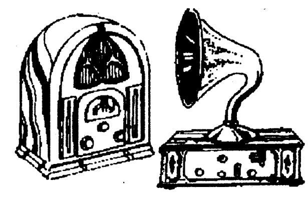
Vintage Radio



by PETER LANKSHEAR

The vintage Beverage

No, *EA* is not joining the glossy magazine fashion in featuring a wine column — this month we are presenting the story of a legendary aerial. Now about 75 years old, the Beverage or 'Wave' antenna is generally regarded as the ultimate for low and medium frequency reception.

Much of modern electronics would be practically unrecognisable to the early radio pioneers, but some early technology, especially that of aerials has survived. One of these, the Beverage, is still unsurpassed for its directional qualities combined with weak signal reception in the crowded broadcast band.

Dr Harold H. Beverage was the leader of the team who worked on a directional receiving aerial project, officially known as the 'Wave Antenna', early this century. Some of the background information that follows has come from a letter written in 1981, in which he relates the story behind the evolution of the aerial that later took his name.

In 1917, as America entered World War 1, the Chief Radio Engineer of General Electric was Swedish born Dr E.F.W. Alexanderson, best known for his development of the Alexanderson RF alternator — until the early 1920's the most efficient and powerful generator of what was then called 'RF'.

The final version of Alexanderson's alternator was capable of producing 200 kilowatts directly into an aerial, at frequencies of up to 33kHz. Twenty of the 50-ton 200kW monsters were built, and some were not retired until after World War II! In fact, one at Varburg in Sweden is still operational, and is run up for a test period each month.

In those far-off days, 2MHz was the upper limit for existing technology and what is now the broadcast band was actually called short wave. America's Expeditionary Force in France depended on the trans-Atlantic telegraph cables and VLF radio transmissions for their vital communications with Washington. The French pointed out that, as at any time the Germans could cut the cables and jam the radio transmissions, these links were very vulnerable.

A countermeasure suggested to Dr Alexanderson as a consultant, was that a receiving system could be set up in Eastern France to balance out German jamming, at the same time as an Allied jamming 'barrage' set up in Western France would prevent any German eavesdropping of the American transmissions. The problem was to develop a directional receiving aerial with two 'nulls': one to eliminate the German jamming, the other the Allies' own barrage signals.

The resourceful Dr Alexanderson had about five possible solutions, but the one chosen for development was similar to a 'Ground Aerial' developed in Europe by F. Kieblitz.

Several early workers, including Marconi, had discovered that a wire near the ground exhibited directional receiving effects. In 1911, Kieblitz (who was investigating currents induced in the earth by passing radio signals) found that he could obtain good directional signals at the centre of a length of wire supported about one metre above the ground and earthed at its extremities.

Beverage's tests

Preliminary experiments were conducted by Dr Beverage, one of Alexanderson's staff, at New Brunswick (New Jersey) near the high powered Alexanderson alternator equipped US Navy station NFF. Two rubber insulated wires, each two miles in length, were laid in line on the ground in a Southwest - Northeast direction.

The test equipment was connected in the middle, at the junction of the wires, by adjustable phasing networks. Although the Southwest wire terminated only two miles from the NFF transmit-

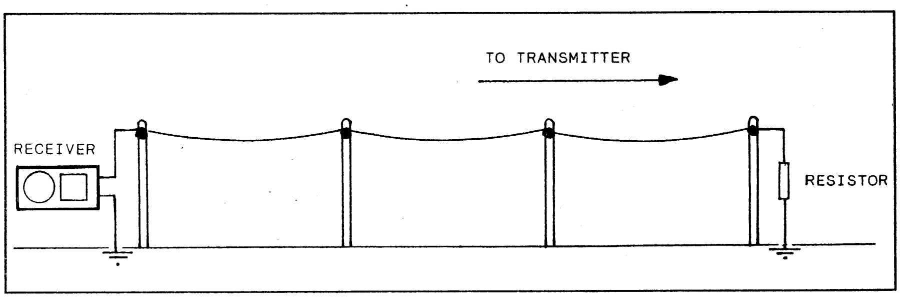


Fig.1 (above): The classic Wave or Beverage broadcast aerial, with a length of wire between 300 metres and one kilometre for MF reception, and supported about three metres above the ground.

