# VINTAGE RADIO

# The Mysterious Mickey OZ by Astor

## By Ian Batty

**This is an iconic, well-performing radio from the early 1930s; it was built into a Queensland Maple case, and is a 'must have' for any serious collector of Australian electronic technology. However, it's a nightmare to work on.**

**This radio was previously** described by Rodney Champness in the March 2004 issue (siliconchip.com.au/Article/3438), but as it's an important early Australian set, I decided to revisit it in a more in-depth manner. That earlier article went into very little detail on how the circuit operates, and the radio was not actually restored nor tested. Some aspects of the circuit are unusual and interesting, as I shall describe later.

The Astor Mickey began as a transformerless AC/DC set adapted from an American 110V design. All valve heaters were in series, with the US design modified for the Australian release as serial numbers 1 to 460. The 110V set's heater dropping resistor was increased to 580Ω to permit operation on our nominal 230V mains and maintain the heater string voltage of around 69V. This resistor dissipated some 51W of the total 80-odd watts.

This heating was managed by ventilation slots in the sides and bottom of the compact timber cabinet, and by inserting a sheet of asbestos inside the upper right (viewed from behind).

The asbestos heat shield continued well in to the 7000 series. From around 1935, some early models that had been returned to the factory were re-released with a repaired chassis and new cases. The sets are distinguished by the curved 'ogee' depression in the case's front edge, but low serial numbers. Also, some sets had an asbestos sheet fitted between the output valve and the mains transformer.

Asbestos is a known carcinogen. The complete serial numbers of these sets are not known. At some point, the asbestos sheet was replaced by a thin sheet of timber. Readers are advised to examine their sets to determine whether the asbestos is in place. For advice on how to handle asbestos, see siliconchip.com.au/link/ab9k

### Notable aspects

Donald Haines lodged his US2148266 pentagrid patent in 1933 (the design used in the 2A7/6A7/6A8 and descendants), and Astor released the AC/DC Mickey in that same year. So it's a standout example of a very early superhet.

Other notable aspects of this set are the use of back bias for the 6B7 and the use of regeneration in the converter, a most unusual circuit strategy used

### Article sources

This article draws on Philip Leahy's Circuits 1934-1940 Book 11, Astor/Breville Circuits and its Supplement, published by the Historical Radio Society of Australia (HRSA). Philip, assisted by Jim Easson, has collected comprehensive circuits and technical notes for very many radios made and sold in Australia, and the Astor/Breville book has proven invaluable in writing this article.

Refer to Philip's book for complete descriptions, circuit diagrams, circuit voltages and sensitivity/performance figures.

Consider also getting Philip's entire series – it contains many Australian radios not listed in the famous Australian Official Radio Service Manuals that were either not included, released before the AORSMs began publication in 1938, or manufactured after the AORSMs ceased publication in 1956.

See the HRSA website (www.hrsa1.com) for Leahy's ten-volume series' contents, but note that book ten is still in preparation at the time of writing this.

**It's important to note that most models of the Astor Mickey OZ used asbestos in the timber cabinet, so the utmost care should be taken when handling this – [siliconchip.com.au/link/ab9k](siliconchip.com.au/link/ab9k)**
**The cabinet itself is small for its time at 305mm wide, 180mm high and 140mm deep.**

only by a very few designers, and one that had disappeared by the late 1930s.

Returning to the power supply, serials 461 onward used a mains transformer with full-wave rectification. The change to AC-only operation resulted in the OZ circuit of 1933 (Leahy, p11; see adjcaent panel). This design underwent frequent change; consult Leahy for the most complete collection of circuits. He lists six variants.

The basic circuit was also used for other Mickey sets (the Bakelite EC and the stunning Mickey Grand among them) and for other, later sets from Astor.

The set I'm describing, serial number 7490 (OZ7490), appears in the Leahy Supplement on p11. The principal difference from the more common issues is the use of back-bias for the demodulator/AGC/audio valve, a duo-diode pentode 6B7.

There were many changes to the OZ circuit, the cabinet and even the dial cloth and cabinet ventilation/geometry over the production run. Philip Leahy and Jim Easson have compiled the most complete list of these changes (see the adjacent panel).

## Reality check

The reason I described this set as a nightmare to work on is that it looks as though one team bolted the power transformer, IF cans and gang on to the top of the chassis, the next team turned it upside down and threw in a handful of parts before the final team just soldered everything to everything else.

