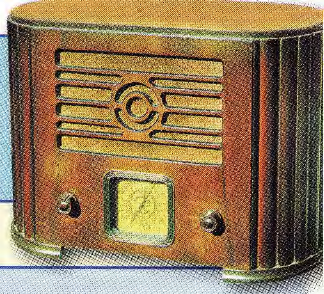
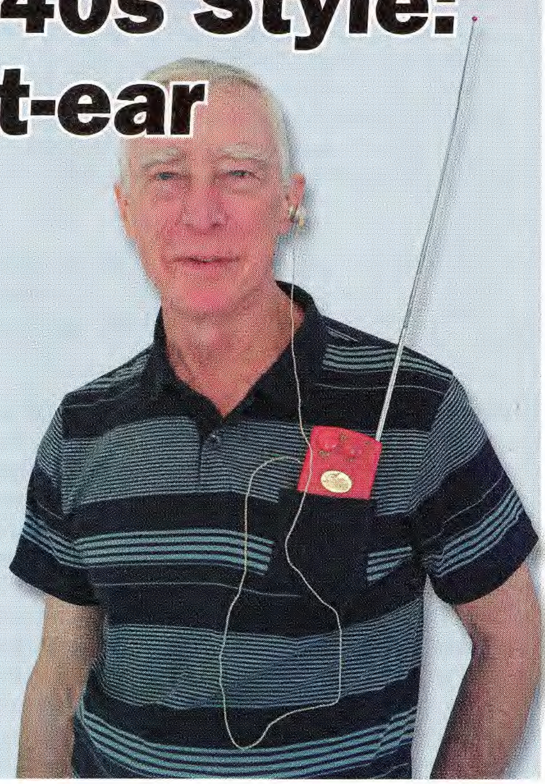
Vintage Radio



By Ian Batty

Pocket Radio, 1940s Style: The 2-valve Privat-ear



This little portable radio looks like it might be an early transistor radio but it was produced in 1949, well before "trannys" became ubiquitous. In fact, it used subminiature valves and permeability tuning, which eventually became the standard in pushbutton car radios almost 20 years later. It was the ultimate in 1940s portability.

Valve technology experienced a technological revolution with the release of all-glass B7G miniature valves just prior to 1940. The initial release of a "superhet kit" of pentagrid, RF/IF pentode, diode-audio pentode and output pentode featured famously in Galvin's BC611/SCR536 "handie talkie" squad radio.

Civilian uptake was rapid, with 4-valve and 5-valve B7G portables dominating the postwar market and lasting almost up to the release of Regency's all-transistor TR-1 in 1954. Almost? Yes. There was a brief-and-brave interregnum fuelled by the development of subminiature battery valves.

To set the scene, consider an anti-aircraft shell. It has to go off near the enemy aircraft to have any effect, but how? You might try to set the fuse for a certain time, but you'd have to know how long the shell would take to approach the target. You might try an altitude setting but it's a bit hard to predict what the atmosphere might be doing at, say, 6000 metres altitude.

If only you could get the shell to go off near your target. A proximity fuse would do nicely. Put a small, expendable transmitter/receiver in the nose of the anti-aircraft shell, design it to go off when it detects a large metal object, and you would have an ideal solution.

Except that the radio has to survive an acceleration up to 20,000g (!) as the shell is fired. And so the subminiature valve was born. Building on the metallurgy and glass-making technology of the B7G, subminiature design eventually offered pentagrids, RF pentodes, diode-pentodes and output pentodes.

As well as a triode-hexode, a VHF triode that rivalled the "firecracker" 3B4 used in US-designed VHF backpacks, twin-triode equivalents of the 12AU7/12AX7,and even a subminiature version of the well-regarded 6AC7 video pentode.

Few all-subminiature valve sets were ever offered, as transistor technology took over in the late 1950s. And you'll find even fewer hybrid sets, using valve "front end" converter/IF/demodulator/audio designs and push-pull audio transistors in the output stage.

Frank Stuck's Privat-ear

Having developed subminiature valves during WWII, Raytheon acquired Belmont Radio to design and market subminiature valve equipped radios. The Belmont Boulevard, a complete, 5-valve superhet using the earphone cord as the antenna, was released in 1945.

