Vintage Radio

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The Astor KM 4-Valve Reflexed Receiver

Developed during the very early days of radio, reflex circuits were used in receivers right up until the 1950s. One such set was the Astor KM.

REFLEX RECEIVERS were sets that used one of their valves to perform several functions. In fact, some early receivers had more than one stage reflexed. In the case of the Astor KM, it's the intermediate frequency (IF) stage (6B8G) that performs several functions – ie, IF amplifier, detector, AGC and first audio stage.

Despite using quite conventional components, radios with reflexed stages were not particularly popular with servicemen. To understand why, read the early "Serviceman Who Tells" articles in "Radio and Hobbies" which came out from 1939 onwards (now available on DVD from SILICON CHIP). My own experiences with this set back up those early Serviceman stories.

The servicemen of the era were usually self-taught. Some of them had a good understanding of the radios they serviced but others were purely "valve jockeys". A "valve jockey" had no understanding of the workings of the receiver and just replaced valves until (hopefully) the receiver worked. Valves weren't as reliable back then as they were in later years and valve jockeys often got sets going reasonably well, even if the real cause of the fault had not been found.

Another problem for early servicemen was the lack of test instruments. During the 1930s, even a basic multimeter was an expensive item and this situation persisted right up until the 1960s.

Today, we can buy a digital multimeter (or DMM) that is vastly superior to the meters of the 1930s for as little as $8.

After taking inflation into account, the comparative cost of a simple multimeter in the 1930s would have been many hundreds of dollars. However, even that doesn't reflect the true cost, since wages in the 1930s were considerably less than they are now in real terms.

As for other test instruments, oscilloscopes were only laboratory instruments before WW2, while capacitor testers, modulated oscillators and even simple valve testers were very expensive and relatively rare.

To get around this problem, many servicemen built their own test instruments, often from the designs that appeared regularly in "Radio and Hobbies". At the same time, servicemen were becoming better trained thanks to organisations such as the Australian Radio College and the Marconi School of Wireless, the latter an adjunct of AWA. In addition, many radio servicemen learnt their trade through the PMG, DCA (Department of Civil Aviation) and military training schools.

Servicing reflex receivers

So why didn't servicemen like servicing reflex receivers? Well, the IF circuit in a reflex receiver is more complicated than a normal IF stage, as it amplifies audio signals as well as the IF signals. To do this, the operating conditions for the stage must be suitable for both audio and IF signals.

This by its very nature involves a compromise and so when the valve or any of its associated components deteriorate, the stage quickly malfunctions. The problem for servicemen was that, with the elementary servicing tools they had at their disposal, it wasn't easy to determine which component or components were at fault. Most servicemen, for example, were unable to test paper capacitors (eg, for leakage and capacitance) and so many faulty capacitors would have remained in the receivers they serviced.

Replacing multiple components in an attempt to eliminate a stage fault wasn't the answer either. Components at that time were much more expensive than they are today and replacing multiple components to eliminate a single faulty part wasn't an economic proposition.

So if reflex circuits were such a problem for servicemen, why were they used? Quite simply, valves were very expensive up until the 1950s and reducing the number of valves used in a receiver saved a considerable amount of money. In fact, a valve in the 1920s could cost as much as a man earned in a week. As a result, receiver manufacturers and experimenters used reflex circuits to keep costs down, without compromising performance to any extent.

The logic was simple: a 4-valve set that could perform like a 5-valve set would be cheaper to manufacture than a set that actually used five valves.

The Astor KM

The little Astor KM receiver featured in this article sat on a shelf in my garage for years before its eventual restoration. I don't remember where it came from but it had obviously lived in a dusty kitchen before being relegated to someone's shed as a background source of "noise". The dust had been well and truly stuck to the chassis and cabinet by vaporised cooking oil and the chassis was in a sorry state.

A brief inspection revealed quite a few obvious problems. First, the loudspeaker was just hanging in the general area where it is normally mounted and the speaker transformer leads had been cut off (I have no idea why this had been done). In addition, the dial pointer was missing, the dial cord was broken, the speaker cloth had disappeared and there was a crack in the dial scale.

These two views show the top of the chassis before restoration. Note the bodgie (and unsafe) extension job on the dilapidated power cord.

The twin-lead power cord had also been lengthened using another length of mains cable and was in quite an unsafe condition. It was also crudely "anchored" using just a knot tied in the cable, which is illegal these days. It was later replaced with a securely-anchored 3-core mains lead, so that the metal chassis could be earthed.

