A modern regenerative receiver for shortwave listening

The All-Wave Three

Here is an inexpensive receiver to introduce you to the joys and mysteries of shortwave listening. Using just two transistors, a few diodes and one integrated circuit, the "All-Wave Three" as we have called the receiver, is surprisingly efficient in pulling in those distant shortwave stations. And it covers the broadcast band too.

by IAN POGSON

While there are many sensitive commercial shortwave receivers on the market which really do represent excellent value for money, the "All-Wave Three" is the do-it-yourself receiver which will appeal to the many readers whose budget does not run to several hundred dollars or more. Not that we are claiming that this under $50 unit will outperform those classy commercial receivers — far from it. But we can guarantee a great deal of enjoyment for relatively little outlay.

At the same time as saving a lot of money, the would be constructor will have the benefit of putting the "All-Wave Three" together. And with an efficient aerial and a modicum of operating skill, budding DX enthusiasts will be really enthused at the number of stations they can log. Interested? Then read on.

To get some idea of what it is all about, let us have a look at the circuit. The first stage is a regenerative RF amplifier using a 2N5485 JFET. Each coil, with the exception of the broadcast coil (L1), has two windings: a tuned winding and a feedback "tickler" or reaction winding. The antenna is connected to a tap on the tuned winding and this winding is tuned to the wanted signal with a variable capacitor of about 400pF maximum capacitance. Feedback via the respective coil winding is controlled by a 1k potentiometer in the FET source circuit. By varying the amount of resistance in the source of the FET, we vary the gain of the stage and so the amount of regeneration.

There is also a fixed resistor of 100 ohms in the source circuit of the FET bypassed by a 0.1uF capacitor to provide a minimum working bias.

Due to the relatively high current taken by the FET and the modest supply voltage, it is necessary to use a 2.5mH RF choke as the drain load. This provides a high impedance load for RF signals but is a low resistance to DC.

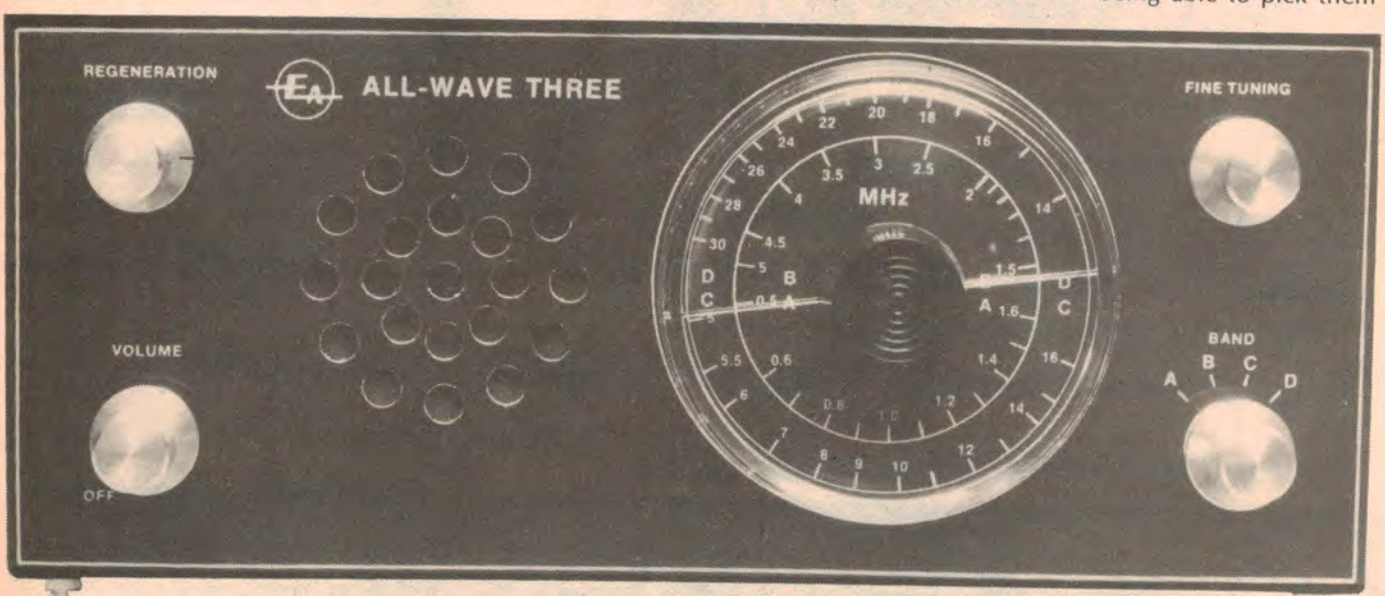
It was found during development however, that the characteristics of the RF choke were not conducive to smooth operation over the very wide frequency range from 500kHz to 30MHz. The solution was to damp the RF choke by placing a resistor in parallel with it. Furthermore, it was also found that the value of this damping had to be varied for each of the ranges.

