VINTAGE RADIO

By Ian Batty

Healing 404B Aussie Compact

This set was picked up at an HRSA auction some time ago. It's an Australian-made, portable, 4-valve superhet from 1948.

Alfred George Healing started making bicycles in Bridge Road, Richmond, Victoria (Melbourne) in 1907. By the 1920s, radio sets represented the pinnacle of advancing technology and Healing Radio took on the challenge. They started manufacturing radios in 1922 and their famous "Golden Voice" brand was introduced in 1925.

At the same time, they imported and distributed Atwater Kent receivers from the UK, ceasing in 1930 as import tariffs increased. They worked out of premises at 167-173 Franklin St, Melbourne for some twenty years.

World War II saw Healing pitch in to build radar and other equipment for the armed forces. They then began manufacturing television sets in 1956. The brand still exists today although not as a TV set manufacturer.

The amazing shrinking radio

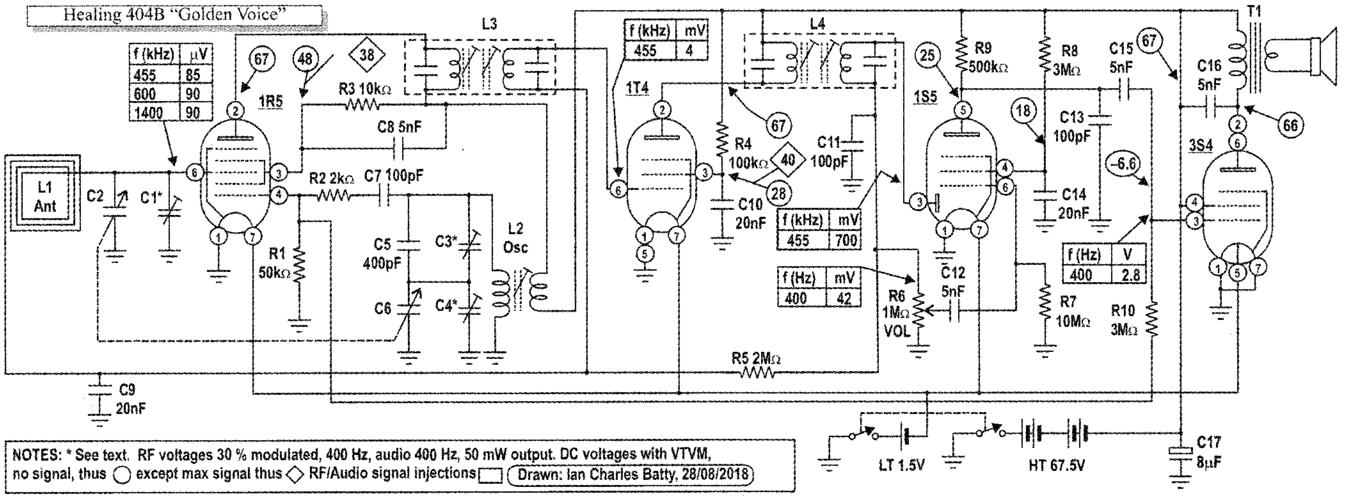
The design of the 404B portable follows RCA's landmark BP-10, one of the first sets using the new B7G all-glass miniature lineup of 1R5, 1T4, 1S5/1U5 and 1S4/3S4/3V4. These B7G valves, at under 25% of the volume of even the most compact octals, challenged designers to apply miniaturisation techniques elsewhere.

The speaker used in these miniaturised, portable sets was typically three to five inches in diameter. While buyers prized portability and convenience over fidelity, they would only accept so much "squawkiness" as a trade-off for size. Output transformers remained similar in size to older designs.

Without using solid dielectrics, tuning gangs could not shrink too much either. The volume of minor components stayed about the same, although IF transformers and coils could be shrunk.

The largest single components, the A and B batteries, became a limitation. The 1.5V LT supply could come from a single 950 ("D" size) cell. B7G valves work just fine with high tension supplies of at least 60V, so the logical choice was 67.5V – one-half of the old 135V HT battery.

This combination would only give some 3~5 hours of life for the LT cell against some 25-40 hours for the HT battery. Purchasers were advised of the discrepancy and warned to try replacing the LT cell before replacing the HT battery.



