VINTAGE TELEVISION

The Admiral 19A11S TV and its unique deflection circuit

By Dr Hugo Holden

This set features a unique horizontal deflection circuit that has been sitting under everyone's noses for about 67 years, invented by Britons Faudell & White. Over the last 35 years, I have asked many veteran TV technicians if they know about it but so far, none have been familiar with the technique.

Early CRT TV sets like the Admiral 19A11S used electrostatic deflection rather than magnetic deflection, which became the standard until cathode ray tubes (CRTs) were made essentially obsolete by LCD screens. The difference is how the electrons in the cathode ray are deflected to land at the desired spot on the front of the screen.

As you might guess from the names, electrostatic deflection works by creating an electric field to deflect the electrons, basically by charging capacitors placed on either side of the electron beam (left and right for horizontal deflection or top and bottom for vertical). In contrast, magnetic deflection uses coils to create magnetic fields that bend the electron stream.

The amount of deflection created by the electrostatic method depends on the applied voltage, while the magnetic deflection works on the current through the coil. Either way, this voltage/current must be carefully controlled so that the electrons trace out a zigzag to illuminate the phosphor(s) on the face of the cathode ray tube.

The circuit concept used for the horizontal deflection system in the Admiral 19A11S has not been featured or described in standard television technology textbooks such as those by Fink, Grob or Von Ardenne. As far as I am aware, the only two TV sets which contained this "circuitry masterpiece" were the Admiral 19A11S and the Motorola VT71; both use the 7JP4 electrostatic CRT.

Perhaps it was overlooked by people servicing the sets because 'it just worked' and they put no further thought into it; they needed to fix the TV and get it back to the customer.

I recently posted this circuit on a vintage TV internet forum, again seen by many people with a long history in TV repair, design & construction. Nobody was familiar with it, and it surprised most.

Before reading this article, imagine you have studied all there is to know about designing TV sets with valves. You walk into an exam room and are confronted with this question:

Design a circuit with a single triode and any other R, C & L components you wish which runs from a 250V DC supply (ignoring the triode's heater). It must produce two anti-phase 450V peak-to-peak linear sawtooth waveforms (one for each horizontal deflection plate) and be suited to television horizontal scan and flyback timing.

It needs an adjustable frequency of around 15,750Hz, and it will be synchronised to the horizontal sync pulses in the usual way.

I think most engineers familiar with television scan stage design would find this question too challenging. On its face, it seems impossible. Conventional wisdom is that this task requires a separate oscillator and a two-triode para-phase amplifier running from plate supply voltages of 700V or more to allow enough linear amplification for generating the 450V peak-to-peak anti-phase sawtooth signals.

As argued in some texts, electrostatic deflection was abandoned in favour of electromagnetic deflection because sets with larger CRTs required very high voltages for the deflection amplifiers. This is because of the higher drive voltages required for larger tubes.

Note that in electrostatic CRTs, the amount of deflection is inversely proportional to the EHT voltage, so if you double the EHT, you have to double the sawtooth deflection voltages to get back to the same picture size.

On the other hand, the amount of magnetic deflection is inversely proportional to the square root of the EHT voltage, so if you double the EHT, you only need to increase the deflection current by 41% to get back to the same picture size.

How I noticed this circuit

I came into the possession of the 'shell' of a vintage television set, an Admiral 19A11S, while I was in New Zealand in the very early 1980s. I had to bargain hard to get it. In the end, I think I traded it for a fully working 26-inch colour television monitor.

Unfortunately, back then, I did not see the wisdom in making pre-restoration photographs. It consisted of a rusted chassis with a tuner unit on it. Most of the RF coils were there, including the RF power supply. All of the deflection oscillator parts, including two blocking oscillator transformers and one horizontal output transformer, were missing. No power transformer was present either.

There was no manual available at the time (no internet either). As TV broadcasting didn't start in NZ until 1958-1959, there was no service information on this 1949 model available from TV service shops.

The 1949 Admiral 19A11 set in a contemporary advertisement is shown opposite, with my set shown above.

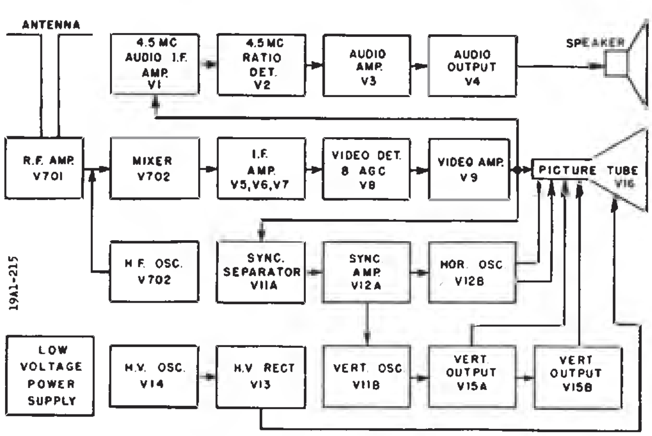
Luckily, the fellow I got it from had an old copy of the schematic. It looked to me like an old treasure map; at least, I thought of it that way. It was faded and drawn over in Biro in places and had tears repaired with clear tape, but enough of it was there.

