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Building the best 2-3 valve radio receiver

Almost every year, the Vintage Radio Club of North East Victoria runs a competition called the "Hellier Award". The challenge is to build an item of equipment, usually a radio receiver, to see who can produce the best result.

Eric's 1967 All-Wave-Two was built on a simple folded aluminium chassis and is neatly laid out. The addition of a "band-spreading" capacitor in parallel with the main tuning gang should make tuning a breeze.

THE PROJECTS FOR the Hellier Award are designed to stretch members' abilities and this year's project was to produce a 2-valve radio receiver. What made this a challenge was that each valve could have more than one active device in the one envelope. Valves such as the 6BL8, which has both pentode and triode sections, could be used or going even further, a 12-pin Compactron valve such as a 6AF11 could be pressed into service.

The 6AF11 incorporates two triodes and a pentode in the one envelope, so just imagine the sort of set that could be built using a couple of Compactrons – if you could obtain them.

If the set was to be mains-operated, then the rectifier valve was excluded from the valve count. In addition, the set could be a broadcast-band or multi-band unit, it could be housed in a suitable cabinet and it could have either loudspeaker or headphone output or both. Both superhet and tuned radio frequency (TRF) receivers were eligible for the 2010 competition.

Unfortunately, a few members ran out of time to produce a suitable entry, including yours truly. In the end, four members came up with workable sets, all of them TRF receivers.

One receiver was a variant of the "1955 Miniature DXer" while another was based on the "1958 Basic Three", both originally described in "Radio & Hobbies" (the forerunner of "Electronics Australia" magazine). The other two sets were based on the "1967 All-Wave-Two" from "Electronics Australia".

Only one entrant (Dennis) built a cabinet, which made his entry complete and he was also judged the winner. Dennis's cabinet is based on the "Aristocrat 3", circa 1931.

As can be seen from the photographs, the construction techniques used varied somewhat. We'll look at each set in turn a little later on.

The 1967 All-Wave-Two

This little TRF receiver was originally published in "Electronics Australia" in June 1967. It has some interesting design features that overcome some of the limitations of a regenerative TRF receiver, with the first stage functioning as both an RF amplifier and a detector.

A common problem in most TRF sets occurs because antennas are a complex combination of inductance, capacitance and resistance. In combination with the RF coil, this combination gives rise to a number of resonances across the tuned frequency range, especially in multi-band receivers which cover from 500kHz to