Despite its outstanding design and miniaturisation, sales only reached some 5000 and the set was discontinued.

Frank L. Stuck, having previously registered US Patent 2521423 for a 3-valve radio, released the 2-valve Privat-ear through Electronics Systems Corporation in 1949. Obviously an economy design, it sold for as little as one-third the price of Belmont's Boulevard.

Being a 2-valve, non-superhet pocket radio and lacking a ferrite rod, you'd have to wonder whether the Privat-Ear could have worked at all. But ever the optimist, I got this little set off the shelf, fitted some batteries and gave it a try.

Few comparable sets exist. There's Belmont's Boulevard (mentioned above), the Pocket-Mite (a 3-valve kit released in 1948), and the 2-valve Tiny-Tooner. Other subminiature sets were released but these were scaled-down versions of conventional battery superhet portables.

You might mistake it for a hearing aid of the day but for its two controls and the striking red colour of the set I successfully tested. Other colours included maroon and white; distinctly different from the black cases commonly used for hearing aids.

First oddity: no power switch? Instead, you just pull out the telescopic antenna to turn it on; collapse it fully to turn off. It's not a superhet but a classic reflex design, albeit with a few wrinkles.

Consider that Regency's TR-1 (still a few years down the track) had to use a bulky air-spaced tuning gang but Frank Stuck decided to continue the use of permeability tuning as first described in his US2521423 patent.

Permeability tuning varies the inductance rather than the capacitance of the adjustable tuned circuits. It does this by moving the slug cores inside the inductors. Years later, most car radios would have permeability tuning to provide five preset stations with a preselect pushbutton mechanism.

What's unusual in this Privat-ear design is the two-"gang" design, with tuning slugs in both the grid and anode circuits. The mechanical arrangement is a bit agricultural but properly adjusted, it's effective and totally fit for purpose. It's also smaller than the 2-gang tuning capacitors of the day.

There are two versions of this tiny set, with both versions using just two subminiature pentodes in a reflex (regenerative) circuit. Fig.1 shows the first version, using 2E31s.

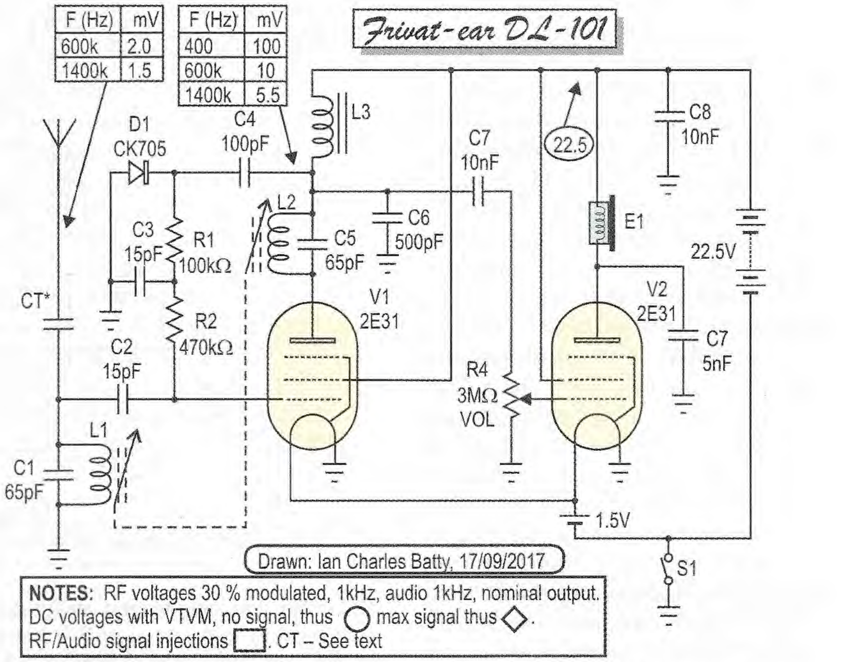


Fig.1: this unusual reflex radio used just two pentode valves which were subminiature types. Apart from being compact they also enabled the use of a very low HT voltage of only 22.5V. Another unusual feature of the Privat-ear was the use of permeability tuning which varied inductance rather than capacitance.