The original circuit for the Healing 404B, found in AORSM Vol.7 1948, is slightly different to this one. Instead of R10 connecting to pin 4 of V1 as shown above, R10 (2MΩ instead of 3MΩ) was wired in series with a 900Ω resistor which formed a resistive divider with the negative end of the HT supply. The padder (C3-C4) is not used in all 404Bs; when not present, the oscillator trimmer is mounted under the coil. The wire trimmer C1 is also not always included.

Some other manufacturers of these compact sets used a pair of 950 cells, doubling the "A" supply lifetime.

The Healing 404B

RCA's engineers offered one major innovation in the BP-10: a loop antenna hidden in the hinged lid. This freed the antenna from the capacitive and inductive effects of other components in the case. Opening the lid also activated the power switch.

In practice, the set could be stood up in any position for the best sound, then the loop re-positioned for the best signal by adjusting the door's angle.

The Healing 404B uses a similar design. It's a conventionally constructed valve set, using valve sockets and point-to-point wiring mounted onto a pressed-and-punched steel chassis. There's just one tag strip.

Healing's engineers did a good job of keeping the radio compact and portable but they failed on a key factor in all equipment design – maintainability.

The 404B is so compact that IF alignment is difficult. Not only are two out of four brass adjusting screws inaccessible but the adjusting flats on the two that are exposed have been snipped off! Fortunately, IF alignments don't drift much and swapping valves rarely demands a complete re-alignment.

The set uses cotton-jacketed multistrand wire, some of which vanishes in the maze of components. The valve sockets are also well buried, making voltage readings difficult. Although I like this set for its convenience and performance, it's not one I'd want to work on too often.

The construction quality is acceptable without being noteworthy.

Circuit description

The design appears to be an evolution of the RCA BP-10 circuit but the 404B omits the BP-10's back bias circuitry for the output stage, instead picking off a negative voltage from the 1R5 converter grid.

The signal from the loop antenna connects directly to the 1R5's grid. The loop is tuned by one half of the 12-375pF ganged tuning capacitor. There is a wire trimmer (C1, typically a fixed 4pF capacitor) but the alignment notes advise against adjusting this. See the references below for more details on this and on the local oscillator (LO) circuit operation.

The 1R5 converter's local oscillator uses the screen grids (internally-connected grids 2 and 4) and the valve's anode as the oscillator anode.

This is common with the 1R5, as it lacks a dedicated oscillator anode element. The common alternatives are either to use just the G2/G4 connection or to put the oscillator coil's primary in the filament lead and use an RF choke for the connection to the filament supply.

No space wasted

As the tuning gang has two identical 12-375pF sections, a padder is needed. This part of the circuit was modified over various versions of the set, so you may find that yours does not match the circuit shown in this article.

The 1R5 screen connects to the "cold" end of the IF primary via dropping resistor R3 and bypass capacitor C8, with its anode connected to the other end of the IF primary. These two connections then meet the "hot" end of the oscillator coil's primary, using screens and signal anode as the oscillator anode.

