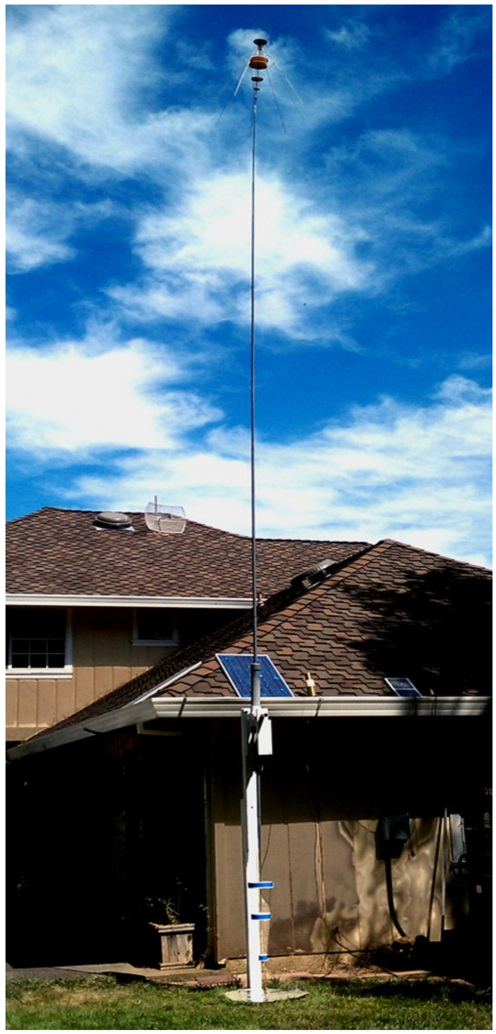
An All-Band Antenna



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An All-Band Antenna

The third of three construction articles for ARRL Pacificon 2011

This article describes the construction and operation of an antenna that can be used on the amateur bands from 160M through 3 cm. This extremely broad range is made possible by combining two structures, a traditional HF vertical antenna and an extended discone antenna. The HF vertical is used on amateur bands from 160M through 6M. An antenna for VHF and above is placed at the top of the HF vertical and uses the HF vertical as a surface wave transmission line (SWTL) feed line by means of its integrated SWTL launcher and a second launcher located at the bottom of the HF vertical. This part of the antenna can operate from the 2M amateur band through the 3 cm band. Figure 1 shows this combination of HF and VHF+ as a single All-Band antenna.

In many ways this article is a combination of two articles previously presented. It uses an extended discone antenna at its top in the same way as the Mercury Capsule of the first article and it uses a SWTL similar to that presented in both the first and second articles as feed line. A difference is that the SWTL for this antenna is made from relatively large conductor. Instead of using #24 magnet wire, it uses the 3/8” to 1 1/14” aluminum tubing of the HF vertical.

The addition of the VHF+ antenna to a conventional vertical antenna made from aluminum tubing causes some shift in electrical length of the vertical at HF but otherwise functions in the two regions are fairly independent and with appropriate filtering and matching, can operate at the same time. If suitable radios are available, it is possible to transmit or receive on the HF amateur bands at the same time one is operating on 144 MHz or above.

Operation of the HF vertical is in the commonly accepted manner with the possible exception of the use of a base-located antenna tuner to provide good match virtually anywhere within HF. There is no reason to run a vertical such as this only on bands where it is an odd number of quarter-waves long and near a low impedance resonance, where it has a feed point impedance near 50 ohms. Good matching technique bypasses this restriction and allows the antenna to function well, even in the absence of an extensive grounding system at most frequencies. This is because where it is not an odd number of quarter-waves in length, and particularly where it is an even number of quarter wavelengths, the impedance is high and corresponding currents at the bottom feed point of the vertical are low. This reduces the power losses in the ground or radial system used to provide a ground reference (image plane). Even a very small counterpoise can provide an adequate reference for feeding and matching an end-fed half wave antenna. Commercially available antennas such as the DX Engineering **T**hunderbolt™ MBVA-1UP use a fixed length vertical but provide matching and tuning to cover all of the amateur HF bands with a single structure in this same manner. Over most of the HF range, this antenna exhibits relatively high impedance and has correspondingly low ground currents.

The antenna does not need to operate near a resonance since matching which provides good power transfer between a 50 ohm radio and the antenna is possible down to below 2 MHz. In fact, the vertical need not be any particular length, though longer is better for the VHF operation of the All-Band antenna since it places this part of the structure higher and generally improves communications.

The mode of operation at VHF and above is probably less obvious. While essentially it is a vertical SWTL connected to a modified discone antenna, there are practical details that must be addressed in order to get this arrangement to work well. The first of these is the method of providing good coupling to the SWTL. Both at the bottom and at the top of the vertical the SWTL is made from conductor considerably larger than that used in the previous articles. Since the launcher's function is to transform 50 ohms to 377 ohms and the TEM mode in coax to the TM mode on the SWTL conductor, increasing the conductor size forces the wide end of the launcher to be larger. This is because in order to reach near-377 ohm impedance in the transformer the outer/inner conductor diameter ratio must be a little more than 500:1. To prevent this dimension from becoming impractical, at the ends of the vertical where the launchers attach the tubing tapers to relatively small diameter, ¼" or 3/8". Also, at both ends of the HF vertical, the outer conductor of this Klopfenstein taper transformer is fabricated from 1/16" brazing rod rather than solid sheeting. This has the effect of reducing the influence of the outer, shielding conductor and producing a higher impedance from a smaller structure size.

However, as a practical matter, a launcher with a mouth 500 times 1/4" is still over 10' in diameter and not structurally (or visually) viable. Fortunately, because the impedance of coaxial line in the launcher varies as the logarithm of the outer/inner ratio, it is possible to compromise a little on the high impedance end and greatly reduce this size without too much degradation in performance. For the launcher integrated within the extended discone at the top of the SWTL, 330 ohms was targeted instead of 377 ohms. This produces a little additional mismatch error but fortuitously, at the high impedance end of the launcher, most of the energy is already converted to TM mode so impedance mismatches have less influence on the overall performance. By limiting the wide end of the extended discone to 36" and using 1/4" as the center conductor diameter a practical compromise was reached.

The bottom end of the SWTL has an identical problem. Here, even more deviation from ideal was made in the interest of practicality. The launcher shown is actually one that was designed as an all-weather version of the SWTL launcher shown in the second article. It was originally designed for use with #24 copper wire. For expedience, we simply used this launcher and inserted it into the 3/8" aluminum tubing until the tubing inner diameter matched the taper of the center. This is a fairly serious compromise but it avoids a larger structure at the bottom of the antenna which was not visually acceptable on the backyard lawn at the N6GN station QTH. Using the launcher this way effectively truncated it's transformation function and ability to generate 377 ohm impedance at the wide end.

Because of these compromises, the resultant SWTL impedance match is worse than the 1.22:1 SWR (20 dB return loss) target for a properly built and applied Klopfenstein taper launcher shown in the second article. That greater SWR along with the approximately 2:1 SWR of the extended discone results in higher overall SWR for the finished antenna at 2M and above. However, the actual impact of this higher SWR is not as severe as might generally be thought. Even a SWR of 4:1 which equates to a return loss of about 4.4 dB only results in about 2 dB of mismatch loss. This means that with a 50 ohm transmitter that can generate full power into such a load, the actual difference is barely perceptible. This antenna generally has SWR much better than this over the entire VHF/UHF range.

Somewhat better match would be easily achievable by substituting a 36” diameter launcher at the bottom like the cone portion of the extended discone at the top. The version we built shows a final VHF+ SWR as plotted in Figure 3, works well and is really quite acceptable on all of the amateur bands below 2.4 GHz.

