Antenna Workshop

Jürgen Hemme HB9ANR tells of the day he saw a fellow Swiss Radio Amateur drilling holes in his brand-new Audi car, and of the lessons he learnt!

If you happen to see someone with a power drill and savage looking bits approaching a new automobile, then you can be sure they means business - whether it's the owner or not! Well, the someone I saw was my colleague, Hans fitting an antenna mounting base right in the middle of his Audi's rear end.

Some time later, when I saw the completed job, a slender mobile whip rose from the boot area of the Audi. It was a shortened h.f. antenna for transmitting from the car.

"Are you sure you've drilled the holes in the right spot?" I asked...trying to tease him.

"It's an antenna designed for the 14MHz band" Hans said, beaming, "just three metres long, and it's made from a fishing rod".

Looking at the smooth outline of the antenna, it seemed to be missing something: "Where's the loading coil?" I queried. All mobile antennas I'd seen for short wave had loading coils, either at the base or at the centre - this one didn't have one at all.

No Loading Coil

"With this antenna, no loading coil is needed," explained Hans, "look at the spiral winding: that's a helically wound antenna. It's my own design". And he started telling me about radio contacts he had made with this antenna on side-band-telephony with American Amateurs, all from his car, an Audi.

Hans is the owner of an HB9 call with a two letter suffix. I knew, that he had been in the hobby a long time. I also knew that he had studied the book *Single Sideband Principles and Circuits*[‡] soon after it was published.

My friend Hans studied the book so well, that soon afterwards he'd built himself a shoebox sized s.s.b. transceiver. A piece of equipment which at that time was 'state-of-the-art' and that others could only dream about.

The receiver that Hans built was a single conversion superhet with 9MHz as the intermediate frequency (i.f.). The local oscillator (l.o.) tuning coverage was from 5-5.5MHz. The beauty of this combination of l.o. and i.f. is that you can cover the 3.5MHz (80m) and the 14MHz (20m) band with very few circuit changes.

When using the l.o. below the input signal, the two frequencies combine to give you coverage of the 14MHz (20m) band. And conversely when the l.o. is on the high side of the input signal , you cover the 3.5MHz band. No oscillator switching required! It was an elegant system that appeared in the early 1960s.

Memories Back

While listening to Hans' description of his mobile antenna, memories flashed back from the time when I was a boy, aged 14. Then, the great thing was riding a bike while listening to radio. I'd made myself a pocket set with a battery driven one-valved radio clamped to the handlebars.

Wearing headphones while listening and with a hazel branch supporting the wire antenna running back to the carrying rack above the rear wheel - that's how I cycled and received Radio Hamburg (the station was on the medium wave band, of course.)

Years later, there was Ralf, who, I remember as always wearing a red sweater, and who had an ex-army radio on his bike. With a quarter-wave whip antenna and the bike's frame as ground-plane, this was Ralf's mobile station. With perhaps a watt or two of power, he'd got as far as England when using amplitude-modulated (a.m.) signals on 28MHz - via short skip in summer.

The sound of further explanation from Hans brought me back out of my bout of dreamy nostalgia. From Hans I learnt that, in one of the large department stores in Zurich, he'd found low-priced fishing rods made from fibreglass. The fishing rods were in two sections, they were lightweight and were a little over two and half metres long when joined together.

At the handle end of the rod, it had a diameter of some 20mm. At the tip of the upper section the diameter had tapered down around five millimetres. The fibreglass rod served as a carrier for the spiral winding of the 14MHz band antenna.

I've shown the arrangement, in **Fig.s 1** and **2**, that Hans used on his antenna, with brass ferrules made to fit on the ends of the sections. The brass sections were machined to fit and were all glued into place using an epoxy resin glue with good heat resisting properties.

I've made only one change to Hans' original design and that is the through hole for a locking screw. This may be fitted if the sections are not a particularly tight fit.

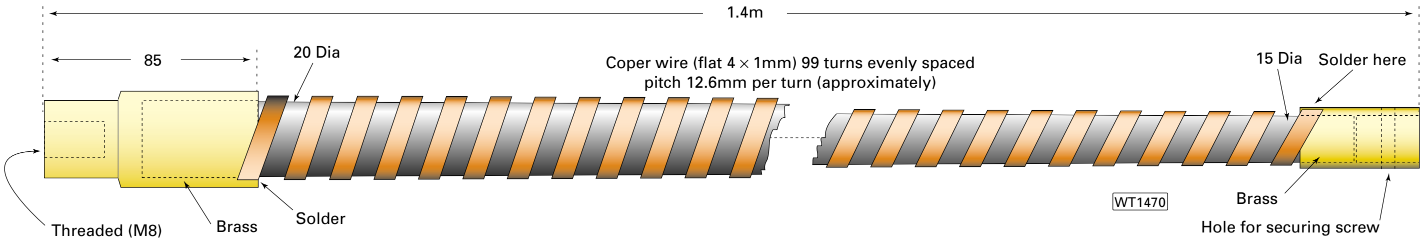


Fig. 1: The lower section of the helically wound antenna consists of 99 turn of flat section copper wire (4 x 1mm) with turns spaced at approximately 12.5mm per turn. The brass sections at top and bottom will probably need to be manufactured to fit well. See text for more detail.

