Vintage Radio

By Rodney Champness, VK3UG

The AWA Radiola 523-M: the last vibrator-powered radio

Battery/vibrator-powered domestic radios started life in the 1930s and continued to be manufactured in Australia until the late 1950s. They were still used in some areas of rural Australia well into the 1970s. Here we take a look at AWA's battery/vibrator-powered Radiola 523-M, a 4-valve superhet design with some interesting features.

WHAT EXACTLY IS a vibrator? Well, it's not what you might be thinking, a least not as used in battery-powered valve radios. In operation, a vibrator converted a low battery voltage (typically 2-32V) to a much higher voltage, necessary to power the valves used in battery-operated receivers.

A vibrator is basically an electromagnetic switch that opens and closes a set of contacts at a fixed frequency of 50-150 times per second, depending on the particular circuit it's used in. It's either a double-pole or 4-pole switch that switches DC power one way and then the other through the centre-tapped primary winding of an iron-cored transformer.

This rapid switching results in a waveform across the winding that approximates the waveform from an AC supply. The secondary winding has many more turns on it than the primary and so a much higher voltage is produced across it. The secondary is also centre-tapped and its AC output is converted to DC by a second set of points in the vibrator. These are synchronised with the first set of points, hence the name "synchronous vibrator".

Synchronous vibrators are the most likely type to be found in domestic radios intended for remote areas where mains power was unavailable. By contrast, so-called non-synchronous vibrators were more likely to be found in car radios. This latter vibrator type required an external rectifier to convert its AC output to DC and either a 6X5GT or 6X4 valve was often used for this task.

So that is basically how vibrator power supplies work but there are other things to consider to make them suitable for powering radio receivers. In operation, a vibrator makes and breaks the voltage applied to the transformer and this results in an abrupt change in the current being drawn from the supply. As a result, the transformer's winding inductance tries to maintain this current across the vibrator's points as they open. Unless steps are taken to prevent this, the result is severe sparking which would completely destroy the points within a few hours of operation.

To solve this problem, one or more capacitors are connected across either the primary or the secondary of the transformer, or both windings in some cases. By carefully selecting the capacitor values, the circuit (including the winding) resonates at the switching frequency and the sparking is markedly reduced.

If you are repairing a vibrator and the value of the capacitor is unknown, the trick is to try a variety of values and select the value that causes the vibrator to draw the least current. The voltage ratings of these capacitors, commonly called "buffer capacitors", may need to be as high as 2000V DC.

Because they are used under quite arduous conditions, polypropylene types should be used. Polyester capaci-