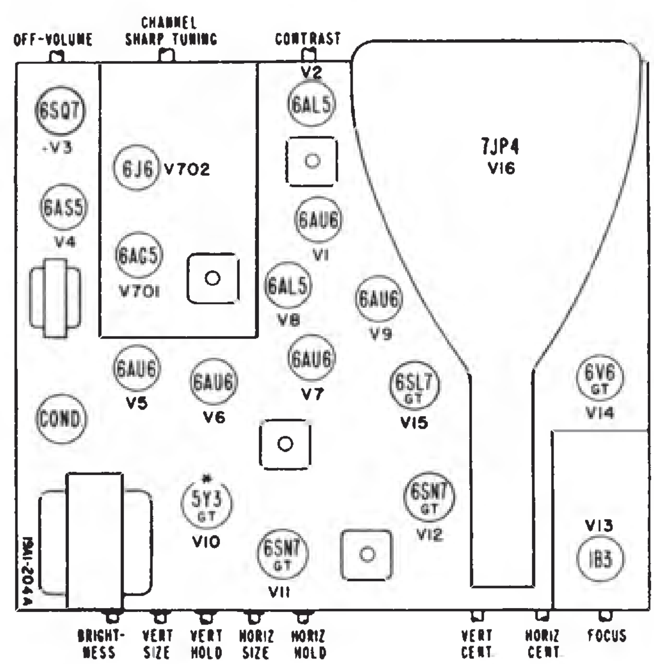
Nowadays, it is simply a matter of searching the 'net; the entire Rider's manual for the 19A11S is online, including everything one could ever want for servicing (you can find it at siliconchip.com.au/link/abd4). But perhaps the lack of information back then did me good. I had to carefully study the design of the frame and line deflection systems to work out how to re-create the missing transformers and make the set work again.

It was there that I discovered this ingenious circuit. The line deflection stage or horizontal deflection stage generated two anti-phase linear 450V peak-to-peak sawtooth waves, running from a mere 250V DC supply. How does it do that?

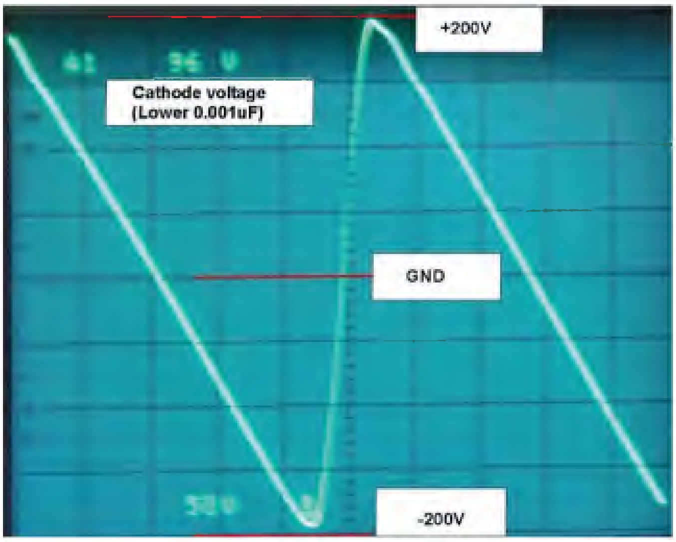
How it works

The circuit documented on the faded schematic (or in the Rider manual) was drawn in a way that almost concealed how it worked. After

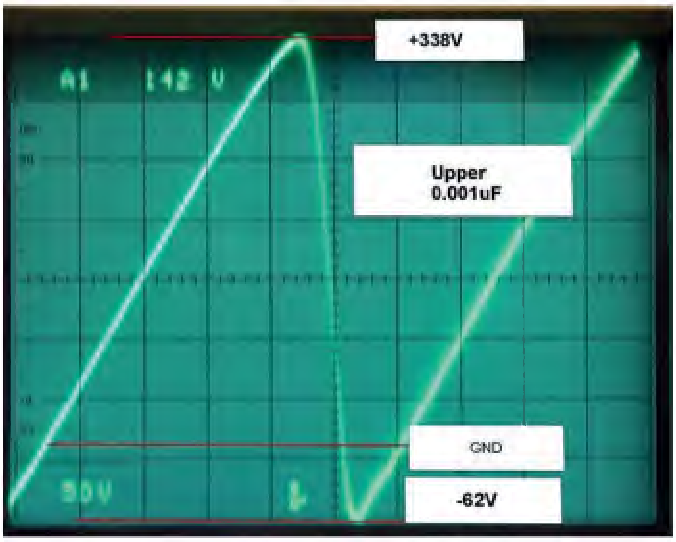




The functional block diagram (above) and location of the valves on the chassis (right), reproduced from the service manual. The Admiral 19A11S shared a circuit with many other models which are part of the "19A1" series, such as the 19A11SN, 19A12S, 19A12SN, 19A15S and 19A15SN.



Scope 1: the voltage across C2 is essentially symmetrical about GND as it is connected to the cathode of the 6SN7 valve.



Scope 2: the waveform across C1 is a mirror-image of that shown in Scope 1; however, the average voltage is quite a bit higher (around +138V in this case) due to C1 being connected to the anode of the valve rather than the cathode.

re-drawing it, I realised what they had done. The designer had nested a blocking oscillator inside a low-frequency (2-3kHz) resonant circuit.

Due to the high-Q nature of the resonant circuit, when it 'rings', there is voltage magnification above the applied voltage. The really clever part is that since the first 20-30° of a sinewave is pretty much linear, the blocking oscillator simply chops out about ±30° of the oscillation cycle to produce a near-perfect linear wave.

The circuit, re-drawn, is shown in Fig.1. And depending on the width adjustment, it can produce 350-450V peak-to-peak sawtooth waves. In the set, they are generally about 400V peak-to-peak but adjusting the control can easily give 480V peak-to-peak.

The circuit is very efficient, and calculations show that the 6SN7 is run well inside its maximum plate dissipation. The peak-to-peak cathode voltage is just on the edge of its maximum rating. In the blocking oscillator circuit, the valve is not conducting most of the time; it only conducts during flyback. When the valve conducts, it charges C2 to about +200V at the end of the flyback period. By then, C1 is discharged to about -62V.

