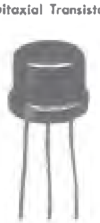
VINTAGE TELEVISION

Restoring a Sony 5-303E Micro-TV

By Dr Hugo Holden

The Sony 5-303 Micro-TV was revolutionary in 1962. It set the stage for what Japanese electronic engineers do very well; miniaturise things. It was not Sony's first miniature TV, though. In the USA, the small Philco Safari TV beat Sony's first small transistor TV, the TV8-301, to market in 1959.

Epitaxial Transistor



Brief Specifications of the SONY Epitaxial Transistor 2SC140

Maximum Collector-Base Voltage .	60 V
Maximum Collector Current :	1A
Collector Dissipation (Max) :	1.7 W (without heat sink)
Collector Saturation Resistance (Rs) :	2Ω
Maximum Junction Temperature :	175°C

Fig.1: these specifications may not seem anything special today, but in the early 1960s, they were a big deal.

The Sony Micro-TV sported a new generation of silicon power transistors that had temperature specifications and stability unheard of compared to the germanium transistors that preceded them. Sony developed these transistors especially for use in their own TV sets. The one that was proclaimed to be the mover and shaker was the 2SC140 (see Fig.1).

Clearly, Sony was very proud of this transistor and they wanted to show off its spectacular features. The 2SC140 was used in the vertical output stage and the horizontal oscillator and horizontal driver.

Oddly, there was a 2SD65 NPN Germanium transistor buffer stage between them, the importance of which will become clear later.

Other silicon transistors used were the 2SC15 as the video output device and a 2SC41 as the horizontal output transistor. Generally, the rest of the transistors in the set are germanium PNP types, including those in the tuner, IF stages and the push-pull transformer-coupled audio amplifier. 2SC73 NPN germanium types are also used.

Other interesting features of this set include a somewhat retro unregulated 12V DC power supply based on a selenium bridge rectifier (see Fig.2).

The EHT rectifiers were 1DK1 small tube diodes, a commercial type, wired as a voltage multiplier to produce 8kV for the screen. As this EHT voltage is very high for the screen size (just under 14cm diagonal), the set can produce amazing high-contrast images even in bright light; screen brightness is quoted as 500 lux by Sony.

The CRT (Fig.3) is a 5-inch (13cm) 70° deflection type specially designed by Sony. Its specifications are shown in Fig.4. Not mentioned there is the resolution, which is 300 columns x 400 lines, at 28 columns/cm and 45 lines/cm.

◀ Fig.2: selenium rectifier stacks are famous for producing lots of toxic fumes when they fail. That's why many people prefer to replace them with modern rectifiers. Still, you have to be careful because modern rectifiers can lead to much higher surge currents and have lower forward voltages.

Fig.3: the 5-inch 140CB4 CRT was designed for this application. It provides excellent contrast.

Specifications of Picture Tube 140CB4

Type :	Rectangular Frame
Neck Diameter :	20 mm (3/4")
Diagonal Dimension :	137 mm (5-3/8")
Full Length :	161mm (6-5/16")
Deflection :	Electromagnetic
Deflection Angle :	70-degree
Heater Voltage :	12.0V, 70 mA
Anode Current :	50μA
Anode Voltage :	8 KV
Focusing Voltage	0~120 V
Focusing :	Electrostatic Automatic
Ion Trap :	Unnecessary
2nd Grid Voltage :	300 V
1st Grid Cut-off Voltage	Approx. —25 V

Fig.4: specifications for the cathode ray tube used in the Sony 5-303E Micro-TV.

Block diagram

It was customary at the time to include a block diagram in the manual (Fig.5). It shows the arrangement of the diodes and transistors. The label at the rear of the TV also says how many diodes and transistors the TV contains. Since these were expensive items, there was perceived value in the number of semiconductors inside: 25 transistors and 20 diodes (five of the transistors were silicon types).

The Micro-TV was amazingly sensitive; Sony quoted a maximum sensitivity of 10μV at the input for 10V at the picture tube cathode. The set also had a gated AGC system, which was advanced for the time.

The power consumption was quoted at 13W on AC operation and 9.6W from DC (12V). The set weighs in at 3.5kg (8lbs). I read on a website that this sets "runs hot", which is nonsense. At 13W, given the size of the set, it barely warms up, and there is plenty of convection cooling.

Sony's goals for this TV were:

1. Be small in size & low weight.
2. Have the lowest power consumption of any mass-produced TV.
3. Operate perfectly as a completely portable TV set under all conditions.
4. Provide easy servicing.

That last objective has now all but completely disappeared from the electronics industry. Many items now are designed for rapid and expedient assembly at a factory.

Disassembly and repair is another matter, if it can even be done without special tools etc. Items are "life cycled" and the expectation that a customer would have any items repaired has

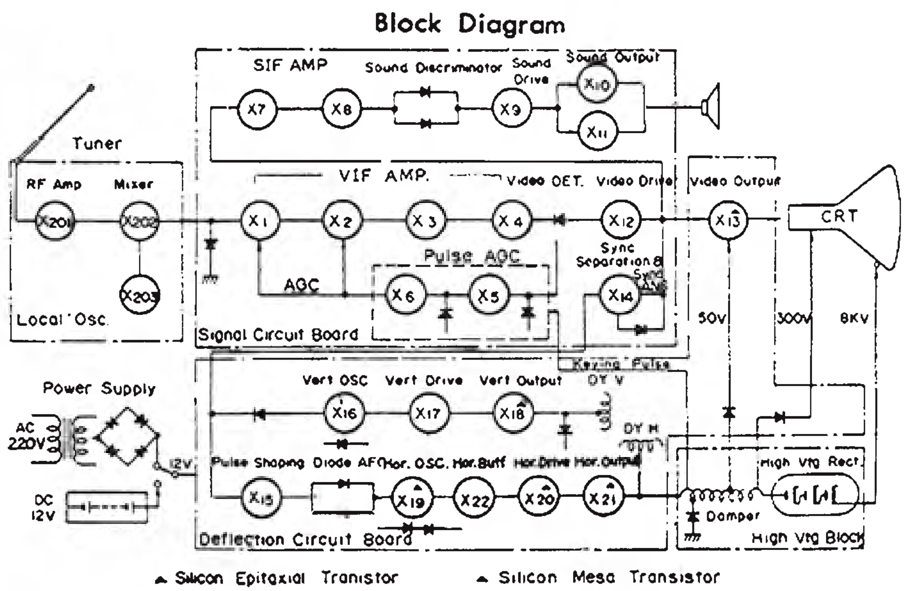


Fig.5: helpfully, Sony provided this block diagram in the TV's user manual, showing the role of each transistor and diode.