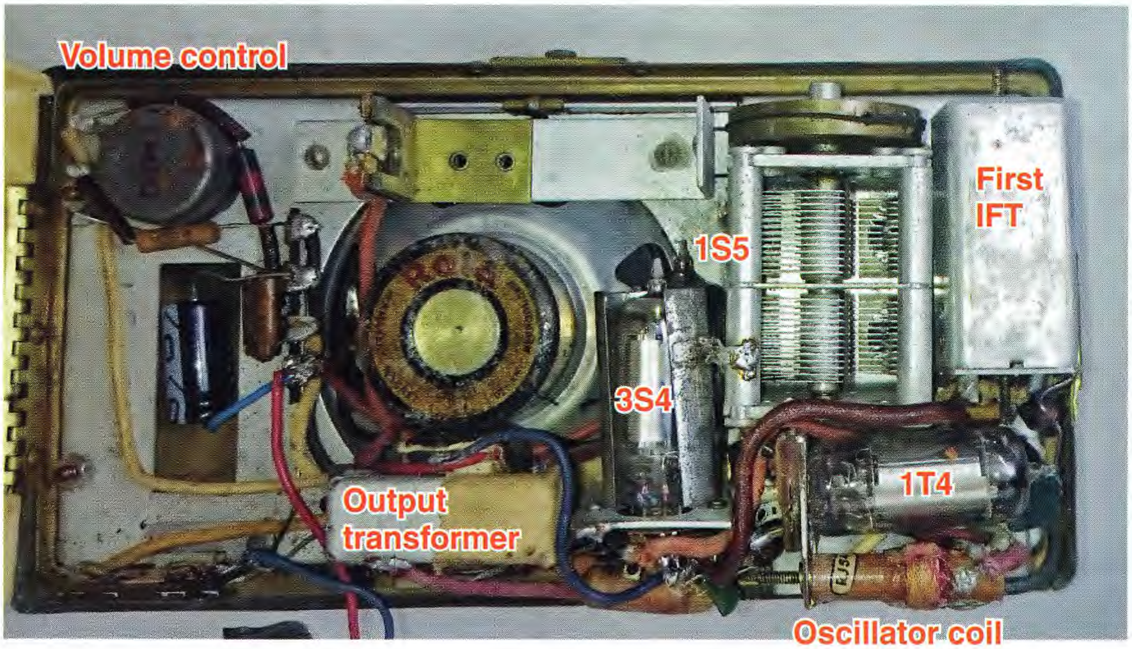
Valve local oscillators work in Class C, where the grid is driven into conduction during the positive peak of the operating cycle, with current cut off at the opposite peak.

Driving the grid positive forces it into rectification, establishing an overall negative bias on the valve. It's usually negative by a few volts; enough to pick off as bias for the 3S4 output valve.

Bias for the output stage does rely on a fairly constant LO grid current to generate a constant grid bias, and low (or no) LO activity will reduce or eliminate output stage bias. I found that the bias voltage varied from around -5V to -6V as the set was tuned from its low end to the high end.

This bias is developed across the LO grid resistor R1 (50kΩ), with grid stopper R2 (2kΩ) in place to give more constant LO activity and (hence) a more constant output valve bias.

The first IF transformer has a tuned, untapped primary and secondary. The secondary feeds the 1T4 IF amplifier. You'll see this type of valve used with full HT on the screen or (as in this set) supplied via a bypassed dropping resistor, in this case, R4 (100kΩ) with a 20nF bypass capacitor (C10).



Converter V1 (1R5) is located directly behind the first IF transformer, while the second IF transformer is behind IF amplifier V2 (1T4). The padder is located behind the oscillator coil, and the hard-to-see 1S5 (V3) pokes out from behind the 3S4 (V4).

Reducing screen voltage on a pentode/tetrode reduces gain, and it's common in highly compact sets (and those with two IF stages) to "starve" the screen to prevent IF oscillation from unnecessarily high gain.

The output signal from the second IF stage goes to the 1S5's demodulator diode. This supplies demodulated audio (via 5nF capacitor C12) to 1MΩ volume control potentiometer R6.

The DC component of this signal is used for AGC and this is fed via a 2MΩ resistor (R5) and 20nF smoothing capacitor (C9) back to the control grid of the IF amplifier (via the first IF secondary) and then to the converter via the loop antenna.

Audio from the volume control goes (via 5nF capacitor C12) to the control grid of the 1S5 pentode section. This gets "contact potential" bias via 10MΩ resistor R7.

The circuit around the 1S5 is optimised for voltage gain; it hits the sweet spot between low anode and screen current (which both reduce voltage gain) and a high-value anode load resistor (which gives a high gain). In practice, you can expect a voltage gain of some 40-55 times. This circuit uses a 500kΩ anode load (R9) and 3MΩ screen dropping resistor (R8).

The 1S5 anode is bypassed to ground for intermediate frequencies by 100pF capacitor C13 and its screen is bypassed to ground for audio by 20nF capacitor C14.

Audio from the 1S5 is fed, via 5nF capacitor C15, to the 3S4 output stage's signal grid. This is DC biased to about -6V via 3MΩ resistor R10 and the aforementioned negative bias from the 1R5 oscillator grid.