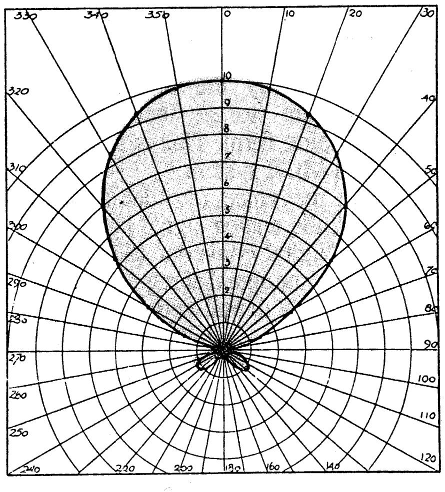


Fig.2 (right): The polar diagram of a one-wavelength long Beverage aerial, showing the gain and directivity performance usually associated with VHF arrays. A little surprising, considering the aerial's simple contruction...

ting aerial, by balancing out NFF signals with the phasing network, and despite there being only a small frequency difference, reception of the MUU transmissions from Carnarvon in Wales was possible.

The success of what was at this stage called the Barrage aerial was noted by the US Navy, who requested that a similar system should be installed by Dr Beverage at its receiving station at Bar Harbour, on the coast of Maine in the far Northeast of the US. Again two-mile lengths of wire running Northeast and Southwest were strung out. Although here the terrain is quite mountainous, results were again excellent.

As expected, the Northeast pointing wire received strong European signals, but the Southwest wire produced little but heavy static. At first Dr Beverage attributed this apparent anomaly to a 'dog-leg' in the aerial, where it deviated to cross a river by way of a bridge; but when he straightened up the wire there was no difference.

Fig.3: The Southland Branch of the New Zealand DX League has a listening post with a selection of Beverage aerials providing world-wide reception of MF transmissions. Situated on a tussock and scrub covered shingle spit with sea water on practically three sides, and with the nearest power line a couple of kilometres distant, conditions are ideal for this type of aerial. This is a typical aerial pole for the Southland array.

Intrigued by this odd behaviour, he took a receiver to the Southwest end of the Southwest wire — to find that there was no static, but the European signals were now just as strong as with the other wire! Obviously the aerials were highly directional and the static, which was coming from thunderstorms in the US Southwest, was only a problem when the wire pointed towards the source.

Beverage next shifted his experiments to sandy country at Riverhead on Long Island, where he ran out a six-mile length of wire alongside a road. Cutting the receiver in at various points along the wire enabled him to make observations to gain a better idea of what was happening.

He determined that the wavefront of a signal built up an increasing voltage as it travelled along the line of the aerial wire. Signals or static from the reverse direction were not reflected back, but were absorbed in losses in the wire which, due to its proximity to the ground, were high.

By a fortunate coincidence, at the frequencies used, the two-mile length decided on turned out to be optimum for wire in contact with the ground.

Rice & Kellogg again

At this stage measurements were required to confirm the experimental conclusions. For this work the team was joined by Chester Rice and Edward Kellogg, who were later to make the first practical moving coil loudspeaker (see *EA*, May 1990). A nine-mile aerial was built, using regular telephone line construction. With the height now several metres above ground, losses were reduced and the velocity of signals in the wire increased.

With the end nearest to the transmitter terminated with a suitable resistor, signals from the reverse direction were completely absorbed without the need of phasing networks.

Officially called the 'Wave Antenna' from its being about a wavelength long, the new aerial worked well over a wide frequency range. The results and conclusions from these experiments were published in an extensive report in the *Transactions* of the American Institute of Electrical Engineers for 1923.

