

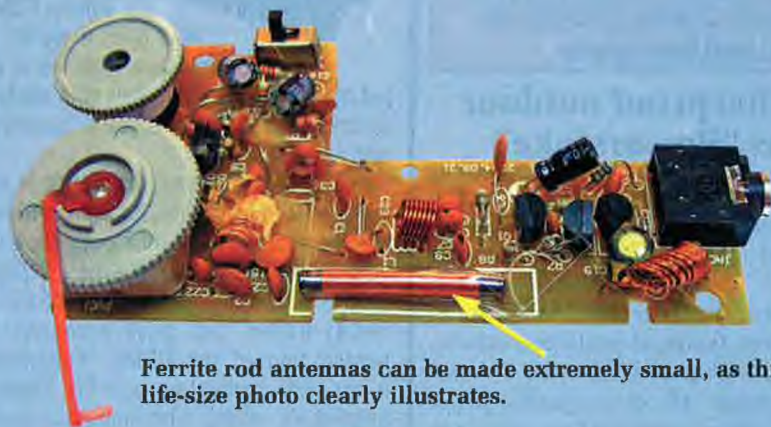
Vintage Radio

By RODNEY CHAMPNESS, VK3UG



Those mysterious antenna coils & loop antennas

Ever wondered about those mysterious antenna coils used in vintage radio receivers, or about those old-style loop antennas? This article unravels some of the mysteries.



Ferrite rod antennas can be made extremely small, as this life-size photo clearly illustrates.



This small AM/FM receiver uses the PC board shown above and is intended for use in strong signal areas only. Its miniature ferrite rod antenna means that its AM performance is pathetic compared to larger sets.

Broadcast-band radio signals are radiated from tall masts that are fed from nearby transmitters. One way to receive these radio signals is to put up an external wire antenna that's as high and as long as possible. One end of this antenna wire is brought down to the receiver and attached to the aerial terminal, while an earth wire is connected to the earth terminal (valve radio chassis were often not earthed back through the mains).

This type of "long-wire" antenna system largely responds to the electric component of the radio waves.

Another way to intercept these signals is to use a loop antenna. They vary widely in size, ranging from antennas consisting of several turns of wire which form a coil about one metre in diameter to very small, ferrite-cored loopstick antennas. Loop antennas couple to the magnetic component of the radio waves.

Both loop and long-wire antennas have been used since radio began.

Long wire antennas

Many vintage radio restorers have probably been puzzled as to why some receivers need only a small antenna to perform well, while others need a large antenna to give the same result.

The simple answer is that some sets require large antennas because they are either low-performance types or because they have faults which seriously degrade their performance. However, if we assume that a set is well-designed and that its sensitivity from the input of the converter onwards is good, then the only component that should further influence performance is the antenna coil.

By necessity, antennas are some-

thing of a compromise between size and performance. The best antenna for a broadcast radio is theoretically a quarter-wave unit fed against earth. However, this is hardly practical as at 531kHz, a quarter-wave antenna would be 141 metres long.

In fact, our so-called “long wire” antennas are still short when compared with a quarter-wave antenna at 1602kHz, as the latter is 47 metres long. This means that various techniques must be used to increase the effectiveness of wire antennas that are much shorter than the optimum length.

One simple method (as used in my crystal set in the April 2007 issue) is to employ an adjustable coil in series with the antenna. This adjustable coil resonates the antenna to the frequency being received and is commonly called a “base-loaded antenna” system. It worked well in my crystal set which was able to receive stations up to 300km away at comfortable head-phone volume.

Early methods

The very early antenna-to-receiver coupling methods were designed to extract the maximum amount of signal from the antenna system. This was necessary because there was no amplification in those early receivers to boost the signal fed to the detectors which were based on inefficient coherers and cat’s whiskers. Because of this, the antennas employed were huge in many cases.

With the advent of valves, it became practical to amplify the incoming signal and complex antenna coupling/matching systems were no longer needed. In fact, if you look at the circuits of some very early pre-valve receivers, you will see that there were many adjustments that could be made to achieve best reception. It was also quite easy to get these wrong and not receive a signal at all.

By simplifying the antenna-to-valve matching circuitry, receiver tuning became a much less arduous undertaking. It was now only necessary to adjust the tuning and the regeneration controls (pre-superhet receivers), although correct adjustment of the regeneration could be tricky. Often, in those early days, the lady of the household was not allowed to even touch such a technologically advanced piece of equipment!



The antenna coils in these early regenerative receivers coupled the energy from the antenna via a primary winding into the secondary tuned winding. This coupling was quite arbitrary. In addition, another coil was wound at the opposite end of the secondary tuned winding and this functioned as the feedback winding for the regeneration control.