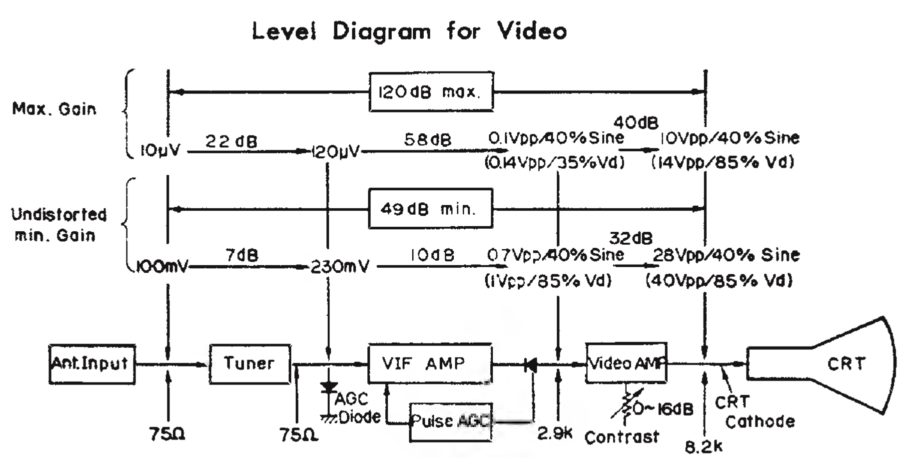
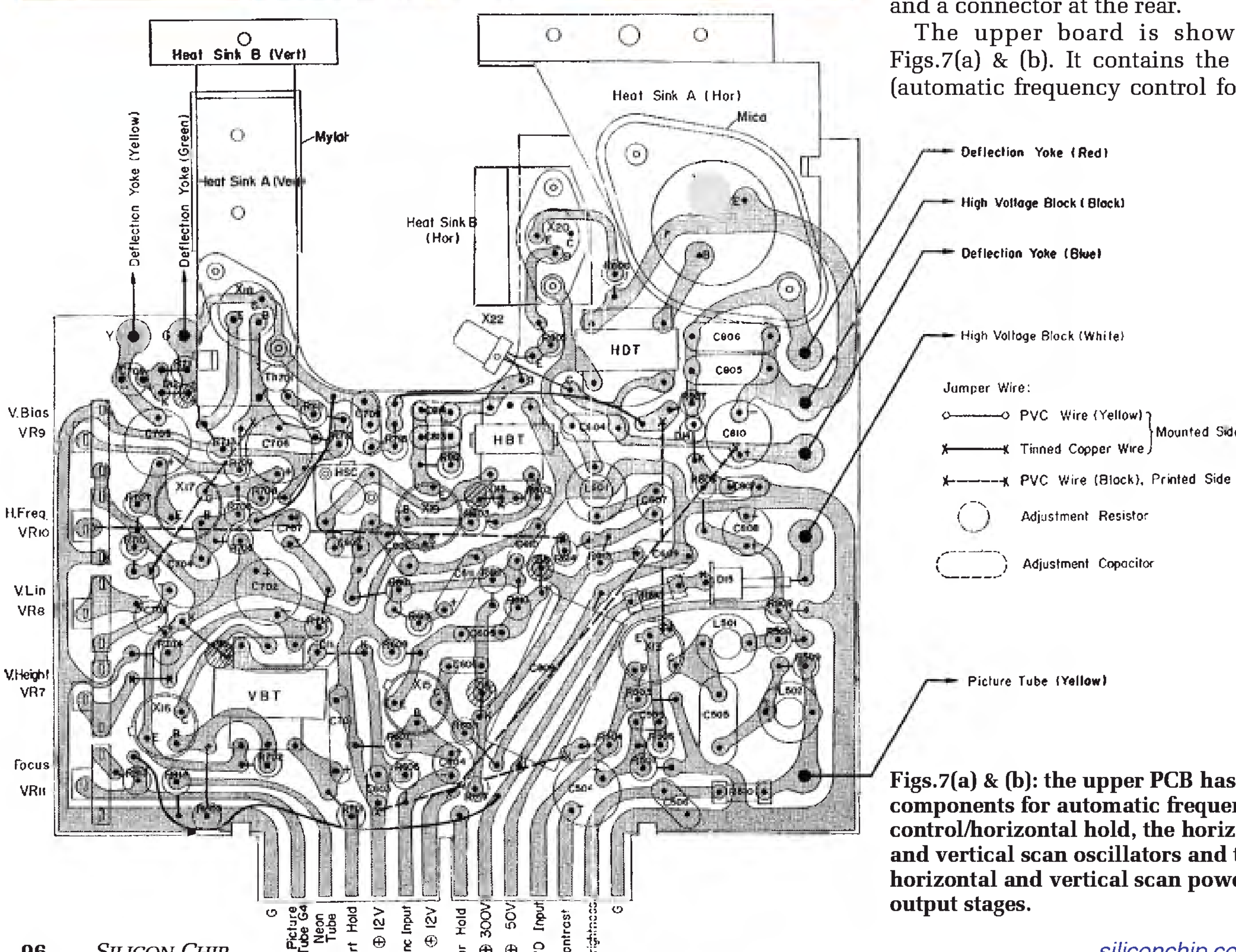


Fig.6: this diagram shows the minimum and maximum signal levels which can be expected throughout each stage of the TV during reception.



faded away, into a new age model of replacement goods.

Sony claimed that the AGC system (with its pulse or gated design and the automatic noise suppression they dubbed ANS) would maintain synchronisation in a moving car where the signal strength varies suddenly and almost continuously, even in the presence of intense ignition noise.

Sony also published a very unusual and helpful signal level summary that is seldom seen in other manufacturers' TV service manuals, shown in Fig.6.

As indicated, the maximum signal gain is an astonishing 120dB. In practice, I have found that for a stable visible picture and sync, it requires about 100μV input at the set's 75Ω input connector. By about 150-200μV, it is driven just out of the snow and a super-clean video image results.

Two PCBs

Cleverly, to help servicing, Sony broke the set into two PCBs, one near the top of the chassis and one below. They have similar geometry, with a cut-out near the front for the CRT bulb and a connector at the rear.

