# The Ultra-audion and/or Marnikay Receiver

**The very early single valve Ultra-audion is a such a seemingly simple set that it's a wonder it works at all. However finding out just how it *does* work was not an easy task...**

THIS MONTH'S story has been prompted by my restoration of a 'Varcola' one-valve set, made long ago by the Adelaide firm Varcoe & Co, of 57 Gawler Place in Adelaide. Varcoe & Co seemed to be one of the plethora of dealers-cum-builders who appeared and disappeared again within a couple of years (if that) in the mid 1920s.

The little set appears in Fig.1. It probably started life as a crystal set, and where there may well have been the crystal, there is now a valve holder. Similarly there may have been a stud switch for the coil, where there is now a rheostat. Varcoe and Co advertised in *The South Australian Wireless and Radio Weekly* in July 1925 as building their own sets and 'rebuilding and upgrading' your existing set.

The little sloping-fronted cabinet is more akin to a crystal set than a valve set, and when found was in a fairly sorry state. Each of the thin oak panels had cracked and in some cases warped, and a great amount of care and know-how was required to reglue and straighten them. A close friend who is a dab hand at French Polish finished it off to a high standard.

The panel was very badly oxidised, but was professionally cleaned and re-whitened.

Inside, there was practically no 'guts'. There was a very shabby coil former with a very loose single winding. Inside the former was the 2-ohm filament rheostat, thereby indicating a 'bright emitter' valve. (It's the position of the rheostat, inside the coil former, which suggests that this may have been where the stud switch was originally placed.) The tuning gang was missing, and the other wiring was so scant that it too was presumed to be incomplete.

However, upon tracing it out, the circuit appeared to be almost identical to that of the Ultra-audion (so-called) which appears in *Wireless Weekly* for December 30, 1927 — as reproduced in the booklet *The Best of Australia's Wireless Weekly in 1927*, produced a few years ago by *EA*.

The only difference to the Varcola and the *WW* circuit is that the grid leak is a fixed resistance, and in this case it appears to have been a home-made type: a piece of thin card upon which is a simple line drawn with 'Indian Ink' and then connected across the grid capacitor. In the Varcola set only a fragment remained, and it has been replaced with an older style 2MΩ resistor.

***Fig.1:* The little 'Varcola' set, which is really very simple and compact. It probably started life as a crystal set.**

By extreme good fortune, a tuning capacitor was unearthed in the spares department, complete with vernier, that bolted exactly into the existing mounting holes on the panel — and not only that, the dial matched exactly the large dial of the rheostat. There can be times when lady luck smiles!

## Theory of operation

It's not easy to understand the theory of operation for this (ostensibly) simplest of valve receivers. Firstly, it's necessary to understand how an oscillator works, and trying to find out that in words of one syllable or less can be likened to standing up in a hammock!

The so-called 'standard texts' such as *Radiotron Designers' Handbook*, Terman's *Radio Engineering* and *The Radio Amateur's Handbook(s)* were all remarkably brief and superficial in their description of an oscillator. However, a somewhat obscure publication called *Practical Radio Communication* (Arthur R. Nilson and J.L. Horling; McGraw-Hill Book Company Inc, 1943) describes the action of an oscillator very succinctly, and the following description and diagrams are largely quoted therefrom.

## Fundamental oscillator

Fig.2(a) shows the fundamental oscillator, and Fig.2(b) shows the curves illustrating the oscillator action. When switch S is closed, electrons are emitted and bombard the plate. This electron flow thus described will cause current flow in the plate circuit. At $t_0$, the moment of switch-on, there is no grid bias by Roger Johnson

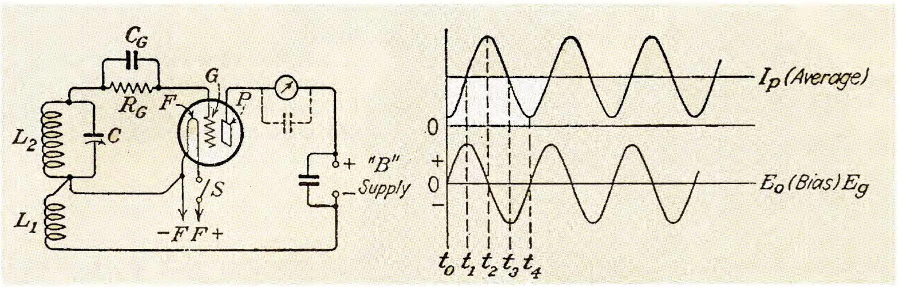


***Fig.2: The basic valve oscillator circuit, with the respective phasing diagrams of grid voltage and plate current.***

developed nor plate current flowing.

Beginning at $t_0$, the current will flow through coil L1, resulting in a magnetic field around the coil. This magnetic field subsequently induces a voltage in L2. The phasing of the coils, and hence the polarity, is important, and must be positive at the grid to cause an increase in plate current.