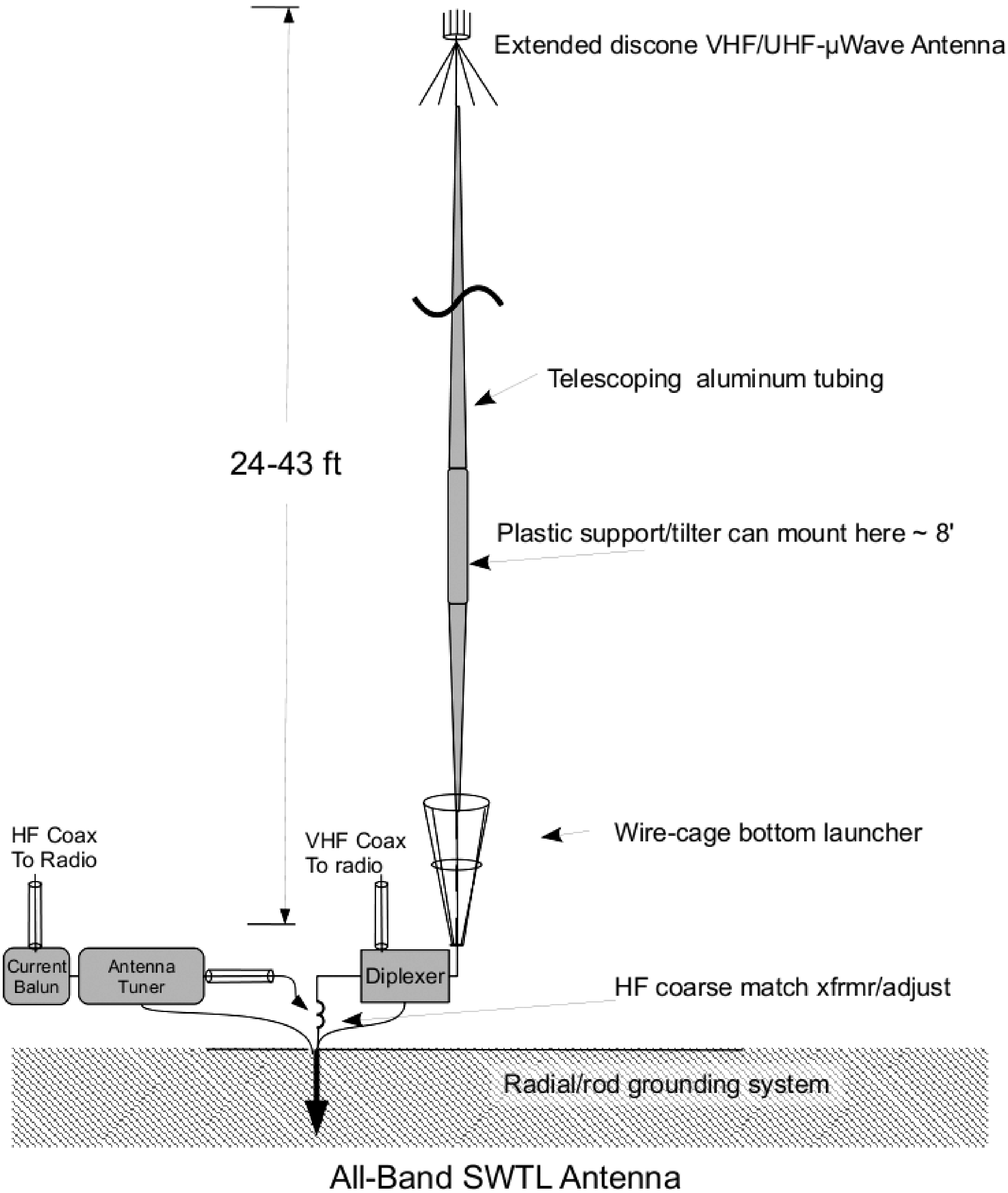

Figure 1: A combination of an HF vertical and a VHF+ extended discone are used to make an effective antenna that can be used on all amateur frequencies from 1.8 MHz through 10 GHz. The VHF+ antenna is fed by a surface wave feedline which uses the HF vertical aluminum tubing and special launchers at the top and bottom. The top launcher is integrated into the extended discone itself.

Vertical Construction

The HF vertical portion of the All-Band antenna is constructed from 6 foot sections of telescoping aluminum tubing of multiple diameters. Each section nests snugly and overlaps with adjacent sections providing a way to taper from the 3/8” diameter at the bottom where the bottom launcher attaches out to 1 1/4” diameter in the middle and back down to 3/8” diameter at the top where the extended discone attaches. This tapering provides adequate mechanical strength along with good SWTL performance.

In order to access and change the extended discone as we were developing it a “tilter” was constructed from plastic pipe to hold the vertical at its wide, stronger midsection and allow lowering the entire antenna to horizontal. This plastic pipe does have some negative impact on SWTL performance but it isn't too bad. A different method of support that doesn't have metal or plastic near the aluminum tubing would probably be better but hasn't yet been built. It is likely that a permanent antenna constructed without the tilter but with dielectric guys, perhaps of Dacron, could be simpler and perform even better than the design we show here.

Because the tilter supports the antenna at the 7.5 foot point, it is necessary to taper rapidly from the 3/8” tubing at the bottom to the 1 1/4” diameter tubing at the support point. We used a linear taper, with approximately equal length sections along the taper. On the upper part of the vertical where it is necessary to taper back down from wide to narrow, we used the full 6 foot lengths of the the largest three diameters and then tapered linearly down to the 3/8” in order to gain as much rigidity as possible. The tilter can be constructed from PVC pipe fittings as seen in shown in Photo 7. Other than keeping plastic as far as possible from the aluminum tubing, there are not special requirements.

Because neither the HF or VHF modes of operation rely on resonance, there is really no reason that the antenna can't be a length different from the 33 feet we used. If it is possible to go longer, and thus higher, both HF and VHF/UHF performance will likely improve.

At this relatively short length, 160M matching is a bit more challenging and probably not quite as efficient as a longer antenna would be. If you have the possibility of making the antenna longer, using additional sections of larger diameter is perfectly acceptable and probably worthwhile. However this will likely require guy lines to be placed at one or more points in order to withstand wind.

We first used plastic hose clamps to capture the vertical with the plastic tilter and to adjust the lengths of the sections but once we were happy with the strength and electrical performance we replaced all the clamps except those at the tilter with sheet metal screws close to each section end to tie the whole structure together. Avoid using metal hose clamps since they produce discontinuities to the surface wave and can negatively impact the VHF/UHF performance.

Bottom Launcher Construction

Wire-Cage 144+ MHz SWTL launcher for use with #24 wire

This is a wire substitute for the original K&S + Paper Cone SWTL Launcher that was detailed in the second article.
It is also used as the bottom launcher for the All-Band Antenna
The center conductor is made from 6 (hexagonal) 1/16” brazing rod tapers. The outer conductor is a conical “ca
A female bulkhead N connector is mounted on a 1/2” copper water pipe flange and receives the 1/16” rods of the outer conductor and also a single connection from the N center pin to the tapered centered conductor
At about 27”, the inner conductor/hex-cage ends by trapping a 3/16” OD tube that the connector pin solders inside.
When used for the bottom launcher on the All-Band antenna, 3/8” aluminum tubing of the antenna slides over the center conductor from about 23” forward – truncating the taper

Position, Inch	desired Z0	Outer Wire Spacing	Center-center Inner Wire Spacing	Inner Wire Spacers	
		Flange	Pin	N Connector Here	
0	61	0.87	0.34	61 16 rods around .25” tube w/ hole for N Conn pin	
1	62.5	1.05	0.44		
2	64.2	1.23	0.53		
3	66.1	1.41	0.63	.625 @ 2.95	
4	68.3	1.59	0.72		
5	70.8	1.77	0.81		
6	73.5	1.95	0.86	.875 @ 6.25	
7	76.5	2.13	0.92		
8	79.8	2.31	0.96		
9	83.6	2.5	1	1 @ 9	
10	87.7	2.68	1		
11	92.2	2.86	1		
12	97	3.04	1	1@ 12	
13	102.4	3.22	0.97		
14	108.3	3.4	0.93		
15	114.7	3.58	0.88	.875 @ 14.9	
16	121.6	3.77	0.83		
17	129	3.85	0.74		
18	137	4.13	0.64		
19	145	4.31	0.62	.625 @ 18.75	
20	155	4.49	0.53		
21	165	4.67	0.46		
22	175	4.85	0.4	.375@ 22.36	
23	186	5.04	0.33	11/32 joiner?	For All-Bander, Aluminum attaches about here.
24	197	5.21	0.28		and this and all below truncated away
25	208	5.4	0.23		
26	220	5.58	0.18		
27	233	5.76	0.14	3/16” clump around 1/16” tube	
28	245	5.94	0.11		
29	258	6.12	0.08		
30	271	6.3	0.05		
31	284	6.48	0.03		
32	296	6.61	0.02	#24 wire from here to mouth	
33	309	6.85			
34	321	7.03			
35	333	7.21			
36	344	7.39			
37	355	7.57			
38	365	7.75			
39	374	7.93			
39.34	377	8			

Table 1: Dimensions for bottom launcher inner & outer conductors and spacers.

