration level.

Towards the low frequency end of each band (VC1 vanes well meshed) it will almost certainly be found that the detector cannot be brought to the threshold of oscillation with VR1 turned well back. It is then necessary to advance VR1 somewhat. This does reduce the detection efficiency of the set, but the gain of the detector is increased. This increased gain tends to compensate to some degree for the loss of efficiency, and good results should still be obtained.

It is very worthwhile experimenting a little with the settings of the reaction controls to see which positions give the best results. Every time the setting of the tuning control is significantly altered, some readjustment of the reaction controls will be required in order to maintain optimum working conditions of the detector. A fair amount of skill is required when using simple S.W. receivers, and it will probably be necessary to gain a certain amount of experience with the receiver before the operator learns how to get the most out of it. This applies to all simple S.W. sets.

Simple Improvements

It is possible to make one or two simple improvements to the basic receiver, and these improvements also apply to most of the other sets described in this book.

Bandspread

Although the crystal set covers a wide range of frequencies, tuning in a station accurately is quite simple as the set has a relatively wide bandwidth. The regenerative receiver has a very much more narrow bandwidth than the crystal set and a much higher sensitivity. This makes tuning much more difficult, as adjusting the tuning knob through only one or two degrees could tune the receiver over a dozen or more stations. Thus very careful adjustment of the tuning control is required in order to accurately tune to a station. Most people find tuning to a station with a reasonable amount of precision quite difficult on this type of set, and usually some form of bandspread is fitted to the receiver to make tuning easier.

There are two forms of bandspread, mechanical bandspread and electrical bandspread.

Mechanical bandspread merely means fitting a slow motion drive to the tuning control. If, for instance, a six to one reduction drive is fitted, instead of only half a turn of the tuning knob being required to tune from one end of a tuning range to the other, three complete turns will be required. This makes tuning very much easier.

Several commercially produced tuning reduction drives are available, and some have two reduction ratios, usually six to one and thirty-six to one. The higher reduction ratio is used for normal tuning, and the lower ratio enables the user to quickly tune from one end of the tuning range to the other without laborious turning of the tuning knob.

Some drives are a combination of a tuning dial and a reduction drive. These are excellent, although they are usually a little expensive.

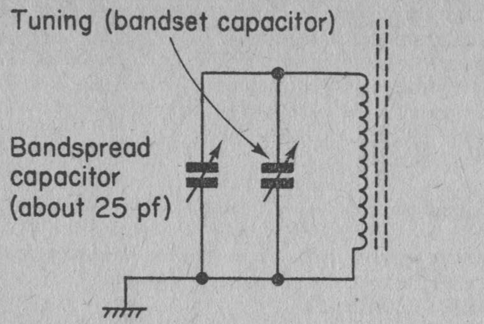


FIG. 13

Electrical bandspread is an electrical equivalent of a mechanical reduction drive, and simply consists of adding a low value variable capacitor in parallel with the main tuning capacitor. This is shown in the circuit of Fig.13. The value of the additional capacitor is not critical, and can be anything from about 15 to 50 pF.

In use the main tuning control, or 'Bandset' control as it is normally termed when a bandspread capacitor is fitted, is set to the band that is to be searched for transmissions. Then the actual tuning is accomplished using the bandspread control.

As the bandspread capacitor has a much lower value than the bandset one, it only covers a very small part of each tuning range. Tuning is therefore far less cramped using the bandspread control.

This type of electrical bandspread used to be the standard method used in simple receivers, but variable capacitors are relatively expensive these days, and mechanical or other electrical methods are now often employed instead.

A special type of diode known as a variable capacitance diode (often abbreviated to varicap.) can be used as a cheaper alternative. This component has the property of changing its capacity in proportion to the level of reverse bias applied to it.

What is happening is that the two pieces of silicon that form the diode are acting as the plates of the capacitor. The insulating layer that exists between the two pieces of silicon, and which is called the depletion layer, acts as the dielectric of the capacitor. The larger the reverse bias that is applied to the diode, the deeper the depletion layer becomes. This, in effect, increases the distance between the two plates of the capacitor, and causes a reduction in the capacity of the diode.

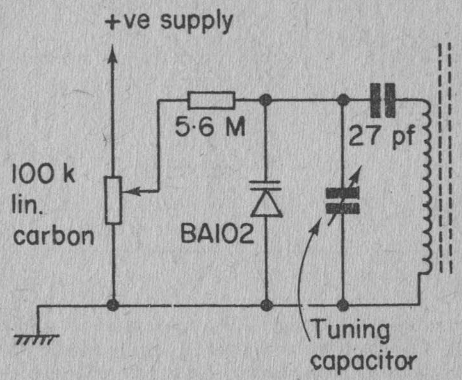


FIG. 14

The circuit shown in Fig.14 illustrates how a varicap. diode can be used as the basis of a simple bandspread control. The fixed capacitor provides D.C. blocking and prevents the voltage fed to the diode from being short circuited through the tuning coil. The tuning voltage set at the slider of the potentiometer must be fed to the varicap. diode via a high value resistor, so that the capacitance of the diode is shunted by a very high value of resistance. Since only minute leakage currents flow in the resistor, a significant voltage is not dropped across it despite its high value.

Another simple method of adding bandspread is shown in Fig.15. The operation of this is very straightforward. The variable resistor virtually cuts the capacitor out of circuit when it is set for maximum resistance. When it is at minimum resistance the capacitor is shunted across the tuning capacitor. Intermediate settings of the variable resistor give intermediate levels of effective capacitance across the tuning capacitor, and the potentiometer thus acts as a simple bandspread control.

While this method is much cheaper than the previous methods, it does have the disadvantage that it will only provide a relatively small tuning range. It cannot be used in quite the same way as the other two circuits, and it is best to use the main tuning control to roughly tune to the desired station, and then use the bandspread control for the fine tuning.

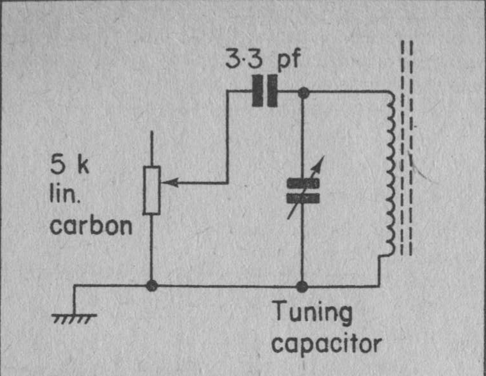


FIG. 15

Overloading

Another problem with simple S.W. receivers is that of overloading on strong signals. When this happens there is usually a large amount of background noise from the headphones, and the set will have an apparent lack of selectivity.

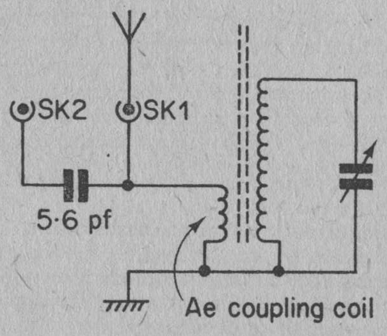


FIG. 16

When this occurs it is necessary to reduce the strength of the aerial signal, and this can be accomplished using the simple attenuator circuit shown in Fig.16. SK1 is the normal aerial socket, and when overloading occurs the aerial is connected to SK2 instead. This introduces a low value fixed capacitor into circuit between the aerial and the input coupling coil of the receiver. Losses in the capacitor reduce the signal level that reaches the detector of the receiver, and so illiminate the overloading. The less tight coupling of the aerial to the tuned circuit increases the selectivity of the receiver slightly, and this also helps to remove the overloading.

Cases

If the constructor wishes to house any of the receivers described here in an outer casing, it is an easy matter to construct a case from plywood using ordinary glued butt joints. Self adhesive plastic material can be used to cover the completed case, and should provide a very attractive finish.

One point must be borne in mind however. Unless the receiver is to be used on only one range, the lid of the cabinet must be easy to remove in order to facilitate coil changing. Another popular method is to use a hinged lid, or to have a hinged compartment in the lid above the coilholder.

Construction Hints

Fairly detailed constructional information has been provided for these first two receivers, and this should give the reader a good general idea of the methods used when building simple S.W. sets. The circuits shown in the remaining part of this book will be discussed in comparatively broad terms and constructional information will not be provided.

Provided a few points are kept in mind, little difficulty should arise when translating a circuit diagram into a practical design.

It is important that all wiring that carries R.F. should be kept as short and direct as possible. This is particularly important in the case of R.F. decoupling capacitors. For this reason it is advisable to use point to point wiring in the R.F. and detector circuitry.

Avoid having R.F. chokes, tuning coils, and even speaker coils very close to one another. Feedback between two closely spaced coils can upset the operation of the circuit.

Wiring of the audio circuitry of a receiver is not usually too critical, and Veroboard, plain matrix boards, tagstrips, etc. are suitable for use here. However, try to keep input and output leads well away from one another, particularly where two stages of audio amplification are used. It is also a good idea to keep the wiring at the input of the audio stages as short as possible so that there is a minimum of stray pick-up of mains hum, and similar A.F. interference.

One final point is that with S.W. receiver designs it is not a good idea to deviate from the specified component values. These tend to be a little more critical than with other types of equipment, and even if changing a component value does not prevent a receiver from working all together, it may well result in a loss of performance.

CHAPTER 3

General Purpose Receivers

In this chapter a number of general purpose S.W. receiver designs will be described. These will all give good results on both the amateur and broadcast bands. Some of the circuits are extremely simple and inexpensive to construct, and others are a little more sophisticated. In general, and as one would expect, the more complex designs offer the best performance and greater flexibility in use, but even the more simple designs will provide excellent results.

Regenerative FET Receiver (Fig.17)

Field effect transistors (FETs) have several advantages over ordinary bipolar transistors in the stages of a S.W. that handle R.F. signals. There are two basic types of FET, Junction Gate FETs, and Metal Oxide Silicon FETs. These names are usually abbreviated to JUGFET and MOSFET respectively. Most MOSFETs currently in use have two gates, and are called Dual Gate MOSFETs. Any of these devices will work well in simple S.W. receiver designs, provided of course, that they are intended for use at high frequencies. In the present design a JUGFET is used, and this is the widely available and inexpensive 2N3819 device.

The complete circuit diagram of the 'Regenerative FET Receiver' is shown in Fig.17, and as will be seen from this, apart from the FET, only one other active device is used. This is a 748C operational amplifier which is used here as a high gain audio amplifier.

If we consider this circuit in greater detail, the aerial signal couples to the primary winding of T1, and the secondary winding of T1 together with VC2 forms the tuned circuit. VC2 is the normal tuning capacitor. The signals induced into the tuned circuit are coupled direct into the gate of Tr1. An FET has three terminals, and these are termed the gate, drain and source. These are the equivalents of the base, collector and emitter, respectively, of a bipolar transistor.

The direct coupling to the gate of Tr1 will seem a little unusual to those who are unfamiliar with FETs. Unlike a bipolar device, a FET has quite a low resistance between its drain and source terminals with no bias applied to its gate. Whereas an ordinary transistor must be forward biased before it can be used as a practical amplifier, a FET must be reverse biased. This is achieved by using source resistor R2 and holding the gate at chassis potential. Usually a resistor is used to tie the gate to chassis, but in this case the tuned winding of T1 performs this task.

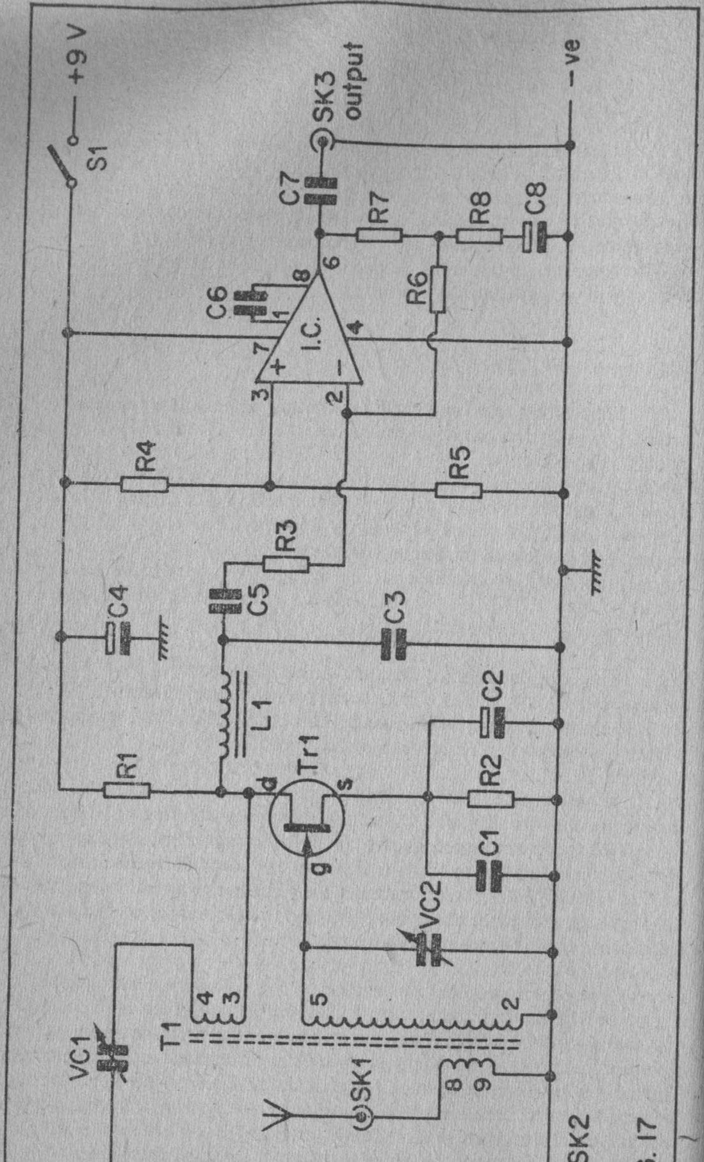


FIG. 17

Components List for Fig.17

Resistors (¼ watt 5%).

