Vintage Radio

By RODNEY CHAMPNESS, VK3UG

Radio Corporation's WS108 Transceiver

The "portable" radio equipment used by the military at the start of World War 2 was bulky, heavy and inefficient by today's standards. Here we take a look at Radio Corporation's WS108 transceiver, as used by the Australian army.

The WS108 transceiver – the first backpack set designed and built in Australia.

BEFORE AND DURING World War II, Radio Corporation made many radio transceivers for use by the military. In fact, we've already looked at the advanced WS122 in Vintage Radio for October 2002.

The WS122 was intended for fixed, portable and – at a pinch – vehicle mobile use. By contrast, the WS108 in all its various marks was intended as a backpack transceiver (basically, a predecessor to "walkie talkies"), although it was also used for low-power fixed operation.

This set is claimed to be the first backpack set designed and built in Australia. A Morse code only variant, designated the 208, was used by Australian commandos and coast watchers in the Pacific area during World War II.

Bulky equipment

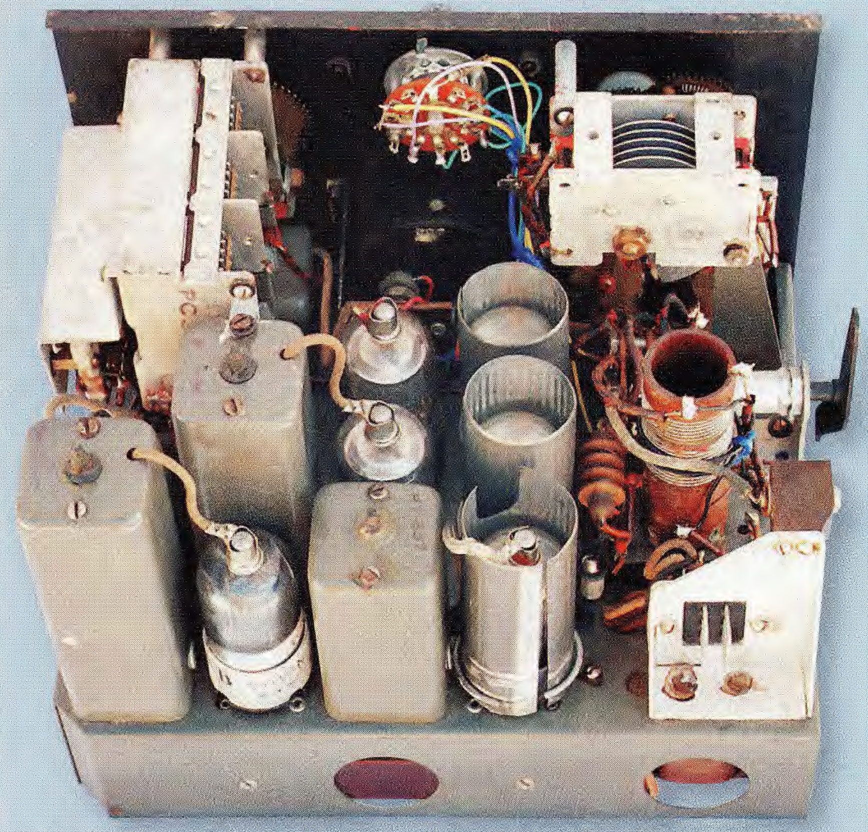
Most of the radio equipment used at the start of WWII was bulky, heavy and inefficient, with high current consumption. Designing equipment for mains operation is relatively easy, as it's not necessary to be concerned about the total electrical power requirements. However, it's a different story when it comes to designing equipment for battery operation.

It soon became obvious that there was an urgent need for a fully-portable voice transceiver for use by troops within an infantry battalion or similar unit. This had to be small enough for a soldier to carry on his back and he had to be able to operate the set on the move. This was probably not a favoured task, as the high frequency (HF) whip/rod type antenna connected to such sets would be sticking up above the horizon and acting as a beacon for the enemy's sharp shooters!

The British military had the No.18 set and this became the blueprint for the "Australianised" backpack set. Radio Corporation (Astor) designed and built this version, the 108. The 108 Mk.1 (1941) only tuned the range from 8.5-8.9MHz, while the improved 108 Mk.2 (1941) tuned from 6-9MHz. The final production model, the Mk.3 (1943/4) tuned from 2.5-3.5MHz and had provision for Morse code transmission as well.

