Vintage Radio

By Ian Batty

The AWA 897P: Australia's first transistor radio

Designated the model 897P, Australia's first transistor radio was developed by AWA and first marketed in November 1957. It uses seven transistors, is built onto a metal chassis and uses the same case as its valve predecessor.

WITH THE centenary of Amalgamated Wireless Association's listing on the Sydney Stock Exchange, it seems timely to review their first transistor radio. Formed as a result of the rivalry between the German Telefunken and British Marconi companies, AWA has been a pioneering presence in radio and electronics here in Australia and around the world.

The first chairman, Hugh Denison, eventually made way for the better-known Ernest Fisk. Fisk's later knighthood and towering presence eventually extended to the familiar "Fisk Radiola" badges on many of the company's radios and even to the naming of the former Imperial Wireless Chain station as "Fiskville". For a more complete history on this, see the Historical Radio Society of Australia's *Radio Waves*, July 2013.

Early transistor radios

Regency (USA) marketed the first successful all-transistor radio in 1954, designated the TR-1 (SILICON CHIP, April 2013). Given the stupendous engineering task (a learning "cliff" rather than a "curve"), AWA's offering of the 897P in November 1957 is remarkable. The initial offering used a mix of "2N" and "OC" transistor types, the latter echoing AWA's early association with German company Telefunken.

The CSIRO had begun investigating semiconductors in 1953, initially with the assistance of Bell Laboratories. Dr Louis Davies had spent six weeks at Bell Labs and came back from the US armed with two essential precursors to making transistors: the technologies for purifying germanium and for growing single crystals of germanium.

A subsequent symposium attracted the attention of industry, rather as the original Bell Labs seminars had in the USA. Although all the "big four" Australian companies attended, it was the work of Ted Watt and Henry Banks that led to AWA starting local production in 1958. Watt and Banks had attended an engineering "apprenticeship" at RCA and their efforts were pivotal in AWA's entry to the local market.

The 897P transistor radio used an existing valve portable case design from the model 581PZ. Like many sets of the era, it also used a pressed and punched metal chassis and the parts were all installed by hand. It's quite similar the RCA Victor Transistor Seven, even down to the 2-gang volume control (the RCA set was described in the October 1956 issue of *Radio, TV and Hobbies*).

Two restorations

This article summarises two restorations, as I was very generously loaned a number of 897 variants by the HRSA's Ray Gillett. And while on the subject of variants, the original 897P used RCA 2N219 (converter) and 2N218 transistors in the RF/IF section and Telefunken OC602/604 types in the audio stages. By contrast, the later 897PX/PY/PZ used all RCA types, with 2N408 & 2N270 types now in the audio amplifier. These are all

