VINTAGE RADIO

By Ian Batty

Healing M602T transistor mantel radio

Good performance and long battery life with 'modern' 60s styling – a transistor radio that's at home in the kitchen.

I picked up this transistor set at an HRSA auction a while ago. It's an Australian set, compact and easy to use.

I recently described Healing's fine valve portable, the 404B (April 2019; siliconchip.com.au/Article/11533). So we can now directly compare that to the six-transistor M602T from the same manufacturer.

The M602T was released in 1960 and followed on from the designs that had matured by the late 1950s. It uses six alloyed-junction transistors: three in the RF/IF section and three in the audio stages. This puts it in the second generation of transistor sets. The short-lived first generation used inferior grown-junction transistors.

So as well as comparing this set to the valve radios that were designed just a few years before it, we can also compare it to the transistor sets which came soon after (ignoring the few hybrids which bridged the gap).

The M602T's construction uses a design that was passing out of favour at the time: a punched and pressed steel chassis using tag strips, transistors mounted in grommets, and point-to-point wiring. Its mechanical construction is complicated, with three metal sub-chassis sections.

The plastic cabinet is quite generous, putting it in the 'small mantel/portable' class. The chassis, although not especially compact, leaves plenty of room for its 5-inch Rola 5F speaker and the long-lasting type 276 battery.

It's a conventional six-transistor set, using the same cabinet as mains-powered valve models 410E & 411E.

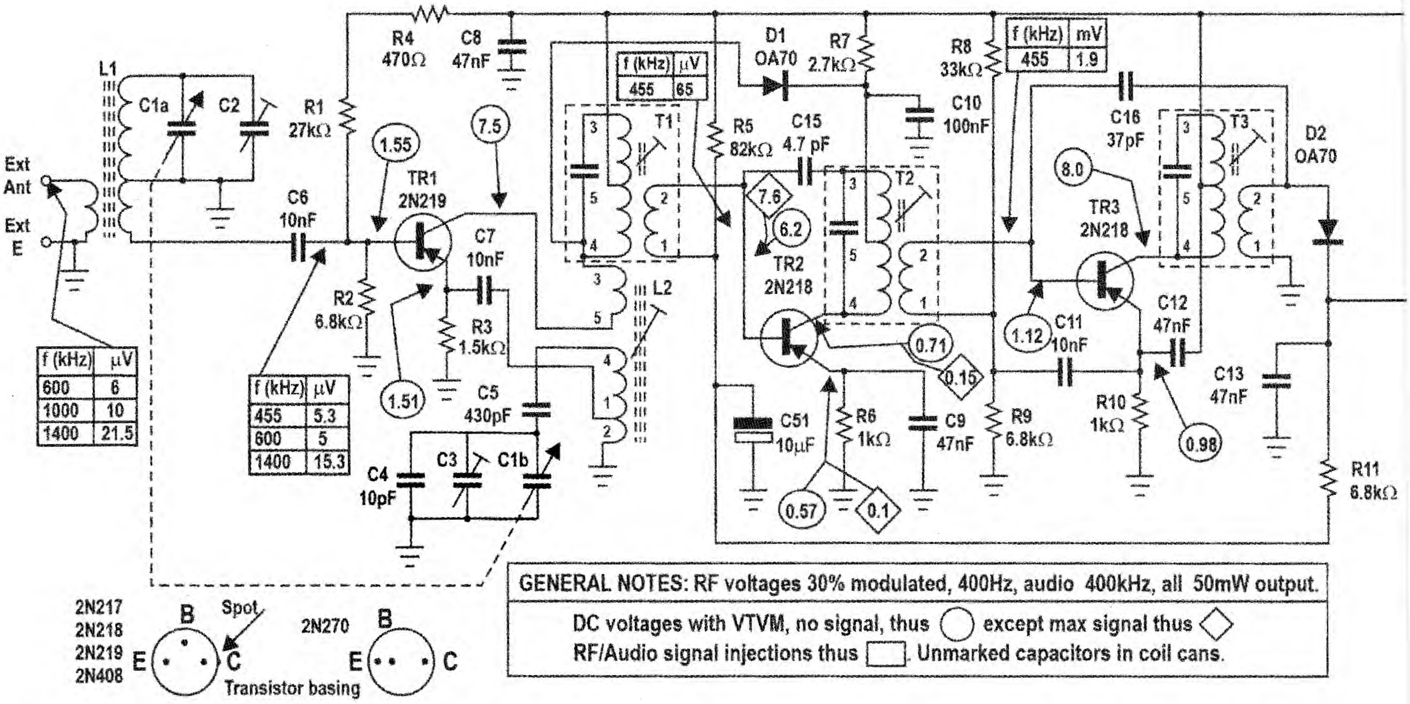
Being a larger set than the 404B, the M602T has a more relaxed and usable control layout. The large dial features station call signs, a reminder of Saturday afternoon footy and Top Forty Hit Parades. The slow-motion dial makes tuning easy.