The bottom launcher is made mostly from 1/16” brazing rod, for both the inner and outer conductors of the Klopfenstein tapered coaxial transformer. Target dimensions and impedances versus length for the coaxial line formed are shown in Table 1. The last column in this table also gives locations and center-center dimension for the metal spacers used to maintain the inner conductor shape. These spacers are made by drilling six holes, laid out in a hexagon with diameters and longitudinal locations shown in the Table 1, in 1.5 inch square pieces of .01” thick brass shim stock. The rods are threaded through these holes and everything set squarely into position on a flat surface. Once everything is correct the spacers can be first tack-soldered and then completely soldered into place. At this point, the square spacers have done their job and can then be trimmed and sanded or filed down to circles as seen in Photo 1.

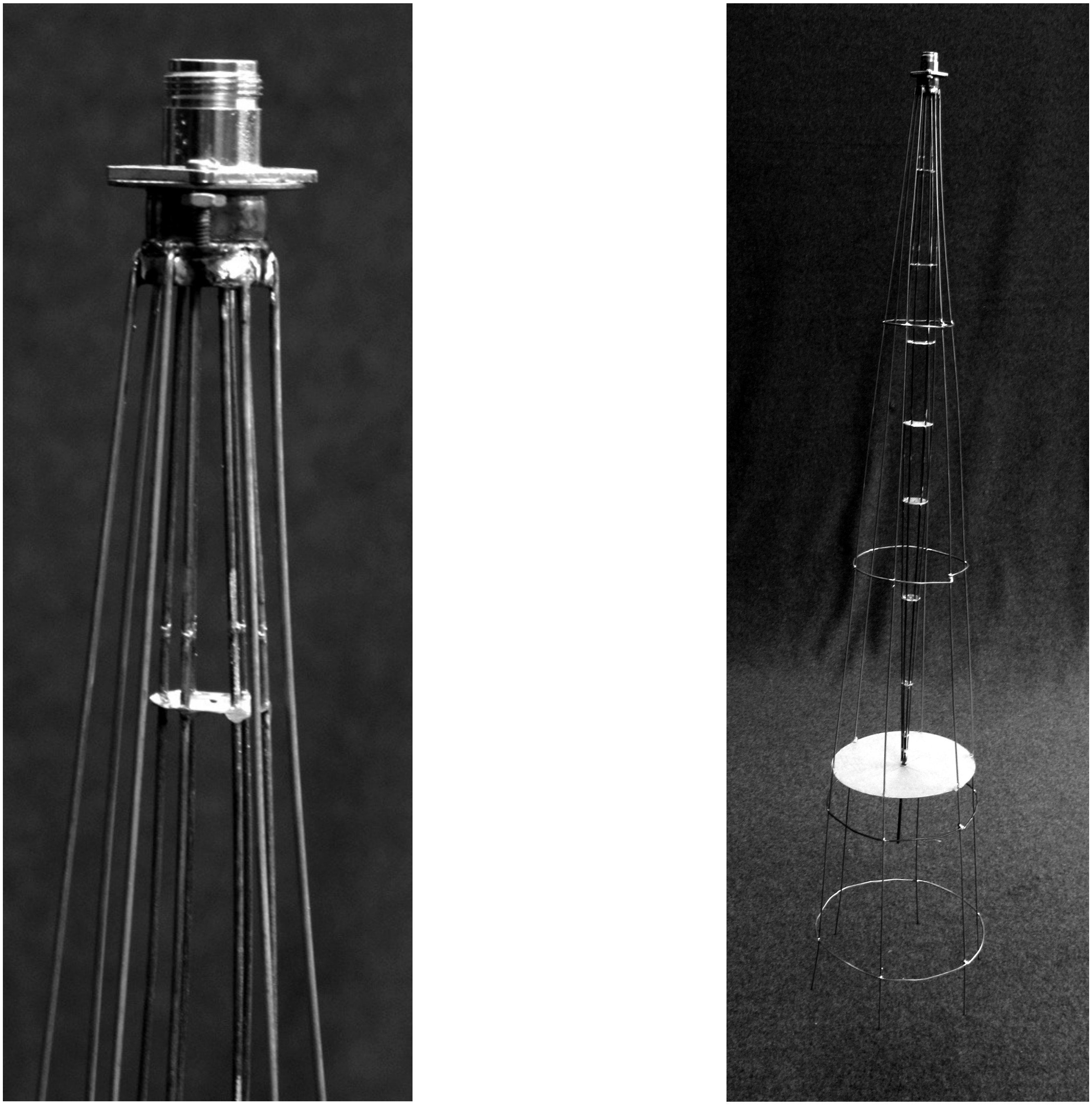

Photo 1: Detail of coaxial end of the bottom launcher showing an N connector mounted on a copper flange(left) and the complete bottom launcher(right) with both the inner and outer assemblies made from 1/16" brazing rod. A sheet plastic or Styrofoam disc is used to maintain alignment, spacing and shape between the inner and outer conductors. The outer conductor is held in shape by copper wires formed into circles and soldered around the outer rods.

Extended Discone/Launcher Construction

Integrated launcher in VHF+ extended discone antenna. As for the bottom launcher, this launcher is constructed from 1/16” brazing rod. The Inner Conductor is a hexagon of 6 rods, separated by plastic spacers. The outer conductor, which doubles as the cone portion of the antenna Is made from 8 brass rods, each 36” long. The plastic spacers hold the inner conductor rods in position while copper wire circles help keep the outer conductor/cone dimensions..

Position from narrow end of cone	Desired Impedance	Outer Diameter of 8 rods in Dis-Cone	Inner Conductor of 6 rods, center-center
0	60	2	1
2	66	4.5	2.7
4	70	6.5	4.2
6	77	8.5	5.2
8	86	11	6.2
10	97	13	6.2
12	111	15.5	6
14	127	17.5	5
16	147	19.5	4
18	168	2105	3
20	193	23.5	2
22	218	26	1.4
24	247	28.5	0.9
26	273	30.5	0.58
28	298	33	0.38
30	320	35	0.26
32	330	36	0.25

Table 2: Dimensions for top launcher inner & outer conductors along with target impedance for the Klopfenstein taper. The outer conductor of this launcher doubles as the bottom cone of the integrated extended discone antenna. Although this outer conductor/cone makes no electrical connection to any other part of the SWTL or antenna, its presence is vital to the proper operation of both.

The combined SWTL launcher and extended discone antenna is made mainly from 1/16” brazing rod in generally the same way as the bottom launcher. Table 2 provides all dimensions.

The top disc is 5” in diameter and made from copper sheeting, pre-drilled at the center to clear the 1/4” threaded center support. Four 24” brazing rods are bent into U's and soldered to the top of this disc to form a 9” high, 6” diameter cylinder. Prior to soldering, these can be held in place by drilling two pairs of holes for each of the 8 resulting upright rods, one pair near the outer edge of the disk and the other an inch or two from the center hole. A short piece of bare wire can be stitched around the rod at each location and twisted to hold things tight while soldering. Once soldered, the center of each U is snipped away to leave room for a 1/4” brass nut and washer which attach to the central supporting rod. A 1” PVC plastic reducer is attached to the disc with short sheet metal screws. Photo 3 shows the bottom part of the finished cylinder joined with the cone. A setscrew holds the PVC pipe and reducer together but provides a way to easily disassemble the cone and cylinder parts when necessary.

The cone portion which does double duty as the outer conductor of the Klopfenstein tapered SWTL launcher is built on a very short section of 1” PVC plastic water pipe. The ends of eight 36” long brazing rods were bent and inserted into one of eight equally space holes in the pipe.

Circular copper wire rings were then soldered at the pipe, as seen in Photo 3, and also at a point about 2/3 of the way to the bottom of the cone. The resulting cone apex angle is about sixty degrees.

The inner conductor of the launcher is specially tapered to provide impedance matching between the high impedance of the SWTL line and the lower impedance of the extended discone. As already described, to keep the structure size down, the target transformation was from 50 to 330 ohms rather than to 377 ohms. This was made with eight 1/16" brazing rods equally spaced around a central 1/4" threaded rod which runs almost to the top. Near the top we extended the steel rod with a section of 1/4" threaded brass. Because the steel is everywhere inside brass or aluminum, no significant RF current flows in it. The conductor taper and shape is set by four plastic and one metal spacer as seen in Photo 2. Metal or plastic are equally acceptable as spacers but plastic spacers were used at the wider portions for reason of mechanical strength and reduced weight. At the narrow end of the center conductor the eight rod ends are captured inside a length of 3/8" brass tubing around the threaded rod and the center conductor from that point on is made either from tubing or 1/4" rod. When assembled, the threaded rod will slip inside the top vertical aluminum tubing which is 3/8" OD and a little more than 1/4" ID. The top inch or so of the aluminum rod can be slotted and clamped around the threaded rod with a plastic hose clamp to guarantee good electrical contact or, as an alternative, a short set screw can be used. If you use a set screw, pick the length so that no unnecessary extra length extends away from the tubing as this can produce unwanted reflections of the surface wave.