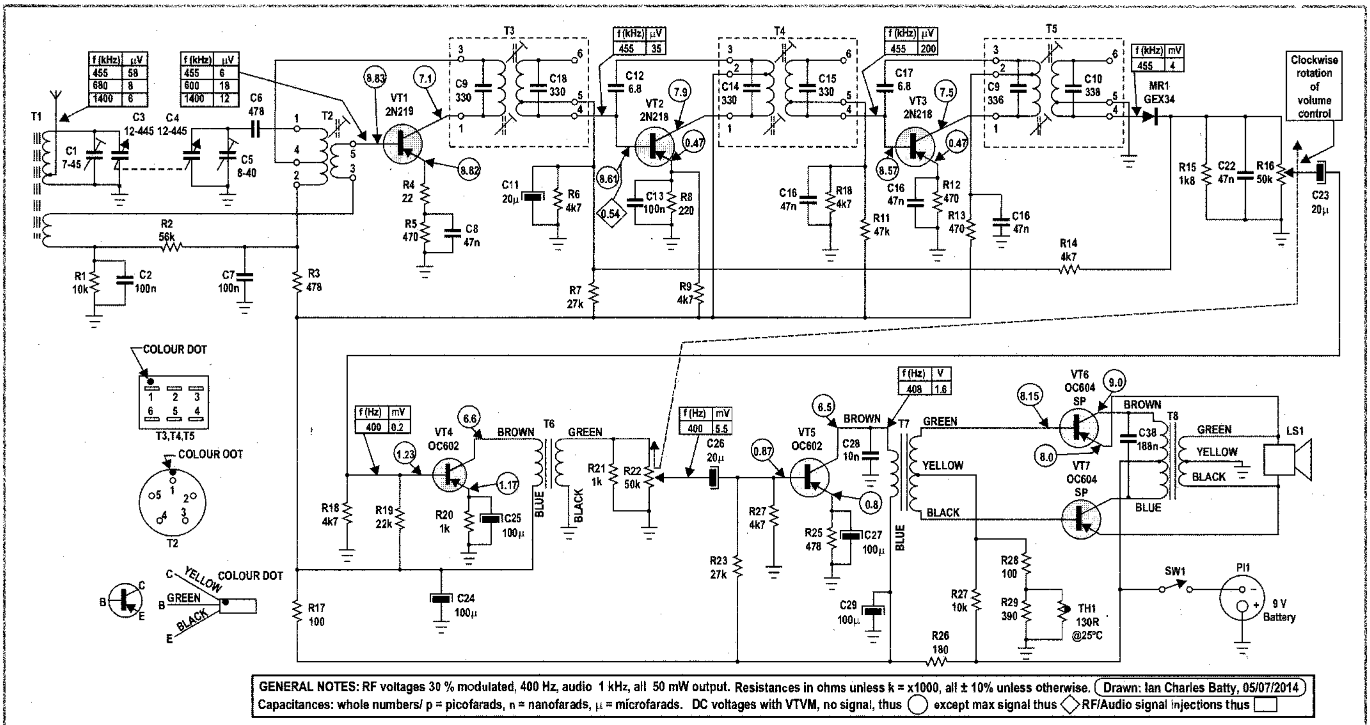


Fig.1: AWA 897P is a 7-transistor superhet design with 455kHz IF stages. Transistor VT1 is the converter stage, VT2 & VT3 are IF amplifier stages, VT4 is an audio preamplifier, VT5 an audio driver stage and VT6 & VT7 function as a push-pull output stage.

"second generation" alloyed-junction types.

The 897P: first look

As stated, AWA's 897P uses a pressed and punched metal chassis just like the Bush TR82C (SILICON CHIP, September 2013). It uses seven transistors, five of which are fitted into chassis-mounted rubber grommets with their leads then wired to adjacent solder tags.

By contrast, the two output transistors are held in heatsink clips which are screw-mounted on the underside of the chassis. This differs from the later PX, PY & PZ models which (strangely) also have their output transistors mounted in rubber grommets, defeating any possibility of heatsinking.

Unfortunately, the grommet-mounting technique means that the transistor leads are underneath the chassis. This means that unless the chassis is removed, the only circuit access, either for measurement or signal injection, is at the aerial coil, the volume control and speaker terminals.

As shown in the photos, the chassis is mounted in a substantial leather case, with the wrap-around shell closed off by stitched-on ends. The front dial turns easily with a direct drive. It sits within the front escutcheon which also contains the speaker grille. The volume/power switch is mounted on the righthand end of the set.

897P circuit details

Fig.1 shows the circuit details of the AWA 897P. Many of its components were common to the valve era and apart from the the transistors and the low-voltage electrolytic capacitors, they appear much the same as those found in portable battery valve sets.

Some models use the classic Philips tuning gang with rounded edges on its frame, brass plates and identical aerial and oscillator sections. The 897P and 897PY models use gangs with 445pF per section and a 470pF padder, while the 897PZ and 897PX models use 385pF sections and a 420pF padder. There are also minor mechanical differences, with the 897PZ and 897PX models using a different dial scale.

The circuit itself is a fairly conventional 7-transistor superhet design. The RF signal is picked up by antenna rod T1 and tuned by C3, one section of the tuning gang. The other section, C4, tunes the local oscillator. The tuned RF signal is then fed to the base of PNP transistor VT1 via coil T2.

VT1, a 2N219, is the converter stage (ie, a combined local oscillator and mixer) and this uses collector-base feedback (ie, via T3's tuned primary and a tapping on T2's primary) to maintain oscillation. While this works reliably, it does increase the amount of local oscillator (LO) radiation back out through the antenna rod.

