Vintage Radio

By Ian Batty

Philco Safari: the first transistor portable projection TV set

Saturday afternoon "footie" on the verandah. The chassis is in the leather-covered lower section, while the brown plastic upper section houses the mirror optical system.

Released in June 1959 and costing $250.00, the Philco "Safari" was the world's first battery-powered transistor portable TV set. It was an unusual design employing a simple projection system to enlarge the image produced by a tiny 5cm upwards-facing picture tube buried inside the case.

PUBLIC TV transmissions essentially began in 1936 with BBC and German broadcasts but it wasn't until after World War II that television really began to take off. Indeed, the 1950s saw the introduction of what could be called the "Television Age".

The all-valve sets of that era, with their progressively larger and larger picture tubes, were power-hungry monsters. Small radio sets on the other hand had been around for some time, with an explosion of personal portables and so-called "shirt-pocket" sets in the late 1940s. Miniature and later subminiature valve designs were then rapidly replaced by all-transistor sets. Regency and Sony set the pace, followed rapidly by other major electronics companies.

The start of Philco

The Philadelphia Storage Battery Company, registered in 1906, began releasing products under the Philco brand in 1919.

Philco had been early adopters of transistor technology, releasing their proprietary Surface Barrier Transistors (SBTs) in 1953 and their first transistor portable radio (the T7) in 1956. Philco also developed what is claimed to be the world's first general-purpose, solid-state computer, the S-2000, in 1957.

With such a pedigree, it's no surprise that Philco joined the race to develop an all-transistor TV set. They already had a fine catalog of valve sets and were active in developing and manufacturing cathode ray tubes (CRTs). They would go on to develop the "Apple" single-gun colour CRT.

Philco had even employed television pioneer Philo Farnsworth for awhile. As in the race between Regency and Sony for the first transistor portable radio, Sony were breathing down Philco's neck to be first to market with a portable transistor TV set. Philco eventually won the race with their Safari model but Sony came a creditable second with a more usable, better-designed set designated the TV8-301.

It's always easy to be critical of "the first" of anything. There's a story that some critics once ridiculed Christopher Columbus for discovering America, claiming it was no great feat. He simply challenged them to take a fresh egg and stand it on end. They failed, of course, so Columbus took the egg and very delicately tapped it on the table, crushing the end in just enough to make it stand freely. "That's no great trick," they said.

"Perhaps not. But I did it!"

Philco Safari: first look

The set featured here is the second such unit to come into my possession. The first was fine electrically but its parabolic mirror (used to reflect and enlarge the image from a small upwards facing CRT) had lost its reflective surface and the picture was only barely viewable.