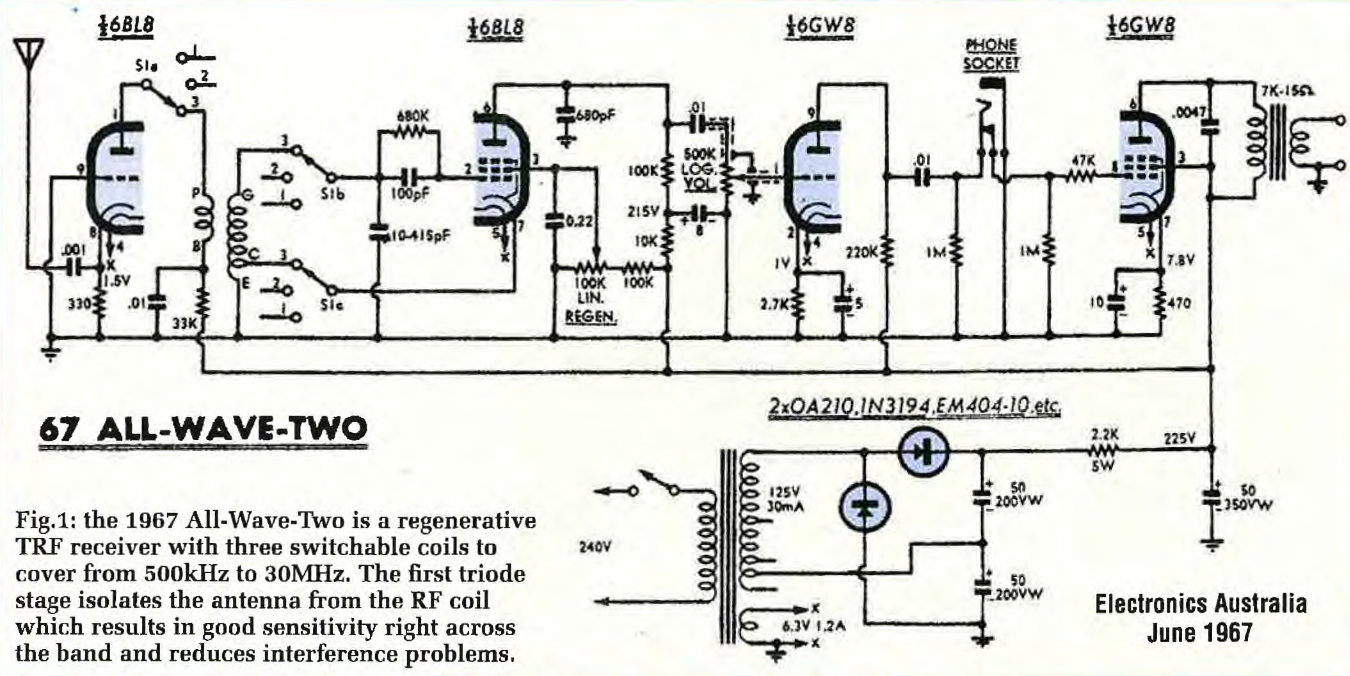


Fig.1: the 1967 All-Wave-Two is a regenerative TRF receiver with three switchable coils to cover from 500kHz to 30MHz. The first triode stage isolates the antenna from the RF coil which results in good sensitivity right across the band and reduces interference problems.

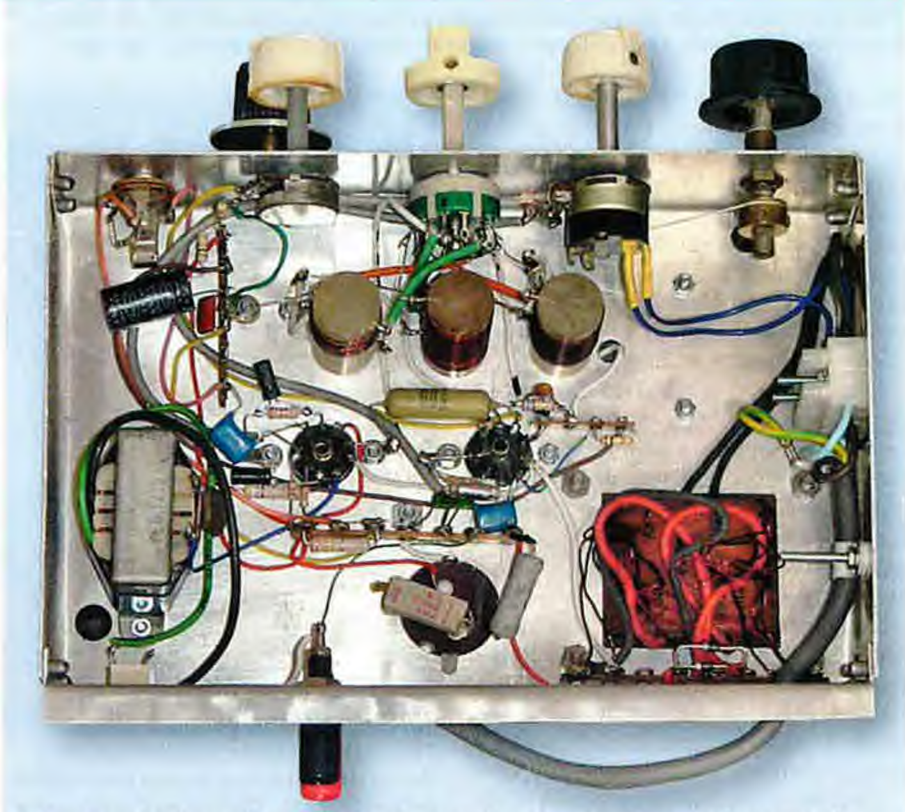
30MHz. The effect is to desensitise the front-end circuitry at these resonant frequencies.