Simplifying the controls

If you look back at the many circuits published on simple regenerative receivers, you will see that the coil diameters, wire gauges, number of turns used on each winding and their spacing, etc, varied so widely that no real design concept could be discerned. There was often little science involved in the process but quite large external antennas were still being used at that time so it didn’t really matter that the antenna system was not well-matched to the receiver’s input.

Things gradually changed as radio/wireless progressed out of the experimenter’s realm. Experimenters had prided themselves on getting good reception from their receivers and had relied on large antenna systems, substantial earths and their ability to fiddle with the adjustments on their receivers to extract maximum performance.

By the early 1930s, a new group of radio users had appeared who wanted to just turn the set on and enjoy the program. They were not interested in large antennas or fiddly receiver adjustments and most lacked the ability to even make these adjustments.

As a result, manufacturers could see that they had to design receivers that were usable by the average citizen. Innovations to achieve this included superheterodyne reception, automatic volume control (AVC/AGC), single knob tuning, loudspeaker output and the ability to operate from much

to find a way to get good performance with such short antennas and this was achieved in short order.

As mentioned above, I achieved good performance from my crystal set by using an adjustable loading coil in series with the antenna tap on the tuning coil. However, using this technique on domestic radio was never going to be accepted by the non-technical public.

The way around the problem was to design the aerial coil primary to have a reasonably high impedance and to be broadly resonant at a frequency somewhere around 320-420kHz (ie, below the lowest tuned frequency). This gave a rising response/sensitivity at the low end of the broadcast band, although some coils also required an external 100pF capacitor across the primary.

The coupling to the secondary was relatively light, so that changing an antenna wouldn't upset the tuning of the secondary coil. The performance at the high-frequency end of the band was enhanced by wiring a low-value capacitor from the top of the primary winding to the top of the secondary winding.

Typical values for this capacitor ranged from 2-5pF or it could simply be formed by connecting a lead to the primary winding and laying it close to the secondary.

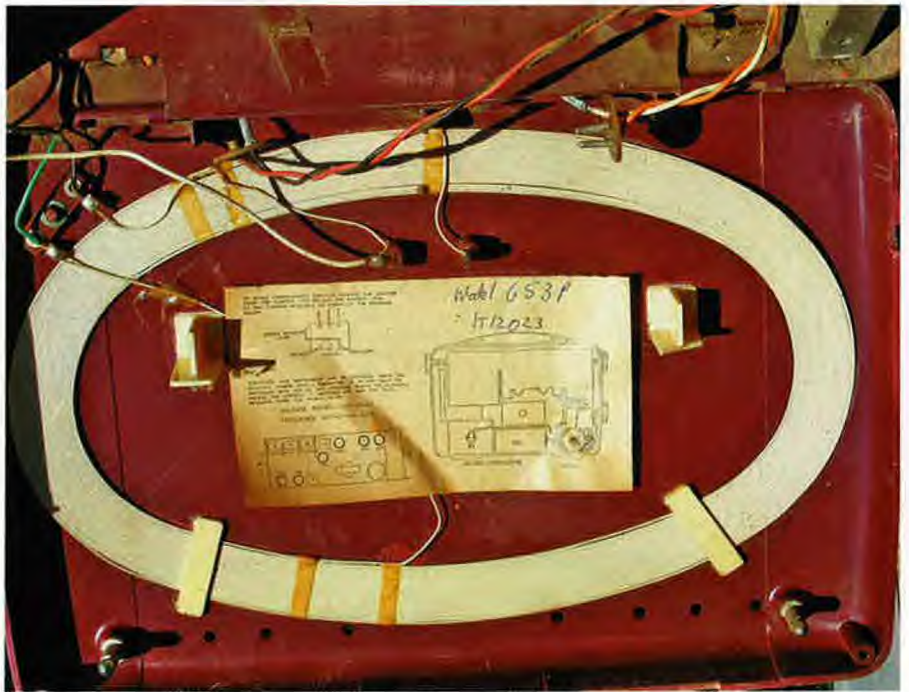
Basically, the coil was optimised to give high sensitivity on the BC (broadcast) band with a short antenna and substituting larger antennas gave little improvement. Another advantage was that using differing antenna lengths or antennas with different characteristics did not cause any severe detuning of the circuit.

Most manufacturers of domestic household valve receivers used variable-gang tuning capacitors. There were some exceptions though and Astor was one of the few that also used inductance tuning of the antenna (and oscillator) circuits. A typical circuit is shown in Fig.2.

In that circuit, the antenna impedance is matched to that of the valve using capacitors 45, 11 & 16. This matching remains substantially the same across the broadcast band. No series-loading coil was used.