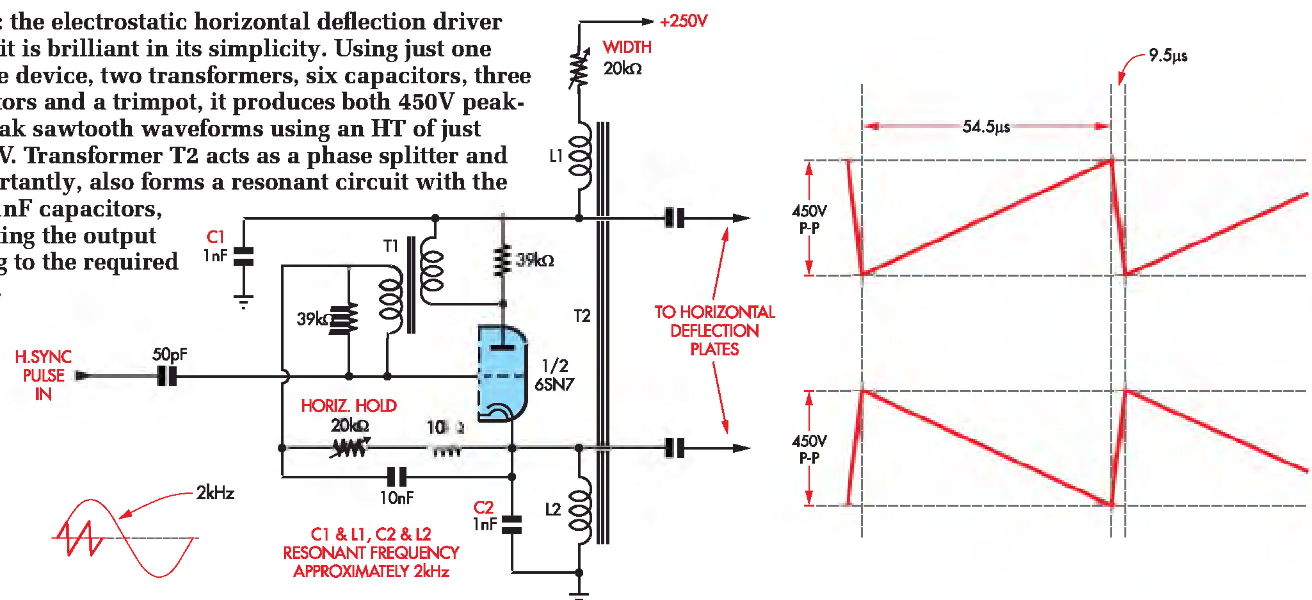
Scope 1 & Scope 2 show the voltages across C2 and C1: As expected, since there is no average DC of any significance on the transformer, the cathode waveform (voltage across C2) straddles zero volts. However, that is not the case for C1, which swings from -62V to +338V here. The 400V peak-to-peak amplitude is the same, but it has a +138V offset (approximately half the +250V HT).

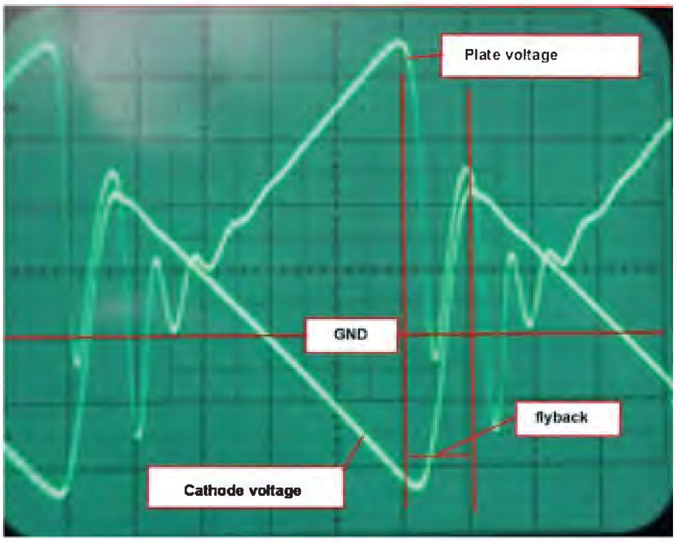
Energy is imparted to transformer T2's magnetic field during the flyback period. When the 6SN7 comes out of flyback (conduction), T2's field begins to collapse at a rate determined by the values of C1 and C2.

Due to the circuit Q, the voltages across C1 and C2 can rise well above the power supply voltage; or at least, they would do if the oscillations were not reset by the blocking oscillator conducting again about 25-30° into the sinewave cycle.

Even though the voltage on C1 falls to -62V and the cathode voltage on the valve climbs toward +200V at the end

Fig.1: the electrostatic horizontal deflection driver circuit is brilliant in its simplicity. Using just one active device, two transformers, six capacitors, three resistors and a trimpot, it produces both 450V peak-to-peak sawtooth waveforms using an HT of just +250V. Transformer T2 acts as a phase splitter and importantly, also forms a resonant circuit with the two 1nF capacitors, boosting the output swing to the required level.





Scope 3: this scope grab demonstrates how the valve's plate (anode) voltage stays above the cathode voltage during the flyback conduction period. The valve is not conducting the rest of the time, so it doesn't matter that the anode and cathode voltages cross over.