This is due to the regenerated signal being "absorbed" by the antenna (which acts as a tuned circuit at some frequencies). As a result, it may not be possible to adjust the receiver so that it is just shy of going into oscillation, thus significantly reducing the gain.

This problem was overcome in the 1967 All-Wave-Two by using a triode to isolate the antenna – see Fig.1. This triode stage very effectively isolates the switched RF coil from the antenna circuit (more on this shortly).

As a bonus, this feature also makes life much easier for people listening to sets nearby. When the receiver is being used to listen to Morse code or single sideband (SSB) transmissions on shortwave, the detector circuit must be oscillating. In most sets, this injects a signal into the antenna which is then radiated (ie, the set acts as a transmitter). This signal then interferes with other receivers tuned to the same frequency nearby.

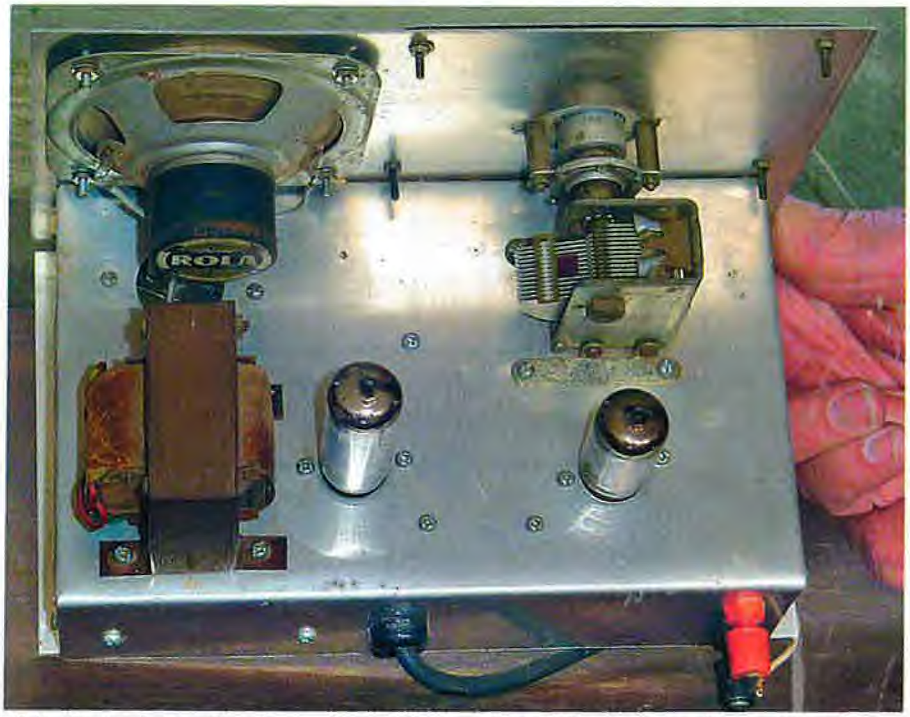
However, because the antenna is well isolated in the 1967 All-Wave-Two, that problem does not arise in this design. As shown in Fig.1, the first valve in this receiver is a 6BL8 or a 6U8. Its triode section is connected as a grounded-grid amplifier and the antenna is connected to the cathode. The output is taken from the plate as normal.



The three tuning coils in Eric's set are quite close together, so there may be some problems with mutual inductance upsetting the performance. All parts are readily accessible for servicing.

This configuration doesn't provide much gain but what it does do is to make the characteristics of the antenna relatively unimportant. It effectively smooths the operation of the regeneration on each band and reduces any radiation from the detector when it is oscillating.