Later renamed

After World War I, there was a concentrated effort to receive American amateur transmissions in Britain. As initial tests were unsuccessful, leading US amateur Paul Godley was sent to Scotland in 1920 with an Armstrong superheterodyne receiver. He happened to be travelling on the *Acquitania*, at the same time as Harold Beverage who, when he discovered Godley's mission, promptly designed a suitable Wave antenna for the project. The results were most successful, with many US signals received, and in his report in *QST* magazine, Godley referred to the aerial as the 'Beverage'. The name has stuck ever since.

Fig.4: Fence posts can provide secure mountings for lightweight poles, as this close-up shows.

So much for the background. How does the Beverage aerial work, and what are the constructional requirements?

The bad news

First though, it is not normally possible to construct a Beverage aerial in an urban area. The absolute minimum size is about half a wavelength at the lowest frequency to be received. To cover the broadcast band, the shortest length is about 300 metres, with a kilometre not too long. Furthermore the wire must run reasonably close to the direction of the incoming signals. However, if space is available, as Fig.2 shows, the directivity and signal pickup are superb, making it the ideal broadcast band aerial for DX and for country listeners remote from transmitters.

Regardless of whether it is a wire suspended from a pole, a bed spring, or just a lead dangling from the rear of the chassis, the usual medium frequency domestic receiving aerial, other than the ferrite rod aerial and the loop, is an adaptation of Marconi's original aerial system. The earth forms half the Marconi aerial, and the practical outcome is that the vertical portion does the real work of receiving. The greater the height, the better the signal pickup.

Unlike the Marconi, the Beverage aerial does not rely on height for its operation, but the horizontal portion in line with the path of the incoming signal. As the wave travels along the wire, the voltage induced builds up until it reaches a maximum at the receiver end of the aerial wire. So far so good, but in real life this does not work with a wire remote from the ground. The reason is that an electric current does not travel as quickly in a wire as an electromagnetic wave moving at the speed of light in free space. The two get out of phase and cancellations result.

The trick with the Beverage aerial is to have the signal 'drag its feet', as it were. This happens close to poor-to-medium conductivity soil, where the wavefront becomes tilted. With the wire at the correct height the retarded signal and the induced voltage remain in step, with the result that the further the wave travels along the wire, the greater is the voltage build up in the aerial.

Conveniently, with typical soil conductivities, a suitable height for the broadcast band happens to be two or three metres. One perhaps unexpected condition could arise where very high conductivity soils may not create sufficient retardation.

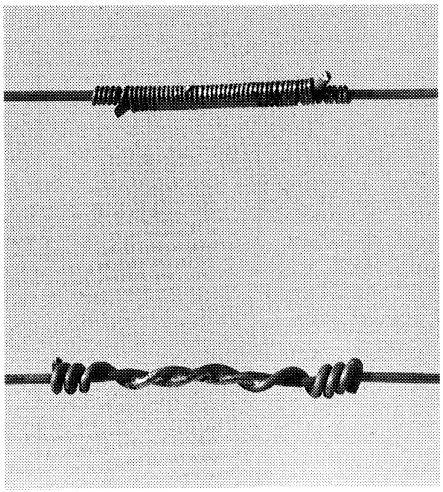


Fig.5: Two splices suitable for aerial wires. To avoid corrosion, the binder wire in the upper example should be of the same metal as the line wire. Solder only the centre of splices, or metal fatigue may eventually cause them to fracture.

Signals arriving at the side of a Beverage antenna encounter a different situation. The voltages that are induced are random in phase, and are not additive. Side on, it behaves more like a Marconi aerial of very small height, and consequentially there is relatively little conventional aerial action.

Making one...

For readers with plenty of real estate available who would like improved broadcast reception, a 'homebrewed' Beverage could be well worthwhile. The ideal is to use standard telephone line construction, and it may be a practical proposition to purchase some surplus Telecom equipment.

Depending on height and strength, poles can be spaced at intervals of 50 to 75 metres. Copper wire has the best conductivity, but galvanised iron wire is quite satisfactory and is stronger than copper. Any wire splices should preferably be soldered, and two suitable methods are shown in Fig.5. Oxidised contacts from unsoldered splices can create diodes, which may generate intermodulation and other interference.