Using the military criteria of Reliability, Maintainability and Availability, I give it scores of 8, 0, 10, getting zero for maintainability only because you can't give a negative score.

All wiring is point-to-point without tagstrips; my set had several instances of connected components just having their pigtails twisted together in mid-air and soldered.

You can pick repairs and modifications pretty easily. Resistors are mostly the old 'cartridge-cap' body-end-band coded or cylindrical 'dogbone' body-end-dot coded types. All original non-electrolytic capacitors were from Aerovox or TCC.

The picture overleaf of an original Mickey, supplied by Andrew Wakeman, shows four 'dogbone' resistors (three green and one red), and one cartridge-cap resistor (purple body).

There is also a large paper capacitor (C27, sitting vertically) with a band of black friction tape insulating some of the back-bias circuit's solder connections. The undisturbed friction tape is factory-original.


**The overall layout of the chassis was very compact, with metal sheeting needed to help with airflow. This set was serial number 7490.**

**The top view of the chassis gives a better look at the 'messy' arrangement near the tuning gang which is for the antenna circuitry.**

## Circuit description

The circuit is shown in Fig.1. There is a filter circuit (L1/C1) between the antenna connection and the antenna coil primary (L2).

Some references describe this as necessary to suppress interference/IF breakthough from marine/spark transmitters in the lower end of the HF band, and to suppress image responses in the 986~2111kHz range.

By 1932, 500kHz had been declared as the International Distress Frequency, but would have presented little interference due to infrequent traffic. 'Everyday' maritime communications were relocated to frequencies of 425, 454, 468, 480 and 512kHz, so the potential for IF breakthrough (especially from the 454kHz allocation) would have been a reality.

The filter certainly does have significant attenuation towards the bottom end as the sensitivity graph (Fig.4) and the IF injection voltages on the circuit diagram show. It would also (as the manufacturer's description states) improve image suppression as the set is tuned past about 1000kHz. Unfortunately, it does this by cutting receiver sensitivity, by a factor exceeding two times at the top end.

A simple notch filter (rather than the bandpass filter used) would have given immunity to IF breakthrough without compromising the performance.

## Converter

The 6A7 converter uses grid 1 for the oscillator grid and grid 2 as the oscillator anode in the conventional pentagrid circuit. It uses 'padder' feedback, where the primary winding couples via 1nF capacitor C14 to the secondary, in addition to the mutual inductance between primary and secondary. That RF connection goes to ground via padder C12, a fixed 300pF shunted by a variable 30~60pF.

Padder feedback is used to improve oscillator activity (and thus conversion gain) in converters with known weak oscillator performance. Although the 6A7 is specified for anode voltages as low as 100V and should work reliably with the conventional circuit, OZ7490 showed considerable variation in oscillator output over the tuning band.

The use of padder feedback suggests that the conventional transformer-coupled "Armstrong oscillator" design was found inadequate with the set's low HT.

The tuning dial, with reduction drive, is uncalibrated. It is marked (confusingly) as "100" at the low end of the band to "0" at the high end – see Fig.2.