The output stage drives a 5kΩ speaker transformer, which is bypassed by 5nF capacitor C16. This acts to damp the output transformer's natural primary resonance. It also reduces the set's high-frequency response. Some manufacturers connect the "cold" end of these capacitors to ground but that's a recipe for disaster.

Should this capacitor become shorted, the full HT voltage appears across the output transformer's primary winding. While this set's HT battery may not be able to deliver enough current to burn out the transformer, it can certainly happen in a mains-powered set. It's better to connect the "cold" end of the capacitor to HT, as done in the 404B.

The Healing 404B uses a small A battery to supply the 1.5V heaters and a larger B battery for the 67.5V HT.

The 3S4 output valve in this set has an external metal shield, which at first glance seems odd. You'd expect to see a shield in the RF/IF section but not at the audio end. But this set's highly compact design made it vulnerable to audio feedback and the shield prevents the output's anode from radiating back to the audio input section.

Although I find it didn't cause any problems if I removed it, I've left it in place in my set for safety reasons.

Cleaning it up

The set was in good cosmetic condition when I bought it, with minor ageing on some of the metal parts.

Electrically, it had seen one repair: audio coupling capacitor C15 had been replaced with a polyester "greencap".

Preliminary testing showed that the audio response dived at about 700Hz. Closer examination showed C16 to be a 10nF capacitor connected from the 3S4 anode to ground.

Puzzlingly, this appeared to be an original component. Aside from the non-recommended connection method, the value was twice that shown in the diagram and this had a major effect on the high-frequency cutoff point.

The IF bandwidth test (detailed below) indicated a potential response considerably better than a measly 700Hz. Replacing C16 with the recommended 4.7nF value improved the top end to 1.2kHz, as expected. I replaced leaky HT bypass capacitor C17 (8µF) at the same time.

How good is it?

My trusty ferrite rod radiating antenna required careful orientation with its axis perpendicular to the plane of the loop for good results.

Air sensitivity results appear "about right" for this kind of set. I'm offering these readings for comparative and fault-finding use; my readings may not represent the set's true air sensitivity.

Under my test conditions and for a standard 50mW output, the 404B needs around 160µV/m at 600kHz and 110µV/m at 1400kHz. The signal-to-noise ratios exceeded 20dB in both cases.

RF Bandwidth is around ±1.2kHz at -3dB; at -60dB, it's ±23kHz. AGC action is only fair; a 20dB input signal increase gave an output rise of 6dB. Audio response is 90Hz-2.4kHz from volume control to speaker; from antenna to speaker it's 90Hz-1.2kHz.

The set's audio output is about 85mW at clipping, with 10% THD (total harmonic distortion). At 50mW, THD is around 6%; at 10mW, it's about 3.5%.

The set's loop antenna is directional, with the hinged lid making it easy to orientate for maximum pickup. Testing on-air, it was able to pull in my reference 3WV over in Western Victoria with ease.

Low-battery performance

It's often said that the weakest valve in the set is the converter; it'll stop at the top (or bottom!) end of the band, won't start with low supply voltages, only works in months containing the letter "r" and so on. This was certainly true with the first 2V battery-powered pentagrid valve, the 1A6.

So, I tested this set with a good 1R5. I found that the converter worked with a filament supply voltage as low as 1.0V. Reception was weak but reliable, so I dropped the HT voltage. I could still get some reception with only 45V HT and 1.0V for the filament supply.

So while it's true that the converter is the most critical stage in a superhet, don't automatically start "valve-jockeying" converters in the hopes of fixing a set until you've done some proper testing.

Conclusion

This is a nice set, but I have an RCA BP-10 sitting on the shelf waiting for an outing. It'll be interesting to see how well the 'original' performs against one of its 'descendants'.

There's a lot more information on the 404B on Kevin Chant's website, at www.kevinchant.com/healing2.html

Also see Ernst Erb's Radio Museum: www.radiomuseum.org/r/healing_404b.html

For more information on Healing's radio models, see: www.hws.org.au/RadioHistory/manufacturers/Healing.htm SC

The Healing 404B was sold for £20 (including batteries), with cream being the only available colour.