By contrast, this second set worked

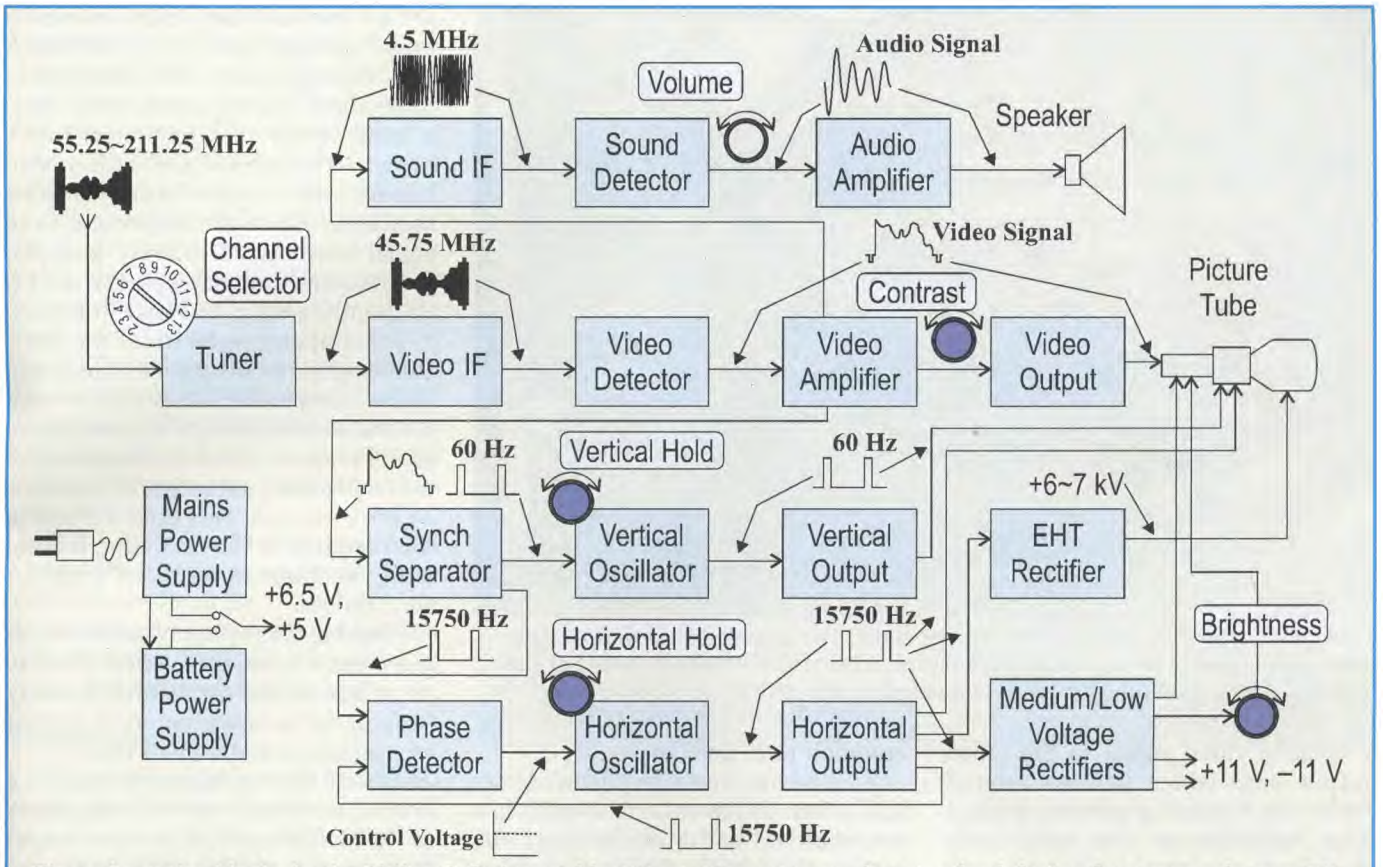


Fig.1: the major blocks in the Philco Safari portable TV set. It's pretty much a standard design for a monochrome TV set. Note that the deflection waveforms have been simplified and may not exactly match those in a working unit. Note also that the IF and deflection frequencies shown are for the American NTSC system.

first time. It easily tuned in my bench-top RF converter set-up, thereby allowing me to view analog versions of local digital television transmissions. We'll look at the signal conversion set-up later in the article, along with a method for dealing with the NTSC (US) sound channel IF which is at 4.5MHz, rather than the 5.5MHz used here in Australia.

As an aside, the Philco Safari was featured in cover articles in several magazines, among them "Popular Science" of August 1959 and "Electronics Illustrated" of November 1959.

Circuit description

The main chassis diagram covers three pages and there's another for the tuner. However, we'll simply look at the main features of the set instead of describing the circuit stage-by-stage. Before going further though, note that the Philco Safari is an NTSC set and so has vertical and horizontal frequencies of 60Hz and 15.75kHz respectively.

Fig.1 shows the block diagram. The Safari uses 21 transistors (all PNP types), 12 semiconductor diodes, two high-voltage rectifiers and a picture tube. The main power supply (described in detail later) is positive to ground but a subsidiary negative-to-ground power supply is also derived from the horizontal output stage.