R1	1k	R5	39k
R2	680 ohms	R6	100k
R3	2.2k	R7	100k
R4	39k	R8 1k	1k

Capacitors.

C1	10nf plastic foil or ceramic.
C2	100mfd. 10v.w.
C3	15nf plastic foil.
C4	100mfd. 10vw.
C5	470nf plastic foil.
C6	3.3pf ceramic.
C7	100nf plastic foil.
C8	10mfd. 10v.w.
VC1	75pf air spaced (Jackson type C804).
VC2	365pf air spaced (Jackson type 0).

Semiconductors.

Tr1	2N3819.
I.C.	748C.

Inductors.

T1	Denco Green D.P. coils, Ranges 3, 4, and 5.
L1	10mH. (Repanco CH4).

Miscellaneous.

S1	S.P.S.T. toggle switch.

Sockets, chassis, panel, etc.

R1, the drain to source resistance of Tr1, and R2 form a potential divider, and about 1V is present at Tr1 source. Thus the gate of Tr1 is held about 1V negative of the source terminal, and the required reverse bias is produced.

Probably the major advantage of FETs over bipolar devices in this type of receiver is the fact that FETs have input impedances in the region of 1000 Megohms, whereas bipolar devices have input impedances of only a few kohms or even less. As mentioned earlier, a very low level of loading must be placed on the tuned circuit as otherwise selectivity will be seriously degraded. This is obviously achieved here, and the circuit provides very good selectivity.

C1 and C2 are source bypass capacitors, and these are needed to prevent R2 from introducing a degree of negative feedback to the circuit with a consequent loss of gain and efficiency. C1 provides R.F. decoupling and C2 is used to give A.F. decoupling. At first sight it might appear as though C1 is superfluous, with C2 providing both A.F. and R.F. decoupling. Theoretically this is indeed the case, but in practice electrolytic capacitors are not very efficient at high frequencies, and this makes necessary the inclusion of C1.

The output of Tr1 is developed across R1, and some of this output is fed to the third winding on T1. This provides the regeneration for the circuit, and VC2 is the regeneration control. The signal is inverted between the gate and drain of Tr1, and so it is necessary to connect T1 with the phasing shown, so that it also inverts the signal, and provides positive rather than negative feedback. For this reason it is essential that the connections to the windings of T1 are as shown in the circuit diagram, and that, for instance, the connections to pins 5 and 2 of T1 are not reversed.

There must be a low level of loading on the output of Tr1 at radio frequencies by the audio circuit, or it may be found that sufficient regeneration cannot be obtained. R.F. choke L1 has therefore been interposed between Tr1 drain and the R.F. filter capacitor. L1 and C3 provide very effective R.F. filtering, but allow an easy passage for audio signals. The high impedance of L1 at R.F. ensures a very low level of R.F. loading on Tr1's output.

Operational amplifiers such as the 748 I.C. used here have two inputs, a non-inverting one (+) and an inverting one (–). Normally these devices are used with a centre tapped power supply when used in the configuration employed here. The non-inverting input would connect to the centre tap. In this circuit a single supply is used, and the junction of R4 and R5, in effect, forms the necessary centre tap.

The voltage gain of the I.C. is extremely high, being typically some 100 dB (100,000 times!), and in a practical circuit it is necessary to use a large amount of negative feedback between the output and the inverting input in order to reduce the gain to the required level.

The most simple way of doing this is to connect the input signal to the inverting input of the I.C. via a resistor which has a value which is equal to the desired input impedance of the amplifier. The inverting input forms what is termed a 'virtual earth', and so the input impedance of the circuit will be approximately equal to the value given to this resistor. A resistor having a value equal to that of the required voltage gain multiplied by the value of the input resistor is connected between the output and inverting input of the I.C.

Unfortunately, this simple arrangement is often unsatisfactory when a fairly high voltage gain is required, as it is here. This is because the feedback resistor has to be extremely high in value, and this can seriously upset the D.C. biasing of the amplifier. To overcome this problem the feedback resistor has been made up from two resistors in series (R6 and R7), and these have a low enough combined value to provide stable D.C. biasing. Some of the A.C. feedback is decoupled by R8 and C8, and this boosts the gain at audio frequencies to the required level.

C5 provides D.C. blocking at the input to the A.F. stage, and C7 plays the same role at the output. SK3 can feed any type of high impedance headphones or earpiece, and there is a good volume level available.

C6 is the compensation capacitor for the I.C., and this ensures that the circuit does not break into oscillation. It also gives a degree of high frequency roll-off to the response of the audio stage. Note that a 741C I.C. (which has an internal compensation capacitor) cannot be used in this circuit. This would provide too much roll-off, and the resulting audio output would be totally unsatisfactory.

S1 is the normal on/off switch and C4 is the only supply decoupling capacitor that is needed.

Using the Set

This receiver is used in much the same way as the regenerative set described earlier. It is a little easier to operate this design as there is only one reaction control to manipulate.

For reception on the amateur bands it is necessary to advance the reaction control to just beyond the threshold of oscillation. This is because the two modes of transmission mainly employed on the amateur bands are C.W. (Morse) and S.S.B. (Single Sideband). Ordinary A.M. is only very rarely encountered on the amateur bands these days.

C.W., S.S.B., and amateur band reception will not be covered any further here, as this is all explained at some length in a later chapter, and those requiring further information should refer to this.

Reflexive Receiver (Fig.18)

A reflexive receiver is one where the amplifying device is used to amplify the R.F. signal first, and then after detection the same device is used to amplify the audio signal. Thus a single transistor can be used to provide two stages of amplification.

A reflexive circuit is different to a regenerative one, as in the former the signal that is fed back to the input to be amplified for a second time is at A.F. In the case of the latter it is at R.F.

Regeneration is usually employed in reflexive circuits as although it cannot improve the detection efficiency of the circuit (a normal diode detector is used), it can increase the selectivity and R.F. amplification of the receiver.

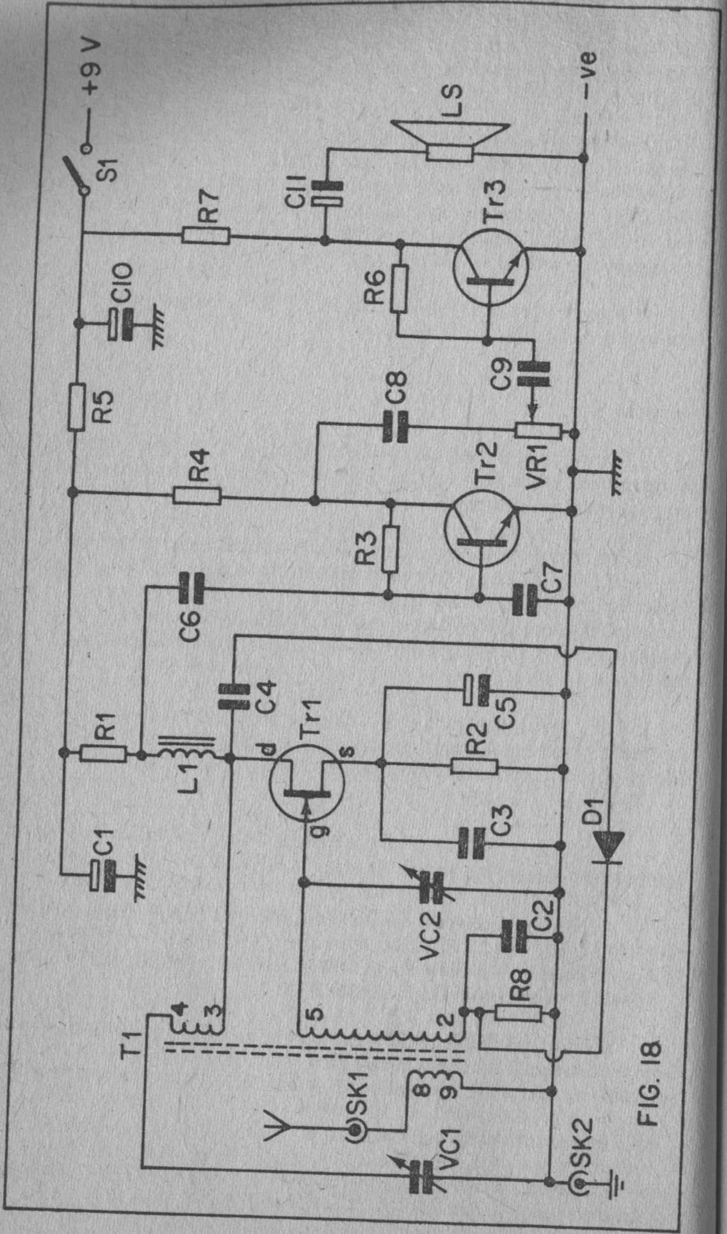


FIG. 18

Components List for Fig.18

Resistors (¼ watt 5%).

R1	1k	R5	220 ohms
R2	1k	R6	220k
R3	8.2Meg.	R7	390 ohms
R4	5.6k	R8	6.8k
VR1	10 log. carbon.		

Capacitors.

C1	100mfd. 10v.w.
C2	10nf plastic foil.
C3	4.7nf ceramic.
C4	5.6nf plastic foil.
C5	10mfd. 10v.w.
C6	100nf plastic foil.
C7	10nf ceramic.
C8	470nf plastic foil.
C9	470nf plastic foil.
C10	100mfd. 10v.w.
C11	100mfd. 10v.w.
VC1	50pf air spaced (C804).
VC2	365pf air spaced (type 0).

Semiconductors.

Tr1	2N3819.
Tr2	BC109.
Tr3	BC109.
D1	OA90.

Inductors.

T1	Denco Green D.P. coils Ranges 3, 4, and 5.
L1	10mH. (Repanco CH4).

Miscellaneous.

High impedance speaker. S.P.S.T. toggle switch (S1).

Chassis, panel, battery, etc.

Fig.18 shows the complete circuit diagram of the reflexive receiver. The wiring to T1 has much in common with the previous circuit, the main difference being that R8 and C2 have been included in the earthy side of the tuned winding of T1. At R.F. these do not have any significant effect as C2 provides a low impedance path to earth for R.F. signals. Neither is the D.C. biasing noticeably affected since R8 provides a suitable path for the minute gate bias current for Tr1.

L1 forms the R.F. load for Tr1, and R1 and C6–C7 in series form an R.F. decoupling network which feed the positive supply to the R.F. amplifier circuit. The R.F. output from Tr1 drain is coupled by way of C4 to the detector diode, D1. R8 now acts as the load resistor for D1 and C2 is the R.F. filter capacitor.

The audio signal developed across R8 is fed via the tuned winding of T1 to the gate of Tr1. Here it is amplified with the resultant audio output appearing across R1. L1 can be ignored as far as the A.F. signal is concerned as it has an extremely low impedance at audio frequencies.

C6 couples the audio output of Tr1 to the base of the first audio amplifier transistor, Tr2. C7 provides high frequency roll-off. Tr2 is a conventional high gain common emitter amplifier having collector load resistor R4 and base bias resistor R3.

The output from Tr2 collector is coupled via D.C. blocking capacitor C8 to VR1, which is the volume control. From here the signal is coupled to a second common emitter amplifier through C9. This is basically the same as the first audio stage, except that the component values have been chosen to provide a higher level of output drive.

With one stage of R.F. amplification, and three stages of audio amplification this set has a considerable level of gain. Despite the fact that headphones are probably more convenient for S.W. listening than using a speaker, many S.W.L.s prefer to use a speaker. This set can be used with any normal type or impedance of headphones, and has a sufficiently strong output to give good volume from a high impedance speaker. Ideally the speaker should have an impedance of 80 ohms or more, but it will work perfectly satisfactorily with speakers having impedances as low as 25 ohms. With this type of circuit, larger speakers such as a 6 in. x 4 in. or 7 in. x 4 in. eliptical types, almost invariably perform much better than the sub-miniature variety.

With the circuit having such a high level of audio gain it is absolutely essential that the positive supply rail is well decoupled, and this function is performed by C1, R5 and C10. S1 is the on/off switch.

Apart from the fact that this set has a volume control, it is operated in much the same way as the previous design. It does not have a regenerative detector, of course, but the regeneration control will be found to behave in much the same manner as when a regenerative detector is used.

The current consumption is considerably higher than that of the other two battery-operated receivers described so far, and is about 10 to 12 mA. In the interest of low running costs it is advisable to use a fairly large capacity battery, such as a PP7 or a PP9.

Infinite Impedance Detector (Fig.19)

Infinite impedance detector is rather an old-fashioned term, it used to be used to describe a type of regenerative detector which used a valve as a cathode follower, or common anode amplifier as it is sometimes called. The bipolar equivalent of this circuit is the emitter follower, and the FET equivalent of this is the source follower.