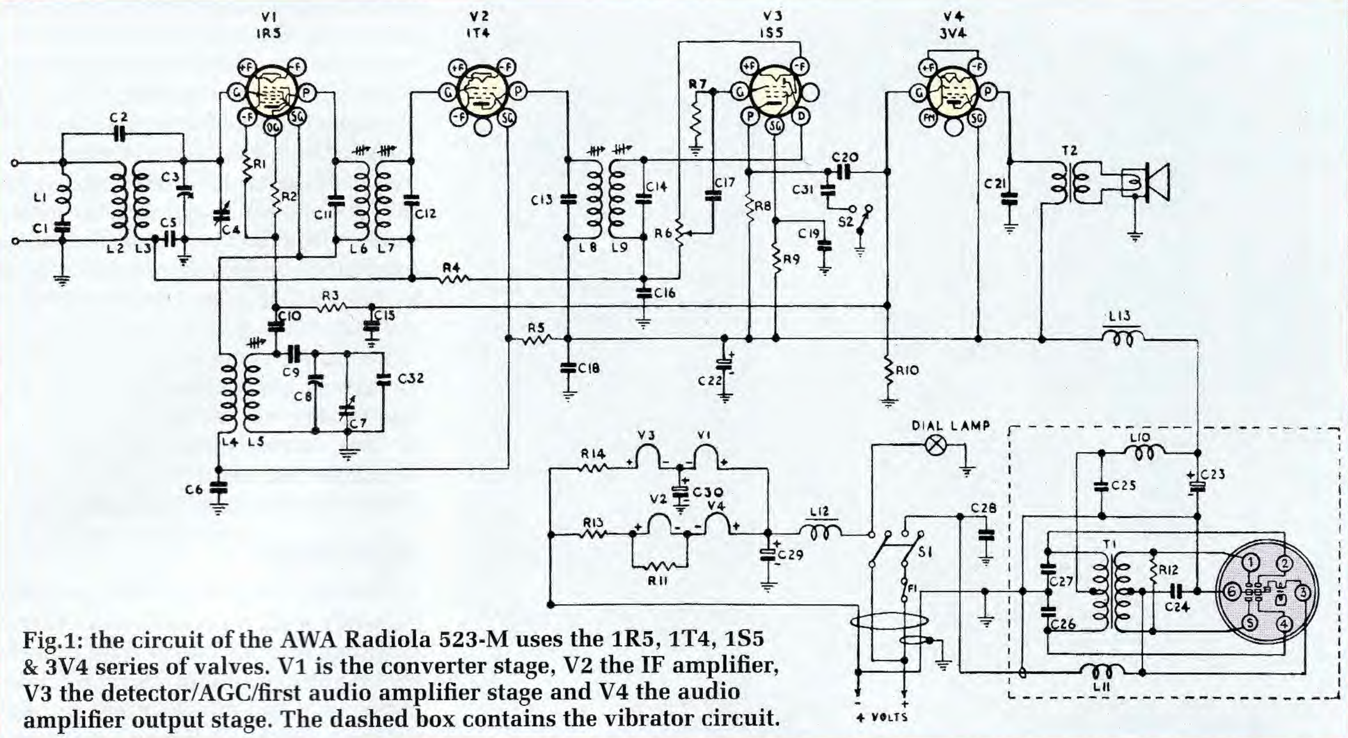


Fig.1: the circuit of the AWA Radiola 523-M uses the 1R5, 1T4, 1S5 & 3V4 series of valves. V1 is the converter stage, V2 the IF amplifier, V3 the detector/AGC/first audio amplifier stage and V4 the audio amplifier output stage. The dashed box contains the vibrator circuit.

tors can have a short life-span when used as buffer capacitors and so should not be used. However, they can be used in all other parts of the power supply where paper capacitors were used.

One drawback of a vibrator supply is that while the sparking is reduced by using suitable buffer capacitors, RF (radio-frequency) interference can still be quite evident. To overcome this, the whole vibrator supply is housed in a shielded metal enclosure and the leads going into or out of this enclosure are filtered to remove interference. In addition, the supply is mounted on rubber buffers so that there is little or no physical noise from the operation of the vibrator.

In short, designing a vibrator power supply with low electrical and acoustic noise is not as simple as designing a conventional power supply.

Circuit details

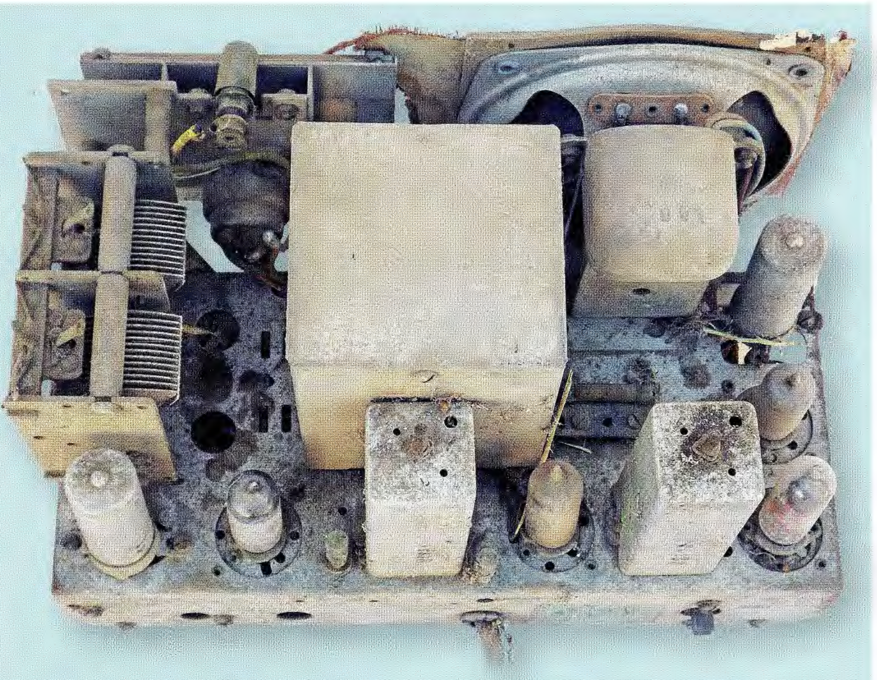
Fig.1 shows the circuit details of the AWA Radiola 523-M. It's really quite conventional for a 4-valve battery/vibrator-powered receiver built around 1949 and uses the economical 1R5, 1T4, 1S5 & 3V4 series of valves. These valves required only 90V HT and 50mA of filament current to perform well, the low filament current being necessary to minimise power consumption from the dry batteries used to power the receiver – important in remote regional areas.