In essence, the first pentode is an RF amplifier which feeds a diode demodulator and that demodulated audio is fed back into the grid of the first valve into what is then a two-stage audio section. So in other words, it is a reflex design, as mentioned above.

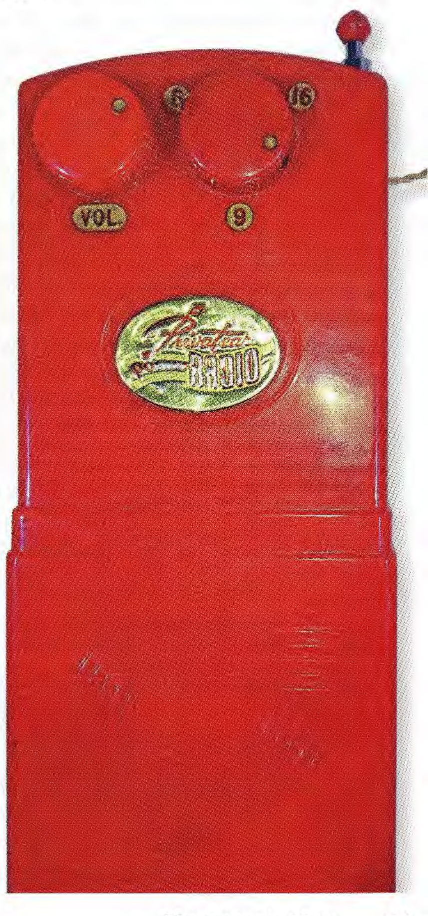
In more detail, both valves are described as pentodes but with the data sheet stating that "grid 3 is composed of two deflector plates, one connected to lead 3 and the other to lead 5".

The envelope is the T2X3 (2/8" x 3/8") favoured by Raytheon, with a flattened glass (ie, oval) cross-section and the connecting leads exit via the flattened section on the bottom. This was made by heating the glass to melting point and compressing the envelope to flatten and seal the leads; it's known as the "press".

I guess the assembly is so tiny that it made sense to omit a wound spiral construction for the suppressor grid and use the proven beam tetrode alternative.

This sees the screen winding accurately aligned to the control grid. This creates intense, flat beams of electrons whose density overcomes the lower-density nature of secondary electrons attempting to return from anode to screen. The "deflector plates" are added to condition electron flow on either side of the grid structure, where

Below: the Privat-ear uses two knobs, one for volume and the other for tuning. Tuning was not precise so the frequency indications are fairly vague.



"beaming" is less effective.

And the valve numbering? It's the Radio Manufacturers Association (RMA), a pre Radio, Electronics Television Manufacturers Association (RETMA) type. RMA number-letter-number codes were actively used for some two years from 1942 until they were superseded by the "5500" series which simply allocated sequential numbers. Reason took over with the RETMA coding beginning in 1953.

Under RMA's 1942 number-letter system, the first number is the heater/filament power: "1" for cold-cathode, "2" for power up to 10W and so on. The first letter designates the number of electrodes or type: B for a diode, C for a triode, D for a tetrode, E for a pentode and so on. The remaining numbers are allocated in registration order.

Thus a 1B23 is a cold-cathode radar Transmit/Receive tube (a diode) with a 20kW rating, the 2E31 is a subminiature pentode with a maximum anode dissipation of 45mW, and the 2J30 is a 300kW magnetron.

RETMA coded for heater/filament voltage and (more or less) number of electrodes but lost the indication of valve type. Thus the 1J6 was a 2V twin triode, while the 1H6 was a duo-diode triode, also with a 2V filament and the 1S5 was a 1.5V diode-pentode.

The set being reviewed here used the 6007 pentodes, as shown in Fig.2. As well as using a cylindrical T3 envelope rather than the 2E31 "flat" types, the 6007 gives about the same performance for only about 25% of the filament current; 13.5mA versus 50mA in the 2E31.

