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MODERN CRYSTAL AND TRANSISTOR SET CIRCUITS FOR BEGINNERS

BY

B.B.BABANI

35p

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B. B. BABANI
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CONTENTS

SIMPLE CRYSTAL AND TRANSISTOR SETS

"Please send me a circuit for a crystal set" is one of the most regular pleas through our query service. This, despite the fact that we have described many crystal sets through the years and that, more recently, we have tried to encourage beginners to start with something only slightly more expensive but certainly much more satisfying.

What follows is an attempt to satisfy the honour of all parties—information which will allow you to build a crystal set if you really want to, or to take the further and recommended step into transistor circuitry.

Therefore in easy-to-follow steps, beginning with the crystal set, we progress to an amplified crystal set, then to a regenerative receiver.

It will be found by comparison with the crystal set that the performance of our final receiver certainly justifies the very small additional expense involved.

With these thoughts in mind and the fact that many will be on limited budgets, we have confined our thinking mainly to the use of "junk box" parts and to simple "breadboard" construction.

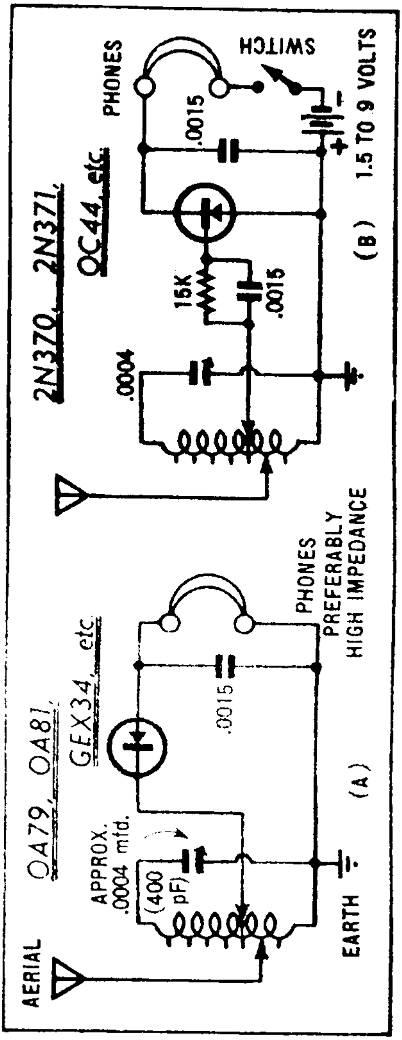
Considering firstly the theoretical side of things, the function of a crystal set is to select the desired signal by a selective tuning circuit and convert the radio frequency signals into audio frequency signals by the process of demodulation or detection.

To understand how this latter process works, it is desirable to understand first of all, something of the action which takes place at the broadcast station.

Firstly, the transmitter generates a radio frequency signal or "carrier" which is of constant average amplitude and this is used, as a medium for transporting the required intelligence from the transmitter to the receiver. Music or speech is caused to "modulate" or vary the carrier amplitude at a rate which is governed by the frequency of the modulating signal. In fact, the term amplitude modulation (AM) is given to the type of transmission normally used.

If the incoming signal were applied to the phones directly, nothing would be heard because the phones are unable to respond to the rapid alternations of the carrier. But if we remove alternative half-cycles of the carrier wave by passing it through a rectifier, each successive half-wave pulse will be in the same direction and the movement of the diaphragm of the phones will be according to the average carrier strength.

Early crystal sets generally depended upon the rectifying properties of "galena" crystal (lead sulphide, PbS) to carry out the detection process. This substance exhibited to some extent the properties of the valve diode in its ability to pass current in one direction and impede it in the opposite direction. The crystal was held in a clamp while a thin wire "catswhisker" was adjusted to make contact with it at a point which gave the best signal.



Circuit A is that of a crystal set in which either a germanium diode or the base-to-emitter junction of a transistor can be used. The polarity of the detecting device is not important. Circuit B shows how few parts need be added to obtain an amplified signal.

This, as dad will probably remember, was quite a fiddly adjustment and the family had to tread warily in order that the "whisker" would not be bumped from the sensitive spot.

Point Contact Diode

Today a whole series of germanium and silicon diodes are available which are widely used as detectors. Most of these are inside tiny glass envelopes and are able to withstand quite heavy vibration without ill effect.

The first circuit described here, the crystal set, uses a "point contact" germanium diode which consists of a small wafer of germanium containing a small amount of arsenic or antimony to produce N type semiconductor material, in contact with a phospher bronze wire. This has the peculiar property of allowing electrons to flow only in the direction of semiconductor to contact.

Diodes of this type, subject to a voltage in the forward conducting direction, can have a resistance of a few hundred ohms. When subjected to a voltage in the reverse or non-conducting direction, their effective resistance may be several hundred thousand ohms.

The detection process is accomplished by applying the incoming signal across the diode in series with a detector load which, in the case of a crystal set, is a pair of high impedance headphones.

It is usual, though not essential, to connect a capacitor across the phones which assists in smoothing out the half-wave pulses of carrier signal delivered by the detector. The capacitor charges during each pulse of carrier and maintains this charge during the intervals between pulses, resulting in a smooth audio signal closely resembling the original modulating signal at the transmitter.

So much for detection, but what of the unit's ability to detect a particular signal and reject all others?

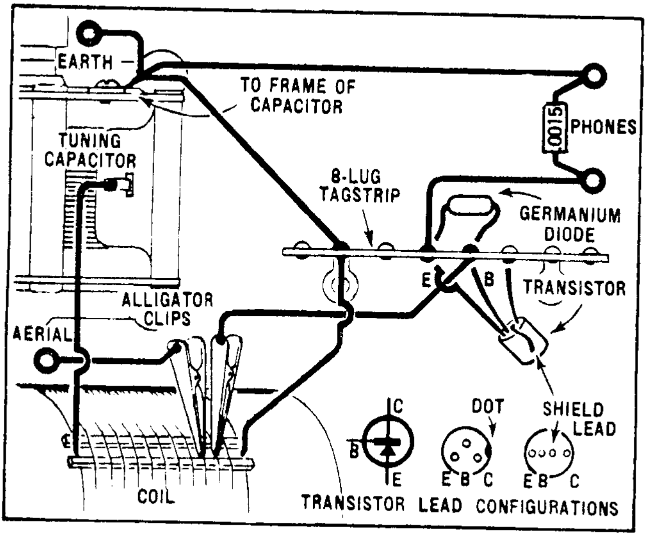
This calls for a parallel tuned circuit consisting of a tapped coil and a variable tuning capacitor capable of resonating at any desired frequency within the band used by the broadcast stations.

Resonates with Coil

Signals reaching the set via the aerial are fed to a tapping on the coil, while the capacitor is adjusted to resonate with the coil at the frequency of the desired signal. Stations on other frequencies are rejected, while the wanted signal is retained by the tuned circuit. This selected signal is then fed to the detector via an appropriate coil tapping.

These tappings on the coil are to enable the aerial and detector to be suitably matched into the coil in order to obtain the best compromise between signal level (sensitivity) and ability to select wanted stations (selectivity).

Thus, tapping the aerial across a larger proportion of the winding may result in louder signals, but the selectivity will be poorer, resulting in stations overlapping. Bringing the tapping closer to the earth end, on



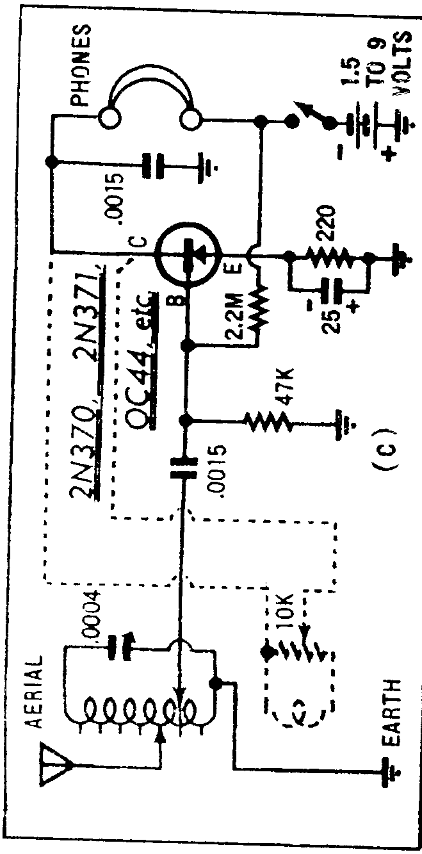
The wiring diagram shows clearly the layout of components and the small amount of wiring necessary to construct the crystal set according to circuit A. Either the diode or transistor can be used.

the other hand, will improve the selectivity at the expense of signal strength. The tapping which gives the best balance, in any particular situation, between selectivity and sensitivity is the one which should be used.

The results just discussed will vary with the length of the aerial. Generally speaking, a long aerial will have to be connected to a tapping close to the earthed end while a short aerial will connect toward the "hot" end. Location may also influence the final result.

The optimum tapping for the diode is also a compromise between maximum signal with reduced selectivity and maximum selectivity with reduced signal. Tapping the diode across a major portion of the winding is like placing a resistor across the coil, damping it, and reducing the selectivity.

The results obtained from the crystal set are good providing that you are in a reasonably strong signal area and have a good earth and aerial. The fundamental limitation is that the only power available to drive the headphones is that which is collected by the aerial. It cannot amplify the incoming signals, it can only make them audible.



Our final circuit is shown in two forms. Firstly, functioning as a simple detector-amplifier, the collector connects directly to the headphones while, in the second form (dotted) the regeneration winding is connected in series with the headphones.

If you desire to build just the crystal set, then you can purchase one of the diodes suggested in circuit (A). Turn to the latter part of article, go right ahead and construct it from the details given.

But, if you take our advice, you will invest in a transistor of the type called for in circuit (C). By using only two leads of the device, it will be possible to make the crystal set, but you will also be able to use it for larger sets.

But firstly, what is this transistor?

Similar to Diodes

The very first transistors were similar to the point contact diode referred to earlier, except that there were two wires contacting the wafer of N-type germanium instead of one. Nowadays, "point contact" transistors have given place to more sophisticated types such as the "junction" transistor.

This is basically a thin wafer of N-type germanium sandwiched between two regions of P-type material, together forming the PNP transistor. Suitable leads are connected to the three regions and the unit is sealed into a metal or glass envelope.

When wired into circuit, one junction is normally "biased" in the forward direction which results in a low resistance to current flow, while the other junction is biased in the reverse direction, resulting in a high resistance to current flow.

Because the N region is thin, charges or "current carriers" so-called, flowing into the N region, due to the forward bias, continue through to the region of the reverse biased junction. A high proportion of this current passes through to the high resistance P region, while the small remaining current flows out of the N region via its external connection.

Because the input current is fed into a low resistance circuit and appears in a high resistance output circuit, the device effectively exhibits power amplification.