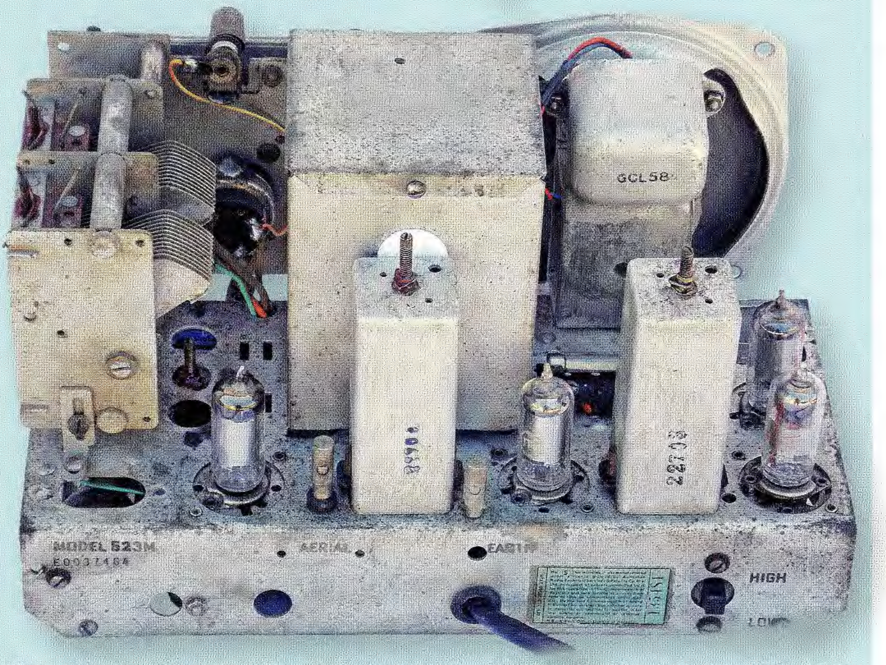
As shown on Fig.1, the antenna input circuit has an IF (intermediate frequency) rejection circuit (L1, C1) connected across the antenna-earth terminals. That's there to prevent IF signals from being picked up and fed back in through the converter stage, which could upset the receiver's operation.

The rest of the input circuit is conventional, with capacitor C2 giving some boost to the higher-frequency signals. C3, one section of the tuning gang, tunes the incoming signal and this is then fed to the grid of converter stage V1.

The oscillator tuned circuit is connected between V1's grid and chassis, while feedback winding L4 is con-

This photo shows the dilapidated state of the cabinet, dial scale and speaker cloth before restoration, while the photo on the facing page shows the set after restoration. The exterior of the set now looks almost like new again.





These photos show the chassis before (top) and after (bottom) restoration. The valves were cleaned by washing them in soapy water, while the chassis was cleaned by brushing away the dust, then scrubbing it with a kerosene-soaked pad. The enclosure in the middle of the chassis houses the vibrator supply.

nected to the screen grid which acts as the plate for the oscillator. The other end of L4 is at virtual earth/chassis since capacitor C6 bypasses any RF signals (whether IF or local oscillator) to earth. In addition, L4's inductance is low enough that C6 effectively bypasses the lower ends of C11 & L6 to earth as well.

The output from converter stage V1 is fed through the first IF transformer consisting of C11, L6, C12 & L7. From there, the resulting 455kHz IF signal is fed to IF amplifier stage V2 (1T4) and then fed via a second IF transformer to the detector and AGC diodes in valve V3 (1S5). The recovered audio is then amplified by V3's pentode section after which it is fed to the grid of audio amplifier stage V4 (3V4). Output stage V4 then drives the loudspeaker via a transformer.

The 3V4 needs around -6.5V of bias in this circuit. To achieve this, the filament supply line is series connected across the 4V supply, with pins 1 & 7 connected to +4V (via L12) and pin 5 connected to the filament of the 1T4. By doing this and earthing the grid via resistor R10, the valve is effectively biased to around -3.25V without further measures. To get the additional bias voltage required, a portion of the oscillator's grid voltage is also applied to the 3V4 to raise the bias level to around -6.5V.