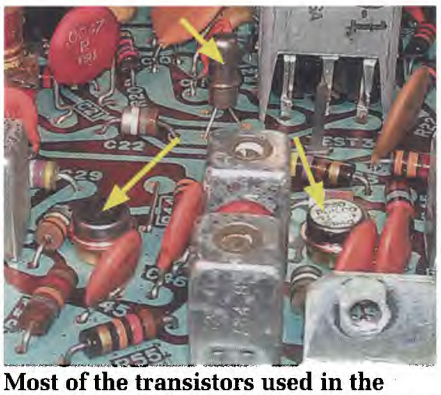
The tuner uses a simple multi-wafer ganged switch with coils wired between its contacts. This has the advantages of simplicity and low cost compared to a turret tuner but these advantages are offset due to the fact that any adjustments interact between switch positions.

In operation, the channel selector "clicks" between channels, much as a turret tuner would do.

Philco transistor packages

This is a VHF-only set – UHF transistors were not available at the time of production. It uses an RF amplifier, converter and a separate local oscillator.

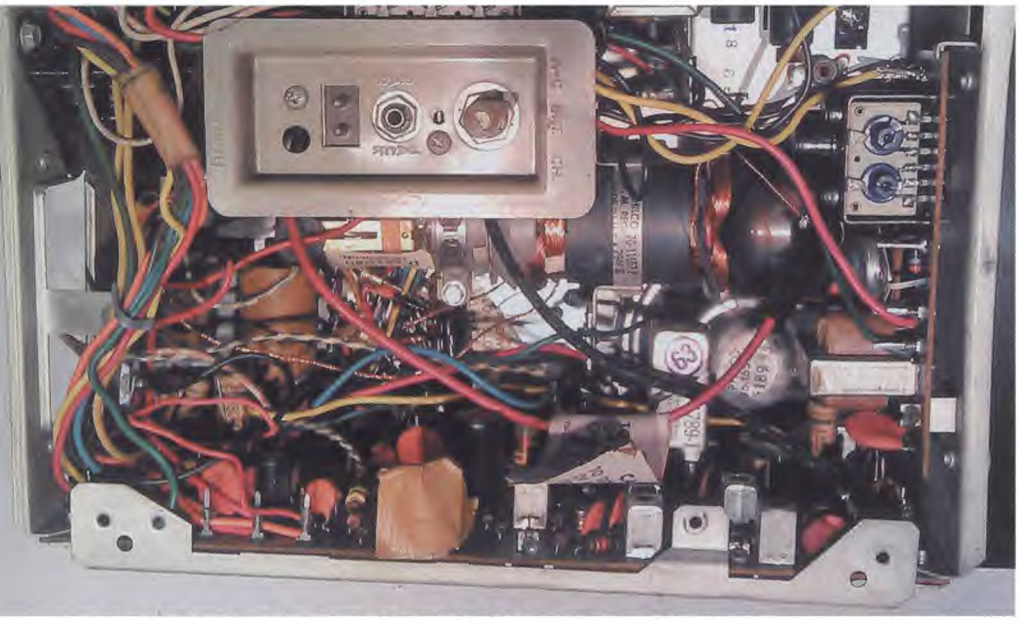
The wide bandwidth demanded by TV signals (some 6MHz for NTSC), combined with the high IF (intermediate frequency) of 45.75MHz results in low IF stage gains. As a result, there are



Most of the transistors used in the Safari are proprietary Philco types so suitable substitutes would have to be found if they require replacement.

four stages in the main video IF strip. In addition, feedback capacitance is significant at 45MHz, so each stage has a neutralising circuit. Two tuned "traps" help control the IF passband and "notch" the 41.25MHz sound converter signal, thus preventing possible visible interference in the picture.

The video section begins with a conventional diode demodulator, in turn feeding an emitter-follower first video amplifier. The contrast control feeds



This view inside the Philco Safari TV set shows the chassis construction. The deflection board is at the top of this picture, while the IF/audio board is at the bottom. The picture tube (or CRT) is located in the centre.

a variable video signal to the video output stage which delivers around 7.5 V peak-to-peak (p-p) to the picture tube. This stage uses dual supply rails of around ±11V or 22V total.