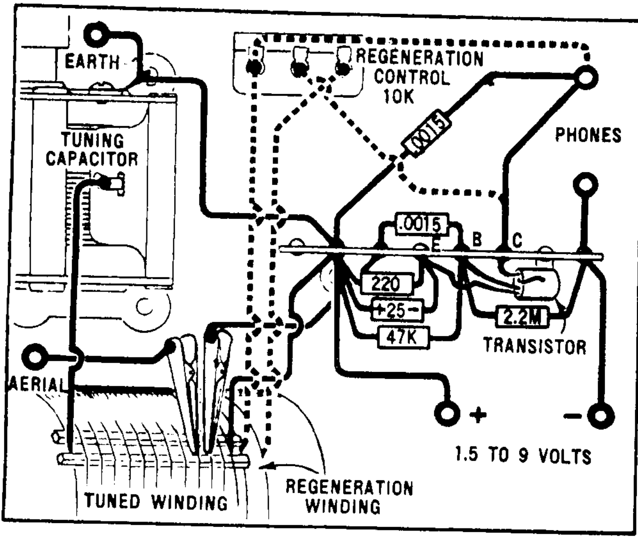
In all transistors, the outer electrode of the forward biased junction is called the "Emitter", the centre electrode the "Base" and the reverse biased electrode the "Collector".

In general, a transistor can be compared to a thermionic valve in that the base is similar to the grid of the valve which serves to control the flow of electrons through the unit. The emitter and the cathode of the valve both provide the source of current carriers; the collector and the plate of the valve are similar, in that they are both normally part of the output circuit.

The transistor's input and output impedance, along with other characteristics, is governed by the method or configuration in which it is used, somewhat similar to that of the valve. In each case, one electrode is common to both input and output circuits and is referred to as being either grounded or common.

The "common base" configuration is analogous of a valve when used as a grounded grid amplifier and has the characteristics of low input impedance and high output impedance. So used, a transistor has considerable voltage amplification and approximately unity current amplification, resulting in moderate power amplification.

The recotnised symbol for the current amplification in the common base configuration is "Alpha" and the frequency at which the current amplification falls to 0.707 times, or by 3dB, its value at 1Kc, is known as the "Alpha Cut-Off Frequency". This is governed by the transistor design.



This slightly more complex diagram shows the wiring connections required to construct circuit C. No battery on/-off switch has been shown. We used an alligator clip for connection to one terminal but any type of switch could be used.

The common collector configuration is analogous of a valve used as a cathode follower and possessing similar impedance characteristics, in that the input impedance is high and the output impedance is low. This arrangement is only used in special applications, mainly serving as an impedance matching device. Although the voltage amplification is near unity, there is a considerable current amplification which accounts for a moderate power amplification.

The final method of operation is that of "common emitter" and is similar to a common cathode circuit. In this configuration both input and output impedances could be considered as being medium. A high amplification in both voltage and current are obtained, resulting in a power amplification higher than the two previous configurations.

The symbol used for the current amplification in common emitter is "Beta" and the upper frequency limit is the "Beta Cut-Off Frequency". This is approximately one-tenth that of the common base or alpha cut-off frequency.

The common emitter configuration is generally employed in conventional circuit applications but, whichever is used, the maximum ratings of collector voltage, current and operating temperature must not be exceeded.

At high temperature the collector leakage current can increase to the extent where "thermal runaway" will occur. This comes about when an increase in temperature leads to sufficient rise in leakage current to cause still further rise in temperature, and to a degree where the process keeps on going.

Thermal runaway is thus the transistor's cumulative process of self destruction.

In order to minimise the chances of this occuring it is always desirable to provide some means whereby a change in base to emitter voltage will maintain the collector current within acceptable limits for a reasonable range in operating temperature. This is referred to as bias stabilisation and should receive due attention.

Our transistor can be used in the first circuit (A) by ignoring the collector lead and using just the base and emitter leads.

But we need not stop here. From circuit B it will be seen that an attempt has been made to use the collector in conjunction with a small battery to obtain an amplified version of the detected signal.

The signals obtained in our first attempt were strong but distorted. The addition of a resistor/capacitor network in series with the base lead across which the audio could develop improved things somewhat. But even so, with this circuit it was apparent that the transistor, although functioning effectively as a detector was not operating under optimum conditions for audio amplification.

We therefore set about to devise a circuit in which the base and emitter electrodes could function as a detector and also, along with the collector, provide efficient audio amplification.

Forward Bias

This involved the provision of a forward bias network and bias stabilisation as can be seen in circuit C. A voltage divider across the battery consisting of a 47K ohm and 2.2 meg. resistor enable the base-emitter junction to be slightly forward biased, while the base-collector junction is reversed biased.

A form of bias stabilisation is provided by the use of an emitter resistor across which portion of the supply voltage is developed. If the collector current increases above the quiescent point, the voltage drop across the resistor will increase, reducing the effective base-emitter potential.

This circuit constitutes an extremely good "amplified crystal set" and is well worth those extra few shillings. The high sensitivity achieved with this set enables a coil tapping nearer to the earthed end to be used for both aerial and base connection, resulting in improved selectivity.

However, in order to obtain a still further improvement in selectivity, we recommend that the final step be taken in the addition of a regeneration winding and control.
As before, the signal is tuned, detected and amplified. But the added requirement of the transistor is to amplify the incoming radio frequency signals sufficiently to enable a controlled portion of this signal to be coupled in such a manner as to produce positive feedback.

This will be seen, in the dotted portion of circuit C, in that the collector load now consists of a pair of headphones in series with an untuned winding, which is positioned at the earthed end of the tuned winding. The headphones provide the load for the audio frequency signal as before and are bypassed to radio frequencies while the regeneration winding is the load for the radio frequency signals.

It will be appreciated that the polarity of this winding is of major importance, in that the feedback signal must assist the received signal to the extent of being able to produce an audible oscillation in the headphones as the control is advanced.

However, the amount of regeneration is vital when actually listening. Too little, and the signals may not be separated sufficiently or loud enough; too much and the detector will commence to oscillate.

We then have two frequencies, the incoming signal and that of the oscillating detector. These produce a hotorodyne note which appears as a continuous whistle along with the required signal.

Optimum performance is normally obtained with the detector adjusted just short of active oscillation.

The transistor used in all the circuits, including the elementary crystal set arrangement, was a 2N370, which has a fourth lead interposed between the base and collector leads. It serves as a shield in special applications but you can please yourself whether you connect it to the emitter or leave it disconnected as we have done. A locally made equivalent of the above is type 2N1636, which has the more conventional three leads.

Other Types

Similar types are 2N371, 2N372, 2N373, OC170, OC171. These have an alpha cut off frequency of 30 megacycles and higher. When used in the common emitter configuration the cut off will be much lower than this, but still adequate for present requirements.

By the way, the above types of transistor were recommended for the Simple All-wave Two Transistor Set described in the June 1960 issue, along with data on coils operating up to 20 megacycles. This could open the way to further development of the circuit after the regenerative set, if you want to continue your experiments.

Other transistor types having a lower cut off frequency and recommended in previous broadcast band regenerative receivers could also be used in the accompanied circuits. These include types OC44 and OC45.

The tuning capacitor can be of almost any type, providing that it has a maximum capacitance of about .0004 mfd (micro-farad).

Almost any junk box will contain at least one of these, be it either a single or a double section ganged type either of which will suit. If the latter is used, only one tuned circuit is involved.

Our capacitor consists of about 12 plates held rigidly in a metal frame by insulating supports and a second set of about 13 plates which can be rotated so that the two sets may be interleaved to obtain the desired capacitance. Make sure, by the way, that the plates do not touch as the spindle is rotated.

Many of the large capacitors of the type used in our set have a 3/8in diameter shaft intended to fit the many standard dials used with larger sets. As most instrument knobs available are designed for ¼in diameter shafts, it will be necessary to use a reduction shaft which itself has a ¼in spindle, but fits over the 3/8in shaft of the capacitor. Both the very early types and the latest miniature type have ¼in diameter shafts and will not require an extension shaft.

All later-type capacitors have provided with them a set of mounting feet which allow them to be attached to the baseboard. Older types may lack this feature and a special bracket will need to be made from a scrap of aluminium.

Coil Details

To make the coil, you will need a coil former and a length of enamelled copper wire. The former can have a diameter between 1½in to 2¼in and this can be purchased in the form of a bakelite or cardboard tube or made from stiff cardboard.

Our coil was wound on a 2¼in former, using 24 B and S enamelled copper wire, but a few gauges either way will not alter things greatly.

What will alter things is the coil diameter in that the number of turns will have to be adjusted to give the same inductance for different diameters. A small diameter coil will require proportionately more turns than a large diameter one in order to have the same inductance.

Therefore we have included a table giving details for three likely coil diameters.

The regeneration winding included in this table will be used for the regenerative detector and can be either wound at this stage or left until you require it.

The following remarks on coil winding should assist those readers who have not as yet constructed a coil.

Firstly, to anchor the wire to the former at the start, drill two small holes toward one end about ¼in apart. Then wind one end of the wire through the holes a couple of times, allowing about 6in of free lead for connecting into circuit. Proceed to wind until it is required to provide a tapping as given in the table.

Before laying this turn, place a wooden matchstick along the former and pass this turn over it. Wind on more turns, passing the wire under the matchstick until the next tapping point at which the wire again passes over the matchstick. Continue in this manner until the total number of turns have been wound in accordance with the table. Drill two more holes in the former to anchor this end and again allow 6in of wire for connection into circuit.

Next, push a second matchstick alongside the first under the raised turns, then push the two matches apart by about ¼in. These wires will now be clear of the remaining turns, enabling the enamel to be scraped away without damaging the adjacent wire.

The regeneration winding is wound in the same direction and the ends anchored similar to those above.

With regard to headphones, the high resistance types of between say 2,000 and 4,000 ohms are most suited for our sets, particularly the crystal set. Next best in terms of performance are the relatively low impedance ex-disposals type, having a resistance of several hundred ohms.

The ex-disposal dynamic type headphones, the type fitted with ear-muffs and of about 45 ohms resistance, are quite unsuitable for these circuits.

As an alternative to purchasing a set of headphones, one of the hearing aid type earpieces could be used. There are two types available, the low impedance magnetic, which is unsuitable for our circuits, and the crystal type, which can be used, though with some loss in performance.

As with all crystal devices, there is no path through which a direct current can flow in order to fulfil the requirements of the associated circuitry.

We therefore suggest that a resistor of say 15,000 ohms be connected across the phone terminals. The earpiece connects across this resistor, in series with a .01 capacitor.

The supply used in the latter circuits could be either a single 1.5-volt cell or a battery of any voltage up to 9 volts. There is surprisingly little difference in performance with large variations in supply voltage, so you need not spend extra money if a couple of torch cells are available.

Remember that the positive battery terminal is the one to be earthed when using PNP transistors. A reversal of the supply terminals could result in permanent damage to your transistor.

Care should be taken that excessive heat is not applied to the transistor by the soldering iron. The suggested idea is to hold the lead with a pair of long-nose pliers until the joint has cooled.

With the aid of the wiring diagrams there should be no difficulty in constructing these sets. There are no problems with layout except possibly the need to allow some space between the coil and the tuning capacitor.

With the regenerative receiver, optimum performance is normally obtained with the regeneration control adjusted just short of active oscillation and the actual position of the control will vary from station to station. Some adjustment to the placement and number of turns of the feedback winding is permissible if you desire to experiment.

