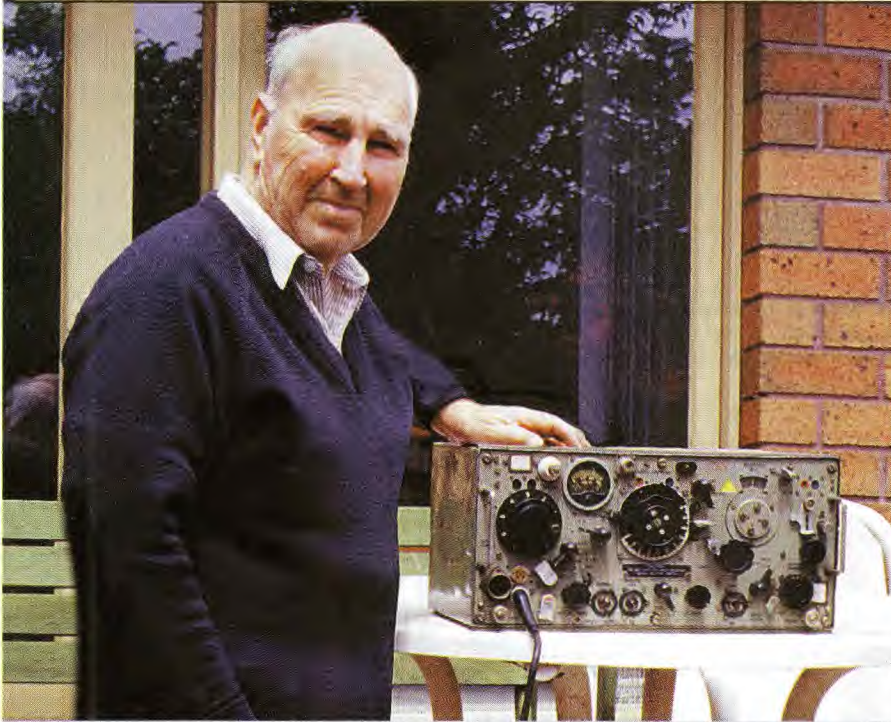


Vintage Radio

By RODNEY CHAMPNESS, VK3UG



Bill Clarke with the author's fully-restored WS122 transceiver. Bill designed the modulator and much of the switching mechanism for the WS122, while two other engineers – Lindsay Cobb and Geoff Frew – designed the receiver and transmitter sections and the vibrator power supply

Meet a designer of the legendary WS122 army transceiver

Ever wondered about the people who designed our vintage radio equipment? Most of the names have now been lost but not all. Recently, we were given the opportunity to talk to one of the engineers who helped design the Australian Army's classic WS122 transceiver.

VINTAGE RADIO has several different aspects that are of interest to its devotees. In the main, it involves collecting and restoring old radio receivers but other areas of interest include the collection of historical information, advertising material, and instruction manuals and data books from the era.

However, there is one area in which very little interest has historically been shown – the designers of the equipment and the circuit designs they produced.

The original designers of our vintage radio equipment were something of a mixed bunch. Many were highly qualified electrical and radio engineers but they also included many self-taught people with no formal education in the electrical or radio fields. But how many designers have you seen mentioned in vintage radio articles or in the historical literature? The answer is “very few, if any”.

Of course, very few of the designers from the valve era are still alive. They are a mostly forgotten group of people but they engineered the many unique Australian designs that we can rightly be proud of today.

In the October 2002 issue, I described the WS122 portable high-frequency (HF) radio transceiver built by Radio Corporation for the Australian Army during WW2. About a week after the publication of the article, I received a phone call from Lewis “Bill” Clarke. I’d never spoken with Bill before but he introduced himself and told me that he was one of the designers of this set.

It was too good an opportunity to miss. I asked Bill if I could interview him when I next came down to Melbourne. He agreed and a few weeks later we sat down for a very interesting trip down memory lane.

Lewis (Bill) Clarke (VK3ZLN)

Bill turned out to be a sprightly, very “with it” octogenarian who was born in 1921. And his theoretical and

practical knowledge of electronics is quite extensive.