Country antennas

The antenna coils fitted to receivers in country areas were more like those



A typical flat-loop antenna, in this case from an AWA 653P AC/Battery portable receiver (circa 1954). It was attached to the inside back of the cabinet.

used in early sets. Basically, the design concept was similar to that used in the suburban sets but the antenna coil was designed for optimum performance with a larger antenna.

Receivers for country areas were generally more sensitive than their suburban counterparts to enable them to pick up signals in regions remote from radio stations. AM commercial broadcasting stations in the heyday of valve radios generally used 5kW transmitters in the city and 2kW transmitters in the country. This now seems rather odd, as a country audience would have been spread over a greater distance compared to the audience in the city. Higher-powered stations in the country would have been more logical, not the other way around.

Because country signals were weaker, radios were commonly fitted with a radio frequency (RF) stage to boost their sensitivity. In addition, a long outside antenna was usually necessary to ensure that a good signal was fed to the receiver. An outside antenna was also necessary to avoid picking up in-home electrical interference.

Shortwave antennas

Shortwave antenna coils were designed to mate with long antennas too. They are often solenoid wound with the primary and secondary in close proximity to one another.

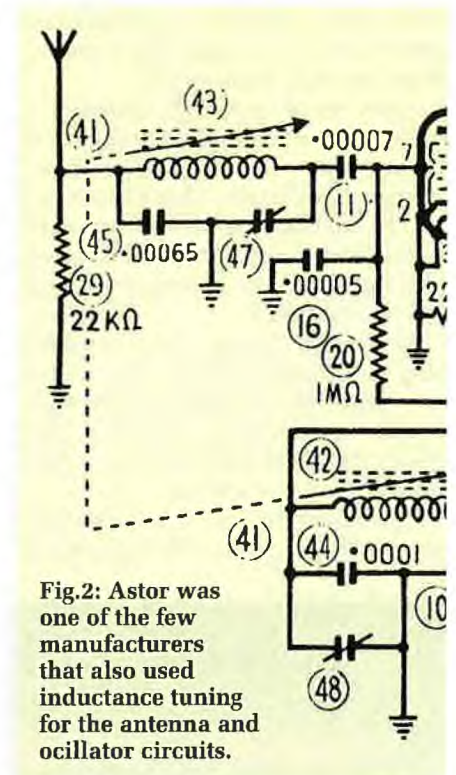


Fig.2: Astor was one of the few manufacturers that also used inductance tuning for the antenna and oscillator circuits.

In reality, their design was very much a compromise and the sets to which they were fitted often used an RF stage to increase the gain, to make up for the barely adequate antenna and RF coils.

When tuning the common 6-18MHz shortwave band, a quarter-wave an-



The loop antenna for this 1925 RCA 26 portable radio receiver is contained in the hinged section at left. It can be rotated for optimum reception.

tenna will vary from 4.2 metres long at 18MHz to 12.5 metres long at 6MHz. This means that even a picture-rail-antenna may be longer than a quarter wave on some frequencies.

However, it was still desirable to have a decent outside antenna even though it may be much longer than a quarter wavelength. That's because it would then be outside the household noise field (a consideration that was also important on the broadcast band in country areas).

Shortwave signals vary considerably in strength and 4-valve radios were generally considered to be inadequate for shortwave reception. As a result, most sets with shortwave fitted used at least five valves.

For those who were really keen on shortwave listening, AWA produced

sets like their famous 7-band, 6-valve sets, while Astor and HMV produced receivers capable of covering several international shortwave broadcast bands. The antenna coils used in the Astor sets consisted of a single winding coupled to the antenna by a 4pF mica capacitor.

Resonant antennas

Antenna coils designed for use with resonant antennas (eg, those used by radio amateurs) are different again.

In this case, the antenna coil winding is designed to suit the impedance of the antenna. The primary winding may have one end earthed or it may have both ends floating so they can be attached to a resonant dipole antenna or to a balanced feeder cable.

This floating winding may also

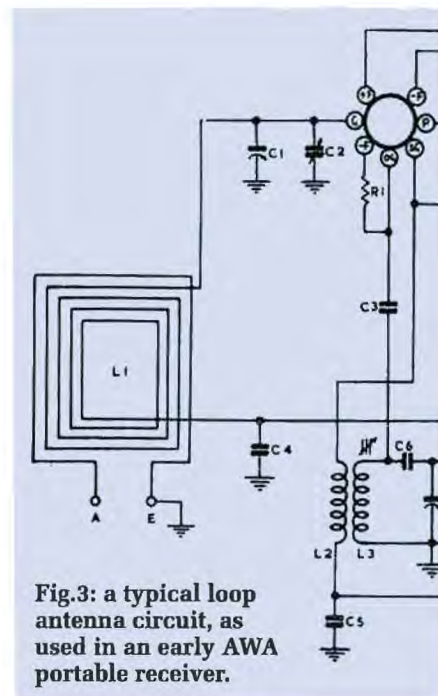


Fig.3: a typical loop antenna circuit, as used in an early AWA portable receiver.

have a centre tap, which is earthed. The purpose of this is to balance the two sections of the coil and to act as an earth to discharge any static-charge build-ups on the antenna.