Basically, some innovative circuit variations are needed when the filaments of valves are series connected, so that correct operating conditions are achieved. We'll take a look at the power supply circuit later on.

Restoration

The chassis is easily removed from its cabinet by removing two screws and then sliding it out. Note that the on-off volume and tuning controls are concentric and are mounted through the centre of the dial scale, so they also come out with the chassis. This would have to be the easiest set to dismantle for service that I have come across.

Once the chassis had been removed, the very grubby cabinet was scrubbed clean using a nail brush dipped in soapy water. This was done carefully though, to avoid wetting the paper label pasted inside the cabinet (this label shows the chassis layout). The cabinet was then carefully rinsed with clean water and rubbed down with car cut and polish. It now looks almost like new again.

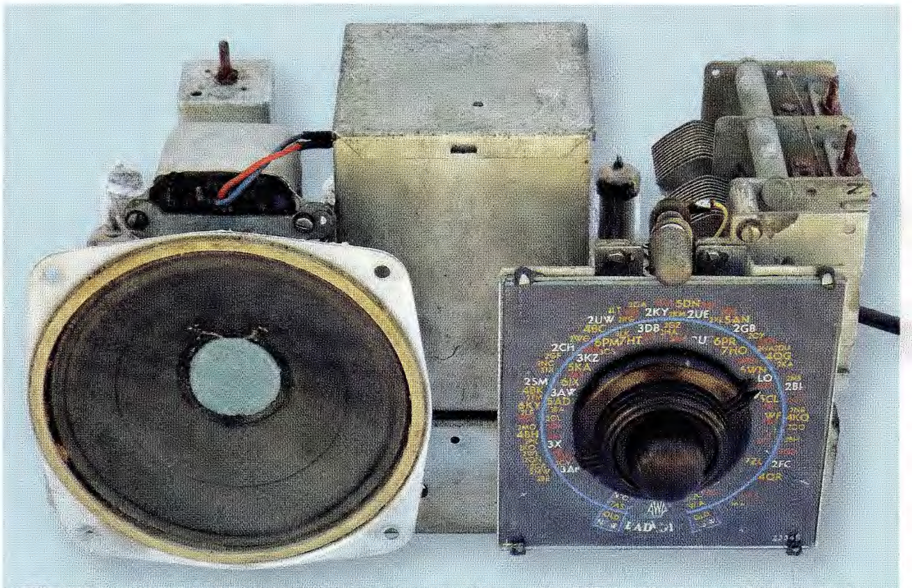
Restoring the chassis wasn't anywhere near as easy, as mice had made a home in the set and the acid in their urine had etched through the plating on the chassis in quite a few places. Dozens of small pieces of paper had also been left in the chassis by the mice but they hadn't done any damage to any of the parts or the wiring.

I began by brushing away the dust and other muck as best I could, then used a kitchen scourer soaked with household kerosene to clean the chassis. Restoring the chassis to pristine condition would have involved removing all the parts and the wiring, then re-plating the chassis and other metal parts and rebuilding the set. In fact, some vintage radio enthusiasts actually do this and their restored radio sets look like new.

When it came to this set, I was happy to leave most of the parts in place and simply clean the chassis as best I could. Removing everything and completely rebuilding the set is a time-consuming process.

The dial scale was also dirty so I very carefully cleaned it with a soft brush. I then used some soapy water on an inconspicuous part of the dial scale to see if the lettering remained in place. All seemed to go well, so I cleaned the rest of the dial and all the lettering remained intact. Unfortunately, it was still a little dirty when the water dried, so I tried the same technique again on the test area and this time some of the lettering did come away.

Apparently, the letters had been softened by the first round of cleaning so I left the remainder of the dial scale alone and simply left it to dry before carefully putting it back together. It wasn't a tragedy but I still wasn't at all pleased with myself as I hadn't been careful enough. It's always important to be very careful with dial scale markings – some remain on the glass and so the dial can be easily cleaned while in other cases, the letters can come away with very little provocation.



The chassis and dial scale cleaned up quite well, although some of the lettering at the bottom of the dial scale lifted off during the cleaning process. Great care needs to be taken when cleaning dial scales to avoid this problem.