Circuit details

Fig.1 shows the circuit details of the 4-valve Astor KM. In this set, the antenna circuit has a primary winding that resonates just below the broadcast band and there is a small coupling capacitor from the top of the primary to the top of the tuned winding. This type of antenna circuit is designed

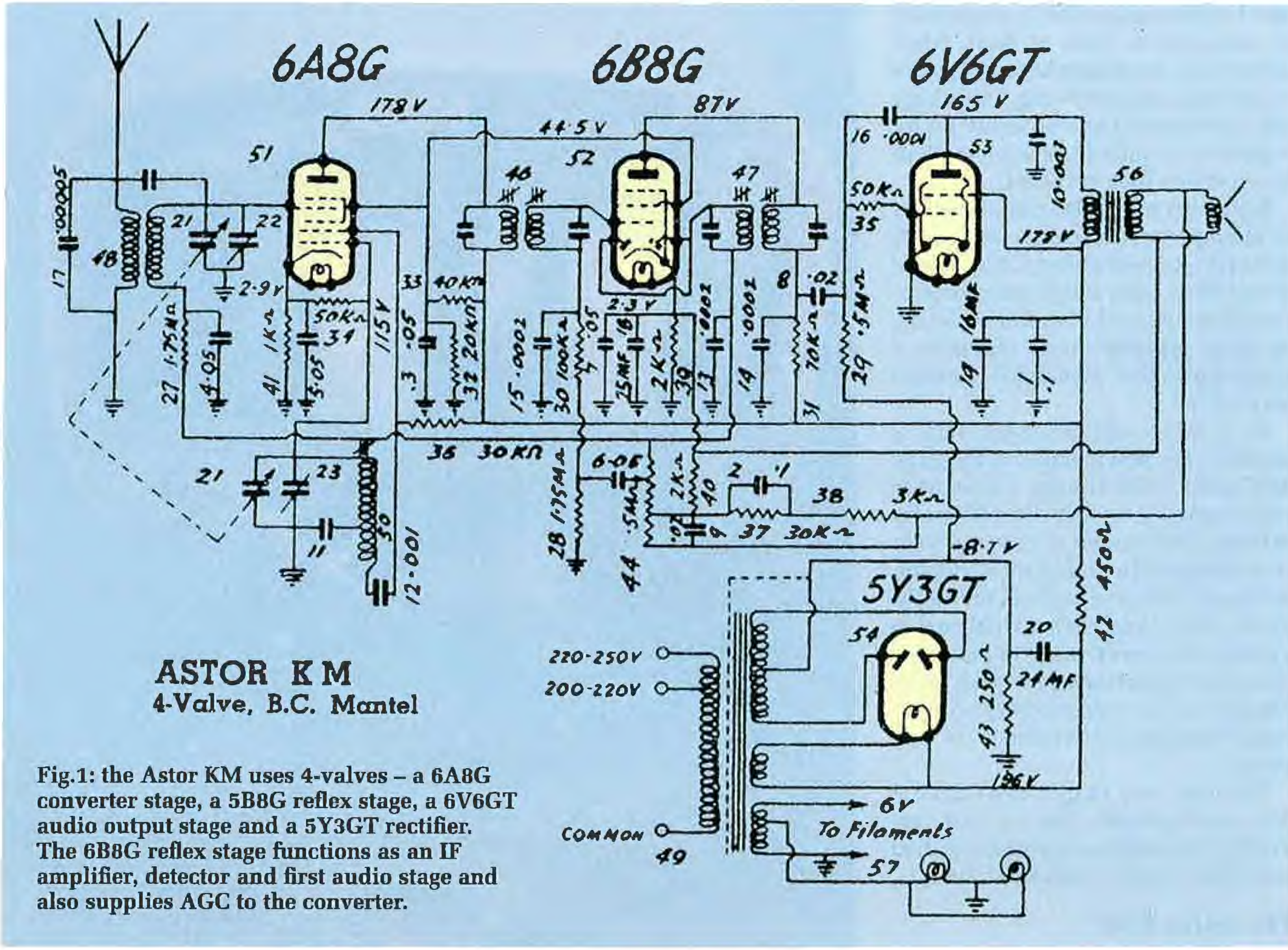


Fig.1: the Astor KM uses 4-valves – a 6A8G converter stage, a 5B8G reflex stage, a 6V6GT audio output stage and a 5Y3GT rectifier. The 6B8G reflex stage functions as an IF amplifier, detector and first audio stage and also supplies AGC to the converter.

to give good performance across the broadcast band with relatively small antennas.