The upper board is shown in Figs.7(a) & (b). It contains the AFC (automatic frequency control for the

Figs.7(a) & (b): the upper PCB has the components for automatic frequency control/horizontal hold, the horizontal and vertical scan oscillators and the horizontal and vertical scan power output stages.

horizontal hold system), the horizontal and vertical scan oscillators and the horizontal and vertical scan power output stages.

On account of this, Sony created aluminium flanges that extended from the PCB area to the front metal escutcheon of the set, to move heat away from the power output devices.

Fig.7(b) is the overlay diagram from the manual, with the tracks shown as if you are looking through the component side of the PCB.

When working on the underside of the board, it can be useful to scan these into a computer and flip them over, so the tracks seen on the diagram match the tracks that you see on the PCB surface. That is especially true for the upper PCB, as it is mounted with the tracks facing upwards and the components out of view.

The signal board is equally as impressive for the time, and is shown in Figs.8(a) & (b).

Restoration

Back in the late 1970s or early 1980s when I bought this TV, it was defective. Even by then, nearly all the small electrolytic capacitors had failed, except for the Alox types (described below). The large main power supply capacitors were OK (and interestingly, they still are).

I recapped the set and did a full RF alignment with a sweep generator and scope. I found some of my original notes from that time, where I kept a record of the video IF response curve and how the particular IF adjustments affected it (Fig.9). I also kept notes on the sound IF alignment.

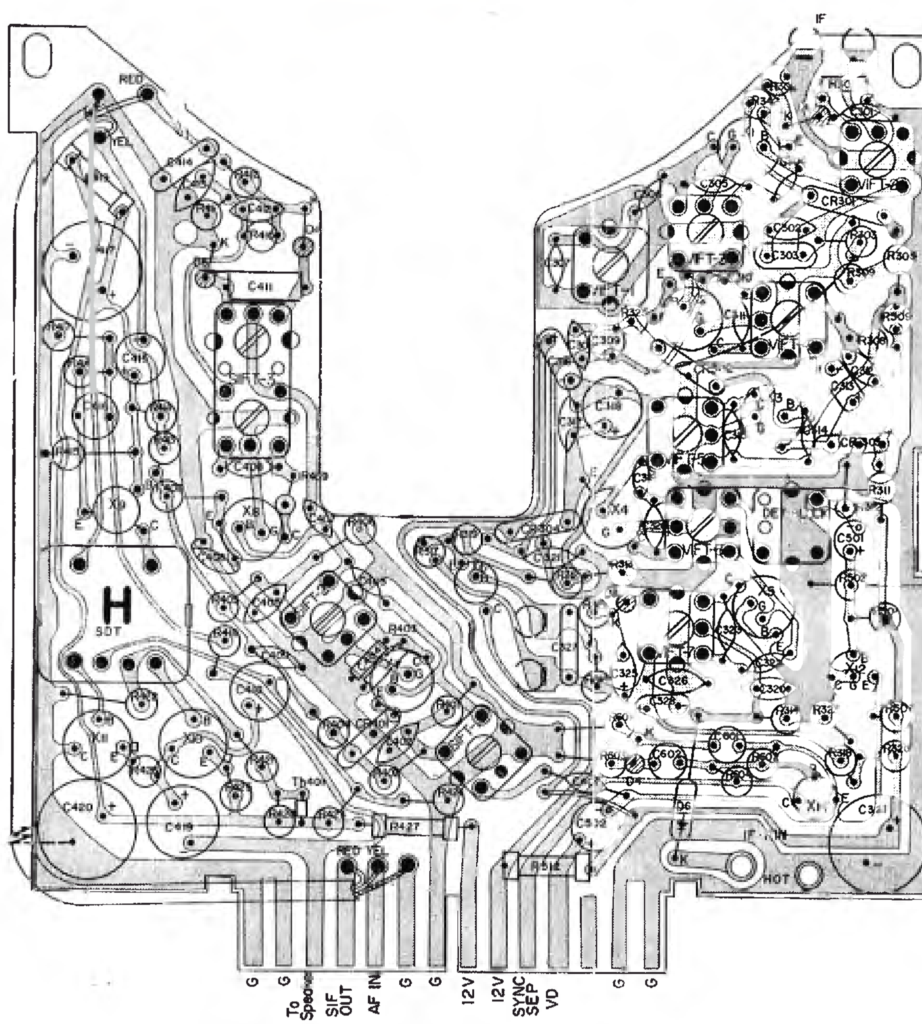
The sound response and adjustments are ideal when the set is tuned such that the high-frequency detail in the video image is optimal.

I adjusted the IF bandwidth of the set at 3.75MHz (as per Sony specs). I found that the 3.8MHz bars from my pattern generator were easily resolved. The 4.8MHz bars are not visible, as expected (see Fig.10).

This is the sort of performance you can expect to get with the video IF correctly set up with a sweep generator and oscilloscope.

Latter-day TV restorers often try to set up the video IF by other methods, but I'm afraid there are no shortcuts here, and for excellent results there is no escaping the need for the sweep generator and scope.

Figs.8(a) & (b): the signal board carries the remaining TV circuitry not on the upper "deflection" board.



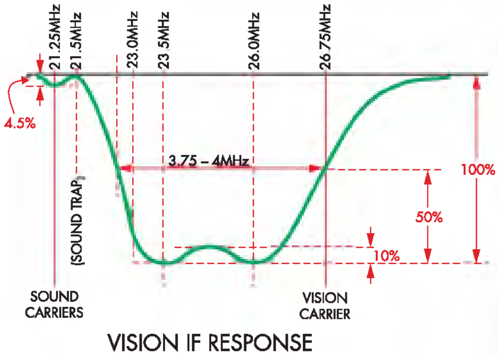
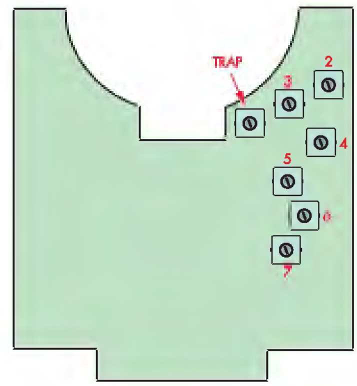


Fig.9: a redrawn version of my hand-written notes on the shape of the video IF curve and location of the adjustments on this set. I made these some time in the late 70s or early 80s.