By contrast, nearby receivers tuned to the same frequency are likely to receive interference if the regenerative detector is the first stage of a receiver



This photo shows the above-chassis views of David's version of the 1967 All-Wave-Two. It closely resembles the original "Electronics Australia" design.

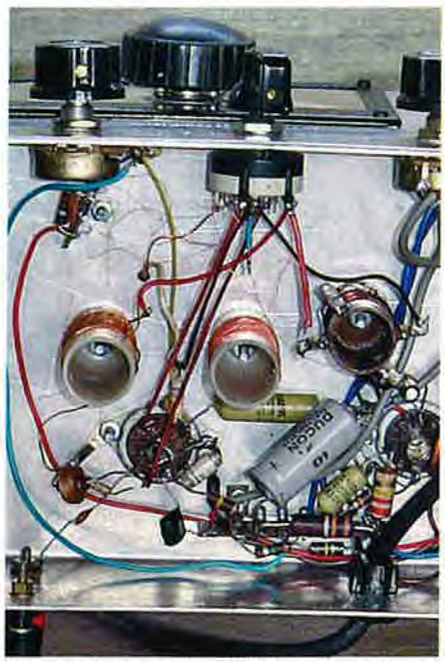
(as in most other TRF designs). However, after looking at this part of the circuit, I wonder whether the gain of the stage could be increased by inserting a small RF choke in series with the 330Ω cathode resistor. This resistor places a fairly heavy load on the antenna signals and isolating these signals from ground with a small RF choke could be worth a try.

The pentode section of the valve is used as a regenerative detector. Instead of having a tertiary winding for regeneration, the tuned winding is configured as a Hartley oscillator. The screen voltage is varied to control the gain of this stage and hence the point at which oscillation occurs.

This method obviates the need for a variable capacitor (eg, 100pF) regeneration control. These are now hard to come by and in any case, are more expensive than a carbon-track potentiometer.

The RF stage has three tuned coils and these are switched by a 3-pole, 3-position switch. As stated in the original article, these tuning coils must be carefully positioned, otherwise the mutual coupling between them (if great enough) can create sensitivity problems in some sections of the frequency band.

The audio amplifier is conventional and uses a 6GW8 triode-pentode. This stage then drives a loudspeaker via a



The coils are more widely spaced in David's set, leading to less interaction between them. The set performs quite well.

transformer and there is more than enough gain for most stations to be heard at good volume.

The power supply uses a mains transformer with a 125V secondary. This feeds two silicon diode rectifiers which are wired as a simple voltage doubler to derive a 225V HT (high tension) supply. Two 50μF 200V electrolytic provide the necessary filtering for this HT rail, while a 6.3V winding on the transformer feeds the valve heaters.

In summary, the 1967 All-Wave-Two is a good choice for this project. It is a simple design with band-switching to cover from 500kHz to 30MHz. It also has high gain and due to the carefully-designed front-end, is much more docile to use than many other regenerative receivers.

Eric's 1967 All-Wave-Two

Unfortunately, Eric didn't quite get his version of this receiver finished, so it can be considered a work in progress. And like most of the other entrants, he hasn't yet built a cabinet to house the chassis.

The chassis and front panel were both made out of aluminium sheet. The chassis was bent to suit and the edges riveted, while the holes for the valve sockets were made using a hole punch. The cut-out for the power transformer was made using a nibbling tool.

Most of the other holes in the chassis were drilled and these are fitted with rubber grommets where appropriate, to protect the wiring insulation. In a few cases though, the edges of the holes were simply chamfered to make sure no damage could be done.

Considerable care has been taken to ensure that no mains wires or terminals are exposed within the receiver. The cable is clamped and is sheathed with heatshrink tubing on all terminations, including on the on-off switch/volume control pot.

The layout of the coils is reasonably critical to avoid mutual inductance problems, as occurred to some extent in the original receiver described in "Electronics Australia". What happens is that the distributed capacitance of an unused coil resonates on a frequency that's covered by the next coil up the band. As a result, some of the energy in the selected coil at this frequency is coupled into the unused coil and this significantly reduces the performance.