It is hoped that these circuits provide interesting hours during construction, followed by more hours of enjoyable listening.

COIL WINDING DATA

Tuned Winding				Regeneration Winding
Diameter	Length*	Turns	Turns per tap	Turns
1½in	2.75in	130	10	21
2in	1.9in	90	7	15
2¼in	1.6in	75	6	12

***Based on 24SWG wire.**

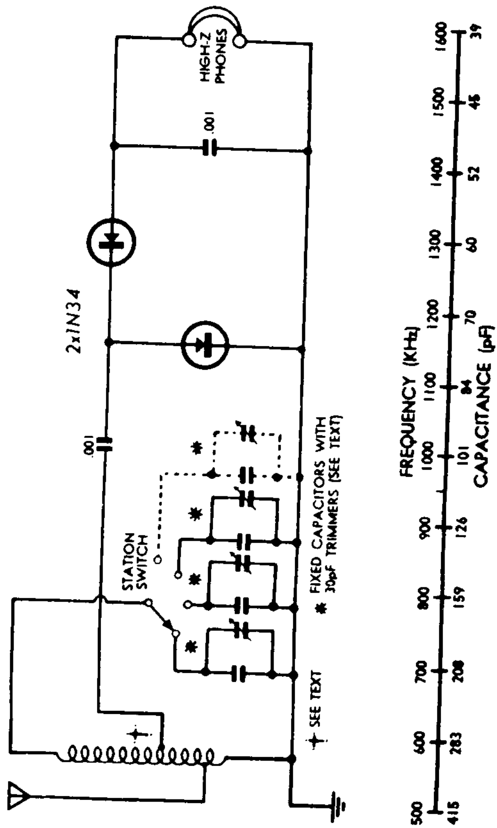
CRYSTAL SET USES SELECTOR SWITCH

This novel crystal set uses a switch to tune various stations in place of the usual variable capacitor. Instead of fiddling with a knob to select the station, the flick of a switch tunes the station in "spot on" every time.

This crystal set is capable of driving a pair of headphones in the normal way. If the reader wishes to incorporate an amplifier, a resistor of 10K or more would be substituted for the phones. The earthed side of the resistor would connect to the "earthy" input of the amplifier, while the other end of the resistor would go to the amplifier's "live" input connection.

Apart from the "switch-tuned" aspect of this set, another novel feature is incorporated. This is the "voltage doubler" detector, which is claimed to have twice the output of a normal detector using only one diode in series with the headphones.

Although the two diodes are specified as 1N34s on the circuit diagram, they may be almost any of the common type of germanium diode, for example: 0A91, 0A90, 0A85, 0A81, 0A80, 0A79, 0A5, etc. The values of the two capacitors, however, should not be changed.



The coil used in this set may be any coil of a type designed for use from 500KHz to 1600KHz. It may be a commercial type, or may be home-made.

Coil details are as follows: "Coil wound on 2-inch diameter former. 80 turn 22SWG wire, close wound and tapped every 5 turns. Approximately 7 taps required commencing from earthy end."

Experimenting with the different taps will give the best position of the aerial and "active" lines. Start by placing the aerial on the 2nd tap and the active on the 4th tap from earthy end. This should give results. Then moving one or the other to a different tap and comparing loudness will help to determine the best position. This setting up would probably best be done using a normal tuning condenser.

The switch used will depend on the number of stations required. An ordinary rotary switch (as shown in the circuit diagram) would be the easiest to use. It would need to have an extra pole and an "off" position only if an amplifier was incorporated, as there is nothing to turn off in a crystal set.

The greatest problem in a set of this type is to determine the amount of capacitance to be used to select the station. Besides the obvious method of a large number of capacitors being substituted by trial and error until the correct one is found, some method of accurately determining the capacitor is required.

One method requires the use of a capacitance bridge. An ordinary 10-415-pF tuning condenser is connected in parallel with either a 15pF capacitor or a 30pF trimmer set at its middle capacitance. This is substituted in the circuit for the switching bank. A station is then tuned (like a normal crystal set) and the amount of capacitance is read on a capacitance bridge. This reading should be of the tuning condenser alone, taken out of circuit. A fixed capacitor of this value (or one very close to it) is put in parallel with the 30pF trimmer and soldered into the circuit.

Another method is to use the graph herewith, which has been worked out for a broadcast band coil and a variable capacitor of 10-415pF.

Start by adjusting the coil (adding or removing turns from the switched end) until the lowest frequency station in your area can be tuned with the predicted value of capacitance. Other stations should be received with about the predicted values of capacitance.

To take an example in reading the value from the graph, London has a frequency of 930Hz. Looking at the graph, we see that 930 lies somewhere between 126 and 101. As the graph is not a linear function, (i.e. the distance between each unit of capacitance is not a constant), it is necessary to take an educated guess at where the exact figure lies. In this case, 120pF would be close enough. As we are using a 30pF trimmer across this, we must allow for it, by subtracting 15pF (i.e. half the value of the trimmer) from the value we read. So to tune Radio 104, we would require approximately 105pF in parallel with a 30pF trimmer.

Setting up now becomes a simple matter of switching the required station in, then adjusting the trimmer for maximum gain. Subsequent tunings will then only require the switching in.

TYPICAL CRYSTAL SET

The construction and wiring of the receiver should be fairly obvious from the photographs and wiring diagram. The components are mounted on a piece of plywood some 6½in x 5in, to which is nailed a wooden front panel approximately 8in x 6in.

Two terminals on the front panel are used to allow the aerial and earth lead-in wires to be connected easily. The aerial should be as long and as high as is practical, and should preferably be a length of 7 x 0.022in copper "earth" wire. It must be insulated from its supports, and this may be done with "egg" type insulators of plastic or porcelain.

The earth may be connected to the house water-pipe near where it leaves the ground, or if this is not practical, it may be a connection to a yard or so of galvanised pipe driven into fairly damp ground. Don't connect to a gas pipe, though, for this is frowned upon by the authorities.

The tuning capacitor need not be a new one. A tuning gang salvaged from an old radio set may be pressed into service providing it is still working satisfactorily. Make sure that none of the moving plates touch the fixed plates, and connect to only one set of fixed plates if the unit happens to be a multisection or "gang" capacitor.

The shaft of the capacitor is taken through a hole in the front panel and fitted with a large knob, as can be seen in the photograph. A dial scale pasted on the front panel can then be marked with the station names when the set is completed.

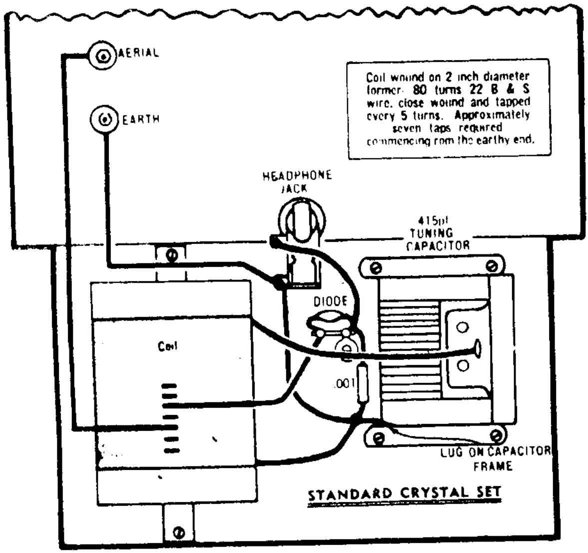
The table in the wiring diagram gives coil winding details for those who would like to wind their own. The former may be of plain or waxed cardboard, or even of wood. To make the taps, wind the appropriate turns over a piece of match-stick. The raised wire at each tap can then be scraped free of enamel and soldered to when required.

If desired, of course, a commercial coil may be used in place of the home-wound one. The most suitable type would be a high-gain transistor aerial coil, such as that used for our "Three Band Transistor Eight" receiver. Connect aerial, earth, and the two sets of capacitor plates to the coil exactly as originally intended, using the "base" tapping for the detector in the crystal set.

The germanium diode may be almost any of the common types, such as the OA91, OA90, OA85, OA81, OA80, OA79, OA5, GEX35, GEX34 or GEX33. If readers have an old "cats-whisker" detector they could try it, but results generally will not be as good as with one of the modern diodes.

For this particular application, it does not matter which way round the diode is connected into the circuit.

The 0.001uF capacitor may or may not have much effect, depending upon the type of earphones used. Since it will only cost a few pence,



Using this wiring diagram and the circuit shown in the theory article, it should be a simple matter to build up the receiver even if you have never wired up a circuit before.

it may as well be put in.

Low impedance earphones are not suitable for this type of receiver. For best results, use high impedance 1000-4000 ohm units. Crystal earpieces are in general rather too insensitive, despite their high impedance, although they may prove satisfactory in strong signal areas.

The earphones are connected to a jackplug, which plugs into a jack mounted on the front panel of the set.

There is no need for an on-off switch, for there is nothing to turn on and off. Simply connect up the aerial and earth, plug in the earphones, and you should be able to tune in to one or more stations, provided you are not further from them than about 15-20 miles.

How many stations you will actually be able to receive without mutual interference will depend on relative strengths at the listening site, some sites being much more favourable for crystal sets than others.

A VHF CRYSTAL SET FOR SHORT WAVES

Shown below is the circuit for a relatively simple crystal set–but it is a crystal set with a difference. Unlike normal crystal sets, which are only able to receive on the broadcast band (530-1600KHz), this set is able to receive a small portion of the VHF band (Very High Frequency).

We live about five miles from the transmitting mast of ABS channel 2 (63-70MHz), and in this location output from the crystal set is quite sufficient to drive a pair of high impedance headphones.

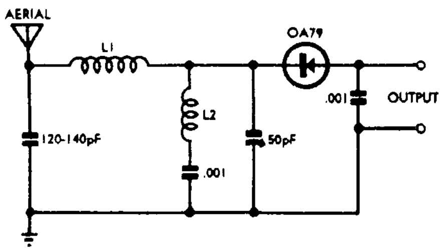
When used with a simple amplifier, the output is quite remarkable.

The design makes use of the "slope detection" method of demodulating an FM (or Frequency Modulation) signal. All TV sound is broadcast as FM. Also, an AM (or Amplitude Modulation) signal can be detected, in the same way as a normal crystal set.

The aerial used was a single piece of wire cut to resonant length. Alternatively, we simply connected the set to a TV antenna. (Our correspondents do not say how this was done, but we imagine that it was across the 120pF capacitor, ie, the aerial and earth terminals.)

While we do not know if it is possible, we should imagine that by some experimentation this simple set could be made to cover possibly a couple of TV channels, and maybe the 52MHz amateur band. This may be possible by varying the values of capacitors.

Practically any small signal germanium diode could be used for the detector.



L1: 5 TURNS 16 GAUGE B & S ON FORMER 1-1/16" DIA, SPACED TO 1-3/8" LONG

L2: 46 TURNS 30 GAUGE B & S ON 5/16" FORMER, CLOSE WOUND

In Gt. Britain for L1 use 18 S.W.G.
for L2 use 32 S.W.G.

A TWO-TRANSISTOR, REFLEX BROADCAST RECEIVER

A two transistor reflex broadcast receiver is the subject of our feature.