The sound channel begins with a "pick-off" at 4.5MHz from the first video amplifier stage. This feeds two sound IF stages (amplifier and limiter) to provide a fairly constant signal to the demodulator, thereby eliminating any amplitude modulation (AM) components and interference.

Like the video IF stage, the sound IF stage uses neutralisation. The FM demodulator uses a Foster-Seeley discriminator rather than the more common ratio detector.

Audio from the demodulator (detector) is fed via the volume control to a conventional audio driver stage, the output of which is then transformer-coupled to a push-pull output stage. This audio section is very similar to that found in portable transistor radios.

Chassis details

Inside the unit, the various circuit board assemblies and other components are mounted on a plated steel frame. Note that the battery carrier has been removed from the unit shown in the photo.

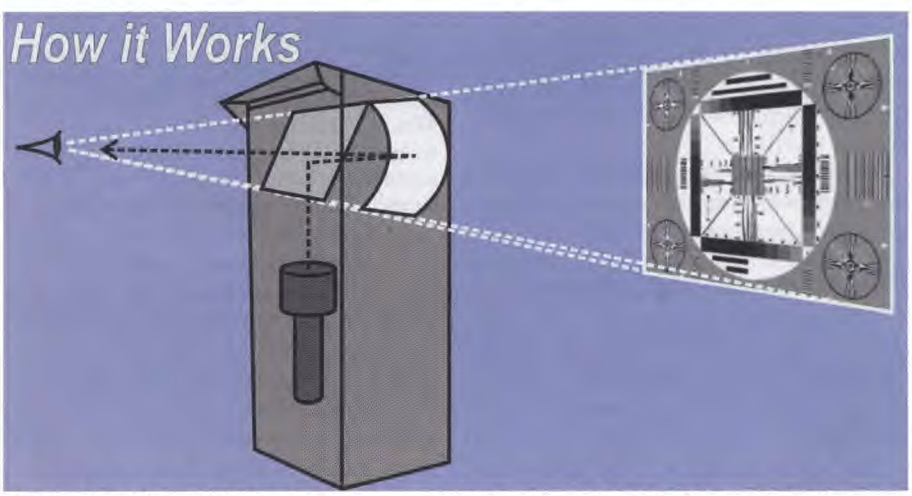


Fig.2: the Philco Safari optical system. The image on the CRT is projected upwards to an angled, half-silvered mirror. From there, the image is reflected and magnified by parabolic mirror. The final enlarged image, as seen by the viewer, appears to be about 1.2 metres behind the set.

The vertical amplifier delivers a broad voltage pulse to the deflection coil, relying on the coil's inductance to produce a linear current and thus a linear sweep over the picture tube's screen. Horizontal deflection also begins with a transformer-coupled oscillator. Since the horizontal sync signal is extracted directly from the video signal, the sync separator has little damping effect on noise impulses.

To compensate for this, the horizontal sync circuit uses a dual-diode phase comparator. This detects any difference between the incoming sync signal frequency and the frequency of the horizontal oscillator and generates an error voltage. This error voltage is then applied to the oscillator, forcing it to synchronise with the received sync pulses.

Filtering of the phase detector's output greatly reduces the effect of noise impulses on the oscillator's stability (this circuit is now commonly known as a phase-locked loop or PLL).

As with the vertical output stage, the horizontal output stage delivers pulses to the deflection coil via the output transformer. In this case, however, a damper diode also helps ensure a linear current sweep across the screen.

There is a short period during each sweep where current in the deflection coil falls (or collapses) to zero. This creates a short, high-voltage pulse somewhat like the spark pulse in a car ignition coil. The resulting pulse train is then fed to a transformer to provide four output voltages.

