By Ian Batty

Astor Aladdin FG Dual-Band Receiver

Good performance from four valves

Using just four valves, Astor's Aladdin FG is an interesting battery-operated set with a vibrator power supply and a reflexed IF amplifier/first audio stage. Restoring this particular unit to full working order proved to be straightforward.

THE ASTOR Aladdin FG really is an interesting set, partly because of its age and partly because of its advanced design (for the time). I bought this particular radio at a Historical Radio Society of Australia (HRSA) auction some years ago, mainly for its Art Deco styling. When I subsequently discovered that it was a 6V DC set with a vibrator supply, I left it on my display shelf for some years.

Just recently, I decided that it was time to dust the old Astor off and rediscover this classic piece of design from 1937. That's almost 80 years ago!

This is a 4-valve superhet set with two IF stages, the last one being reflexed. It's a dual-wave (broadcast and shortwave) design and I was interested in finding out if Astor had overcome a fault inherent in many early directly-heated designs, namely unreliable local oscillator (LO) operation.

The Art Deco styling aside, one of the first things you notice about the Aladdin FG is that it's quite a heavy set (10kg). This is partly due to the transformer used in the vibrator power supply and its associated shielding and filtering circuits. The steel chassis also contributes to the set's weight.

Visually, it's one of those sets that really catches the eye, with its large dial and the three bars across the speaker grille. The 2-part dial features switched dial-lights which illuminate the selected band (broadcast uppermost, shortwave below), as well as two magnifying windows to allow for more accurate tuning.

The leftmost control turns the set on and offers three tone control positions: "normal", "soft" and "softer". The volume control sits in the middle, just to the left of the dial, while the band switch is immediately below it. The remaining control at far right is the tuning knob.

As shown in the photos, the set is built on a conventional "bathtub" chassis, with a separate insert chassis for the aerial/oscillator coil pack. The valves used are either 6-pin (V1-V3) or 5-pin based (V4).

Circuit details

Fig.1 shows the circuit details of the Astor Aladdin FG. As mentioned earlier, it's a 4-valve 6V DC set with a vibrator power supply. In fact, most 6/12V valve sets used vibrator power supplies, with valve-based car radios probably the most familiar of these. A few exceptions used motor-generator (genemotor) supplies.

In operation, a vibrator uses a vibrating reed to switch battery current through the push-pull primary windings of a step-up transformer. By operating at 100Hz, vibrator supplies can use smaller transformers and filter components than 50Hz mains supplies.

The vibrator's major drawbacks are: (1) a limited life-span due to contact corrosion and (2) a high degree of radio-frequency interference (RFI). This RFI

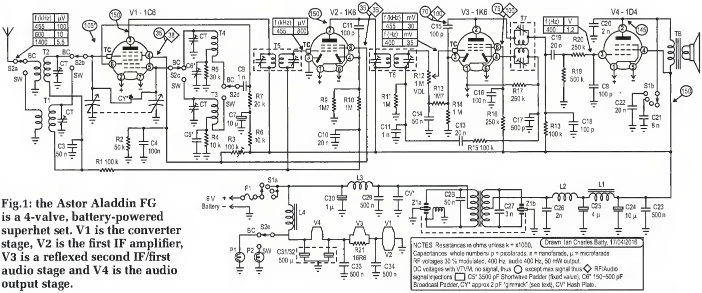


Fig.1: the Astor Aladdin FG is a 4-valve, battery-powered superhet set. V1 is the converter stage, V2 is the first IF amplifier, V3 is a reflexed second IF/first audio stage and V4 is the audio output stage.

is mainly generated when the current through the transformer is interrupted each time the contacts open. Since the transformer is heavily loaded by the rectifier connected to its secondary, we might expect that back-EMF and sparking would be kept down but there's still a substantial amount of RFI in even the best designs.