In this receiver, provided the coupling between the two coils is not excessive, the problem can be overcome simply by advancing the regeneration control further than normal at the affected frequencies. However, if the detector cannot be brought into oscillation by the regeneration control, then it's necessary to modify the coil layout to solve the problem.

David's 1967 All-Wave-Two closely resembles the original "Electronics Australia" design. A cabinet will be necessary to protect the user from high voltages under the chassis

In fact, the original article offers a few suggestions to reduce the coil inter-coupling problem, including metal shielding and orientating the 2-8MHz coil at right angles to the other two coils. Taken together, these two techniques should virtually eliminate the problem.

In Eric's set, the under-chassis wiring is laid out so as to provide easy access to all valve pins. This makes it easier to troubleshoot the circuit later on, should it become necessary. However, the tuning coils are quite close together, so he may experience some of the problems referred to above. The speaker is mounted externally, which is different to the layout of the original.

Eric also added a low-value variable capacitor in parallel with the main tuning gang. This technique is called "band spreading" and makes it easier to tune single sideband (SSB) and Morse code transmissions on shortwave. Band spreading was a common technique in amateur radio receivers during the home-built era.

Unfortunately, Eric ran out of time with this set. The dial scales had not been completed by the judging deadline and the control shafts were also still at full length. In addition, on the day of judging, the set threw a "hissy" fit and refused to work when the speaker transformer decided it had had enough and the primary winding shorted to the frame.

Apparently the speaker had become disconnected whilst the output was at high volume. As a result, high voltages were developed across the speaker transformer primary and the insulation broke down because there was no load on the transformer.

It's a pity that Eric had not been able to complete the set by judging day, as its ability to easily tune SSB would have been interesting. Tuning SSB voice transmissions on shortwave is not usually easy with simple TRF receivers and Eric's band spread modification should make a big difference in this regard.

David's 1967 All-Wave-Two

David's receiver was also built on an aluminium chassis. Like Eric, he bent the chassis himself but instead of riveting it together, it is secured with self-tapping screws. The front panel has been rubbed down with steel wool and the finish looks good.

In fact, David's set more closely resembles the original set shown in "Electronics Australia". He hasn't made a cabinet for it but this will have to be done at some stage in the near future, if only to protect the user from dangerous voltages under the chassis.

The power transformer is mounted above the chassis and is secured in place using four screws. The mains cord is clamped with a through-hole cordgrip grommet and the chassis securely earthed.

The coils in David's set are more widely spaced than in Eric's receiver and so any interaction between them should be inconsequential. Basically, David has closely followed the original design when it comes to the component layout. As a result, the parts are a little crowded around the audio amplifier.

Once the set was performing satisfactorily, the dial scale was calibrated. The resulting receiver works quite well.

Ray's Basic Three 1958

"Radio & Hobbies" magazine (the forerunner of "Electronics Australia") occasionally described receivers that used valves that were older in vintage than those commonly in use at the time and the "Basic Three 1958" is one such receiver. The circuit is basically the same as that for the "Miniature DXer" of 1955. However, Ray's Basic Three uses a 6SJ7GT and a 6V6GT instead of the 6AU6 and 6BV7 valves used in the "Miniature DXer".