The following 6A8G valve acts as the converter. It has cathode bias as well as AGC applied to the signal grid. Its signal is coupled to the 6B8G IF stage via IF transformer 46. The output from this stage is then fed to IF transformer 47 and the resulting signal detected by the two diodes wired in parallel in the 6B8G. These diodes also supply simple AGC (automatic gain control) back to the converter stage.

Note, however, that AGC is not applied to the 6B8G as this would alter the operating conditions of this valve and cause the audio output to drop with increased signal level.

The audio output from the detector is fed to the volume control (44) and then fed back to the grid of the 6B8G via the tuned secondary output of the first IF transformer. This IF transformer has no effect on the audio signal but RF bypassing is achieved using capacitor 15 at the bottom of the transformer's secondary (its value is small so that it doesn't shunt the audio signal to ground).

The audio output from the 6B8G is fed through IF transformer 47 and is developed across resistor 31. Capacitor 41 bypasses any IF signal to ground, after which the audio signal is coupled to the grid of the 6V6GT audio output valve via a .02μF capacitor (8).

The 6V6GT stage includes both RF bypassing and audio top-cut filtering, achieved using capacitors 10 and 16. As with most Astor circuits, a quite complex tone correction circuit is run from the voice coil winding on the speaker transformer back to a tapped volume control. With only slight modifications, this network acted as a very comprehensive and effective tone control circuit in many Astor receivers.

Note that the 6V6GT is the only one in the circuit that has back bias applied from the power supply.

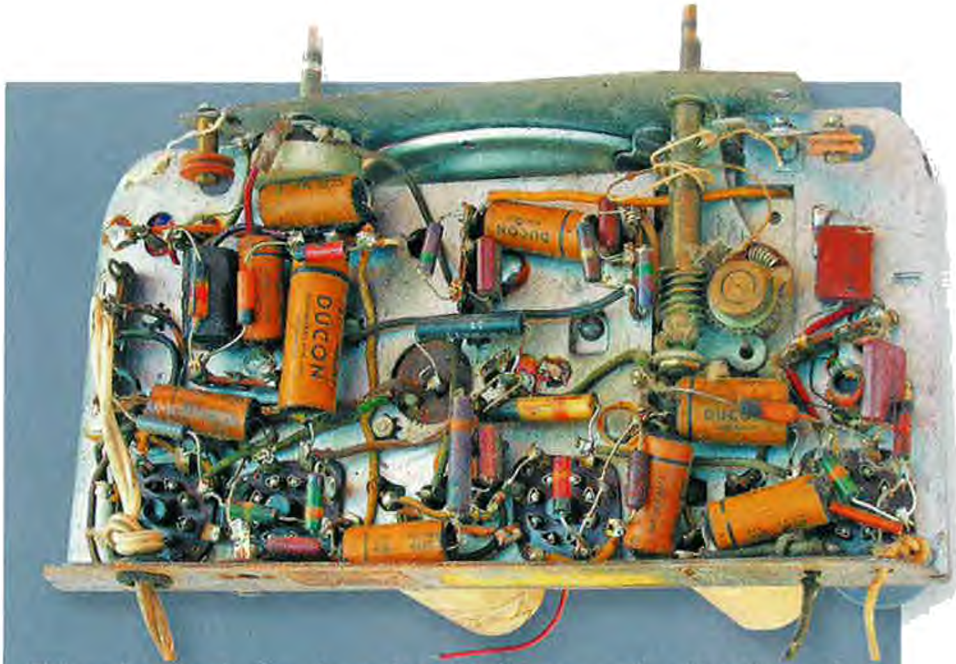
The power supply is conventional and uses a 5Y3GT as the rectifier. All valve filaments, except the 5Y3GT, are supplied from a 6.3V filament winding on the power transformer, while the dial lamps are supplied from a lower voltage tapping on this winding. This is intended to prolong the life of the lamps.