Bill spent most of his primary school years in Naracoorte, South Australia. His father was a bank manager and as a result they lived in one of the substantial residences provided for managers in those days.

According to Bill, the family obtained a battery-operated radio some time around 1930. As a result, a short water-pipe mast was installed on top of the second storey of the residence to support one end of the antenna, while another water-pipe mast was erected in the back yard to support the other end.

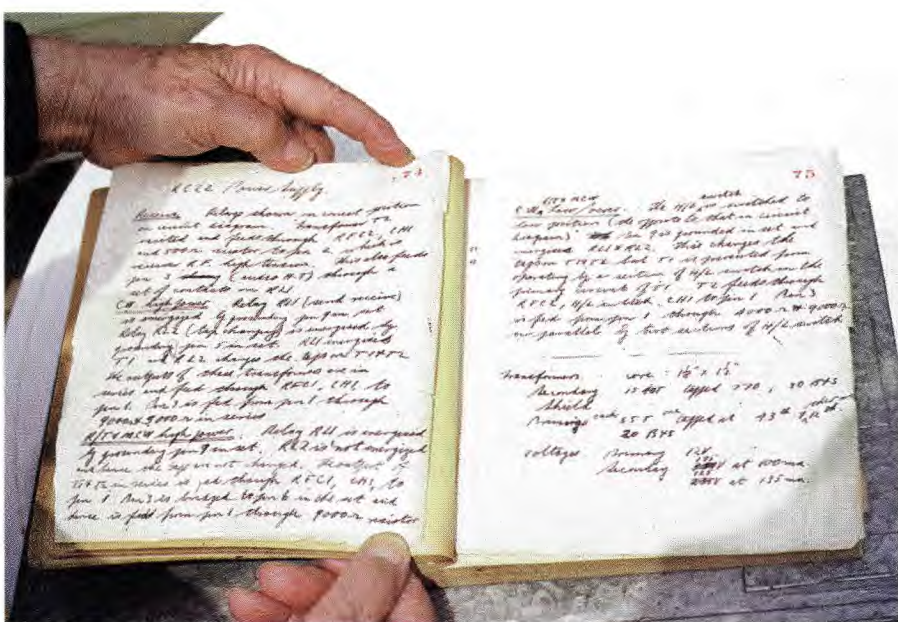
He estimates that the antenna would have been between 18 and 20 metres high, which meant that the radio quite easily received ABC stations 3LO and 3AR from Melbourne. The transmitting power of these two stations at the time was quoted as 5kW but that may have been the DC input power rather than the output power.

At the time, Bill enjoyed constructing many projects with his Meccano set. He ponders whether Britain's ability in the engineering field deteriorated at the same rate that Meccano sets disappeared from boys' lists of "toys".

At the end of 1932, the family moved to Ballarat – just after Bill had finished grade 6. And in one of the rooms of their new bank residence, there was a crystal set with a horn speaker attached. Yes, a loudspeaker crystal set and it did produce quite reasonable volume. Of course, such sets are rare but it was also quite rare to live right across the road from the local broadcasting station. In this case, it was 3BA which was located on the roof of a bank building across the street.

The family shifted again in 1934, this time to Melbourne, where Bill completed his secondary education at Scotch College. It turned out that a friend at the college had a crystal set and from here on Bill really became interested in radio, setting the scene for his life-time interest in the radio-electronics field.

When he had completed his studies at Scotch College, he entered Melbourne University to study Electrical Engineering, with particular emphasis on maths and physics subjects. This gave the degree a leaning towards the field of radio. His studies went well and during holidays, Bill took technical jobs with the railways in 1939-40



Bill Clarke still has his design notebook from his days with Radio Corporation and these pages show the notes he made on the transceiver's power supply.

and with the tramways in 1941-42.

By now, the world was gripped by war and things were very grim in late 1941. As a soon-to-be graduate engineer, Bill could have obtained a commission in the submarine branch of the Navy, so he enlisted and continued with his course. But things didn't work out that way.