The completed SWTL/extended discone mounted on top of the aluminum vertical can be seen in Photo 4. The plastic spacers of the center conductor look dark in this picture only because the protective paper was left on for this photograph.

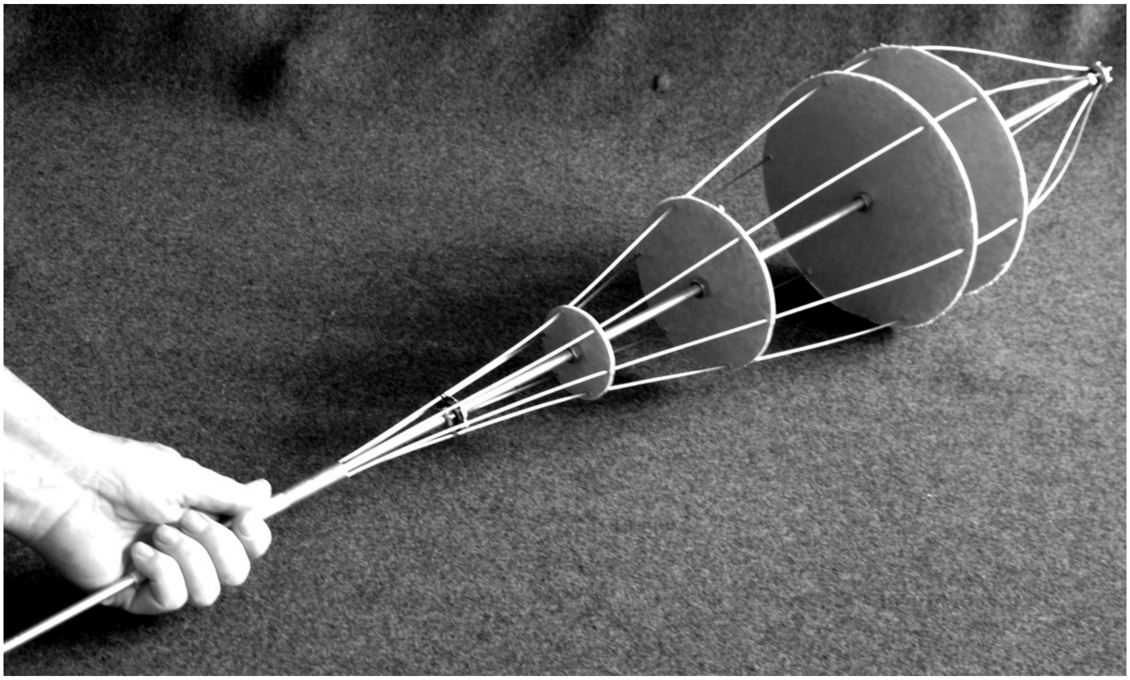

Photo 2: In conjunction with a conical outer conductor the tapered center conductor of the integrated top launcher uses a combination of metal and plastic spacers to conform it's shape to produce the correct TEM impedance for a broadband Klopfenstein coaxial transformer. The conductor is assembled around a central 1/4” threaded steel rod which Is extended by a short section of 1/4” brass rod near the wide end. This brass rod extends through a hole in a PVC plastic cap that the top disc/cylinder (not shown in this photo) is built around.

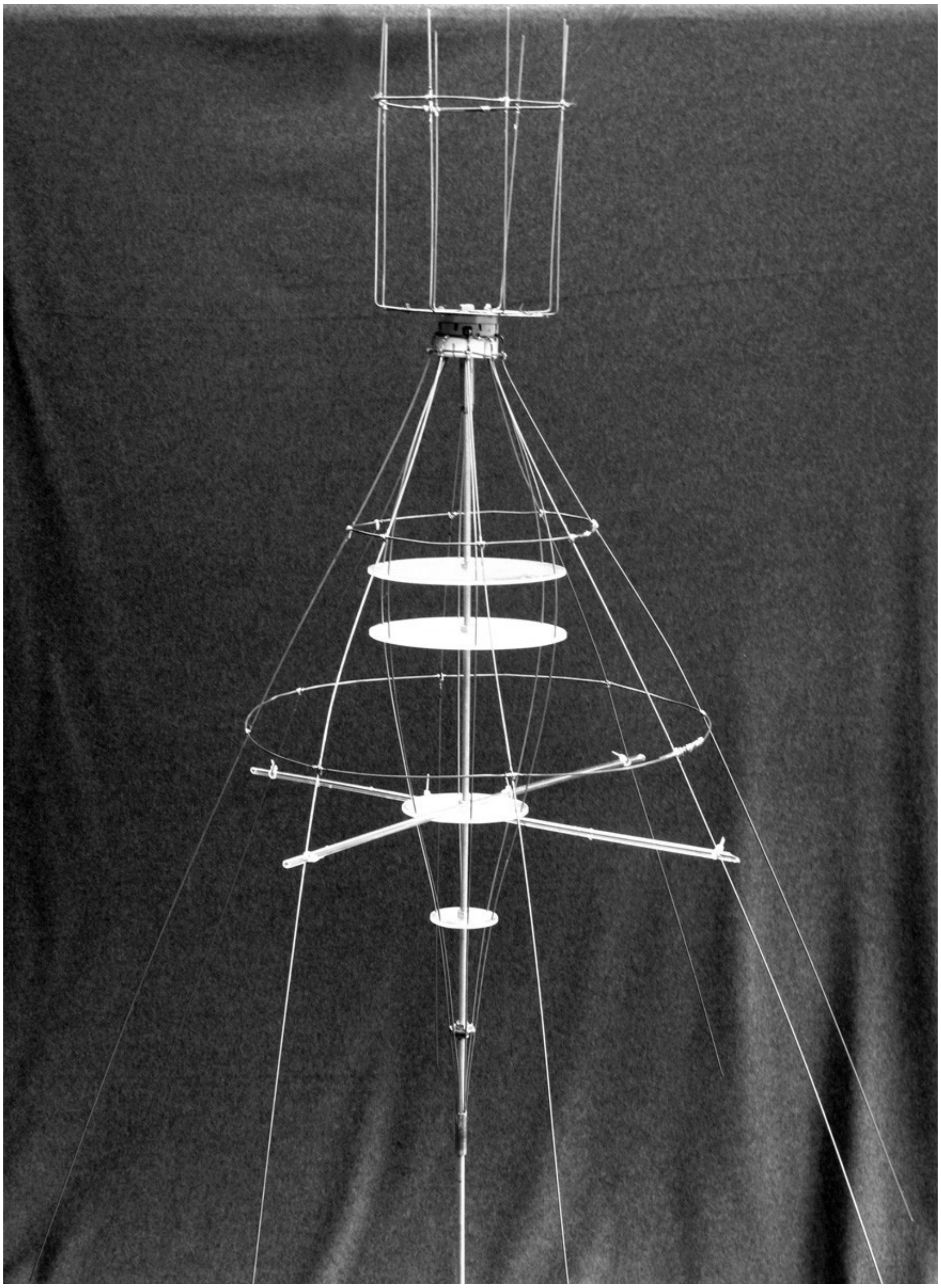

Photo 3: Detail of the extended discone cylinder and cone. The cylinder is built on a PVC plastic reducer that mates with a short section of plastic pipe on which the cone is constructed. The cone is insulated from the center conductor and cylinder. The central threaded rod from the center conductor of the launcher attaches to a copper disk that, along with the brazing rod, makes up the top cylinder. A single set screw is enough to secure the cone to the reducer on the cylinder and two screws attach the disc to the reducer.