This circuit, as far as I can ascertain, includes certain features that are original. I have chosen to call it the "Transporta Two", as it is truly transportable, giving a most creditable performance at the bedside or on the beach. Its volume is more than adequate and inter-station interference is at a very low level in the background. At my location, stations at the top end of the band are received rather weakly.

The circuit was designed around a two-stage RC coupled amplifier possessing high gain and wide band width. Use of alloy diffused AF115 transistors, together with low loads, assures sufficient bandwith to amplify all frequencies within the broadcast band to the same degree as at AF. Those wishing to use transistors other than these must be prepared to experiment.

T1 is operated at approximately 0.5mA, which might seem to be unduly high at such a low power level, but is necessary in order to obtain sufficient Beta. T2 draws approximately 0.3mA and little improvement is to be gained by operating it at a higher current level. The total drain should not amount to more than approximately 0.9mA, so battery life should be quite long.

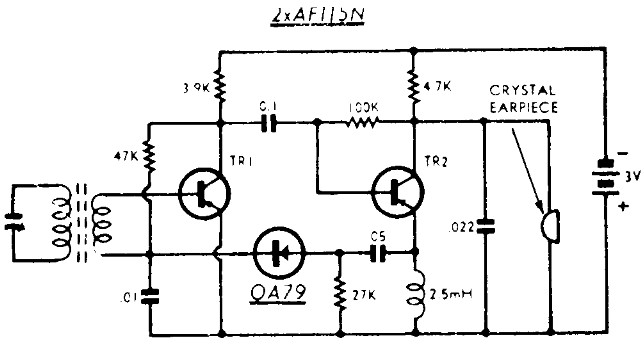
Bias stability is not the best, but good enough for such an application, unless of course the set is to be operated in a laundry or some such place. Those who decide to operate the receiver from a source higher than the specified 3V, would be well advised to re-design the bias network along more conservative lines.

A few words regarding the 0.1uF interstage coupling capacitors: Crystal earpieces are notoriously inefficient at low frequencies, but those that are sufficiently powerful enough to be heard produce an annoying buzz. If it is considered that the final result is a bit "tiny" these may be increased to 0.22uF.

At AF, the circuit operates as a two-stage, RC coupled, common emitter amplifier, with its input derived from the demodulator, and its output taken across the 4.7K resistor. At RF, the input transistor is connected as a common collector, the collector being effectively maintained at chassis potential by the .002uF capacitor.

The load for T2 is provided by the 2.5mH choke, the demodulating network, consisting of the OA79 diode, .05 and .01uF capacitors, the 27K resistor, and the input impedance of T1. The 27K and 47K resistors forward bias the diode slightly, thus giving a higher detection efficiency, the result being equivalent to that obtained from a voltage doubler.

The value of the coupling capacitor is chosen to give a small degree of negative feedback at high frequencies to improve the stability. By directly coupling the diode to the base of T2, one coupline component is saved and a small amount of AGc is gained.



Whilst higher gain could be achieved at RF by operating T2 in common emitter, the circuit would then be potentially unstable due to the feeding back, in phase, of high frequency components through the demodulating network to the base of T1. By operating T2 in common collector, any high frequency component is fed back to T1 out of phase, and the problem of instability is eliminated. Also, with T2 operated in this configuration, there is good isolation between the input and output at RF. Admittedly, its gain is then restricted to approximately 10dB, but, overall, sufficient gain is available.

No volume control is provided as sufficient control over this can be exercised due to the directional characteristic of the rod aerial, and the limited AGC present. The selectivity is adequate without resort to regeneration, but sensitivity is low.

The aerial coil is wound on a piece of ferrite rod of approximately 2½in in length. The number of turns on the primary is dependent on the tuning capacitor used, with 10 turns on the secondary a good compromise between sensitivity and selectivity. Those living in a good reception area might be able to reduce this number of turns, but do not expect any spectacular increase in selectivity by doing so.

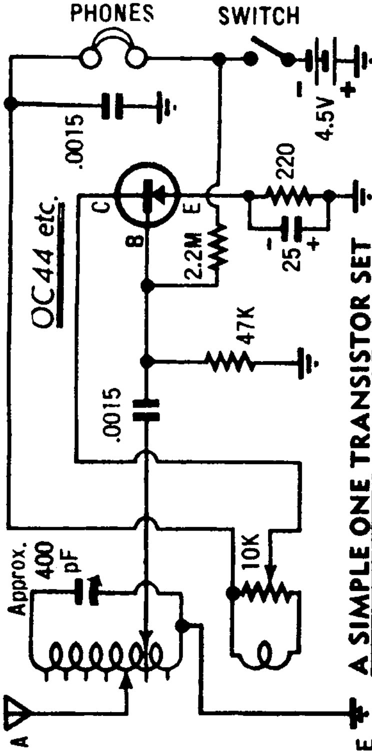
Finally, just how small the set may be built is up to individual ingenuity.

A SIMPLE TRANSISTOR SET

For beginners we are presenting another version of the popular single stage regenerative receiver. Using a relatively inexpensive transistor it has been deliberately designed to use as many "junk bos" parts as possible, and should appeal particularly to younger readers on a limited budget. In spite of this, it is an excellent performer.

Along with the crystal set, the simple regenerative receiver has always provided a good starting point for the beginner. Even in the days of valves, many a schoolboy chose this type of set for his first venture into the wonders of radio. With the advent of transistors, the job has been made a good deal simpler and cheaper.

There is nothing new about this circuit, and we have described a number of similar sets in the past. However, these usually incorporated modern techniques and components, such as coils wound on ferrite rods or toroids, midget tuning capacitors, crystal earpieces, and so on.



Although these components contribute towards smaller overall size and, sometimes, greater efficiency, they can also contribute to the discouragement of prospective beginners by their sheer strangeness and expense. We have therefore, in this set, attempted to preserve the early "breadboard" layout and components more familiar to constructors of the classic crystal set.

In fact, if you already have a crystal set it should be quite a simple matter to convert it to this present set. You will already have the necessary tuning capacitor, coil former and headphones, and all that will be required is a few resistors, capacitors, a short length of coil winding wire, the transistor and a battery.

Before describing the actual construction, a few words about the purpose of the main components may assist the reader to form a picture of how the set functions.

The tuned circuit, consisting of a coil and variable capacitor, enables us to select the desired station and attenuate stations on other frequencies. In other words, to "tune in" the station we want.

The signal developed across this coil/capacitor combination is fed via a suitable tapping on the coil, to the transistor base-emitter circuit. The transistor performs three functions, the first being detection This is performed by the base and emitter junction acting as a diode and is the process of extracting the audio frequency signal (modulated carrier wave). An audio signal voltage is therefore developed across the 47K resistor.

The second function is to amplify this signal. To do this the transistor performs as a common emitter audio amplifier with the signal injected at the base and a pair of headphones providing the collector load. The voltage divider formed across the battery by the 47K detector load and the 2.2Meg resistors, together with the 220 ohm emitter resistor provides the necessary bias stabilisation for the transistor.

RF Amplification

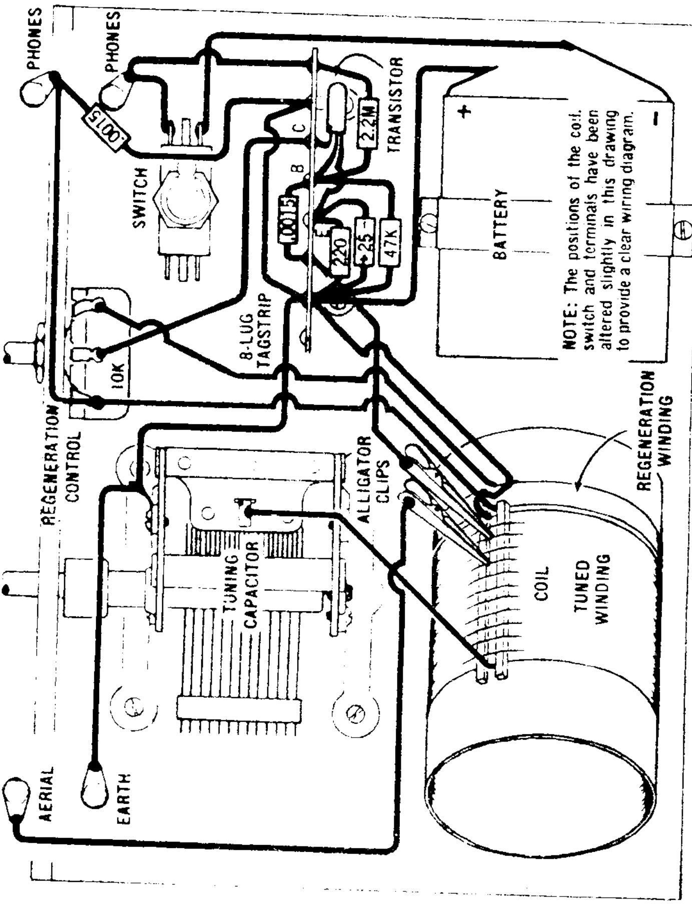
The third function is to amplify the incoming radio frequency signals. Because the headphones are bypassed for radio frequency, the load will be provided by the small winding beside the main tuned winding.

Providing that this amplified RF energy is coupled back into the tuned winding in phase with the received signal, positive feedback or 'regeneration" is produced. When correctly adjusted, this amplified RF energy can be usefully employed in improving the efficiency of the tuned circuit and restoring the energy lost during detection.

It is not unusual for the amplification from regeneration to be almost as great as that obtained by adding another transistor, while the selectivity can be better than would result if an extra tuned circuit were included.

The amount of regeneration is vital, however. Too little and the performance may not be boosted sufficiently; too much and the receiver will commence to oscillate or generate a signal of its own accord. We then have two signals, the incoming signal and that of the oscillating detector. These produce a heterodyne note which appears as a continuous whistle, mixed up with the required signal.

Optimum performance is normally obtained with the regeneration adjusted to just short of active oscillation.



The 10K potentiometer shunted across the feedback winding provides a means to control the regeneration. Minimum regeneration occurs when the moving arm of the potentiometer carries the collector directly to the end of the winding connected to the phones. Maximum regeneration occurs at the other end of the winding.

In small sets this control can be used as a volume control because reducing feedback reduces the efficiency of the circuit and hence the volume. When a number of audio stages are employed it is usually desirable to have a separate volume control.

So much then, for elementary theory, which we hope may help the reader to understand something of how the set works. Now let us consider some of the more practical aspects: the types of components, method of construction, etc.

Almost any transistor will detect radio frequency signals with reasonable efficiency and amplify the resulting audio frequency components. But to enable smooth and reliable regeneration while tuning across the entire broadcast band a transistor must be chosen which is capable of amplifying signals up to at least 1.5 megacycles.

We have used an OC44, but listed below are a number of types which have also been recommended on previous occasions: OC45, 2N218, 2N252, 2N308 and SFT108. Any of these should be perfectly satisfactory.

Variable capacitors come in many phisical shapes and sizes, but the main requisite is that the one selected should have a maximum capacity of 350-450 picro-farads (.00035-.00045 mfd). Almost any junk box will contain at least one of these, be it either a single or a double section "ganged" type, either of which will suffice. In the latter case, one section will remain unused.