Another variant was the 208 (1941/2) which was purely a Morse code (CW) transceiver. There was also a Mk.4 version developed but the war ended before it was put into full-scale production. Army cadets got to play with the few that were made, according to Rod Allen, VK4CJ.

The 108s were subsequently superseded by the vastly superior 128 transceiver, which was approved for production in 1945. In addition, towards the end of the war, the American SCR536/BC611 walkie-talkie came into use and this was so superior to the 108 that the Mk.4 would have been obsolete even before it was built.



This view shows the top of the chassis after restoration. Note the rewired "netting" switch on the front panel.

The 108 Mk.2

The 108 Mk.2 has a conventional superhet receiver with an RF stage, converter, two IF amplifiers, a detector/AGC stage and two audio stages – see Fig.1. A well-designed set with that number of battery valves is sure to be a good performer. It was designed to operate with a very small whip antenna 1-2 metres long and this is connected to the top of the antenna coil via blocking capacitor C1A. The tuned circuit for the coupling between the RF amplifier and the converter is in the plate circuit of the radio frequency (RF) amplifier (V1A) rather than in the grid, as is the more usual practice.

The oscillator section of V2A (1A7-GT) is similar to other pentagrid mixers. The intermediate frequency (IF) is at 1600kHz and is selected from the various mixing products at V2A's plate.

By contrast, the IF of the Mk.1 was 455kHz and breakthrough on the image frequency (double spotting), which is only 910kHz away from the desired signal, would have been a real problem. In addition, the selectivity of the antenna circuit and the broad-banded RF tuned circuit would have been inadequate to reject this unwanted frequency.

By using an IF of 1600kHz for the Mk.2, break-through of unwanted stations 3200kHz away would be rare due to the selectivity of the RF and antenna stages, which would strongly reject signals at the image frequency.

Following the mixer, the signal is passed through double-tuned IF transformer T1A, valve V1B and double-tuned IF transformer T1B to V1C, and then via IF transformer T2A to the diode detector in V3A (1D8GT).

The signal is detected in V3A (1D8GT) and AGC voltage is fed back to V1A and V1B. V2A and V1C do not have AGC applied to them.

Following the detector, the audio is fed via volume control (R8A) to the grid of the 1D8GT's triode section. The resulting signal on the plate is then applied to the grid of the pentode in the 1D8GT, after which it is extracted from the pentode's plate circuit and fed to the headphones via T3A.

The way that the 1D8GT has been drawn in the circuit diagram is unusual to say the least (and confusing as well). Reference to a valve data book makes it easier to follow this part of the circuit.