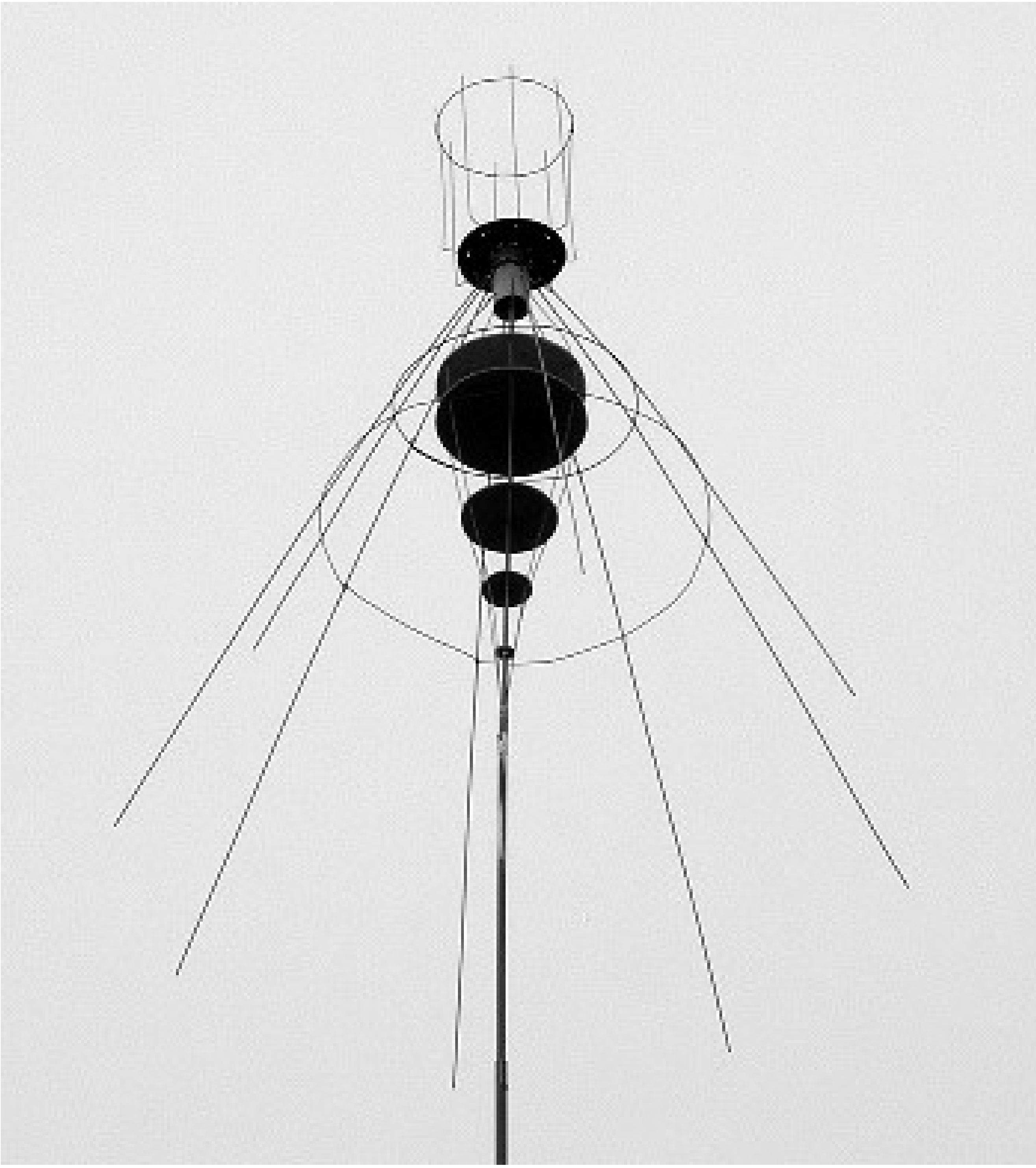

Photo 4: *Extended Discone antenna with integrate SWTL launcher mounted atop the HF vertical.*

HF/VHF Diplexer Construction

It isn't necessary to build a HF/VHF diplexer in order to use the All-Band antenna but it can help provide all-band use with radios which have separate HF and VHF connections or with two radios without requiring any switching. We use the All-Band antenna with ICOM IC-706 MKIIG transceivers which cover 160M through 6M using one coax connection and 2M and 3/4M on a second.

The goal of this design was just to protect the second radio port from RF energy during transmit on the first. It was not intended as a low-pass filter for HF or a high-pass filter for VHF/UHF. If this functionality is desired, it can still be placed between the radio and the diplexer. By using this diplexer and an automatic antenna tuner for HF on the Icom transceivers, complete all-band and even automated operation over the entire range of the radio is possible. We can run WSPR on 160M through 432 MHz completely automatically this way.

It may also be desirable to insert a high-pass filter in the HF side of the radio. At N6GN, the All-Band antenna can deliver a significant portion of one watt from a local AM broadcast station which causes problems for 160M operation. An additional high-pass filter to reduce this can be inserted between the transceiver and the diplexer's HF input if strong AM broadcast signals are a problem.

Construction of the diplexer isn't particularly difficult but in order to get good UHF performance, use of good connectors and a micro-strip transmission line is important. We used surplus Mini-Circuits bias tees as a starting point because they provided a nice package with good connectors and exactly the internal transmission line we wanted. The bias tee components were removed and replaced with the inductors and capacitors shown in Figure 2. You should be able to build your own package from scratch by mounting appropriate connectors on double side PC board walls and cutting a piece of the same material to shape so that the connector grounds can be soldered to the bottom side and the center pins laid directly on the board. For 1/16” epoxy board, 50 ohm micro-strip will be a trace about .110” wide. Really only the UHF diplexer path needs to be made in this manner and normal lumped techniques and point-point wiring can be used on the HF side.

Because the impedance at the base of the All-Band antenna can be high, so can the RF voltage, even when not driven by a kilowatt transmitter. To withstand this, we used multiple surface mount mica capacitors connected in series. Otherwise, there's nothing special about the components.

Wind the inductors exactly as indicated in Figure 2 and you'll obtain the indicated inductance. Mount them with minimum lead length to the surface of the 50 ohm micro-strip. Lay the capacitors across gaps cut in the 50 ohm micro-strip line.

A picture of the finished diplexer is shown in Photo 5.