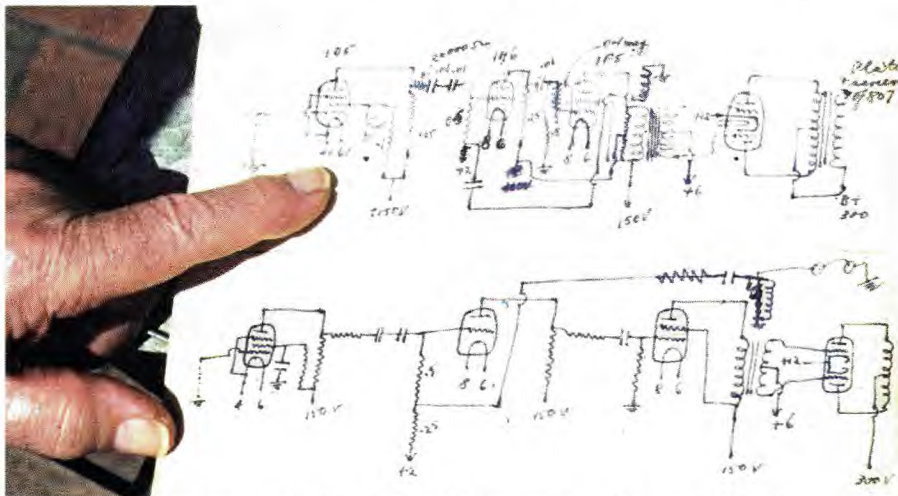
The British government had learnt from the first world war that there was no future in sending skilled and highly-qualified people off to the trenches to be killed. Australia quickly followed the British example and in early 1942 enacted manpower control. This meant that skills would be used where they would achieve the best results for the war effort. The final

year of the course had to be crammed into half a year as the shortage of engineers was acute and so Bill qualified in June 1942.

Bill joins Radio Corporation

Bill commented that his long term interest in amateur radio may have saved his life, as he was drafted to work at Radio Corporation alongside another engineer (John Hill) who had done the same subjects (no – it wasn't the John Hill who previously wrote for "Vintage Radio"). John was also interested in amateur radio and ultimately obtained the callsign VK3DAD.

Bill found Morse code difficult to learn, as many very technically competent people do, but ultimately obtained



This photo shows some of Bill's notebook diagrams of the modulator he designed for the WS22 and WS122 transceivers.