In order to keep costs down, we have used a simple handspan dial to drive the tuning capacitor directly. This is all right for tuning the stronger broadcast stations but when it comes to tuning the weaker shortwave stations, then the extra "bandspread" afforded by the fine tuning knob makes tuning very much easier. A varicap diode is connected across the main tuning circuit and a 10k potentiometer controls its capacitance.

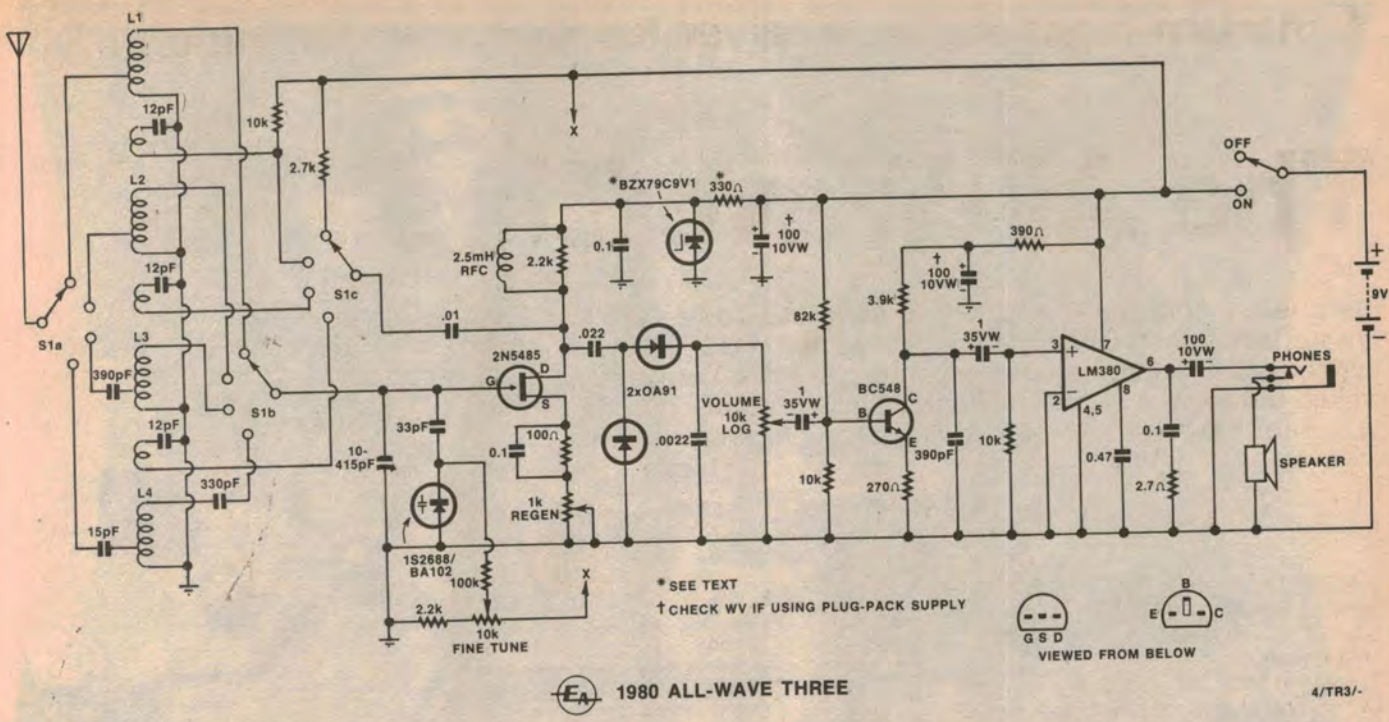
Following the RF stage is a half-wave voltage doubling detector consisting of .022uF and .0022uF capacitors and two germanium diodes.