From top to bottom, the knobs are the on/off switch, volume control and tone control. Separating the on/off and volume functions reduces wear and extends the life of the volume pot, as it can be left in the same position most of the time. I wish the controls were labelled; maybe you're just meant to know.

Compared to the all-valve 404B, the M602T is a pleasure to work on, though its complicated construction sees the tuning gang buried between the front and back chassis plates, and the trimmer capacitors partly obscured, so adjusting it is a bit difficult.

As the IF transformers are all single-tuned, the slugs are easily accessible from the rear.

On my set, they appeared to use wax to prevent accidental movement, so I strongly advise against using metal-tipped alignment tools. If you need



to get a slug to move, try using a hair dryer/heat gun to warm the can and soften the wax.

All minor components, including the transistors, are easily accessible for measurements or replacement.

Circuit details

The circuit of the M602T is shown above. Note that some sets may have alternative transistor types to those shown, especially the ones which were made in Japan.

The circuit begins with the usual self-oscillating converter, TR1. This is a 2N219 or a 2SA15, roughly equivalent to an OC45 rather than the higher-performing OC44 or similar that we're used to seeing in this stage. The converter uses emitter injection, so it's easy to inject a signal directly into the base for testing.

The antenna circuit has a ferrite rod with a separate primary winding to allow an external antenna connection to be used.

As is usual for converters, the base-emitter forward bias of some 50mV is lower than the usual 150~200mV for germanium transistors. This is because converters need to operate in a non-linear mode close to Class-B, so that they can create the necessary sum-and-difference signals from the incoming radio station and the local oscillator (LO).

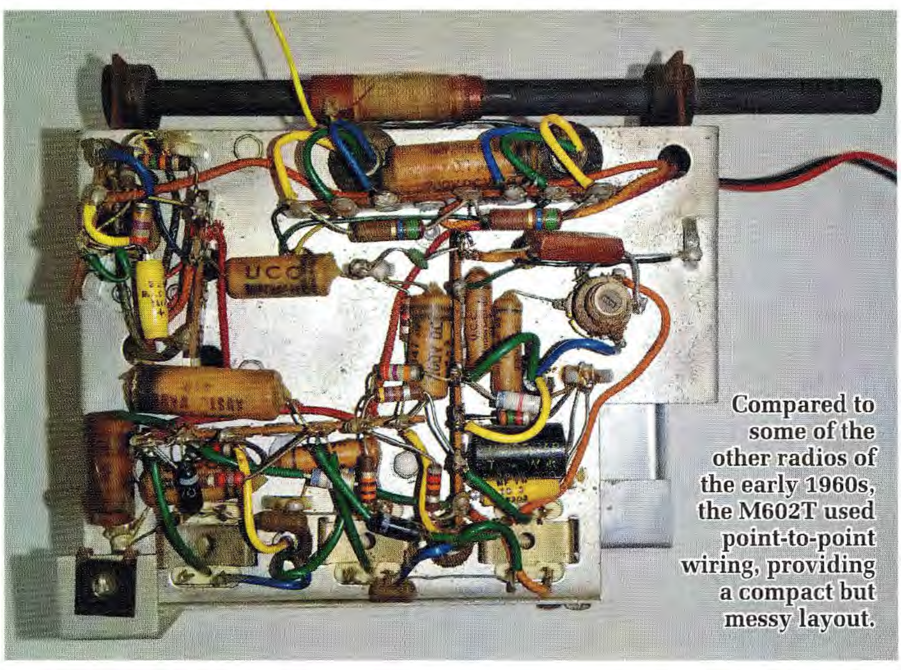
LO transformer L2 has two windings, with the secondary tapped to supply feedback to the low-impedance emitter.