Overhauling the vibrator

Having cleaned the chassis and dial, I turned my attention to the vibrator assembly. First, I removed the HT (high tension) filter choke (L13) and the LT choke (L12) to improve access to the vibrator mounting points. That done, I disconnected the three wires going into the vibrator supply module (earth/chassis, +4V input and the HT+ output) and disconnected the earthing braid that connects the vibrator's metal case to the chassis.

The next step was to remove the three circlips that secure the resilient mounting to the chassis and remove the assembly. The plastic sleeves over each of the three mounting posts were still in good order but the resilient mounts were in a bad way. I didn't have the correct "spongy" material for these mounts on hand, so improvisation was necessary when it came to replacing them.

First, I glued some foam rubber material to the bottom of the shielded enclosure, to keep it clear of the chassis. This was simply cut to suit and mounted near each of the mounting posts. The material used is approximately 5mm thick and 25mm wide and is readily available from Clark Rubber in whatever length you want.

Once the glue was dry, I remounted the vibrator supply on the chassis, with an 8mm ID rubber grommet fitted to each mounting post. This was followed by a thick fibre washer, the original metal washer and the circlip, to hold the mounting assembly together. I also attached a self-adhesive felt furniture pad to the side of the enclosure, so that it could not possibly touch an adjacent IF transformer which is only a few millimetres away.

As stated above, resilient mounting of vibrator supplies was routine so that the physical noise made by the vibrator was minimised.

The actual vibrator power pack is also mechanically isolated from the shielded enclosure. In order to remove it, it's necessary to remove the self-tapping screw at the top back edge of the enclosure and the three screws which go through the side. The supply can then be lifted out of the enclosure for restoration.

I began by replacing all the paper capacitors, even though I found that they all tested OK, much to my surprise (the same types in the main part of the receiver all later tested leaky). Buffer capacitors C26 & C27 were replaced with polypropylene types and the other paper capacitors with polyester types. The 20μF 200V electrolytic capacitor was replaced with a 22μF 160V unit and that was quite safe to do as the HT voltage won't exceed around 120V, even if the valves aren't drawing any current.

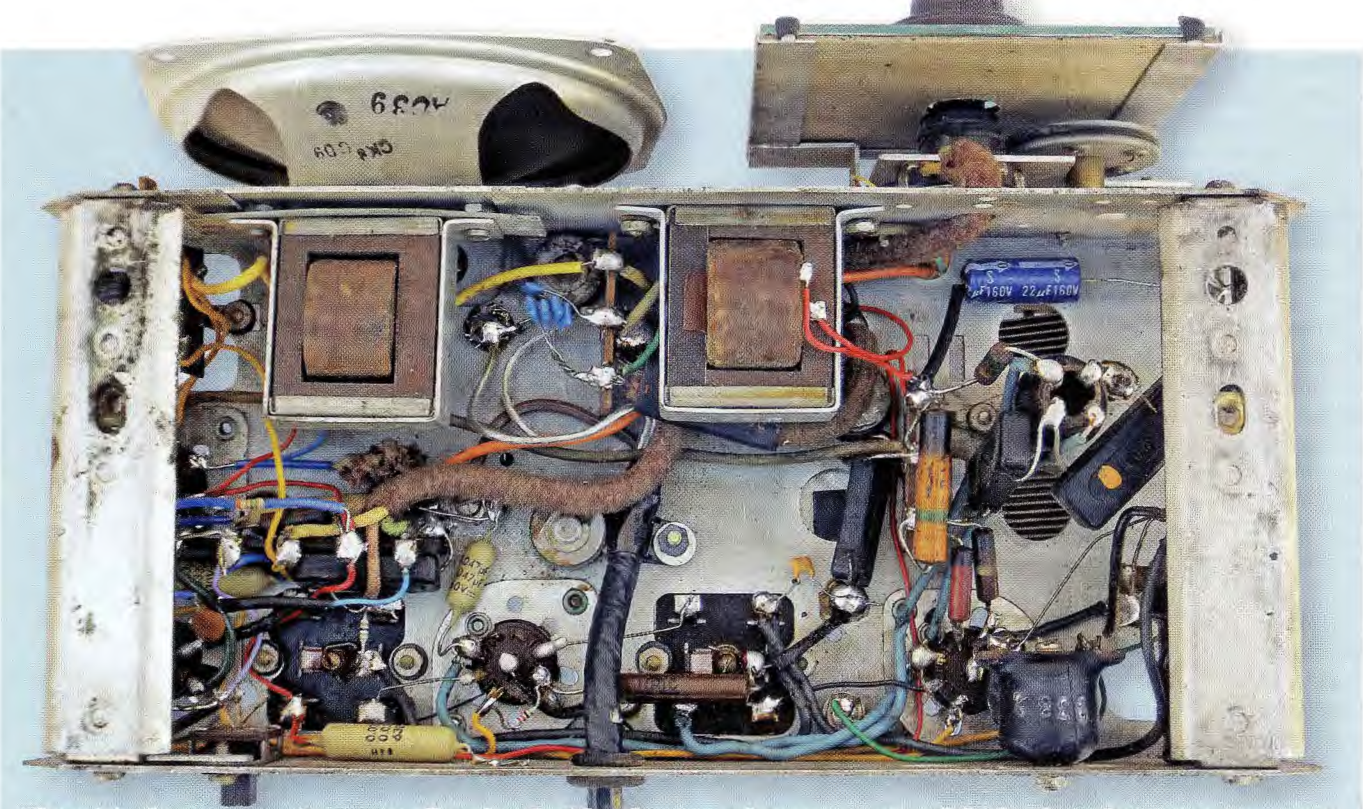
Basically, I replaced all the capacitors just to be sure and because it's very time consuming to access the vibrator supply to replace any defective parts. The only part in the supply that is easily accessible is the vibrator itself, as it was considered to be a consumable item with a limited life.