This means that careful filtering and shielding are a vital part of any vibrator supply design. The Aladdin FG's circuit reflects this, with heavy filtering on the input side (L3, C30, C29 & CV), the secondary (C26, L2 & C23), and even in the filament circuit (C31/32, C33 & C34). CV, the "hash plate", is a common feature of vibrator supplies. It's usually a simple metal plate riveted to the chassis but isolated by a sheet of mica or fibre insulation.

There's also C28 & C27. You may not find a capacitor (C28) on the primary in all designs but you will see the equivalent of C27. This is the buffer capacitor and it's there to damp out high-voltage transients in the primary circuit due to contact openings.

This capacitor is typically a high-voltage, high-reliability type (2kV in this 160V supply), as a short-circuit failure will stop the power supply dead. It could also damage the vibrator or transformer, as the vibrator would be attempting to switch the supply voltage to ground with virtually no transformer primary inductance to limit the current flow.

Conversely, an open-circuit capacitor will result in excessive sparking at the vibrator contacts, leading in turn to greatly-shortened vibrator life.

This view shows the control layout on the front panel. Note the two magnifying windows that form part of the dial-scale tuning indicator.

Many vibrator sets use a valve rectifier such as a 6X5, 6V4 or 6X4. While these work just fine, the alternative is to economise on valve count and use the vibrator itself as a rectifier. The FG circuit uses just such a design – Z1 is a synchronous vibrator, with Z1a on the low-voltage DC-AC side and Z1b on the high-voltage AC-DC side.

Note that simpler, non-synchronous vibrator supplies can work just fine with reverse battery polarity but the FG's synchronous design would give a negative output with battery reversal.

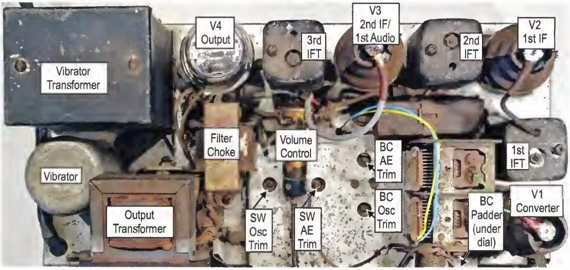
You'll find an excellent description of vibrator supplies in the references listed in an accompanying panel. And as always, there's the Radiotron Designer's Handbook (RDH) which is also listed (see chapter 32).

Astor Aladdin FG controls

As stated, early dual-wave sets suffered from unreliable local oscillator operation on the shortwave band. In fact, the very first 2V converter valve, the 1A6, was unreliable even on broadcast band frequencies.

The 1C6 (octal version = 1C7) converter used in the Aladdin FG was a much better performer. This improved performance was achieved by doubling the 1A6's filament current to 120mA and is a reminder that filament emission is as important as physical design in valve performance.

The 1C6 (a pentagrid) uses grid 1



This view shows the layout on the top of the chassis. The set was in quite good condition considering that it's now almost 80 years old.

as the oscillator grid and grid 2 as the oscillator anode. Grids 3 & 5 form screens, while grid 4 is the signal grid.

Ideally, the LO (local oscillator) only interacts with the incoming signal inside the anode cylinder. Any extraneous interaction has little effect on broadcast frequencies, as the LO frequency and tuned signal frequency are some 455kHz apart.

On shortwave, it's a different story. At this set's top end (around 18MHz), the LO is less than 3% away from the tuned frequency, so any external interaction will affect the valve's input impedance and disturb the aerial circuit tuning. Unfortunately, good physical design cannot defeat the main source of such interaction – a space charge effect occurring inside the valve itself.

The solution, as seen in many multiband sets, is to apply a neutralising signal via a 2-5pF capacitor. In the Aladdin FG, it consists of a short length of wire which runs from the oscillator section of the gang and is wound around the aerial circuit converter's top cap lead (CY). It's commonly called a "gimmick" capacitor.

The local oscillator uses "padder" feedback. It's a form of Hartley oscillator, with the anode supplying a signal via bandswitch S2d to either T4 (BC) or T3 (SW). The signal is then fed back to the oscillator grid via bandswitch S2c. Each band has its own padder capacitor, this being either C6 or C5. C6 is used for the broadcast band and is adjustable, while C5 is switched in for shortwave and is fixed.