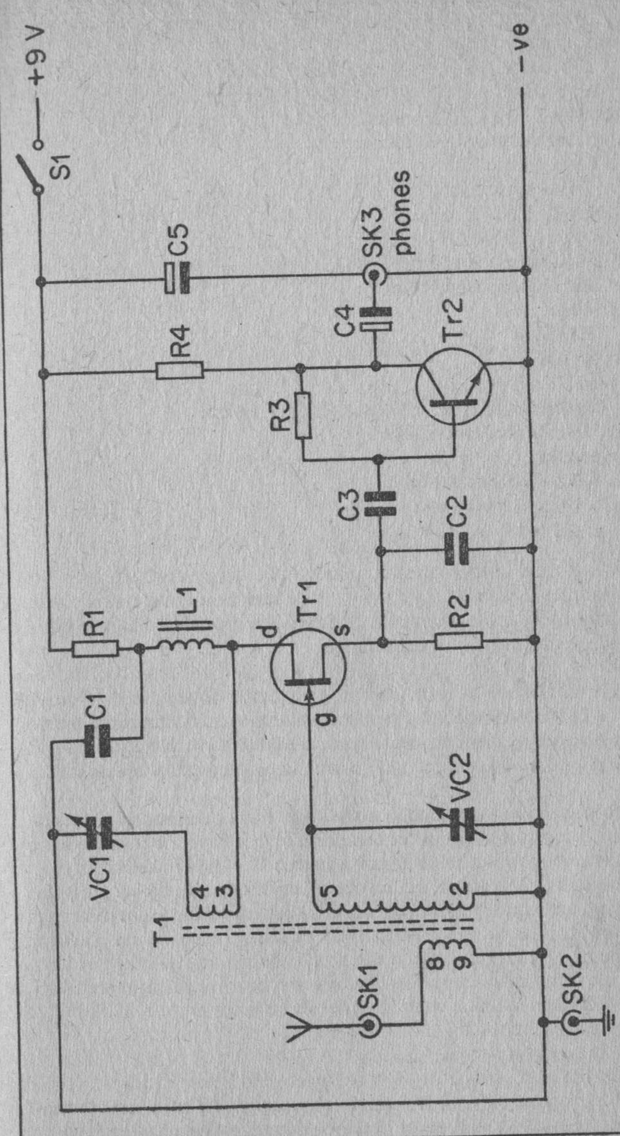


FIG. 19

Components List for Fig.19

Resistors (¼ watt 5%).
R1 390 ohms
R2 1k
R3 1.8Meg.
R4 4.7k
Capacitors.
C1 5.6nf ceramic.
C2 15nf plastic foil.
C3 470nf plastic foil.
C4 4mfd. 10v.w.
C5 100mfd. 10v.w.
VC1 50pf air spaced (type C804).
VC2 365pf air spaced (type 0).
Semiconductors.
Tr1 2N3819.
Tr2 BC109.
Inductors.
T1 Denco Green D.P. coils Ranges 3, 4, and 5.
L1 10mH. (Repanco CH4).
Miscellaneous.
S1 S.P.S.T. toggle switch.
Sockets, chassis, panel, etc.

When used in these modes, none of the devices provide any voltage gain, and, in fact, they have a little less than unity voltage gain. They act as a sort of impedance transformer, converting a high input impedance to a low output impedance.

The advantage of using this mode is that it is supposed to provide a higher quality output than when using the more usual common gate or common source configurations (or the bipolar or valve equivalents). It is also supposed to provide a detector that is not easily overloaded.

It is unlikely that in use a noticeably higher output quality will be obtained with this type of circuit, but it does have a better performance on strong signals, and it has an apparent increase in selectivity because of this. The actual selectivity is not really any higher, it is simply that a strong signal on the band being tuned can sometimes make it impossible to use a tight aerial coupling to the input coil without the set being overloaded, with weak signals being unintelligible as a result. An infinite impedance detector allows a much stronger input signal to be used, and in consequence weak signals can be received even if there is a very strong signal close by.

On the other hand, its slightly lower gain is something of a disadvantage when propagation conditions are poor, and only weak signals can be received. Anyway, this type of detector does provide an interesting alternative to the more usual circuits, and the circuit described here is capable of excellent results.

The circuit diagram of the infinite impedance detector receiver is shown in Fig.19. This circuit has many basic similarities to the previous two designs. The wiring to T1 for example, is exactly the same. However, the audio output is not taken from the drain circuit of T1, but instead it is taken from the source circuit via C3. C2 acts as the R.F. filter capacitor.

The FET is really being used in two operating modes in this circuit. As far as the regeneration is concerned it is operating as a common source amplifier with L1 acting as its load and the output being taken from its drain. C2 then acts as the source bypass capacitor. As a detector it operates as a source follower with the output being taken from the source.

Tr2 is used as the basis of a high gain common emitter amplifier, and the audio output is coupled from this to the headphone socket (SK3) via D.C. blocking capacitor C4. High, medium or low impedance headphones can be used with the receiver.

S1 provides on/off switching and C5 is the supply decoupling capacitor.

The receiver is operated in the usual manner.

D.G. MOSFET Receiver (Fig.20)

This design is a little more sophisticated than the previousdesigns, and it is shown in basic form in Fig.20. This basic version has an output that can only be used to feed a pair of headphones, and the circuit of an optional I.C. output stage which increases the output to a level that is capable of driving a speaker is shown in Fig.21.

In the previous circuits the aerial has been coupled directly to the input coil of the R.F. transformer. In this design the aerial is coupled to an untuned R.F. stage using Tr1. As this is an untuned stage with no tuned circuit at the input, it does not provide a very large increase in gain. It does, nevertheless, provide a very useful increase in sensitivity.

Tr1 is used as a common gate amplifier, and the aerial couples direct to its input terminal (its source). The output is developed at the drain of Tr1, and the primary winding of T1 forms the drain load. In order to ensure good stability, the R.F. stage must be decoupled from the rest of the circuit so that there is no feedback through the supply lines. R1 and C1 form the decoupling network.

Tr2 is a dual gate MOSFET, or insulated gate FET as this type of device is sometimes alternatively termed. If we ignore the g2 terminal for the time being, this can be considered as being very similar

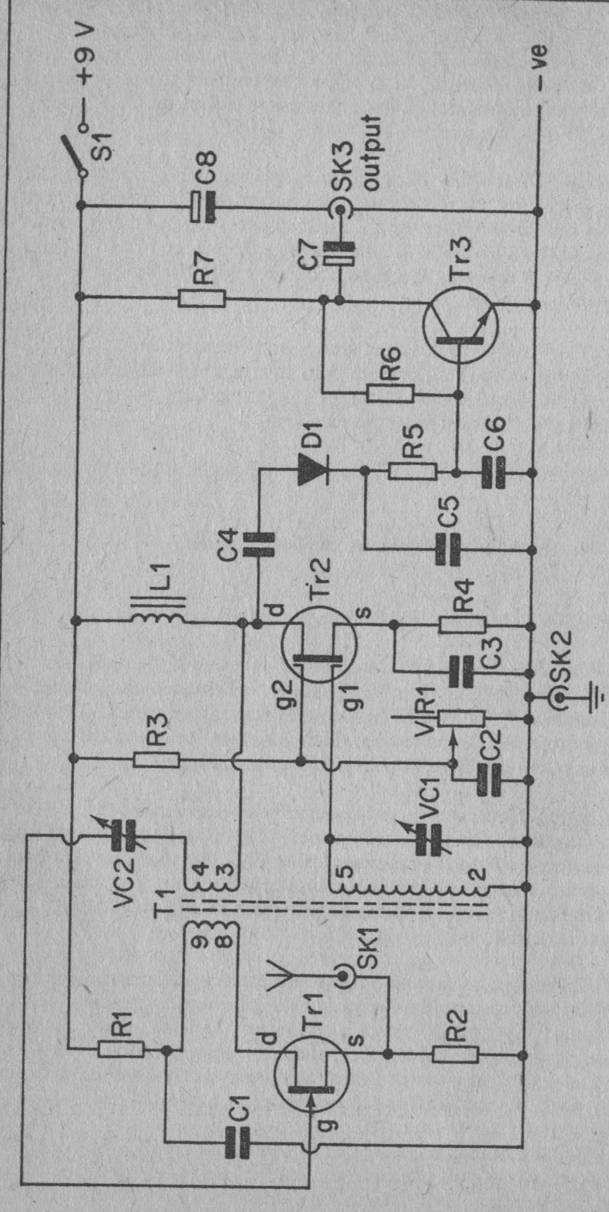


FIG. 20

Components List for Fig.20

Resistors (all ¼ watt 5%).

R1	680 ohms	R5	680 ohms
R2	1k	R6	2.2Meg.
R3	47k	R7	5.6k
R4	1k		
VR1	10k 1in. carbon.		

Capacitors.

C1	100nf plastic foil.
C2	100nf plastic foil.
C3	5.6nf ceramic.
C4	100nf plastic foil.
C5	5.6nf ceramic.
C6	5.6nf ceramic.
C7	4mfd. 10v.w.
C8	100mfd. 10v.w.
VC1	365pf air spaced (type 0).
VC2	50pf air spaced (type C804).

Semiconductors.

Tr1	2N3819.
Tr2	3N140 or 40673.
Tr3	BC109.
D1	OA90.

Inductors.

T1	Denco Green D.P. coils Ranges 3, 4, and 5.
L1	10mH. (Repanco CH4).

Miscellaneous.

S1	S.P.S.T. toggle switch.

Chassis and panel, sockets, 9V. battery, etc.

in operation to a JUGFET. It does, however, have an even higher input impedance, this being something in the region of 100,000 Meg ohms.

Tr2 is used as a regenerative R.F. amplifier and it has L1 as its drain load. The method of obtaining regeneration, and coupling the input signal to the device is the same as in the three previous designs. So is the method of basing the FET.

The gain of a dual gate MOSFET is controlled by the voltage at its gate 2 terminal. Gain is at maximum with the g2 terminal biased slightly positive of the source terminal. Reducing the g2 bias causes a reduction in gain.

R3 and VR1 form a potential divider across the supply lines and the g2 terminal of Tr2 is fed from the slider of VR1. When VR1 slider is set towards the top of its track, the gain of Tr2 is at about maximum. When it is set towards the bottom of the track, gain is at around minimum.

It will probably not be immediately apparent why it is necessary to have a gain control for Tr2. There are two very good reasons for Firstly, with Tr2 biased for maximum gain there is sufficient regeneration at some frequencies to cause the set to oscillate, even with VC2 adjusted for minimum capacitance. When this occurs, VR1 can be adjusted for slightly lower gain so that A.M. transmissions can be properly resolved by the receiver.

Secondly, the high gain of Tr2 makes fine setting of the reaction level rather difficult using VC2 alone. VR1 can be used as a fine regeneration control, rather in the same way as the regenerative receiver described in Chapter 2 had a fine regeneration control. Note however, that there is a slight difference in the use of the fine reaction controls on these two sets. On the regenerative receiver of Chapter 2, the fine reaction control was kept turned well back in order to give efficient detection. Here this control has no effect on the detection efficiency, and it should be kept well advanced (where possible) in order to give a high level of gain.

The use of a dual gate MOSFET produces a circuit which can handle quite high signal levels without overloading. On the other hand, the set is extremely sensitive, and it is not completely immune to overloading. If an overload should occur, it will probably be possible to cure this by backing off VR1 and advancing VC2 somewhat.

Detector and A.F. Stages

The output from Tr2 is fed to detector diode D1 via D.C. blocking capacitor C4. C5, R5 and C6 form a very effective R.F. filter.

The audio stage is a high gain common emitter amplifier using Tr3. This has R7 as its collector load resistor and R6 as its base bias resistor. C7 couples the output signal to SK3, which can be used to feed any type of medium to high impedance headphones.

S1 is the on/off switch and C7 is an A.F. supply decoupling capacitor.

Some readers may be wondering why it is necessary to use a separate diode detector, rather than simply use Tr2 as a regenerative detector. It would be quite possible to do this, and such an arrangement would work very well, but using a separate detector does have a couple of advantages. Furthermore, using a separate detector does not greatly increase the cost or complexity of the receiver.

The bigger of the two advantages is that MOSFETs generate rather a lot of noise at A.F. If Tr2 were to be used as a regenerative detector, this noise would be coupled to the audio stages of the set. With the set up used here, the diode detector blocks virtually all the A.F. noise from Tr2 from reaching subsequent stages of the set, and a much improved signal to noise ratio is obtained.

The second advantage, and the more minor of the two, is that a diode detector is more efficient than a regnerative one, if one ignores the fact that a regenerative detector has a degree of R.F. gain. Thus by using a regenerative R.F. amplifier followed by a diode detector, a higher output is obtained than would be the case if a regenerative detector were used.

MOSFET Protection

One drawback of MOSFETs is that they are rather easily damaged by static charges. Even just touching a MOSFET could conceivably destroy one of the gate junctions. Because of this many types of MOSFET have integral diodes that limit the input voltages to safe levels. This is the case with the 40673 device specified for D.G. MOSFET Receiver. However, the 3N140 specified as an alternative has no such protection circuitry.

This device is normally supplied with a wire shorting clip which connects the four leadout wires to the metal case of the component. This clip should not be removed until the device has been soldered into circuit, and all the other wiring to the receiver has been completed.

If at any future time it should be necessary to carry out any work on the receiver that involves removing the MOSFET or doing any soldering near its leadouts, it is a good idea to use some thin wire to short its leads together until the work has been finished.

Output Stage (Fig.21)

The audio output stage is based on an LM380N I.C., and very few discrete components are required. This I.C. is capable of an output of about 2 watts R.M.S. under the right operating conditions, but here it is only used to provide about 500 mW into an 8 ohm speaker. It can be used with a lower impedance speaker, and will provide a slightly higher output power (about 1 watt into 3 ohms). It can also be used with higher impedance speakers, but the maximum available output power will then be reduced (about 250 mW into a 25 ohm load).

In its simplest form, a practical amplifier using the LM380N can be achieved using just two discrete components, the input and output D.C. blocking capacitors. These are C12 and C13 respectively in Fig.21. In this case some additional supply decoupling is needed, and this is provided by C9 and R8. VR2 is the volume control.

