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Notes on Mediumwave Beverage Antennas

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Recently, a number of Beverage antennas were set up by the authors at Pembina Forks, Alberta (52°59'N 116°38'W) and along the Diversion Reservoir at Jordan River on Vancouver Island's west coast (48°30'N 123°59'W). A primary intention was DXing of course, but a number of observations were made (mostly at Pembina Forks) concerning the apparent directionality and gain of the wires related to their height, length and use of a termination, along with some experiments with grounds and ground substitutes and with paralleling of wires. Most of our comparative readings were made using the S-meter of an IC-R71 receiver which had been calibrated against a lab grade signal generator. Most observations were on reasonably distant groundwave signals which gave solid S-meter readings. Comparisons of distant signals were more subjective, as splatter often made good S-meter comparisons impossible.

The Pembina Forks site is an open meadow with space for wires in the 210 to 280 degree range; further north was possible if a road was crossed. We used 210, 240, 270 and 320 degree wires of varying lengths. Although the site is in the foothills of the Rocky Mountains, relatively distant horizon blockage was minimal, no more than 2°, but there was a low hill about 8 meters/25 feet high about 100 meters beyond the ends of our 300 meter wires at 210° and 240°. The 270° and 320° wires were unblocked. The meadow was somewhat soggy at this time of year (early October) but judging by some of the DX heard, relative wetness of the ground was not too detrimental to the antennas.

The Jordan River site was also soggy, and the horizon is rather jagged. Only wires at 270° and 90° were used, and in these directions blockage was about 2°, but a steep hillside directly to the south meant blockage at 240° was approximately 15°, and it got worse as the bearing moved to the south. Bearings to the north of 270° also suffered blockage, but it was around 5 or 6 degrees.

One subject that is often brought up in discussion of Beverage antennas is the use of a terminations resistor to ground at the far end of the wire to attenuate signals arriving from the back end of the wire. We made a number of observations on daytime signals directly off the back of the wire. The "ground rod" used was a 9" spike, hardly the best thing to use, but the ground was very damp at the point it was used. Termination resistors used were 470, 510, 560 and 680 ohms. Variation in resistor values over this range did make some difference in the amount of attenuation suffered by signals from the back of the wire. The 680 ohm termination resistor provided about 8 dB more attenuation on CBK-540 than the 470 ohm one using a 300 meter wire lying on the ground at 270°. But the 470 ohm resistor was already providing 12 dB of attenuation. So, for best results in attenuation off the back end of the wire, the exact resistor value seemed to make a difference, at least at 540 kHz, and with a 300m wire.

However, a 375 m wire in the same direction and lying on the ground did not show any attenuation difference between using a 470 ohm and a 680 ohm resistor. More interestingly, the attenuation of CBK was now only about 7 dB. Using a 375m wire raised to 2m above the ground showed the 470 ohm resistor to be the most effective in attenuating CBK, but even then the greatest attenuation was on the order of 11 dB. The use of a termination resistor seemed to be most effective on a shorter wire (at least for one lying on the ground; we didn't try a shorter wire in the air), and more effective for a wire in the air than for one lying on the ground. These results were only for 540 kHz, but even there, a 75m increase in wire length did show some noticeable changes in back end attenuation, more significant than the change in termination resistor value.

It did seem that the "longer" the wire was related to the wavelength of the received signal, the less effective any termination resistor was in attenuating signals from the back of the wire. CBW-990 was attenuated about 10 dB at best when CBK-540 was being attenuated 20 dB by a suitable termination resistor, and we never managed to get more than 4 or 5 dB attenuation on CJOI-1440. Again, variation in termination resistor values did not make a great difference in attenuation, particularly at the higher frequencies. Incidentally, CBK, CBW and CJOI were all within a few degrees of co-linear with the direction of the wire.

We should have checked signal strengths of CBW and CJOI on the unterminated wire against signals on an unterminated wire running towards these stations, i.e. 180° away from the test wire. The wire may have already attenuated these signals somewhat, as they had to travel to the far end of the wire, then be reflected back to the receiver. It was noted for example, that CJOI was about 10 dB stronger on a 50m random wire in the trees than on the 270° unterminated Beverage. John Clements and Chuck Hutton in "Some Thoughts/More Thoughts on Beverages" (NRC Reprint A27) noted that terminations became less useful as the wire was made longer, as transmission line losses in the wire attenuated signals coming in from behind the wire. A signal which has already suffered these losses in getting to the receiver would presumably not show so great an attenuation when a termination resistor was placed at the end of the wire, because the reflected signal from the far end of the wire would have been attenuated anyway by the time it arrived at the receiver. But should transmission line losses have increased 16 dB between 540 and 1440 kHz as we observed, or are there other factors involved? From a practical standpoint, however, it appears that termination makes more of a difference for short Beverages (in terms of wavelength) and for those raised above ground.