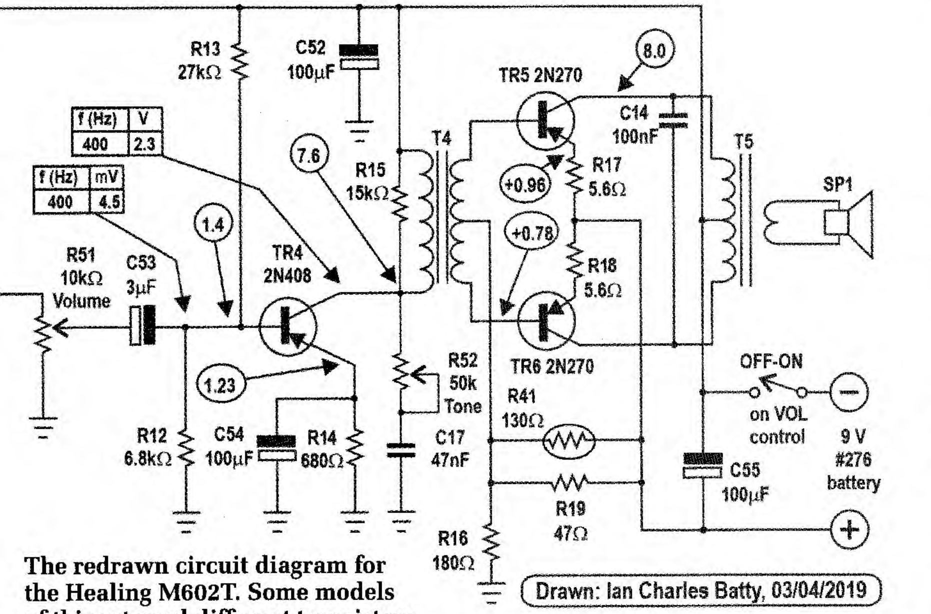
As the tuning gang has identical sections, padder C5 (430pF) reduces the LO section's capacitance swing to give a ratio of roughly 4:1 as the set tunes over the broadcast band.

The converter feeds first intermediate frequency (IF) transformer T1. This has a tapped, tuned primary and untapped, untuned secondary.

The first IF amplifier transistor, TR2, is either a 2N218 or a 2SA12, both slightly lower-performing versions of the 2N219/2SA15. As the stage is gain-controlled, bias resistor R5 has a relatively high value of 82kΩ. This allows the AGC signal from diode D2 to reduce TR2's gain with increasing signal strength. This is filtered by 6.8kΩ resistor R11 and 10µF capacitor C51 to remove the audio component.

TR2 feeds second IF transformer T2, also with a tapped, tuned primary and untapped, untuned secondary. The collector is fed from the supply via a 2.7kΩ resistor, R7. AGC extension diode D1 has its cathode connected to R7 and its anode to the primary of first IF transformer T1.


Compared to some of the other radios of the early 1960s, the M602T used point-to-point wiring, providing a compact but messy layout.



The redrawn circuit diagram for the Healing M602T. Some models of this set used different transistors, most of them made by Hitachi, for the Japanese market. Additionally, the values of C8 (330nF), C11 (47nF) & C16 (56pF) differ, likely for similar reasons.

In normal operation, there's a voltage drop of about 1.8V across R7. Since the converter's collector sits at about 7.5V, D1 will have a reverse-bias of around 1.3V. This means that D1 is cut off with weak signals so it will have no effect.

As the AGC takes over, and TR2's collector current falls, TR2's DC collector voltage rises. This brings D1's cathode voltage closer to 7.5V, so D1 will start to conduct with strong signals. As it does so, it shunts current from the converter's collector, further reducing the set's gain and giving improved AGC action.

The 2N216~219 series are all alloyed-junction RF transistors, exhibiting collector-base capacitances of around 9pF. So both IF amplifiers need neutralisation, with 4.7pF capacitor C15 providing this for TR2.