Loop antennas

Loop antennas were developed around the same time as long-wire antennas. They were a very convenient way of receiving signals, as they didn't require the construction of a large outside structure. However, they did require a frame up to about one metre in diameter to accommodate the antenna coils and this was usually installed on top of the receiver or incorporated into the cabinet.

As time went by, the loop diameter progressively decreased and there were a few reasons for this. First, the strength of the signals increased due to broadcasting stations increasing their output power and improving the antenna systems. Second, various components such as valves improved and so receivers became more sensitive. As a result, smaller loop antennas gave the same end result as a larger loop antenna in earlier days.

Another reason was that consumers wanted the antenna to be less intrusive and they wanted their receivers to be more portable, so that they could be easily moved from room to room.

The original loop antennas consisted of several turns wound around a wooden frame. These turns were



Left: a solenoid-type aerial coil as used in the Raycophone "Pee Wee" AM radio from about 1933.

spaced well away from each other to minimise any inter-winding capacitance. The tuning capacitor was mounted inside the receiver and was connected to the antenna loop by two flexible wires, ie, one to each end of the winding.

Loop antennas had one feature that proved invaluable if there were two strong stations on adjacent frequencies. By rotating the loop, the unwanted station could be almost completely nulled out so that it did not cause interference to the wanted station, a feature that can still be important today.

This particular characteristic was also used in direction finding receivers during the war, to determine where a transmitting station might be.

By 1925, loop antennas had been reduced down to quite manageable sizes. The loop antenna used in the RCA 26 receiver featured in the August 2008 issue illustrates this.

It's also worth noting that when loopstick antennas became the fashion, the primary winding (which is attached to the antenna) was more like that used in the antenna coils for amateur radio receivers. However, they also featured an RF choke (wound on a resistor) in series with the antenna lead and this basically acted as a loading coil.

This allowed the set to be peaked with an "average" antenna to some spot on the broadcast band. The resistor loaded the coil and reduced its "Q", so that this peaking effect was spread out over a much larger section of the broadcast band, ie, the peaking effect at the resonant frequency of the antenna and loading coil was significantly reduced.

Portable receivers

Portable radio receivers have used loop antennas of some sort almost since radio began. A typical antenna in such sets (before ferrite rod antennas became common) consisted of a flat coil which was usually in the back of the receiver case (eg, as in the AWA 653P featured in the September 2008 issue). The loop also generally had a 2-turn primary winding that could be connected to an external antenna and earth.

Astor sets often used a damped loading coil in series with their loop antennas, as subsequently used with many ferrite rod antennas.

Photo Gallery: Peter Pan BKJ



The Peter Pan BKJ was manufactured around 1946 by Eclipse Radio in Melbourne and this particular example was restored by Bill Smith. It employed a conventional superhet circuit and the valve line-up was as follows: 6J8G mixer, 6U7G IF amplifier, 6B6G detector/first audio amplifier, 6V6G audio output and 5Y5G rectifier. Photo by Kevin Poulter for the Historical Radio Society of Australia (HRSA). Phone (03) 9539 1117. www.hrsa.net.au

Some personal portables even used a carrying strap embedded with tinselled wire as the loop antenna. This was not tuned but was wired in

parallel with the tuned antenna coil primary.

Summary

Antenna coils, whether attached to external antennas or used to receive signals directly (as loop antennas do), were all designed to suit their particular application. Large loop antennas like those shown in the photos are extremely efficient. If a small transistor portable is placed within such a loop antenna, the performance of the set will be markedly improved when the loop is tuned to the station of interest and rotated for maximum pickup.

Ferrite rod antennas are now used in virtually all AM broadcast band receivers. Their development (along with the invention of transistors) meant that receivers could be made much smaller than before and still work satisfactorily in most areas.

Ferrite rod antennas can be made extremely small, as can be seen in a photograph at the start of this article. In that case, the ferrite rod is about half the size of a matchstick! Of course, the set's performance is pathetic compared to sets with ferrite rods like that used in the AWA B32. **SC**



A typical "pocket-portable" AM radio from the 1970s. The small loopstick antenna is at the top and gave adequate performance on strong local stations.