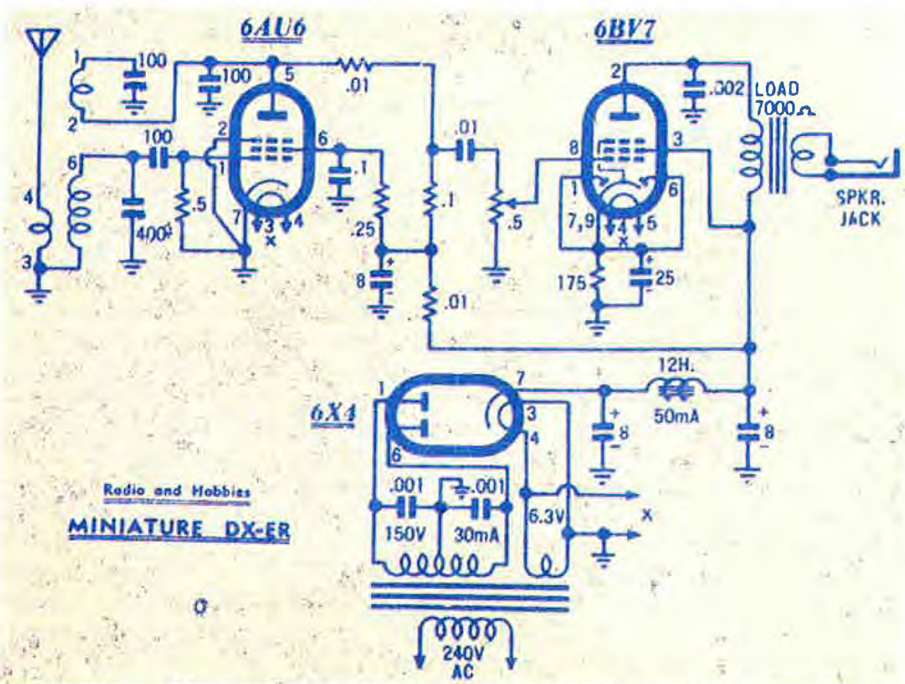
Most 2-valve regenerative receivers with just two active stages are almost identical to each other. In fact, it isn't hard to find your way around the circuit without a circuit diagram, although a diagram does makes working on a set somewhat easier.

As can be seen in the photographs, Ray's entry is not conventional in presentation. It is built more like a display item, with the valves, controls, major components, speaker and transformers all mounted on one flat sheet. No part of the receiver is mounted on the wooden surround. The oval-shaped loudspeaker faces upwards and is protected by perforated aluminium mesh which covers two large round holes directly in front of the cone.

Unlike the other entries, the mains input to this receiver is via a male IEC socket. All the exposed mains terminations have been covered with heatshrink tubing to ensure safety and the mains wires have been secured with cable ties. The wiring is neat, with easy access to all the valve and coil pins at their respective sockets.

The first stage uses five plug-in tuned coils to cover from 500kHz to 32MHz, with generous overlapping of each range. Each of these coils was wound onto PVC tubing, which was then glued onto an octal plug. The coils are inserted as required into a

Ray's 1958 Basic Three is built like a display item, with the major parts clearly labelled. It uses five plug-in coils to cover from 500kHz to 32MHz



The circuit used by Ray is basically the same as that for the "Miniature DXer" of 1955 (also used by Dennis for his set). However, Ray's set uses a 6SJ7GT and a 6V6GT instead of the 6AU6 and 6BV7 valves shown here.

matching octal valve socket on the top of the chassis.

There are three windings on each coil assembly – the antenna coil, the tuned winding and the regeneration winding (also known as the reaction or tickler winding). The 6SJ7 valve is wired as a conventional regenerative detector.

Normally, an RF choke is wired into the HT feed to the plate of the detector to prevent RF from being passed to the following stage. However, an RF choke is not used in this instance as any inductor will have a resonant frequency or multiple resonant frequencies across the receiver's tuning range of 500kHz to 32MHz.

As a result, a 10kΩ resistor has been used instead and on the broadcast band, at around 530kHz, this has a greater resistance to RF signals than a 2.5mH RF choke.

The power supply uses a transformer that Ray wound on a lathe. One possible problem is that the speaker transformer is quite close to the power transformer. This is risky, since the power transformer can induce hum into the speaker transformer that no amount of filtering will eliminate. However, it looks as though Ray has been fortunate in this set, as there is no obvious hum.

One deviation from the original design is that the valve rectifier has been eliminated and replaced by a diode bridge arrangement. This is more compact and efficient than the valve rectifier used in the original design.

In practice, this set worked quite well and many stations can be heard on the broadcast band.