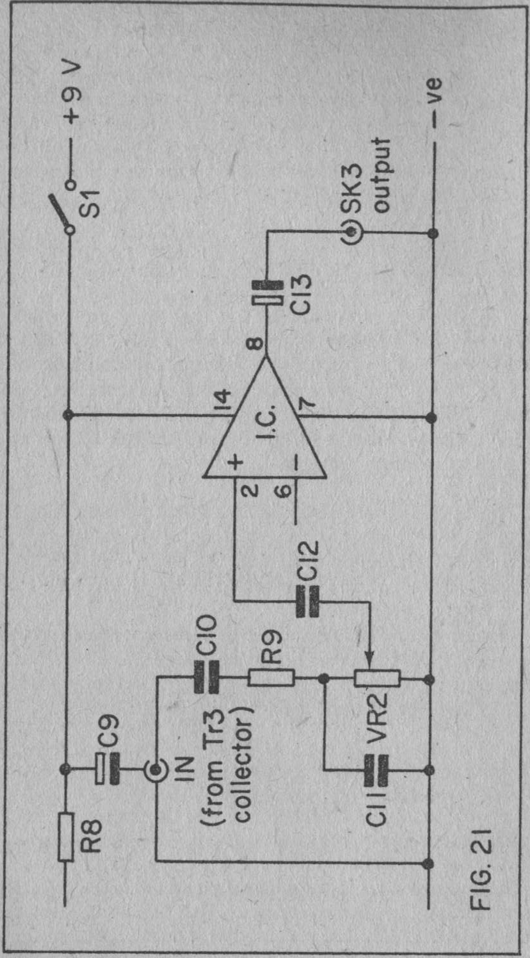


FIG. 21

Components List for Fig.21

R8	680 ohms.
R9	220k.
VR2	50k log. carbon.
C9	100mfd. 10v.w.
C10	22nf plastic foil.
C11	2.2nf ceramic.
C12	22nf plastic foil.
C13	100mfd. 10v.w.
I.C.	LM38ON.

Wiring board, etc.

The gain of the I.C. is fixed at approximately 50 times (34dB.) by an integral feedback network. This is rather more than is required in this particular application, and in fact very little voltage gain is required here as the output from the basic receiver circuit has quite a high amplitude. The output stage is really only required to provide the high signal currents required to drive the speaker. R9 is used to attenuate the output from the basic receiver to some degree, and so provide a more realistic level of audio voltage gain.

It is extremely important to ensure that no R.F. signal finds its way into the output stage, as this would result in violent instability. Additional R.F. filtering is provided by C11.

Note that if the output stage is added, C7 of the basic receiver plays no useful part in the operation of the set, and is omitted.

Apart from feeding a speaker, the output stage will also work satisfactorily into any type of headphone or earpiece.

CMOS Receiver (Fig.22)

CMOS devices seem to appear in circuits for the amateur with increasing frequency. These are a range of logic circuits, but they are also suitable for many linear applications, including S.W. receivers. This receiver is based on two of the four gates that are contained in an R.C.A. CD4001AE I.C.

It should perhaps be pointed out that this is not intended to be a joke, or a gimmick. This receiver is capable of a very good performance, and with the cost of the I.C. being less than that of many R.F. transistors and f.e.t.s, it provides a very novel and practical alternative to more conventional sets.

The CD4001AE contains four 2 input NOR gates. By connecting the two inputs of a gate in parallel, an inverter can be formed. This can be biased to operate as a linear amplifier by connecting a resistor between the input and output. CMOS devices are based on complementary MOSFETS, and they thus have extremely high input impedances. When used in this way as a linear amplifier, the input impedance of the circuit is approximately equal to the value given to the biasing resistor. In this case a high input impedance is required so that a low level of loading is placed on the tuned circuit.

As will be seen by refering to Fig.22, the tuned circuit is coupled to the input of one amplifier by way of D.C. blocking capacitor, C1. R1 biases the inverter.

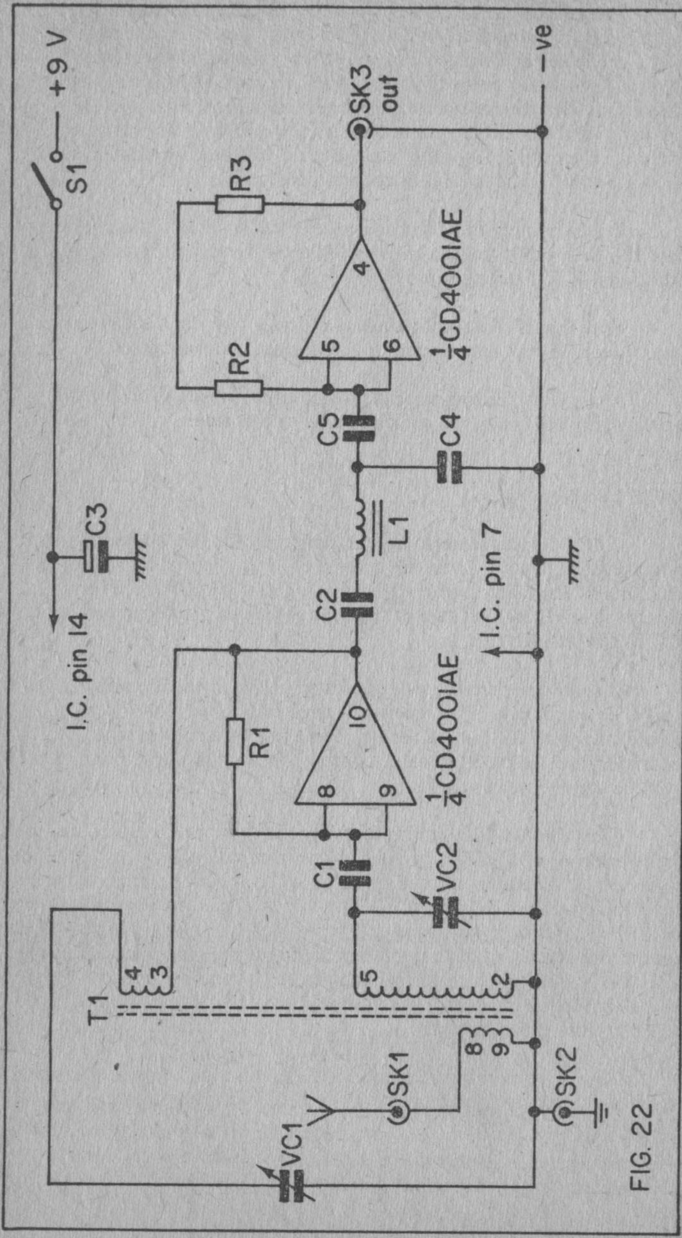


FIG. 22

Components List for Fig.22

Resistors (¼ watt 5%).

R1	220k.
R2	10 Meg.
R3	10 Meg.
Capacitors.	
C1	10nf plastic foil.
C2	10nf plastic foil.
C3	100mfd. 10v.w.
C4	10nf ceramic.
C5	10nf plastic foil.
VC1	50pf air spaced (type C804).
VC2	365pf air spaced (type 0).
Semiconductor.	
I.C.	CD4001AE.
Inductors.	
T1	Denco Green D.P. coils Ranges 3, 4, and 5.
L1	10mH. (Repanco CH4).
Miscellaneous.	
S1	S.P.S.T. toggle switch.

Chassis, panel, sockets, connecting wire, etc.

Regeneration is provided from the output by way of a winding on T1 and variable capacitor VC1. The latter acts as the reaction control. Although the gate is said to be biased as a linear amplifier, like any practical amplifier it has some degree of distortion, and by applying regeneration it performs very well as an regenerative detector.

The output of the first amplifier is coupled by C2 to the R.F. filter which comprises L1 and C4. From here the signal is coupled to a second amplifier by C5. This is used as an audio amplifier and is biased by R2 and R3. Two resistors in series are used here as a single resistor having a suitably high value is not readily obtainable. A high value is not required here in order to provide a really high input impedance, but to provide a high level of voltage gain. Using a high value bias resistor reduces the amount of negative feedback that is applied to the circuit, and so gives a higher level of voltage gain.

The output of the audio amplifier is directly coupled to SK3, and this can be used to feed a crystal earpiece or a pair of crystal headphones. Other types of headphone are not suitable.

Only one supply decoupling component is required, and this is C3. VC2 the usual tuning control and S1 is the on off switch.

CMOS devices have extremely low current consumptions, and this receiver draws only about 1mA. from a 9 volt supply. The circuit does not have to be used with a 9 volt battery, and will work satisfactory with any supply potential of between 4.5 and 15 volts.

Like MOSFETS, CMOS I.C.s can be damaged by static charges. They are normally supplied with their leads embedded in a piece of conductive foam. It is best to leave them in this until it is time to fit the device into circuit. This should be left until all the other wiring has been finished. Use an I.C. socket for the device (14 pin DIL) and handle it as little as possible once it has been removed from the conductive foam.

This is one receiver where it is probably not practical to wire up most of the R.F. circuitry using point to point wiring. Instead plain 0.1in. S.R.B.P. or a p.c.b. will have to be used. This is satisfactory provided the unit is layed out in such a fashion that all leads carrying R.F. signals are no more than a few inches long.

Single Band Receiver (Fig.23)

The circuit shown in Fig.23 is extremely simple, but works very well using a Range 4T coil. It is not suitable for use on other ranges. It provides good reception on the popular broadcast bands, and is also good for reception on the 40 Metre and 20 Metre amateur bands.

This circuit has the usual aerial coupling and tuned windings on T1. Tr1 is a bipolar transistor, and this has a fairly low input impedance. The tuned circuit cannot be coupled straight to the base of Tr1 in the way that the tuned circuit has been coupled to the active device in the other G.P. Receivers. A low impedance coupling winding on T1 must be used to provide an efficient coupling, and to ensure that Tr1 does not heavily load the tuned circuit. C2 provides D.C. blocking at the input.

Tr1 is used as a common emitter amplifier and it is biased by R1. L1 is its R.F. load and VR1 is its A.F. load. Positive feedback is used between Tr1 collector and the tuned circuit, and the feedback path is provided by C1.

The level of regeneration is fixed, and the regeneration level is controlled by altering the sensitivity of the circuit. This is achieved by VR1. The gain of Tr1 increases as VR1 is adjusted for decreasing resistance. VR1 functions and is operated as a normal reaction control.

C3, R2, and C4 form an R.F. filter, and the audio output from these is fed to the base of Tr2 via C5.

Tr2 is used as a high gain common emitter audio amplifier, and the output can be used to feed any medium to high impedance headphones.

S1 is the on/off switch and C7 provides supply decoupling.

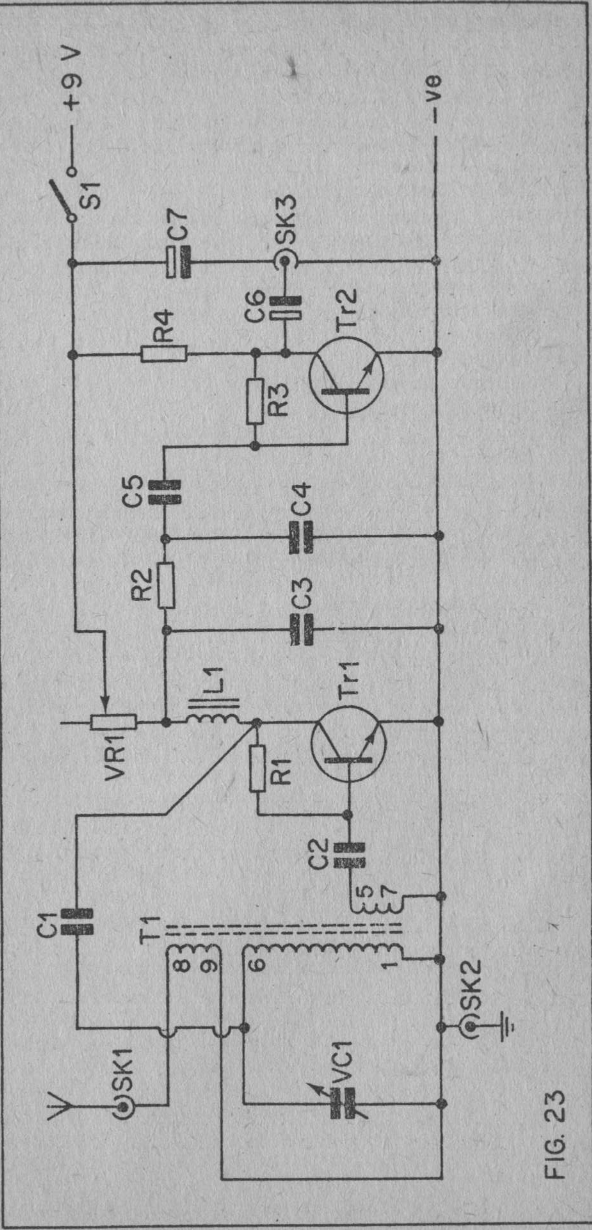


FIG. 23

Components List for Fig.23

Resistors (¼ watt 5%).	
R1	2.2 Meg.
R2	1k
R3	1.2 Meg.
R4	4.7k
VR1	50k 1in. carbon.
Capacitors.	
C1	2.2pf ceramic.
C2	470pf plastic foil.
C3	5.6nf ceramic.
C4	47nf plastic foil.
C5	100nf plastic foil.
C6	4mfd. 10v.w.
C7	100mfd. 10v.w.
VC1	365pf air spaced (type 0).
Semiconductors.	
Tr1	BC107.
Tr2	BC109.
Inductors.	
T1	Denco Transistor useage coil, Yellow Range 4T.
L1	10mH. (Repanco CH4).
Miscellaneous.	
S1	S.P.S.T. toggle switch.
Chassis, panel, battery, wire, etc.	

CHAPTER 4

Portable Receivers

One might think that a simple S.W. receiver designed for use with an ordinary telescopic aerial and no earth was suitable only for over optimistic DXers. While it is true that such a set will not give such good results as one designed for use with and equipped with a proper aerial and earth system, very good results can, nevertheless, be obtained using such a receiver.

In this chapter, two very simple portable S.W. receiver circuits will be described. The first of these is described in two versions, one having a headphone output and the other having an internal speaker.

Portable Reflex Receiver (Fig.24)

Although this design only employs one active device and uses only a telescopic aerial, it gives a very strong output to a pair of medium or high impedance headphones, and is surprisingly sensitive. It uses a bipolar transistor in a reflexive circuit with controlled regeneration. The circuit diagram of this receiver is shown in Fig.24.

This circuit is a little unusual in that it uses a bipolar transistor and coils intended for valved circuits. The reason for this is simply that in practice it was found that the Denco D.P. coils worked better in the circuit than the coils for transistor useage.