A wire running 180° away from the test wire was used at Jordan River a few weeks later (both were unterminated and 300m long), but due to the lousy S-meter on the homebrew receiver used, and the fact that observations were made at night, no accurate comparisons could be made. However, on all signals from Australia and the Pacific Islands observed, strengths were better on the wire pointing towards rather than away from the target area. In many cases weak but readable audio became a carrier when the antenna was switched from the "forward" to the "backward" wire. Generally similar reductions were noted on domestic stations when the wire used was 180° away from the target area. It would appear these transmission line losses can be of great importance in determining whether DX is heard or not.

Terminating a wire is difficult in some situations as decent grounds are hard to obtain in dry rocky or sandy areas. A substitute ground that has been suggested is the use of a further ¼ wavelength of wire running beyond the termination resistor, which is used in place of a ground rod. We tried a 75m extra length of wire beyond our termination resistor (75m is ¼ wavelenght at 1 MHz) and it was comparable to our ground spike on CJOI-1440 and gave about 3 dB more attenuation on CBW-990, but on CBK-540, the ground substitute was vastly inferior used with the 375m wire in the air, and actually acted as an added length of antenna when used with the 300m wire on the ground, i.e. received signal strength increased rather than decreased! As 75m of wire is closer to one-seventh rather than ¼ wavelength at 540 kHz, these results are hardly surprising, but for a wire in the air, a 75m length of wire seems to act as a reasonable ground substitute for use with a termination over at least the central portions of the MW band.

Grounding the receiver end of the wire is also difficult when the soil is unsuitable, but should probably be attempted for safety reasons. Most of our DXing was done without a ground, and the reception of distant signals did not seem to suffer for the lack. Three 75m lengths of wire were laid out on the ground behind the van at about 50° intervals and were connected to the van's chassis (and thusly to our receivers). As a substitute ground, these radials did not have a great influence on our receptions. There were random increases and decreases in signal strengths on domestic stations, increases being mainly limited to stations at the low end of the band, and off the back end of the wires. There were no changes noted in the signal strengths of the long haul down-under receptions.

One thing that is always surprising when using Beverage antennas run in different directions is how directional these wires can be; there really are noticeable differences in strengths of stations received, and sometimes different stations are received. The most spectacular examples for us were off the backs of the antennas. Latins were best off the 320° wire; and the 270° wires gave best receptions of CBJ-1580 and WQXR-1560 while the 240° and 210° showed mostly XEDM-1580 and KPMC-1560. In general, all through the band, eastern clears were greatly superior on the 270° wires. It was particularly noteworthy that wires of only 30° separation could show such significant differences on signals received. At one point, 4QR-612 was received only on the 270° wire; generally, Queensland stations were better on the 270° wires, while New South Wales was better on the 240° wires. (Townsville is at 263°, Brisbane at 253°, Sydney at 249° from Pembina Forks). Fiji-891 was dominant on the 210° wire one morning while 5AN was dominant on the 240° wire (Fiji is at 240°, Adelaide at 257° from the site). The 210° wire was often inferior to the others for DU reception due to heavier domestic splatter (all the stations from San Francisco to Vancouver, B.C. are in a swath from 200° to 235° from the site). The list really goes on and on---it pays to put out more than one Beverage if it can be managed.

Directional effects were also apparent on two parallel antennas of different lengths and/or heights. Before any observations were made on two parallel wires, it was important that we find out whether one wire would greatly influence another one strung a few meters away. A 300 meter wire at 270° was set up, then a parallel wire was run out about 4m away from the first. S-meter readings of CFUN-1410 were taken from this wire and from the first one as the second wire was put out in 50 meter segments. There was some daytime skywave fading on the signal, but there was no large variation in signal strength on either wire as the second wire was rolled out. Hutton's "Analysis of the Beverage Antenna" (NRC reprint A28) quotes varying distances for significant coupling to take place between two parallel Beverage antennas, but our simple test seems to show that there was not a large amount of coupling between wires of the spacing we used. This is not to say that the wires did not influence each other at all, especially when we were DXing and had a number of different wires running into the van we were using as a DX shack. At one point, leaving one wire unconnected to a radio or a ground caused one of us to completely lose a signal from Radio Paradise-825 off the back end of another wire. This was just as likely due to signals from the wires mixing and cancelling within the wires inside the van as to influence between wires along their length, but we won't swear to it.