Mechanical restoration

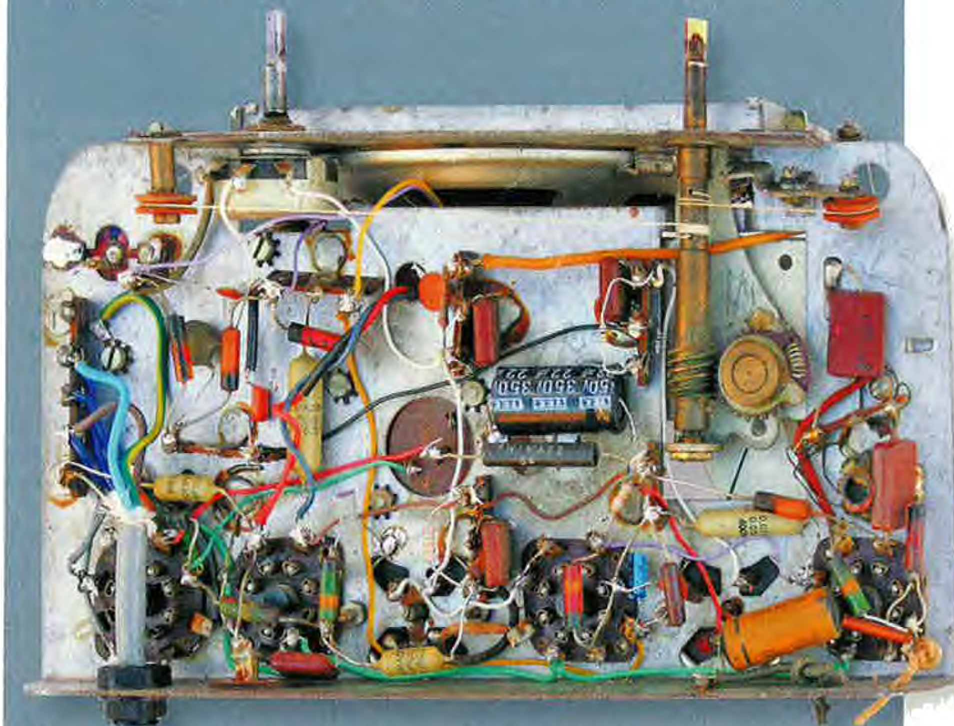
The chassis can normally be slid out of the cabinet after removing the knobs and two screws on the back edge of the chassis. However, due to the build up of gunk, this chassis had to be prised out of its cabinet. Originally, there would have been a cardboard back on the set but that had long since disappeared.

Once the set had been dismantled, the cabinet and knobs were scrubbed clean with warm soapy water and a large nailbrush. They came up looking pristine, apart from some sticky residue left over from some packaging tape which a previous owner had used to hold the back on (before it was lost). This sticky residue was easily cleaned

The loudspeaker had several tears in its cone (top) and these were repaired using several layers of nail polish. Despite its age, the repaired speaker still worked quite well.



This under-chassis view shows the unit before restoration. Note the crude (and now illegal) method of "anchoring" the power cord (ie, using a knot).



The unit after restoration. All but one of the original paper capacitors has been replaced, some resistors changed, the dial restrung and a new 3-way mains cord fitted and anchored using a cable clamp. In addition, the chassis is now earthed, in the interests of safety.

off using a rag soaked in methylated spirits.

The cabinet now look quite good, so much so that I didn't bother resorting to my customary treatment with car cut and polish.

The chassis was also rather grotty so I began by removing all the valves and the loudspeaker. As mentioned above, the speaker was just sitting in its mounting position but was not actually attached to the mounts.

Removing these parts gave reasonable access to the chassis and the loose dust and fluff was brushed away from under and on top of the chassis using a small paintbrush. I then got busy with a kitchen scourer soaked in kerosene and some cleaning rags and thoroughly cleaned the chassis and any large components mounted on it. This is a straightforward task and the kerosene does a great job when it comes to loosening the muck.

Perished insulation

One thing that was obvious during the chassis clean-up was that the insulation on the power transformer leads had hardened and become brittle. In fact, the previous owner had noticed this and had put electrical tape around a number of these leads.

This tape looked rather ordinary so I decided to remove it to see just how bad the insulation was. It was, in fact, very bad and I ended up cracking the remaining brittle insulation off eight of the leads using a pair of pliers. I then cut off the wires one by one where they terminated in the circuit and slid plastic sleeving over each one before reconnecting them.

Once all the leads had been reconnected, I used neutral-cure silicone on the transformer ends of the leads to hold them in place. No shorts were found when I tested the transformer with my multimeter.

This top-of-the-chassis view shows the Astor KM receiver after restoration. The chassis was cleaned using a kerosene-soaked kitchen scourer, while the valves were cleaned by washing them in warm soapy water.