The tuning capacitor appropriate for the job will consist of one set of about 12 parallel plates held rigidly in a metal frame by insulating supports, and a second set of about 13 plates, mounted on a shaft which can be rotated so that the two sets of plates may be interleaved to any desired capacity. The sets of plates are electrically insulated from each other and must remain so throughout the entire tuning range.

Most large tuning capacitors, of the type used in our receiver, have a 3/8in diameter shaft intended to fit the standard dials used in larger sets. Therefore, in some circumstances, it will be necessary to use a 3/8in to ¼in reduction shaft to enable a knob to be attached.

Virtually all tuning capacitors made in recent years are provided with mounting brackets. However, some very old ones may lack this feature, in which case it may be necessary to make a suitable bracket from a scrap of aluminium.

The coil is home-made. It consists of a tuned winding, which must be tapped, and a regeneration winding. A former is required, having a diameter between, say, 1½ to 2¼inches. This need be nothing more than a piece of cardboard tubing which can be readily purchased, or, alternatively, quite a good one can be made from ordinary cardboard by pasting it together.

According to the diameter of the former used, so the number of turns will have to be adjusted in order to produce a coil with the same inductance as the original. The accompanying table gives the number of turns required for several likely former diameters, together with the number of turns per tap, length of winding, and turns for the regeneration winding. The latter may require slight modification as a result of "on the air" experiments.

The gauge of winding wire used is not critical and must be goverened by what is available locally. We have used 24 B&S gauge and the details given will not alter greatly for a few gauges either side of this.

For the benefit of those readers who have not as yet constructed a coil, some details outlining the procedure which we followed will be of considerable advantage.

Firstly, to anchor the wire to the former at the start of each winding we drilled two small holes about ¼in apart, through which the wire was threaded a number of times, remembering to leave about 6in of wire free for terminating.

We then proceeded to close-wind five turns, after which a wooden matchstick was placed along the former and the sixth turn was passed over the top of this. Five more turns were wound under the matchstick and the twelfth turn passed over the top. This was continued until the final turn was anchored in the same manner as that detailed at the start of the winding.

The next job was to push a second matchstick in alongside the first, then push the two apart by about ¼in. By carefully removing the enamel from the wires passing over the matchsticks we were able to make connection to these taps with alligator clips.

The feedback winding was wound starting about 1/16in from the bottom or earthy end of the main tapped winding. This consisted of 12 turns of the same gauge wire wound in the same direction. Both ends were anchored to the former in the manner described above and sufficient wire allowed for termination on the regeneration potentiometer.

Resistors

Resistor values are not critical, and ordinary half-watt types with a tolerance of 20 percent are used. Values given are from the "preferred value" range (e.g., 47K) and those readers wishing to salvage resistors from old receivers will have to set about looking for similar values but under the old system (e.g., 50K) and therefore different colour bands will be encountered.

The two fixed capacitors may have values anywhere between about .001 and .002 mfd. (1000 to 2000 picrofarads). The lowest voltage rating available will be quite suitable.

With regard to headphones, undoubtedly the best results will be obtained from the standard high impedance types. This term embraces those which have a DC resistance of about 200 to 4000 ohms and an impedance of about 7000 to 20,000 ohms, depending upon their construction.

Down the scale somewhat in terms of performance are the so-called low impedance ex-disposals headphones which are often cheaper to buy. These have a DC resistance of little more than 100 ohms and an impedance of several hundred ohms to AC.

Ex-disposals dynamic headphones, the type used with earmuffs and with an impedance of about 50 ohms, are not suitable for this set.

Although we have used and recommended a 4.5 volt battery, any supply, from a single 1.5 volt cell to a 9 volt battery will work, and is worth using should you already have one on hand. The change in performance is almost imperceptible between 4.5 and 9 volt operation.

The potentioneter used for generation control was an old carbon type. Should it be necessary to purchase this part new it can be obtained with an ON/OFF switch attached to the rear, and this will eliminate the need for a separate switch. As it was, we had this pot on hand and therefore elected to use a separate toggle switch for ON/ON facilities.

Spring-loaded terminals have been used for earth, aerial and headphones. Should your phones be fitted with a standard phone plug (tip and sleeve type) it will be just as easy to install a matching socket (phone jack) on the panel instead of a pair of terminals.

For the baseboard we used a piece of ½in plywood measuring approximately 8½ x 6½inches. The front panel was ¼in ply measuring approximately 9 x 6 inches. Both pieces were planed square and then given a coat of varnish stain to improve the overall appearance.

The general layout of both the base and panel can be seen clearly from the drawing and photographs. We drilled the appropriate holes in the panel and attached the components to the base, using 3/8in x No.4 wood screws.

We screwed the coil to the chassis by making a pair of diametrically opposed saw cuts, each 3/8in long and about ¼in from the end of the former. A piece of scrap metal 3/8in wide and 2½in long, with a hole through the centre, is pushed through the slots. The coil is then mounted on the baseboard by a single wood screw.

An eight-lug tagstrip screwed to the base supports most of the wiring and small components, including the transistor. A major portion of the wiring was done using tinned copper wire, which was first cut to length then covered with spaghetti.

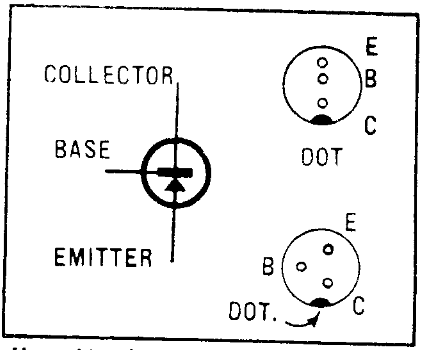
The physical form we used is only a suggestion and if you have ideas about making it in a box or cabinet which you already have, there is no reason why you should not do so. The coil is the only component which is critical with regard to mounting position. It should not be placed hard against the frame of the tuning capacitor or any other metal surface.

Having completed the set and connected an earth and some kind of aerial for testing purposes, the stage has been reached at which you are about to switch on. This is a good time to have just that final check that both the transistor and battery have been connected in the correct manner. If incorrect, there is a good chance that you will not have another opportunity–at least, not using the same transistor.

After switching on, a quick tune across the band and an increase in the amount of feedback by advancing the regeneration control should be sufficient to verify that the set is operating and that positive feedback is occurring. This will be signified by heterodyne oscillation (whistles) as you tune across a station.

The correct wiring for the regeneration winding and control to ensure both positive feedback and a clockwise rotation for increased feedback, will be assured by closely following the wiring diagram given. But if some difficulty should arise and regeneration does not occur, try the receiver with the winding connected both ways. In this way the marked difference between the correct and incorrect connection will remove any doubt which may exist.

Should the set still fail to oscillate, it would signify insufficient turns on the regeneration winding, a faulty transistor or flat battery, assuming that the headphones are known to be okay and all wiring is correct.



Use this diagram to identify your transistor leads. The collector is the marked lead in each case, or it may simply be spaced from the other two.

For the benefit of readers in country areas, who may be a considerable distance for a broadcast station, we would suggest that they provide themselves with a reasonably efficient aerial.

The simplest form which the aerial can take is that of the "Inverted L", or, better still, an almost vertical wire, the height being the important factor. This will be governed by existing trees, masts, and chimneys (where available). Copper wire, thick enough to support itself in the wind, can be attached to some high point via an insulator and halyard, the other end being attached in a similar manner to, or near, the house. A lead-in wire, attached to this end, connects to the receiver aerial terminal.

An excellent "earth" is obtained by connection to a water-supply pipe buried in the ground, or, alternatively, a length of waterpipe driven into the ground.

With a small regeneration set such as this, in which the aerial is directly coupled to the tuned circuit, there is an optimum position for both the aerial and transistor base to tap into the coil. These must be determined by experiment to obtain a compromise between sensitivity and selectivity.

In general, when using a long aerial, you will get best results by tapping it down toward the earthy end of the coil. A short aerial will give better performance if moved toward the top. The transistor base will be tapped toward the earthy end, because of the low input impedance of this device, as mentioned earlier. There is no reason why both aerial and transistor base clips should not be connected to the same tap.

Optimum performance is normally obtained with the regeneration control adjusted just short of active oscillation and the actual position of the control will vary from station to station. Some adjustment of the number of turns and placement of the feedback winding is permissible if you want to experiment.

Increasing the number of turns or reducing the space between the regeneration winding and the tuned winding will cause regeneration to occur when the control is close to its minimum position. Either reducing the number of turns, or increasing the space between the two windings, will require the control to be advanced well toward maximum.

Incidentally, it is not necessary to have any special licences to carry out experiments with receivers. The Broadcast Listeners' Licence, which covers other receivers in the same house, also covers any set with which you may wish to experiment.

COIL WINDING DATA

	TUNED WINDING			REGENERATION WINDING
Diam.	Length*	Turns	Turns per tap	Turns
1½in	2.75in	130	10	21
2in	1.9in	90	7	15
2¼in	1.6in	75	6	12

Of the figures quoted we used those given for the 2¼inch former.
*Based on 24 SWG gauge wire.

PARTS LIST

1 Tuning capacitor about 400pF max.
1 Coil former, from 1½ to 2¼in dia. (see text)
Enamelled winding wire 24 SWG approx. (see text)
1 Transistor OC44, 2N218, SFT108, etc. (see text)
1 Potentiometer 10,000 ohms
1 Pair headphones, perferably high impedance
1 4.5 volt battery
1 ON/ON switch if required (see text)
2 .0015 mfd capacitors
1 Low voltage electrolytic capacitor, 4 to 25 mfd.

RESISTORS (all half watt, 20% tolerance)

Values:	*Colour Bands 1st*	*2nd*	*3rd*
1 2.2 Meg.	*red*	*red*	*green*
1 47K ohms	*yellow*	*purple*	*orange*
1 220 ohms	*red*	*red*	*brown*

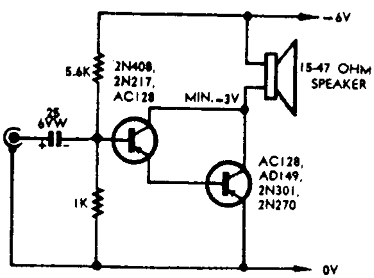
MISCELLANEOUS

Plywood for baseboard and panel. 1 8-lug tagstrip, 2 Knobs, 2 Alligat clips, 4 Terminals, Wood screws, Hookup wire.

A SIMPLE AMPLIFIER

This design is a novel and economical way of obtaining sound from the loudspeaker. However, it does have one major drawback. DC flows through the speaker voice coil.

Normally, this should not happen. DC causes the cone to deflect more in one direction, resulting is distortion on loud signals. If one is prepared to risk this deterioration in quality, the circuit is a handy one to keep in mind.



A SIMPLE RECEIVER OF NOVEL DESIGN

This little receiver should have an appeal to beginners, experimenters and more experienced readers alike. It is economical, exhibits high sensitivity and represents a quite novel approach. It may be used as it is, or it could be the basis for further development and experiment.