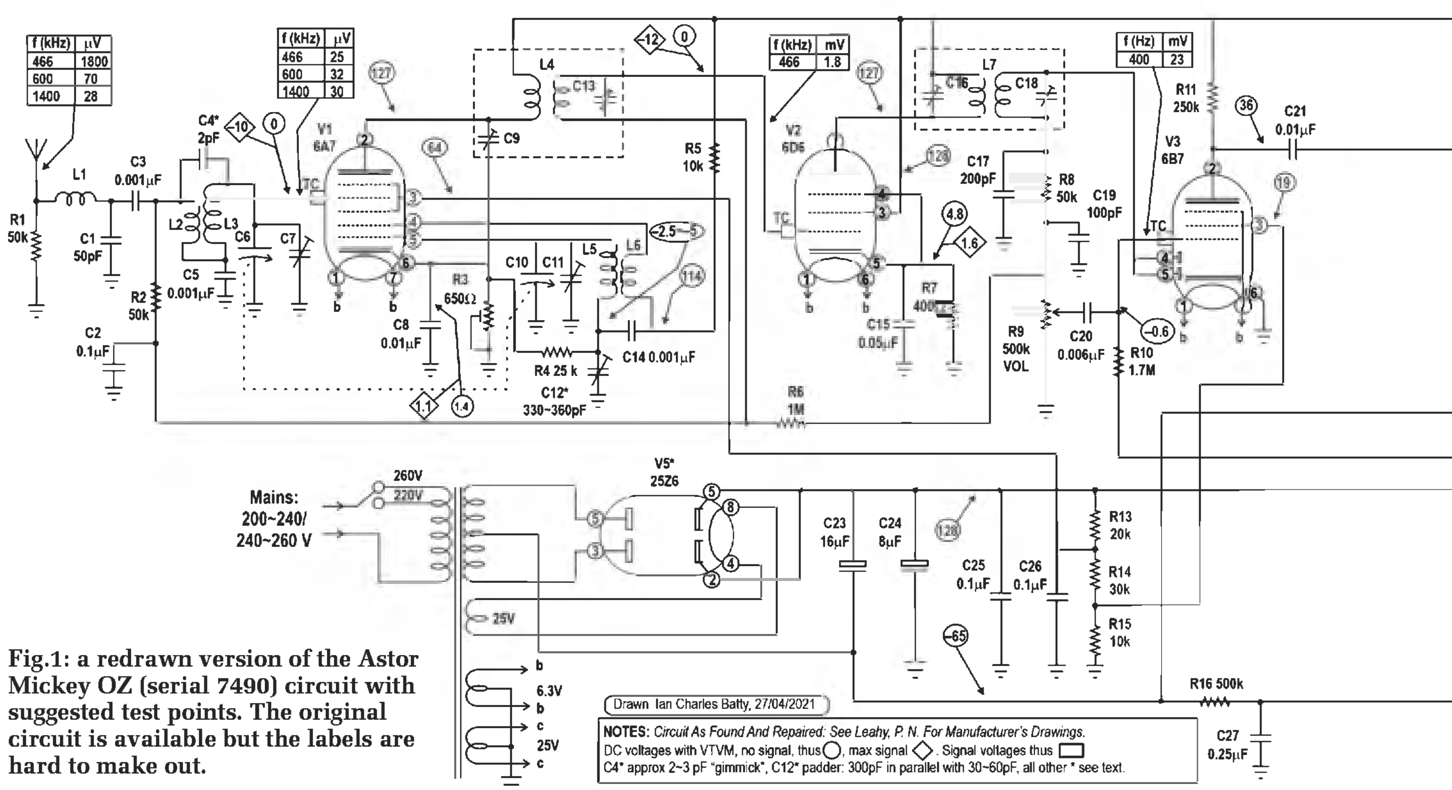



**Fig.1: a redrawn version of the Astor Mickey OZ (serial 7490) circuit with suggested test points. The original circuit is available but the labels are hard to make out.**

An original Mickey showing four 'dogbone' resistors and one large paper capacitor.

The vacant space in my set and the chassis hole to the right would have been occupied by the internal/external speaker switch on earlier releases. No original electrolytic capacitors remain in my set.

## IF circuitry

The IF transformers have tuned primaries and secondaries. Despite their somewhat 'agricultural' construction, OZ7490 returned a -3dB bandwidth of ±2kHz, and a -60dB bandwidth of ±35kHz, an acceptable selectivity even today.

The first IF's primary tuning capacitor (C9) is a bit of a head-scratcher, as its 'cold' end is returned not to the HT side of the primary (as is near-universal), but to the converter cathode.

This gives a feedback path from the converter's anode to its cathode via the first IF primary tuning capacitor, C9. As there is no signal inversion between cathode and anode (the 'grounded grid' principle), C9 forms a capacitive voltage divider with cathode bypass capacitor (C8) to give positive feedback and a moderate boost in gain. This explains the 'low' value used for C8.

OZ7490 used 10nF, while Leahy (Supplement, p11) shows 6nF. You would expect it to be the same as the IF amplifier's C16 bypass value, 50nF. This is a reminder of just how clever some early designs were. In practice, the feedback circuit in OZ7490 gives a gain of some +4dB, about 1.5 times; the lower value of 6nF would give more boost.