The picture tube receives some 6-7kV via a vacuum-tube voltage doubler/EHT rectifier connected to the output transformer's high-voltage secondary. In addition, lower-voltage taps drive half-wave rectifiers that provide +280V for the picture tube electrodes, +11V for the IF amplifier strip, video amplifier and vertical oscillator, and -11V for the video amplifier.

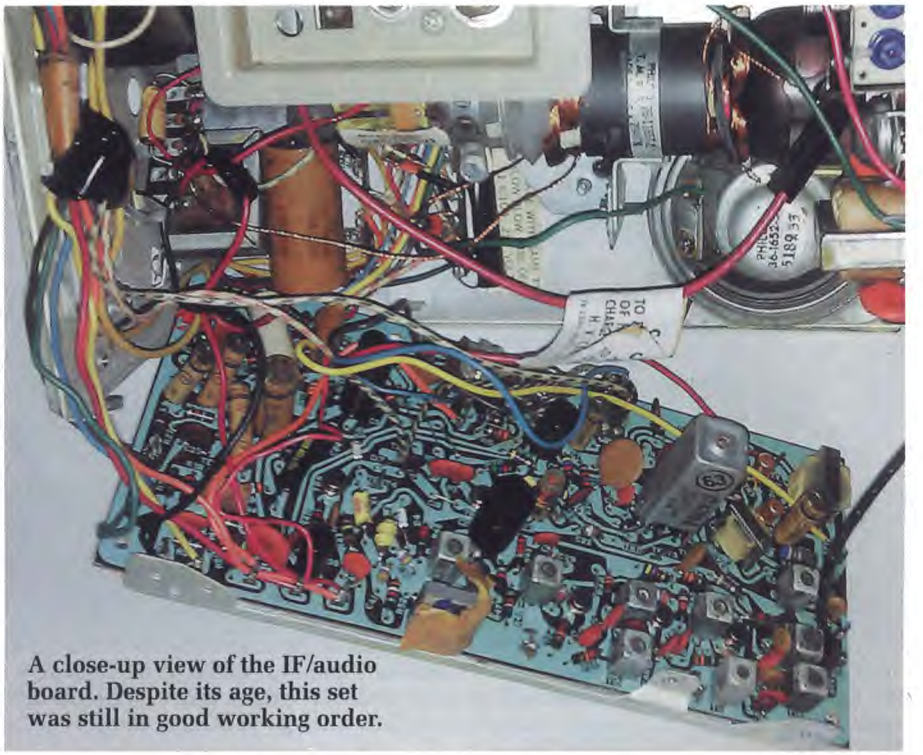
The picture tube (or CRT) is Philco's own two-inch (5cm) magnetically-deflected 2EP4, the "P4" denoting a white phosphor. Unlike the 2EP4, picture tubes this small are commonly electrostatically-deflected "CRO" types. However, electrostatic deflection demands many thousands of volts in basic tubes – voltages not possible with the transistors of the day.

By contrast, magnetic deflection currents can be easily handled by transistors powered from low-voltage

supplies and transformer-coupling between the output stage and the deflection coils. As well, the small screen size means a smaller deflection angle than the common 70°+ of conventional tubes. This simplifies circuit design and reduces power consumption.

Magnetically-deflected tubes generally use high accelerating voltages (with the advantage of potentially higher brightness) and the 2EP4's final anode voltage is some 6-7kV. The 2EP4's circular face projects upwards through a rectangular mask to a partially-silvered mirror angled at 45°. A portion of the resulting image is then reflected backwards to a concave mirror.

This mirror produces a magnified virtual image with an apparent diagonal of about 35cm (or 14 inches). Unfortunately, the combination of partial reflection and magnification reduces image brightness considerably.



A close-up view of the IF/audio board. Despite its age, this set was still in good working order.

Power supply

The power supply uses a 110VAC mains transformer which feeds 7.5VAC to a full-wave rectifier. After filtering, the set receives supply rails of -6.5V and -5V for all stages not fed by the horizontal output stage. The set can also run on a 7.5V battery pack, rechargeable from the mains supply.