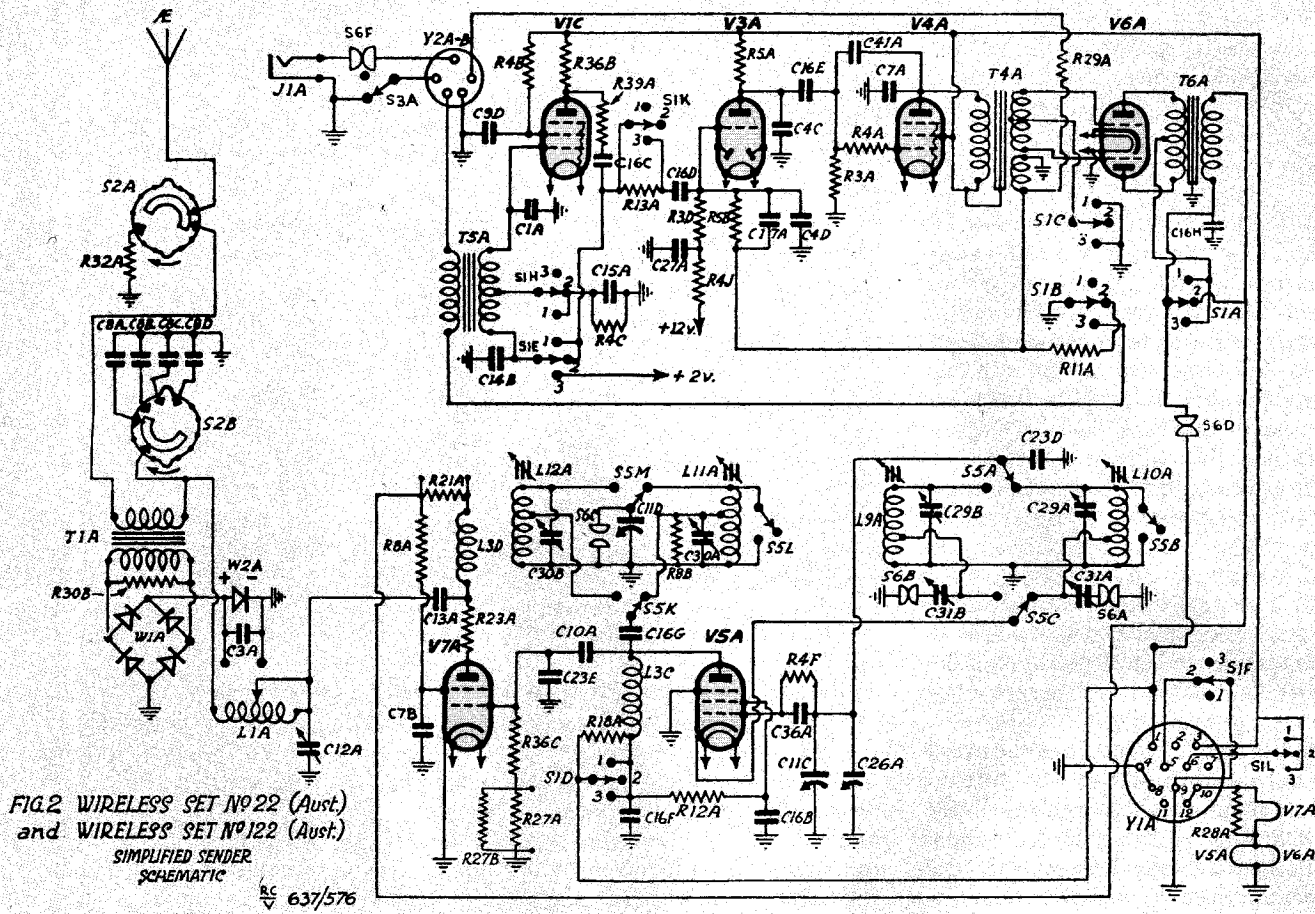


Fig. 1: a simplified circuit of the WS122's transmitter. It had three modes of operation: voice (AM), Morse (CW) and modulated continuous wave (MCW).

the callsign VK3ZLN. Amateur radio operators were not allowed to operate their stations during the war so neither Bill nor John obtained licences at that stage.

By now, the Americans were bringing large quantities of radio communications equipment into the country and these required crystals to suit frequencies used in Australia. As a result, there was a large backlog of crystal orders and so Bill's first position in Radio Corporation was in the crystal laboratory. Here, he was responsible for the final grinding of the quartz crystals to the correct frequency.

According to Bill, the work load was so great that three shifts over 24 hours were initially required to catch up on the backlog. He was fortunate that his parent's home had shutters on the windows, so he could sleep during the day while working the night shift.

Once the crystal backlog had been eliminated, Bill was transferred to the design laboratory. But like many "new

boys" in a job, he was initially given a variety of tasks to see what he was capable of. One of these tasks involved the development of a pre-heater for bakelite pellets, prior to moulding. As we know, bakelite was used extensively for radio cabinets at that time but not for military equipment. Apparently, Radio Corporation was still involved in domestic radio production to some extent, at that time.

He was also given the task of designing and building a 500-watt public address amplifier for the factory and this ended up using a couple of high-power transmitter valves to achieve the necessary output power. But perhaps one of the more interesting jobs at that stage involved fault-finding equipment that wasn't performing as it should.