Just a week prior to the time of writing, we were looking through an issue of "Wireless World" and came across a short article by G. W. Short. In it, the author described a four-transistor TRF receiver using only one tuned circuit and designed to operate from selenium photo cells, at about 1.3 volts.

To say the least, we were fascinated by the circuit concept. As the writer pointed out, the receiver was meant for the use and amusement of small children. Selenium cells were chosen for the power supply, because they operate from sunlight and it would not matter at all if the young owner forgot to switch it off. In addition, operation had to be as simple as possible and this amounted to a tuning dial and a volume control in the original set.

We duly decided to make up one of these little sets and see for ourselves. The idea of using selenium cells was discarded, however, mainly on the score of cost. Many dry cells could be bought for the cost of the selenium cells.

As no constructional details were given, we elected to make it up in the way we imagined that a schoolboy would do. So we started out with a piece of ½-in thick board for a base, to which was added a front panel made of thin plywood.

A word of warning was issued by the "Wireless World" writer to the effect that the receiver had quite a lot of gain and that, unless the ferrite aerial rod was either kept well away or screened from the rest of the receiver, instability would be a likely problem.

Noting the warning, we made a rough mock-up of the circuit in such a way that we could move the rod around with respect to the RF amplifier system. This made it possible to check the need for—and the effectiveness of—a suitable screen. The screen was indeed necessary but the layout, as shown in our model, proved to be both simple and effective.

Before proceeding with constructional details, let us have a look at the circuit. As mentioned previously, there is only one tuned circuit, involving a coil wound on a ferrite aerial rod. This has a high intrinsic "Q", providing a reasonable amount of selectivity in its own right. There is a second winding on the rod to feed the signal to the base of the first transistor, this winding having deliberately few turns, to minimise loading on the tuned circuit.

Immediately following, are three transistors constituting a direct-coupled, wide-band RF amplifier system. Circuitwise, this is about the simplest arrangement that could be conceived. It gives high gain and at the same time, avoids the need for additional tuned circuits.

The three transistors used in our prototype are the silicon planar type BF115, which are readily obtainable at quite low cost. We have not tried other types but it is more than likely that other NPN silicon planar transistors would be satisfactory. Among these would be the BC108, 2N3565, etc.

It should be noted that the BF115 has a shield connection, effectively earthing the metal cap; most other types do not include this protection. In addition, the BC108 has higher gain than the BF115 and this, along with the lack of shielding, could lead to instability. However, if the builder is inclined to try other types, by all means do so.

In the collector circuit of the third transistor, is a 330-ohm resistor and an RF choke in series. We found it necessary to shunt the RF choke with a 1K resistor to ensure stability of the RF amplifiers. This was not shown in the "Wireless World" circuit and it could be that the transistors which they were using were of somewhat lower gain.

Between the junction of the 330-ohm resistor and the RF choke, is a 100K pre-set potentiometer, the other end of which goes to earth. The rotor picks off the correct amount of bias for the base of the first transistor and enables suitable operating conditions to be set up for all three directly coupled RF amplifiers.

The detector is a germanium diode and almost any type would do in this position. The diode is forward biased by connecting it directly to the collector of the third transistor. This arrangement means that the load resistance should fall between the values of 25K and 100K and for this reason a 50K volume control has been specified. We advise that this value be used.

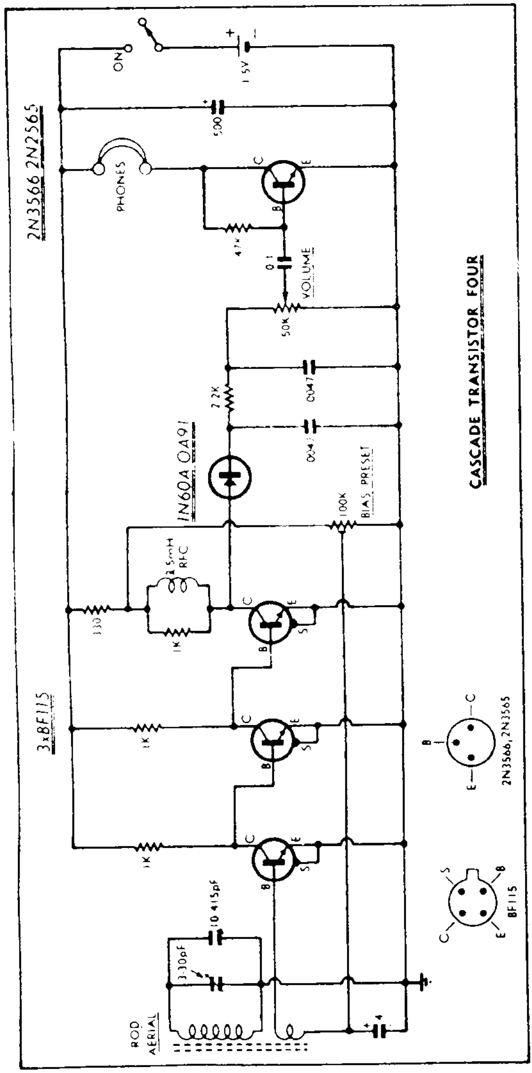
Immediately following the detector is an RF filter, consisting of two .0047uF capacitors and a 2.2K resistor.

The fourth transistor is the audio amplifier, the signal being fed to its base via a 0.1uF capacitor from the rotor of the volume control. Forward bias is provided by the 47K resistor. A pair of headphones is connected between the positive line and the collector of the audio amplifier.

The transistor which we used here is a 2N3566, a type which happened to be handy. The application is not a critical one and we could have used a 2N3565 or a BC108, just as effectively. In fact, the requirements are such that almost any type similar to those mentioned could be used.

The "power supply" is a humble 1.5 volt dry cell and perhaps the most convenient type to use is the 915. Across the 1.5 volt supply is a 500uF electrolytic capacitor, which becomes useful when the cell begins to run down. The total current, as we measured it, is a mere 4.5 milliamps. With this drain, a 915 cell should last quite a long time.

A few general observations should prove useful to readers. As already mentioned, certain precautions must be taken to make sure that the


CASCADE TRANSISTOR FOUR
2N3566 2N2565
3xBF115
1N60A OA91
ON
1.5V
500
PHONES
47K
0.1
VOLUME
50K
22K
.0047
.004
BIAS PRESET
100K
2.5mH RFC
330
1K
1K
1K
10-415pF
3-30pF
ROD AERIAL
4
2N3566, 2N3565
BF115

unit will be stable. The main one is that the aerial rod must be isolated from the wide-band RF amplifier. This is covered in the details on construction.

The actual type of aerial rod assembly will have a definite bearing on the performance. The assembly shown in the photograph is one which is readily available but has been modified to suit our purpose. When purchased, the rod was 8in long, which was somewhat longer than could be accommodated in this little set. We shortened the rod to 5in, although it could have been left as long as 6in. Shortening the rod does slightly reduce its directivity but it also reduces inductance. The latter can be corrected by adding a few turns to the coil and this point will be dealt with later on.

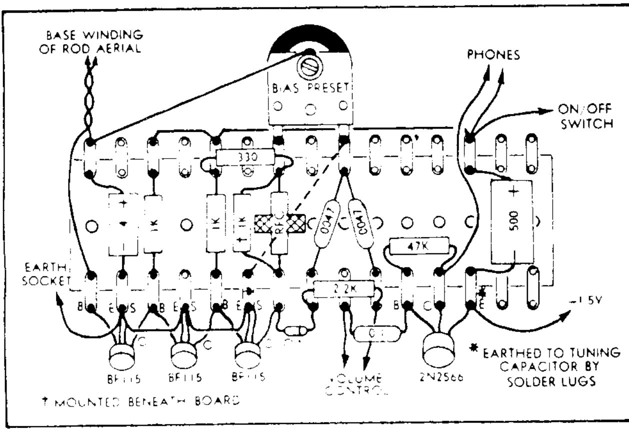
We also tried a Japanese replacement aerial rod assembly, which is quite small by comparison, being only 2¼in long. When compared for performance with the longer rod the small one seemed to have almost as much pickup, but the selectivity and null from the ends, was not as good. Unless space is at a premium, it would seem that there is a good case for the larger rod.

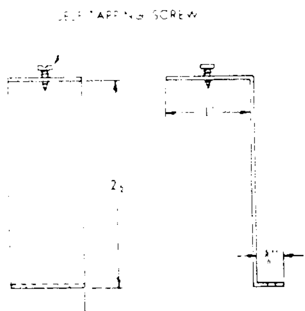
Before leaving the subject of the aerial rod assembly, there is another important point which should not be overlooked. The rod must be kept away from metal, particularly ferrous, otherwise the "Q" of the coil will be seriously reduced, resulting in loss of selectivity. More will be said about this under constructional details.

Needless to say, such a modest receiver is only intended to operate a pair of headphones. Crystal headphones are not suitable for this application. Magnetic headphones come in a wide variety of impedance values, perhaps 2000 ohms being the most common. It will be found that these are quite satisfactory and even 4000 ohm types will work but with somewhat reduced sensitivity. The most successful headphones from a sensitivity point of view are the low impedance variety which were so common on the disposals market a few years ago. The resistance of the pair which we used is 25 ohms and these gave excellent results.

We were also hopeful enough to try a small loudspeaker and with reservations, it gave acceptable volume. A 4in speaker with a voice coil impedance of 33 ohms was found to be quite good giving sufficient volume for a quiet room. On the other hand, as the voice coil impedance is reduced, so does the output fall accordingly. At 2 ohms, the output had dropped to a level which could not be considered usable.

The idea of using a transformer to provide a better match between the audio transistor collector and the speaker was also tried. Although from a theoretical point of view, we were able to obtain a fairly reasonable match, results were not encouraging. It would seem that the efficiency and DC resistance of the transformer was such that the improvement in matching was more than offset by the losses. However, interested experimenters could pursue this idea further, if they feel so inclined.





BATTERY CLAMP

A good idea of the construction may be obtained from the pictures and the wiring diagram. The base board, 6in x 2¾in x ½in, accommodates the variable capacitor, wiring board and dry cell. The front panel is used to mount the On/Off switch, volume control, headphone sockets, dial assembly and aerial rod assembly.

The panel measures 6in x 4½in x 3/32in thick. It was made of three-ply wood but any suitable material could be used, such as hardboard or bakelite. We would suggest that you increase the height of your panel to at least 4¾in, to give more space under the shield for the dry cell and to permit slightly increased spacing of the aerial rod above the shield.

The shield just mentioned, consists of an "L" shape piece of tinplate. Allowing sufficient clearance for the dry cell, the shield should measure 6in wide, 3-3/8in to the bend and with a 2in fold at the top. We used tinplate, but some may prefer aluminium.

The front panel is screwed to the baseboard with a couple of wood screws, the shield being clamped behind the front panel and held in place by the same two screws. Holes for the variable capacitor spindle, switch, volume control and headphone sockets, are drilled through the panel and shield and the clamping effect of the bushes helps to make the assembly more rigid. The banana socket on the right was originally fitted for an earth connection but it is not necessary in practice.

The aerial rod assembly is mounted on the front panel by means of two spring clamps with are obtainable at good hardward stores. The clamps must not, in any circumstances, form a shorted turn around the rod.