Since many stages derive power from the horizontal output transformer, this set will appear dead unless the entire horizontal deflection system is working. This is common with transistorised TV sets. Because of this, a "dead" transistor TV set may have a perfectly good mains supply, so be sure to check the horizontal output stage if the main supply voltages are normal but one or more stages are "dead".

Compromises

The Safari uses "simple" AGC that responds to the strength of the IF signal and thus to the average picture level (APL). The problem is that, with negative modulation, dark pictures give higher APLs, forcing the AGC to reduce the gain and make the picture appear even darker. The opposite happens with bright pictures – in this case, the low APL allows the AGC to relax, thereby increasing the gain and making the picture over-bright.

Additionally, the video circuits are AC-coupled, so the original DC value for picture black is lost. As a result, the bias level on the picture tube "floats" at the average level of the signal. This means that dark pictures will become artificially bright as the average level drifts.

Basically, a more advanced design would give constant black levels so that a very dark object remains very dark, whether appearing in a brightly-lit scene or a dark one.

Condition

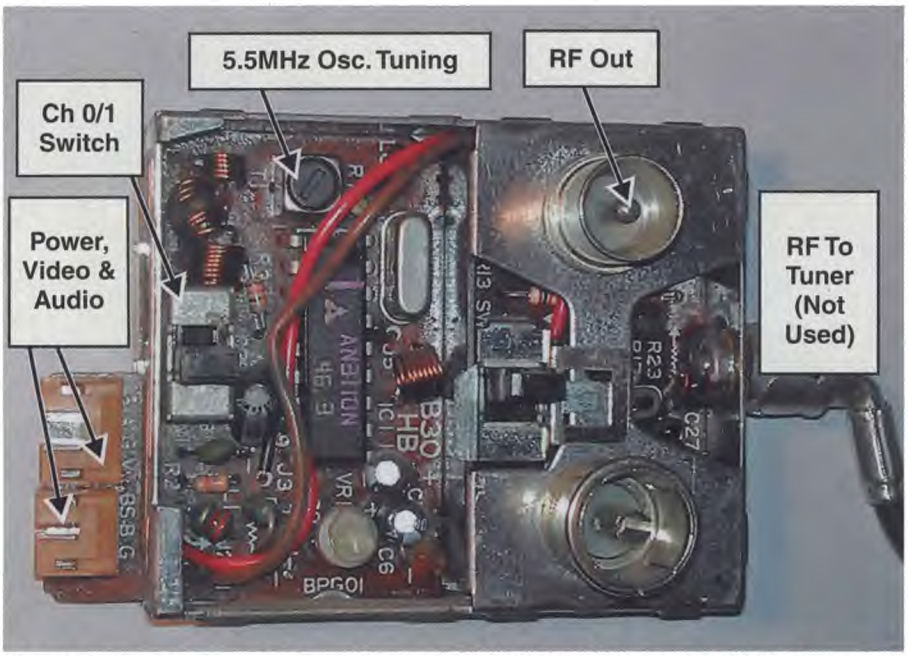
Despite its age, this set worked just fine as it came to me. Most of the transistors used are proprietary Philco types but it's unclear whether they are SBTs or alloy-junction transistors. Detailed specifications for the Philco "T1nnn" types were unavailable but Ernst Erb's Radio Museum gives basic descriptions.

As an example, transistors such as the AF186, with its 860MHz cut-off frequency, could replace the tuner's RF amplifier (T1561). However, it's the high-power components that are more likely to fail and the vertical output transistor (T1601) could be replaced by an AD149 which has a similar package and is described as "suitable for vertical output service".

The internal battery had died long ago and left a "corrosion hole" in the case due to leakage. It's about the right size for a C-cell repack to restore it to true portable operation.

TV sets invariably use many specialised parts, particularly in the timebase circuits. Such parts may be unique to one model and these can be a real problem (if not impossible) to obtain

An off-air picture on the Safari, as seen by the viewer. The image has an apparent diagonal of about 35cm.