Often, equipment faults were due to the use of below specification valves. To solve this problem, Bill usually tried substituting good-quality valves of JAN (Joint Army Navy) specifications in the equipment (note: as many

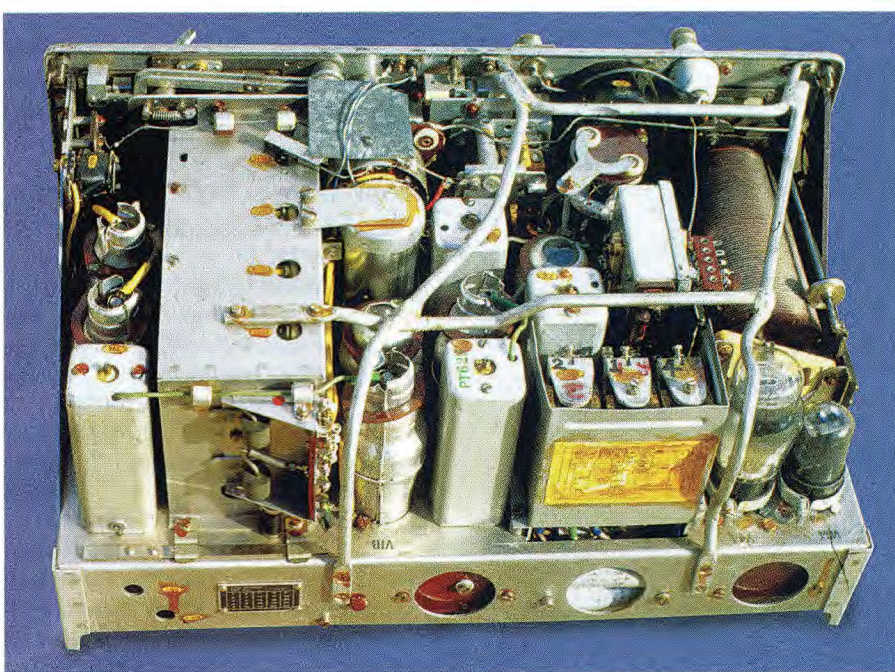
vintage radio restorers already know, some valves are marked to indicate that they meet JAN specifications).

For example, one particular VHF AM/FM communications receiver was found to be quite noisy and was giving quite poor performance. It was eventually found that the IF stages had insufficient gain and that the last IF stage would not saturate on FM signals. This problem was overcome by changing the screen and bias voltages in the IF stages to increase the gain.

Bill thinks that the receiver in question was an RT17 and it became quite a successful piece of equipment in its modified form. And once a piece of military equipment had successfully passed all tests, a handbook had to be written for it.

Designing the 22/122

Bill's next job involved designing the WS22 and WS122 army transceivers (the "WS" stood for "Wireless Set" and was commonly dropped from the type



This rear chassis view gives some idea of the complexity of the WS122 transmitter. Note the roller inductor tuning coil at the right of the photograph.

number). There were three engineers on the project: Lindsay Cobb designed the receiver, Geoff Frew designed the transmitter and the vibrator power supply, and Bill, the junior engineer, designed the modulator and much of the switching mechanism.

Geoff Frew had been an amateur operator (VK3PM) before the war and had the unusual nickname of "Afternoon Tea". Apparently, this came about because of the "3PM" in his callsign, 3pm being the usual time that people stopped work for a "cuppa" tea. His experience with transmitters proved to be invaluable in designing the RF section of the set.

In fact, Lindsay Cobb and Geoff Frew were arguably the best design engineers in Radio Corporation at that time, having been there for many years.

The design criteria for the WS22 and WS122 transceivers were set down by the military in general terms. The RF power output, frequency range, modes of operation, power source, receiver sensitivity and ability to load into certain types of antennas were some of the parameters that had to be met. But just how Radio Corporation met these design requirements was entirely up to them.

Prior to the development of the WS22 and WS122 sets, an earlier set named the "Yellow Band 22" had been developed which had used a

grid-modulated transmitter. This set was an Australian adaptation of the British 22 set but Geoff disliked the grid modulating system and set Bill the task of designing a high level modulator.

As a result, Bill looked around for quite some time to find a valve (or valves) and a practical circuit configuration that would provide 10W of audio output from the modulator. At that time, class B amplifiers were not looked on particularly favourably as they tended to have high distortion. For example, the No.19 battery twin-triode class-B amplifier was used in a number of pre-war battery receivers. Unfortunately, it was unable to provide a low-distortion output, mainly because it was used without negative feedback.