Transmitter circuit

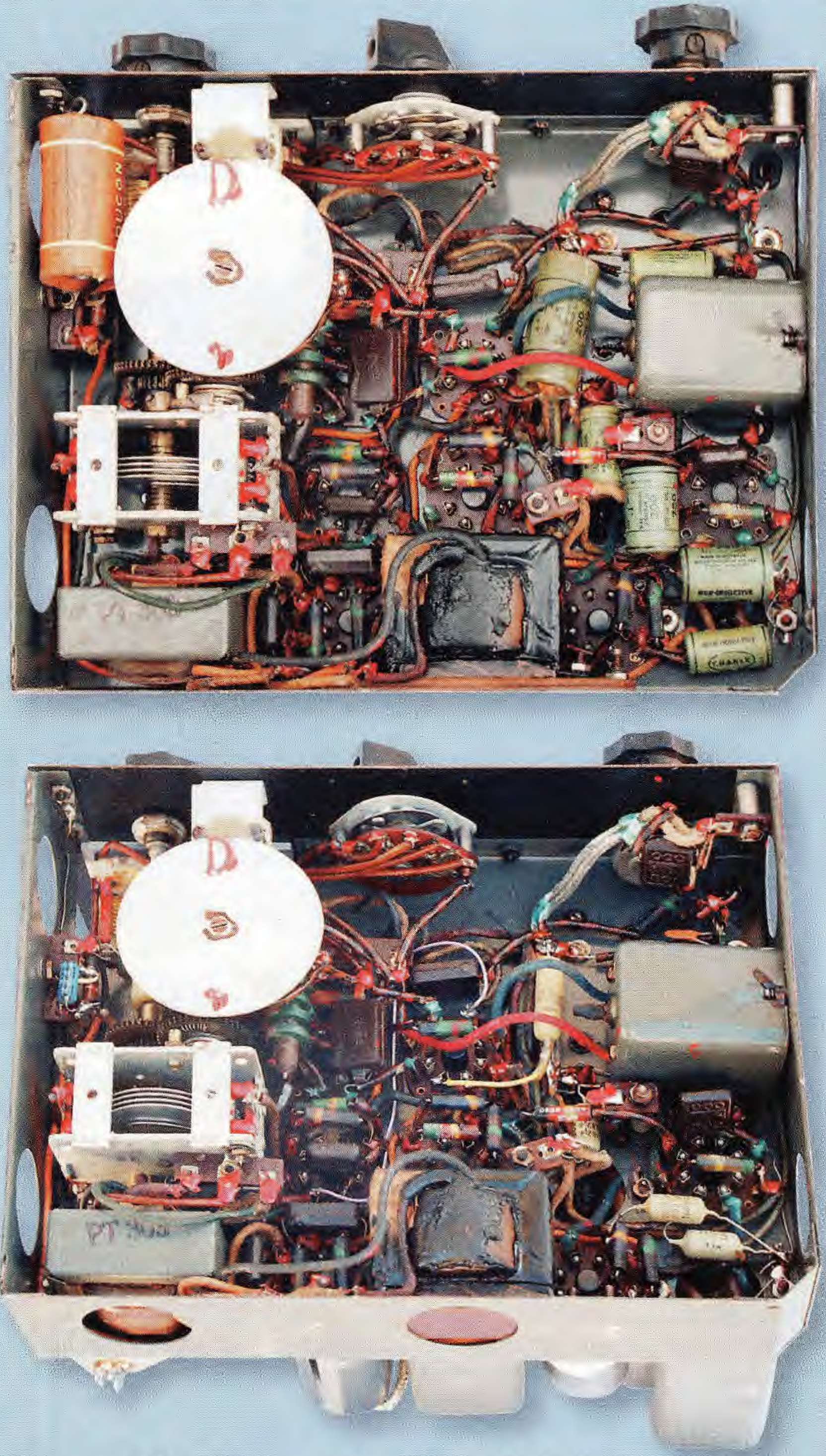
The transmitter circuit is fairly simple. The carrier frequency is derived using a variable frequency oscillator (VFO) based on V4A (1Q5GT). This VFO covers from 6-9MHz and this frequency range is spanned by two complete turns of the frequency-control knob. As a result, it's not easy to accurately set the transmitter frequency with such a direct tuning mechanism.

An alternative method of selecting a frequency is to select one of four preset frequencies using switch S3A. However, in the handbook, it is suggested that these preset frequencies should not be set in the field in the absence of technical personnel (more on this later).

The output from V4A is coupled to the grid of V4B, which functions as an RF (radio frequency) power amplifier. It's output is fed to the antenna via a tuned circuit consisting of L8A, C11D and C16A.

Because the antenna length is only a fraction of the signal wavelength, it is connected to the unearthed end of tuning capacitor C16A. Capacitor C11D passes the RF and blocks the 90V HT from being applied to the antenna.

In order to put voice onto the carrier,



These two under-chassis views show the unit before restoration (top) and after restoration (bottom). Most of the work here involved replacing defective capacitors.

it is necessary to have a modulator and this is provided by the 1D8GT (V3a). V3a fulfils a dual role as it also functions as the audio output stage for the receiver. On receive, the lower secondary winding of T3A is switched through to the headphones. Conversely, on transmit, the upper winding on the secondary is switched in series between the 90V supply rail from the batteries and the plate and screen of the power amplifier (PA) valve.

In operation, the modulator's audio output appears across the secondary winding of T3A and this modulates the 90V supply to the PA (V4b). This causes the amount of voltage applied to the PA stage to vary, which means that the transmitter's output varies as well.