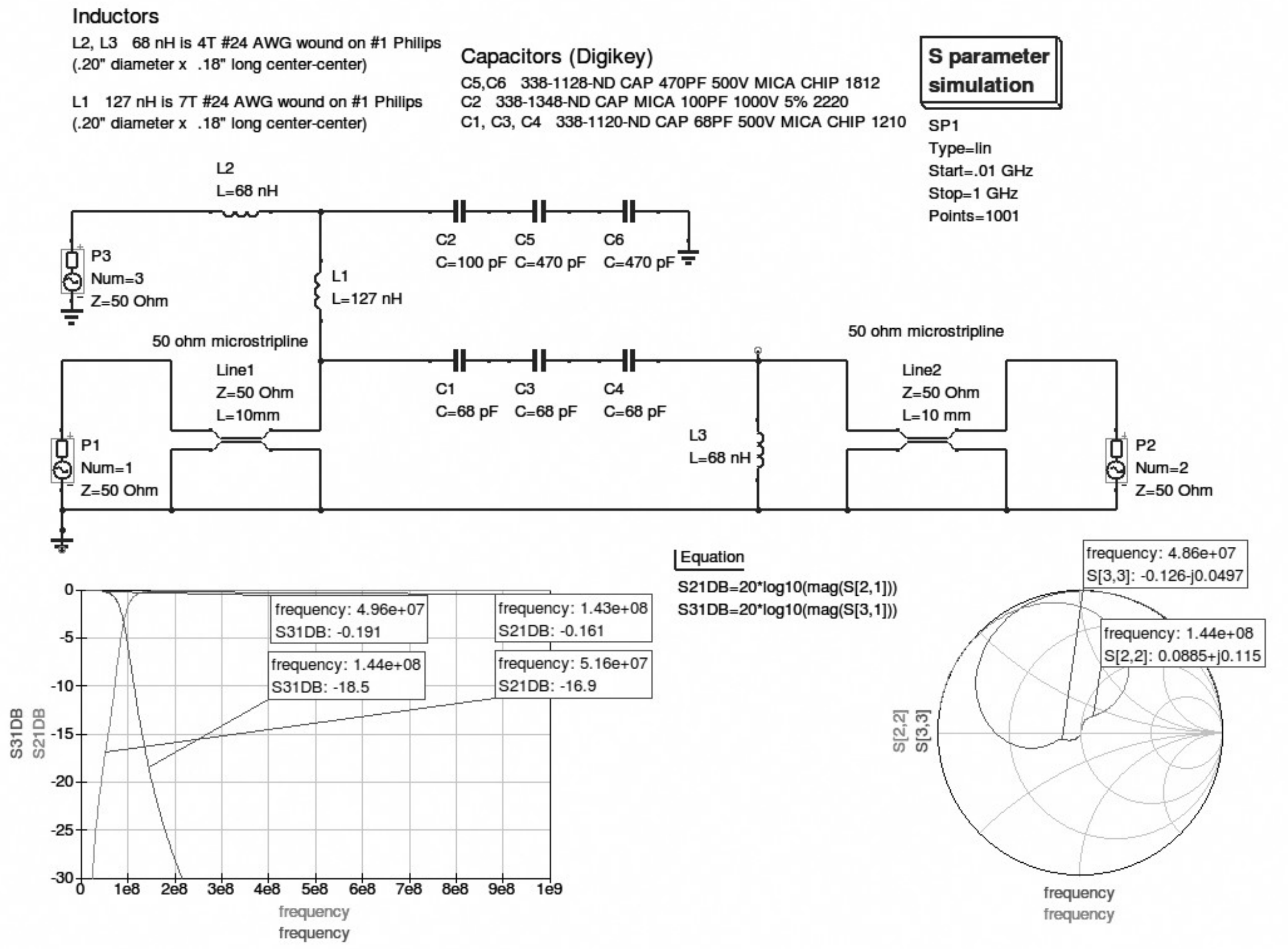

Figure 2: HF/VHF+ diplexer used with the All-Band antenna.

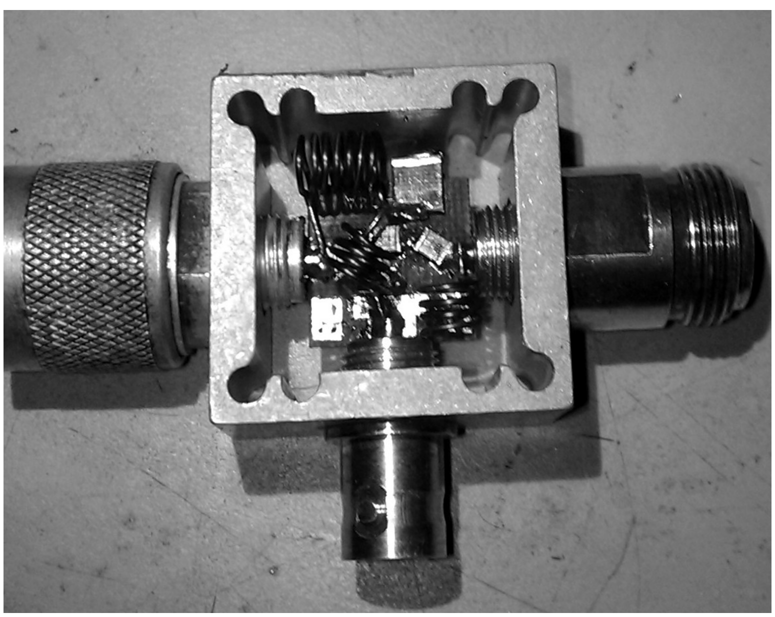

Photo 5: The diplexer was constructed from a surplus Minicircuits ZFBT-2G-1 bias tee package which already had connectors and a PC board with a 50 ohm micro-strip transmission line.

Impedance Matching

The setup shown in Photo 6 was used to measured the antenna. The corresponding SWR with a 50 ohm reference impedance is plotted in Figures 3,4 and 5.

Figure 3 shows the feedpoint impedance of the HF vertical in the absence of any launchers. This is just a simple monopole-over-ground operated with an 8 foot ground rod but the image plane (ground) has been further improved for higher frequencies by adding a 2 foot diameter disk at the base, as shown in Photograph 6. The transmission line nature of the monopole is particularly obvious where the ground is good. At lower frequencies the impedance is increased due to imperfect conductivity. A larger disk or radial system would improve this. In use, the coarse tuning coil or transformer shifts the center of these circles to more nearly coincide with the 50 ohm impedance of coaxial cable.

The effect of the SWTL above the launcher low frequency cut-off is easy to see in Figure 4 and relatively good match is available for VHF and above. The compromises made to achieve acceptable launcher dimensions do hurt the match slightly, but match is still acceptable and the impact on communications is minimal.

Above the launcher cutoff frequency the antenna ceases to act like a resonator. But in the transition region between 60 and 100 MHz the All-Band structure is operating partially as a normal vertical and partially as an extended discone. This transition can be seen by the relative strength of FM broadcast stations at 88 MHz as compared to 108 MHz, with the higher end stations stronger as the discone takes over.

On HF, a coarse matching inductor was used as an auto-transformer between the LPF output of the diplexer and the automatic antenna tuner to transform the HF antenna impedance nearer to 50 ohms. With no transformation, the impedance rotates about a central point on the order of 120-200 ohms. By providing a 4:1 impedance step down, SWR and variation of SWR can both be reduced over the entire HF range of the antenna.

The transformer used is simply a center-tapped air coil with a 1:2 turns ratio and provides a 1:4 impedance transformation along with some leakage inductance. This transformation and inductance is helpful to move the nominal center of impedance of the vertical nearer to 50 ohms and thereby reduces the SWR that the antenna tuner needs to accommodate. The best inductor value is somewhat a trade-off between being large enough to improve 160M and 80M impedance match while not not having so much leakage inductance that it worsens the match at 6M. A coil made by winding five turns of #14 AWG bare copper wire on a Styrofoam form seems to work pretty well. The coil we used was 4” in diameter and 1 1/4” long and center tapped. This gives an inductance of a little less than 4 uH and a transformer with a k factor of about .8.

Near the low impedance quarter wave resonances ground resistance may impact SWR, but with the 33' length “top loaded” by the extended discone, none of the amateur bands should show much of this effect. One advantage of the All-Band antenna is that it is not operated near an odd-quarterwave resonance and generally presents a higher impedance in all of the bands so that even with poor grounds a simple ground rod is adequate.

Figure 5 shows the SWR of the vertical before and after addition of the air core auto-transformer. For 160M operation, a larger inductance may be needed with some tuners and for 6M operation the auto-transformer can probably be removed entirely, depending upon the capability of the antenna tuner used. We were able to achieve a match at least as good as 1.5:1 on all bands from 160M to 6M using the air core auto-transformer with an LDG IT-100 automatic antenna tuner.

Generally the tuner should be placed as close to the auto-transformer and diplexer as possible. Cable length between the tuner and the N connector add capacitance which is not what is needed for 160M match which is already high impedance and capacitive. Coaxial cable between the tuner and the transformer is somewhat less of a problem than between the diplexer and N but should still be avoided, even though this will no doubt require a weatherproof enclosure for the tuner.

Performance and Use

This antenna performs well on both HF and VHF. Although we've only used it for a short time, it is a pleasure to operate WSPR and span bands from low HF all the way through 432 MHz- the full range of the ICOM IC-706 MKIIG transceiver.

On HF, this is a vertical antenna. There are times when it solidly beats a horizontal dipole at the same height and times when the reverse is true.

Signal reports on HF appear to be typical for a ground mounted vertical. For low angle communications, which can provide particularly long DX at the MUF just as a band is opening or closing, this antenna consistently beats a horizontal dipole by a wide margin. For stateside QSOs from California it doesn't have the high angle component of a low horizontal antenna but we have no trouble working stateside with it.

As with any HF antenna where the ground characteristics in the far-field affect the take off angle, its pattern may vary seasonally due to changes in the ground surrounding the QTH.

Performance of the All-Band antenna on VHF and above has been excellent. It appears to act very nearly the same as a ground plane, dipole or discone located at the same height above ground. On 432 MHz, signals are about 10 dB stronger on both transmit and receive when compared to an omni-directional vertical antenna mounted at roof height. The attenuation of the bottom launcher, vertical/SWTL and integrated top launcher appears to be no more than a few dB and competitive with a similar length of common coaxial cable.

Modifications and Improvements

It seems that any good project always inspires changes that make it better, more useful and more fun. We think this project is no exception. While we are pleased with the results we've experienced building and using the All-Band antenna as shown, other radio amateurs will certainly have different needs and desires and, we hope, will want to experiment. The following are a few possible changes we've thought of so far:

- Weatherize

  Although the photographs show the antenna free-standing, for all-weather use in most climates this antenna will probably need to be guyed. As a guy line, don't use anything that is conductive within a few feet of the attachment point on the vertical as doing so could interfere with the SWTL operation of the antenna – if not with the HF performance as well. If you have to use a conductive guy, break its length up in a non-periodic fashion as you would for any HF vertical by using suitable insulators. Except for fair weather, we'd recommend that you use Dacron or similar non-conductive twine. We also found it necessary to drill holes in the copper flange at the N connector on the bottom launcher to keep rain water from accumulating at the feedpoint.