The aerial rod which we used, measures 3/8in diameter and the clamps are nominally ½in. You may be able to get 3/8in clamps or do as we did namely wrap sufficient insulation tape around the rod to increase its diameter to ½in. This has the advantage of providing some cushioning of the rod against stress. Finally, as suggested earlier, the rod and clamps should be mounted as close to the top of the front panel as possible, clearing the shield by the maximum amount.

The variable capacitor is fixed to the base-board with small wood screws. Due to the thickness of the front panel and shield combined, the spindle of the Roblan variable capacitor may not be quite long enough. This can be remedied by reversing the front mounting foot, turning it under the capacitor assembly, and allowing the capacitor to be mounted closer to the front panel. Only one screw hole of the front foot will be accessible but three screws are quite enough to hold the capacitor down firmly.

The dry cell is held in position by a small clamp fashioned from a piece of scrap aluminium. The sketch shows how it is made. A hole in the foot is drilled for a wood screw, which holds the clamp to the base board. A solder lug, fitted under the screw, provides for the positive lead from the cell to the switch. A self-tapping screw is screwed into the turnover at the top in such a position that the screw makes contact with the positive cap of the cell. Into the base-board, central with the cell position, is screwed another wood screw, also holding a solder lug. The cell sits over the head of the screw and the lug becomes the negative connection from the cell to the earth line.

A miniature tagboard, with 13 pairs of tags is used as a base for the general wiring. Our board has 15 pairs of tags, as can be seen from the picture but the two at the extreme right are not used. Reference to the wiring diagram shows clearly where all the components are mounted and very little explanation should be needed.

It is a good idea to wire in all the resistors, capacitors and the RF choke first. The detector diode and the four transistors are then soldered in and the usual care should be taken not to overheat these items.

The tag-board assembly may be put aside for the moment and the aerial rod assembly readied for use. Just how this item is dealt with, depends upon the type of assembly which you decide to buy.

One which is readily available is not suitable for our purpose, as purchased, and modifications must be made. The rod is 8in long and it needs to be shortened to 6in or thereabouts. Before this is done, the coil should be slid off the rod.

Where the rod is to be cut at the 6in point, run a file around the rod and cut a shallow groove. Now hold the rod in a vice with the groove just clear of the jaws. Do not tighten the vice too much, or you may crack the rod at another place. The surplus rod may be knocked off with a sharp tap from a hammer. The break may not be straight but this does not matter.

The coil windings must also be modified but the large tuning winding must be kept intact for the present at least. With a pair of wire cutters, cut off the leads to the lugs marked with the blue and red dots. These leads may be cut right back to the winding but they may be left in this condition. Using the vacated lugs for terminations, wind on four turns of enamelled wire over the end of the main winding and nearest the lugs. The gauge of wire is not critical and anything around 30 gauge will be in order.
This new winding becomes the one for the base circuit of the first transistor. One end goes to the transistor base and the other end goes to the 4uF electrolytic and the pre-set potentiometer. It does not appear to matter which way the connections are made to this winding.

As the rod has been shortened, the inductance of the tuning winding will be slightly reduced. This may be corrected by adding a couple of turns to this winding but we consider that it is not really worth the trouble. There will be a small error in dial calibrations at the low-frequency end of the dial but scarcely enough to worry about.

The winding is slipped back over the rod, with the winding located in the centre. It can be held in place by wrapping a couple of turns of plastic insulation tape over one end of the former, such that the tape also contacts the rod.
If you decide to use one of the miniature aerial rod assemblies, referred to earlier, a different approach will be necessary. Mounting arrangements will need to be changed but the two plastic feet provided will suggest the method to be adopted and we can confidently leave this to the builder. One point only must be stressed–what we said earlier about keeping the rod away from metal objects still applies.

However, there is more to the installation of this little rod than the mounting process. First of all, the four leads will have to be identified. At one end, there is one lead only and this goes to the fixed plates of the variable capacitor. One of the three leads at the other end belongs to the winding and is connected to the rotor plates of the variable capacitor and the earth line. Identification of this lead can best be carried out by using one of the "ohms" ranges on a multimeter.

The remaining two leads on the aerial rod assembly are for the base circuit of the first transistor. One lead will go to the base and the other to the 4uF electrolytic capacitor and the rotor of the 100K pre-set potentiometer. It does not appear to matter which way these leads are connected. If you feel inclined, you can check for yourself.

When the rod is installed and the receiver is working, it may be found that the receiver is tuning to a much lower frequency than the lower limit of the broadcast band. The tuning winding of the assembly, as pictured, had far too many turns for our purpose and presumably it had been wound for use with a much smaller tuning capacitor. Just a few turns at a time should be removed from the end with the one lead. The coil should then be refitted and checked for alignment at the low frequency end of the band. More will be said about adjusting the alignment against the dial scale further along.

With all the components and subassemblies now ready, we can now proceed with the final assembly. Mount the variable capacitor on the base-board first. In doing so, place a solder lug under each of the two back screws, with the lugs pointing towards the back.

If you have wired the tag board according to the wiring diagram, you will find that the bottom lug at the extreme right and another lug, seven to the left, are earth-line points and will correspond with the lugs on the capacitor mounting feet. The four lugs concerned can be used to solder the tag board assembly into the vertical position as shown in the photograph.

Another solder lug may be screwed to one of the holes at the top back of the variable capacitor frame and this may be used as an earth point for the trimmer and the aerial rod.

The dry cell could now be conveniently fitted into place, by sitting it on the screw on the base-board. The clamp is also screwed into place and the self-tapping screw is tightened on to the top contact of the cell so as to hold it firmly in place.

Having assembled all the components on the front panel and metal shield, these can now be screwed on to the base-board. Interconnecting leads between the various components will virtually finish the construction work. If you use the same sort of dial and scale as we did, the scale should be carefully stuck on the front panel and the dial pushed over the tuning capacitor spindle. With the capacitor fully meshed, the line on the dial should be horizontal.

Before switching on, the big moment should be delayed and a check should be made to ensure that there are no wiring errors.

Having satisfied yourself that all is well, plug a pair of headphones into the appropriate sockets and adjust the 100K pre-set potentiometer so that the rotor is at the earthy end. Now set the dial so that it points to a local station frequency and turn up the volume control. Switch on but do not expect to hear a signal at this stage.

With a screwdriver in the slot of the pre-set potentiometer, advance the rotor slowly, adjusting the tuning as necessary, until a signal is heard; do not advance the rotor further for the moment. If the signal is a loud one, turn down the volume control until the volume is at a comfortable but fairly low level. Return to the screwdriver adjustment and make slight alterations until the audio is clean and not distorted.

Do not advance the rotor more than necessary for good results, as it tends to reduce selectivity. It should be possible now to tune around the dial and get whatever stations may be within range.

The stations, one toward each end of the dial if possible, should be checked for correct calibration. The trimmer across the tuning capacitor should be adjusted to bring the station in at the correct point at the high frequency end of the dial. Now check the station nearest the low frequency end. If this is not correct, then the easiest way to bring it into line is to move the dial slightly on the capacitor spindle. The alternative to this is to add a turn or two to the tuning winding on the aerial rod but, as we said before, this may not be considered worth the trouble.

If it was necessary to make this adjustment, then it will be necessary to go back to the other end and re-adjust the trimmer to bring the high frequency station into line. The process must be repeated at the other end and any adjustment should be made.

Referring back to the miniature aerial rod assembly and our earlier remarks. If you are using one of these, a few turns should be removed and the calibrations checked at the low frequency end. This should be carried on until the station concerned is getting close to the correct spot. It would be wise then to adjust for the station at the high frequency end, with the trimmer as described above. If it is necessary to remove any more turns at this stage, then it should be done one turn at a time.

With the receiver now in working condition, a little experimenting will be well worthwhile. The directional properties of the aerial can be used to advantage, by turning the whole set around until weak stations are heard at best strength. On the other hand, if you happen to be close to a broadcast station, then it may be necessary to turn the set so that one end is pointing toward the transmitter; this will reduce the pickup to a minimum.

There are often cases where there are a number of stations audible and the stronger ones may interfere with the weaker ones. By careful rotation of the set, it is often possible to reduce the strength of an interfering station and so get good reception from a weaker one.

The idea of adding an extra stage of audio amplification has already been suggested. This appears to be an attractive proposition but we have not pursued this idea up to the present time. However, we hope to be able to do some work on this and any other possible refinements which could be added, at some future date.

PARTS LIST

1 Aerial rod assembly (see text)
2 Clips for aerial rod
1 On/Off toggle switch
2 Banana sockets
1 Dry cell, type 915
3 Transistors, type BF115
1 Transistor, type 2N3566, BC108, 2N3565, etc.
1 Diode, type OA91, 1N60A, etc
1 RF choke, 2.5mH
1 Knob
1 Dial and scale

RESISTORS
½ watt, 10 per cent tolerance
1 330 ohms
3 1K
1 2.2K
1 47K
1 100K preset potentiometer
1 50K logarithmic potentiometer

CAPACITORS
1 10-415pF variable
1 3-30pF trimmer
2 .0047uF low voltage plastic or ceramic
1 0.1uF low voltage plastic
1 4uF low voltage electrolytic
1 500uF low voltage electrolytic

SUNDRIES
Wood for base and front panel, Tinplate for shield, Aluminium for battery clamp, Hook-up wire, solder, screws.

These are Australian designed crystal set circuits where reception may be required from stations that may be up to 1000 miles distance and are included in this book to show the wide variety in crystal set design.

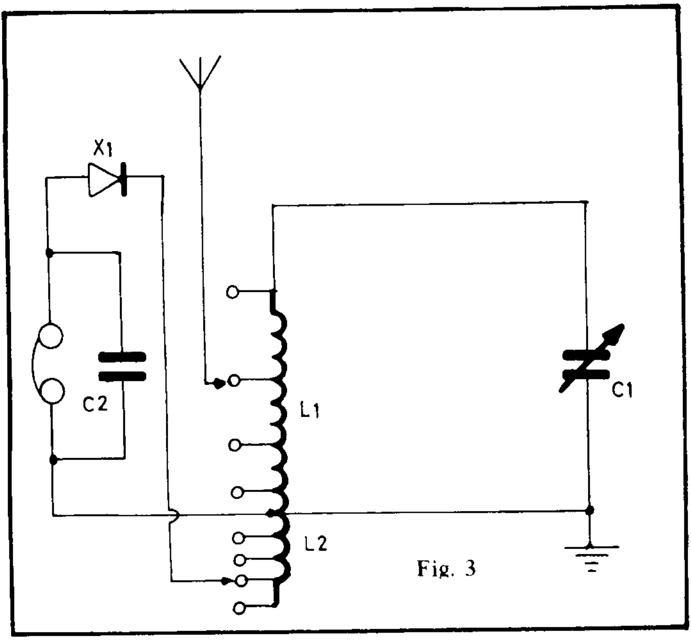
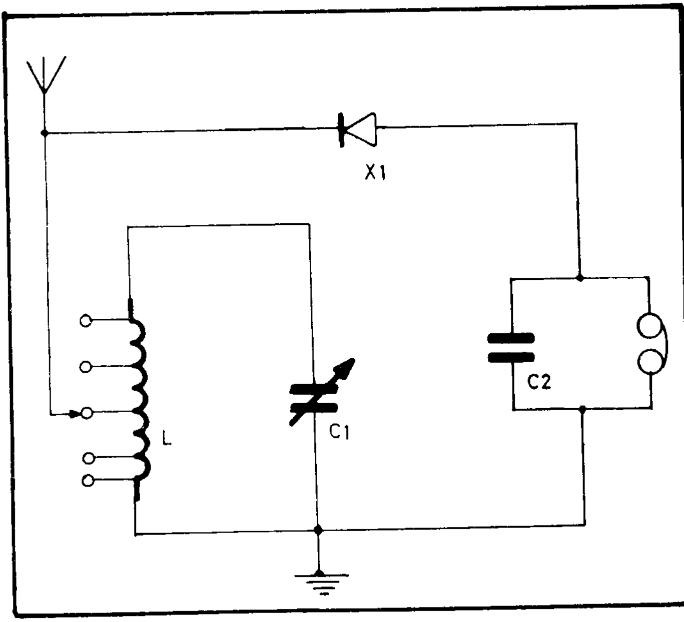