Second IF amplifier TR3 uses another 2N218/2SA12 with fixed bias. The usual emitter bypass capacitor to ground seems to be missing, but this stage has its base bypassed back to the emitter terminal via 10nF capacitor C11, and its collector supply is bypassed to the emitter via 47nF capacitor C12.

This configuration is most often used in VHF circuits, as it is more effective than running everything to ground. In this circuit, it also saves one capacitor – the emitter bypass capacitor, such as C9 used by the first IF amplifier TR2.

TR3 feeds third IF transformer T3's tuned, tapped primary, and T3's untuned, untapped secondary feeds demodulator diode D2, another GEX34/OA70. D2's audio output, filtered by C13, goes to volume pot R51 and also provides the AGC signal, as described earlier.

Note that the AGC filter capacitor, C51, is an electrolytic type. Electrolytics are not recommended for RF/IF bypassing, so if you have an M602T suffering from oscillation or some other strange RF/IF fault, C51 may be the culprit.

The signal from the volume control is coupled to the base of audio driver TR4, a 2N408. TR4 has conventional combination bias, and its collector drives the primary of output transformer T4. The tone control pot, R52, and 47nF top cut capacitor C17 connect between TR4's collector and ground.

As R52's resistance is reduced, C17 progressively shunts more of the high audio frequencies, giving more and more top-cut and producing a more 'mellow' audio tone.

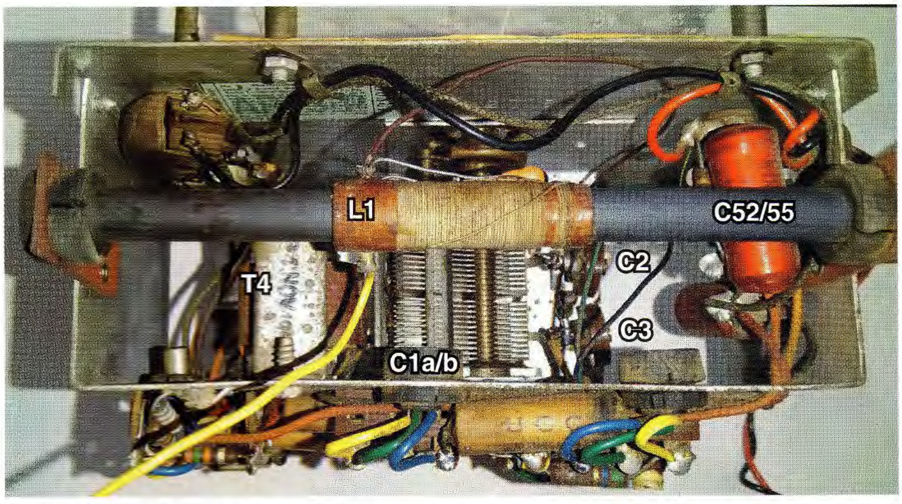
T4's secondary provides the push-pull drive to transistors TR5/6, both 2N270s. These have higher power ratings than the OC72, but less than the later OC74/AC128 types from Philips/Mullard. TR5/6 operate in Class-B, with around 180mV of forward bias.

Don't be confused by the positive voltage readings in the emitter/base sections of the circuit; I've measured relative to chassis ground, and since R16 is connected between the battery and chassis, the chassis sits about one volt below the battery's positive terminal.