Most of the wiring under the chassis had also perished and so had to be replaced. This was done one lead at a time (as with component replacement) to prevent any wiring mistakes and took almost a day to complete. In addition, the speaker had a few tears in its cone and this was repaired using several coats of nail polish. The cone moved in and out of the annular gap quite freely and did not appear to be poling, so the speaker was still OK.

Component replacement

The next step was to replace any paper capacitors that showed excessive leakage. I also found a few resistors that were out of tolerance and these too were replaced. I then tested the electrolytic capacitors and replaced two out of the three (my electrolytic capacitor reformer did a good job of sorting out the good from the bad).

The speaker transformer was next on my checklist. Unfortunately, this had an open-circuit primary winding and this type of fault can quickly destroy a 6V6GT. What happens is that when the transformer primary is open-circuit, the valve's plate has no voltage on it. As a result, the screen acts as the plate and the valve draws too much current.

Subsequently, I found that the 6V6GT had indeed been ruined by this fault.

Getting back to the transformer, this was replaced by first drilling out the rivets that secured it to the speaker and then bolting another transformer into place. I then refitted the speaker into the set and wired it into circuit.

Firing up

It was now time to start bringing the set back to life but first I used my high-voltage tester to check for leakage between the power transformer's primary winding and its frame and between the primary and secondary windings. This is an important safety step and in this case the transformer proved to be in good condition.

Having cleared the transformer, I wired in the new mains cord and applied power with no valves installed. All the voltages were as expected, being a little higher than the published figures because there was no load on the transformer.

Previously, I mentioned that the dial lamps are supplied from a tapping on the 6.3V filament winding. However, in this set the dial lamps had been connected across the entire 6.3V winding and not to the 5V tapping on this winding. This was corrected by wiring the dial lamps to the tapping, to agree with the circuit diagram.

Next, I plugged in the 5Y3GT and carefully checked the resulting HT voltages and the operation of the power supply. All was normal, with the HT voltages slightly higher than specified because there was still no real load on the power supply. The set was then left running like this for some time, then disconnected from the mains and checked for signs of overheating in the transformer and other components. Only the 5Y3GT was getting hot, so all was well so far.

At this stage, the original 6V6GT was plugged in but it didn't draw any current (ie, there was no voltage across resistor 42). It had indeed been overloaded and had failed when the speaker transformer primary had gone open circuit. A replacement 6V6GT solved that problem.

Chaos reigns!

Everything was looking good so far, so I fitted the other two valves – a 6B8GT and a 6J8G for the converter. These are not the specified types but will work perfectly well in this set. I then turned the set on and it immediately started working and drew 36W of power, which is normal for a set of this size.

Unfortunately though, it wasn't working properly as the set motorboated and also appeared to be squegging. Motorboating refers to a "pop-pop" type of noise a little like that made by old single-cylinder inboard motorboat engines and is a form of instability.

By contrast, squegging usually oc-

A new dial pointer was made by gluing a length of thick copper wire to an aluminium bracket. The pointer was then painted white.


The replacement speaker cloth was held in position using clamps until the glue (contact adhesive) dried.

curs with oscillators. What happens is that the oscillator operates briefly and then stops due to cut-off bias being applied to the grid of the valve (due to incorrect operating conditions). After a short time, the charge dissipates and the valve starts operating again.

In this case, the set would operate at low volume reasonably well but turned nasty at high volume. Inadequate filtering in the power supply usually causes motor boating but I had already replaced the faulty filter capacitors. I tried adding extra capacitors but to no avail.

Next, I took a closer look at the 6B8GT in the IF stage. I'm not sure if this valve is supposed to be shielded or not in this set, so I substituted the specified G version, fitted a shield around it and earthed this shield to the chassis. This slightly improved the performance of the set but was clearly not the answer.

My next step was to try replacing the 6J8G with the specified 6A8G. This made no difference to the set's stability but it did alter the tuning range. Instead of tuning to around 1650kHz at the top end of the dial, it now tuned to around 1750kHz. It would appear that either the capacitance of the valves was different or that the Miller effect was causing the apparent capacitance across the tuned circuit to change.

I retuned the front-end stages and also the IF stage but again there was no improvement in the stability. In fact, the set's alignment was fairly accurate except for the highest frequency that the oscillator tuned to. This was easily corrected by adjusting the oscillator's trimmer capacitor.

At this stage, I considered that there might be too much IF energy from the detector circuit getting back into the input of the 6B8G. As a result, I fitted an additional RF filter consisting of a 270pF capacitor from the "hot" end of the volume control to chassis and a 56kΩ resistor from the "hot" end of the control to the top of capacitor 13. This removed most of the RF from the line to the grid of the 6B8G but there was still no noticeable improvement in the stability.