It's also a conventional pentode with a wound suppressor grid. One of my sets used a handmade spiral of wire to shield V1 to prevent regeneration and oscillation; unnecessary with the spray-shielded 2E31.

The Privat-ear is assembled into a plastic chassis, a bit like the previously-reviewed Deutscher Kleinempfänger DKE38 set featured in the July 2017 issue (siliconchip.com.au/Article/10728).

I found the Privat-ear difficult to work on. The valve leads were protected by plastic sleeving to prevent shorts and many component connections onto the plastic chassis were buried under the actual components.

In detail, the telescopic antenna rod connects directly to the RF amplifier's grid tuned circuit comprising capaci-

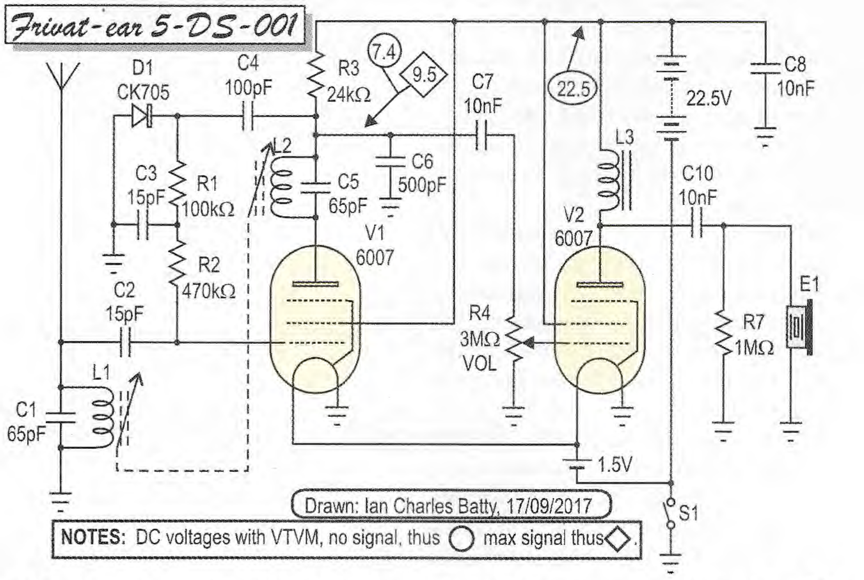
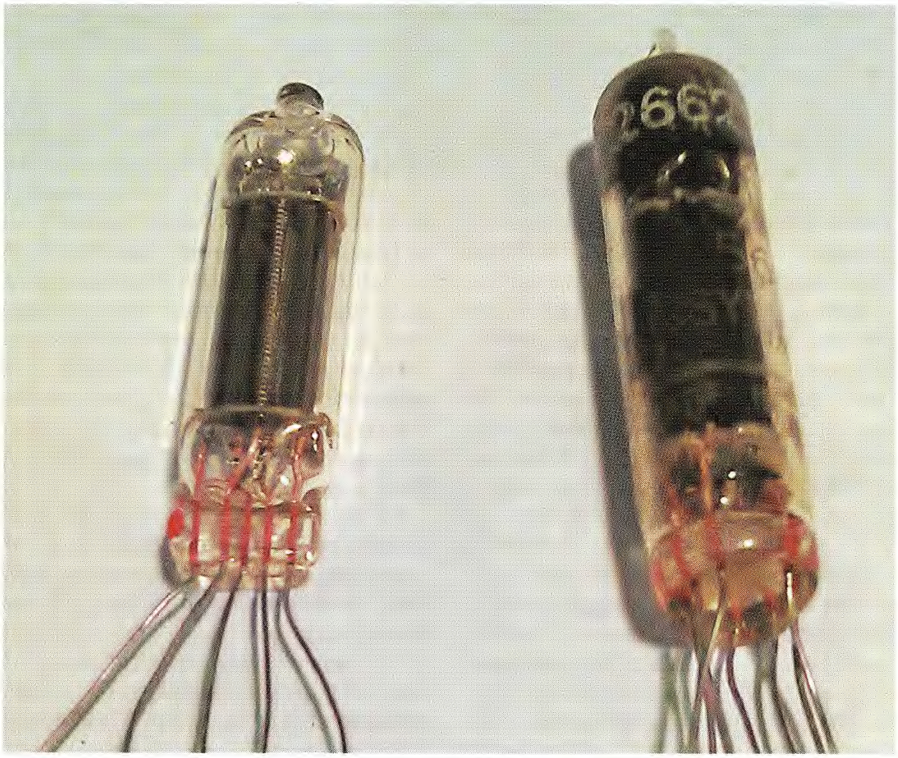