Netting

It was usual for transceivers such as this to transmit and receive on the same frequency and this was achieved using a facility called "netting". This involved providing a low-level signal from the transmitter that was then picked by the receiver. When the transmitter and receiver frequencies were the same, the receiver would go "quiet". Alternatively, if the "control" station was transmitting, the local transmitter signal would initially appear as a whistle in the receiver as the VFO was adjusted.

In practice, the transmitter frequency control was adjusted until the whistle disappeared – ie, at "zero beat" or zero frequency difference. The local unit and the "control" station would then be on the same (nominal) frequency. In fact all stations in the group would "net" to the "control" station so that they could all talk to one another. The netting switch in the 108 is S2A and this is located just below the common earth line in the circuit diagram.

In this set, when netting occurs, the receiver is operated as normal, the VFO is run at reduced voltage and the PA is made inoperative. Only a low-level signal is required, as the transmitter is in the same case as the receiver.

Overhauling the receiver

The first thing I noticed when it came to the restoration was that the netting switch was missing from the top-centre of the control panel. This didn't augur well for restoring the set to its original condition and I was concerned as to what other modifications might have done to the set.

In fact, it's sometimes necessary to admit defeat if the modifications are too extensive and I sometimes wonder why people do such extensive modifications to sets. One of our local club members has bought sets on eBay and has been caught out this way.

Fortunately, in this case, there didn't appear to be any other drastic modifications, so I decided to go ahead with the restoration. It wasn't hard to find and fit a 4-pole 2-way switch and matching knob. The only problem here was that I didn't have a spring-loaded switch like the original, so I would have to manually switch back to receive from "net".

However, that was a minor problem compared with finding out what the previous owner had done with the eight wires that had gone to the switch. I couldn't see where they had come from, as the wiring in the set is rather dark and it's hard to find your way around.

Eventually, I was able to locate the transmitter and receiver filaments so I was able to initially wire the extreme left switch contacts into circuit. Figuring out the remaining wiring to the three switch sections was a much more time-consuming task and it took me two full days to complete this job.

About this time, I also discovered that the 10mA meter in the plate circuit of the PA valve had gone open circuit. I dismantled the meter but no obvious breaks in the wiring could be found. Fortunately, I had a meter from another Radio Corporation transceiver and it had the right sensitivity and the correct mounting hardware. Unfortunately, its appearance and meter scale are different to the original but it will do the job until an exact replacement comes along.

I was going to repaint the case but changed my mind when I discovered that suitable matte-finish paint would set me back $25. As a result, I thoroughly cleaned the case with household kerosene on a rag and while it looks better that it did, gouge marks and rust are still quite evident. Of course, it's always a moot point as to whether an item being restored should look exactly as it did when it came out of the factory or simply restored to working order but left with its original finish.

Unfortunately, I have only a few of the bits and pieces that make up the complete station. For example, I don't have the antenna or the control cables and had to "make do" with a microphone and set of headphones from another military set.

Removing the chassis

The chassis itself is quite easy to remove from the case, it being necessary to remove just one knurled-head screw on the front of the set. However, it isn't normally possible to operate