The audio amplifier which follows is built around the popular LM380. Because of the fixed gain of 50 of the LM380, we added a transistor preamplifier to increase this gain to a more usable value. The LM380 is capable of driving a speaker of 8 or 16 ohms.

As well as providing a small loudspeaker mounted on the front panel, we have also made provision for connection of a set of low impedance headphones. When you are listening to those really distant or weak stations, headphones can make all the difference in being able to pick them



With a good antenna and skilful operation of the controls, many distant shortwave stations can be heard.



Four toroidal coils are used to cover a frequency range from 0.5 to 30MHz in this easy-to-build regenerative circuit.

out from the noise.

We have provided for battery operation but this little receiver can be run from the mains, using a plug-pack power supply which will deliver more than nine volts but no more than about 12V DC, at up to about 100mA. For this situation provision has been made on the PCB for a series resistor and a 9V zener diode to be fitted. This supplies the RF amplifier with regulated 9V, while the rest of the receiver is fed directly from the plugpack.

For battery operation omit the zener diode and replace the series resistor with a link.

At the time of writing, all the components used in the All-Wave Three are available but at the same time, some comments on some of the items may be helpful.

In order to further reduce the cost of building this project, many readers may by able to salvage some components from old radio and possibly television receivers. While we used new components in the prototype, there is no reason why you should not save a few dollars here and there.

It is important to use the same toroidal formers for the coils as used on the prototype, to ensure that the dial calibrations track and to obtain similar performance generally. We obtained our toroids from Watkin Wynne Pty Ltd, 32 Falcon Street, Crows Nest, NSW 2065. From the same source, we also obtained the Roblan 10-415pF variable capacitor, the Jabel wave-change switch and the handspan dial. These items should normally be available from your local supplier.

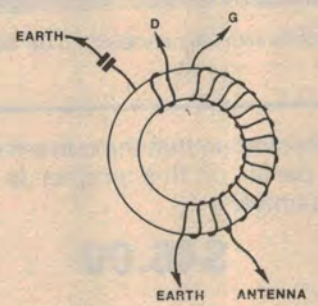
The Scotchcal front panel overlay gives a professional finish to the unit and provides the extra facilities of dial calibrations and functions. Ready made panels may be obtained from Radio Despatch Service, 869 George St Sydney, or you may make your own from the full size reproduction of the panel which we have provided.

We used a metal "L" shaped chassis to accommodate all the components and PCB assembly. Readers may do the same, or it would be possible to mount the printed circuit board on a wooden base but an earthed metal front panel is a "must" in order to minimise hand capacitance effects when tuning.

Whatever physical arrangement you use, it is very important that you make the finished assembly quite rigid, for frequency stability. The assembled chassis may be fitted into a suitable cabinet to improve the overall appearance.

Although the All-Wave Three is a modest little receiver, there is quite a deal of work to be done to build it. However, by using a PC board the job is somewhat simplified and the chance of making wiring errors is also reduced. There is no particular order in which the job should be tackled but all subassemblies should be made up first.

A logical place to start is to wind the toroidal coils. All of the relevant information is given in the coil table and should be followed closely. To ensure that the coils perform similarly to those on the prototype, it is important to use the gauges of wire as called for in the table, otherwise there will be deviations from the original windings and it is possible that the calibrations on the dial will be inaccurate.