- Use Noise Cancellation

  Particularly in suburban locations, noise level on receive is sometimes higher with a vertical than with a horizontal antenna but signals seem bigger too. Because of the lower take off angle, WSPR often reports little difference in S/N on distant stations even in the presence of increased noise – indicating that the vertical is actually capturing more signal. A future project is to add noise cancellation to further improve the reception of weak signals. With the improved performance of the vertical and a lower noise floor, the All-Band antenna may be one of the best multi-band solutions possible – short of multiple large and highly directive arrays.

- Improved 1:4 Transformer

  A toroidal ferrite 2:1 voltage transformer might be an alternative to the air core inductor we used. A W2AU 2:1 current balun works fine at 160M and 80M but not as well at the high end of HF and 6M. However, it may still be possible to match using it with some antenna tuners. A better solution might be a toroidal transformer with only a few turns on a low permeability core. This might reduce leakage inductance and still adequate for 160M operation but not be operating above self resonance at 6M. A band-switched matching network is another possibility.

- Taller

  Because resonances are not used, are actually suppressed with this antenna, there is no particular length required for the HF section. As of the time of writing this, K6PZB is experimenting with a 43 foot design. Making the HF section longer reduces the burden on the matching network at the low frequency end. Generally speaking the impedance gets higher and capacitive at frequencies below one quarter-wave.

- Shorter

  If low frequency operation can be sacrificed, the matching over most of the amateur HF bands, certainly 30M and above, is easy even with a vertical considerably shorter than 33 feet. Height is good to get the radiating tip above surrounding clutter but in some situations this may be less of a problem and a short antenna may be an excellent solution

- Operate HF-Only

  The SWTL and VHF portion of the antenna and the diplexer can be eliminated and the result operated only as a conventional vertical, but with broadband matching. If a really good planar ground is used, like the one shown in the Photograph 6 but perhaps ten feet in diameter, and if good attention is paid to the connections between a flange N connector mounted in its center and the bottom of the tubing, above about 90% of the quarter-wave length frequency the impedance can be transformed down such that the SWR is almost constant and not much greater than 3:1. This is within easy range of almost any antenna tuner.

- Move the Transition Frequency

  We chose to make the HF/SWTL transition between 6M and 2M. However, this could have been placed elsewhere. Pushing it higher reduces the effect of the SWTL launchers on HF operation. Pushing it lower gives broader VHF-and-above operation with the top antenna.

- Replace the Discone with Single-band Antenna(s)

  We have built single band antennas with built-in SWTL launchers and successfully used them with SWTL feed. One of the first narrow-band antennas we made was a type of halo antenna for 432.1 MHz horizontally polarized operation on SSB and CW. This was to match the polarization of the UHF DX and terrestrial weak signal operators in our area. A 50 ohm connector can be placed where the discone cylinder attaches and used to allow easy VHF+ antenna change.

- Integrate Coarse & Fine matching

  HF-Only as above plus automatically switch coarse tune inductors and 2-3 transformers to cover 137 kHz to 144 MHz.

- Build 2 or 3 HF-only antennas spaced by their height and add an automatic phasing network to produce 6-9 dB of wideband gain along with electronic steering.

These are just a few of the alterations that can be considered. Hopefully you will build and use this antenna or one similar to it and think of more for yourself. If you do, please contact us and let us know. We would like to learn from both your successes and failures.

Photo 6: All-Band Antenna measurement setup, simple vertical with good grounding (left) and with SWTL launcher and VHF antenna on top (right).In addition to the hexagonal aluminum foil disk, which provides a good VHF ground, an 8' ground rod near the wooden post is also connected to the disk and this arrangement is left in place for all measurements even though the disk is not necessary when the launcher is in place.

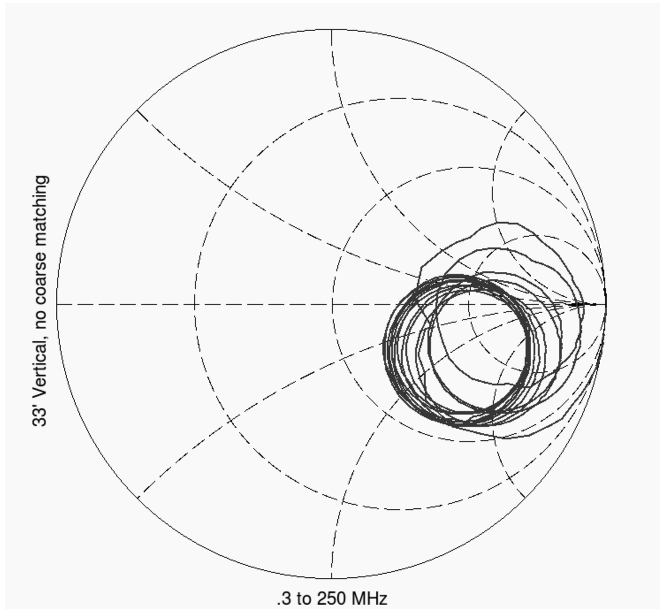

Figure 3: Measured S_{11} (50 ohm reference) of 33' vertical (without SWTL) with 24" metal disk improving a sod+ground rod image plane. Improvement by this disk is evidenced by the cleaner, lower impedance circles at higher frequencies. Note that in operation the antenna actually uses a transformer to shift the circles' centers to nearer 50 ohms.

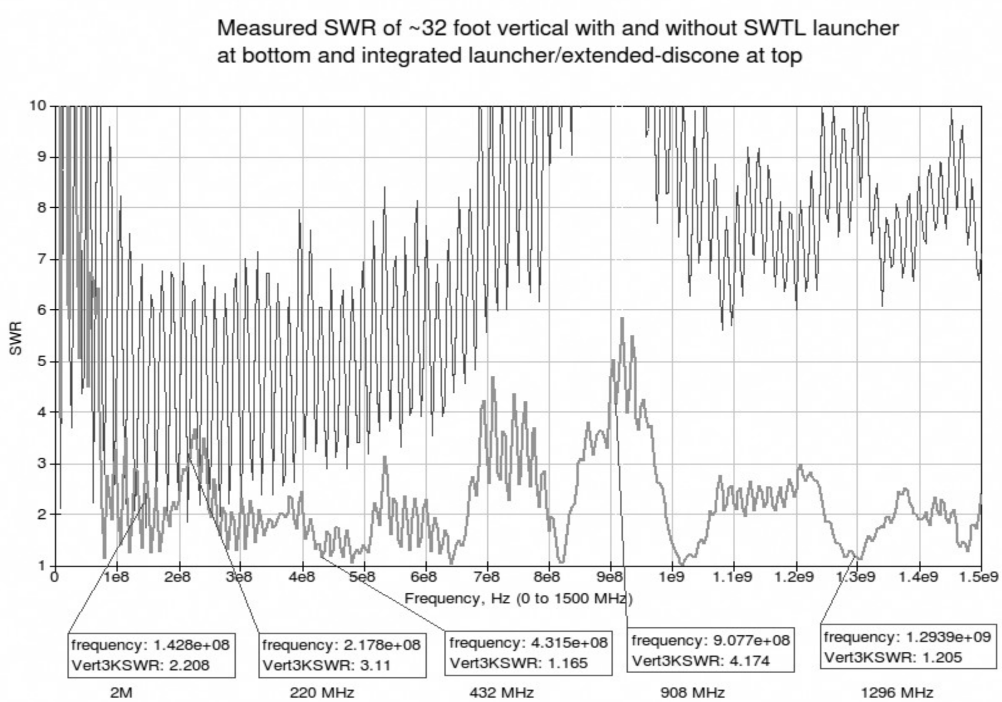

Figure 4: Measured UHF SWR of All-Band vertical with(green)/without SWTL launchers& Extended Discone