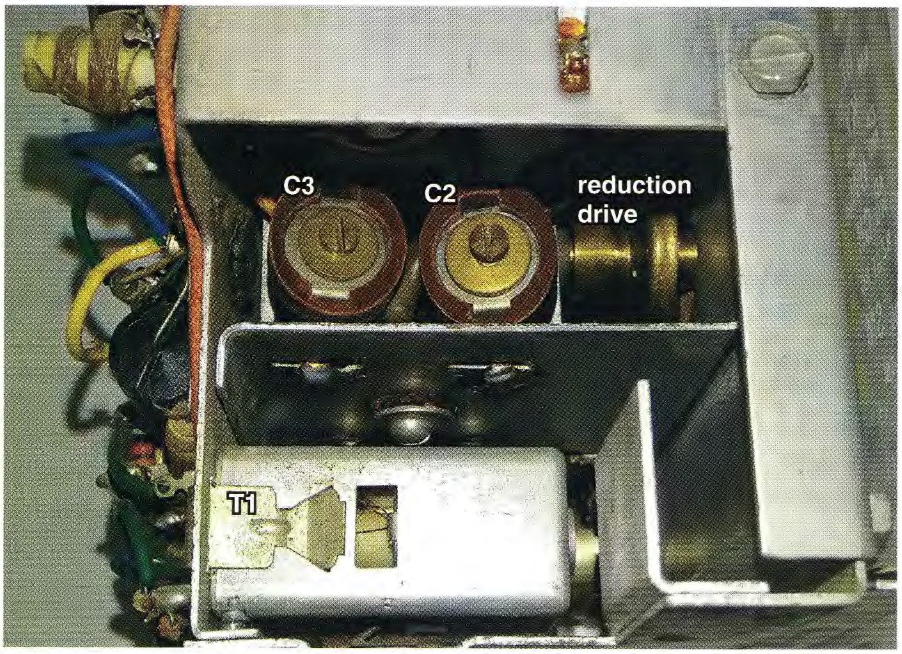
TR5/6 get their bias from the parallel combination of R19/R41 – again, a slightly confusing connection, but it works perfectly. Thermistor R41 compensates for ambient temperature, reducing the forward bias for TR5/6 at higher temperatures, where their base-emitter junction voltages fall. This provides a relatively constant collector current, protecting from thermal runaway.

Quirky decoupling

Class-B output stages draw low



From the top of the M602T, you can see two large red 100µF electrolytic capacitors, used for filtering the supply, at the far right. There are a few other electros in the circuit, which may cause oscillation problems if they degrade.



Variable trimmer capacitor C3, used to calibrate the oscillator, is shown at centre left. To its right is trimmer capacitor C2 for the antenna. Again to the right of C2 is the planetary reduction drive for the dial.

quiescent (idling) currents – it's the main reason for using them, despite their complexity compared to Class-A stages. But Class-B operation results in considerably larger swings in supply current, increasing substantially on output peaks.

These current peaks can impress the output signal on the supply voltage, making the entire set prone to audio feedback as the output signal finds its way back to driving stages. The simple remedy is to use decoupling, often just a simple resistor-capacitor filter, in the supply line going to the low-level RF/IF/audio section.

But the M602T applies the full battery negative supply to all stages. The decoupling circuit is placed in the positive supply, which in this case, is ground. It's odd but effective: output transistors TR5/6 do get the full battery supply, but the battery positive's connection to chassis and set Earth is via 180Ω resistor R16.

The battery itself (and thus the output stage) is bypassed by 100µF capacitor C55, and the driver/RF/IF stage supply is bypassed by 100µF capacitor C52.

The circuit office appears to have numbered ceramic and paper capacitors consecutively from C1, but started the electrolytics from C51.

The output stage's thermistor is renumbered as R41, and the volume pot as R51, despite there being about 20 fixed resistors in the circuit.

Cleaning up my set

The set I acquired was in fair cosmetic condition, the only damage being two melted areas on the top of the case and a missing "Transistor" badge on the decorative metal panel across the top of the front panel.

The tuning was very stiff. Inspection showed that the planetary reduction drive was stuck tight, so I removed, dismantled, cleaned and re-assembled it. It was then time to power up the radio, which still had all of its original components.

Perhaps unsurprisingly, it was dead. The culprit, an oxidised power switch, responded to contact cleaner and a good number of on-off-on-off cycles.

Having resurrected the set, it was time to check its alignment. It seemed to come up well in the IF department, and responded well at the low end of the broadcast band around 600kHz. But it got progressively more and more 'deaf' towards the top end.

I checked all the voltages but found nothing wrong. So I completely dismantled it and washed the 'dust of ages' from the tuning gang and the rest of the set with isopropyl alcohol. Once it dried, I checked it again, but still found it relatively poor at pulling in stations at the upper end of the frequency range.

Test results

Under my test conditions and for the standard 50mW output, the M602T needs around 175µV/m at 600kHz, 300µV/m at 1000kHz and 700µV/m at 1400kHz. Signal-to-noise ratios exceeded 20dB in each case. That's a significant drop-off in sensitivity. Signal injection figures recorded on the diagram also reflect this loss of sensitivity at the high end, and direct injections to the converter base confirm these figures.