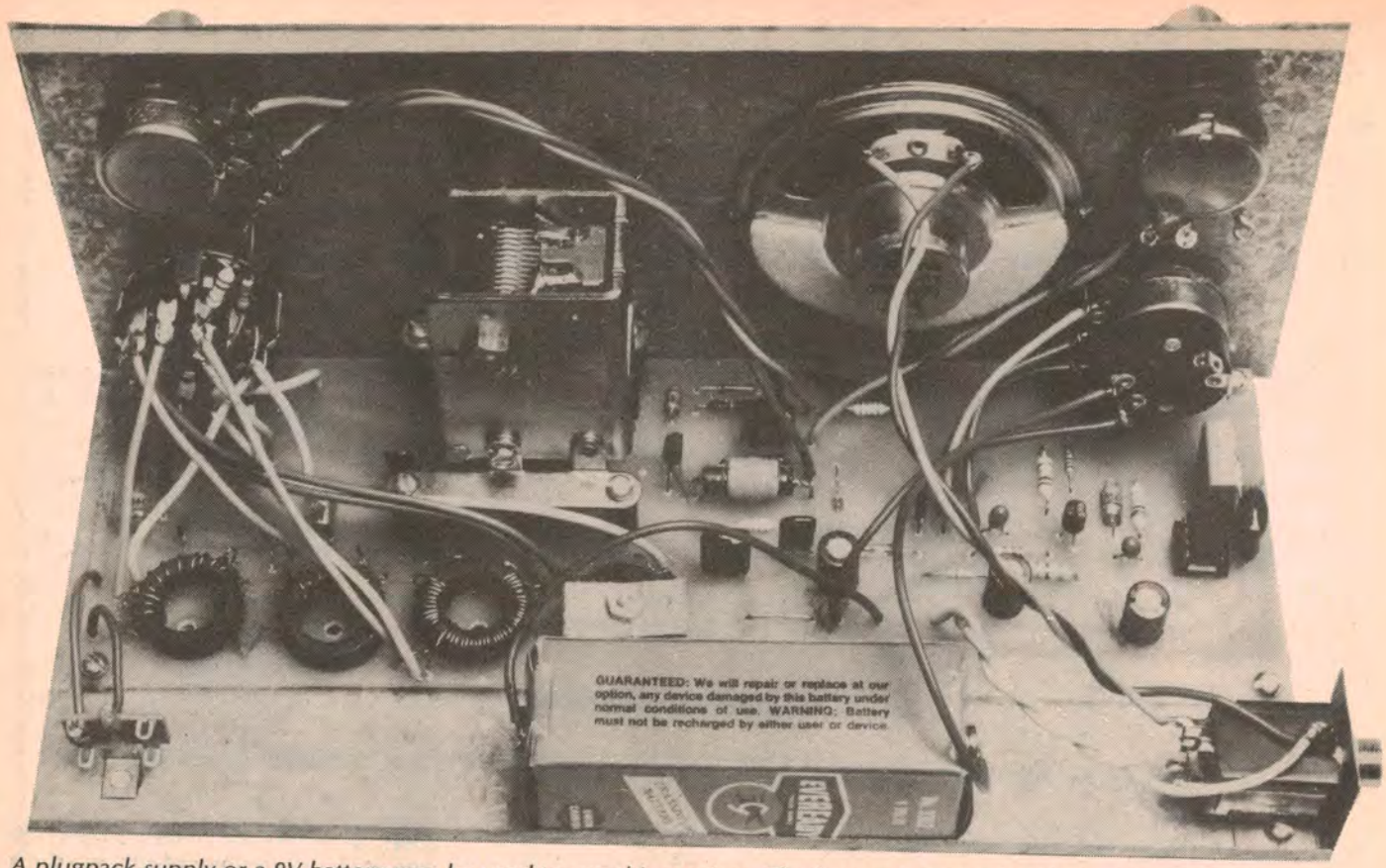
COIL DETAILS

L1 Tuned winding: 90 turns tapped at 5 turns, 30 B&S enamel wire close wound to occupy about 80% of toroid.

L2 Tuned winding: 30 turns tapped at 4 turns, 24 B&S enamel wire close wound to occupy about 45% of toroid. Reaction winding: 11 turns 24 B&S enamel wire close wound and spaced from the gate end of the tuned winding by about 2mm.

L3 Tuned winding: 8 turns tapped at 1 turn, 24 B&S enamel wire spaced to occupy about 30% of toroid. Reaction winding: 3 turns 24 B&S enamel wire on the same pitch and spaced from the gate end of the tuned winding by about 2mm.

L4 Tuned winding: 4 turns tapped at 1 turn, 24 B&S enamel wire spaced to occupy about 20% of toroid. Reaction winding: 2 turns 24 B&S enamel wire on the same pitch and spaced from the gate end of the tuned winding by about 2mm.



A plugpack supply or a 9V battery may be used to run this receiver. The battery is secured with double-sided adhesive tape.

When assembling the PCB it is usually best to start with the small components, such as resistors and diodes, followed by capacitors and then the larger components. It is important to note that the coils vary in the way they are orientated on the board. This has been done to keep the wiring orderly.

We have clamped the broadcast coil to the PCB using a small piece of stiff cardboard cut to shape and secured with a screw and nut. The other three coils are wound with a heavier gauge of wire and this enables them to be located and held without clamps.

