THE ASTOR "DIAMOND DOT" CJ-12 CAR RADIO FROM 1966 AND EXTRAORDINARY AUSTRALIAN MADE TRANSISTORS OF THAT ERA. (H. Holden July 2021)

BACKGROUND:

I was cleaning out my shed and found a very rusty old MW band car radio with missing knobs and a broken and yellowed dial. I recalled I had acquired to go in my 1966 Triumph TR4-A car, so it was period correct. Instead I had ended up fitted a Motorola brand AM radio with an FM converter. So I had forgotten all about this Astor radio.

I noticed the brand name Astor, which is Australian and on the chrome escutcheon on the upper right it had what looked like a Diamond set into the metalwork. Not a real diamond of course, more like a costume jewellery variant, but still it gave the front escutcheon an eye catching look.

The radio was in such poor condition one part of me wanted to toss it away as I was in the process of a big cleanup. But I decided to take a closer look. The more I looked at the radio, the more interesting it became and I decided the radio was worthy of a complete restoration.

The photo below shows the restored Astor Diamond Dot radio:

The radio's dial itself is quite a piece of Australian medium wave broadcasting history, with rows of station ID's for different states: TAS, NSW, VIC, SA, NT, WA and QLD. I also noticed, one of my favourite radio stations listed as KQ, which is 4KQ in Brisbane. Obviously when this radio was made, it was intended to used anywhere in Australia in any state, with the stations of interest listed on the dial.

Car Radio Technology and History:

I have always found car radios to be interesting in their design, especially because of the permeability tuning mechanism which also permits easy push button tuning.

Also, my very first job, out of school, was working at a car radio factory, called Aerial Radio in Auckland in the 1970's. That is where I learned about car radios. I worked in a final testing station, putting the radio through its paces & fixing any assembly bugs, before it was boxed up for sale.

Car radios made prior to 1955 were tube types. Generally the HT supply was provided by a Vibrator and step up transformer and the tube anode voltages were run at similar to those in a line powered domestic radio in the 200V to 300V range.

Later on, in the mid to late 1950's, tubes which required only 12V anode voltages (such as the EF98 and ECH83 and others) were devised and combined with a single germanium power transistor, typically a 2N441, in a class A audio output stage with a collector choke. This "Hybrid" design was very popular until the early 1960's.The hybrid design with the low HT voltage tubes eliminated the need for the vibrator.

Typically the Hybrid radio audio stage used one EF98, with a 10 Meg Ohm input g1 grid resistance would drive a 23:1 ratio transformer. This would drive the base-emitter junction of the 2N441 power transistor, which would have a choke as the collector load, with the speaker connected directly across the choke, or a tap on it.

Typically this Hybrid design resulted in an audio amplifier system, which required about 2v to 3v peak drive for full volume and output power of up to 4 or 5 watts.

Also it created an audio amplifier with an input impedance of 10 Meg Ohms at the grid of the EF98 and an output impedance of 4 or sometimes 8 Ohms from the collector choke. It was impressive, especially for just the one tube and one transistor. However, it was not energy efficient and the transistor required moderate heat sinking, because in Class A, the idle power consumption is often a similar value to the maximum audio output power.

While these hybrid radios were still popular, as early as 1955, the first “All Transistor” car radio appeared on the scene in the USA. This was the Mopar model 914HR. This radio was made possible by some revolutionary new surface barrier radio frequency transistors, with very low base to collector feedback capacitances. Rivalled only perhaps by Germanium RF transistors such as the OC169, which appeared later in 1960. There is an interesting You-tube video about this revolutionary Mopar radio:

https://www.youtube.com/watch?v=Qz3JkFnvBuA

Mopar all transistor radios were fitted to the 1956 Chrysler and Imperial car models. And after that time, many USA manufacturers had not caught up and were still fitting Hybrid style tube radios to new cars. So it would seem to take a while, perhaps 5 years or more, before the “All Transistor” car radio notion took over. The Mopar 914HR was definitely some years ahead of the times.

By the early 1960’s most countries started to mass produce “All Transistor” car radios and by the mid 1960’s, not only were most car radios “All Transistor” but in keeping with other transistor radios, the audio output stages had moved to push-pull class AB designs, significantly improving the efficiency over the class A designs of Hybrid radios.

In this class AB design the output transistors are essentially in class B but given enough initial bias to overcome cross over distortion. This greatly improved the efficiency and cut back the power consumption of the radio. You could get away with accidentally leaving your car radio on overnight and just be able to start your car in the morning.