This seemed unlikely to be a problem with the converter, a case of the mythical "tired transistor". Just to be sure, I replaced it with a new old stock (NOS) OC44, with no improvement.

You may know that conversion gain varies significantly with LO injection, so that there is a fairly narrow span of injection voltage for best performance. The LO voltage falls by more than 35% from 600kHz to 1400kHz, so perhaps this explains the weak top-end performance.

You may recall Kriesler's Mini 41-47 handheld radio (December 2013; siliconchip.com.au/Article/5633) using a germanium diode across the LO primary to help stabilise oscillator output. Perhaps that's what this set needs.

RF bandwidth is around ±1.6kHz at -3dB; at -60dB, it's ±33kHz. AGC action is excellent: a 40dB increase at the input gave an output rise of just 6dB. This set was excellent on strong signals, needing some 500mV/m before reaching overload.

Audio response is 150~4600Hz from volume control to speaker; from antenna to speaker it's 135~2000Hz. Fully on, the tone control slashes the upper -3dB point to just 450Hz.

This set can give 400mW of output at clipping, although that figure is a bit misleading. At 10mW, Total harmonic distortion (THD) is just 2.5%, but it's 7% at the test figure of 50mW, rising to the usual cutoff value of 10% at only 120mW output.

I suspect that mismatched output transistors are the reason for this, but my junk box failed to disclose any 2N270s. Rather than substitute, I'll leave this set all-original until I can get proper replacements.

At half the nominal battery voltage, the output clips at 120mW, which is still quite loud and enough to usefully squeeze those last few electrons from the battery.

The connections on the back of the set, next to the carry handle, are for an external antenna and ground.

Healing 404B vs M602T

The M602T weighs in at around 2.7kg, with the valve-based 404B a lightweight at just 1.95kg. The M602T is also a fair bit larger all around, giving a volume of $5700cm^3$ versus $1470cm^3$.

The M602T is about as sensitive as the 404B at the low end, but nowhere near as good at 1400kHz, needing some four times as much signal for the same audio quality.

The M602T's audio performance is superior, giving over four times the maximum output of the 404B, with a better frequency response due to a larger output transformer and speaker.

But I do like the 404B's visual design: it looks smart and perky with hints of Art Deco (despite being made roughly 20 years after that movement was popular). It stands out in a way that the more stolid M602T simply does not.

This all makes sense in context. The 404B was aimed at the burgeoning market of the late 1940s, with each manufacturer spruiking the newfound convenience of "camera case", all-miniature portables and hoping their attractive design would stand out from the pack. The M602T, with its external antenna and Earth connections, is clearly aimed at the more everyday "mantel market".

Which is the better radio? At moderate volumes, there's not a lot of difference. The M602T's transistor design, with its type 276 battery, gives over 100 hours of use, while the 404B's single filament supply cell runs out in less than five hours.

Given the 404B's total power consumption at over 900mW compared to the M602T's which is less than one-tenth of that, one of the transistor's principal advantages over the valve is confirmed: greatly reduced power consumption when doing much the same job.

And there's a clue in the M602T's rear cover. It's held in place with screws. That suggests that you're not expected to remove it very often to replace the battery.

Special handling

The four knobs (tuning, on/off, volume and tone) are push-fits. Mine were very hard to remove, so I used some dial cord looped about the shaft and re-looped to give four drawstrings. Be aware that the metal rims on the knobs are thin, and any attempt to lever under them will cause damage.

Output transistors TR5/6 are mounted in rubber grommets, effectively insulating them and providing even less heatsinking effect than wiring them onto tag strips and leaving the cases unobstructed, in free air.

If this set is delivering its full output of 400mW for any substantial time, that may cause significant heating of Q5/6, possibly leading to their destruction.

So if testing for maximum output with a continuous sinewave signal, be sure to keep the test brief.

You can find additional information on this set in the links below:

siliconchip.com.au/link/aau2
siliconchip.com.au/link/aau3
siliconchip.com.au/link/aau4 SC

A size comparison of the Healing M602T and previously described 404B.