Before mounting the variable capacitor, the four pads on the copper where the capacitor is screwed down should be lightly tinned with solder to ensure a good earth return to all four points. The capacitor is stood off the board with four 12mm long tapped brass spacers, and secured with eight round head screws. Before screwing the capacitor in place, a piece of tinned copper wire is wrapped around the fixed plates lug under the capacitor and soldered. It should be long enough to protrude through the appropriate hole in the PCB, where it will be soldered later on.

The "L" shaped chassis may be bent up from a piece of scrap aluminium, or you may use a metal front panel and a piece of wood for the baseboard. In either case, care must be taken to get all the dimensions correct, so that the variable capacitor spindle passes through the exact centre of the circular dial scale on the front panel. With the tuning capacitor fixed as to position, the correct height may be obtained by adjusting the height of the stand-off screws which are used to hold the PCB to the base board or the chassis metalwork.

We estimate that the current cost of parts for this project is approximately

$46.00

This includes sales tax.

The mounting centres for the other four controls are marked on the front panel artwork. With these controls fixed to the panel, this only leaves the speaker to be fixed. As it is only very small and lightweight and with no provision for screws, the speaker may be glued to the front panel, using an epoxy resin adhesive.

We mounted the headphone jack behind the PCB at the left side of the chassis. The antenna and earth terminals consist of a miniature tag strip fixed to the chassis at the opposite end to the headphone jack. In-between, is ample space for an Eveready 2362 9V battery.

Considerable care should be taken when terminating all the leads from the PCB. This applies particularly to the leads from the coils to the band switch. It should go without saying that leads should be as short and reasonably direct as possible, particularly from the coils and the volume control.

When fixing each of the knobs to the spindles, due regard should be given to the direction of the pointer. In the case of the switch-volume control, with the switch in the "off" position, the pointer should correspond with this marking on the panel. The regeneration control pointer should also point in about the same direction with the rotor in the extreme anti-clockwise position. Obviously, the pointer of the wave-change switch should point to the correct band.

The handspan dial for the main tuning scale is a push fit onto the capacitor spindle and the cursor should be set exactly horizontal when the capacitor moving plates are fully closed. The fine tuning knob should be set so that with the rotor and the knob pointer vertical, somewhere between the extremes of travel, rotating the control in each direction will give equal amounts of frequency tuning. This will have to be set after the receiver has been put into operation.

At this stage, the unit is almost ready for testing. Before proceeding however, all work should be thoroughly checked. Make sure that all components are in the right place and that polarities are correct. All wiring should also be checked for accuracy. Satisfied that all is well, the battery may

be connected, also with due regard to polarity.

USING THE ALL-WAVE THREE

Here are some pointers which should be useful as a guide to the tuning and operation of this kind of receiver.

For the reception of morse code or "CW" signals, the RF amplifier is brought to the point of oscillation and then the signal is tuned slightly to one side or the other, thus producing a signal or beat note. The note is selected to suit the convenience of the listener. The side selected does not matter but if interference is present it can often be avoided by selecting a particular side.

When the reaction or regeneration in the RF amplifier is increased, the sensitivity is also increased and selectivity is sharpened as well. Sensitivity and selectivity reach a maximum just at the point of oscillation. For the reception of AM signals, the regeneration should normally be set just below the point of oscillation. However, when attempting to receive very weak signals which are not satisfactory under these conditions, it is often possible to copy them if the RF amplifier is made to oscillate and the signal carefully tuned so that there is no whistle.

For SSB reception, the RF amplifier is also made to oscillate and the signal is resolved by carefully tuning for the best speech quality. It is important to note that when the RF amplifier is made to oscillate for all the conditions just mentioned, there is no point in advancing the regeneration control beyond the position where reliable oscillation is achieved.

Another important point concerns adjustments for volume with strong AM signals. Do not back off the regeneration control if the volume is too high. This practice will certainly reduce the volume, but the selectivity will be seriously degraded as well. The correct procedure is to leave the regeneration at maximum and use the volume control. For CW and SSB reception, the question does not arise, since the volume level can be adjusted only with the volume control.