It's usually easier to lay a Beverage antenna directly on the ground rather than put it up on supports, so we planned to find out what sort of differences in reception would be likely when similar length wires in the same direction were used but with one 2m above the ground (wire A) and one lying on the ground (wire B). A daytime bandscan showed that stations within about 35° of the far end of the antennas suffered some loss in signal on wire B compared with wire A, on the order of 3 dB or so. However, CFPR-860, the one closest to the 270° bearing of the antennas produced a marginally better signal on wire B. Wire B showed greater losses for signals from the back end, on the order of 6 to 9 dB, with only one at -3 dB. Perhaps there was greater ground losses on the reflected signal with wire B. Two stations, KGA-1510 and KBOI-670 were at 90° to the wires, and in both cases showed a 3 or 4 dB gain when wire B was used. With long distance signals from down under next morning, it was generally found that signals were marginally better strength with less splatter on wire B, though two signals on 1575 and 1629 showed markedly stronger signals on this wire. Bearings of the received signals were in the 230 to 260° range. The poorer directionality of wire B (implied by stronger signals from KGA and KBOI) was also in evidence at night. Wire B was comparable in its reception of Latins with the 320° wire, yet wire A was much poorer. Two later wires at 240°, one on the ground and one in the air, also showed similar tendencies in receiving Latins--the one on the ground was reasonably good for Latins, while the one in the air rejected them. It appears then that a wire on the ground gives somewhat poorer signal strengths off the ends, particularly off the back, and somewhat broader directivity.

Another comparison of interest is that of a longer Beverage versus a shorter one. We ran a 300m wire at 240° then another 240° wire that was about 650m long, both lying on the ground. This latter wire was not perfectly level as the land rose abruptly 8 meters or so about 400m from the site. Results with this longer wire were quite peculiar, as it showed consistently less strength on all signals compared with the shorter wire. Signals from the Vancouver area just 5° off the antenna bearing were poor compared to the shorter wire, as were almost all Australians. When there was improvement in strength with the longer wire it was minimal, and only at the bottom end of the band. This did not correspond with expected results, nor did it correspond with later tests at Jordan River using a 300 and a 600 meter wire at 270°, both about 1.5m above the ground. There, the longer wire gave consistently better signals on co-linear domestics (all off the back), and on a suspected Papua New Guinea station on 864 and on the low band NHK stations. PNG is at 270° from the site and Japan at 300°. Australians, except for 6DL-531 (also at 270°) were consistently poorer on the longer wire, though the terrain might have had some bearing on that result.

At one point at Pembina Forks we had one 375m wire and one 300m wire, both raised, and at 270°. Daytime observations generally confirmed that the longer wire gave better signals on the mid and upper band, but only in the direction it was pointed in. Vancouver signals at 235° were down 2 or 3 dB on the longer wire over the shorter one. KGA-1510, perpendicular to the wires was also about 2 dB less on the longer one. Only at the lower end of the band were signals improved in strength on the longer wire if they were off the back or more than 20° removed from the forward direction of the wire. The literature leads one to expect that longer Beverages (in terms of wavelength) would be more directional and deliver more signal from the direction that they do favour, and the 270° wires seemed to confirm this. But our longest wire (at 240°) did not live up to expectations. Perhaps it was simply that the wire was lying on the damp ground and ground losses were too great. Also, the Pembina Forks area is coal mining country, and according to a geological map of Alberta, the area we were in is liable to have coal deposits. If coal is a reasonably conductive ground material, and there was coal in the ridge that we extended the 240° wire over, then it might help explain our lack of results with this antenna, but that's really a shot in the dark.

A phasing unit similar to Mark Connelly's MWDX-1 described in IRCA reprint A40 was used with various pairs of Beverages. Most of the undesired signals received suffered from a mixture of skywave and groundwave, making them difficult to null, and to maintain nulls once they were found. Best success in nulling such stations was when using a 10 kilohm potentiometer as a series Q-spoiler for each tuned leg of the phasing unit. With about 5 or 6 kilohms in each leg, there was some loss of signal from the wires, but nulls were easier to maintain. The most impressive result from the phasing unit was nulling CFFR-660 to yield WNBC, using a 210° and 240° wire. On neither wire alone was there any sign of another station behind CFFR, and even on the 270° wires, which were hearing plenty of east coast DX that evening, there was absolutely no sign of WNBC on 660. It is usually suggested that phasing units use parallel Beverages, but reasonable results were obtained with wires separated by 30° in this case, as well as when using parallel wires. The phasing unit did not seem to be able to separate long-haul signals on the same frequency and off the ends of the wire if they are separated by only a few degrees. Trying to null New Zealand on 756 ended up nulling the desired Australian signal at the same time, but distant signals widely separated in azimuth were no trouble--nulling WCCO-830 to hear Belize for example. The phasing unit is not something to be used during sunrise enhancement, as the DX is fading in and out so rapidly at this time that one is better off to tune around and ID what is strong at the moment. But for whiling away those long night hours on a Beverage expedition, a phasing unit is ideal, as one can ID more stations on each channel than one can with a single Beverage.

