LOOP AERIALS

The first ever receiving aerial was a loop – a type of aerial that has had periods of limited popularity. Today its descendants dominate broadcast band reception.

The German physicist Heinrich Hertz is generally credited with putting the science of electromagnetic radiations on a firm footing. During the years 1886-88, he conducted a series of experiments to confirm the existence of the phenomena that had been predicted in 1864 by the Scottish mathematician James Clerk Maxwell. Many of Hertz's experiments were conducted in what is now known as the VHF band, and the receiver he most frequently used incorporated a directly excited single-turn tuned circuit that was in fact, a loop aerial.

With his loop, Hertz was able to prove that electromagnetic waves behaved like light in that they could be directed, reflected and refracted. He also observed that the orientation of the loop affected the intensity of the received signal.

Since then, loops have come in many different shapes and sizes. Generally multi turn, it is today most used at medium and low frequencies.

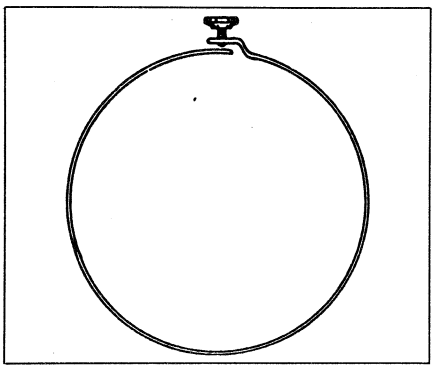

Fig.1: Hertz's receiver. This diagram from a 1906 book shows how the loop included a microscopic spark gap which discharged on receiving a signal. It has been estimated that at least 300 volts would have been necessary to create a visible spark. But with this elementary and insensitive equipment, Hertz was able to prove Maxwell's predictions of the behaviour of radio waves.

Wound on a cruciform wooden frame as either a flat spiral or as a box, the loop aerial became one of radio's early symbols. To be domestically acceptable, some were made to be folded for easy storage. Today, use of the loop in its modern form as the ferrite rod antenna is almost universal.

How loops work

As there is a detailed analysis of loop operation in just about every book on radio fundamentals, this description will be brief.

The electromagnetic component of a passing radio wavefront generates voltages in the vertical portions of the loop, but nothing in the horizontal sections. If the vertical legs are in the plane of the radio wave, there will be equal voltages generated in each. These will cancel and the net result at the terminals will be nil, accounting for the well known nulling and direction finding properties of the loop.

If the loop is turned through 90°, the vertical legs are now spaced through the line of the cyclically moving wavefront. The induced voltages will no longer be equal, but there will be a small difference voltage which is dependent on the distance between the legs, their length, and the number of turns. This difference voltage becomes the useful output of the loop.

Provided that there are no re-entrant components, the shape of the loop is unimportant and it can be rectangular, square, triangular or even circular. Output is proportional to area and significantly, height above the ground is unimportant.

Early uses

During the last decade of the 19th century, workable systems of wireless telegraphy evolved. Increased transmission range was a prime requirement, and, following Marconi's discovery that

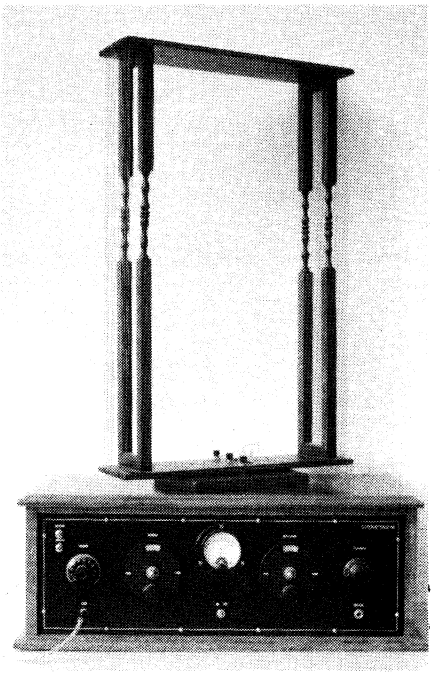

Fig.2: Homebuilt box loop and superheterodyne receiver from the late 1920's. The loop is centre tapped, to enable regeneration to be applied to the RF amplifier valve. Many early superhets used a self-oscillating mixer coupled to the aerial.

elevated wires improved signal strengths considerably, development concentrated on large open aerials. Prior to the availability of the high vacuum triode valve, there was no way of amplifying received signals, and the big Marconi aerial was essential to extract sufficient energy for reasonable reception. Loop aerials were far too inefficient for practical communications.