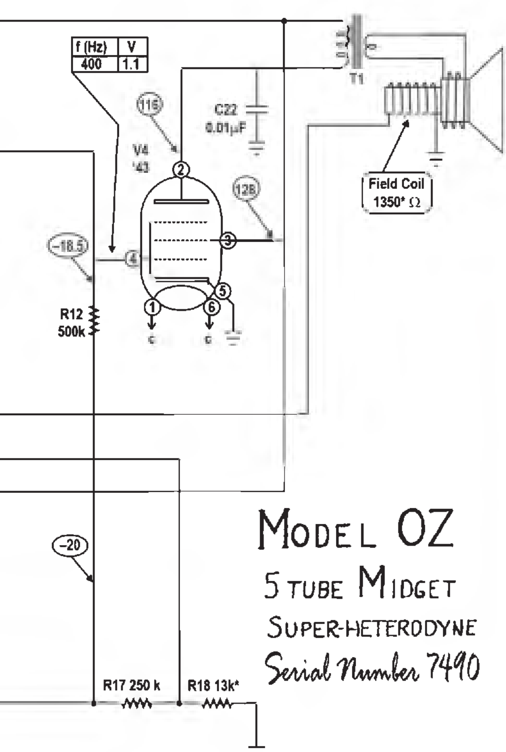
For a full description of this part of the circuit, including a warning about oscillation, see Leahy, p108. That reference describes the design's use in the similar model AC.

## Loudspeaker driving

The OZ model uses an electrodynamic speaker on a plug-in frame that mates to a chassis-mounted four-pin socket, held in by two side catches. This allows the entire speaker assembly to be removed easily.

The initial release used a 1.9kΩ field coil, which was reduced to 1.35kΩ, then 1.2kΩ. The Type 43 output valve is specified for a 4kΩ load, implying that that the speaker transformer has a 4kΩ primary.

As the field coil is used as the filter choke in a back-bias circuit in most versions, back-bias voltages change with field coil resistance. The power transformer's HT secondary voltage must be suited to the field coil resistance, thus restorers need to know



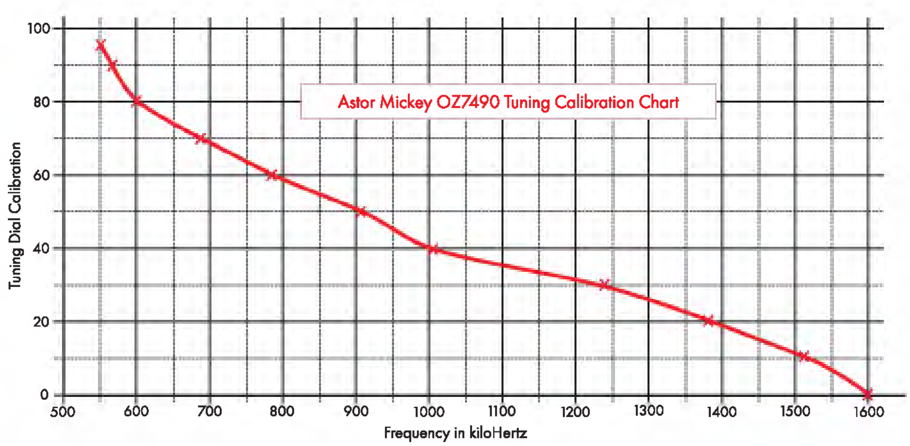




**Fig.2: this is how the dial markings correspond to the actual tuned frequencies. Not only is the tuning dial unusual because it is marked 0-100 without any frequencies, but also because setting it to 0 tunes it to the highest frequency, and 100 the lowest.**

which field coil they have if they intend to replace the power transformer. Be aware that there were at least three different mains transformers over the life of the model. OZ7490's speaker was marked as 1.35kΩ but it measured as 1.195kΩ.

If the speaker is replaced with one having a different field coil resistance, that will alter the back-bias supply, so unless you also change the power transformer secondary voltage, the resistive divider may need modification to preserve the output valve's bias supply of around -19.5V (measured as -18.5V at the grid using a 10MΩ input impedance voltmeter).

Some sets also use back-bias for the 6B7 demodulator/AGC/first audio stage. Matching the divider to the field coil's voltage drop is vital for correct operation.

You might see sets with a 550Ω resistor in series with the field. This allowed the lower-resistance 1.35kΩ (later 1.2kΩ) speaker to be substituted for the original while demanding no modification to the back-bias circuit.

The "Minnie" (ad shown in Fig.3) also used an electrodynamic speaker with transformer attached. Contained in a case approaching the size of a console radio, it gave much-improved bass response. Connecting via a four-pin socket on the back of the chassis, output was switched from the internal speaker to the Minnie via a side-mounted switch.

The switch was no longer fitted by OZ9490, with the hole in the cabinet side remaining, and the socket hole in the chassis rear blanked by a Bakelite sheet.