Pins 8 and 9 of T1 connect to a winding that is intended to be used as the aerial coupling coil. However, here such a short aerial is used that the tightest possible coupling between the aerial and the tuned circuit must be used. This is achieved by the simple expedient of connecting the aerial direct to the non-earthy end of the tuned circuit. The winding between pins 8 and 9 is then used as the low impedance coupling winding which feeds into the base of Tr1. This arrangement is extremely efficient.

C1 provides the earth return for one side of the base coupling winding, and the other side connects direct to Tr1 base. L1 is the collector load for Tr1 at R.F., and the R.F. signal is coupled by way of C2 to the diode detector, D1. C1 now acts as an R.F. filter capacitor, and it is across this component that the demodulated audio signal is developed. This audio signal is coupled to Tr1 base through the base coupling winding of T1, and it is then amplified by Tr1 which now operates as a high gain common emitter audio amplifier. L1 has a very low impedance at A.F., and plays no active role as far as A.F. amplification is concerned. R2 is the collector load for Tr1 at A.F., and it is across this that the final audio signal is developed. C3 filters

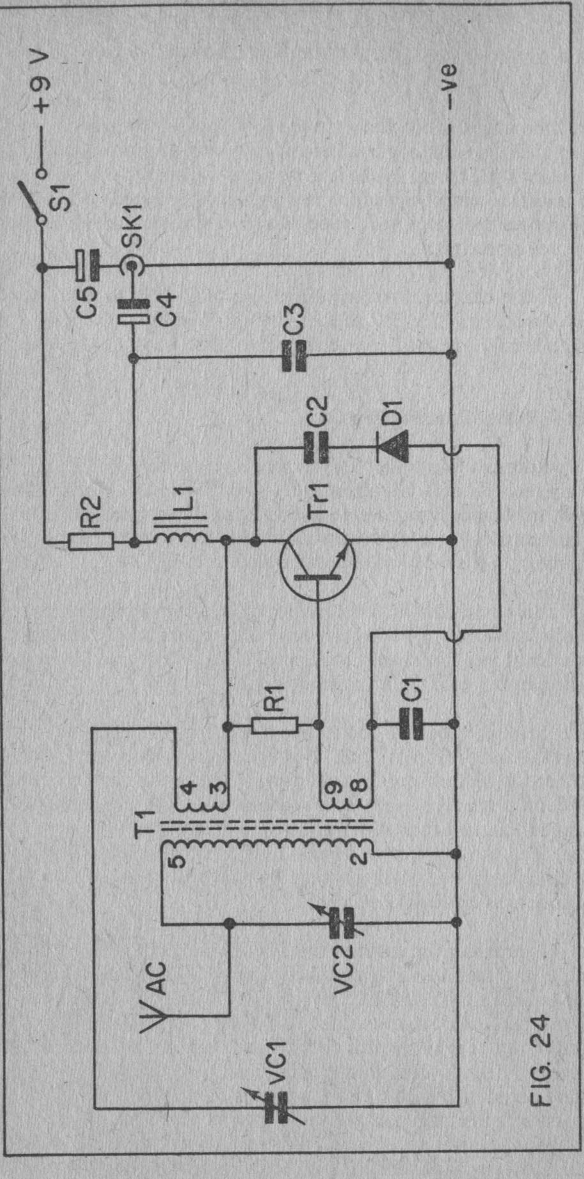


FIG. 24

Components List for Fig.24

Resistors (¼ watt 10%).	
R1	1.2 Meg.
R2	3.3k
Capacitors.	
C1	15nf plastic foil.
C2	5.6nf plastic foil.
C3	4.7nf ceramic.
C4	4mfd. 10v.w.
C5	100mfd. 10v.w.
VC1	50pf air spaced (type C804).
VC2	365pf air spaced (type 0).
Semiconductors.	
Tr1	BC107.
D1	OA91.
Inductors.	
T1	Denco D.P. coils Ranges 3, 4, and 5 Green.
L1	10mH. (Repanco CH4).
Miscellaneous.	
S1	S.P.S.T. toggle switch.
Chassis, panel, battery, sockets, etc.	

out any R.F. that might find its way to the output, and could otherwise cause instability.

C4 is the output D.C. blocking capacitor and C5 is a supply decoupling capacitor. S1 is the on/off switch. R1 is the bias resistor for Tr1. Regeneration is provided by using feedback between Tr1 collector and the third winding on T1. VC1 is the reaction control. VC2 is, of course, the ordinary tuning capacitor.

Using the Set

The receiver is operated in much the same way as the previous sets. One difference is that if VC1 is advanced more than fractionally beyond the threshold of oscillation, the detector breaks into an ultrasonic oscillation on top of the R.F. oscillation. This makes it rather awkward to use for amateur band reception, although this is possible. However, if the reader's main interest is in amateur band reception, the f.e.t. portable described later would better suit his or her needs.

One does not obtain something for nothing with this circuit, and the price that is paid for the tight aerial coupling is a loss of selectivity. This is due to the loading effect of the aerial on the tuned circuit, and this effect was demonstrated earlier in the section describing the crystal set.

Normally the telescopic aerial should be fully extended, and a fairly long type should be used (say about 1.2 Metres long). When conditions are good and many strong signals are being received, it may be beneficial to contract the aerial slightly, so as to give improved selectivity. Naturally, this will result in some reduction of received signal strengths.

Loudspeaker Version (Fig.25)

It is perhaps an advantage for a portable receiver to be completely self contained, so that there are no trailing wires from headphones. Thus, although most people prefer headphones for normal S.W. listening, an internal loudspeaker is probably more convenient in the case of a portable S.W. set.

The circuit diagram of the loudspeaker version of the 'Portable Reflex. Receiver' is shown in Fig.25. This is the same the original circuit except for the addition of a high gain common emitter output stage. This uses Tr2 and has R4 as its collector load. R3 is the base bias resistor.

This set will provide good volume from any reasonably efficient speaker having an impedance of 25 ohms or more. It can also be used with any type of headphone if a suitable socket is provided.

It is operated in the same way as the basic version of the receiver.

F.E.T. Portable Set (Fig.26)

The circuit of Fig.26 is for a sensitive portable receiver that incorporates only two active devices, a f.e.t. and an integrated circuit. The f.e.t. is used as a regenerative detector and the I.C. is an LM38ON audio power amplifier.

As in the previous design, the aerial is directly connected to the tuned circuit in order to give optimum signal transfer. The aerial coupling winding on T1 is simply ignored. No connections should be made to pins 8 and 9 of the coil, even if these appear to be convenient anchor points for components. The tuned circuit couples straight into the gate of Tr1, and R4 is the source bias resistor. The latter has C3 as its R.F. bypass capacitor, and C4 as its A.F. bypass capacitor. R2 is the drain load for Tr1.

Regeneration is applied to the circuit in the usual way. R3 is connected in series with the audio output from the detector in order to ensure that a low level of R.F. loading is placed on Tr1 drain by the audio stages, and in particular the R.F. filter capacitor, C6. If this were not done there would be a very adverse effect on the regeneration circuit.

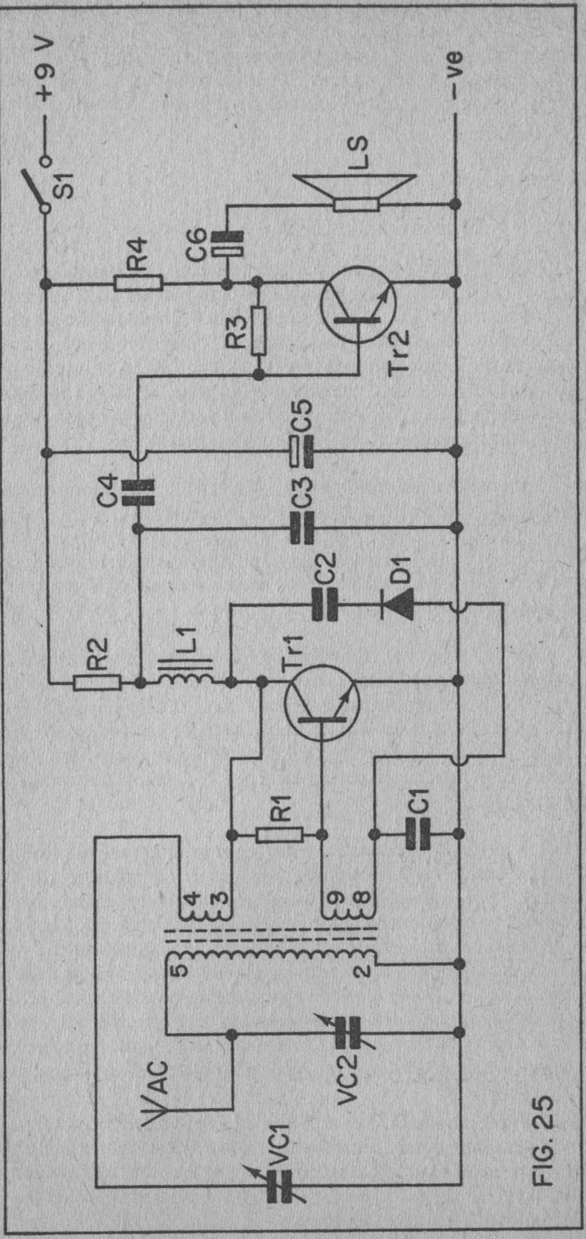


FIG. 25

Components List for Fig.25

As Fig.24, except C4 is reduced to 100nf plastic foil.
Add the following: –

R3	330k
R4	390 ohms
C6	100mfd. 10v.w.
Tr2	BC109.

high impedance speaker.

The audio output from R3 is coupled to the volume control (VR1) via D.C. blocking capacitor, C6. The output from the slider of VR1 is taken to the I.C. output stage. This will supply ample output to any speaker, regardless of impedance. The available output power increases as the speaker impedance is reduced. A 25 ohm unit gives what is probably the best compromise between battery consumption and available volume. By the addition of a suitable socket, any type of headphone or earpiece can be used with the set.

S1 is the usual on/off switch. Very effective supply decoupling is needed, and this is the purpose of C1, C2, and R1.

This set is used in much the same way as the previous design, except that it will be much easier to use on reception of amateur C.W. and S.S.B. signals.

One problem that frequently arises when this type of set is used for amateur band reception is that of hand capacity effects on the tuning. This is where moving ones hand near the tuning capacitor slightly alters the tuning. This is unlikely to be noticed on the broadcast bands, but can be a severe problem on the amateur bands where the use of C.W., and more particularly S.S.B., makes the tuning far more critical.

It is advisable to construct the receiver in a non-metalic case, or if a metalic case is used, this should be completely insulated from the circuit. It is also a good idea to use a non-metalic extension shaft between the tuning control knob and VC1. The same applies to any form of bandspread control that may be fitted and also to the volume control. Shaft couplers are readily available from the larger component retailers. The additional length of spindle can be a piece cut off a potentiometer (these normally have rather long spindles) or a piece of ¼in. dia. dowel can be used. As just mentioned, potentiometers usually have fairly long spindles, and an extension may well not be necessary in the case of VR1.

The components are mounted on a bracket behind the front panel, and their spindles protrude through 9/32in. diameter holes in the front panel. This is usually fairly easy to arrange, and the only real disadvantage of this is that it slightly increases the size or the case which is needed to house the project.

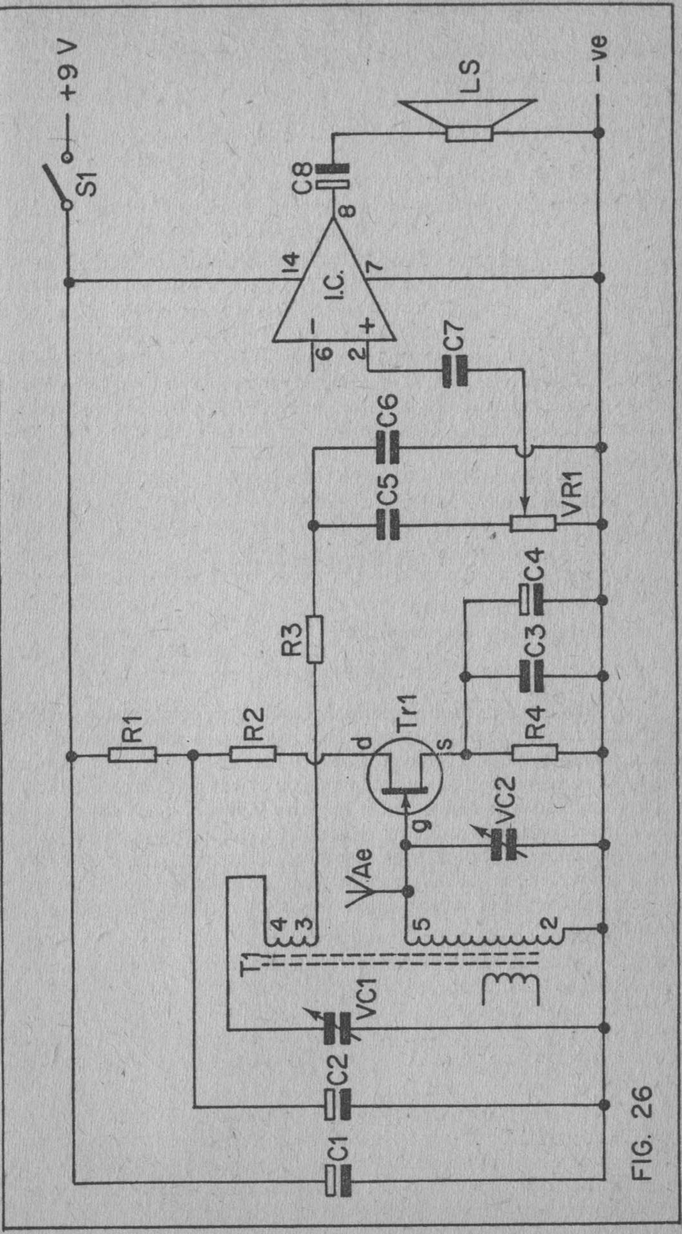


FIG. 26

Components List for Fig.26

Resistors (¼ watt 5%).	
R1	150 ohms
R2	1k
R3	2.2k
R4	1k
VR1	50k log. carbon.
Capacitors.	
C1	100mfd. 10v.w.
C2	100mfd. 10v.w.
C3	10nf ceramic.
C4	100mfd. 10v.w.
C5	47nf plastic foil.
C6	15nf plastic foil.
C7	47nf plastic foil.
C8	100mfd. 10v.w.
VC1	50pf air spaced (type C804).
VC2	365pf air spaced (type 0).
Semiconductors.	
Tr1	2N3819.
I.C.	LM380N
Inductor.	
T1	Denco Green D.P. coils Ranges 3, 4, and 5.
Miscellaneous.	
S1	S.P.S.T. toggle switch.
Case, battery, telescopic aerial, etc.	