Nevertheless, during 1905, H.J. Round of the Marconi Company investigated the direction-finding properties of loop or frame aerials. This characteristic had important implications for marine radio location, and the outbreak of the 1914-1918 war stimulated further re-

search. The high vacuum triode valve had recently become available, and RF amplification of loop signals, although somewhat inefficient, was possible.

Loops in WW1

Honouring H.J. Round in an address to the Radio Club of America in 1952, Edwin Armstrong – of superhet and FM fame – related how his friend Captain Round had by 1916, developed a stable RF amplifier with no less than 19 stages of amplification! This was used in conjunction with a direction finding loop to eavesdrop on the German Navy, safe at anchor in Willemshaven, 300 miles away. The unsuspecting Germans actually used plain language for their traffic, not imagining that they were being monitored.

Armstrong quoted from the memoirs of the First Sea Lord, Admiral Sir Henry Jackson, who was himself a naval radio pioneer. Jackson wrote how one day Round's direction-finding equipment had indicated that the source of the signals from one of the German ships had changed position about 1.5°. This alerted the British Admiralty to the possibility that the Germans were putting to sea, and the order was given to the Royal Navy's Grand Fleet to intercept them. The German fleet was located and the outcome on the 31st May 1916 was the great Battle of Jutland. Already, the loop aerial was a vital piece of equipment in marine radio.

During the early post war period, the prime application of the loop was as a direction-finding aid. It is useless as a transmitting aerial and its low efficiency meant that there was little incentive to use it as a receiving aerial for normal communication work. It was no match for the large wire aerials that were readily erected on ships and at land stations.

With the development of broadcasting in the early 1920's, the emphasis was still on aerial efficiency. At first, transmitters were low powered and receivers insensitive. In the United States, as in Australasia, listeners were frequently long distances from transmitters, many of which were low powered. Large aerials, today erroneously called 'longwire', were essential and forests of poles sprouted in back yards.

Britain different

In England, the situation by the late 1920's was somewhat different. The country had good coverage from a network of high powered transmitters, and although many listeners could only afford crystal sets which did need large aerials, loops could often provide adequate reception with multi-valve radios.

Many listeners preferred their radios to be movable. In his book *Radio Radio*, Johnathan Hill claims that around 1926, portables had a leading share of the British market. It was common for these receivers to have a loop aerial either in the lid or wound around the inside the cabinet. During most of the year, they were used as domestic receivers, but could be taken outdoors if and when the weather permitted.

Here, and in America, portable receivers had not been anywhere near as common as in Britain. However, prior to 1930, many of the early superheterodynes did use loop aerials. A major reason was that they frequently used a self-oscillating mixer valve, which could radiate a considerable amount of interference if coupled to a large aerial. Early New Zealand radio regulations actually required superheterodyne receivers to use loop aerials!

The early RCA superhets were often supplied with ornate loop aerials and some sensitive American neutralised-triode TRF receivers were provided with loop aerials that could be folded away inside the cabinet when not in use. By the use of a jack plug that disconnected the input tuning coil, use of the loop could be optional.

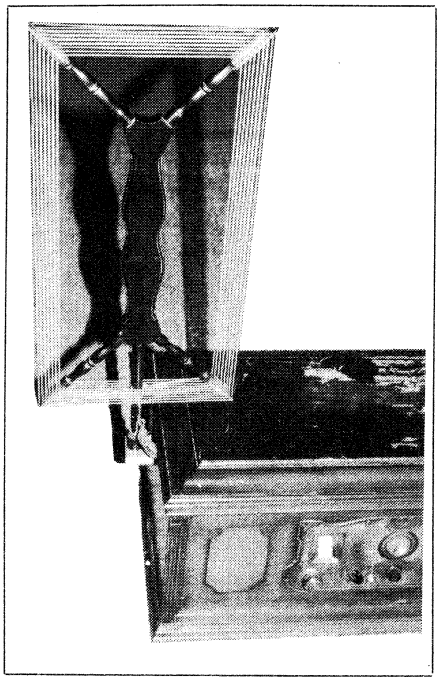

Fig.3: This spiral loop belongs to an American FADA model 480B Neutrodyne receiver built in 1927, and can be folded away in the top of the receiver when not in use. Only a few large US receivers from this period were supplied with loops. The 480B used four tuned RF and three audio stages.

Loops in decline

The situation changed after 1930 with the widespread use of mains power and the modern high gain and stable superhet. Often, a short piece of wire was adequate for an aerial.

For most of the decade, loop aerials and portables were generally neglected. The term 'portable' still referred to the provision of carrying handles rather than compactness and convenience, and running costs were high.