Generally, the initial push pull audio output stage designs used a driver and output transformer. Later, with changes to circuit topologies, a split driver transformer was used, eliminating the output transformer, saving the cost and weight of the iron core. In this case the speaker was coupled to the power output transistors via a capacitor.

Then, with abundance of good silicon NPN & PNP power output transistors, totally transformer-less circuit topologies with complimentary audio output transistors appeared. After the mid 1970’s, the entire audio stages often became replaced by a single IC, as was the trend in many domestic radios.

One could expect therefore, that a transistor car radio from the mid 1960’s era, like the Astor Diamond Dot radio, to be sporting a push pull output stage, probably with coupling transformers, which is indeed what it has.

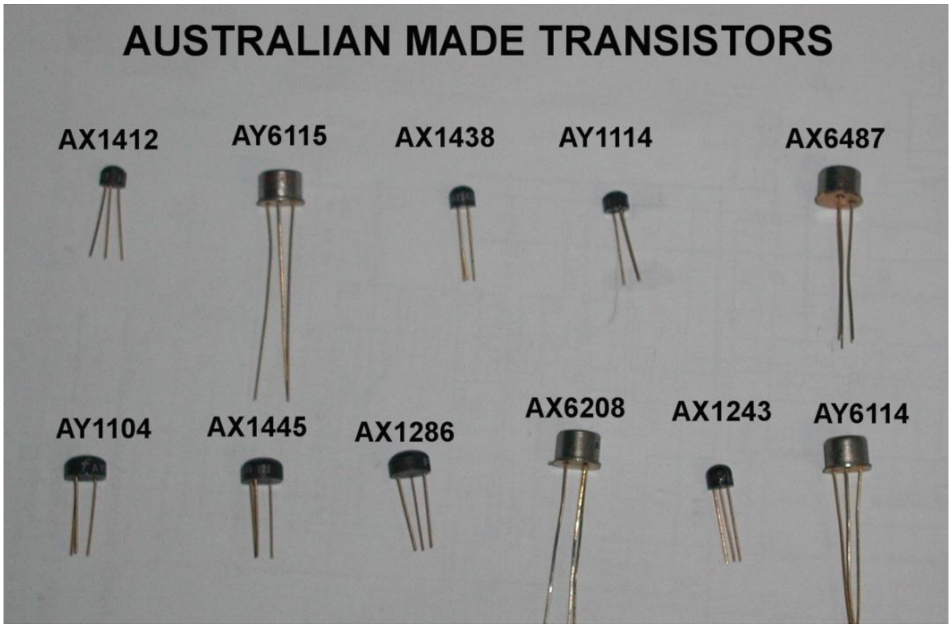
But what about the transistors, what was Astor using and where did they come from?

Inspecting my radio I immediately noticed two grey ceramic transistors with black resin tops with the part numbers AX1130 on their sides and I was about to learn more about the sadly lost and once amazing Australian transistor manufacturing industry.

AUSTRALIAN TRANSISTOR MANUFACTURING:

As History records, Bardeen, Brattain and Shockley invented the point contact transistor at Bell Labs in December 1947 and announced to the world in 1948. Shockley's junction transistor was also announced that year. Within a decade four companies came to invest in Australian transistor manufacturing and it included AWA, STC, Philips & Ducon and all came to manufacture germanium alloy junction transistors here in Australia in the late 1950's to early 1960's period.

What about the Silicon transistors, specifically the AX1130 in the 1966 ASTOR radio ? I looked in my parts inventory for similar transistors and came up with the following:



Investigation quickly revealed that the transistors, all with the A prefix, were manufactured by Fairchild's Australian division. They are relatively rare now, unlike most transistor types, if you search them on eBay trying to find a spare part, you do not get any hits, as these transistors are "unique Australiana".