A few brief experiments were tried using a 210° and a 240° wire hooked up together to a receiver's antenna terminal, to see if stations within the "V" formed by the two wires were enhanced in any way. Results were rather random; in the daytime both CFUN-1410 and KIRO-710 increased strength by about 6 dB as did KVAN-1550. All were within the "V", but some stations outside the "V" such as CJOC-1220 and CKRM-980 also increased in strength, even if weaker CKDA-1220 and CKNW-980 within the "V" became slightly more readable. New Zealand stations (also within the "V") were attempted using the two antennas the next morning and all lost rather than gained strength using this system.

However, hooking up two parallel wires to the receiver was generally more successful. Increases in signal strength of a few dB over one wire alone were noted on all Australians tried with two 375m wires in the air at 270°. But hooking up a 270° wire in the air with one on the ground caused all sorts of random cancellation effects. Two 210° wires of 250 and 300m lying on the ground were also unpredictable---no gain on 1YA-756 (at 228°) yet gain on 4MK-1026 and 2RPH-1629, both further off the direction of the wire. Further observations concerning changes in directional patterns were not performed, though no increase was noted on KGA-1510, perpendicular to the wire, when two wires were used.

Conclusions

Performing experiments like these and then writing them up later makes one realize just how many more observations there are to be made. It would be useful for example, to observe further just how much loss there is on signals coming from behind a Beverage, and how this loss is related to frequency, wire length, type of ground, height above ground etc. Further observations comparing long and short Beverages could be useful. And trying to find out what directional pattern is shown by an array of two or more parallel Beverages would also be of interest.

All conclusions we draw should be taken with a grain of salt, as there may have been variables we were unaware of (ground conductivity and effects of terrain for example) which may have made some observations suspect. In general, our aim in all this was to allow those lucky enough to have a temporary Beverage site (ourselves, for example!) to take greatest advantage of the space and time they have available. For now, these conclusions seem to be justified:

-----Point your antenna in the direction from which you want to receive signals. Even if the antenna is unterminated, signals off the back end of the wire will be attenuated somewhat, and it may be enough to lose your DX.

-----If you have room for another Beverage, even 30 or 40° away, and have the wire, use it. Even a 300m wire shows a good deal of directionality.

-----If you can get wire(s) up on poles or trees, they will give greater directional effects and somewhat more signal strength. But a wire on the ground (or for that matter a short random wire thrown up in some trees) will give you more of an idea which direction conditions are favouring at the time.

-----For a temporary site, don't worry too much about exact termination resistance for the wire. Any resistor in the 500 ohm range will help, and for the upper reaches of the MW band may not really be necessary. Unless there is a specific strong station off the back of the wire that you must null, you probably won't miss the termination on a temporary site unless the wire is quite short.

-----A 75 meter wire extended beyond your termination resistor will perform as a ground substitute for at least the middle of the MW band if a reasonable ground is hard to obtain.

-----Ground the receivers if you can, for safety reasons, but a ground probably won't help your DX much.

-----Parallel wires will give somewhat more signal strength in the desired direction if the same length and height above ground. If you have the construction skills and like to tinker, build a phasing unit and increase the variety of your DX heard by nulling the stronger signals to yield weaker ones.

Further reading:

Beverage, H.H. and DeMaw, Doug. "The Classic Beverage Antenna Revisited", QST, January 1982

Clements, J. and Hutton, C. "Some Thoughts/More Thoughts on Beverage Antennas", NRC reprint A27, available from National Radio Club Publications, P.O. Box 164, Mannsville, NY 13661

Fischer, Dave. "The Super Signal Snatcher", IRCA reprint A11, available from IRCA Goodie Factory, 1017 West Manhatton Dr., Tempe, AZ 85282

Hutton, C. "Analysis of the Beverage Antenna" NRC reprint A28

Moman, Don. "The Practical Beverage Antenna" in A DXer's Technical Guide pp 85-6, also available from IRCA Goodie Factory

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