My next step was to remove the mechanical vibrator assembly from its case. This involved desoldering the lug at the base of the can, then removing the circlip that holds the vibrator's base in place and sliding the assembly out.

The first thing I noticed was that a foam rubber support at the top which keeps the assembly away from the case had gone "gooey". I scraped the goo off and then got busy with some contact cleaning strips that I've had for years to clean the points. Quite a lot of black dust came off the points so the effort was worthwhile.

If you don't have contact cleaning strips, then very fine wet and dry paper can be used instead to carefully clean between the various points in the vibrator.

Before cleaning the points, I found that the vibrator wouldn't start reliably but it did so after the points had been cleaned. Once it was all working, I found some thin rubber strip around 20mm wide and wrapped this around the end of the vibrator assembly. This was then tied in place with thin plastic spaghetti tubing, the idea being to prevent the vibrator from coming into



The original paper capacitors were all replaced with polyester and ceramic types, while the electrolytic capacitors were all replaced with modern equivalents. Several resistors and the speaker transformer also had to be replaced.

contact with the inside of the can and causing acoustic noise.

The refurbished vibrator supply has since proved to be reliable although its output voltage is somewhat less that I would prefer. But then, this unit is now over 65 years old.

Electronic repairs

Quite a bit of work was necessary to restore the chassis to working order. My first step here was to check the paper capacitors and these all proved to be leaky. As a result, they were replaced with polyester and ceramic types. The electrolytic capacitors were also all replaced, as they had been in this set for many years. Further component checks then revealed three resistors that were out of tolerance and so they too were replaced.

In addition, much of the wiring had perished so I cut the lacing away from the loomed wires and replaced any suspect leads. In the end, I replaced about 80% of the wiring which was a rather time-consuming task.

Next, the valves were removed and cleaned in soapy water after checking that their filaments were OK. The filaments were all intact but not so the primary winding of the speaker transformer. This meant that the speaker transformer had to be replaced and I then took a close look at the speaker itself. It initially looked to be a dead loss as there was grit in the voice coil. However, after removing the felt pad in the centre of the cone, I was able to gently blow out the gritty bits. The felt pad was then re-glued in place, as was the outer edge of the voice coil which had separated from the frame.

Once these repairs had been completed, the speaker worked quite well again. And that really was good news because I didn't have a matching spare.