As mentioned earlier, we have used a direct drive dial for the main tuning and this has been supplemented with a "fine tuning" control. In practice, particularly on the higher frequencies, the main tuning control should be set about the middle of an immediate tuning range of interest. This setting is then maintained and tuning for each individual signal is carried out by the fine tuning control. When the range of the fine tuning control is insufficient to proceed further, then the main tuning control should be readjusted.

SUITABLE ANTENNAS

This could be quite a topic in itself. For best results over the full coverage of the receiver, a number of different types of antenna would be desirable. The needs will vary according to the location and the frequencies on which most interest rests. In addition, a good earth connection is required. A fairly

PARTS LIST for the All-Wave Three

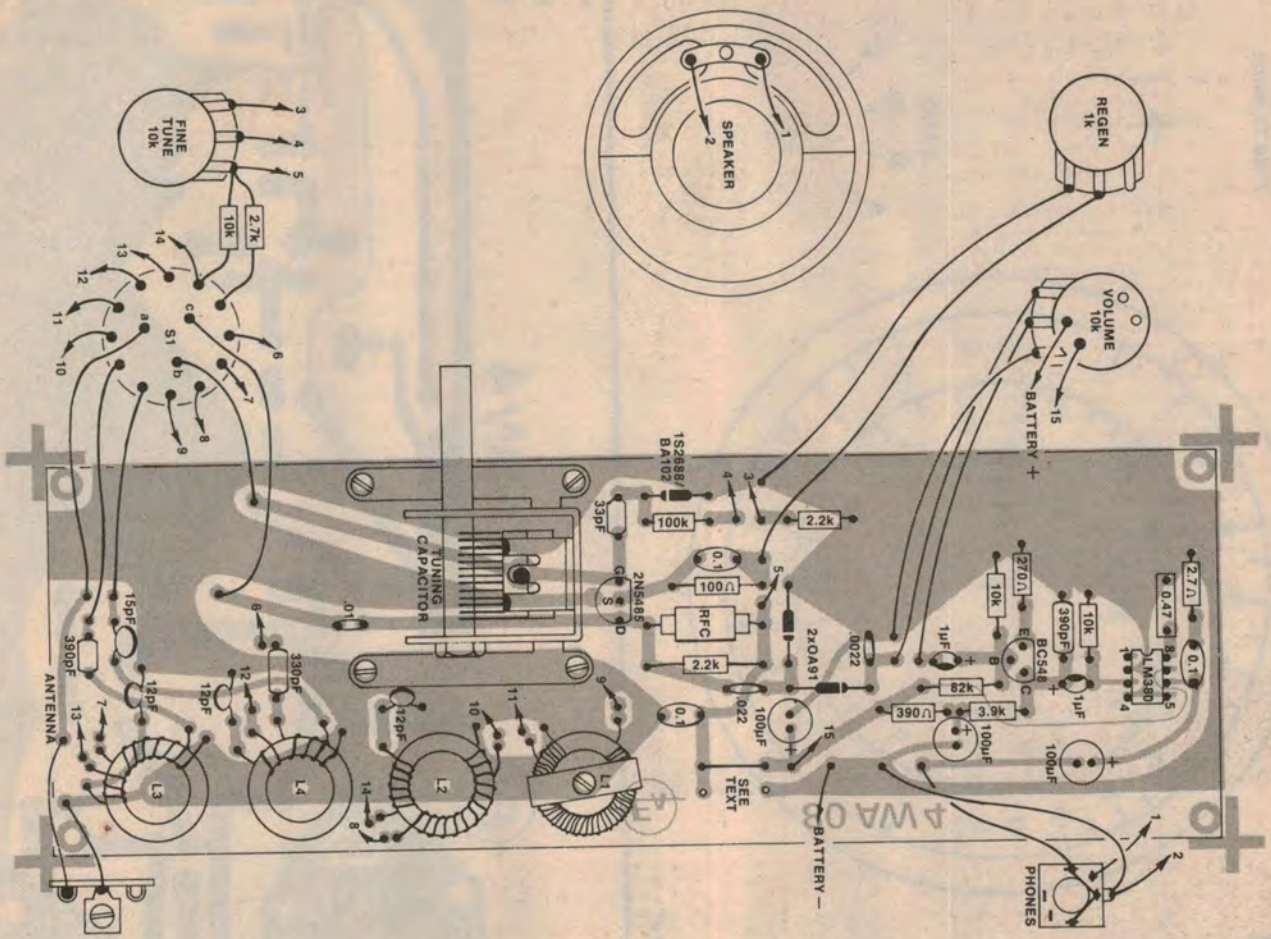
1 Front panel 239 x 98mm
1 Metal chassis 239 x 98 x 106mm
1 Cabinet to suit (optional)
1 6.5mm stereo jack socket, to suit headphones
1 miniature tag strip, 3-tags
1 60mm miniature loudspeaker
1 1k (linear) potentiometer
1 10k (linear) potentiometer
1 10k (log) potentiometer with switch
1 3-pole 4-position Jabel rotary switch
1 Jabel "handspan" dial knob
4 knobs
1 PCB 229mm x 76mm, code 80aw4
1 Roblan single gang variable capacitor 10-415pF
4 12mm tapped brass spacers
4 Neosid toroid formers 4329R/2/F5
1 2.5mH RF choke
1 IC socket 8-pin DIL
1 2362 9V battery
1 BC548 NPN transistor
1 2N5485 JFET, or similar
2 OA91 diodes
1 1S2688/BA102 varicap diode
1 BZX79C9V1 zener diode
1 IC LM380 8-pin DIL