The voltage on the grid is proportional to the rate of change of plate current. When the plate current has reached $t_1$ on the curves, its rate of change (the interval between $t_1$ and $t_2$) will decrease due to the characteristics of the valve. As can also be seen, as the rate of change of plate current decreases, so the rate of change of grid voltage decreases, causing the rate of change of plate current to decrease even more.

Some careful understanding is required. Even though the plate current is actually on the increase, the *rate of change* is decreasing. Hence at time $t_2$ on the curves, the plate current is at a maximum, its rate of change is zero, and the induced voltage on the grid is zero.

As the plate current starts to decrease, the rate of change is now negative. Thus a negative voltage is induced on the grid, and the plate current decreases even further. This action continues until $t_4$ on the curves, when the plate current is minimum and the grid voltage is zero.

One cycle of oscillation has now been completed, and the process continues as long as the voltages are applied. The important thing to remember about an oscillator, is that the grid is positive for half of the cycle, and therefore grid current flows.

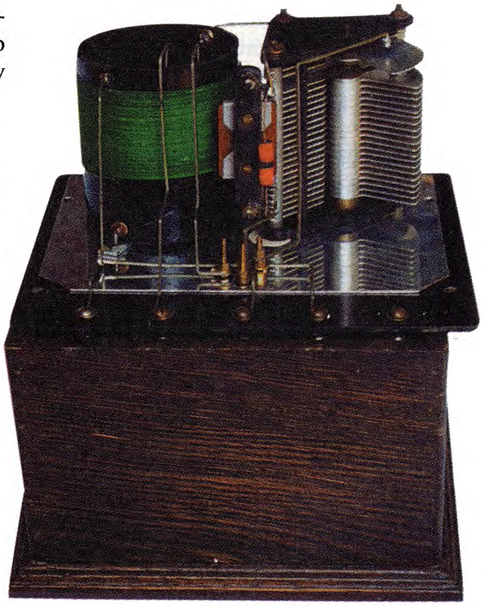
Another important concept about oscillators is that the valve itself does not oscillate. What it does is amplify the electrical impulses impressed on its grid from the oscillatory circuit, and delivers this amplified energy back to the output circuit to make up for the intrinsic losses and thereby maintain oscillations.

## Colpitts oscillator

Fig.3 illustrates the basic Colpitts capacitive feedback oscillator. The grid excitation voltage appears across the capacitive reactance C3. The initial excitation is produced as before through the plate blocking capacitor C2 in the form of electron displacement, which in turn causes electron displacement in the plate excitation capacitor C1. This produces a potential difference across C1 and C3 which excites the grid and produces sustained oscillations.

It may help the explanation if we remember that at the point of switch on, Ep charges C1 and C2 in series. These capacitors then commence their discharge at point X, through the coil to point Y which then charges C3. The discharge of C3 then produces the small positive grid voltage corresponding to the period $t_0$-$t_1$ of the previous diagram, and sets in motion the whole train of events to sustain oscillations.

In other words, the instantaneous voltages at the ends of the circuit are opposite in polarity with respect to the cathode, and are therefore in the right phase to sustain oscillations as described above.



***Behind the front panel, there's very little apart from the coil and tuning capacitor.***

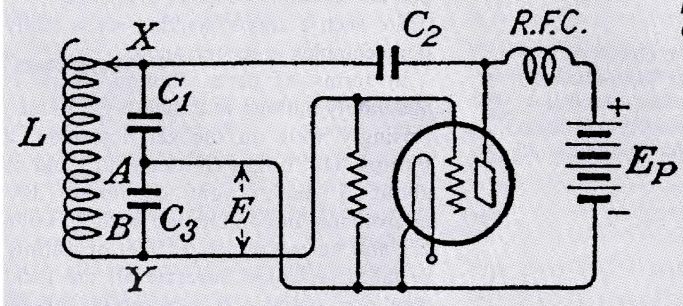
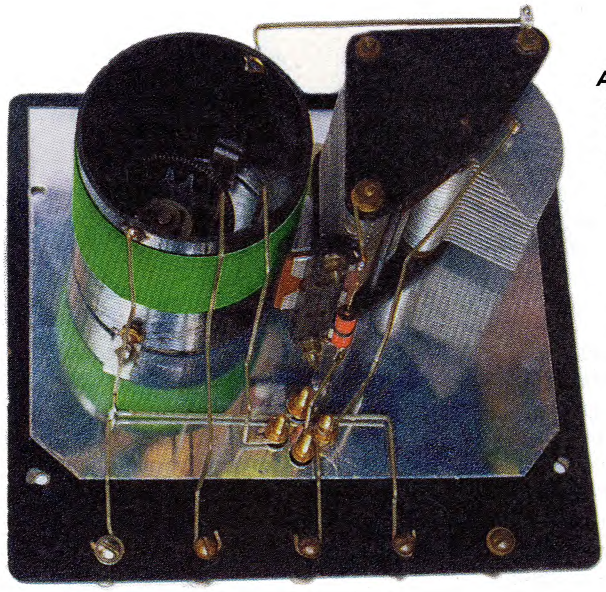


***Fig.3: The classic Colpitts oscillator.***



*Another view inside the set, showing the filament rheostat inside the coil former, and most of the wiring.*

## The Ultra-audion

The ultra-audion is said to be the equivalent of the Colpitts, but with the voltage division for oscillation brought about by the grid-to-filament and plate-to-filament capacitances of the valve itself. In the circuit of Fig.3 (in which incidentally the grid capacitor Cg is not shown, since it is illustrated as an oscillator and not as a detector), C1 is replaced by the plate-to-filament capacitance of the valve, and C3 is replaced by the grid-to-filament capacitance. However, this implies that the DC blocking capacitor C2 can no longer exist in the circuit. But does it have to be in the positive leg? Why not the negative leg?