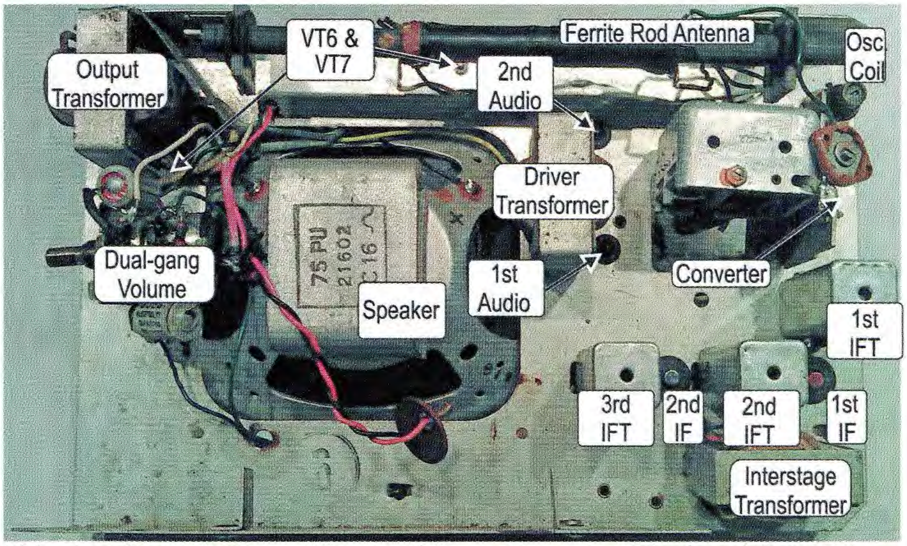
The mixer's output feeds the primary of the first IF transformer (T3). This uses a tapped secondary winding to match into the low base impedance of the first IF amplifier.

The two following IF transformers use tapped primaries and secondaries, with VT2 & VT3 (both 2N218 transistors) functioning as IF amplifiers.

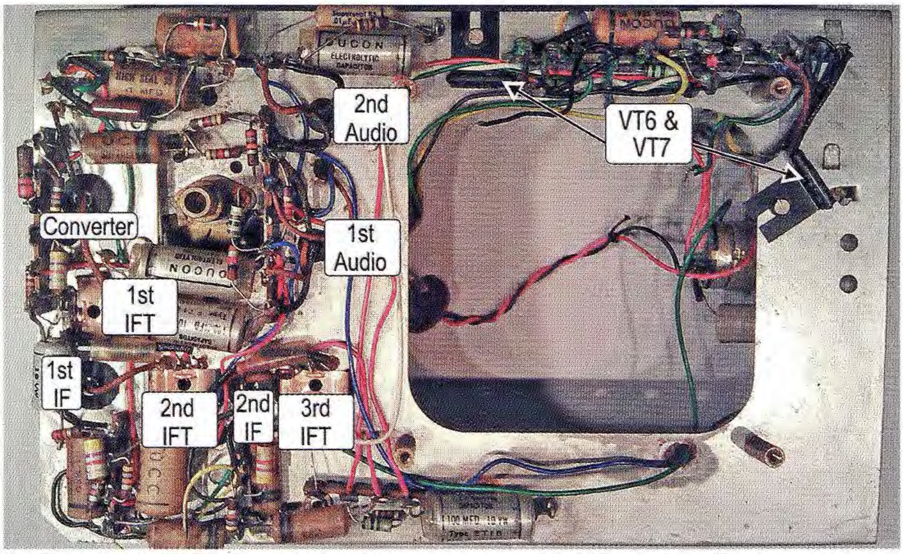
The two IF amplifiers operate similarly to those in most other sets. AGC action is applied to the first IF amplifier stage (VT2) alone, reducing base bias and thus the total collector current on strong signals. In common with other designs, reducing the collector current reduces current gain and thus the stage gain.

The applied AGC voltage (at VT2's base) is quite small, with the base bias dropping by only about 70mV at full signal. This is much less than in many other sets and is due to the voltage divider connected to VT2's emitter.

Instead of allowing the emitter voltage to also drop with incoming AGC (and thus "softening" the response somewhat like a remote cut-off valve),



This view shows the general layout of the major parts on the top of the 897P's chassis. Transistors VT1-VT5 were mounted by pushing them into rubber grommets from underneath the chassis.



Unlike VT1-VT5, the two OC604 transistors used in the push-pull output stage (VT6 & VT7) were attached to the underside of the chassis using metal clamps. Note the point-to-point wiring technique used to assemble the circuit.