RESISTORS (½W)
1 x 2.7 ohms, 1 x 100 ohms, 1 x 270 ohms, 1 x 390 ohms, 2 x 2.2k, 1 x 2.7k, 1 x 3.9k, 3 x 10k, 1 x 82k, 1 100k.

CAPACITORS
3 12pF NPO ceramic
1 15pF NPO ceramic
1 33pF polystyrene
1 330pF polystyrene
2 390pF polystyrene
1 .0022uF metallised polyester (greencap)
1 .01uF greencap
1 .022uF greencap
3 0.1uF greencap
1 0.47uF greencap
2 1uF/35VW tantalum
3 100uF/10VW electrolytic

MISCELLANEOUS
Screws, nuts, solder, hookup wire.

NOTE: Ratings are those used on the prototype. Components with higher ratings may generally be used providing they are physically compatible. Components with lower ratings may also be used in some cases, provided the ratings are not exceeded.



A printed circuit board and switched coils make this receiver easy to assemble.

heavy gauge of wire should be run to the nearest water pipe and clamped to it.

As a guide, for the broadcast band and frequencies up to about 3MHz, a random length antenna wire would be suitable. This may be inside or outside and of such a length as suits local conditions, proximity of wanted stations, etc. For general shortwave reception, the "Twin Doublet Aerial" as described in the issue for November, 1963 would be very suitable. If on the other hand the amateur bands are of prime interest, then an antenna designed especially for these bands would be the logical choice.

Attempting to test the prototype in our City laboratory proved to be a rather frustrating procedure. To be sure, we received all of the local Sydney broadcast stations very well. However, when switching to the shortwave bands, just about all we got was electrical noise. Also, during daylight hours at the time, there was very little in the way of shortwave signals coming through, although there would be plenty to listen to in the evenings. So, I took it home.

I connected a multi-band aerial designed for amateur frequencies to the set and it burst into life. From very early evening and for the next couple of hours, I received literally hundreds of overseas shortwave signals. Many were not identified due to lack of time but such places as Switzerland, Moscow, Peking, London, Voice of America, standard time and frequency signals, were all there. Some amateur signals on 3.5MHz and 7MHz, as well as some CBers on 27MHz were also logged.