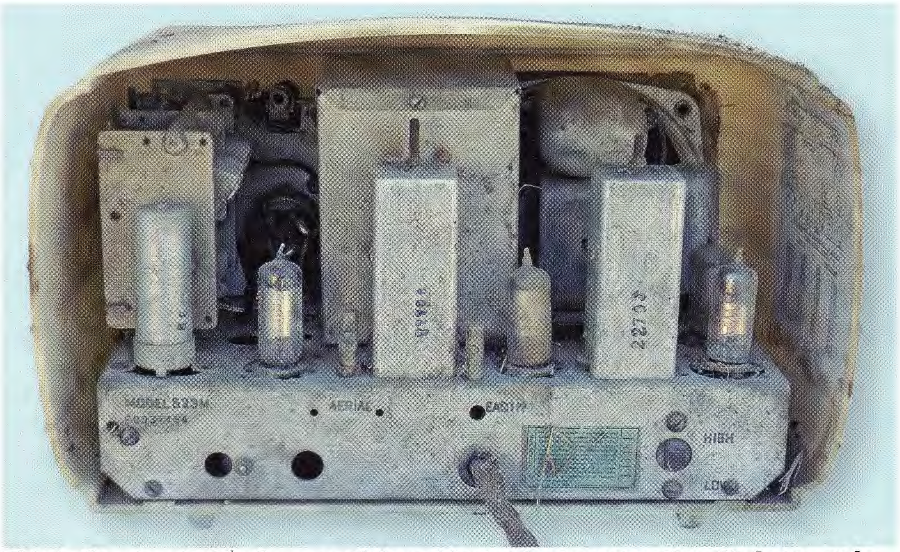
At this stage, the two filter chokes were reinstalled and the leads from the vibrator power supply reconnected. During this work, the 4V supply cable running from the set to the battery was found to be very much the worse for wear. It has two wires which are shielded and another two that are outside the shield.

Obtaining an original replacement cable would have been impossible, so I made a replacement cable up. It doesn't look like the original but it functions the same way. Fortunately, I was able to come up with some braid of sufficient diameter to accommodate four wires through its centre – two for the filament supply and two for the vibrator supply. This braid was obtained from a length of RG213 coaxial cable – it was just a matter of removing the outer cover and pulling out the centre and the insulation.

Once the new cable had been assembled, I wound electrical tape along its length to prevent any mishaps due to short circuits. What was interesting was that once I had the set fully operational, I found that neither of the earth/chassis wires inside the cable performed any useful purpose. The braid was earthed to the chassis and went to the negative terminal of the battery. The two wires that run from the positive terminal of the battery are needed to minimise any ripple on the filament line that runs from the vibrator supply. In effect, the battery acts as a very big filter capacitor.

The braid is necessary to shield the vibrator supply lead as quite noticeable RF is present on this wire. I found that in order to minimise this interference, it was necessary to add a 0.1μF capacitor between the wiper of the lefthand section of S1 and earth (this removed almost all of the interference).

With the valves reinstalled, it was time to test the receiver. After applying power, the HT rose to around 75V which is a bit low but the set certainly showed signs of life. It worked well at the bottom end of the band but it appeared dead when tuned to frequencies above 800kHz. Subsequent



This is the view inside the rear of the cabinet prior to restoration. Unfortunately, mice had made a home in the set and the acid in their urine had etched through the plating on the chassis in quite a few places.

adjustment of the antenna tuned circuit trimmer capacitor then allowed it to pick up stations right across the band, although it still wasn't working all that well.

Suspecting alignment problems, I then tuned to a weak station and adjusted the IF transformer coil slugs, The set's performance improved quite markedly and is now quite good – better than I expected in fact from a set with just four "battery-type" valves. The interference level from the vibrator supply was less than expected, too.

Electronic vibrator

I've always stuck to mechanical vibrators for my receivers and in fact have over 100 vibrators in my collection. Some of these are unused and are in "brand-new" condition, while others are worn out and need servicing.

Over the years, various articles have appeared in radio and general electronics magazines describing how to replace electromechanical vibrators with solid-state versions. However, although these did work, some had a tendency to overheat and most were too bulky to fit inside the housing used for the original mechanical vibrator.

To overcome these problems, Tony Maher of the Historical Radio Society of Australia (HRSA) developed a solid-state MOSFET-based replacement module several years ago. It's designed to take the place of a variety of vibrators and what's more, it fits easily into old vibrator housings.

In fact, Tony has developed two solid-state vibrator versions. If the first version is used, the supply will put out about the same voltage as for a mechanical vibrator. The second V1 version is more efficient and if fitted instead, the supply will have an output that's up to 15% higher than the original.

I decided that it could be an interesting exercise to try one of Tony's electronic vibrators in the old AWA Radiola 523-M receiver. As a result, I purchased two of the V1 modules.

When fitted with its original mechanical vibrator, the 523-M's supply put out around 75V on load. This clearly indicated that the vibrator had seen better days, since the voltage should have been nearly 90V. The current drain of the supply by itself (ie, when tested out of the set) was around 0.6A at 75V output and a 12mA load.