Faudell and White's Time Base

Faudell and White have developed a time base which gives a push-pull output. It consists of a transformer-coupled blocking oscillator time base in which a large inductance is connected in series with the H.T. supply to the time base. A condensor is connected between the valve side of the inductance and the negative supply rail as shown in Fig.66.

Fig.66

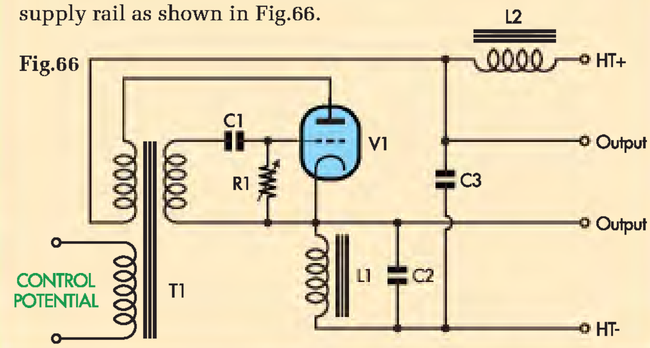


Fig.2: a recreation of an excerpt from Time Bases by O.S Puckle, Chapman Hall 1951, attributing the clever horizontal driver circuit to C. L. Faudell and E. L. C. White. It names several British Patents; unfortunately, unlike US patents, they are not viewable or searchable online.

of flyback, the valve's anode voltage stays higher than the cathode during conduction (flyback). This is due to the voltage on the primary of the blocking oscillator transformer. You can see this effect in Scope 3.

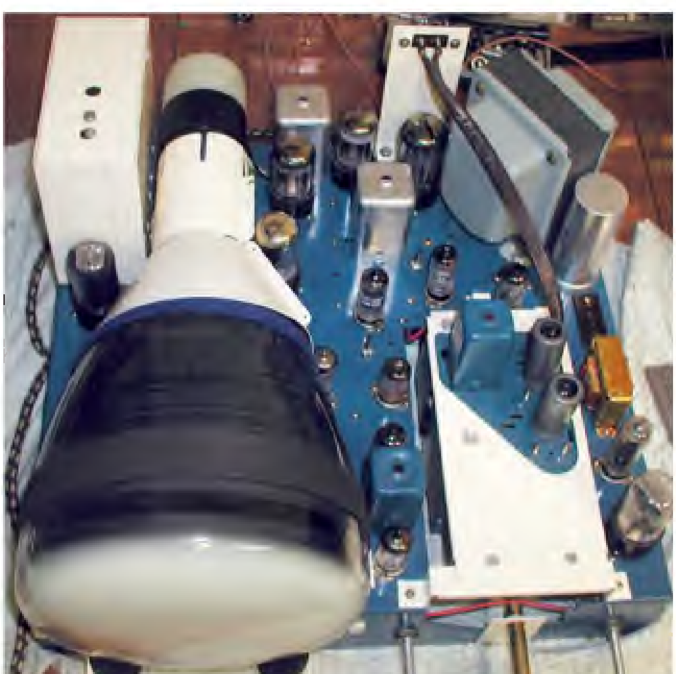
So the plate voltage is always higher than the cathode voltage at any moment during flyback. After flyback, the valve is cut off, but as shown in Scope 3, the plate voltage falls below the cathode voltage. Thus, the oscillations on the plate from the blocking oscillator transformer do not affect the scan as the valve cannot conduct with its plate voltage below the cathode voltage.

Also, because it is a blocking oscillator, the grid-to-cathode voltage is negative during the active scan time, and the valve is not conducting. This is unlike magnetic deflection, where the output stage valve conducts during the scan time and is cut off during flyback. This is possible because the required scan power for electrostatic deflection is minimal, only a few milliwatts.

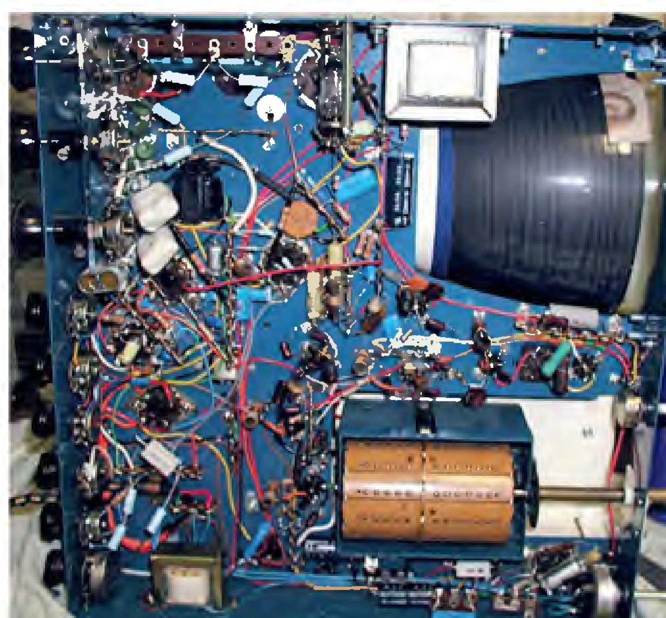
The 'load' for electrostatic deflection is merely the deflection plate tie resistors, which are in the order of 2-5MΩ.