Dennis's Miniature DX Set

Dennis's Miniature DX Set from 1955 uses a similar circuit to Ray's but its execution is very different. That's because Dennis's interest in vintage radio leans heavily towards sets with beautifully-finished timber cabinets.

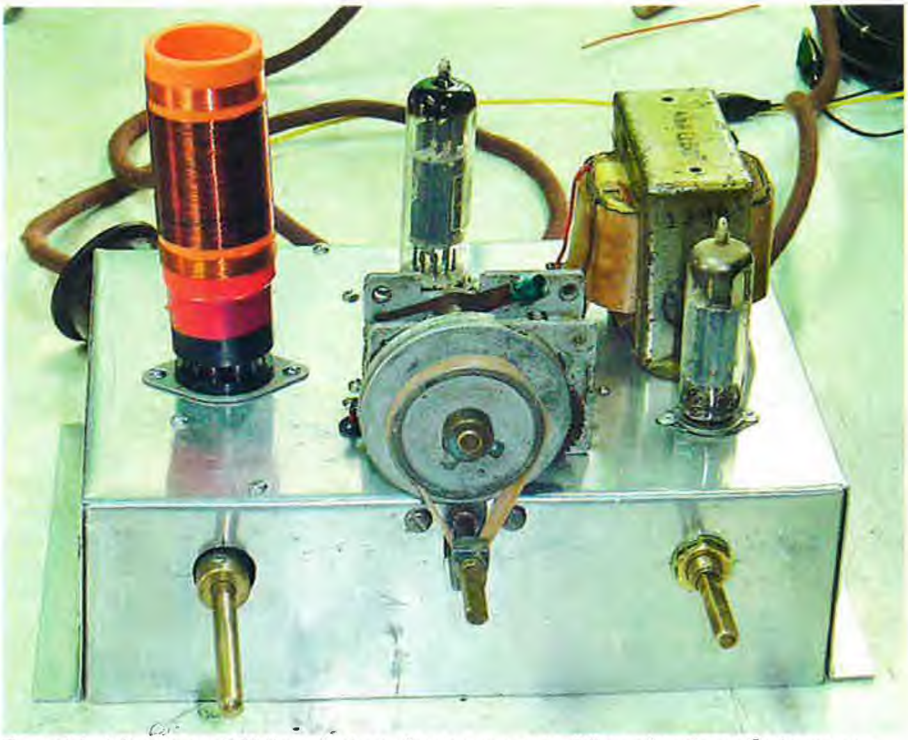
Many years ago, Dennis came across some information on a set called the "Aristocrat Three". During its heyday, this set was advertised as the "1931 Wonder Receiver" and one of its main features was its attractive tower-style timber cabinet.

Dennis decided to reproduce this cabinet for one of his own sets and because no dimensions were available, designed his replica just by looking at a photograph of the original. The cabinet was made from timber that Dennis recycled from some old furniture and is a tribute to his woodworking skills.