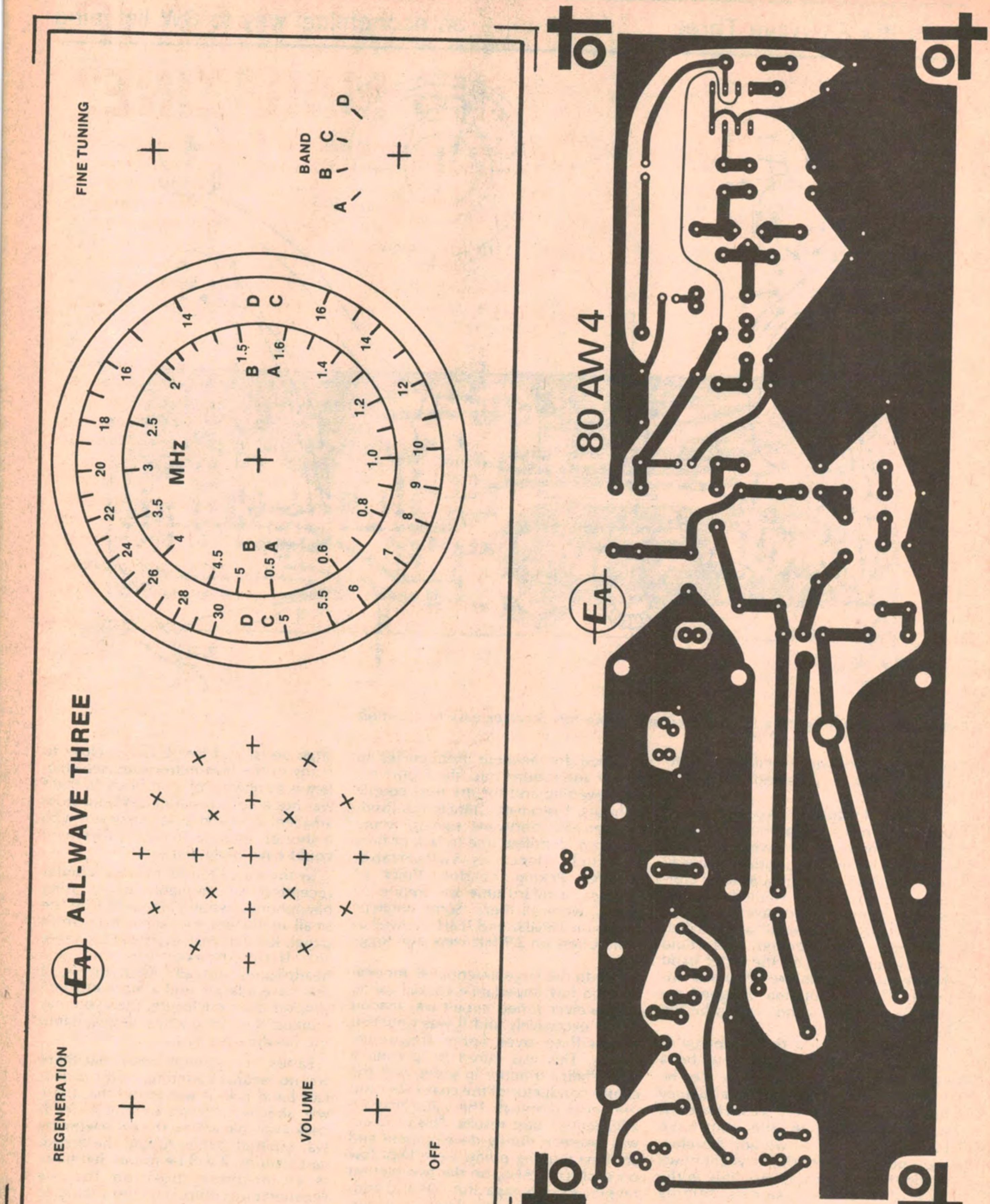
Due to the large antenna (40 metres) and the low impedance coaxial cable, the receiver tuned circuit was loaded rather excessively and it was reluctant to oscillate over some frequency ranges. This was cured by placing a 60pF Philips trimmer in series with the centre conductor of the coax cable and the aerial terminal. The value may be adjusted for best results. This problem was foreseen during development and antenna tapping points were kept low on each coil. Also, on the two highest ranges, a series capacitor was also added. However, for very large antennas, the extra trimmer capacitor was found to be necessary.

On the broadcast band, with the very large aerial and being rather close to many of the transmitter sites, selectivity was somewhat of a problem, in that I was not able to separate 2WS out from adjacent 2CH and 2SM. However, with a shorter antenna some improvement could have been achieved.

By the way, I found that much better reception was available when using headphones, when compared with the small inefficient speaker on the front panel. Readers may even elect to leave the little speaker out and use headphones instead. Alternatively, if you have a larger and a more efficient speaker in an enclosure, then you may connect it up simply by plugging it into the headphones jack.

Earlier, it was mentioned that there was no feedback winding on the broadcast band coil. It was found that there was already a certain amount of feedback available and so the extra winding was omitted. When tuning the broadcast stations, it will be found that there is an optimum position for the regeneration control and this should be kept in mind.

So there it is. Connect up the antenna and go to it.



Here is the full-size artwork for the front panel and PCB.