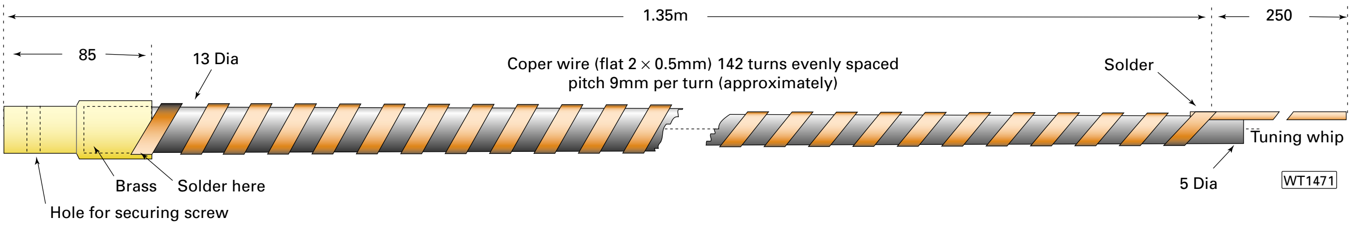


Fig 2: The upper section of the antenna uses smaller cross-section copper strip (2 x 0.5mm) with 142 turns spaced rather closer together than the lower section. The tuning whip should be rather longer than shown here and trimmed to give a good match over the band area of interest. See text for more details.

Although the electrical length of the winding was one quarter of a wavelength (approx. 5m), physically it measured three metres in total length (with the tuning rod and fittings). A useful saving, as it was 40% shorter - that's the point of helically wound antenna elements.

Solid mounting

To create a solid mounting system, the fishing rod's handle was glued into a brass tube that created both a solid mechanical mounting and good electrical contact. The bottom end had an 8mm inner thread for quick assembly. A piece of rigid wire on the tip of the upper section served to fine-tune the resonant frequency of the antenna.

"Look at it as being something between a wide and a close tuned circuit" that's how Hans explained his concept of antennas which, have been shortened by partly coiling them up.

"If you pull the spiral windings of the helix completely apart, you get a regular stretched out antenna wire with distributed inductance and capacity to ground. Regular antennas are what I would call a wide tuned circuits" said Hans. (I nodded approvingly).

"Now, imagine the helix compressed to a small coil. There you have the concentrated inductance of a close tuned circuit. By connecting a physical tuning capacitor to the close tuned circuit, then it may be tuned to the same frequency as the stretched out antenna wire - except that there's rather less radiation!".

"What about bandwidth"? I queried.

"That changes, as the bandwidth now is much smaller" Hans continued, " because the circuit *Q* goes up. And the *Q* of the antenna rises because the loading by radiation is, of course, missing"!

Hans continued, "Consider, the antenna as a transducer that is the interface between the energy bound up in the tank circuit of a transmitter and the radiation energy contained in the electro-magnetic field that is the far-field signal, incidentally the same relationship exists between the far-field, the antenna and the input circuitry of a receiver".

As I listened to Hans, his explanation all fell into place as he continued with his impromptu lecture: "Antennas of reduced length have smaller bandwidth, i.e. higher *Q* and therefore more r.f. current circulating in the antenna. Power losses increase with the square of this current".

Hans went on to explain why he'd made the winding from copper strip rather than the more usual round wire *(strip profile has more surface for a given weight, giving lower losses so, reducing the losses due to circulating currents, shown separately.* Editor). Hans also explained that to obtain quarter wave performance, it was necessary to wind approximately half a wavelength of copper strip onto the rod.

Helical antenna windings should be coated and sealed with varnish or epoxy cement after all tuning is finished. This will protect the antenna from weather and will lock the turns in place, thus avoid detuning.

Curiosity and the hope of having a reasonable, yet inconspicuous antenna for myself, made me fasten a similar helically wound antenna on the balcony of our flat, using the railing as the ground-plane. There wasn't much of a resonance dip, but 50W of r.f. power fed to it, was accepted happily with a low standing wave ratio.

After plenty of calling, with only a few contacts and meagre signal strength reports, I worked out for myself that the rusty iron railing acted more like a dummy load than a ground-plane. So, I set about improving the railing earth plane.

All that brushing and cleaning of the metal railings had an effect, in that my signal reports were a little better. But why did Hans and his helix work so much greater distances from the car?

Later I realised that when Hans had been driving to the office, across those lovely hills overlooking Zurich that he must have found an ideal spot for his mobile operation. Clearly, the world looks different from above - which was equally true for his antenna.

Since that time, I've talked with many other Amateurs, and they all seem to agree that an outstanding location often does more for an antenna's performance than anything else. After trying it for myself. I then understood why Hans had always been so keen on mobile operation!

Cross sections comparison

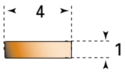
The two types of cross section are shown here side by side. For a given weight per unit length, a flat cross section wire has slightly lower losses at r.f. due to the fact that r.f. tends to flow in the subsurface area of the wire.

Rectangular section
Cross sectional area
4mm^2

$\left[\text{Length} \times \text{breadth}\right] \text{mm}^2$

Surface area
10mm^2 per mm length

$\left[(4+4+1=1) \times 1\right] \text{mm}^2$

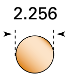


Circular section
Cross sectional area
4mm^2

$\left[\pi r^2\right] \text{mm}^2$ or $\left[\frac{\pi d^2}{4}\right]$

Surface area
7.09mm^2 per mm length

$\left[\pi d \times 1\right] \text{mm}^2$ or $\left[2\pi r \times 1\right]$



References:
‡ *Single Sideband Principles and Circuits*
(E.W. Pappenfus et al, Collins Radio Company, McGrawhill, 1964)