Bill decided that the 53 would be a suitable valve type but its heater requirements of 2.5V at 2A ruled it out. The 6A6 could also be used but the relatively new 6N7 appeared to be even more suitable.

He rang Max Brodribb, a controller of valves in the Department of Supply, to find out the availability of 6N7s. He was in luck – they did have enough 6N7s for the job.

Having determined that the 6N7 would do the job, Bill then had the task of designing the modulation and driver transformers to suit it. Transformers are expensive and heavy

devices but the design team believed that the end result of using them in a class B modulator far outweighed their deficiencies.

There were no computers in those days, which meant that slide rules, charts, technical manuals and many note books were needed to accomplish the design tasks. The accompanying photographs show just a few pages from Bill's note books. Some of the information has faded over time but the test notes and rough circuit diagrams can still be seen.

The 6N7 was normally used with

was about to be made obsolete. One example was the use of a dynamic microphone, as previously featured in the predecessors to the WS22 and WS122.

Tropical proofing

In the early days, there were many lessons to be learnt about building equipment for use in hot, humid locations such as New Guinea. It was not uncommon for equipment to come back for service with fungus growing in it and with open-circuit transformer windings and so on. A lot of this early equipment became useless in a very short time indeed.

However, the lessons were learnt quickly and before the 22/122 went into service, nylon covered wire and potted transformers were installed. In fact, these sets were almost hermetically sealed, as described in the October 2002 issue. All equipment for use in the tropics was then tested in an environmental cabinet at 100% humidity and 100°F.

The design and prototypes were accepted by the Australian Army on 14/3/1944. As far as can be determined, each 122 transceiver cost about 1000 pounds, with Bill being paid 6 pounds per week at that time.

And so the design of one of the icons of portable military radio transceivers was now complete. Bill's contribution can be readily appreciated and gives us an idea of the work that went into designing this and similar radio equipment.

Unfortunately, I haven't been able to provide any detailed information on just how Geoff Frew and Lindsay Cobb went about the design of their sections of the set. However, it's obvious that some very competent engineers were responsible for the WS22 and WS122 transceivers.

I asked Bill whether he would have liked to have serviced the 122. His answer was "No". For its time, there was a lot packed into a relatively small space, so servicing wasn't easy.

Life after Radio Corporation

Bill subsequently left Radio Corporation in June 1945 and joined the CSIRO, which was the predecessor to the CSIRO. Although he wasn't involved in designing radio communications or entertainment equipment for CSIRO, he was involved in the design of high-power radio frequency (RF) heating



Also in Bill's notebook are the original test figures on the WS22 and WS122 prototypes.

zero bias but Bill decided to run it with a bias of -6V to minimise current drain – even though it may not then provide 10W output. The 6N7 required only voltage drive until the audio drive signal overcame the bias, after which it required power as grid current would then be drawn by the valve. This made the design of the driver transformer more difficult and made the load on the 1F5G driver valve (and receiver output valve) quite variable.

As a result, there would be significant audio distortion.

However, it was found that negative feedback from the headphone winding of transformer T4A to the grid of V3A (1H6G) – the second audio stage – overcame most of this distortion. Capacitor C41A, which was connected between the plate of V4A (1F5G) and its grid, also improved matters and so the combination of current and

voltage feedback proved to be very successful.

Bill pleaded with the army to leave out the requirement to have an MCW transmit facility, as it made the switching extremely complex. In fact, the inclusion of MCW meant that six relays were required in the set. However, the military refused to change the requirement and no satisfactory reason was ever given to Bill for its inclusion.

I subsequently spoke with Tony Bell in South Australia on this subject and his thoughts were that MCW was included so that simpler AM-only receivers could be used with the 122 if need be.

Geoff Frew and Lindsay Cobb (both now deceased) relied extensively on their pre-war experience during the design phase of the WS122. As a result, many new designs copied the best features of older equipment that

units to dry timber and to glue timber sections together. These units were, in reality, crude high-power (400-500 watts) radio transmitters.