A much more simple method of illiminating hand capacity effects is to earth the negative supply rail. This need not be a complicated earth, and a small metal spike pushed into the earth will do. Connecting the negative supply rail to any large metalic object has a similar effect. Even a length of wire connected to negative supply and left dangling below the receiver will probably be found to adequately suppress hand capacity effects. Although these last methods are very simple, they are not as convenient as the first method when it comes to actually using the set, and the use of spindle extensions is the method preferred by the author.

CHAPTER 5

Amateur Band Receiver

On the amateur bands ordinary A.M. signals are almost non-existant these days. The place of A.M. has been taken single sideband (S.S.B.) which offers several advantages over A.M. in the context of amateur band communications. Before describing the circuit and operation of a receiver for reception of C.W. and S.S.B. on the 80 Metre amateur band, some background information on S.S.B. will be given.

It should perhaps be stressed that it is by no means essential to have an understanding of S.S.B. before commencing amateur band reception, but is extremely helpful to have at least a basic understanding of S.S.B. There is much more to tuning in an S.S.B. signal than there is to tuning to an A.M. one. Unless the tuning is carried out accurately, the audio signal that is produced will be completely uncomprehendable. Without even a basic understanding of S.S.B. there is a certain hit and miss aspect of amateur bands reception. Reading the following section should help to remove this aspect of things.

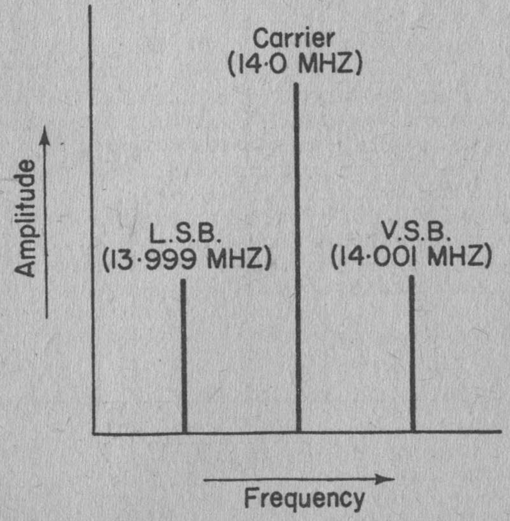


FIG. 27

A.M. Signal

It will be helpful to first consider what exactly an A.M. signal consists of. For the sake of this example we will consider a 14MHZ carrier wave which is modulated by a 1kHZ audio tone. Looking at this in terms of the frequencies that are produced at the output of the transmitter we have the arrangement shown in Fig.27.

Apart from the carrier wave, two other signals are produced, one 1kHZ above the carrier wave, and one 1kHZ below it. If a 2kHZ audio signal were to be used as the modulating signal, these signals would be 2kHZ above and below the carrier wave. Their spacing from the carrier wave is always equal to the modulating audio frequency. The one above the carrier is called the upper sideband, and the one below it is called the lower sideband.

In a practical signal consisting of transmitted speech, there would be many frequencies in each sideband, but the two sidebands would still be symetrically grouped around the carrier. Such a signal might look something like Fig.28.

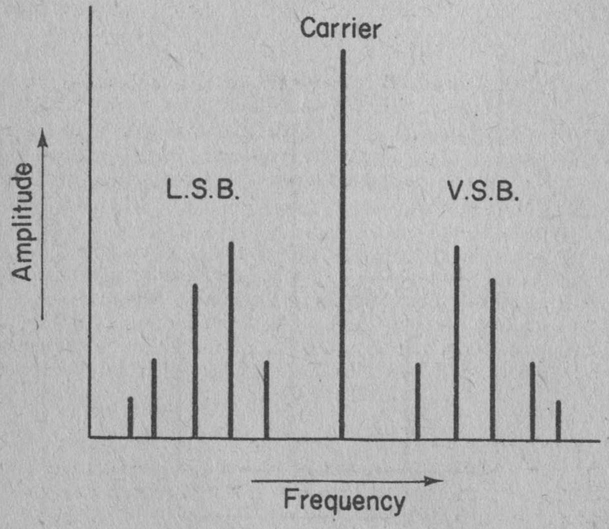


FIG. 28

At the detector of the receiver the two sidebands react with the carrier signal to produce the original audio frequencies at the output. The phasing of the two sidebands is such that they do not react with one another. One drawback of A.M. is that if two transmitters are operating close to one another in terms of frequency, the two carriers will react with one another to produce an audio output. For instance, if the carrier waves are 3kHZ apart, a 3kHZ audio signal will be produced. Furthermore, as the carriers are stronger than the sidebands, this 3kHZ signal will be extremely strong, and it is quite likely that neither signal will be completely comprehendable. This effect is easily demonstrated by tuning over the M.W. band after dark. One or two examples can usually be found without too much effort.

The amateur bands are extremely crowded in recent times, and the widespread use of A.M. is no longer really feasable on these bands. Instead S.S.B. is used, and what this consists of is suppressing the carrier and one sideband at the transmitter, and only transmitting one of the sidebands. Hence the name, single sideband.

It is possible to use an ordinary diode detector to demodulate an S.S.B. signal, but only if an oscillator at the receiver is used to replace the missing carrier signal. There is no need to replace the missing sideband, even if this were a feasable proposition, as both sidebands contain the same information, and only one of them is needed to react with the carrier to produce the proper audio output.

An ordinary diode detector plus an oscillator makes a far from ideal S.S.B. demodulator, and some reaction between the sideband components results with a consequent loss of audio quality. For proper S.S.B. demodulation a completely different type of detector is required. This form of detector is known as a product detector, and it uses the heterodyne principle.

A product detector is a form of mixer, and this has the S.S.B. signal injected at one of its two inputs, and an oscillator signal at the other input. Four signals will be generated at the output. These are the original two inputs, the sum of the two, and the difference between the two. In a practical situation the oscillator is adjusted to the frequency of the suppressed carrier wave, the difference signal is then the required audio signal.

A simple example would be if a 3.7MHZ suppressed carrier is modulated by a 1kHZ tone to produce a lower sideband signal at 3.699MHZ. If the oscillator is adjusted to 3.7MHZ, and these signals are fed into the product detector, outputs at 1kHZ (3.7 – 3.699 = 0.001MHZ, or 1kHZ), 7.399MHZ (3.7 + 3.699 = 7.399MHZ), 3.699MHZ, and 3.7MHZ are produced. The last three signals are at R.F. and are easily filtered out to leave the required audio signal.

As should be apparent by now, if the oscillator tuning is not correct, the correct audio frequencies are not produced. If the oscillator is not adjusted quite close enough to the sideband frequencies, all the audio output frequencies will be too high in pitch. Conversely, if it is taken too close to the sideband signal the audio output will be too low in pitch. Small errors in the oscillator frequency will not matter too much, and the audio output will still be quite intelligible. What is not satisfactory is if the oscillator frequency is put the wrong side of the sideband signal. This results in all the audio signals being inverted, with the high notes coming out as bass ones, and vice versa.

When tuning in a S.S.B. signal one should slowly tune towards it. If it is being approached from the correct side, the audio pitch will gradually fall to correct level. If it is being approached from the wrong side the audio signal will remain completely unintelligible, and it will be necessary to tune through the signal, and then tune towards it from the correct side.

C.W. Signals

A C.W. signal is merely a carrier wave which is turned on and off by way of a morse key. Morse is, of course, the form of modulation used on the carrier wave. To produce an audio output from this type of signal using a product detector is perfectly straight forward. If the oscillator is tuned 1kHZ away from the carrier frequency, an audio output at 1kHZ will be produced. If it is tuned closer than this the audio pitch will drop, if it is tuned further away the audio pitch will rise. It is simply a matter of adjusting the tuning to produce the desired audio note. It does not matter which side of the carrier wave the oscillator is adjusted.

An advantage of S.S.B. over A.M. is that it takes up less than half the bandwidth for identical audio signals. C.W. occupies even less space. S.S.B. and C.W. also make the most of the available transmitter power, as the whole of the signal that is transmitted is carrying information. In the case of A.M., the carrier wave itself does not contain any information, this is present in the sidebands.

Amateur transmitters are limited to relatively modest output powers, and the S.W. amateur bands are usually extremely crowded. It is therefore no surprising that A.M. has almost completely died out on the amateur bands.

Note that it is possible to tune S.S.B. and C.W. transmissions satisfactorily on the receivers described so far, except where it has been stated otherwise in the relevant receiver description. The regeneration control is advanced slightly beyond the threshold of oscillation, and then C.W. and S.S.B. signals can be tuned in the usual way. The oscillations of the detector replace the missing carrier wave and an acceptable audio

signal is obtained. However, for best results on A.M. and S.S.B. a receiver fitted with a product detector is needed. In its most simple form such a set needs few components, and consists basically of just a product detector, an oscillator, an R.F. filter, and an audio amplifier.

80 Metre Direct Conversion Receiver (Fig.29)

The direct conversion receiver described here is of a fairly basic type, the only refinement being an untuned R.F. amplifier. The complete circuit diagram of the set is shown in Fig.29. It is designed for use on only one band, and this is the 80 Metre band. This band has been chosen as it is suitable for both amateur and DX listening, and its relatively low frequency means that oscillator stability is not likely to be lacking. Oscillator stability is an important factor in a direct conversion receiver, as if the oscillator frequency should drift only very slightly, a change in the pitch of the audio output will result.

Tr1 is used as the R.F. amplifier, and VR1 is the gate bias resistor for Tr1. This also acts as a simple R.F. gain control. R2 is the source bias resistor for Tr1, and C2 is its bypass capacitor. R1 and C1 are a supply decoupling network.

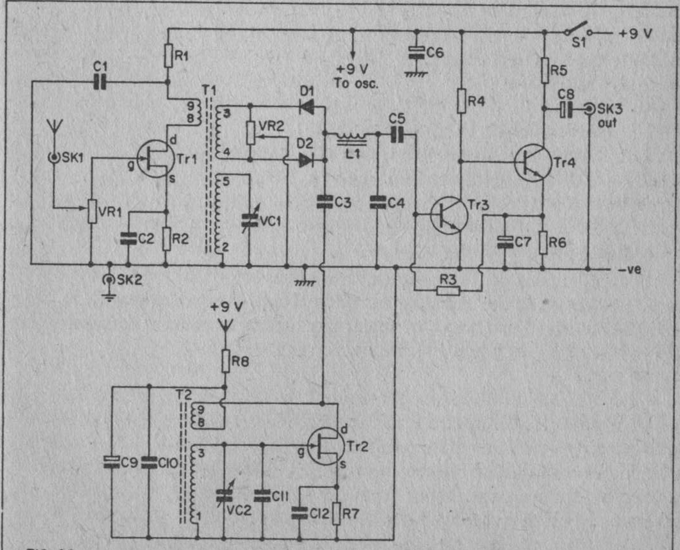


FIG. 29

Components List for Fig.29

Resistors (¼ watt 5%).	
R1	680 ohms
R2	680 ohms
R3	2.2 Meg.
R4	5.6k
R5	5.6k
R6	5.6k
R7	1k
R8	680 ohms
VR1	1k lin. carbon.
VR2	10k lin. carbon.
Capacitors.	
C1	47nf plastic foil.
C2	15nf plastic foil.
C3	4.7nf plastic foil.
C4	100nf plastic foil.
C5	220nf plastic foil.
C6	100mfd. 10vw.
C7	10mfd. 10v.w.
C8	4mfd. 10v.w.
C9	100mfd. 10v.w.
C10	10nf ceramic.
C11	56pf polystyrene or mica.
C12	5.6nf ceramic.
VC1	100pf air spaced (type C804).
VC2	50pf air spaced (type C804).
Semiconductors.	
Tr1	2N3819.
Tr2	2N3819.
Tr3	BC109C.
Tr4	BC109C.
D1	OA91
D2	OA91
Inductors.	
T1	Denco Green D.P. coil Range 3.
T2	Denco Red transistor useage coil Range 3T.
L1	10mH. (Repanco CH4).
Miscellaneous.	
S1	S.P.S.T. toggle switch.
Chassis, panel, battery, etc.	

The output of Tr1 couples to the Primary of T1. VC1 is the tuning control for the aerial tuned circuit, and this tuned circuit is included to minimise breakthrough from strong broadcast transmissions off the H.F. end of the 80 Metre band.

A double diode balanced product detector is fed from the secondary of T1. This uses D1, D2, and VR2, and although this is a very simple circuit, it works extremely well. It is virtually identical to the balanced modulators used in some S.S.B. transmitters to produce a double sideband suppressed carrier output (one sideband is then filtered out using a crystal or mechanical filter).

In a balanced product detector one of the two input signals is balanced out so that it does not appear at the output. In this case it is the aerial signal which is balanced out. This helps to improve performance as the R.F. bandwidth of the set is quite wide, and it is possible for strong signals lying close to the desired transmission to breakthrough. Balancing out the aerial signal using a simple method of phasing prevents this from happening. VR2 is adjusted to give the minimum possible aerial signal at the output of the product detector.