## Power supply

The AC/DC set used the 25Z5's two diodes in parallel to form a half-wave rectifier. This would have given an HT of only about 140V, common in early US mains-powered sets.

From 461 onwards, a conventional mains transformer with a centre-tapped secondary and the 25Z5 were used in a full-wave circuit. While it would have been possible to wind the mains transformer to give a more common (higher) HT voltage, Astor's designers chose to keep the original RF/IF/Audio design, keeping the low HT.

The basic Mickey design was used for other models for several years, so low HT voltages were a feature of Astor designs for some years following the OZ.

The 25Z5, with two independent, indirectly-heated diodes, was also used as a voltage doubler in 110V AC sets, for an HT closer to the more common 200~250V.

Readers may hesitate over the speaker field being in the negative supply lead. This arrangement works just as well as the more common positive-lead connection, with the same total voltage loss, and with two advantages. Firstly, the voltage drop across the field can be used to provide 'free' back bias; the voltage drop is there anyway, so why not use it rather than adding an extra resistor with more HT loss?

Secondly, since the entire field is no longer at HT potential, failures due to electrolytic corrosion are much less likely.

The two HT filter capacitors were originally contained in a single tinplate case, but these were absent from OZ7490. The capacitors were described as 'dry' electrolytics, distinguishing them from the liquid-filled vertical cylindrical types common at the time. The original filter caps were replaced by a Ducon 'pigtail' tubular type (more on that later).

The paper types in the set were Chanex, Ducon and Aerovox brand while the mica types were TCC.

## Valve biasing

Valve biasing varies from one model to another. The AC/DC set used back-biasing on the output valve but individual cathode biasing on the other three.

Converter biasing, initially using fixed-cathode bias, was changed to preset variable from around serial number 7100 on, as found in OZ7490.

The converter's local oscillator anode is supplied from the main HT via a 10kΩ resistor in all circuits, but the converter screen supply comes from the R13-14-15 voltage divider strung between HT and ground.

The original cathode bias on the 6B7 circuit deserves comment. From the initial issue to about serial 7100, it was supplied by a 7kΩ cathode resistor and bypassed using a 5μF capacitor, raising the cathode above ground and providing negative bias for the pentode section.

But this also put a negative bias on the demodulator/AGC diode pair, so that the demodulator would not respond to weaker signals at all. To prevent this, the volume control, acting as the diode load, is returned to the 6B7 cathode.

The demodulator works as usual, and the AGC operates with no delay bias. The only odd effect is to put the entire AGC line a volt or two above


**Fig.3: an ad for the Astor Minnie Mouse "console-size" extension speaker. Despite a similar style to the OZ cabinet, it gave better bass response.**

ground. This means that the converter and IF amplifier grids are also above ground. This unusual biasing is compensated by the cathode voltages being a little higher than usual.

The 6B7 uses very low screen and anode voltages (19V and 36V respectively), derived from the R13-R14-R15 HT divider.

However, this 'starved' design gives a stage gain close to 50 times, adequate for the application. Against this, the Type 75 triode used in the later model EC can achieve a similar gain with a simpler circuit.

From about serial 7100 onward (including OZ7490), the 6B7 cathode is connected to ground, with back-bias for the pentode section. This corrected the problem of a positive AGC line, so the AGC circuit works just as you'd expect it: 0V for no signal and increasingly negative as the signal strength increases.

No manufacturer drawing exists, but Leahy's Supplement has the correct circuit. The later EC model also uses back-bias on its Type 75 duo-diode triode's audio section.

OZ7490's output valve has around -19.5V applied from the back-bias divider, with its control grid returned to ground. Serial numbers from about 1300 to 5300 see the control grid returned to ground with an 810Ω cathode bias resistor and 5μF electrolytic bypass capacitor.

A final note on terminology: original texts refer to semi-variable capacitors as 'padders', regardless of their function. Thus the semi-variable capacitor C9 (tuning the first IF primary) is described as a 'padder', as is C12, the LO tracking circuit. Modern terminology describes C7 (and C9, 11, 13, C16 and 18) as trimmers, reserving 'padder' for capacitors such as C12 alone.

## Repairs

I bought this set at an HRSA auction some years ago and it was on display until just recently. On inspection, it showed some activity, mostly hum.

Some capacitors had been replaced, along with the 6B7 load resistor (R11). Bias divider R16-R17-R18 had been modified to add a resistor in parallel with R18, and an extra bypass capacitor had been added across R18.