In America, car radios, for which the loop aerial was not satisfactory, became popular during the 1930's, and the few portables that were produced had wire aerials. Here the situation was much same. The STC 506 portable described in *EA* for April 1989 was typical. Although it had a door suitable for housing a loop, a wire aerial was preferred, and the chassis was no different from the household model.

Revival

In 1939, the advent of the new 1.4 volt battery valves meant that portable radios could live up to their name, rather than just being radios with handles.

Portables suddenly became popular here and in America, and now with them, loop aerials. These were generally flat spirals, mounted in the lid or back of the cabinet.

The same manufacturers 'discovered' that loop aerials were also very practical for mains powered receivers, something that a small number of British manufacturers had never forgotten. Terminals were generally provided so that the user could connect a conventional aerial if desired.

Most of these loop-fitted receivers were small 'mantle' sets, popular for apartments and 'second sets'. But one American manufacturer, General Electric, brought out an ambitious model using their 'Beam-A-Scope' loop aerial. A large console cabinet contained a rotatable loop fitted with a Faraday electrostatic shield. By shielding the aerial, much local electrical interference would either not be picked up, or could more readily be nulled out.

Monster loop

What must be one of the biggest loops ever, was built around 1940 by the New Zealand Post Office for receiving long-wave transmissions direct from Rugby in England. As I recall, it was about 10 metres square, constructed between two large telegraph poles. Each pole was fitted with four standard 8-insulator cross arms, supporting 16 turns

in two layers. Total length of wire would have been something like 600 metres!

By the early 1950's radio coverage had improved considerably and extreme sensitivity was no longer necessary. Loop-equipped receivers became increasingly popular, due in part to the absence of dangling leads and random bits of wire.

Around this time, the 'DX' (long distance reception) fraternity started taking loops very seriously. In reception of the now-crowded broadcast band, the combination of the directional properties of large tuned loop and a sensitive receiver worked wonders in digging out elusive signals.

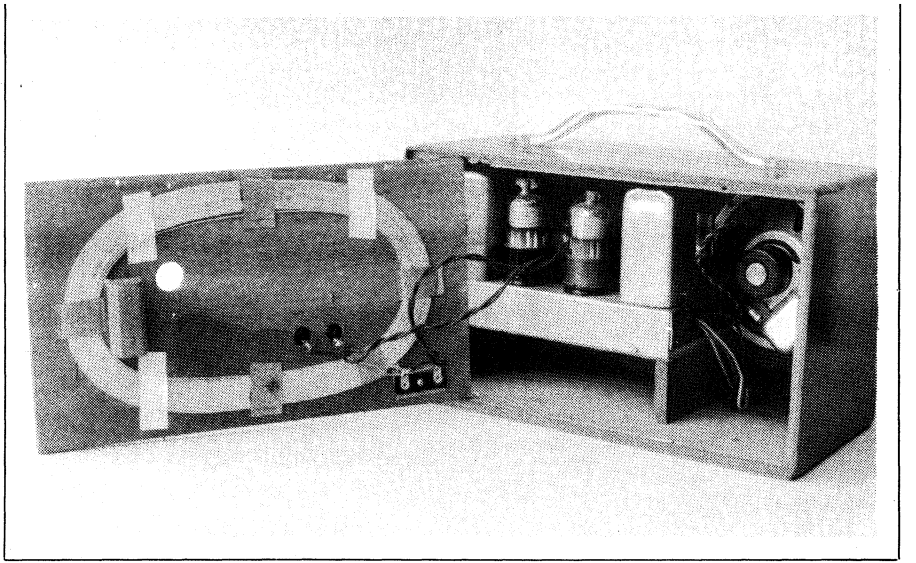

Fig.4: By 1947, portable receivers were reasonably small and were able to produce acceptable results from small built-in loop aerials. This one is mounted on the back panel of the case.

Iron cored loops

Also, during the mid 1950's one of the most significant developments in domestic loop aerials appeared, in the form of the familiar *ferrite rod aerial*. This is, in reality, a small diameter loop with a powdered-iron core to intensify the electromagnetic field. Performance is roughly equivalent to that of a loop with a diameter equal to the rod's length, and its small size restricts unwanted electrostatic pickup as well as making it physically convenient.

It was fortunate that the ferrite aerial turned out to be ideal for coupling to bipolar transistors. Had the ferrite loop not been available, it is unlikely that the small transistor AM radio as we know it would have evolved, and today's domestic radio situation would be very different.

Now, a century after the Hertz experiments, there are millions of ferrite loops in use, and there is no immediate threat to their continuing and justified popularity.