When I substituted one of Tony's V1 (second version) modules, the results were excellent. The output voltage was now around 107V with a 17mA load, while the current drawn from the 4V supply was about the same as it was for the electromechanical vibrator (which produced just 75V). So the electronic version is definitely much more efficient.

In fact, my measurements showed that the supply has an efficiency of 75% when using the Mosfet solid-state module. This drops to just 40% when using the rather tired mechanical vibrator. A new mechanical vibrator should result in better than 50% efficiency.

I also checked the interference produced by both vibrators and found

The view inside the rear of the cabinet after restoration. Great care was taken during cleaning to avoid damaging the label stuck to the inside of the cabinet and the ARTS&P label on the back of the chassis.

that the electronic version produces considerably less than the mechanical version. Added to that, the electronic version is acoustically silent. These initial tests, by the way, were all done with the supply outside the receiver. However, I was confident that the set would be reasonably free of RF noise with either version fitted to the set and that I could then minimise any residual interference once the set was fully operational.

Note that the electronic vibrators can be wired to replace mechanical 4V, 6V & 12V synchronous, non-synchronous and split reed vibrators. In fact, they can be used in any sets in this voltage range with no alteration at all. In addition, by replacing the Mosfets with higher rated types, it's possible to use them in 24V and 32V domestic radio sets.

Both 6V and 12V car radios can be powered by these modules without the use of a heatsink. Note, however, that the electronic vibrators are designed for negative earth, so some vibrators in positive earth vehicles cannot be replaced by electronic versions without making suitable modifications.

By making other modifications, they could also possibly be used in place of the large mechanical vibrators fitted in the 32V DC-to-230VAC inverters that were used to power TV receivers in remote rural areas. In this application, because of the large power output required, it would be necessary to fit the Mosfets to a heatsink and to adjust the frequency of oscillation. In short, this is quite a versatile module.

In-circuit comparisons

With the mechanical vibrator in circuit, the HT was again 75V and the set drew about 1A (more than the printed specifications). I then substituted the electronic vibrator and installed a 1kΩ resistor in series with the HT rail to reduce the HT rail to 90V. This time, the current drain from the 4V source was 0.75A which is noticeably less than for the mechanical vibrator.

In the end though, I decided to leave the old mechanical vibrator in the receiver. It still does the job, even if not as well as it did when new, and it maintains the set's originality.

However, I was very pleased with the performance of the electronic vibrator and can confidently recommend its use. They are available from Tony as a kit and I'll probably convert some of my vintage radio transmitters over to this module. The noise suppression in some mechanical vibrator sets was not very good and Tony's first design using a 4047 IC generates very little noise, so it can overcome such problems. Tony can be contacted by email at tmaher@detection.com.au

Summary

The AWA Radiola 523-M is quite an interesting little set. It works well when powered from 4V, although why AWA chose to use this unusual supply voltage is a bit of a mystery, especially when virtually every other manufacturer in the late 1940s used 6V. I suspect that the reason is due to the earlier use of 2V filament valves, with one 2V cell of a 6V battery being used to power the filaments and the remaining 4V from the other two cells being used for the vibrator supply.

In operation, the current consumption was balanced between the three cells. The battery, of course, could be switched in and out of the car for charging if the farm was in a remote area.

Quite frankly, I had expected a lot more interference from the vibrator supply, so I was pleasantly surprised on that front. Other brands filtered the input and output supply rails more thoroughly than in this set and there was no need for a shielded supply cable to minimise interference.

Physically, the circuit could have been built onto a larger chassis, as there is quite a lot of room between the front of the chassis and the cabinet. This would have made the set easier to service, although it's still relatively straightforward.

One thing I don't understand is why the dial lamp was permanently left in circuit. Almost all vibrator sets had dial lights that were controlled by a pushbutton switch, so that they could be turned on only when tuning the set. This was done to minimise current drain and prolong battery life. Removing the battery when it went flat and taking it to a local garage for charging was a real chore, so the longer the radio worked between recharges the better.

This set was obviously designed for the cheaper end of the market and it did a good job there. However, it does need a good outdoor antenna and earth to give reasonable performance. It is a set well worth having in a collection particularly if, like me, you like battery valve radios. **SC**

This electronic vibrator is small enough to fit inside the case of a mechanical vibrator.