Comments on the K9AY Terminated Loop

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• I enjoyed the article on the crossed terminated loop array by Gary Breed, K9AY, and I thought others may be interested in the origin of the terminated loop element used in the array. [**2**] It is none other than H. H. Beverage! Beverage's patent on this antenna was issued long after his publication of the much more widely known Beverage Wave Antenna. [**3**] The loop is definitely *not* a wave antenna, as pointed out in Breed's article and in the Beverage patent. Its operation depends on making the loop diameter "somewhat less than a half the length of the operating wave". The other key difference between the two Beverage antennas is that the wave antenna receives best when the wave travels from the terminated end toward the receiver end, while the terminated loop receives best when the wave travels from the receiver end toward the termination.

Beverage's patent describes the full terminated loop, while Breed's version is essentially half a loop, reflected in the ground. The evolution of one to the other is easily seen: Start with a full circular loop, with the feed line connected across a break in the loop (just as an ordinary small magnetic dipole antenna), and a terminating resistor connected across another break in the circle diametrically opposite the feed line. Then, make a cut along this same diameter, keeping half the circle, with the other half being replaced by its image in an ideal ground plane. To allow convenient switching of the feed line and terminating resistor, move them to the center of the semicircle, connecting them to the loop by short wires above the ground plane (feed lines). This is similar to the scheme used to switch directions in rhombic antennas. Breed further tilts these wire feeders to link up with the side support guys. Incidentally, in his patent, Beverage states that the loop can be any shape, giving examples of a circle, a rectangle and a diamond (Breed's version), as long as the dimensions are less than a half wave.

Beverage's patent description of how his antenna works is more confusing (to me) than Breed's description in terms of the superposition of a magnetic dipole (R_{term} = 0) and an electric dipole (R_{term} = infinity, with arms distorted into a circle). Both terminations result in a roughly figure 8 pattern, but the relative phases of the loops in the 8 are different, so that in the superposition, they tend to cancel in one direction and add in the opposite direction. The relative contributions from the two superposed antennas depends on the value of R_{term}, and can be adjusted for best cancellation. My colleague at Caltech, Dave Rutledge, KN6EK, and I independently came to this same description. Beverage states that R_{term} "may have a value of 700 ohms" for the sample dimensions he gives, employing the usual vagueness that inventors like to adopt in citing actual numbers in patents.

Incidentally, the Beverage patent specifically refers to this invention as a broadband antenna for television reception. In that case, the full loop is oriented horizontally. I find this rather amazing, since the patent was filed in December, 1938! As far as I know, the only "reduction to practice" of Beverage's terminated loop was as a set-top TV antenna by Gibson and Wilson of RCA (Beverage's patent is assigned to RCA). [**4**] I don't believe it achieved much success as a rabbit-ears replacement (too expensive), but Paul Gordon, N6LL, assures me that KCBS-TV in Los Angeles uses them on all their mobile vehicles. They are currently available from Tandy Corporation. [**5**] Last year, I supervised a Caltech Senior Thesis on an experimental TV version of this antenna with a built-in monolithic chip amplifier. [**6**]

A feature of the antenna noted by Gibson and Wilson—and one designed into their version—is that the termination giving the deepest null in the cardioid pattern is not a pure resistance, but has a reactive component. I verified this for myself using *EZNEC*, and also observed that for the R+*j*X termination giving the deepest null, the feed-point impedance is R–*j*X. I have no explanation for this, but it was true with all the dimensions I used in modeling. In Gary Breed's version, both termination and feed-point impedances will be modified somewhat by the short transmission lines connecting the outer edge of the loop and the terminals. However, anyone building this antenna should experiment with variable reactance as well as variable resistance to get the best front-to-back ratio.

Breed states that the ground conditions will play an important role in the operation of the antenna, and I certainly agree. A perfectly conducting ground plane under the loop would help a lot. With a simple, short vertical antenna, radial wires do the job nicely, because the near-field return currents are all radial. However, here the situation is more complicated. In this case, the antenna is both a bent-over electric vertical, and a half-loop magnetic dipole. The return currents are definitely not just radial, so that simple radial wires will not properly substitute for an ideal ground plane. I do not know what shape such wires ought to be, but they will be complicated!

One way to get around the ground condition problem would be to use this loop as Beverage originally described, that is, as a horizontal loop. The directional switching might be accomplished by putting four gaps 90° apart in the loop, and running transmission lines from the four gaps to the center of the loop, where switching of the load, the termination and two shorts would electrically rotate the pattern in four directions. I haven't tried this configuration in modeling or in fact yet (I currently live in a condo with a "no antennas" restriction), so someone else can pioneer this version of "Beverage's Other Antenna."

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