If Telecom type material is not available, sapling poles can be used, or lengths of 50mm-square timber can be strapped or bolted to fence posts. The chief requirement is to have adequate headroom and security against weather and stock. Heavier poles can be fitted with telephone type insulators, but for small diameter supports, electric fence insulators are suitable.

Must be terminated

For stable operation, low resistance ground connections at each end are important and as anyone who has measured electricity supply earths will know, the efficiency of the traditional single metal rod or piece of pipe driven into the ground can be quite low. Several rods spaced a metre or so apart and wired together should be used.

An unterminated Beverage aerial is of course bi-directional, and results will be less than optimum. There is no discrimination from the rear, and standing waves in the wire may cause cancellations at some frequencies. This effect, of signals varying cyclically, can often be noticed on a car radio when travelling directly towards or away from a transmitter and parallel to a pole line.

The nominal value for the terminating resistor is around 500 ohms, and can best be found by test — although it may not be consistent over the whole of the broadcast band. About the best way to determine the value is connect a 1000-ohm potentiometer between the far end of the aerial and the earth connection.

To adjust the potentiometer may require some ingenuity. A visual link, temporary telephone line, cordless phone or CB radio link or similar, and an assistant are necessary. With a distant signal from the *rear* of the aerial tuned in on the receiver, the potentiometer is adjusted for minimum output. Its resistance is then measured and a fixed resistor of the same value is connected permanently.

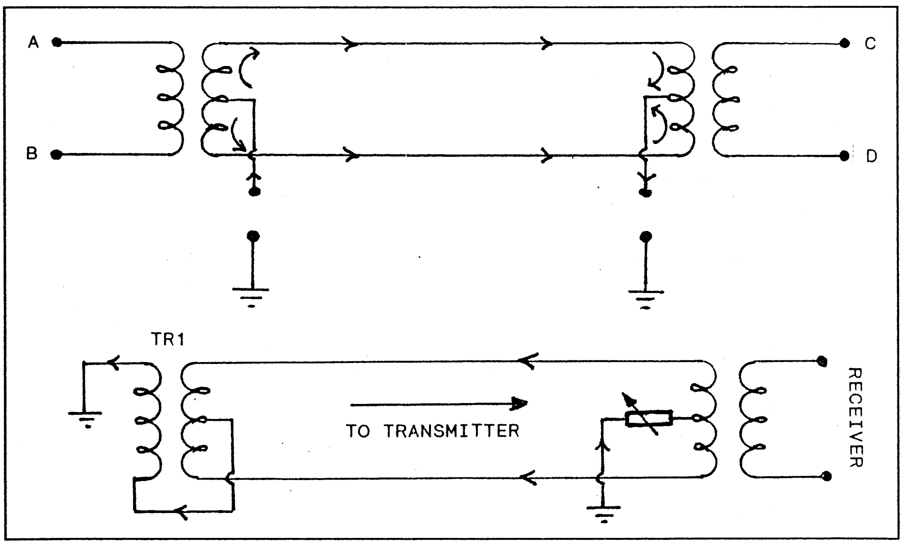


Fig.6: At top is the basic idea of a 'phantom' circuit, with a two-wire line carrying two independent circuits — one from AB to CD via the repeating transformers, using only the two lines, and the other using both lines in parallel with the earth as return path. Below is shown how the idea is used to 'reverse' a Beverage aerial, allowing the terminating resistor to be located at the receiver end.

Coating the resistor with a layer of epoxy resin is sufficient weatherproofing.

Phantoms & ghosts

There may be situations where an aerial can only be built in the 'reverse' direction, and furthermore, adjusting the termination would obviously be easier if the resistor could be alongside the receiver, rather than at the far end.

A Beverage aerial built with two parallel wires can be reversed by means of the *phantom* circuit — a trick nearly as old as telephony. The wires operate as the aerial in one direction and as balanced feeders in the reverse.