As well as reducing the LO's frequency span (to ensure tracking), the selected padder returns its coil tapping almost to ground, the actual impedance to ground being the padder's capacitive reactance. This tapping (added to inductive coupling within the coil) provides sufficient feedback to sustain oscillation and provides the phase reversal needed for the oscillator to work.

Note that each padder is shunted by a grid resistor (either R5 or R4), with R4 (shortwave) being just 10kΩ to help maintain oscillator activity over its 6-18MHz range. Note also that the adjustable broadcast-band padder (C6) is accessed via a hole in the front of the chassis, just below the dial (not where you'd usually look)!

You'll find a thorough description of converters in chapter 26 of the Radiotron Designers Handbook (RDH). Alternatively, for a less mathematical but more extensive descriptive article, check out "Converters & Faultfinding" in the HRSA's *Radio Waves* for April 2012.

Getting back to the circuit, the signal from the converter drives double-tuned IF transformer T5. The resulting IF signal is then fed to the first IF amplifier stage (V2).

At first glance, I could see only one adjustment per IF can, consisting of a slotted, threaded shaft. However, closer inspection of each can showed that I'd mistaken what was a second adjustment for a lock-nut. It turned out that the two adjustments are coaxial; the nut is used for one trimmer adjustment, the threaded shaft for the other.

IF arrangement

IF amplifier stage V2, a 1K6, is a duo-diode pentode. It uses one of its diodes (fed via C11) to provide AGC (automatic gain control) for both itself and the converter (V1). The control voltage is fed back via R10 and R1 and is filtered by capacitors C10 and C3.

This is rather an odd arrangement since the AGC voltage is usually derived from the final IF amplifier stage in the chain. It turns out, though, that the second IF amplifier stage based on V3 has its own AGC.

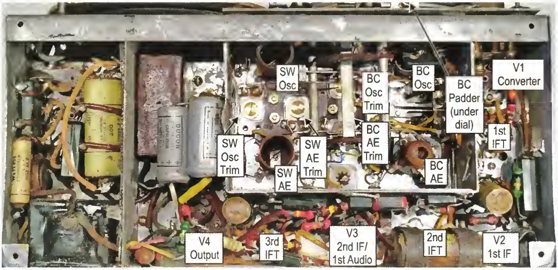
The volume control varies both the IF signal level and the audio signal level fed to V3. Basically, this is a 4-valve set with five stages. V3 is reflexed; it amplifies both the IF signal and the audio signal, so it acts as both a second IF amplifier stage and as a first audio amplifier stage.

It's an economical and elegant arrangement that performs almost as well as a conventional 5-valve set. Its main drawback is that, unless precautions are taken, it can suffer on strong signals if the reflexed valve (V3 in this case) rectifies the IF signal at its grid rather than using its internal demodulator diode.

Chapter 28 of the Radiotron Designer's Handbook describes the basic principles and this set's design also gives us the clues as to how it all works. First of all, applying AGC to V1 & V2 helps to ensure that a fairly constant signal is fed to V3's grid. Second, placing the volume control in the IF path means that the IF signal level is reduced on strong signals, along with the audio signal level. And third, applying local AGC to V3 also helps to prevent overloading on strong signals.

In greater detail, V3 feeds its demodulator diode via IF transformer T7. The demodulated audio is then filtered by C17 and fed to V3's grid via R15, C13, IF transformer T6 and volume control

The parts under the chassis are tightly packed but still accessible. Note the separate chassis insert which houses the band-switch and its associated antenna and oscillator coils.



R12. V3's AGC diode is fed directly from the valve's anode via C15, with the resulting control voltage fed via R13 to the bottom of the volume pot. This provides local AGC for the stage.

Note that the demodulator diode's DC return, via R17 to V3's filament, places zero bias on the diode. As a result, it will respond to all signals as it's intended to do. By contrast, the AGC diode's DC return is to ground via R14. Since V3's filament is some 2V above ground, this applies a small "delay" voltage to V3's AGC circuit.