Fig.2: the second version of the Privat-ear circuit diagram used 6007 valves. The other major difference in this version is that the earphone is piezoelectric and is coupled to the pentode plate via a capacitor.

tor C1 and variable inductor L1. The direct connection doesn't attempt to compensate for the electrically "short" antenna or its considerable capacity. Since the antenna connects directly to C1/L1, I would have expected the wearer's body capacitance to have some effect on grid tuning. We'll find out later on.

C1 is only 65pF and about one-fifth the value you'd find in a capacitance-tuned circuit at the 535kHz end of the broadcast band. This also implies a high inductance value for L1, and if L1



This photo shows the construction of the two subminiature valves employed in the two versions of the Privat-ear. At left is a T2X3 6088 hearing-aid output pentode, with its connecting leads exiting the envelope via the flattened section on the bottom. At right is a subminiature version of the landmark 6AC7, with a cylindrical T3 envelope.

is a low-resistance coil, this implies a very high Q (selectivity factor) for both tuned circuits. Since it lacks a high-selectivity IF stage, the Privat-ear will need all the Q it can get from its two tuned circuits so that it can separate stations adequately.

The signal from the tuned antenna circuit connects to RF amplifier V1 via a 15pF coupling capacitor, C2. Having just finished a series on transistor sets, I'm reminded of the very much higher input impedances of valves and the much lower values of coupling capacitors they can utilise.

RF amplifier V1 gets its grid bias, via resistors R1 & R2, from demodulator diode D1. I'd expected to see the diode's anode as the active connection, as this would give a negative-going output signal and would supply conventional AGC (more negative bias with stronger signals). But in this set, it's just the opposite.

According to the diagram, D1 (since it will conduct on negative-going peaks) will produce a positive-going signal, with V1's grid going less negative/more positive on stronger signals; more on this the point later.

V1 develops an amplified version of its grid signal across the anode tuned circuit comprising capacitor C5 and variable inductor L2 (ganged with C1/L1). This amplified signal is fed to demodulator diode D1 via 100pF capacitor C4. The diode rectifies the applied signal to produce a positive DC voltage proportional to signal strength, and would appear to also produce a positive-going DC voltage.

D1, being a point-contact germanium diode, will need some 100-150 millivolts before it conducts, which means it would need a lot of signal. But D1's cathode connects via R1-R2 to V1's grid and V1 will produce a weakly negative grid voltage due to its "Edison effect".

In practice, D1 gets some forward bias, helping it to conduct with signals well below its normal forward voltage. So this circuit is very similar in principle to transistor radio demodulators, where the diode is also given weak forward bias.

Privat-ear interior details

The internal view confirms the set's simplicity. The two tuning coils appear at top left (anode circuit) and lower right (antenna), with the telescopic antenna just beneath the lower coil. The RF/1st audio valve appears just above the antenna coil and the audio output valve is above the RF/1st audio and slightly behind it.

The dark maroon disc on the left is the top of the tuning capstan, and the black tuning cord runs from the capstan to each tuning slug on their left-hand ends. Another cord joining their right-hand ends and passes over a tensioning spring about half-way up the battery cover on the right.

The CK705 demodulator diode (looking like a ceramic fuse) sits just above the tuning capstan, with the audio choke used as the anode load for the second pentode, V2, being at the top right of the component section.