The oscillator signal is fed to the junction of D1 and D2 via D.C. blocking capacitor, C3. The oscillator is a simple feedback arrangement using Tr2 in the grounded source mode, and T1 to provide the required positive feedback. VC2 is the main tuning control, and R8 and C9 are a supply decoupling network. Although this oscillator circuit is very simple, it is very stable and has a low harmonic output. Harmonics on the oscillator are highly undesirable, as these would give the receiver spurious responses at multiples of the main reception frequency. This would result in breakthrough of unwanted signals.

L1 and C4 form a highly effective R.F. filter, and only the required audio signal remains at the output of this network. Tr3 and Tr4 are both high gain common emitter amplifiers, and these provide virtually all the receiver's gain. Unlike the previous designs, it is adviseable to use the very high gain 'C' version of the BC109 in these stages, as absolute optimum gain is needed for best results. Using the 'C' version of the BC109 will make a more significant increase in gain with this circuit than with most of those described so far, as it has two stages of A.F. amplification. Also, most of the other designs could not use the increased gain effectively anyway, as it is the noise level that limits performance. The initial stages of this receiver have a low noise level, and high audio gain can be used effectively.

Tr3 and Tr4 are used in a simple D.C. coupled arrangement, and the output is developed across R5. C8 provides D.C. blocking at the output and SK3 can be used to feed a pair of high impedance headphones. C6 is a supply decoupling capacitor and S1 is the on/off switch. Current consumption of the receiver is only about 3.5mA., and it can be economically powered from any small 9 volt battery, (PP3 etc.).

It is perhaps worth mentioning that it is not really a good idea to run the receivers described in this book from a mains power supply. This will work after a fashion if a high degree of smoothing and a mains isolating transformer is used. However, pick up of mains hum is likely to be a problem. Most of the receivers described here have a high level of audio gain which helps to encourage such pick up. Also, chokes and tuning coils are very effective at picking up mains hum from the magnetic field of a mains transformer.

If a mains power pack is used, construct it on a separate chassis and keep it well away from the receiver. Earth the negative supply at the mains earth (regardless of whether any other earth is used), and use a high level of smoothing. A circuit which incorporates an electronic smoothing circuit is to be preferred.

The 80 Metre D.C. Receiver with its high level of audio gain and a choke at the input of the audio stages is particularly prone to pick up of mains hum. It is best not to operate it right next to mains operated equipment or a mains cable.

Using the Set

With an aerial connected to the unit and a pair of headphones connected to SK3, turn the unit on and set VC1 for minimum capacitance (the two sets of metal plates fully unmeshed). There will probably be some sound in the headphones, and this should be from a number of broadcast stations. Adjust VC1 for maximum output from these stations. It is possible that sometimes during the daytime there will be no audio output from such stations, and it will be necessary to wait until after dark to make the necessary adjustments. When a suitable output has been obtained, adjust VR1 for minimum output in the headphones. Minimum output should occur with VR1 slider somewhere towards the centre of its track. Once this has been set, no further adjustment should be needed unless it is accidentally moved. It is quite a good idea to mount VR1 somewhere inside the set, rather than on the front panel, as it is then unlikely to be accidentally moved.

VC2, which operates as an ordinary tuning control, is then used to search for amateur transmissions. VC2 is the aerial trimmer control, and this is used to peak received signals. VR1 should normally be adjusted for maximum sensitivity, and is only turned back on very strong local signals which are otherwise distorted.

The core of T2 must be adjusted to give approximately the correct frequency coverage. The adjustment of this is not too critical as the tuning range of the set is considerably more than the 300kHZ which the 80 Metre band occupies. After dark and at weekends the 80 Metre band is usually crammed from end to end with transmissions, and the band limits are usually fairly obvious. Bear in mind though, that the amateur bands are divided into two sections. The lower frequency half is supposedly reserved for C.W. signals, and the higher frequency half can be for both morse and phone transmissions.

Most of the S.S.B. transmissions on the 80 Metre band are of the lower sideband variety. It is therefore easier to tune over the band from the H.F. end to the L.F. end when searching for signals. Using this method, as one approaches a signal the audio pitch gradually falls to the correct pitch. Tuning from the L.F. end to the H.F. one is far less convenient as it is then necessary to tune right through the signal before the audio pitch can be properly adjusted.

If used with a good aerial, and preferably also an earth, this receiver will provide excellent results. It is very sensitive and has good freedom from spurious responses. The use of a high quality product detector also provides quite good audio quality, for an S.S.B. receiver that is.

CHAPTER 6

Ancillary Equipment

R.F. Amplifiers

If one wishes to improve the performance of a simple S.W. receiver, it is no use, in most cases, simply adding an extra stage of audio gain at the output. In the majority of cases doing this will not improve performance at all, because not only does this increase the sensitivity of the set, it also greatly increases the noise content on the output. Thus, although a transmission may be brought up to an audible level, it will be unintelligible as it will be lost in a high level of background noise.

Any additional amplification should be added ahead of the receiver so that it boosts the aerial signal. In this way a useful increase in sensitivity can be obtained without greatly increasing the output noise level.

There is another reason for using an R.F. amplifier, and that is to prevent radiation from the detector when it is used beyond the threshold of oscillation (for the reception of C.W. and S.S.B.). The power of the R.F. signal generated by an oscillating detector is not very great, and it is not very effectively coupled to the aerial. There is therefore little chance of interfering with other users of the band, but it is possible that interference to nearby T.V. or F.M. radio sets could be caused by harmonics of the signal. Also, to be strictly within the law, no R.F. radiation from the aerial should be tolerated. This does not apply to the portable receivers, or any other set using a very short aerial which limits any R.F. radiation to an insignificant level.

Untuned R.F. amplifiers can be very simple, and can make a worthwhile improvement in a receivers performance. They do not have a very high gain, but unless a very inefficient aerial is used, a high gain untuned amplifier would probably just overload the receiver most of the time anyway.

Four untuned R.F. amplifier circuits are given in Figs. 30 to 33. The one shown in Fig.30 uses a Jugfet in the common source mode. This has R1 as its gate bias resistor and L1 as the drain load impedance. R2 is the normal source bias resistor and C1 is its bypass capacitor. C2 provides output D.C. blocking.

This circuit provides quite a reasonable level of gain, but this does drop off at high frequencies due to negative feedback through various circuit capacitances. The common gate circuit shown in Fig.31 has less gain than the circuit of Fig.30 at low frequencies, but it provides more consistant results over the entire S.W. frequency

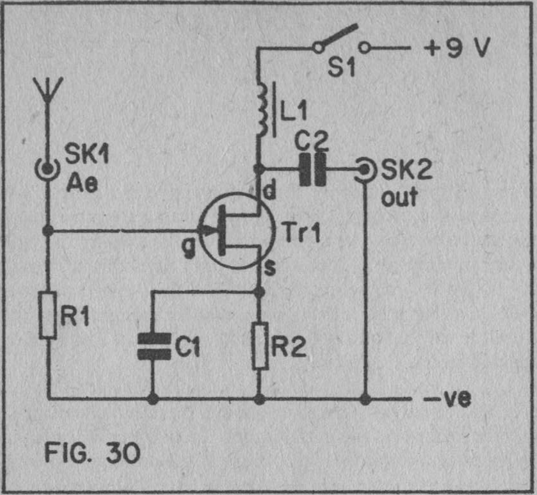


FIG. 30

Components List for Fig.30

R1	3.3k
R2	680 ohms
C1	47nf plastic foil.
C2	22pf plastic foil.
L1	10mH. (Repanco CH4).
Tr1	2N3819.
S1	S.P.S.T. toggle.

Hardware.

spectrum. This is because the input and output of a common gate stage are in phase, and any feedback due to stray circuit capacitances is positive, and tends to increase gain rather than diminish it.

The circuit of Fig.32 is basically the same as that of Fig.30, except that it has been modified to use the aerial input coupling coil of the receiver as its drain load. It will only work with receivers that use an aerial coupling coil (which most do).

This circuit is of the positive earth type, but as it uses its own power source, and is isolated from the receiver by its input transformer, it can be used with both positive and negative earth receivers. In fact any of the R.F. amplifiers described here are suitable for use with either type of receiver.

The circuit of Fig.33 is the grounded base version of Fig.32. Although one might think that the tighter coupling between the receiver that is achieved with the circuits of Figs.32 and 33 would give these a higher gain than the previous two circuits, in practice this would not appear to be the case. Their gain would seem to be fractionally lower.

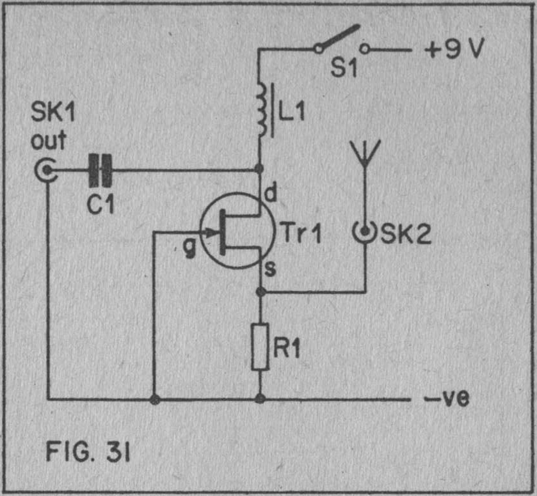


FIG. 31

Components List for Fig.31

R1	680 ohms
C1	22pf plastic foil.
Tr1	2N3819.
L1	10mH. (Repanco CH4).
S1	S.P.S.T. toggle.

Hardware.

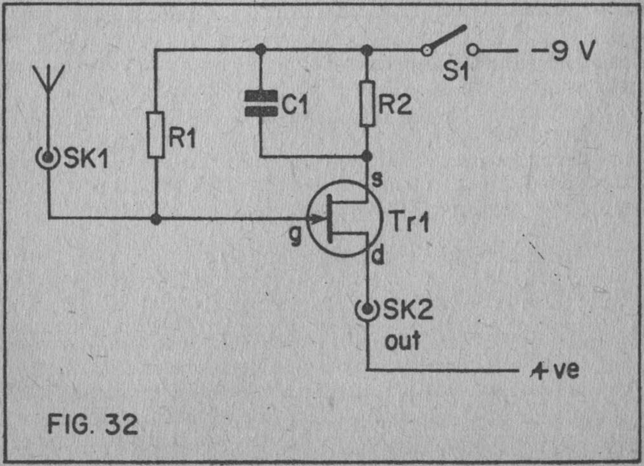


FIG. 32

Components List for Fig.32

R1	3.3k
R2	680 ohms
C1	22nf plastic foil.
Tr1	2N3819
S1	S.P.S.T. toggle.
Hardware.	

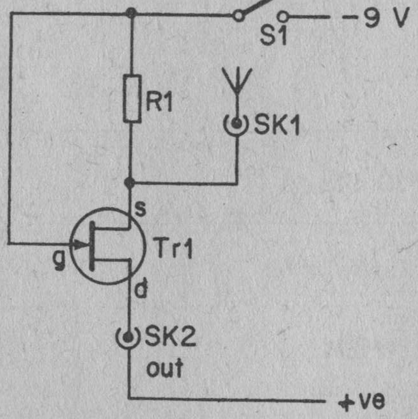


FIG. 33

Components List for Fig.33

R1	680 ohms
Tr1	2N3819.
S1	S.P.S.T. toggle.
Hardware.	

Tuned R.F. Amplifier

A tuned R.F. amplifier will provide more gain than its untuned counterpart. When used as an external adjunct to a receiver this type of unit is usually called a 'preselector'. Unlike an untuned circuit which amplifies all the S.W. aerial signals, a preselector only amplifies over a relatively narrow bandwidth. Thus, despite its higher gain, it is less prone to overload the receiver.

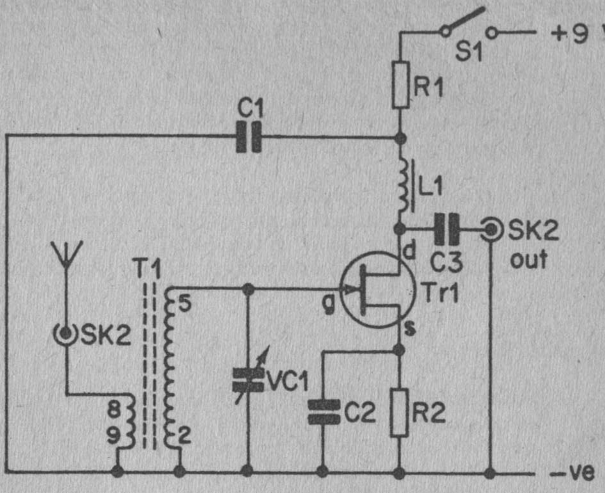


FIG. 34

Components List for Fig.34

R1	680 ohms
R2	680 ohms
C1	5.6nf ceramic.
C2	22nf plastic foil.
C3	22pf plastic foil.
Tr1	2N3819.
VC1	365pf air spaced (type 0).
L1	10mH. (Repanco CH4).
T1	Denco Green D.P. coils Ranges 3, 4, and 5.
S1	S.P.S.T. toggle switch.
Hardware.	

Fig.34 shows the circuit diagram of a simple preselector which uses a Jugfet common source amplifier. This is very much the same as the circuit of Fig.30, the main difference being that a tuned circuit is used at the input instead of a simple resistor. VC1 is the tuning control and this is adjusted to peak received signals. It will need some readjustment each time the receiver's tuning is altered significantly. It was found to be necessary to include the supply decoupling network consisting of R1 and C1, as without this there was a tendency for the circuit to become unstable.

Apart from increasing the sensitivity of a receiving set up, adding a preselector also increases the selectivity when it is used with simple designs such as those presented in this book. This is due to the addition of an extra tuned circuit, and this factor is just as useful as the increased gain. To obtain the best possible increase in selectivity a screened (coax) lead should be used between the preselector and the receiver. Otherwise pick up in the connecting cable will reduce the selectivity.