Fig. 3

Coil L_1 is 100 turns of 22 S.W.G. enamelled copper wire wound on a 4in diameter former. This may be either a large jam jar or can be made by fixing 8 pieces of ½in diam. wood dowels each 6in long in a circle of 4in diameter with plywood end pieces. The 4 tapping points should be at 50 turns, 12 turns and at 3 turns. L_2 is 30 turns of 32 S.W.G. enamelled copper wire wound tightly over coil L_1. L_2 is 30 turns of 32 S.W.G. enamelled copper wire wound tighly over coil L_1. L_2 is tapped at 15, 8 and 4 turns. C_2 is 100pF silver-mica or ceramic fixed capacitor. X_1 is any good quality crystal diode. C_1 variable capacitor of 300pF-500pF. High impedance earphones of 1000 ohms or more are to be preferred.

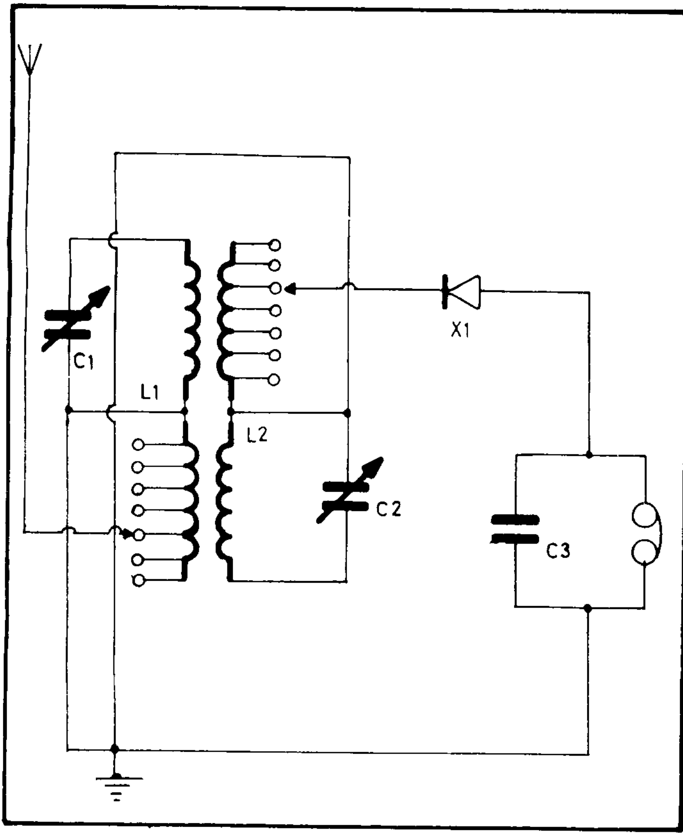


This uses components of identical value . The coil L is again 100 turns of 22 S.W.G. enamelled copper wire wound 4ins diameter.

* SPECIAL NOTES *

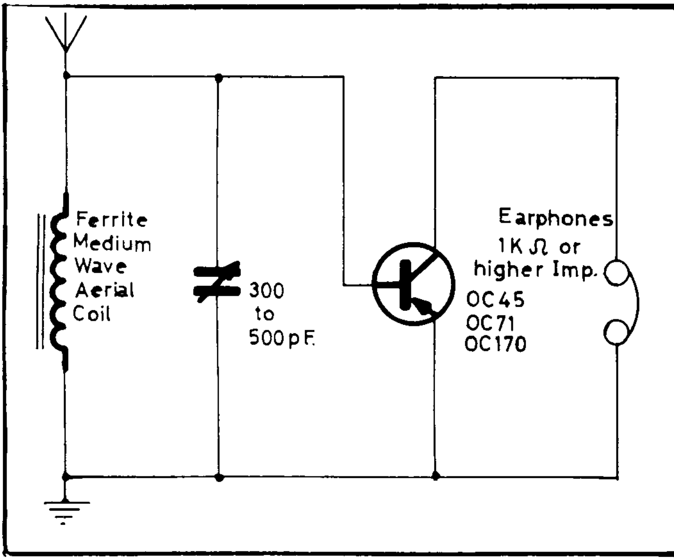
It is most strongly recommended that when constructing any of these circuits that VEROBOARD be used as the basis in the whole assembly. By using VEROBOARD constructors will simplify, speed up and reduce any possibility of error. VEROBOARD may be obtained in a number of suitable sizes from virtually any radio components stockists.

Suitable coils for use in many of the circuits shown in this book may be obtained from a number of manufacturers, these include REPANCO, OSMOR, DENCO etc. These types of coils are obtained from most radio component dealers. It is recommended that the constructor make his own coils from the winding data supplied where large diameter coils are required.

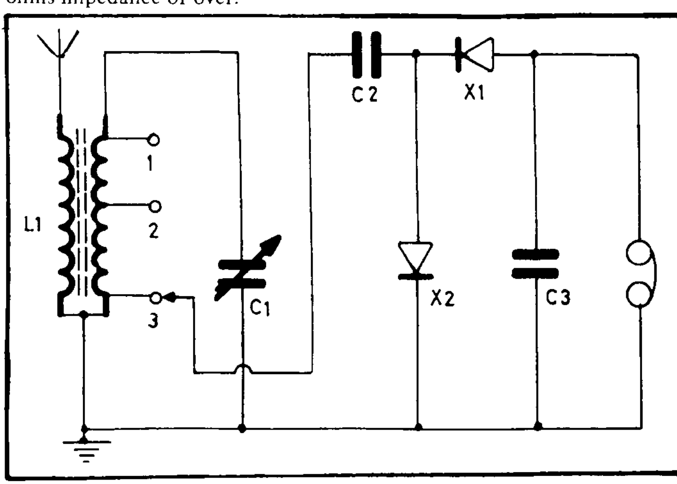


This is a special circuit with superb performance using 2 identical coils shown in Fig.30. These are to be placed exactly 4in apart i.e. centres 8in apart. C_1 and C_2 are two 300pF-500pF variable capacitors, C_3 being a fixed silver mica capacitor of 100pF.

This uses any good transistor as the high sensitivity detector in this circuit. No battery is used. This high gain receiver, which will give good results, if carefully built. Once again any good diode may be used for X_1 and high sensitivity earphones are the preferred requirement here.

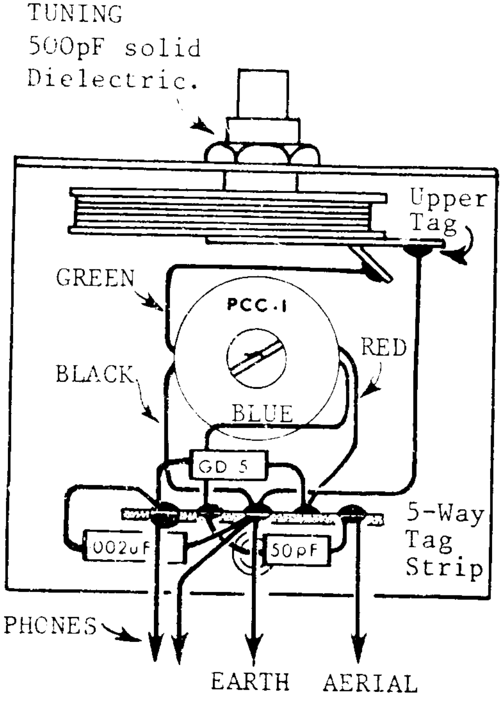


A very unusual design of crystal set using 2 diodes, L_1 and L_2 is a staddard ferrite aerial coil with tapped secondary for increased selectivity. C_1 is 300pF-500pF variable capacitor. C_2 and C_3 are 100pF fixed silver mica capacitors. X_1 and X_2, these two diodes are not critical but should be of the same type. The headphones or earpiece to be 1000 ohms impedance or over.



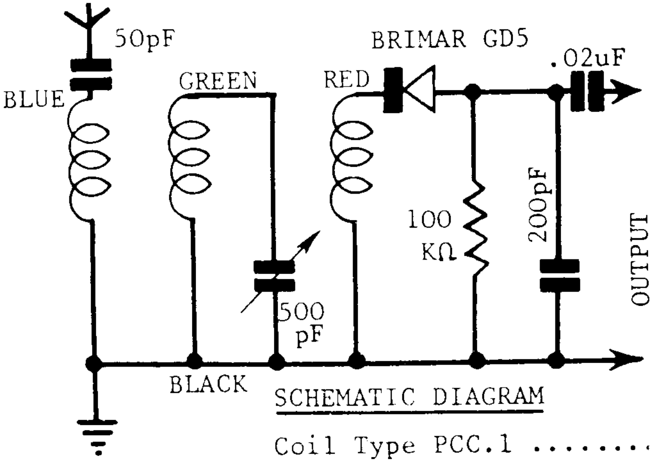
Crystal Receiver
Medium Wave Coil Type PCC.1

The author of this book particularly recommends to constructors who propose to build their own crystal set receivers to follow the instructions most carefully given in the text. However, if any readers have difficulty in making any of the components i.e. coils etc.. it is suggested that they use crystal set coils made by Denco (Clacton) Limited Type PCC1 details and circuit diagrams are shown herewith.



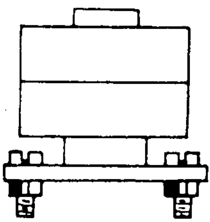
WIRING LAYOUT

These coils are most highly recommended. They also produce efficient components including high efficiency variable capacitors, ferrite rod aerials and multi-wave band coil sets. Many of these Denco com-



SCHEMATIC DIAGRAM

Actual Size



Coil Type PCC.1 ....
Germ. Diode GD.5 ....
500pF. Solid Dielectric
Variable Condenser....
5-Way Tag Strip ....

ponents can be obtained from your local radio component dealer but, in case of difficulty, write direct to this company at the following address:-

Denco (Clacton) Ltd.,
357/9 Old Road,
Clacton on Sea
Essex

Tel : Clacton 22807

This company will then either inform you of your nearest stockist of Denco components or, in case of difficulty, will be able to supply you direct - cash with order.

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