Rebuilding the set

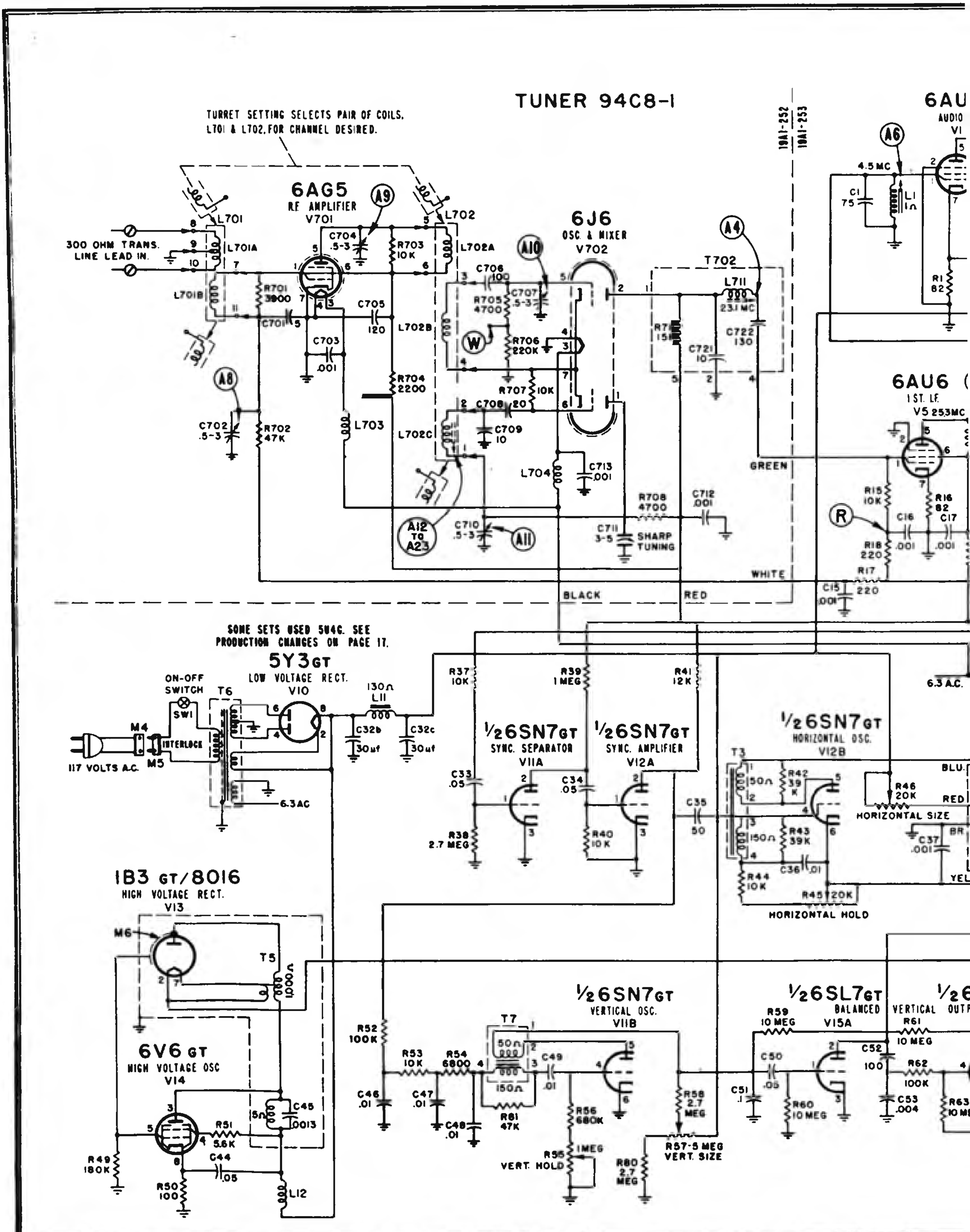
Since I had no data on the missing transformers, I had to guess at their parameters. I wound T2 as two independent