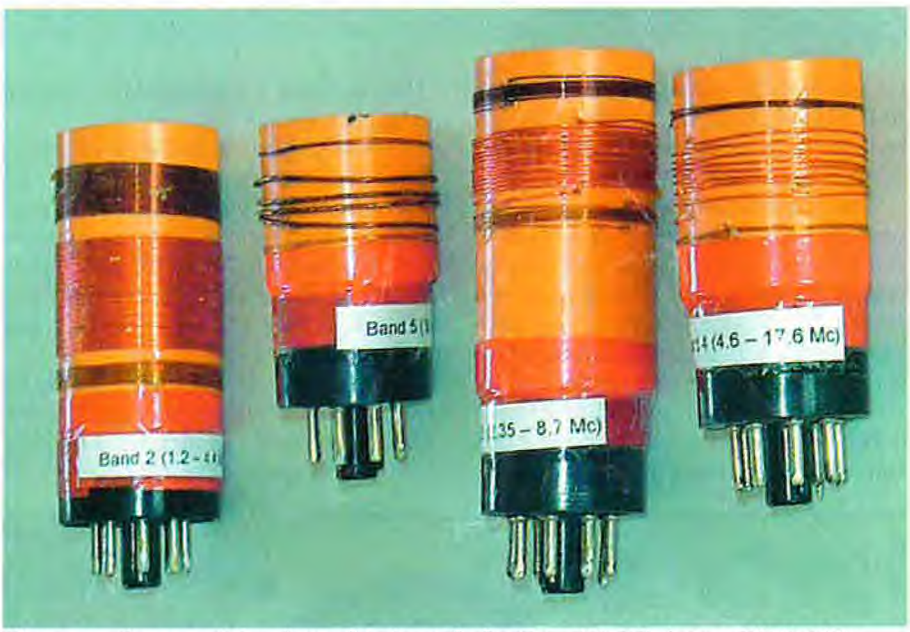
As well as functioning as a radio, the original set also had an "Eight Day Jewelled Movement Luminous Clock" and Dennis was able to obtain a clock that looked very similar. The dial-scale is also similar to the original but is made by Healing.

When the Hellier Award competition for 2009/2010 came along, Dennis decided that the Miniature DX Set would be suitable receiver to fit into his replica cabinet. The receiver is built on an aluminium sheet that has been cut, bent and riveted to make a conventional chassis.

The geared dial-drive system used by Dennis allows the Healing keyhole dial escutcheon to be used. The loudspeaker is mounted at the top of the cabinet facing upwards, as in the original "Aristocrat". In addition, the inside of the cabinet has been painted matte black – just like many sets of



Dennis's Miniature DX Set of 1955 also uses a set of five plug-in coils to cover the broadcast and shortwave bands. The rubber band fitted to the dial drive systems is a stop-gap measure only.



These are the remaining four plug-in coils for Dennis's Miniature DX Set (the fifth coil is shown in the chassis view above). Each coil is clearly labelled.

the valve era were. There is plenty of room for the chassis and there is also ample ventilation, as the chassis sits on raised wooden runners.

The circuit uses the valves originally specified for the Miniature DX Set, ie, a 6AU6 regenerative detector, a 6BV7 audio output (or alternatively a 6M5) and a 6X4 rectifier. The coil formers are made from old valve bases with electrical conduit glued to them. The five coils were then wound onto the conduits and terminated at the appropriate pins on the plugs.

During construction, Dennis fitted a valve that he believed to be a 6BV7 even though part of its type number had rubbed off. Unfortunately, the completed set refused work and after spending some time trying to locate the

The high point of Dennis's set is its beautifully-crafted timber cabinet, complete with a clock and a keyhole dial escutcheon. The loudspeaker is mounted inside the cabinet facing upwards.

fault, he eventually took the set to a friend who pointed out the valve was in fact a 6BM8. This valve is a triode pentode and is quite a different beast.

Unfortunately, this can be a problem with used valves which have missing (or partially missing) type numbers. If you aren't certain, then it's a good idea to compare the unknown valve's internal structure with valves that have their type numbers intact.

Having finally identified the mistake, Dennis then had to fix the problem. He didn't have a 6BV7, so he rewired the valve socket to suit a 6M5. That proved successful – with a 6M5 installed and power applied, the set burst into life.

The underside of the chassis is not unduly crowded, although access to the valve socket pins isn't as easy as it is in the other sets. In addition, one electrolytic capacitor has heat-producing resistors mounted underneath it. Fortunately, the heat produced by these resistors is quite moderate but as a general rule, it's best to keep parts like valves and high-wattage resistors clear of other components to ensure long-term reliability.

One problem with Dennis's set is that he has temporarily "anchored" the mains cord by tying a knot in it, just inside the chassis. This was common practice back in the 1940s and 1950s but it's no longer acceptable and Dennis has promised to remedy this at the earliest opportunity.

Despite this, his set was judged to be the winner in other areas and it's not hard to see why, especially with that beautifully-crafted cabinet. **SC**