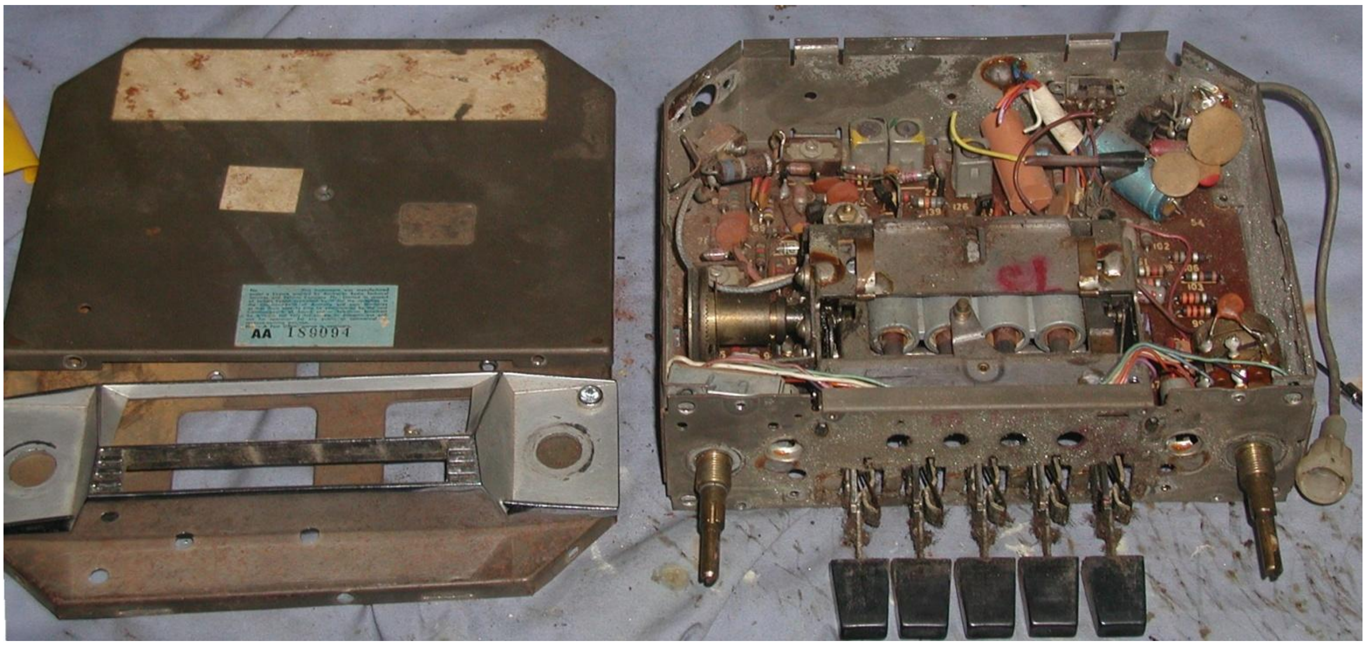
In June 1964, Radio Television and Hobbies magazine carried the following announcement:

"A new Australian company to produce heat resisting silicon transistors has been formed in Melbourne. An offshoot of the Fairchild Camera and Instrument Corporation of New York, the Australian company will be known as Fairchild Australia Pty Ltd".

In 1966, the company opened its laboratory facilities. The factory closed in 1973 and the AY/AX series of transistors which had been unique to Fairchild in Australia became obsolete.

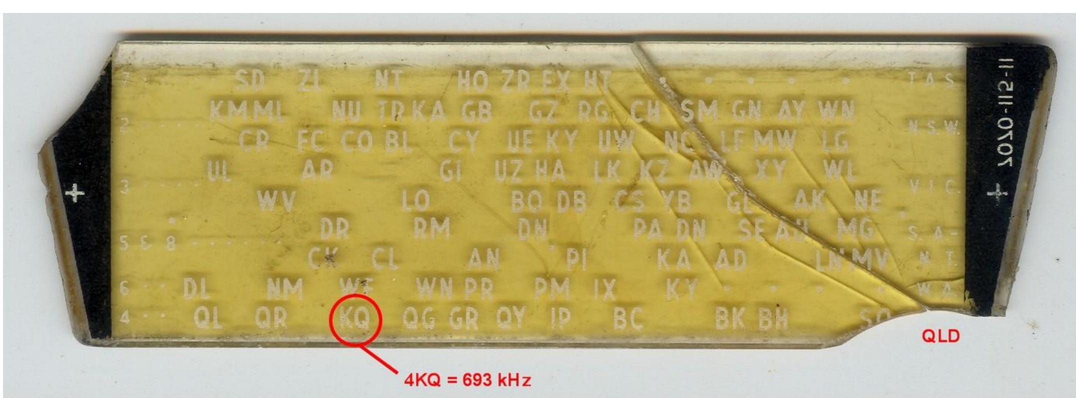
RESTORING THE ASTOR DIAMOND DOT CAR RADIO:

There were some interesting problems to solve. Most of the problems were related to rusting of the metalwork, missing front panel retaining nuts, missing knobs. The photo below shows the radio in a state of disassembly prior to restoration:



The radio was disassembled, this required removal of a number of rivets (replaced with identical ones later) to be able to disassemble the audio amplifier assembly heat sink assembly from the top metal lid.