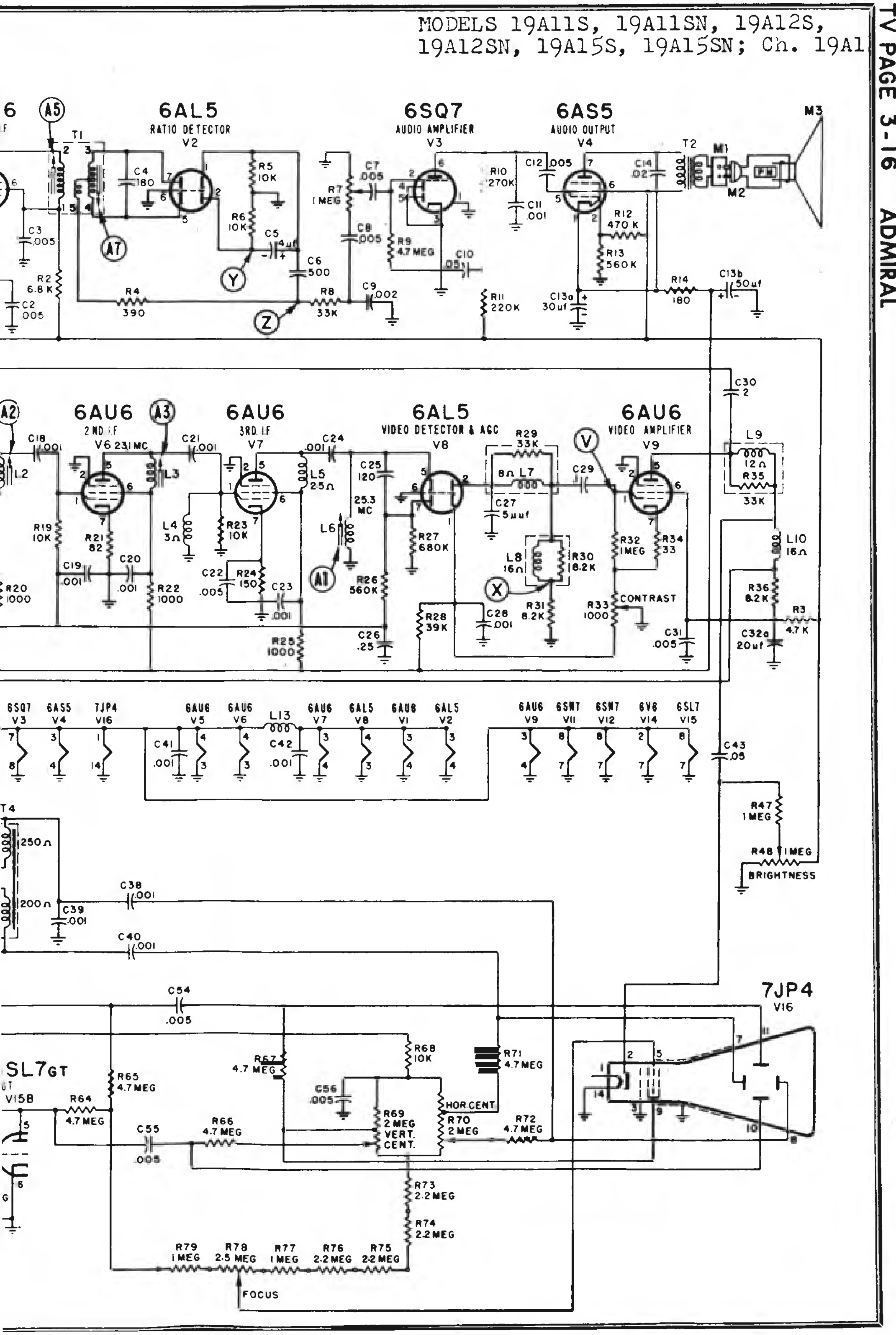


The top of the chassis post-restoration. The only components mounted on this side are the valves, CRT and transformers, lending it a tidy appearance.



The underside is another story; while not exactly the worst mess we've seen, the components are mounted in locations based mainly on convenience for the point-to-point wiring employed. The turret tuning mechanism is enclosed on five sides by metal shielding.


TUNER 94C8-1
TURRET SETTING SELECTS PAIR OF COILS, L701 & L702, FOR CHANNEL DESIRED.
6AG5
RF AMPLIFIER
V701
6J6
OSC. & MIXER
V702
300 OHM TRANS. LINE LEAD IN.
SHARP TUNING
GREEN
WHITE
BLACK
RED
6AU6
1ST. I.F.
V5 253MC
HORIZONTAL SIZE
HORIZONTAL HOLD
SOME SETS USED 5U4G. SEE PRODUCTION CHANGES ON PAGE 17.
5Y3GT
LOW VOLTAGE RECT.
V10
ON-OFF SWITCH
INTERLOCK
117 VOLTS A.C.
6.3 AC
½6SN7GT
SYNC. SEPARATOR
V11A
½6SN7GT
SYNC. AMPLIFIER
V12A
½6SN7GT
HORIZONTAL OSC.
V12B
1B3 GT/8016
HIGH VOLTAGE RECT.
V13
6V6 GT
HIGH VOLTAGE OSC
V14
½6SN7GT
VERTICAL OSC.
V11B
½6SL7GT
BALANCED
V15A
VERTICAL OUTPUT
VERT. HOLD
R57-5 MEG VERT. SIZE



The entire circuit of the Admiral 19A11S has been reproduced here, as the quality of this scan is much better than the circuit that was used to restore the set.

windings on a small ferrite core (scavenged from a small transistor TV line output transformer). The inductance turned out to be 4H per winding, but at the time, I was aiming for it to resonate at about 2kHz.

Later, I measured a transformer from a VT71 set, and it was 1.62H per winding. So the resonant frequency of T2 in the original system (tuned by two 1nF capacitors) was intended to be about 2797Hz (probably 3kHz). Mine resonated at 1780Hz, and it worked fine.

Who was responsible for it?

Recently, browsing the textbook Time Bases by O. S. Puckle, Chapman Hall 1951 (the first edition was 1943), I came across the circuit shown in Fig.2 by Faudell & White. Clearly this is the same circuit, although, unlike the Admiral circuit, the low-frequency resonant circuit is split in two. However, the function is the same.

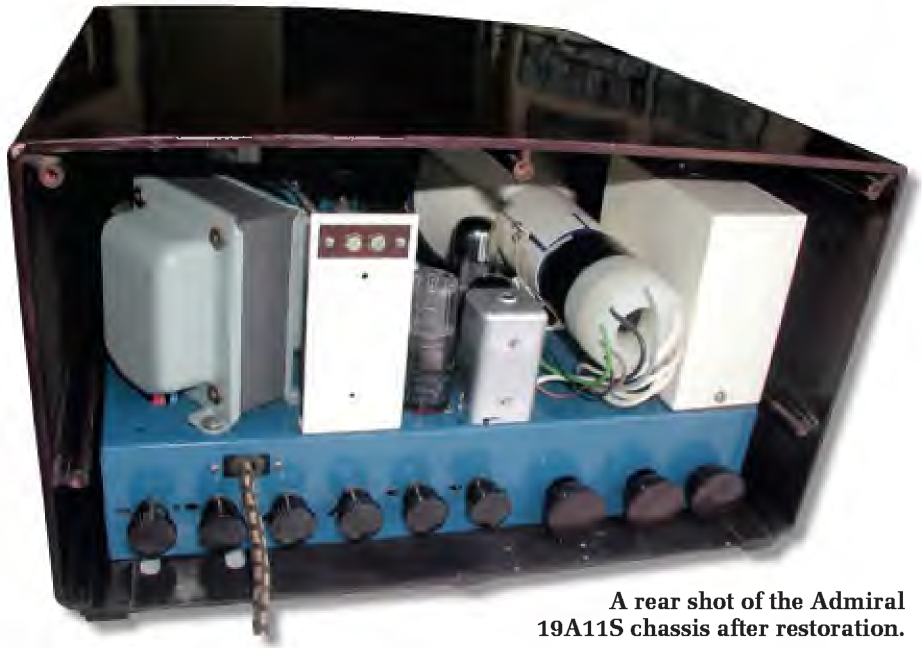
Restoring the rusty chassis

In the early 1980s, there was no electroplater in my locality that I could trust it with. So the next best move was to have it painted after I had removed the rust. Later, my preferred method for chassis restoration was to use a bead blaster with fine glass beads to blow off the rust and have it plated with electroless nickel.