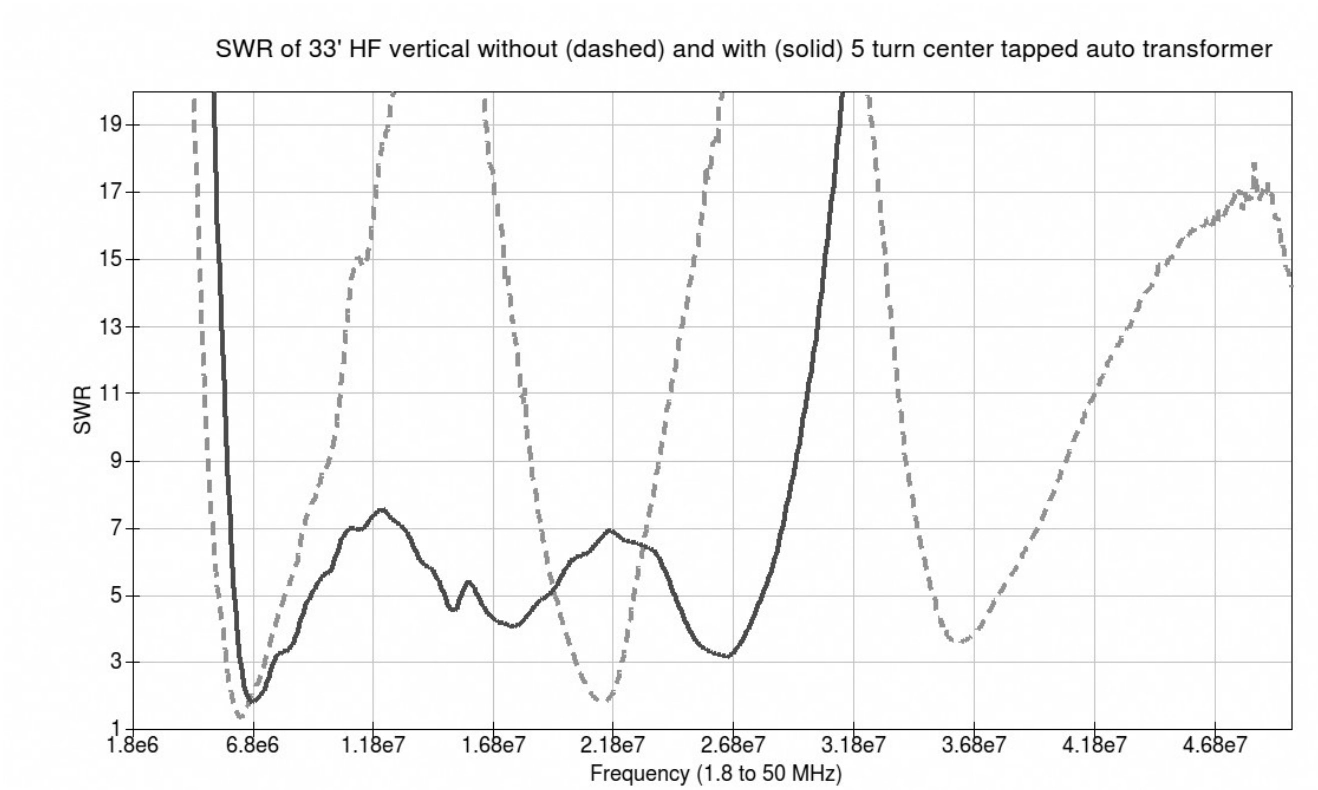

Figure 5: SWR of 33' Vertical (with bottom SWTL launcher but without top launcher/discone) without (dashed line) and with (solid line) auto-transformer coarse matching inductor. Reference impedance is 50 ohms. The inductor improves the SWR presented to the antenna tuner over most of the HF to the extent that most automatic antenna tuners can achieve good match on the HF amateur bands. 160M and 6M may require different coarse matching inductance or to be operated without any at all in order to achieve 1:1 SWR with some antenna tuners.

Photo 7: N6GN holding a bottom launcher and pointing at a second launcher installed at the base of the All-Band HF /VHF/UHF antenna. The tilter detail can be seen in this photograph and can be constructed similarly. Use the largest size plastic pipe that is practical to allow as much air space around the aluminum tubing as possible.

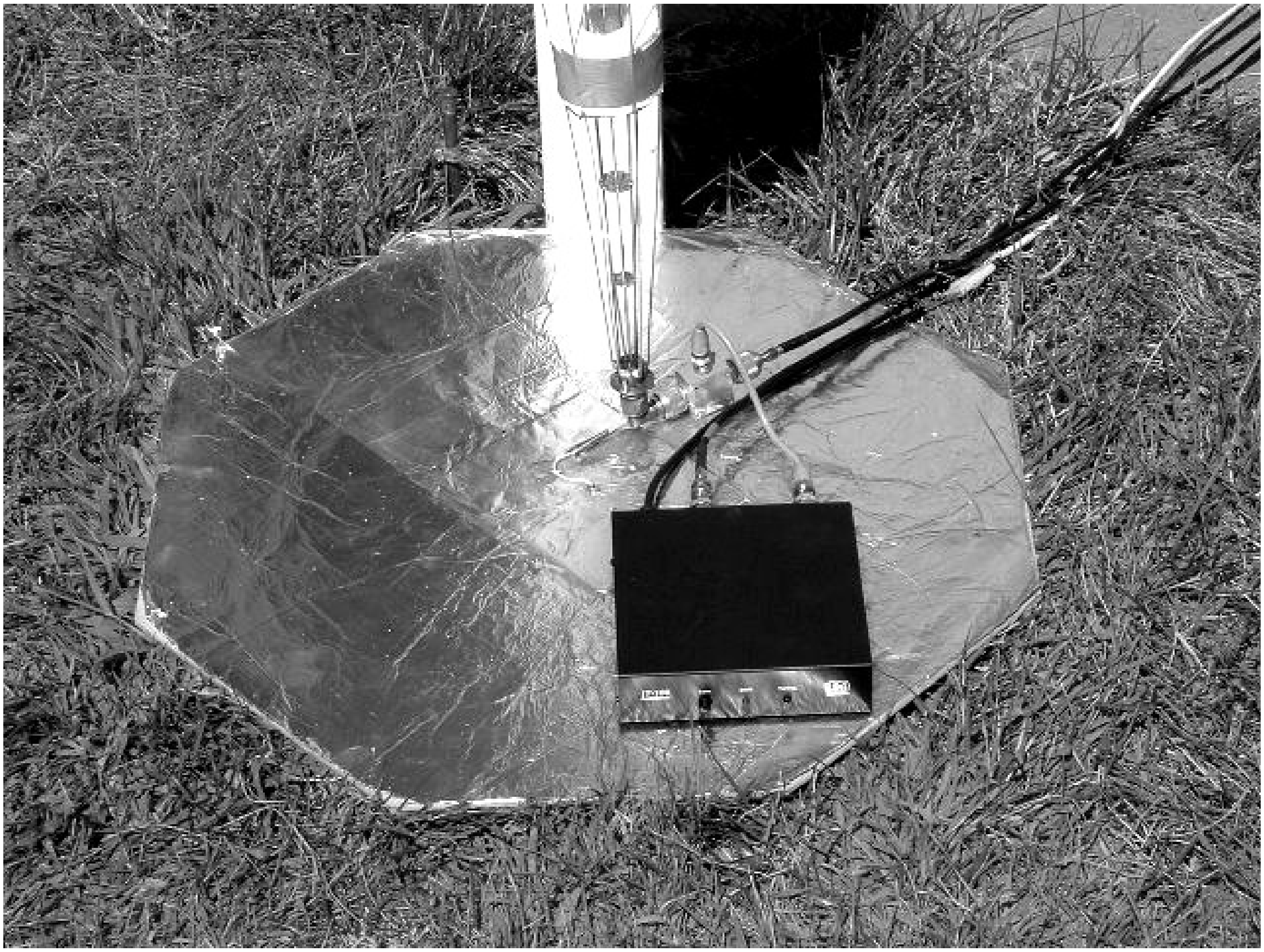

Photo 8: Bottom of the completed All-Band antenna with diplexer and antenna tuner. Two coax cables and one control cable go to the hamshack. The metal foil hexagon is not necessary for normal operation and was only left from the measurements shown in Photo 6 and Figures 3 & 4 in order to separate the electronics from the lawn for the photograph and to provide connection from the grounds of the launcher and diplexer to the HF ground rod which is next to the post near the top of the photo. For normal operation the foil is replaced with a simple coax-braid jumper since the launcher provides ground reference at VHF and only a relatively high-impedance connection is required for HF as long as the antenna is not operated near an odd quarter wave resonance.

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1 http://www.corridorsystems.com