V3's anode current contains two signals: the 455kHz IF signal and the demodulated audio signal. The IF signal is recovered by IF transformer T7, while the audio signal is fed to output valve V4 via C19. Capacitors C18 & C9 eliminate any residual IF signal from the recovered audio.

V4 is a straightforward class-A stage. It gets around 4V of bias because it's at the top of the filament chain, so its grid resistor (R19) simply returns to ground. The Power/Tone switch (S1) switches in treble cut using either C21 or C22, while C20 is permanently in circuit to damp output transformer T8's natural high-frequency resonance.

Getting it going

Despite its age, the Aladdin FG's Bakelite cabinet was in fine physical condition as it came to me, with only some yellowing of the dial covers detracting from its appearance. There was some rust on the rear spreader bar and the usual dust on the valves, chassis and IF cans but this was to be expected after nearly 80 years!

When I switched it on, the set was dead. I should at least have heard the vibrator buzz but it just sat there, drawing about 250mA from a 6V supply. That was consistent with all the valves drawing filament current, so I pulled the vibrator from its socket and removed its outer case.

This revealed that the foam rubber insulation/sound deadening lining inside had badly deteriorated and some had collected in the bottom of the can as a kind of "goop". Worse still, this "goop" had coated the reed and the contacts, thus preventing the vibrator from operating.

Brushing the "goop" with turpentine and scraping it away gave some improvement but it wasn't enough. In the end, I undid the screws holding the contact assembly and the reed, removed the reed and cleaned both it and the frame it sat in. I then cleaned the contacts and after reassembly, the vibrator unit worked just fine.

There were still problems with the radio itself though, with weak reception, distorted sound and no AGC action. Subsequent valve tests showed that valves V2 and V4 weak, so they were replaced.

Further Reading: Vibrator Power Supplies

(1) www.radioremembered.org/vpwrsup.htm
(2) Radiotron Designer's Handbook; eg, http://frank.yueksel.org/other/RCA/Radiotron_Designers-Handbook_Fourth-Edition/
(3) A Practical Guide To Vibrator Power Supplies (in Vintage Radio), SILICON CHIP, December 2015.

I then found that the audio on V4's grid was being clipped on positive peaks. The culprit turned out to be coupling capacitor C19; it was leaky and putting a positive voltage on V4's grid.

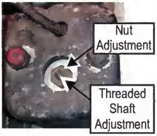
After replacing this capacitor, I found that I could inject an RF signal and see V3's screen voltage rise as its local AGC cut back its control grid bias. Checking the screen voltage in AGC-controlled stages is a handy diagnostic procedure, especially on battery valves where cathode resistors (and cathode voltages) are absent.

What about V1 & V2, the converter and first IF amplifier stages? As shown in Fig.1, their commoned screen circuits (pins 4 & 6 respectively) have an adjustable voltage divider consisting of variable resistor R3 (the "sensitivity control"). However, even with such a voltage divider to stabilise screen voltages, I'd still expect to see some local AGC action in response to signals but there was nothing.

Measuring along the circuit, I found that the connection between the bottom of R10 and the first IF transformer was shorted to ground. Capacitor C10 was the first suspect but disconnecting it made no difference. Eventually, after a bit of mucking about, I discovered that the fault lay in the first IF transformer (T5).

I quickly disassembled T5 and I found that the one of the moving plates on one of the compression trimmers had shorted. Loosening the trimmer's retaining screws allowed me to slide the offending plate into its correct position and remove this short circuit.

The question was, had this fault been there from the day the set was made? It's quite possible, as it's obvi-



The set's IF coils each have two internal adjustments, one made via a threaded shaft and the other via a nut.

ous that the coil can had not previously been opened.

Fig.1 shows the oscillator anode's voltage to be at 105V. Measuring at this point will often stop the oscillator dead and that's what all my meters did. So, in order to measure this voltage, I used a 10MΩ DVM with a 1MΩ resistor connected in series. The 105V value was then calculated from the measurement after allowing for a 10% (approximate) voltage drop across the series resistor.