I have completed several TV sets with that method: an Andrea KTE-5, RCA 621TS and HMV 904. You can see the result on the HMV set in my article (November 2018; siliconchip.com.au/Article/11314); there are before and after photos on page 91.

Looking retrospectively, I chose an interesting colour scheme of blue and white, as you can see in the restored chassis photos. The paint is two-pack epoxy which is oven baked, so it is extremely tough.

The two rectangular aluminium cans on the chassis top contain transformers



A rear shot of the Admiral 19A11S chassis after restoration.

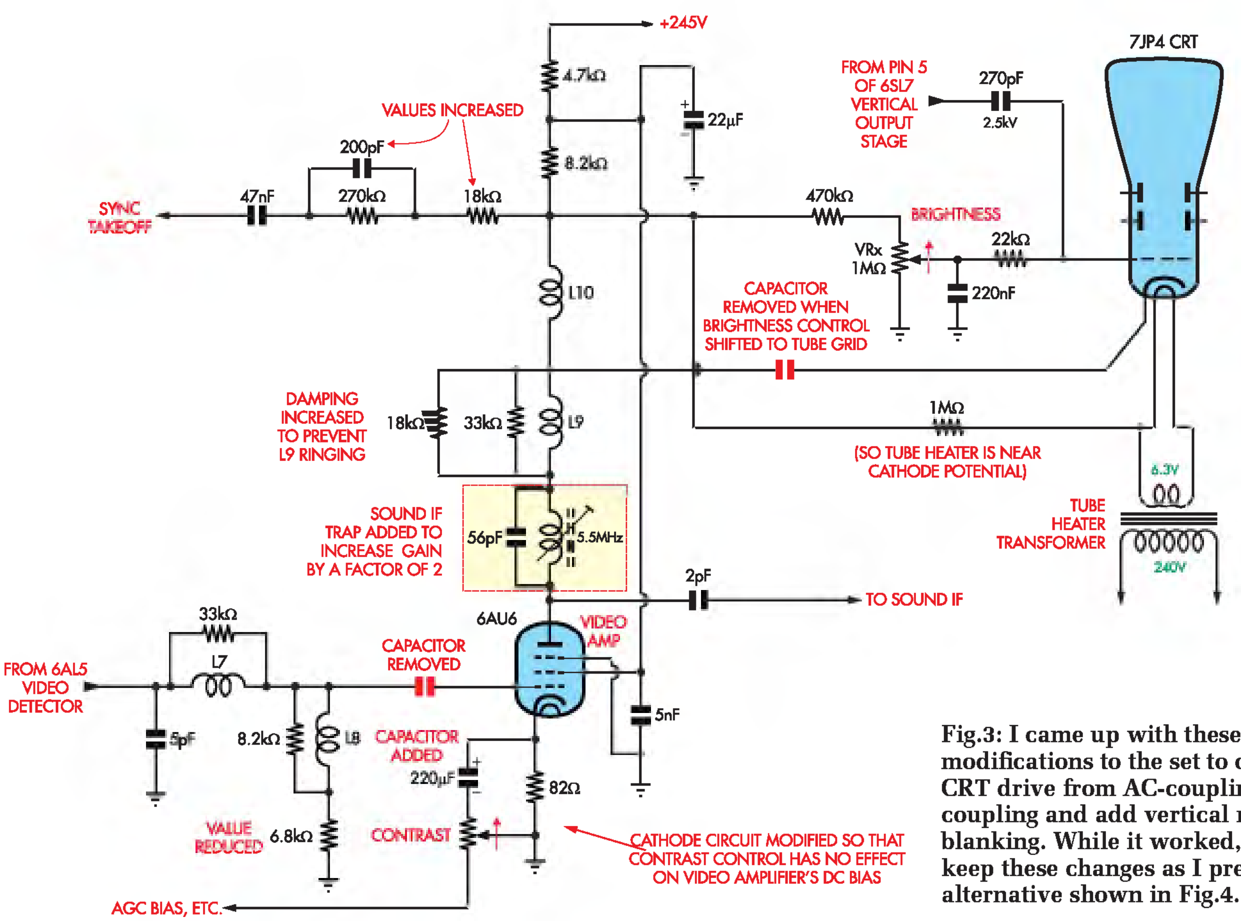


Fig.3: I came up with these modifications to the set to change the CRT drive from AC-coupling to direct coupling and add vertical retrace blanking. While it worked, I did not keep these changes as I preferred the alternative shown in Fig.4.

T1 and T2. Notice how on the centre top of the chassis underside, to the left of a smoothing choke, I added a 6AL5 valve (acting as a DC restorer). It is mounted in a socket on two metal posts and held in place by a coil spring.

The turret tuner assembly in these sets is quite advanced for 1949, although the 1946 RCA 621TS set had a very good turret tuner using three 6J6 valves.