As can be seen from Fig.6a, by using 'repeating' transformers with centre-tapped windings, it is possible to derive a second circuit from a single pair of wires. In the days of open-wire lines, balanced phantom circuits were common, as they enabled considerable savings in wire. For the cost of four repeating transformers, two physical pairs produced a third circuit.

It was further possible to derive a 'ghost' from two phantoms, creating seven balanced pairs from eight wires. Two ghosts could even produce a 'spook', or 15 circuits from 16 wires, but the exercise was by this stage getting a bit out of hand!

By using two conductors, the phantom principle can be adapted to the Beverage aerial. Construction should be reasonably symmetrical, with a wire spacing of about 50cm.

As can be seen from Fig.6b, the two wires work in parallel as an aerial, and the signal builds up in the normal manner as it travels away from the terminating resistor. At the far end, the signal is coupled by means of the repeating transformer back into the two wires — which now operate as a balanced feeder line. A similar transformer at the receiver end connects the line to the receiver and provides the connection for the terminating resistor — which can usefully be adjustable, to allow easy nulling.

During a thunderstorm, an aerial as big as the Beverage can pick up a lot of energy, even without a direct strike. When it is not in use, never leave a receiver connected. For good measure, it is also wise to ground the aerial.

Underground aerials?

Older textbooks commonly refer to underground aerials, and illustrate a wire inside a line of pipes. There is often mention of static reducing properties, implying that the ground acts as some sort of a filter. However, as these descriptions are short on specifics, it is likely that the information is not first hand.

It seems possible that the original idea of an underground aerial was derived from a Beverage aerial, buried just beneath the surface of very low conductivity soil. Presumably any static reducing properties were from the directional effects discovered by Harry Beverage. If this is the case, conventional Beverage aerial construction as described earlier in this article should be as effective as any underground installation, and a lot less expensive! ❖

Collector's Corner

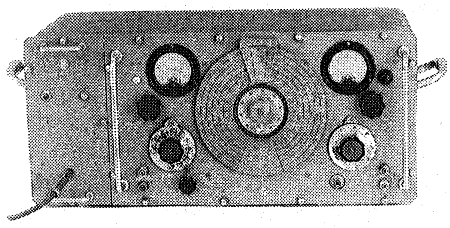
Where readers display prized items of radios and other equipment from their collections, and/or seek information from other collectors...

Thanks, and a request closer to home...

In this column in the January issue, we published a request from 'A.P.' of Cronulla, NSW for the circuit of a Triplett RF signal generator he wanted to restore. We were delighted to see that two different readers responded, sending in copies of not only the circuit schematic but also the complete user manual! Needless to say we sent them off to 'A.P.', who is most grateful and has asked us to convey this to the readers concerned.

There's no doubt that EA's readers collectively possess an enormous fund of technical information, and are most generous in sharing it. This being the case, and also because we're a little short of Collector's Corner items at present, I'm prompted to make a request myself — for the circuit of another old RF signal generator (I too am a collector of old test gear!).

This one is a classic AWA model, pictured at right. It's a type 3R7231, and I think it was made in the 1940's. I remember using one very much like it when I worked there, in the late 1950's. It's built in a big and very solid aluminium case, with a solid brass disc dial on which the tuning scales are all engraved. There are 10 bands, tuning from 95kHz to 31MHz. The two meters read modulation



(AM only) and RF output respectively. The power supply is in the separate compartment on the left-hand end.

It appears to have a 6V6 as the main RF oscillator, and another as a modulator; but there are other valves as well. It's beautifully made, and when I get time I want to bring it back to full working order. Is it possible that one of our readers can provide me with a copy of the circuit, or might even be able and prepared to loan me the manual to make a photocopy? **(Jim Rowe, *EA* editor)**

More contributions, too!

While I'm making requests, we do seem to be experiencing a drought at present regarding Collector's Corner contributions. What's happened to all of you keen collectors — isn't there anything you want to boast about, or need help with?