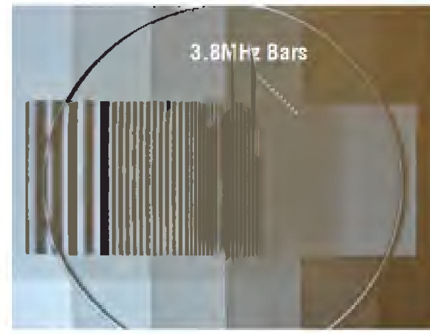


Fig.10: as you would expect from a set with an IF of 3.75MHz, the 3.8MHz bars in this test pattern are distinct while the 4.8MHz bars simply appear as a solid grey block.

Note that while my TV has a VHF tuner, the Sony Micro-TV was also released with a UHF tuner. These were popular in North America.

Fixing it up

Fortunately, the set I acquired had few mechanical problems. One known weak point with these sets is the antenna clip.

The plastic hardens and cracks with time, as shown in Fig.11. Mine was a victim of this, so I simply hand-crafted a new one from a block of Nylon (Fig.12).

This little TV sat in its box for about 40 years after I initially recapped it. I only occasionally used it. Recently, I pulled it out again. Despite just being in storage, it had developed some faults. One fault in particular was intermittent and very difficult to solve; it took a few days and a lot of patience to get to the bottom of it.

1. The vertical deflection linearity was poor at the bottom of the scanning raster. This was not correctable with the height and linearity controls. This is often a symptom of high-ESR electrolytic capacitors in the vertical output stage area, but that was not the case.

2. The horizontal hold was intermittent, with a combination of small left and right jittery movements of the horizontal position of the image, intermittently disappearing for some hours, then returning.

There was also the occasional total loss of horizontal hold at times, with a sudden loss of raster width. The H-oscillator would abruptly run a much higher frequency than it should, around 20kHz.

Improving vertical linearity

For #1, I checked the power supply, the resistors and the electrolytic capacitors in the vertical stages; none were out of spec or defective, including the vertical yoke coil's coupling capacitor.

Fig.13 shows the vertical linearity problem. The horizontal linearity is also not ideal; this is discussed later, as it is intrinsic to the design and not easy to fix.

As can be seen, the raster lines are compressed toward the bottom. In this set, there is plenty of height control and the raster will easily double in height, so there is plenty of dynamic range in the output stage.

However, the vertical linearity control only has a significant effect at the top of the raster. One might think that to acquire a linear vertical scan, the

Fig.11 (above): pretty much all Sony 5-303E sets will suffer from a broken plastic antenna clip by now, as the plastic becomes brittle over time.

Fig.12 (right): I hand-crafted this replacement antenna clip (circled in red) from a small block of Nylon. It isn't pretty, but it works. I could paint it grey in future for a more factory appearance.

current in the vertical output transistor should be a linear ramp, during scan time at least.

On testing with the scope, with the raster shown, the transistor's current appeared as a near-perfect linear ramp, but this is not normal. However, to get a linear scan given the properties of the vertical yoke coils, the yoke coupling capacitor and the collector load choke need to be compensated for.

So the current and transistor base drive voltage that is required for a linear raster scan needs to flare upwards toward the end of the scan. This is shown with the required waveform (red star in Fig.15) in Sony's manual.

Sony achieved the upward curve by placing positive feedback around the vertical output stage with C707, a 10µF electrolytic capacitor, and R714, a 620Ω resistor. This feedback is not enough to cause the amplifier to oscillate, but resulted in the upward rise of current in an exponential-like manner towards the end of scan time. The positive feedback also helped with a fast flyback.

Yet in my set, with original-value resistors and capacitors and tested transistors, the output stage current was more of a linear ramp, and so the raster was compressed at the bottom.

Also, the sawtooth voltage developed across 100µF capacitor C702, by the 330Ω charging resistor R704, was closer to 4V peak-to-peak, rather than the $2V_{PP}$ specified in the service manual.

One aggravating factor here is the 20ms interval with a 50Hz vertical scan frequency versus the 16.7ms interval for the 60Hz scan frequency used in the USA. The voltages here also agreed with calculations.

This means that, in the 50Hz system at least, the height control needs to be set at near minimum (larger resistance).

This reduces the value of the positive feedback signal that is mixed in with the sawtooth voltage (as it has to pass via the height control) to the vertical amplifier's input at transistor X17's base. This aggravates the compression of scan lines toward the end of the scan, at the bottom of the raster.

I corrected the poor scan linearity by increasing the value of R704 from 330Ω to 750Ω. That reduced the amplitude of the sawtooth voltage across R704 to 2.4V peak-to-peak, close to the manual's suggestion of $2V_{PP}$ (with this change, the most negative part of the sawtooth waveform sits at 6.6V).

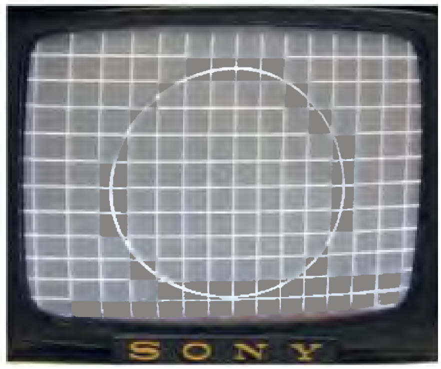


Fig.13: after taking my set out of storage, I noticed that it had very poor vertical linearity, as is apparent from the 'squashed' blocks at the bottom.

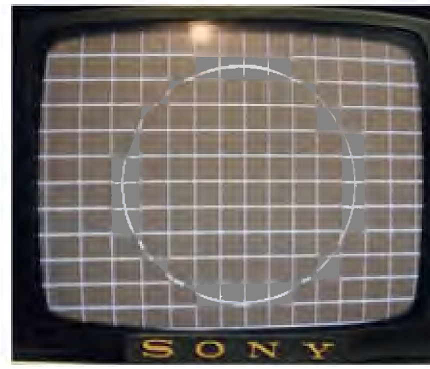


Fig.14: et voila, with a few minor component modifications, the set demonstrated far superior vertical linearity.