VT2's emitter voltage is held nearly constant. This allows the 70mV drop in base voltage to take VT2 from its normal forward-bias value of around 130mV down to virtual cut-off at 90mV, much like a sharp cut-off valve characteristic. So because of the emitter voltage divider, don't expect to measure signal strength by the fall in VT2's emitter voltage.

The second IF stage operates with fixed bias (as usual). Note that both IF amplifiers are neutralised (using C12 & C17) to prevent instability due to collector-base feedback.

The demodulator uses a conventional diode (MR1) and this feeds audio to volume control R16. It also feeds a DC voltage back into the bias network for the first IF amplifier, in common with other designs. Stronger signals reduce the bias on the first IF, thus controlling its gain. As with all AGC systems, the net effect is to keep the audio signal fairly constant with varying RF signal strengths.

Audio stages

The 897P uses three audio stages: preamplifier stage VT4, driver stage VT5 and a Class-B push-pull output stage based on VT6 & VT7. In common with the Raytheon T-2500 and the Bush TR82 radios, the audio section uses transformer coupling. While this adds complexity and potentially reduces both high-frequency and low-frequency audio response, transformer coupling gives optimal power gain and thus improves sensitivity.

As an aside, this design choice implies that the set's RF/IF gain was less than optimal and that the deficiency was compensated for in the audio section.

The biasing in the audio preamplifier and driver stages is similar to that used in the IF amplifiers and works identically. However, larger emitter bypass capacitors are used so that they are effective at audio frequencies.

The set is unusual in using a 2-gang volume control and the "original" 897P model is readily identified by this feature and the use of "OC" series transistors in the audio section. But why use a 2-gang volume control? The articles in the HRSA's *Radio Waves* for July 2013 give two possible reasons: (1) to prevent overloading and breakthrough at low volume with strong signals and (2) to reduce the effects of preamplifier noise.

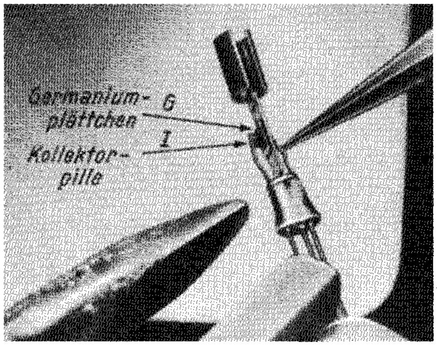
So which of the two is correct, or are they both correct? Well, bypassing the second volume control pot (R22) still resulted in effective control but made the set noisy at low volume. On the other hand, reinstating R22 and bypassing R16 solved the noise problem but caused serious audio clipping and distortion on strong signals. So the answer is that both of the possible reasons given for using a 2-gang volume control are correct.

The output stage uses a conventional transformer-coupled Class-B push-pull circuit based on VT6 & VT7. As in the Bush TR82C, feedback is applied from the speaker to each output transistor's emitter terminal.

In addition, the output stage uses a voltage divider to give about 160mV of base bias to each output transistor. In common with other Australian designs, the lower end of this divider includes a 130Ω NTC thermistor (ie, its resistance falls as the temperature increases).

The combined effect of the thermistor and transistor characteristics ensures a fairly constant collector current in the output stage, regardless of temperature. This arrangement minimises crossover distortion and protects the output transistors from thermal runaway (due to increasing current), thereby saving them from damage due to overheating.

The output stage drives a large 5 x 7-inch oval speaker, which gives good



This internal view of Telefunken's OC604Spez transistor shows the metal half-cyclinder (at top) that was used for heatsinking.

efficiency and volume. Power came from a single Eveready 276P 9V battery and this was capable of powering the set for some 300-plus hours with normal use.

The OC604Spez

The most obvious difference between the 897P and its successors is its use of Telefunken "OC" series audio transistors. Both the OC602 small-signal and OC604 output types use glass encapsulation. This glass encapsulation provides the hermetic seal that's vital for germanium devices but it impedes heat dissipation.

Telefunken's answer to this was the OC604Spez(ial) transistor, a glass-encapsulated type with internal heatsinking that allows it to deliver up to 500mW from a 6V supply. As shown in the above photo, the heatsink consists of a metal half-cylinder that's attached to the base slice (the "Germanium-plattchen").

879PX/PY/PZ differences

By contrast, the PX/PY/PZ models use RCA-derived 2N408 transistors for the audio preamp and driver stages and 2N270 types for the push-pull output stage. Despite this, these variants perform similarly to the 897P.