The dial was yellowed through its full thickness, except where shaded from sunlight along its upper and lower edges. It had hardened and cracked:

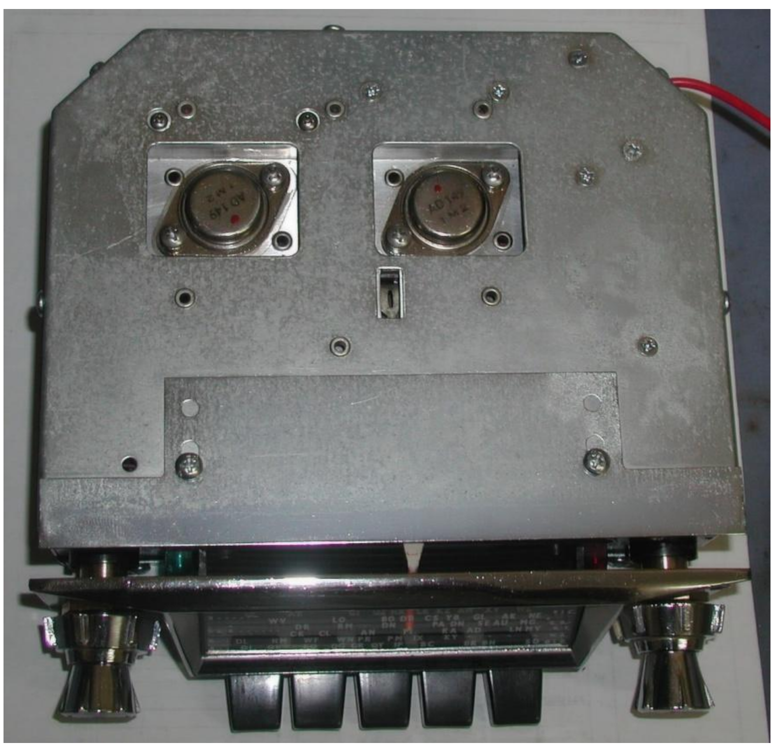


Due

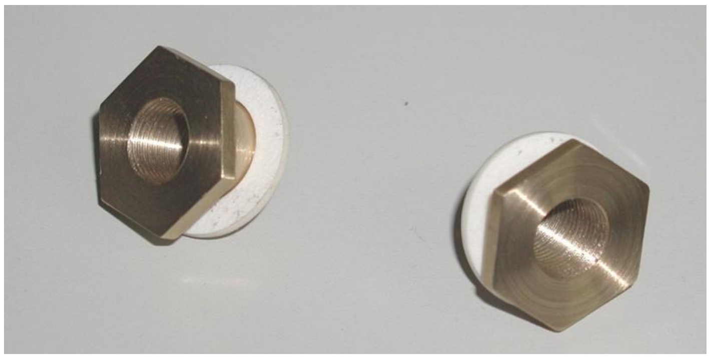
to the fact there was moderate surface rusting, the metal had been pitted, more on the top of the radio than the bottom. When the panels were re-electroplated, the stripping processing prior to this eliminates all the rust crystals. This must be done because rust never sleeps and when I see radios that have supposedly been “restored” by painting over the rust, it makes me cringe. However, after electroplating, the metal pits remain, but at least the surface is plated and not rusting.

The radio has a number of self threading screws, all very rusty. For the ones which were common garden size #4 and size #6, these were replaced with new screws, for the special low profile countersunk head types (that are hard to get) these were sent to the electroplater and re-plated. The rivets were replaced with identical geometry rivets, except for the two small ones, above the AD149 on the left, which were better replaced with small stainless steel screws.

The two original germanium output transistors, the Anodeon AT-1138 types were rusted, so I replaced these with an excellent matched pair of AD149 germanium transistors which are equally good if not superior. I kept the original Anodeon transistors and painted them, in case some day somebody would prefer to use them.