This RF converter was salvaged from an old National Panasonic VCR. Retuning the 5.5MHz oscillator to 4.5MHz will give an audio IF output that's compatible with US NTSC sets such as the Philco Safari.

as spares, particularly in vintage sets such as this. Although it's possible to get transformers rewound, the wise collector will begin with a working set rather than attempting to repair a "renovator's delight".

Television IF alignment is also a laborious business, as I can confirm. Don't expect that "a bit of a fiddle" will improve picture quality. In fact, any temptation to fiddle with IF alignment should be resisted unless absolutely necessary. IF alignments don't change much over time and I would only get out the sweep generator if I'd done significant work on the IF strip.

Using it

The Philco Safari is a very tall set and looks like it is in constant danger of tipping over. In practice though, it's quite stable due to a stand that allows it to be positioned upright for convenient viewing.

As mentioned, the optical system means that the reflected image isn't as bright as the smaller, original image on the picture tube. However, picture clarity is aided by a flip-up hood that shades the top and sides of the viewing area. In addition, the CRT's face is "hidden" within the case, so objects in front of the set create fewer reflections to interfere with the viewed image.

More importantly, the CRT's faceplate is shielded from ambient light, so the brightness can be set to a reasonable level for comfortable viewing. That said, the Safari does benefit from careful placement when used outdoors.

How good is it?

The "Popular Science" report rated the Safari's picture as "excellent: crisp, detailed, natural in tone". In addition, the sound quality was "average for TV" and the sensitivity was "remarkably good for such a compact receiver".

Of course, they were judging it by the standards of the day but what did I think? In short, the picture clarity is good. The simplest test for any analog set is to tune to a blank channel and observe how fine the "snow" (set noise) is. Basically, fine snow means good picture clarity. The brightness was, as "Popular Science" stated, adequate for daylight viewing.

New life for old tellies

There would still be some of these old sets "out there" but with analog transmissions ceasing, the only place I can use the old Philco is in my workshop or display area.

It's great to have this set in working order, though. There is only one "first" of any generation of technology. Also, the first set I acquired still needs repair, so I'm on the lookout for a non-working set that may be able to donate parts. Furthermore, I expect that my local Astronomical Society will know about mirrors and be able to help out with resurfacing.

RF converter

A recent "Radio Waves" article, by Graham Dennes (April 2013), details an off-the-shelf RF converter that will allow you to fire up any old analog set, whether valve or solid-state. Be aware though that many cheap converters only tune over the UHF band and do not suit older VHF-only sets.

As an alternative, you can "liberate" the RF converter from a junked VCR. The signal output is usually switchable between channel 0 or 1/2. Again, some of these VCR converters are UHF only and are not suitable for use with older VHF-only sets.

If you can salvage a converter, it's easy to house it in a box and power it from a suitable DC supply (usually 6-9V). You then feed the video/audio outputs from a digital receiver or set-top box into the converter, connect the converter's output to your old analog TV and you're in business.

If necessary, you can open up the converter and tweak the oscillator that generates the 5.5MHz FM IF for the Australian television standard. They mostly use a simple slug-tuned oscillator and tuning down to 4.5MHz will give an audio output that's compatible with US NTSC sets.

Similarly, retuning a "video beamer" (a high-powered converter with a radiating antenna) allowed me to send a good signal well across the workshop.

Variants

The Philco Safari comes in two models and four variants. The Model H2010L came with a brown leather case, while the model H2010BL has a black leather case. In addition, each model has an early (1959) version and a later (1960) version. The latter eliminated the sound take-off transformer and there were some changes to the transistor types used!

Further reading

You can find the "Popular Science" review of the Philco Safari on Google Books – just search for "popular science august 1959", click on the August 1959 cover and go to page 64.

Technical information (for members only) is also available from Ernst Erb's Radio Museum **www.radiomuseum.org** **SC**