I needed a new CRT socket for this set, as the one that came with it was crumbling away. These are currently available on eBay, but back in New Zealand in the early 1980s, no such part was available. So as shown in the adjacent photo, I machined one out of Nylon.

The pin retainer inside is a round section of fibreglass PCB material with the copper removed and countersunk holes with sharp edges. As a result, when the socket is assembled, it rotates into place and locks all of the pins into position.

As my CRT socket was crumbling and I could not source a replacement, I had to machine this one out of Nylon and fabricate a retention mechanism using a sheet of fibreglass taken from a blank PCB.

Upgrading the set

One failing of the design of this set is that the video output stage is AC-coupled to the CRT. This means that the video signal's DC component is lost. The effect that this causes on changing picture scenes is well known to every television engineer.

I came up with two possible methods to remedy this:

1) Modify the circuit for direct coupling from the detector-video output stage to the CRT (as shown in Fig.3).

2) Add a DC restorer (see Fig.4).

After trying both methods, I elected to keep the added 6AL5 DC restorer. With this circuit, the raster is black or near blacked out when no signal is being received.

I also added vertical retrace blanking and a 5.5MHz sound trap (suited to NZ TV reception) to improve the sound take-off gain from the video output stage.

This method of wiring in the DC restorer uses typical techniques developed by RCA to minimise the loss of high-frequency signals in the video output. It was interesting to look at the notes I made at the time in the neat handwriting I had back in the early 1980s.

Shortly after this, I finished my career in TV and VCR servicing and then went to medical school. I became an Ophthalmologist specialising in cataract surgery which is my current line of work. SC

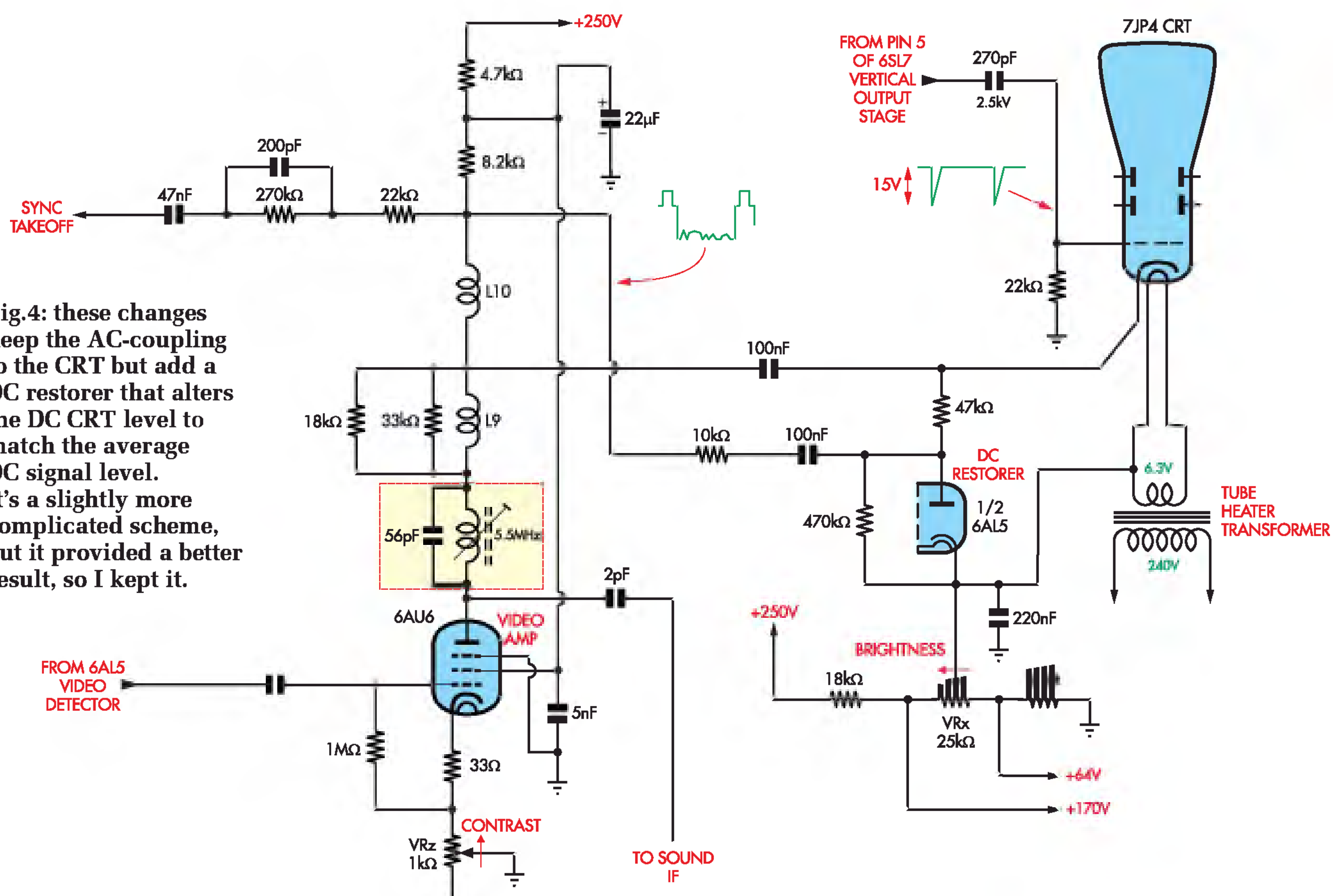


Fig.4: these changes keep the AC-coupling to the CRT but add a DC restorer that alters the DC CRT level to match the average DC signal level. It's a slightly more complicated scheme, but it provided a better result, so I kept it.