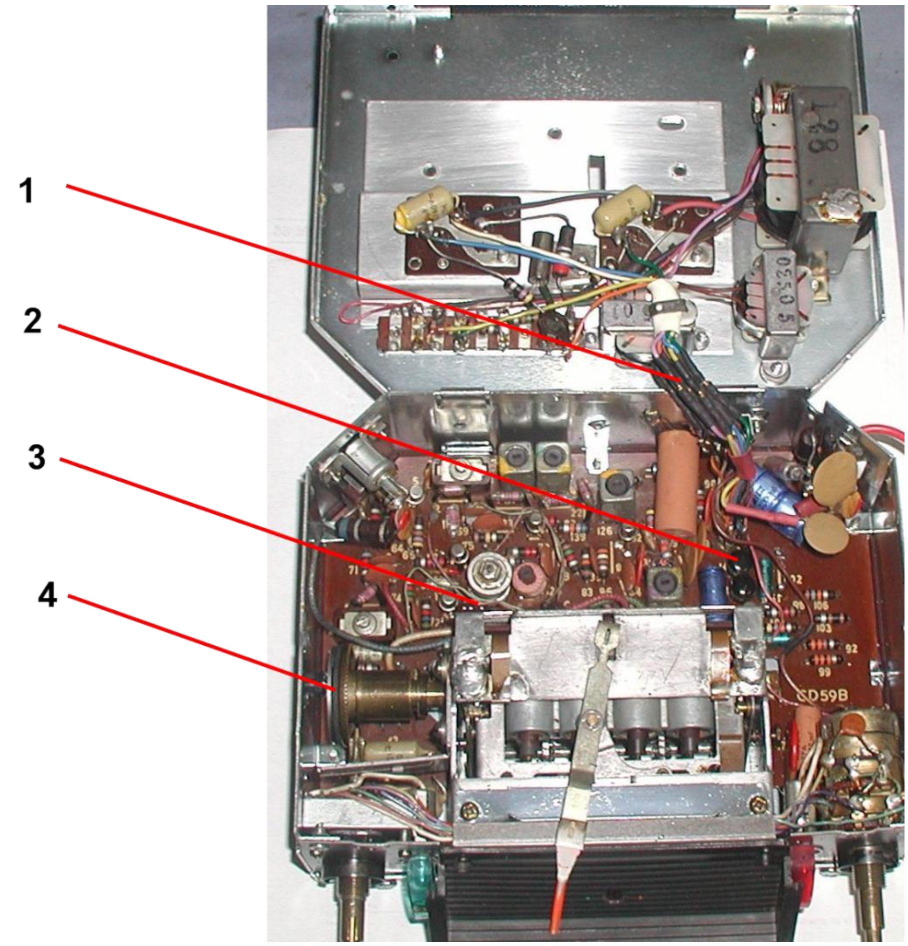


The special nuts which secured the front escutcheon were missing. I searched and could not find any, so I machined two nuts up from Hex brass bar on my mini-lathe. The thread is 3/8” diameter 32 tpi and I was able to get these taps on ebay. An 8.5mm drill size worked well. The fibre washers were taken from some panel mount fuse holders I had in the junk box:



I bought some “plastic” replica knobs on ebay, but was disappointed with the quality. After a while I found some original metal knobs from another model of Astor transportable car radio. Almost perfect but the centre knob was designed to push onto a ¼” shaft. This radio had 3/16” shafts for the centre knob, so I machined some brass inserts to fit into the centre knobs to make them compatible, these inserts are visible in the photo below:

The photo below was taken near the end of the re-build after the re-plated metalwork came back from the electroplater. The numbered areas are interesting points for discussion:



1) The upper panel (radios top lid) holds the audio amplifier assembly and it was linked by a leash of wires to the radio main board. For ease of restoration the wires were cut and 0.9mm gold plated pins and sockets were inserted (these are available from Jaycar) to make it easy to separate the audio amplifier and top plate assembly.

2) These are the two interesting Australian Fairchild AX1130 transistors. These act as driver transistors for the two Germanium output transistors. They are wired into each output transistor as an emitter follower configuration which creates a Darlington pair

(see schematic below). This reduces the required drive current to the output stage as a whole.

When I first powered the radio, one of these transistors was found to be defective. After I had determined this I unsoldered the transistor from the pcb. The transistors (all in this radio on the main board) had sleeved leads, so the lead wires were not directly visible. The transistors are interesting, in that in common with many of the Fairchild types of the time, they have gold plated steel lead wires. I found that the “defective” AX1130 had one lead wire that was totally rusted through. There was enough of it projecting from the transistor body to save the transistor by joining another wire.

I decided to inspect the other transistors on the main board in the radio frequency sections, these all had sleeve leads. All the lead wires had grossly rusted extending right up to the transistor’s plastic body. Ultimately I elected to replace all of them with high quality mil spec 2N2222A transistors to avoid any future troubles. Clearly this radio must have been in a very moist environment, possibly even saturated with water at one point in its past life.

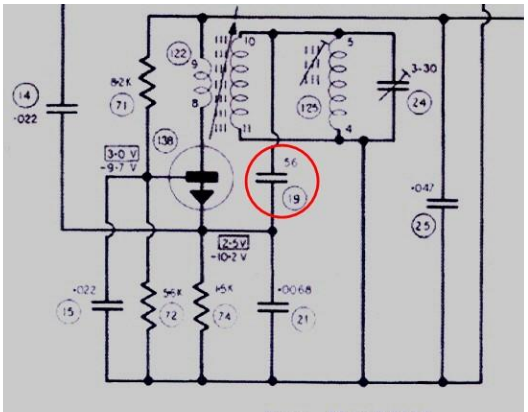
3) This was the location of an interesting faulty component. I thought this fault was worth documenting as I have never seen this defect in a Polystyrene capacitor before. After doing the usual things, replacing the radio’s electrolytic capacitors, powering the radio and adjusting the output’s stages quiescent current, testing the audio output stages with a signal generator, dummy speaker load and scope, I moved onto the radio frequency sections. The radio was stone dead, with just a faint hiss from the speaker.