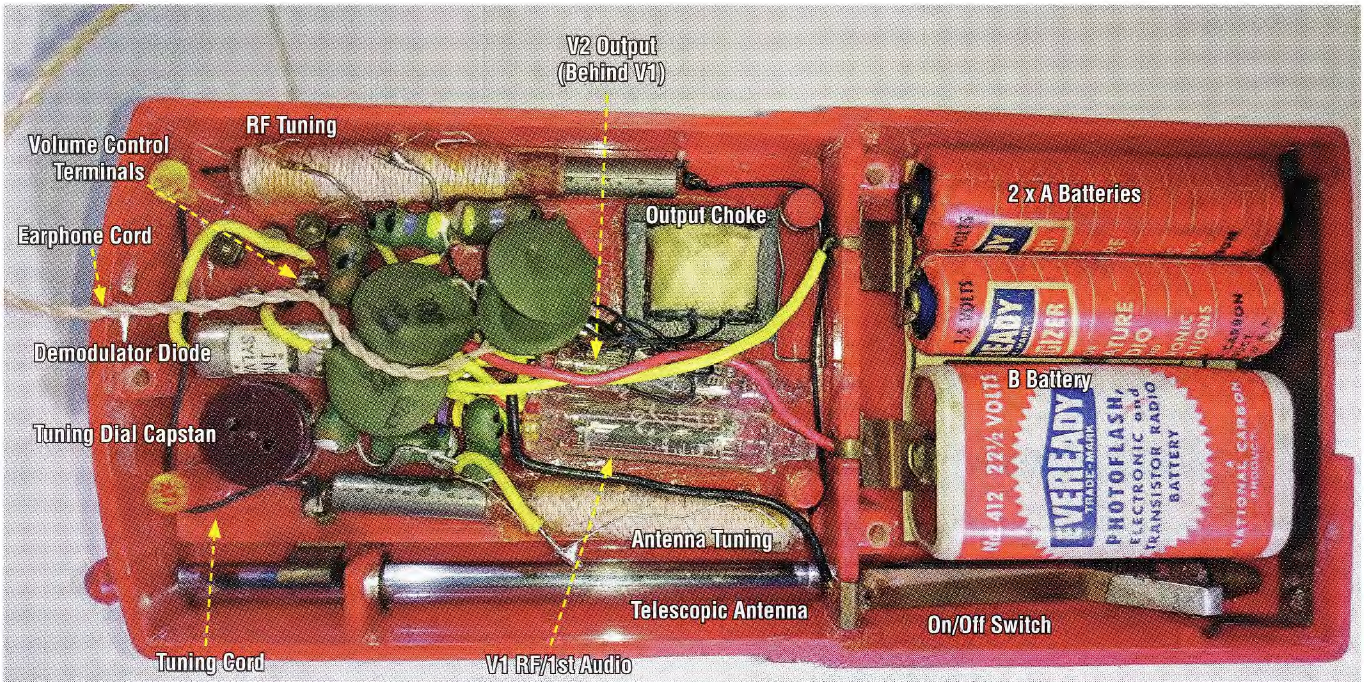
This choke is in the same place for both models. Other components are scattered about in the compartment, comprising flat disc and tubular ceramic capacitors and common quarter-watt resistors.

The volume control sits above the tuning dial capstan, with its two securing nuts just visible. The battery compartment carries two AA cells connected in parallel for the filament supply and a type 412 22.5V HT battery. The copper strip of the on/off switch lies beneath the 22.5V HT battery.

Cleanup

Both of my sets showed cracking in the battery compartments but surprisingly there was no battery corrosion. A spot of superglue on each repaired the cracks, and a clean and polish brought them both up nicely.

The maroon set was dead, and testing showed the audio choke on the output valve to be open circuit. It's the type commonly used in hearing aids, but I'm reluctant to wreck any in



The Privat-ear utilised a quite large telescopic antenna (as seen fully extended in the lead photo), especially compared to other subminiature valve radio sets that were being produced in that period. To switch the set on, the antenna needed to be extended to operate the on/off switch lever located next to the 22.5V B battery.

my collection, so I'll just leave that set and look out for a replacement choke.

How good is it?

Its performance was better than I expected. While its selectivity can't match that of a superheterodyne radio, it pulls in eight local Melbourne stations just fine down here on the peninsula.

Injecting a signal for testing presented some difficulty. Lacking a ferrite rod antenna, I couldn't rely on my usual method of inductive coupling from the radiating ferrite antenna that I've used successfully for many previous sets.