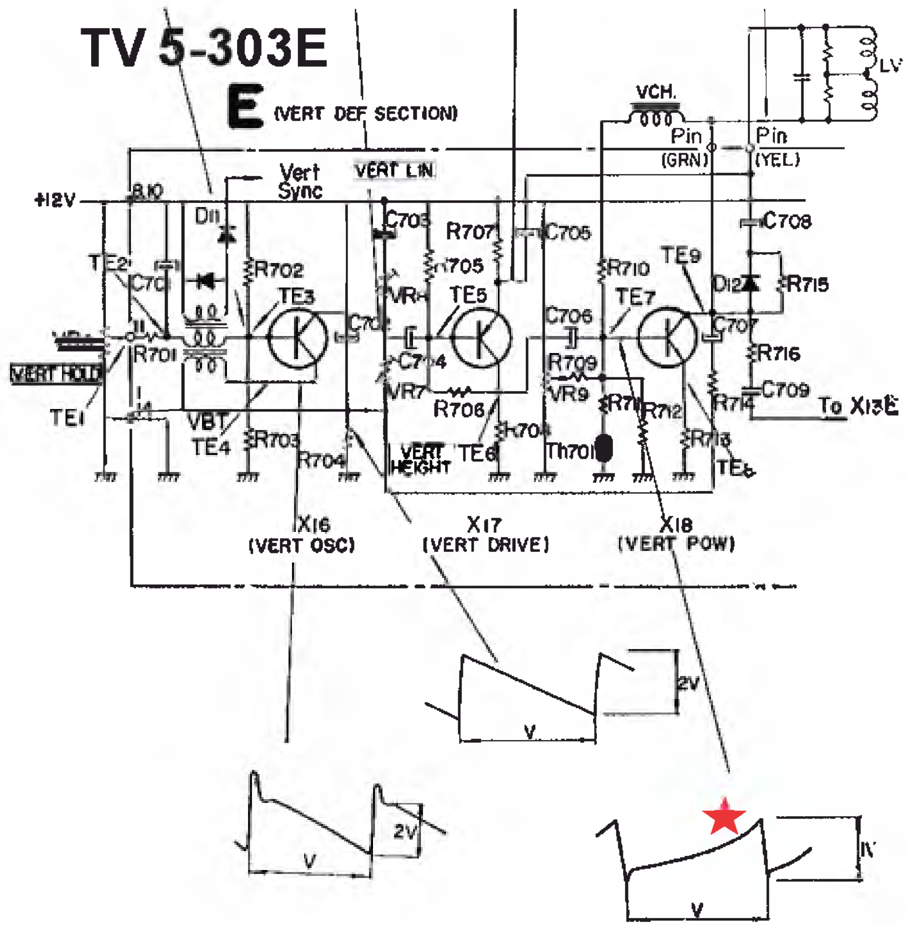


Fig.15: the vertical deflection section of the circuit, with expected waveforms. Note how the waveform at the bottom of C702 is a linear ramp, while the base of X18, the vertical power transistor, has a modified ramp with an accelerated rise rate towards the end of the ramp. This compensates for the properties of the vertical yoke coil, to provide better vertical linearity. My set was missing that spike.

This meant that the height control could be adjusted for a lower resistance (more height). This improved the positive feedback. To further improve the situation, I changed C707 from 10µF to 15µF, increasing the positive feedback.

Another helpful change was to parallel a 3Ω resistor with the existing 3Ω resistor in the emitter of the vertical output transistor. Normally, the voltage across this resistor is 0.33V, giving an emitter current of 110mA. With the extra resistor added, the voltage drops to 0.22V across 1.5Ω, and the new emitter current is 146mA.

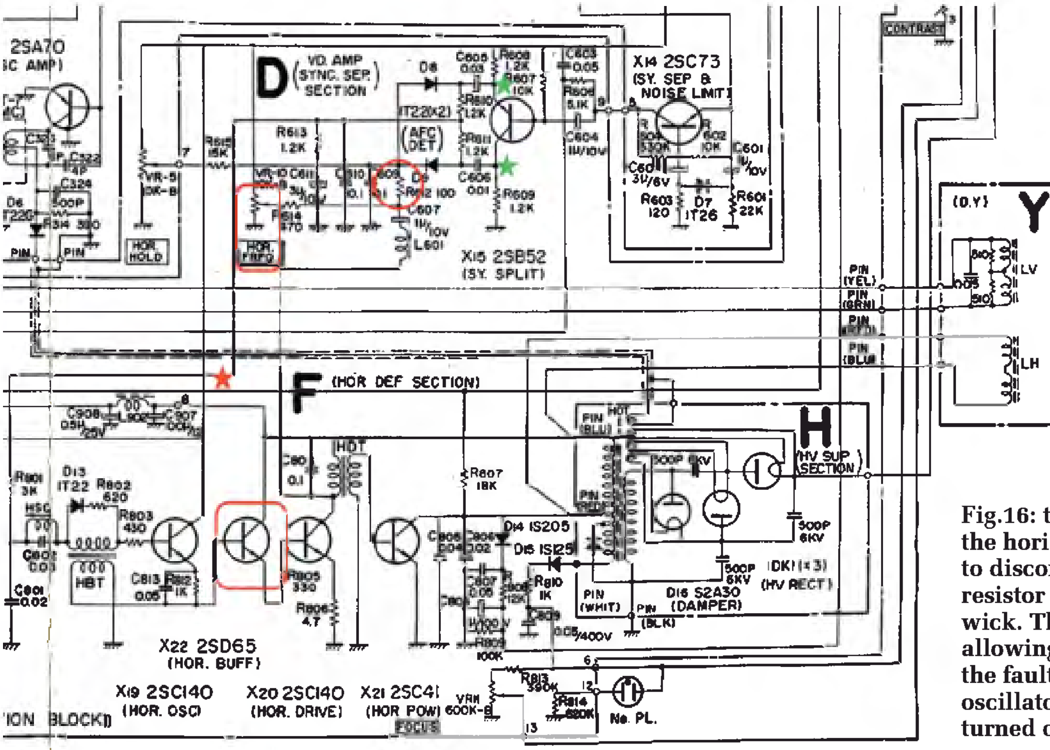


Fig.16: to track down the faults in the horizontal sync circuitry, I had to disconnect one leg of the 3kΩ resistor from its pad with solder wick. That disabled the AFC, allowing me to figure out whether the fault was in the horizontal oscillator or the AFC circuitry (it turned out to be the latter).

This increase of about 36mA takes the transistor's power dissipation from about 1.32W to 1.75W. Sony advises that the 2SC140 is capable of 1.75W without a heatsink, and in this case, it has a heatsink and only runs warm to the touch.

Probably, there are some aging effects on this transistor over time. I do not want to replace it because of its historical significance. The result after these vertical linearity corrections is shown in Fig.14. I think you will agree that it's a big improvement.

Horizontal instability

Once the vertical scan linearity problem was solved, I moved onto to the horizontal image instability and hold problems. Solving this was trickier than usual, as there were actually three problems. The section of the circuit shown in Fig.16 helps to explain it.