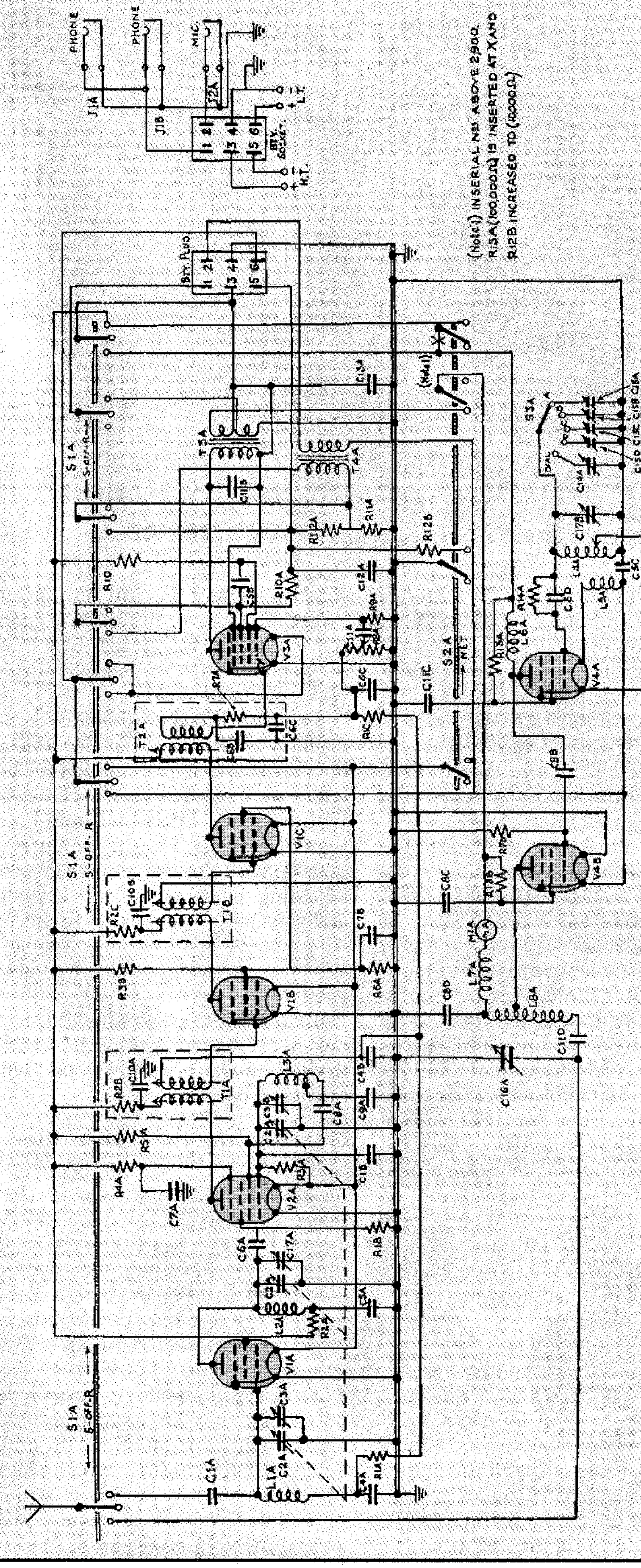


Fig.1: the WS108 uses a conventional superhet receiver with an RF stage, converter, two IF amplifiers, a detector/AGC stage and two audio stages. By contrast, the transmitter is fairly simple and uses a variable frequency oscillator (VFO) based on V4A (1Q5GT) to derive the carrier frequency. V3a functions as the modulator (and as the audio output stage for the receiver section), while V4b functions as an RF power amplifier.

All accessories, including the headphones, microphone, a 3-position remote switch control and a small telescopic antenna are stored in the lid of the case (the black and white photo at left is from the manual). Most of these items are missing from the author's set.

the set out of the case as the batteries and the headphone and microphone leads are automatically connected via a Jones plug and socket arrangement attached to the back of the case and the rear of the chassis. As a result, I obtained a 6-pin Jones socket and wired it so that I could supply 1.4V and 90V to the set and connect the headphones and microphone.

As with all old sets, I checked the AGC bypass and audio coupling capacitors for leakage. As usual, the AGC bypasses were too leaky to leave in circuit and these were replaced with .047µF 50V ceramic disc capacitors.

The audio coupler (C5B) is a mica capacitor, so it was left in circuit. However, all the other paper capacitors were excessively leaky and were replaced with 160V polyester capacitors. The back bias capacitor C12A, a 25µF 40V electrolytic, was also replaced.

Unfortunately, this circuit isn't the easiest to find your way around, as there are a few errors in it. Two were picked up by the military and the corrections published, while I found another one that had been missed.

Receiver tests

The 108 was designed to work with two low-impedance headphones so I connected a 15-ohm loudspeaker to the line that comes out to pin 1 on the Jones plug. I then clipped the output lead from my LSG11 signal generator over an insulated antenna lead I had attached to the set, adjusted the signal generator for full output and tuned the receiver to find the signal. A weak signal was heard, which led me to believe that something must be wrong with the receiver.

So what else had the previous owner been up to? The IF alignment was the obvious suspect, even though the adjustment slugs had been well-sealed with beeswax. Initially, I found that I could get only a weak response on 1600kHz (the IF frequency) so I started adjusting the cores and was immediately greeted by increased sensitivity. And once all the five slugs had been adjusted, the performance was quite good.