So I used the method previously tried on Sony's TR-63 when I was unable to inject a signal directly onto its converter base. Here, I used a 4.7pF capacitor (labelled CT on Fig.1) and jiggled the antenna circuit's slug for maximum gain.

While I can't guarantee my signal voltage to translate directly to a V/m figure, the method does allow anyone else to reproduce my results and judge whether their set is working correctly.

Measuring the audio output level presented another problem. I couldn't find any standard that I could apply, so I set up my signal generator with program audio modulation and just went for "a good listening level".

Sensitivity? Using my series 4.7pF capacitor into the antenna, it was around 1.5mV at 600kHz and 1400kHz. More objectively, –3dB selectivity is ±4kHz and ±20kHz at 600kHz and 1400kHz, respectively. These figures imply combined-circuit Q factors of 75 and 35 respectively.

Importantly, bandwidths are around ±70 and ±170kHz at –20 dB. The broad selectivity was borne out in use, with strong stations flooding the space between them and obvious instances of the 9kHz "whistle" caused by adjacent stations. I'd wondered whether hand/body capacitance would affect the antenna circuit tuning, and found that it does, to some extent.

As expected, the demodulator's DC output was positive-going, overcoming V1's Edison effect bias of around -130mV and sending the grid positive. The test set, with low DC resistance from anode to supply, showed no significant voltage change with signal strength.

The other set (using resistance-capacitance coupling) did show a change in anode voltage from 7.5V to 9.5V on strong signal, despite its grid voltage going slightly positive. That's opposite to what I'd expected and if a reader can offer an explanation I'd be happy to know of it. On test, I could not identify any AGC effect.

Its audio performance was adequate for the purpose. With such close coupling into the ear canal, "some tens" of microwatts translates into a good listening level.

So would I buy another one? I've already done so. You may like to add one of these unusual sets to your collection. It's more on the "enthusiastic amateur" side than the "engineer employed by mega-corporation" side of electronics, but I think that's a large part of its charm.

Two Privat-ear versions

Besides the different valve types used in the original DL-101 (2E31) and the later 5-DS-001 (6007s), there are some other subtle circuit differences.

Anode current for the first audio stage (V1) in the DL-101 flows from the battery through choke L3. This gives maximum gain with a much lower voltage drop than a load resistor.

The output stage (V2) drives the magnetic earphone (E1) directly, ie, it's between the anode of V2 and the B battery. This earphone has a DC resistance of only a few kilohms, so there's little voltage across it.

By contrast, the 5-DS-001 uses a crystal (piezo-electric) earphone, which has a high DC resistance so this can not be connected in the same manner.

So the first audio stage load is resistor R3, giving a lower V2 anode voltage in this set. Choke L3 is the DC load for V2 with C10 providing DC blocking, to prevent V2's anode voltage appearing across earphone E1. R7 shunts any leakage via C10 to ground.

Note that the move to 6007s improved battery life considerably due to their lower filament current. Allowing for carbon-zinc AA cells of the day with capacity of some 500mAh, the two paralleled cells used would run a pair of 6007s for around 40 hours.

While it's not the hundred-plus hours of later transistor sets, this is about double the battery life of the first transistor radio, Regency's TR-1. HT battery drain is similar across all models and, I'm guessing, well over 80 hours of B battery life.

Both my sets suffered a broken corner just below the B battery. It seems that the plastic case had become brittle with age, so gentle handling is recommended. As well, one had suffered a stress break in the opposite corner caused by excessive spring tension in the A battery positive connection leaf – I'd recommend easing the tension off.

The Privat-ear's "throw stuff down and solder it in" construction makes it a challenge to work on. If you do intend to fix a Privat-ear, apply lots of care and patience with your existing skills.

Further reading

For a very fine and detailed description, with history and photos, see: www.jamesbutters.com/privatear.htm

For an exceptional catalog of American valves of all kinds, refer to: *Tube Lore by Ludwell Sibley, ISBN 0-9654583-0-5, 1996, Chernay Printing, Flemington, NJ.* **SC**