He worked on many interesting projects while in the CSIRO, particularly high-precision test instruments. In many cases, it was necessary to develop new techniques to obtain the accuracy and precision needed.

So, overall, Bill has had an interesting and varied career in radio and electronics engineering. He even became involved with valve computers around 1969. He retired from the CSIRO in 1983, after a career of more than 40 years in radio and electronics. He is now living in contented retirement in a beach-side suburb of Melbourne.

Geoff Frew & Lindsay Cobb

Bill felt that he was getting too much of the limelight in this article (the draft was sent to him for approval) and believed that as much information about the other two designers of the WS122 should be included. As a result, Bill put together some notes on these two very talented engineers.

In 1943, Radio Corporation had an RF design department of about 15 staff. There were many other sections such as a machine shop, drawing office, transformer manufacturing section, etc.

In the RF design section (Research Section), the main receiver design work was done by Lindsay Cobb. Lindsay had been with Radio Corporation for many years and was involved in the design of radio receivers for the domestic and other markets. Many fine designs can be attributed to him and he stayed with the company until his untimely death around 1960.

During Bill's time at Radio Corporation (1943-45), most of the transmitter design work was done by Geoff Frew. Geoff had come on strength with Radio Corporation during the war. According to Bill, Geoff's experience before joining Radio Corporation included the design of car radios and vibrator power supplies. His qualifications were in civil engineering but he switched to radio design, in which he excelled.

Geoff Frew left Radio Corporation after VJ day (the day of the Japanese surrender) to concentrate on his own small private company. He initially made moisture meters for the timber

Photo Gallery: 1939 HMV 449



One of a series of mantel receivers produced by The Gramophone Company (Sydney) in 1939, the HMV 449 was a 4-valve super-heterodyne unit fitted with a 6-inch (150mm) electro-dynamic loudspeaker. The valve line-up was as follows: 6A8-G frequency changer, 6G8G IF amplifier/detector/AVC rectifier, EL3NG audio output and 5Y3-G rectifier. Photo: Historical Radio Society of Australia, Inc.

trade under the trade name of "Techtron" but soon expanded into making attenuators, audio signal generators (20Hz - 200kHz) and low RF level vacuum-tube voltmeters.

His crowning glory came when he made the prototype and production models of the Atomic Absorption Spectrophotometer in about 1964 for the CSIRO. He continued to make these for world-wide supply until 1967, when his business was bought by Varian Associates. Geoff was the complete radio and electronics designer and he died around 1975.

Others who made it happen

Although Lindsay, Geoff and Bill designed the transceiver circuit, there was also a team of people who made the WS22/122 transceiver a reality when it came to manufacturing the unit. These people did all the "nuts and bolts" work on designing the chassis layout, the wiring looms and the positions of the front panel controls – and this isn't a simple task in a complex piece of equipment like the 22/122.

It is important that a piece of equipment must work properly under all conditions and component layout can be quite critical. Tropic proofing and semi-hermetically sealing the complete transceiver and power sup-

ply was also a very important activity that was taken on by this team.

In addition, they devised carrying cases, wrote an instruction manual and did lots of other "little" jobs to make the design a success. Their names have all probably been lost in history but without them this highly successful transceiver would never have been more than a prototype.

Summary

The brilliant trio of Cobb, Frew and Clarke designed a cutting edge military transceiver that was well ahead of its time in a number of design areas. In fact, it was still considered quite suitable for use in many communications services for many years after the war finished. It only finally became obsolete when single sideband (SSB) transmissions became mandatory in the late 1970s.

Lindsay Cobb and Geoff Frew were Bill's mentors, providing him with invaluable assistance for his future career. Of course, it would have been tremendous to have been able to talk with both Lindsay and Geoff as well but I'm about 40 years too late.

And so, many thanks to Bill Clarke for sharing some of the history of radio design in the 1940s. It really was intriguing to learn how the WS22/122 transceivers were designed. **SC**