Apart from that, they're recognisable because they also have their output transistors mounted in grommets. The other visible difference is the 897P's use of a Philips-style tuning gang with rounded corners in its frame compared to the more common square-cornered types.

Restoring an 879PX

As it came to me, the 897PX set had a "scratchy" volume control pot and there was no audio output. A quick check of the DC voltages revealed that all was OK in this department so the capacitors THEN came under suspicion. I needed many millivolts of signal at the volume control to get even a "squeak" of output and further checks showed that coupling capacitor C26 (20μF) was open-circuit, as was its companion C23.

Replacing both these capacitors immediately brought the set to life. Further checks then revealed that it had an audio sensitivity of about 200μV for 50mW of output, which is excellent.

Audio response?

What about the audio response? In a word, it was "rubbish" with a response of only about 190Hz to 1.3kHz. That just had to be wrong. My chief suspects were the two top-cut capacitors, ie, C28 (10nF) across the driver transformer's primary and C30 (100nF) across the output transformer's primary. De-soldering both dramatically increased the high-frequency response of the audio stages to 13kHz.

Replacing both capacitors restricted the response to 2kHz. This was quite acceptable, especially given the RF/IF section's bandwidth of about ±1.7kHz. As an aside, removing C28 extended the frequency response to about 6kHz but worsened the set's weak-signal noise figure by over 3dB. So it appears that the heavy "top-cut" technique was a quick-and-dirty way to improve the subjective performance.

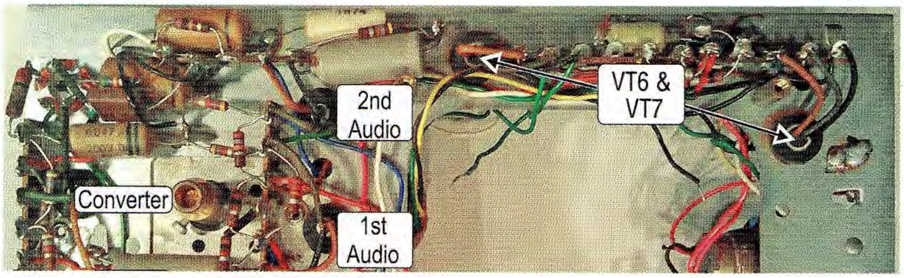
One thing of note is that this set has an unused connection on the ferrite rod. It turned out to be an "aerial terminal" tap on the tuned winding and provided a convenient direct signal injection point for testing.

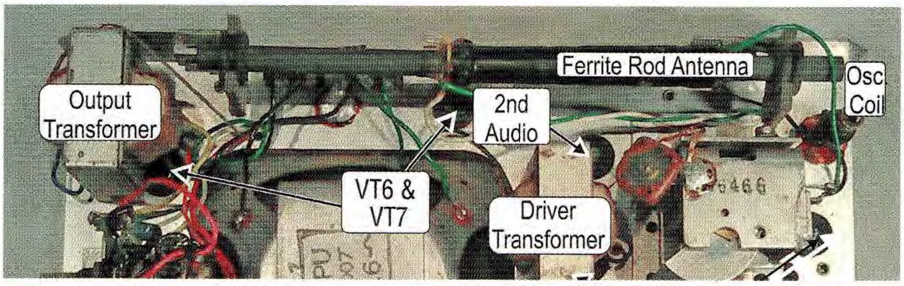
Now for the 897P

When I obtained the 897P, I found an envelope containing a paper inside the case headed "Freddy's Hire Purchase Contract for AWA Tranny 24-12-1957". This was proof positive that this set was indeed made in 1957. The contract, with Industrial Acceptance Corporation, shows a total amount payable of £52 13s or about $105.30 before adjusting for inflation.

In today's money, after inflation is taken into account, that's about $1500 – double the cost of a high-end smartphone. The purchaser was obligated to pay off the set over a period of 19 months.

Cosmetically, my 897P came to me with its leather case in poor condition.





These two photos show sections of the 897PZ chassis. Unlike the 897P, this model used 2N270 output transistors which were mounted in grommets, just like VT1-VT5. The other visible difference is the 897PZ's use of a "non-Philips" tuning gang with square edges.