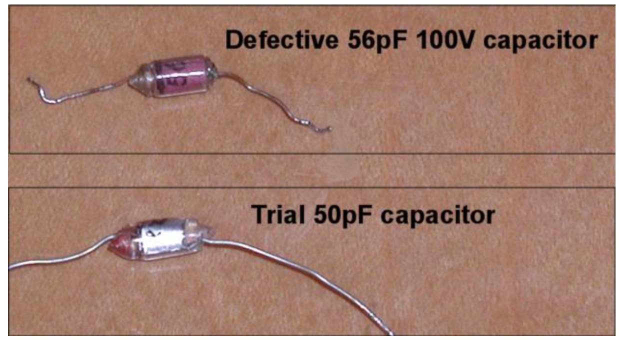
I quickly determined that the Local Oscillator was not running. Checking the transistor’s DC conditions, they were normal. I worried that possibly the oscillator coil in the permeability tuning unit had gone open. Testing showed that the oscillator started when a 47pF capacitor was placed in parallel with the existing 50pF feedback capacitor in the oscillator circuit.

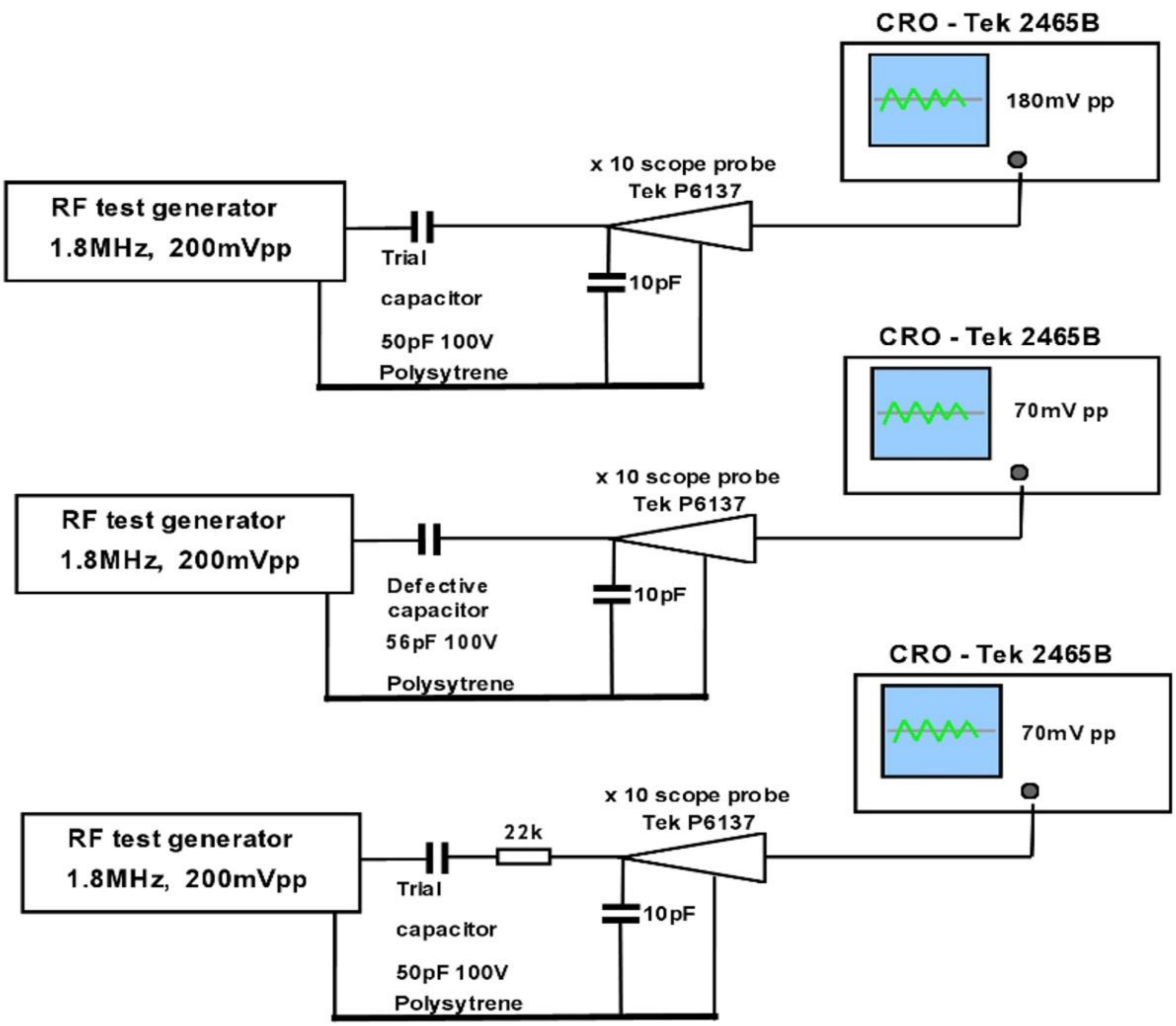
The schematic below indicated the position of this capacitor in the circuit. It provides the positive feedback from the Tank circuit which maintains oscillations. At first I thought that the requirement for more feedback capacitor probably indicated the transistor stage gain had dropped or the coil losses had increased. I had been suspicious from the rusting elsewhere that the radio might have been dunked in water. But, it turned out to be something quite unexpected.