It's difficult to know what the previous owner was doing when he aligned the set. He was certainly liberal with his use of beeswax!

Overhauling the transmitter

The transmitter's RF output circuit is designed to feed a non-resonant short telescopic antenna, which presents a high impedance to the PA's tuned plate circuit. However, the previous owner had modified the circuit so that a relatively low-impedance antenna could be used, such as a quarter wave end-fed antenna.

It's also much easier to measure RF power into low-impedance resistive loads such as a 50-ohm "dummy" antenna than trying to simulate a high-impedance reactive load, as presented by a short telescopic antenna (a suitable "dummy" load can be made using a 50-ohm non-inductive resistor and this acts like an antenna with a resistive feed impedance of 50 ohms).

The transmitter stage uses lots of mica capacitors and none of these required replacement. In fact, the transmitter section was in better condition than the receiver.

Next, I applied power to the set and with the receiver turned on, adjusted the transmitter frequency with the "netting" on until the receiver went quiet (this meant that the transmitter was now tuned to the same frequency as the receiver). I then checked the unit out across its entire 6-9MHz tuning range and found that the dial calibrations for both the receiver and transmitter stages were reasonably accurate.

Now for some power measurements. This was done by attaching the set to a 50-ohm RF power meter (a "dummy" load with a meter attached to measure power) and then turning the transmitter on. Initially, the power was around 40mW which wasn't anything to write home about.

I then experimented with the coupling and was able to get the transmitter output power up to 120mW. This involved winding three turns of insulated wire over the earthy end of the tuned circuit, which proved more effective than the previous owner's modification.

It was now simply a matter of checking that the unit was working correctly. To do this, I tuned in my amateur radio receiver and found that this had no trouble picking up the signal from the transmitter into the dummy load. I then modulated it with tone using a small audio generator and the transmitted audio sounded quite acceptable.

Finally, I tried using a hand-held carbon microphone and once again the transmitted audio was quite satisfactory.

In operation, the transmitter and the receiver are remarkably stable once set to a frequency, with little drift in the tuning. However, as mentioned previously, exact "netting" to frequency isn't an easy task with these sets.

One problem alluded to earlier in the article is the problem of adjusting the four preset transmitter channels. The frequency adjustments are set using a screwdriver to vary four air-spaced trimming capacitors and just half a turn (180)° changes the preset frequency from 6MHz to 9MHz.

As a result, the adjustment is very critical and it's just as well that the selectivity of the receivers in these sets isn't as narrow as it would be with 455kHz IF stages, otherwise it would be almost impossible to get them accurately tuned.

Summary

The 108 is a cumbersome "little" beast, which is not all that easy to use on the move. It remains on frequency remarkably well when operated on the bench but just how well it did when being bumped along on a private's back is another matter.

It's output power is also quite low at around 120mW, which gives it a range of about 3km as a pack set. By way of comparison, a modern 27MHz CB radio has an output power of 4W on AM – more than 33 times that of the 108.

The Mk.1 was probably not much of a success but the Mk.2 would have been reasonably good in the African desert. The Mk.3 would have been even more versatile, as it used lower frequencies which would have been better in the jungles of South East Asia. It was also capable of being used on Morse code and could be operated with a variety of antennas.

Finally, although the 108 may have been satisfactory when was first produced, it was obsolete even before the end of WWII. Radio Corporation also produced the 122 which was a much more advanced design for the time.

The 108 wasn't the most remarkable transceiver of its time but it's still an interesting item to have in a military radio collection. **SC**

Photo Gallery: AWA Model 517M (1948)

MANUFACTURED BY AWA in 1948, the 517M was a very popular 4-valve mantel receiver housed in a bakelite cabinet. It featured concentric volume control and tuning knobs in the middle of a circular dial and was produced in several colours. The green cabinet shown here is now hard to find.

The valve line-up was as follows: 6A8-G frequency changer; 6G8-G reflexed IF amplifier/1st audio amplifier/detector/AVC rectifier; 6V6-GT audio output; and 5Y3-GT rectifier. Photo: Historical Radio Society of Australia, Inc.