Plumber's tape

The Aladdin FG uses Bakelite knobs, three of which have brass inserts to minimise the chances of the grub screws stripping their threads. This is important because both the volume and tuning shafts lack "flats", which means that the grub screws need to be as tight as possible so that the knobs don't slip.

Unfortunately, the only knob that didn't have a brass insert had a stripped thread. I could have re-tapped it and used a larger grub screw but I opted instead for an old friend – Teflon plumber's tape. A short piece, folded over four times and inserted in the hole did the job and allowed the grub screw to be tightened up quite nicely.

Teflon tape also makes an excellent "binder" for ferrite slugs, unlike wax or lacquers which solidify and jam slugs in position.

The sensitivity control

As noted above, variable resistor R3 sets the screen voltages for V1 and V2. The original circuit shows only about 35V, just over half the manufacturer's ratings of some 67.5V for these valves and half V3's screen voltage of 70V.

A gain reduction that's achieved by using reduced screen voltages is common in sets with two IF stages. That's because feedback within the chassis would readily lead to the entire IF circuit "taking off" (or oscillating) if the rated voltages were used.

As an experiment, I tried increasing the screen voltages on V1 & V2 to 70V and this particular set "behaved". This resulted in a sensitivity of about 4μV for a 50mW output, which is on a par with the AWA set referred to below.

Conventional contemporaries

Some three years after the Aladdin FG, AWA described a 5-valve set using the new 1.4V octal line-up in the company's *Radiotronics* magazine No. 104, May 1940. Using an RF stage and a single IF stage without reflexing, this set managed a sensitivity of 3μV for 50mW output but with poorer noise figures than the Aladdin FG's.

Unlike the Aladdin FG, the RF and IF amplifiers in AWA's set operated with full screen voltage. However, when operating the two sets side by side, I doubt that anyone would pick any difference in sensitivity.

How good is it?

So just how good is it? Well, considering it's a 4-valve battery set, it's pretty good. With better than 10μV sensitivity on the broadcast band, an impressive 0.5W output, a power consumption of just 7W, a shortwave band and an elegant cabinet, what's not to like?

If you couldn't afford a large console radio running off battery power at the time, the Aladdin FG would have been an excellent choice. And it would have sat nicely on the mantelpiece.

The measured results back up the subjective impressions. At 600kHz, its sensitivity is 10μV for the standard 50mW output. This figure improves to just 5.5μV at 1400kHz. The corresponding noise figures at 600kHz and 1400kHz are 18dB and 15dB respectively, while a 20dB signal-to-noise ratio would require signal levels of about 12μV and 8μV respectively.

On shortwave, it needed around 16μV at 8MHz but this reduced to just 4μV at 17MHz. It was, however, quite noisy at the high end, with a signal-to-noise ratio of around 6dB. The sensitivity at 8MHz figure was improved to around 12μV by placing a "magic wand" in the aerial coil, indicating some misalignment and highlighting the limitations of not providing any low-end shortwave adjustment.

The IF bandwidth was only about ±1.4kHz at -3dB and ±12.5kHz at -60dB, so three double-tuned IFs can really give high selectivity. That would be an advantage in country areas when trying to pick up distant stations. Unfortunately, the AGC didn't work all that well, with the output increasing by some 6dB in response to a signal increase of just 14dB.

The maximum audio output was also checked and this gave a figure of 500mW at around 11% distortion. At 50mW, the distortion was around 3%, while at 10mW it's around 7%. The frequency response was 240Hz to 3kHz at the -3dB points between the volume control and the speaker but only about 240Hz to 1 kHz between the aerial terminal and speaker, confirming the very narrow IF bandwidth.

Switching in the tone control cut the frequency response at the top end even further, to 600Hz or 500Hz depending on the setting.

Despite these modest figures, I'm pretty happy with the performance of my Aladdin FG and its distinctive looks make it a valuable addition to my vintage radio collection. **SC**