I tested the 56pF Polystyrene capacitor, zero leakage and read 57pF on my YF-150 capacitance meter, yet I found when I replaced it with a new 50pf “trial capacitor” the oscillator ran normally. How could that be when the 56pF capacitor tested normally?

Of course, when a technician finds a faulty part, it most often gets thrown in the bin as it is not cost effective to investigate it. In this case I decided to at least attempt to find out what was wrong with this 56pF capacitor, in light of the disturbing fact that it tested normally on my meters, but didn't work.







The tests, as shown above, indicated that the capacitor had gone high ESR to the tune of about 22k. Of course ESR meters cannot measure low value capacitors like this. Then I tried placing resistors of this value, in series with good low value capacitors in the range of 50 to 100pF, my YF-150 capacitance meter is unable to detect significant series resistance.

Presumably inside the capacitor, the bonds or connection between the lead in wires and the foils have come oxidised or corroded.

The implications of this sort of failure could be interesting, if a capacitor with this fault was used instead in a tuned circuit in an RF amplifier. It would not throw the centre frequency off to any significance, but it would certainly lower the circuit Q, lowering the gain and increasing the bandwidth. Since, after alignment, this radio is now working normally and is a sensitive receiver, I have not removed any of the other polystyrene capacitors for testing.

4) The permeability tuning units of vintage car radios are interesting mechanisms. They have continuous tuning by the control knob and pre-set push button tuning which acts as mechanical memory for preferred stations. When a button is pushed, a sliding arm disengages a clutch mechanism to mechanically isolate the tuning knob.

(As an aside, my view is that the continuously variable tuning knob of vintage car radios is far and away the safest method to use a radio while driving a car. The driver could keep their eyes on the road driving, while turning a knob and just stop on the station they liked the sound of. Other radio tuning methods may require the driver to take their eyes off the road)

With time, these rubber clutches have a habit of slipping even with a well lubricated mechanism elsewhere. The rubber ages and hardens and its surface becomes glazed and the metal disc it runs against can become quite polished. To disassemble it, to replace the rubber disc, requires pressing off a gear from the assembly's shaft and that is better avoided. Cleaning the rubber disc with IPA helps, but often won't solve the problem.

I developed a method to fix these clutches using some very thin cardboard, similar to thin transformer card with an adhesive on one side. A washer is made the same size as the rubber disc and the central hole is opened to the disc perimeter. The clutch is opened manually or by pushing a button and the disc is inserted with the adhesive facing the metal disc surface and it sticks to that. Then the rubber face runs on the card face, rather than the shiny metal surface, this increases the friction and prevents slipping.