The leather was dull, though not badly scratched, and the stitching on one of the end cheeks had degraded, allowing the end to detach.

The case would have been machine-stitched during manufacture but I was able to locate hemp cord at a local craft shop of the same thickness as the original. After removing the original thread, I was able to counter-stitch and restore the case to its original appearance.

Electrically, the set was completely dead, apart from an audible turn-on/turn-off "click". The reason for this wasn't hard to determine – audio transformer T7 had an open-circuit primary. This was rather odd since it's a low-voltage, low-power item.

Replacing this transformer with a similar inter-stage transformer restored the set to life.

How good is it?

As noted above, the frequency response is around 190-1900Hz from the volume control to the speaker and around 210-1600Hz from the antenna to the speaker. Removing that pesky 10nF top-cut capacitor (C28) from VT5's collector extended the response to around 2.6kHz, and the difference in quality was quite noticeable.

The audio performance was otherwise quite good: at 10mW output and 400 Hz, the total harmonic distortion was just 2%, while at 50mW, the distortion was about 3.3%. This rises to around 8% as the set just begins clipping at 220mW output and is 12% for 250mW. Removing the output stage's feedback gave a worst-case figure of 8% distortion at just 50mW output.

The Pye Jetliner transistor radio described in the September 2014 issue has a diode-biased output stage and was able to maintain low distortion down to 50% battery voltage, with little evidence of crossover distortion. By contrast, the 897 is unable to cope nearly as well with falling battery voltage because it uses voltage-divider biasing. As a result, it gives audible crossover distortion when the supply is down to 5V. At this voltage, it clipped at an output of just 50mW.

The 897's selectivity is ±13kHz at 60dB down, reflecting the presence of three double-tuned IF transformers. Although the 897, like the TR82C, uses four audio stages, the 897's design fails to exceed the TR82C's performance, achieving 250µV/metre at 600 kHz and 150µV/m at 1400kHz with the volume control adjusted for a signal-to-noise ratio (S/N) of 20dB.

At full gain, the model 897 achieved 125µV/m at 1400kHz with an S/N of 17dB (note: all inputs are for 50mW output and 30% modulated at 400Hz). Given that Bush's TR82C is a later design using alloy-diffused AF116/117 transistors in the RF/IF section, the 897 (which uses alloy-junction transistors) performs quite well, especially as it was AWA's first transistor radio.

The AGC control is average and a 26dB signal increase from 60µV to 1200µV at the aerial terminal gives a 6dB increase in the audio output. The only reservation is that this set went into violent oscillation with a radiated signal strength much above 30mV/m.

Graham Moore (*Radio Waves*, July 2013) notes the "sharp cut-off" characteristics of a transistor AGC circuit and the 897, with its emitter tied to about 0.47V by voltage divider R8 & R9, certainly exhibits this.

By contrast, most sets use a single emitter resistor to ground, allowing something closer to a medium/remote cut-off. With an IF stage gain of about 30dB, applying AGC only to the first IF can't reduce the stage gain by any more than 30dB before the transistor is left with virtually zero collector current.

Basically, in order to achieve greater AGC range, the converter must also be controlled, either by using an auxiliary diode circuit as in the Pye Jetliner or by applying AGC to a mixer that's fed by a separate local oscillator.

The 4-valve predecessor

When I dusted off a somewhat sorry-looking 4-valve AWA 581PZ and applied power, I was rewarded with absolute silence. I'll leave its restoration details for another article. However, when I did eventually get it working, the 581PZ (which looks just like the 897P) had a sensitivity of about 360µV/m at 600kHz and 250µV/m at 1400kHz.

So the 897 appears to have roughly double the sensitivity. In practical terms though, the two sets would have almost identical performance except on the lab bench. I expect that the 581PZ's audio performance (output power, distortion and frequency response) will be similar to that of its all-transistor 897 successor.

Acknowledgments

Many thanks to Ray Gillett of the HRSA for his very generous loan of a half-dozen variants of the 897.

Further reading

(1) For a more complete history of AWA, see *Radio Waves*, July 2013.
(2) For more detail on the 897P, see the July 2013 *Radio Waves* articles by Graham Moore and Ian Malcolm.
(3) For more detail on early Australian transistor manufacture, see Mark P. D. Burgess' article – go to https://sites.google.com/site/transistorhistory/ and navigate to Australian semiconductor manufacturers. **SC**