Next, I considered the possibility that there might be too much IF energy getting into the 6V6GT audio output valve. To test this theory, I initially placed a 50pF capacitor between the 6V6GT's grid and chassis to reduce the amount of IF energy getting to the valve. This gave a slight improvement so I did some calculations which showed that substituting a 270pF capacitor would cut most of the IF energy but still not affect the higher audio frequencies. Again there was only a slight improvement (note: these

Photo Gallery: Eddystone 77U VHF/UHF Receiver

ONE OF THE BEST RECEIVERS ever made, the Eddystone 770U VHF/UHF set was often found in radio manufacturers' test departments. It employs a total of 17 miniature 9-pin and 7-pin valves and two octal valves in the power supply. It tunes from 150MHz to 500MHz over six bands and its sensitivity is quoted at better than 10µV for 15dB over all bands. The unit shown here outperformed its specifications. Apart from performance, a feature is the flywheel-weighted tuning which allows the operator to spin the dial knob and travel rapidly to each end of the dial, even though it is highly geared. Photo supplied by the Historical Radio Society of Australia Inc (HRSA), PO Box 2283, Mt Waverley, Vic 3149. www.hrsa.net.au

observations were made with a signal tracer and an oscilloscope).

Back to the bible

By now, I was running out of ideas so I decided to consult the "Radiotron Designers Handbook" and see what it said about reflex circuits. And there was a clue, with the text stating that care was needed in setting the audio level being fed back into the IF valve. If this level exceeded the valve's bias, the valve would cut off and the result would be the type of instability present in my Astor KM.

In fact, I had already discovered that the grid and cathode voltages of the 6B8G varied wildly when the instability showed up.

Furthermore, the text stated that the plate resistor used for most reflex stages was around 15kΩ instead of the 70kΩ that Astor commonly used in such circuits. As a result, I reduced the value of this resistor in steps and eventually came down to the recommended 15kΩ. The set was still unstable but the good news was that the instability was not occurring until the volume was wound higher than before.

I also observed that the instability occurred more readily on programs with a lot of low-frequency content.

Next, I disconnected the audio signal from the 6V6GT and used my signal tracer to listen to the IF/audio stage for any sign of the instability. There was none, so I reconnected the audio to the 6V6GT and the instability immediately reappeared.

Frankly, I was at a loss to understand what was going on until I put my finger on the cone of the loudspeaker and the instability largely disappeared. I then wedged a piece of paper between the frame of the speaker and the cone in such a position that cone was distorted and the instability disappeared altogether!

A new speaker will be fitted at a later date when I get one to suit. It would seem that the speaker "fault" was being fed back to the 6V6GT, which in turn fed it back to the 6B8G and caused the instability problems. It could only happen in a reflexed receiver!

Having discovered the cause of the problem, I removed the extra 270pF capacitor and 56kΩ resistor I had fitted and the receiver has remained stable ever since. The plate resistor on the 6B8G was left at 15kΩ, as no discernible difference in volume was observed.

Dial scale & speaker cloth

Having fixed the circuit, it was time to fit some fresh speaker cloth. I have some dark brown cloth and this was cut to size, glued and clamped in place until the glue (contact adhesive) dried.

The next job was to restring the dial cord but this proved to be relatively straightforward. It employs the usual unique Astor method, which doesn't slip like many other dial-drives often do. However, I did have a real problem with the dial pointer – it was missing, which meant that I would have to make a new one.

Eventually, I decided to make one using a small scrap of aluminium roof flashing and a short length of thick copper wire. I cut two slots in one side of the flashing and de-burred them to make sure the edges would not cut the dial cord when it was routed through these slots. I then laid the wire across the flashing and secured it in place using superglue along the join (see photo).

Finally, the pointer was painted white to show up against the speaker cloth. It looks just like the original.

Summary

Reflex sets can be difficult to troubleshoot because it's often almost impossible to determine whether the RF (radio frequency) sections or the audio sections are at fault. However, most reflex sets eventually respond to normal fault-finding techniques so don't be intimidated by them – they are an interesting part of our radio history.

Once its faults were overcome, the Astor KM set performed well and is quite sensitive. However, Astor's choice of rubber-insulated hook-up wire has been a problem in many of their sets.

In summary, it's quite a pleasant little set to use and look at and is certainly worthy of a place in my vintage radio collection. **SC**