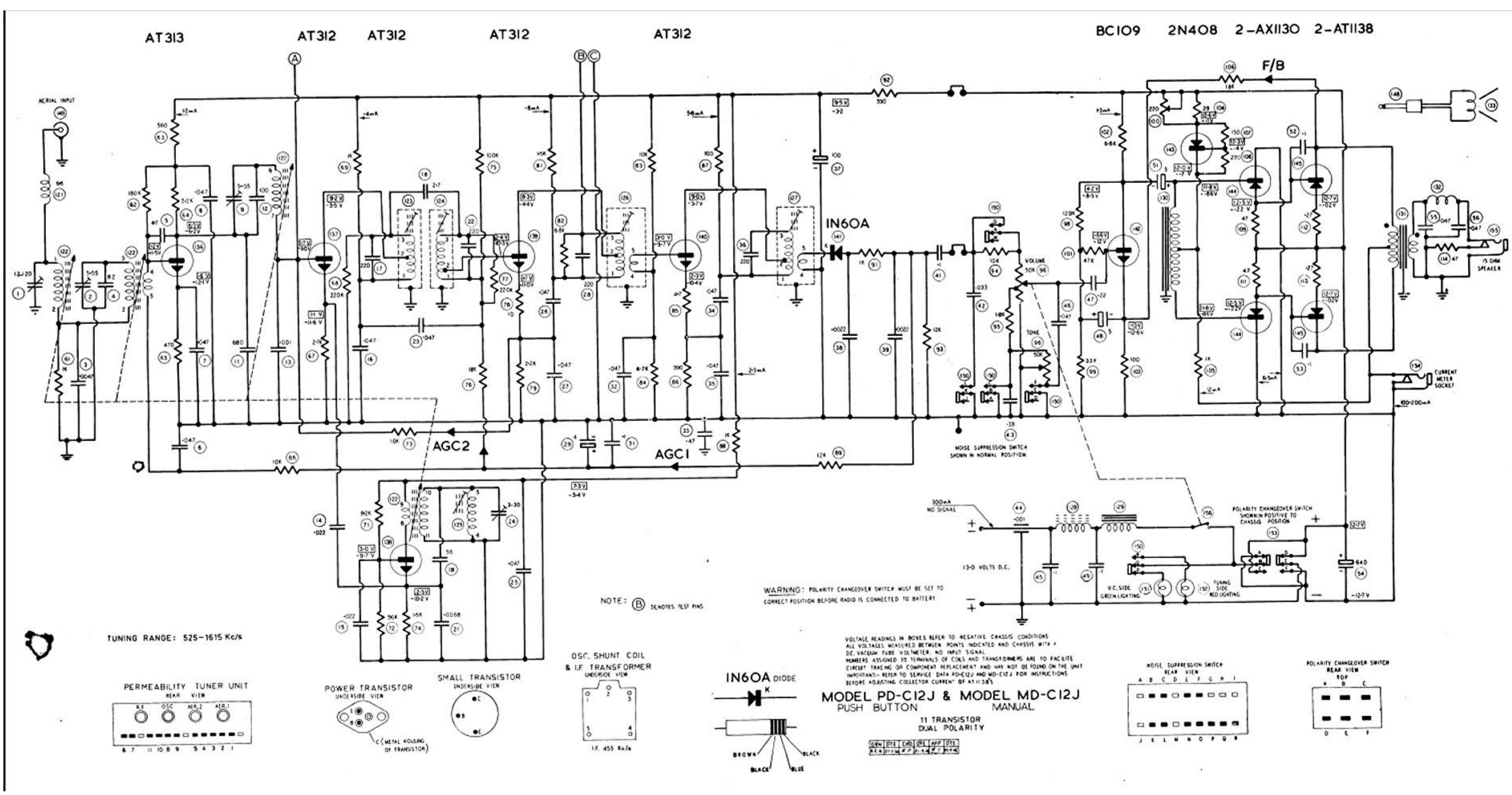
Other features of the restoration:

The radio had a sticker on its body that was moderately marked, so it was scanned and a replica made:

The schematic:

The schematic and the manual is available on this link:

https://www.kevinchant.com/uploads/7/1/0/8/7108231/pd-c12j_md-c12j.pdf



The transistors were drawn in a way typical of some early 1960’s vintage radios. One interesting thing is that the audio driver transformer does not have a primary winding.

Due to the fact they created output Darlington devices from the AX-1130 and AT-1138 transistor combination, this reduced the drive power required from the driver stage and created a higher than usual input impedance to the output stage. Therefore the driver transistor could simply capacitively couple into one side of the driver “transformer”, which is essentially a centre tapped choke.

Performance:

This radio is a good performer, sensitive in the RF circuitry, due to a tuned RF stage, one mixer stage, with separate local oscillator injection and two IF stages. On the Audio side a good performer with a push pull class AB output stage, with plenty of audio output power for use in a car. The radio is very well made physically and rivals any MW band car radio made in any other country. I am glad I could see the potential in this radio, to become something beautiful again and took the time to restore it. In its current condition it would now be very unlikely to be discarded. It would make a fine addition to a vintage car of the same period.

Summary:

This radio is a reminder of how advanced Australian electronics and transistor manufacturing was in the mid 1960’s era. Australian transistor manufacturing history, to some extent, saddens me, as once were able to make our own transistors & IC’s.

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