Firstly, on the simple side of things, the HOR. HOLD preset was defective and at a certain point of its rotation, the resistance value suddenly jumped (not corrected by cleaning). If it was set near that position, the resistance value was erratic. So I replaced it with a modern 10kΩ preset pot on a small piece of plated through-hole spot board, as shown in Fig.17.

Notice that the resistors are radial types, to stand up off the PCB; most are 5% tolerance parts. All but one of these resistors in my set were in excellent condition.

The cause of the sudden massive change in horizontal frequency was very interesting. NPN germanium buffer transistor X22, a 2SD65, was intermittent. It would suddenly lose its ability to buffer, and the sudden loading on the horizontal oscillator forced the scan frequency up very high, to around 20kHz, well outside the capture range of the AFC.

I concluded that one of two things was happening to this transistor: either the collector connection inside the transistor was intermittently going open-circuit, or the base-to-emitter terminals inside the transistor were being intermittently shorted out by something like a tin whisker. Both mechanisms result in the same failure to buffer.

Of the two, I'm very suspicious that it is tin whisker disease, because I could not detect any voltage drop at all across the base-emitter junction at the time of the failure, and one would have expected about 300mV.

A suitable NPN Germanium transistor replacement for the 2SD65 is an AC127. In this case though, since it is a switching circuit and not an analog circuit with specific bias requirements,

Fig.17: one of the preset pots had gone bad, and since I couldn't easily source a replacement, I rigged up a modern trimpot of the same value to fit in the same location.

Alox Capacitors

These capacitors are very interesting. They are potted in a brown resin, somewhat reminiscent of a modern-day tantalum capacitor, but they have a wax coating over the resin too. They have a logo I cannot recognise; it has some similar features to the Siemens logo, but it is not exactly the same. I copied it as best possible below.

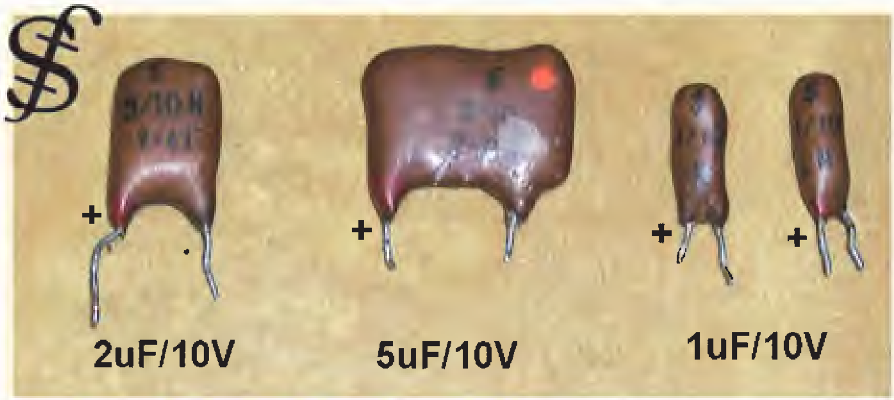
On testing the leakage properties of these Alox capacitors, they are very similar to a Tantalum capacitor.

It is interesting that Sony used these in their sets, since they had the advanced technology to make silicon transistors and might have made their own capacitors if they had wanted.

The fact these capacitors are all working nearly 60 years later says a lot. Presumably, they are some sort of solid aluminium electrolytic (modern versions are available). The one marked 5μF read as 6μF on my meter.

Even though these capacitors tested perfectly, I replaced the 1μF and 2μF ones with non-electrolytic Wima MKP 50V types (the pink-red colour ones seen in the photo of the deflection board) and the 5μF with a 6.8μF 50V tantalum.

This will hopefully avoid any future problems; but who knows, these vintage Alox capacitors may well still be better than modern types. 57 years is a pretty good test window.



and the transistors around it are silicon types, I simply replaced it with a high-quality gold-plated leg vintage BC107A (Fig.18).

Usually, I would replace a germanium transistor with an equivalent germanium type, to avoid any other changes in the biasing. But in this case, it didn't matter.

The third fault was where the fun really began; it took about three days to locate because it was intermittent. After fixing the first two problems, I was initially convinced all was well. Then, much to my horror, another fault occurred. The horizontal position of the locked image had a random jitter; a few millimetres this way and that. Then the problem would disappear for some hours and return.

One problem is with the horizontal AFC in lock, any changes inside the control loop from an intermittent component will be partially cancelled due to the loop behaviour.

So several thoughts crossed my mind: could the incoming sync pulses be changing their shape randomly? Could the phase splitter transistor driving the AFC diodes be noisy? Could an AFC diode be noisy? Or could the old Alox capacitors be defective? Or maybe the horizontal oscillator transistor was defective and noisy, and having erratic small frequency offsets to cause the effect?

I decided the better move was to break the loop (red star in Fig.16). I fed in a clean DC control voltage to the horizontal oscillator via R801 (3kΩ) and watched the test pattern float by horizontally. The oscillator appeared very stable, certainly with no jitter, so at least that part of the circuit was ruled out.

Looking at the AFC voltage on the scope with the broken loop, the fault was present. The DC level of the AFC voltage was randomly jumping up and down about 50-100mV at times.

I also tried feeding clean sync pulses from the generator directly into the phase splitter X15, but the fault remained. At that point, I disconnected the two coupling capacitors on the legs of the phase splitter output (green stars on the diagram) using solder wick and a temperature-controlled soldering iron (these old phenolic PCBs are very heat-sensitive).