The mains lead was figure-8 flex and was not secured against twisting or pulling. I replaced it with a cloth-covered three-core lead that is held to the chassis with a cord anchor. While the anchor is a modern device, it gives complete security and will not split or perish as rubber grommets can.

The bias voltage on V4 (the output valve) was low, as was the HT voltage. The first HT filter capacitor (C23) was missing.

Valve testing showed converter V1 to be weak, so I replaced it. All the others tested OK. This was a relief, as the Type 43 and 25Z5/25Z6 (with 25V heaters) are not so readily available as the 6V heater types.

I attacked the bias divider first. The added electrolytic capacitor (across R18) had enough leakage to leave the 6B7 with virtually no bias. As the capacitor was disrupting the circuit and was not needed, I removed it. The leakage would have been acceptable in a cathode bias circuit but was a disaster in a high-resistance bias circuit passing only microamps.

C27 was also leaky, so I replaced it with a fawn-coloured Philips type.

I reworked the set with new resistor values to give the correct voltage for the output valve, setting the bias for the 6B7 audio driver on a trial-and-error basis for maximum gain, winding up with 13kΩ for resistor R18.

But the HT was still low. I had assumed that since V4 draws the most HT current, its low bias would have caused excessive current drain, pulling down the HT.

OZ7490 has an octal 25Z6 rectifier fitted as a replacement of the original 6-pin 25Z5. Sets later than OZ7490 still have the 6-pin 25Z5 in place, and all circuits show this valve rather than the 25Z6. This is a reminder of just how hard it can be to find a Mickey in original condition.

Circuit modifications – and the absence of the correct schematic for this set – meant that the missing first HT filter had been overlooked. Putting in a replacement brought the HT up to around 130V, so the faulty bias circuit probably had less effect than I first thought.

The audio stage now worked but there was a background hum at 50Hz. This was not a filtering problem; the unshielded lead from the 6B7's demodulator circuit up to the volume control ran past the mains-supplied heater wiring.

The fix was to strip off the braid from an old piece of shielded wire, sleeve it over the existing audio lead and solder it to ground, then slide a piece of old-fashioned waxed cambric 'spaghetti' over the braid. This addition blends with other insulation in the set. Tip: warming up cambric with a heat gun or hair dryer makes it much more flexible.

Next, I checked the function of the RF/IF end. The IF channel lined up pretty well, and feeding in about 20μV to the converter grid gave good output. The IF seemed 'happy' at 466kHz, so I didn't attempt to force it down to the specified 456kHz.

This might upset the purists, but it's only about 2% off and the set works just fine. I was concerned about possibly causing hard-to-fix damage if I tried to adjust it any further.

That said, it was **very** deaf from the antenna terminal. As described earlier, the L1-C1 combination is aimed

**The side view of the Astor Mickey OZ clearly shows the filter circuitry for the antenna.**

at attenuating signals below the broadcast band to prevent breakthrough. Disconnecting L1-C1 and injecting a signal to C3 gave a better result, but still not what I expected.

Resistance checks confirmed that inductor L1 was continuous and that capacitor C1 was not shorted. Then I noticed twisted wires in the antenna circuit assembly, taped with black friction tape.

I realised that this is C4, a 'gimmick' capacitor to improve top-end sensitivity. Undoing the tape, I discovered that the wire ends had been twisted together. This was clearly a factory error.

After rectifying this, the sensitivity was better (see Fig.4) but still low. This turned out to be caused by the L1-C1 filter. Bypassing that, I got 50mW output for just 7μV input at 600kHz (this is without the L1/C1 filter – red line in Fig.4). That's up there with the better sets. So if you have a Mickey with that L1-C1 filter circuit and want the best performance, disconnect it and connect your antenna to C3!

## Performance

This set gives surprisingly good performance; the figures quoted below are with the L1-C1 bandpass filter in circuit and using a standard dummy antenna between the signal generator and radio. See the sensitivity chart (Fig.4) for the intrinsic performance without the filter.

For 50mW output the sensitivity is 7μV at 600kHz and 28μV at 1400kHz. It's noisy, though, with a signal plus noise to noise ratio of about 14dB in both cases. To get 20dB, the tested set needed around 145μV and 60μV respectively. The RF bandwidth is ±2kHz at –3dB and ±35kHz at –60dB.