## The WW circuit

So, is the circuit in Fig.4, the topic of our discussion, a true ultra-audion? Most likely it is not. The text for the article (30/12/27) claims that the circuit is better known as the 'Marnikay', and a closer examination again is warranted.

If it were a true ultra-audion, C1 from Fig.3 is implied by the plate-to-filament capacitance, and in the case of the circuit in Fig.4, would be directly from aerial to earth. (So it would include the antenna capacitance.) The other capacitance, C3 from Fig.3, is shunted across the 500pF tuning capacitor.

For the Colpitts/ultra-audion to function satisfactorily, conventional wisdom says that the ratio of C3/C1 is usually about 3 to 1. It's hard to see if this would apply here, since the plate-to-filament capacitance of the early triodes seldom exceeded about 5pF. Perhaps the antenna capacitance would make up the difference.

Another problem is that for oscillation C3-C1 must appear across the entire tuning coil, which again does not seem to be the case.

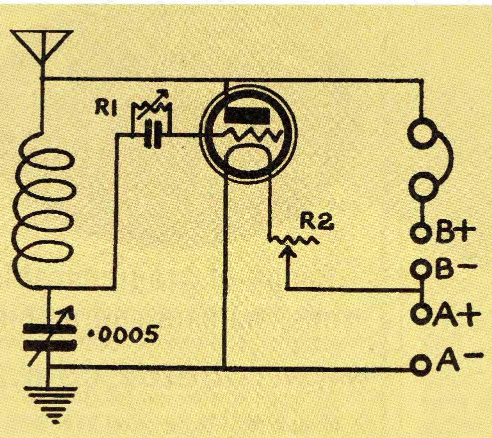


*Fig.4: The circuit for the so-called 'Ultra-audion' or 'Marnikay' receiver that appeared in Wireless Weekly for December 30, 1927.*

## Ultra-audion or Marnikay?

As there are sufficient discrepancies between the circuit of Fig.4 and the description of an ultra-audion, we are going to assume that this is not an ultra-audion at all, and refer to it as the Marnikay. So, just how does this little baby work?

The tuned circuit is a series tuned circuit (refer to my November 1998 column on Aerials, Coils and How it All Works). The full anode potential is applied through the tuning coil with obviously no DC loss. It then fully charges the tuning capacitor, and electrons freely pass from filament to plate thus causing plate current to flow. The tuning capacitor now discharges through R1.

At this stage, no current is being drawn, as there is no voltage drop across R1 and the full DC appears at the grid. The grid will now immediately draw current because it is positive, and hence a voltage drop will appear across R1. In some circuits, R1 is adjustable, and in others it is fixed. Nevertheless, a large enough voltage drop will appear across R1, and a correspondingly small positive grid potential will cause grid current to flow for a fraction of the cycle.

This will now cause the decreasing rate of change in plate current as described earlier on. A point in the cycle will be reached where there is zero grid voltage, maximum plate current, and the whole cycle starts again.

So, why does not a permanent positive DC voltage appear at the grid, by virtue of the plate being directly connected (via the coil, which can be ignored) to the resistor R1? The answer is that we have a resonant circuit, in which there is a voltage gain appearing across the tuning capacitor at the incoming frequency. This voltage is in the order of several hundred millivolts, and the resistor is adjusted to keep the grid just below the point of oscillation, like any other regenerative detector.

R1 also serves as the grid leak, and functions not by being connected directly to the filament as in a conventional circuit, but via the phones and the internal resistances of the batteries and hence to earth. The unmarked grid capacitor is of course the grid capacitor, which in conjunction with R1 forms a leaky grid detector.

The filament rheostat R2 is there for adjusting the gain of the valve, and controls the electron stream from cathode to anode. In the little set which is the subject of this article, R1 was a fixed resistance of 2MΩ and the entire gain, oscillation and ultimate selectivity was controlled via R2. As the valve was a bright emitter, anticipating the thermal inertia delay became a skill approaching a fine art! If R1 were a 1MΩ pot, the set would be easier to operate.

So, such a simple looking set is really quite complex in its operation.

In terms of parts, though, there is absolutely nothing to it, and it works surprisingly well. In the set described, a Philips 'D2' bright emitter with a mu of about 5 and a gm of about 300 micromhos, in conjunction with 45 volts HT and no more than 10 feet of trailing aerial wire, could separate all the local Adelaide stations at comfortable phone strength. Not bad, eh? ❖