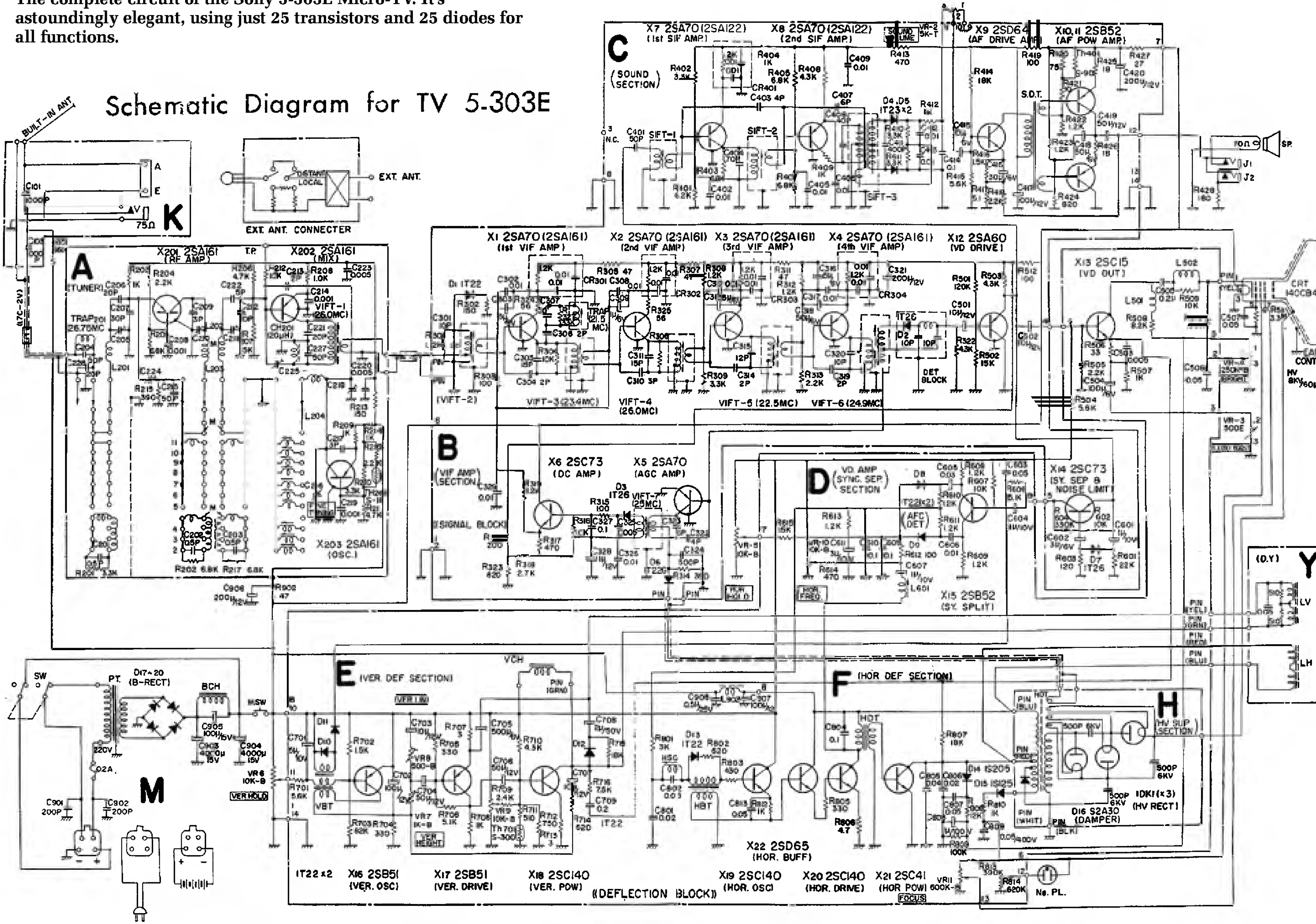
The fault remained, so that ruled out the phase splitter transistor, its resistors and the two disconnected capacitors. At this point, I thought the most likely explanation was that one of the IT22 germanium AFC diodes was defective and probably noisy. I replaced them one at a time with OA47 diodes. The fault and the jitter on the AFC output remained.

At this point, I double-checked all of the capacitors. I had previously replaced Alox capacitors C611 and C607 with high-quality Wima

Fig.18: despite being a silicon transistor, the BC107A (left) was a perfectly fine replacement for the internally faulty germanium 2SD65 (right) in my set. That's only because of the way it was used in the circuit though; it isn't operated in a linear manner. If it were, a germanium replacement with similar properties would have been required.

Fig.19: this innocent-looking 100Ω 5% resistor was the source of all my frustrations! It measured OK by itself, but when current passed through it, its resistance varied wildly.

The complete circuit of the Sony 5-303E Micro-TV. It's astoundingly elegant, using just 25 transistors and 25 diodes for all functions.



non-electrolytic types. I eliminated all the other capacitors by desoldering one leg and by substitution. The intermittent fault still remained.

At this point, I was running out of ideas, so I started checking the resistors. I was worried that if I heated them, the fault might vanish. Looking at the circuit, I could see no reason why I couldn't eliminate each one in a test by shorting it out, avoiding the need to desolder any. The resistors to test for noise were R610, R611, R612, R614 and R615. All of these resistors had correct values on the meter.

When I shorted out 100Ω resistor R612 (Fig.19), the voltage jitter vanished. The intermittent fault causing the small, yet apparent horizontal picture shift was due to this resistor. Inspection of the resistor showed it to look physically normal, but on testing and passing a current, its resistance value was erratic.

Horizontal linearity

Also noted from the screen photos, the horizontal linearity is a little stretched on the left compared to the right. In more modern video monitors and TVs, two things are done to correct horizontal linearity errors. One is to have an S-correction capacitor in series with the horizontal yoke coils; the other is to have an adjustable magnetically saturable reactor coil in series too.

This set has neither an S-correction capacitor or a magnetic linearity coil; it doesn't have a width control inductor either. That explains why the Sony Micro TV has those horizontal linearity errors.

If a technician sees these errors and wants to fix them, without realising that they are inherent to the design, they could spend months trying to improve it. It is quite different with the vertical scan linearity, which can be adjusted simply by changing the drive wave shape to the vertical scan amplifier.

To correct these horizontal scan linearity errors would require more horizontal scan width, meaning an increased HT with the same line output transformer and yoke, and the addition of a width control inductor, an S-correction capacitor and magnetic saturable reactor. So it is not a practical proposition. In this case, I thought it better to accept those errors as a feature of the simpler design.

Raster scanning

I think it was a pretty astonishing feat that Sony came up with an effective vertical oscillator and scan circuit that used only three transistors in total.

Because of this, it is not surprising that the adjustments and mix of currents at the input to the two-stage vertical scan amplifier (transistor X17 and output stage X18) are critical for a linear scan.

A more modern TV would contain at least two or three or more transistors. So I cannot but admire the genius, simplicity and economy of what Sony did with the vertical oscillator and scan amplifier. Later though, they changed the design.

Sony's next model, the TV 5-307U, sported a UHF tuner. It seems that Sony might not have been entirely happy with the design of the vertical scan oscillator and amplifier in the TV 5-303.