The AGC circuit gives an output change of 6dB for a 40dB input range. It would not overload even with 1V at the input!

The maximum audio output is 0.5W at 10% THD. At 50mW, THD is 1.5%, and at 10mW it's 2%.

The response from antenna to speaker is 155Hz to 1.9kHz; from the volume control it's 150Hz to over 3.2kHz.

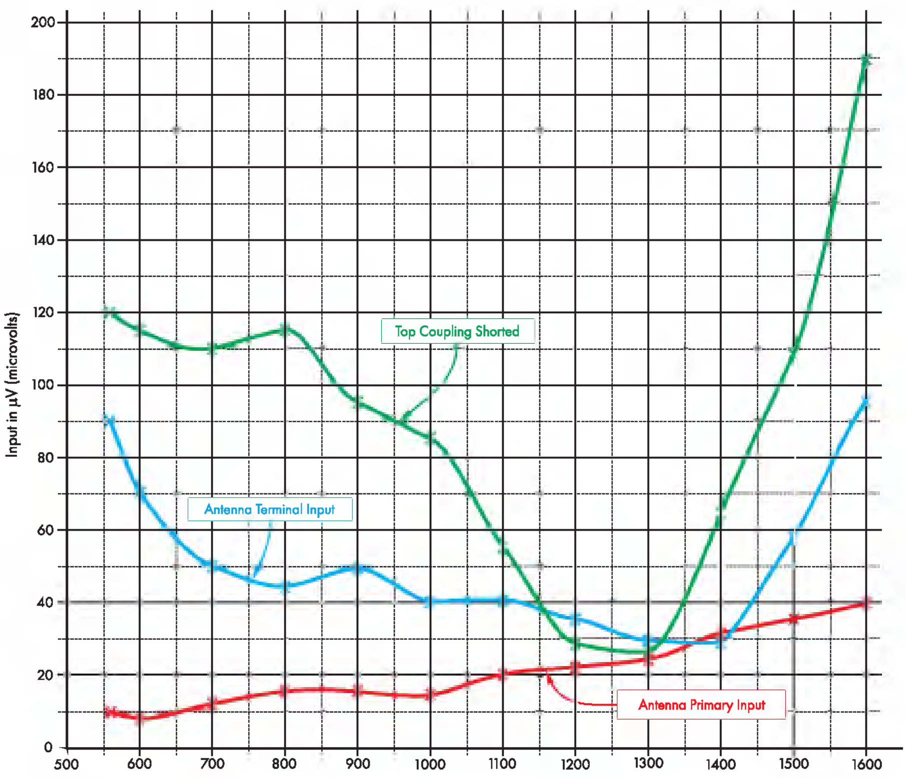



**Fig.4: sensitivity measurements were made across the broadcast three different ways: feeding the test signal directly into the antenna terminal (blue line), directly into L2, bypassing the input filter (red line, giving the best sensitivity figures) and with the factory error that caused C4 to be shorted out (green line). As you can see, this simple mistake had a significant impact on sensitivity.**

Marcus and Levy (p47) quote the input level for an equivalent all-octal set of 5~12μV.

So this set's best figure of 7μV without that bandpass filter is remarkably good. Leahy (p119) quotes figures for the very similar BC set that confirms my test results, and agree with Marcus and Levy's figures.

## Conclusion & thanks

Restored to original cosmetic condition, this is a set that will have visitors dwelling on it and admiring its design and finish.

Restored to proper working condition, it's a solid performer that ranks among the better sets of **any** era.

And it's a midget. We're probably used to compact mantel sets from the 1950s and 1960s, but this was serious miniaturisation for 1933. Read radio magazines and journals of the day and you won't see too many sets that rival the Mickey for compactness.

These come up for sale from time to time, and I think the Mickey OZ is a 'must have' for any Australian collector.

I'd like to thank Jim Easson and Philip Leahy of the HRSA for background information on the entire Mickey product line. You'll find HRSA founder Ray Kelly's history of the Mickey, including the controversy with Disney Studios over naming rights, in Philip's book.

Thanks also to Alby Thomas and Andrew Wakeman of the HRSA for their generous provision of the original filter capacitor block and underside photos, and to the HRSA's Mickey Special Interest Group (MSIG) for their advice.

Not an HRSA member? Visit **www.hrsa1.com** and find out how we can help you explore the wonderful (and weird) world of radio. And don't forget our Mickey Special Interest Group.

## References

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