It is adviseable to use a fairly short cable to connect the preselector to the receiver, and this should preferably be no more than about 300m.m. long. This also applies to the untuned R.F. amplifiers. Using a longer lead will result in some loss of performance due to losses in the connecting cable.

Morse Practice Oscillator

The circuit diagram of a simple morse practice oscillator is shown in Fig.35. This uses an Ne555 timer I.C. in the astable mode. VR1 varies the frequency of oscillation and this is adjusted to give the required audio pitch. A frequency range of a few hundred HZ to a few kHZ is available. VR2 is the volume control, and the output can be used to feed either a high impedance speaker (about 50 to 80 ohms) or any type of headphones or earpiece. The morse key is simply connected in the positive supply lead, and turns the unit on when it is depressed. No other on/off switch is required, as no current is drawn with the key in the up position.

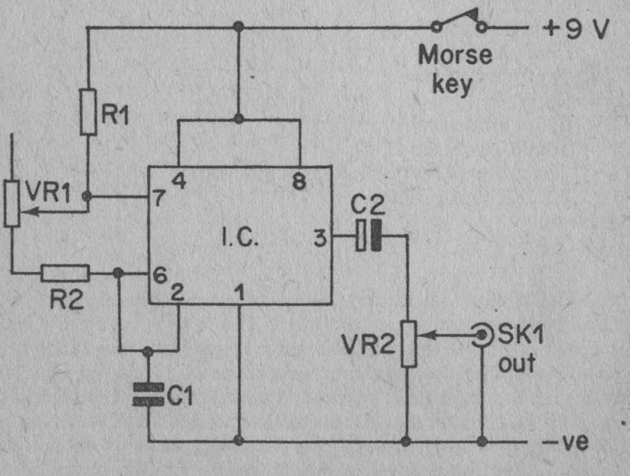


FIG. 35

Components List for Fig.35

R1	1.5k
R2	3.3k
VR1	50k 1in. carbon.
VR2	1k 1in. carbon.
I.C.	NE555V.
C1	47nf plastic foil.
C2	100mfd. 10v.w.
Speaker (or headphones).	
Morse key.	
Hardware.	

It is extremely useful for anyone interested in amateur band communications to be able to read morse code as this mode of transmission is quite widely used, and is very effective. Also, if one wishes to obtain a transmitting licence for the S.W. amateur bands, it is necessary to first pass a morse test (and the Radio Amateurs Examination). The morse code is given below.

A .– B –... C –.–. D –.. E . F ..–. G ––.
H .... I .. J .––– K –.– L .–.. M –– N –.
O ––– P .––. Q ––.– R .–. S ... T – U ..–
V ...– W .–– X –..– Y –.–– Z ––..
1 .–––– 2 ..––– 3 ...–– 4 ....– 5 .....
6 –.... 7 ––... 8 –––.. 9 ––––. 0 –––––
Fullstop .–.–.– Comma ––..––

If a dot is taken to equal one unit, a dash is three, the space between individual characters of a letter is one, the spacing between letters is three, and the spacing between words is seven. It is best not to think of the code in terms of dots and dashes, but think of it in terms of sounds. For instance, many people find it helpful to think of dots as being the sound dit and dashes as the sound dah. Thus one would not think of the letter C as being dash dot dash dot, but as dah dit dah dit. The latter flows much better than the former, and its rhythmic character tends to be much more easily remembered.

Calibration Oscillator

In order to provide a calibrated tuning dial for a completed receiver, some form of calibration oscillator is required. Crystal calibration oscillators are frequently used, but these are expensive and provide a degree of accuracy that is not required even when calibrating a quite sophisticated receiver, let alone a simple one. The calibration oscillator described here is therefore of the L – C type. Its circuit diagram is shown in Fig.36.

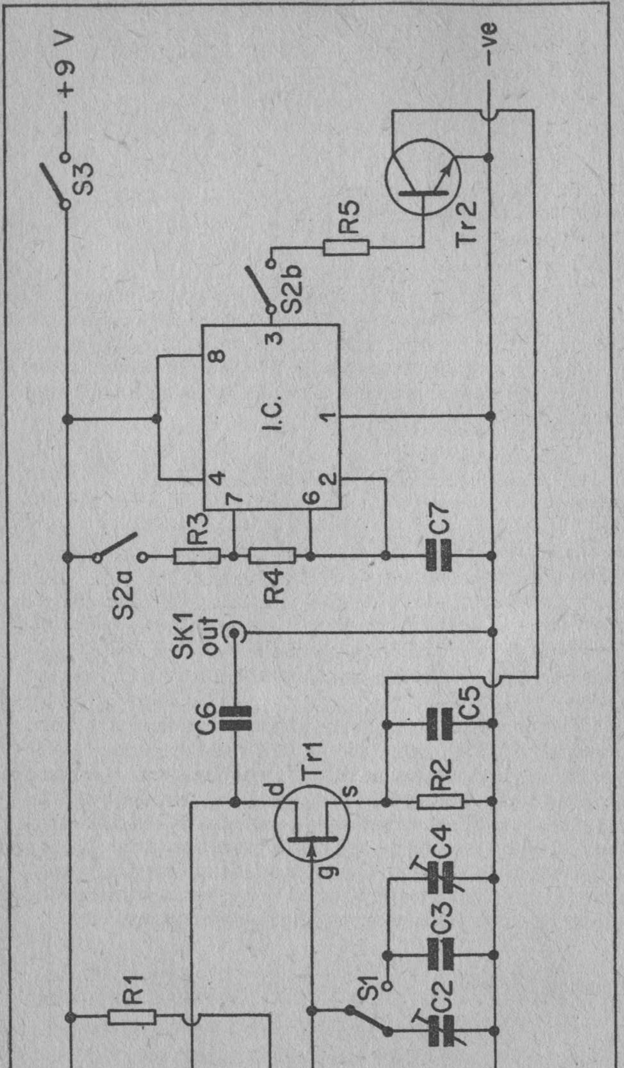


FIG. 36

Components List for Fig.36

R1	390 ohms
R2	390 ohms
R3	5.6k.
R4	39k.
R5	150k.
C1	100mfd. 10v.w.
C2	500pf compression trimmer.
C3	1.2nf polystyrene (5%) or mica.
C4	500pf compression trimmer.
C5	100nf plastic foil.
C6	8.2pf ceramic.
C7	15nf plastic foil.
Tr1	2N3819.
Tr2	BC109.
I.C.	NE555V.
S1	S.P.D.T. toggle.
S2	D.P.S.T. toggle.
S3	S.P.S.T. toggle.
T1	Denco transistor useage Yellow Range 2T coil.

Hardware.

The R.F. oscillator uses Tr1, and this is basically the same oscillator circuit that was used in the 80 Metre D.C. receiver. It uses a different coil though, and is adjusted to operate at a frequency of 1MHZ using C2. When S1 is in the opposite position to that shown in Fig.36, C3 and C4 are shunted across the tuned winding of T1. These have a much higher combined value than that of C2, and they produce a much lower frequency of oscillation. In fact, C4 is adjusted to produce an output at 200kHZ.

It is helpful to be able to modulate the output of the oscillator with an audio tone so that the calibration signals can be easily identified, and are not confused with other signals that may be received during the calibration process. In this circuit an NE555 timer I.C. used in the astable mode provides the audio modulation tone. Tr2 is connected in the source circuit of Tr1, but it will not normally have any effect on the circuit as it will pass only minute leakage currents.

When S2 is closed, the astable circuit comes into operation, and its output is connected to Tr2 base via R5. R5 is a current limiting resistor which is included for the protection of Tr2.

When the output of the I.C. is in the high state, Tr2 is turned hard on and it increases the current through Tr1, and hence also the amplitude of its oscillation. When the output of the I.C. is in the low state, Tr2 is turned off and has no effect on Tr1. Thus the R.F. oscillator is amplitude modulated with an audio tone when S1 is closed.

Using the Unit

Anyone familiar with calibration oscillators will probably be wondering what use a 200kHZ/1MHZ oscillator is when the S.W. bands extend from about 1.6 to 30MHZ. Although it may appear that this unit is of little use, this is not the case, as although the fundamental frequencies of oscillation are 200kHZ and 1MHZ, it also provides outputs at harmonics of these frequencies. Harmonics are simply the multiples of the fundamental frequency. Thus the 200kHZ oscillator also produces signals at 400kHZ, 600kHZ, 800kHZ, and so on. The 1MHZ oscillator produces signals at 2MHZ, 3MHZ, 4MHZ, etc.

The 1MHZ oscillator will produce fairly strong calibration signals to beyond 30MHZ, but the 200kHZ one will only provide signals up to a few MHZ. This does not matter if one looks at it from the practical viewpoint, as it is not really possible to calibrate the tuning dial of a simple general coverage receiver at 200kHZ intervals at high frequencies anyway. The calibration points would simply be too close to one another. The upper limit of the useable 200kHZ harmonics will depend upon the sensitivity of the receiver being calibrated, and upon the individual components used in the oscillator. An upper limit of something in the region of 10MHZ should be obtained.

Before the unit can be used, it is necessary to adjust the outputs to the correct frequencies. The easiest way of achieving this is to set the unit up against B.B.C. Radio 2 on the long waveband, which transmits on precisely 200kHZ. The unit should be set up in this way prior to being used, each time it is used.

Initially the audio modulation should be off, and S1 should be in the '200kHZ' position. Connect a lead to the output socket, and place this near an operating receiver tuned to L.W. Radio 2. By adjusting C4 it should be possible to produce the characteristic whistle of a heterodyne between the fundamental signal of the calibration oscillator and the carrier wave of Radio 2. Carefully adjust C4 to zero beat the heterodyne. The calibration oscillator will then be working accurately at 200kHz.

It is a good idea to try adjusting the receiver's tuning control slightly. This should not affect the pitch of the heterodyne. If it should be found to do so, it means that the output from the calibration oscillator is being received on a spurious response of the receiver. It is then necessary to readjust C4 in an attempt to locate the calibration signal on the receivers main response.

Next try to pick up the output of the oscillator on a S.W. receiver. It should not be necessary to connect the output of the calibrator directly to the receivers aerial terminal, and this could prevent the oscillator from operating. It is normally satisfactory to connect an insulated lead to the output of the calibrator, and another to the receiver's aerial socket. The two leads are then twisted together.

It may not be easy to find out which harmonic is which at first. An easy method of identification is to first tune to a station of known, or approximately known frequency. For instance, if a 160 Metre band phone station is first tuned in, it is known that this station is operating in the range 1.8 to 2.0MHZ. Therefore the harmonics immediately above and below this station must be at 2.0 and 1.8MHZ respectively.

The 200kHZ calibrator can now be used to help with the correct adjustment of the 1MHZ signal. Start by locating a 200kHZ calibration signal that lies at a whole number of MHZ (i.e. 2MHZ, 3MHZ, etc.), and then adjust the reaction control to just beyond the threshold of oscillation. This should produce a beat note due to the heterodyne between the calibration signal and the oscillations of the detector. Adjust the tuning control of the receiver to zero beat the heterodyne.

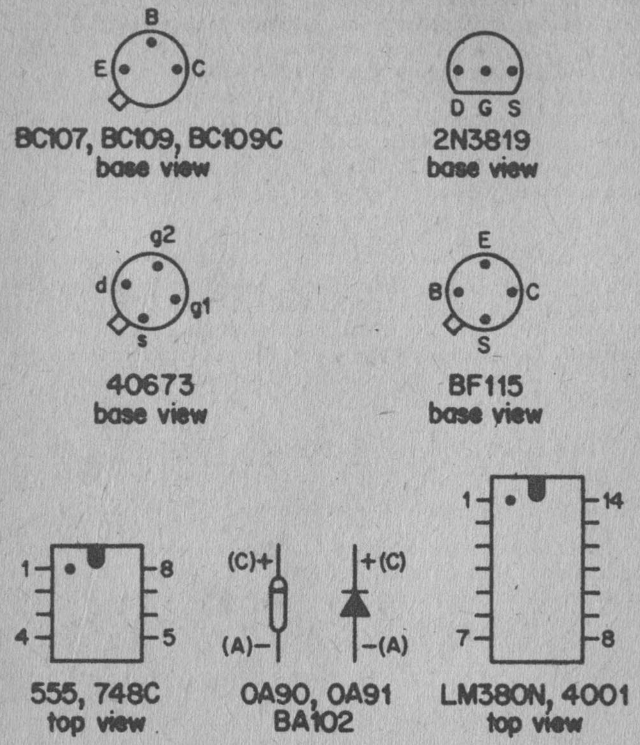
Now switch S1 to the '1MHZ' position and adjust C2 to produce a beat note. Zero beat this heterodyne and the unit is then ready for use.

It is advisable to construct the unit in such a way that C2 and C4 can be adjusted without removing the unit from its case. This is not usually too difficult to arrange, and one way of achieving it is to mount these trimmers on a component panel which is then mounted on the inside of the rear panel of the case (component side facing the front panel).

If a couple of holes are then drilled at strategic points on the front panel, it will be possible to adjust the trimmers through these holes using the appropriate trimming tool.

Alternatively variable capacitors mounted on the front panel could be used for C2 and C4. This is however, likely to be rather expensive unless surplus capacitors of some kind can be obtained (or are already to hand). It could even make the unit more expensive than a crystal controlled type, and therefore the first method is really the better of the two.

One final point is that if the receiver is fitted with a bandspread control, calibrate the receiver with this in the same position for all calibration points. Also, choose a sensible setting, such as with the control at half capacitance, maximum capacitance, or minimum capacitance. Otherwise the calibrations on the tuning dial of the receiver will be meaningless.



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BC109B	BC149B-169B-173B-184B-209C-239B, G13711, MPS6521-6571, SK3020, 40397, 2SC458, 2N5126, RS276-2009.
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OA91	AA117-118-132-144, OA81-95-161, SD38, SFD108, 1N38-55-63-617, IS33, RS276-1136.
2N3819	E304, SK3118, CV10684.
3N140	40673.

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