Sony modified the positive feedback loop design in the 5-307 (Fig.20), as I had to in my 5-303, but in a different way, eliminating C707. They also used a silicon oscillator transistor, lowered the value of sawtooth capacitor C702 from 100µF to 20µF, and used a higher value charging resistor, 2.7kΩ vs 330Ω.

On top of this, they modified the collector-to-base bias resistor R706 on input transistor X17. It is now split into two resistors with a 10µF capacitor to bypass the AC component of the negative feedback. This has the effect of increasing the AC signal gain of input (drive) transistor X17. There are also some other value and transistor type changes.

Final points

If this set is run from a 12V external battery, it is vital that a resistor of at least 1-1.5Ω is placed in series with the battery. This is also shown on some of Sony's diagrams, but not all. The reason is that a lead-acid battery can have a very low internal resistance, especially a car battery.

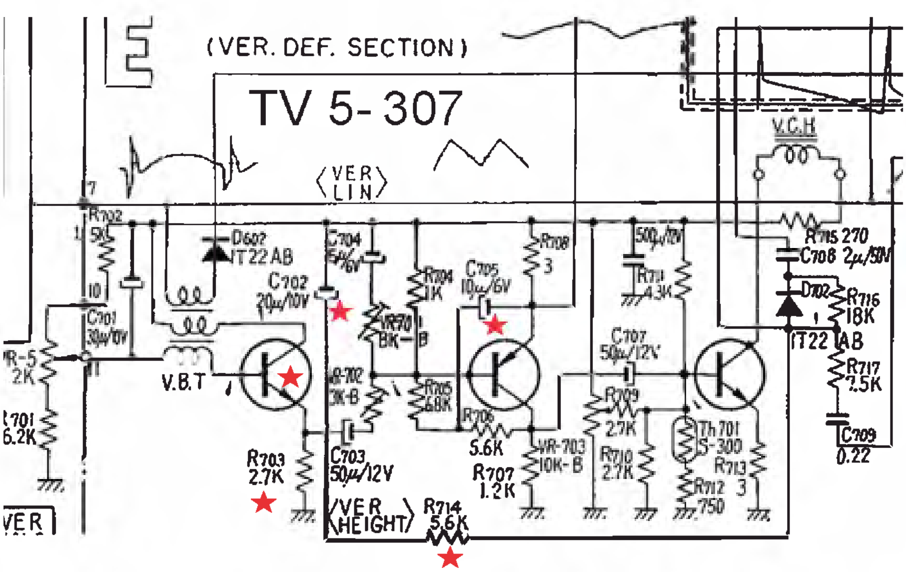


Fig.20: Sony's follow-up was the 5-307 TV, and as you can see here, there are many similarities with the 5-303 (compare this to Fig.15). But they also made some well-advised changes, including some which addressed the very same vertical linearity problems that I encountered in my set.

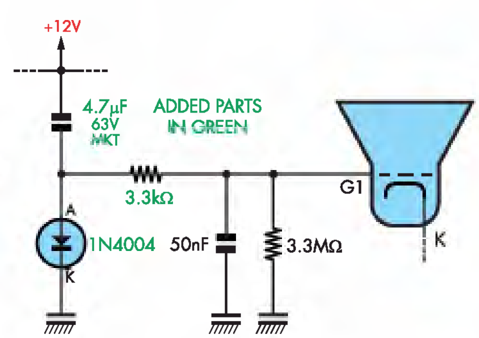


Fig.21: I added these three components to protect the CRT from damage at switch-off due to a bright spot appearing in the centre of the screen. It's caused by the immediate shutdown of the horizontal and vertical deflection, while the electron beam continues for some time. These components shut down that beam at switch-off.

Just how small is this set?

This advertisement from Life Magazine, March 1963, shows this amazing little TV set. While I didn't realise it at the time, it was very clever marketing to show the Micro-TV next to two very young children (possibly around four years old). It gives you an immediate idea of the size of the set, while also showing a real-life application a parent might benefit from: the entertainment of young children.

Sometimes, advertising agencies actually do a great job. In more recent times, the field of advertising has been cynically renamed "perception management".

The text at the bottom of the advert reads:

"People once said Micro TV might happen in the Seventies. Sony research and engineering made it happen a year ago. This revolutionary set weighs just 8 lbs, and is about the size of a telephone, yet it outperforms standard receivers in both sensitivity and durability. And it plays anywhere... on its own rechargeable battery, 12V auto-boat battery, or AC."

"You can put the Micro TV beside your bed, on your desk, in your boat, car, den, patio or picnic basket. High fidelity sound is always assured. Epitaxial transistors – the powerful, sensitive type used in advanced electronic equipment – give it a matchlessly sharp, clear picture. See it at a Sony dealer. Be among the many enjoying the Set of the Seventies today."

When the heater in the CRT is cold and has a very low initial resistance, the surge current can be extreme enough to bright-flash part of it and even fuse it.

With the resistor, in conjunction with the high-value filter electrolytics in the set, the CRT heater gets a softer start, and the voltage applied to it rises more slowly.

Also, on my set (and this problem affects many TVs of the era), at turn off, when the CRT's scan stages initially stop the deflection, the CRT heater is still warm and the CRT's electrode voltages can stay up for a while. The intense energy applied to the phosphor near the centre of the screen can damage it over time, so it loses its sensitivity in that area.

Many TV and VDU manufacturers added "turn-off spot killers" to prevent this problem. The other thing that helps is to remember to turn the brightness to zero before powering the TV off.

I added a small turn-off spot killer circuit to my set, as shown in Fig.21. It charges a capacitor from the power supply via a diode. This is so that, in case the TV gets turned off and on rapidly (or has a bad power supply connection), the capacitor charges very quickly initially.

Then when the power is switched off, the TV's 12V supply collapses fairly quickly to zero. This takes the diode side of the capacitor to about -12V; then after a while, the capacitor discharges via the 33kΩ and 3.3MΩ resistors. This creates a long-duration negative voltage pulse at the CRT grid at turn-off, helping to extinguish the beam current.

These three components are simply mounted on the lower PCB connector pins where the existing 3.3MΩ resistor and 0.05μF capacitor reside. There is plenty of room there.

Another simple method that works is to increase the charge storage on the video amplifier circuit's power rail (in the case where the video amp drives the cathode and is directly coupled). This can be done by powering it via a series diode and adding an electrolytic filter capacitor on the supply rail.

This way, at turn-off, the cathode voltage stays high for a while, also helping to extinguish the beam. In the case where it is AC-coupled, the same idea works with some added charge storage on the brightness control circuit in the cathode. SC