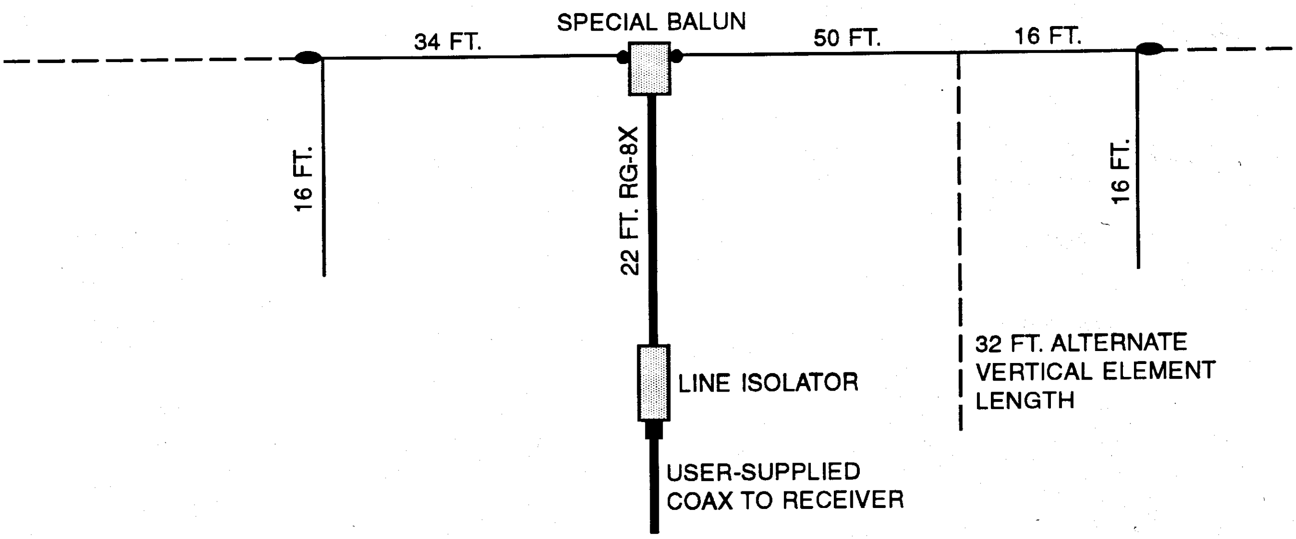
THE CAROLINA BEAM ANTENNA

Guy Atkins with Tony Ward

Despite growth in the number of shortwave listeners during the 1990s, there are still few commercial outdoor antennas designed specifically for the SWBC enthusiast. In comparison the amateur radio community is *much* larger and the ham operator has many more commercial antennas to choose from.

Although it has a ham radio heritage, the Carolina Beam© antenna is useful for the SWBC DXer and it is reviewed from this perspective with an emphasis on tropical band DXing.

The Carolina Beam is one of many high performance wire antennas offered by the Radio Works company of Portsmouth, Virginia, USA[1]. Besides complete antennas, The Radio Works sells insulators, wire, coaxial cable, support ropes, high quality baluns, and some unique items such as Line Isolators© and Remote Baluns©. This firm as well known in amateur circles and advertises frequently in the major publications. Among shortwave listeners The Radio Works is virtually unknown. Perhaps the best known product of the firm is their Carolina Windom© antenna, a star performer during the 1992 Navassa and Albania amateur radio DXpeditions. This is the antenna that the Carolina Beam is patterned after, and the Carolina Windom uses a special impedance matching transformer (balun) and Line Isolator which the traditional windom does not have.



DESCRIPTION

In the words of The Radio Works' catalog, "the Carolina Beam combines the best characteristics of the Carolina Windom and the very high performance wire beam, the Bobtail Curtain".

The [bobtail curtain] antenna system uses the principles of cophased verticals to produce a broadside, bidirectional pattern providing approximately 5 dB of gain over a single element. The antenna performs as three in-phase top-fed vertical radiators approximately 1/4 wavelength in height and spaced approximately a half wavelength. It is most effective for low angle signals and makes an excellent long-distance antenna for either 3.5 or 7 MHz.[2]

The Carolina Beam does not exhibit real gain below 20 meters. Instead, it performs similar to the Carolina Windom with a low-angle radiation pattern for DX reception and transmission. On higher frequencies its gain is noticeable and useful.

The Carolina beam has the three elevated vertical elements of the bobtail curtain, but has similar horizontal spacing to the Carolina Windom as well as incorporating a balun and Line Isolator. It can be erected to be either 84 or 100 feet long, in either a flat-top or inverted-V configuration. The users manual recommends the 100 ft. flat-top orientation, although reconfiguring to 84 ft. long can be useful in moving the pattern nulls to different azimuths.

The antenna may be erected level or at a slope. Recommended mounting height is 40 ft. or greater, although 30 to 40 ft. is useable. I noticed lower noise levels after raising my Carolina Beam to its current height of 68 feet.

The antenna is rated for 1500 watts on transmit, and a transmatch is required on all bands to ensure low Standing Wave Ratio (SWR). Frequency coverage for amateur use is 80 to 10 meters including the WARC bands.

The Carolina Beam is described in the Radio Works catalog as "the perfect high performance antenna choice for the DXer, traffic-handler, rag-chewer, or *dedicated SWL.*". It was this final phrase and the WARC band coverage that convinced me the Carolina Beam was broadbanded enough for SWBC DXing. Its current price is $99.95 in U.S. funds.

Current-Type Balun for Carolina Beam antenna

CONSTRUCTION

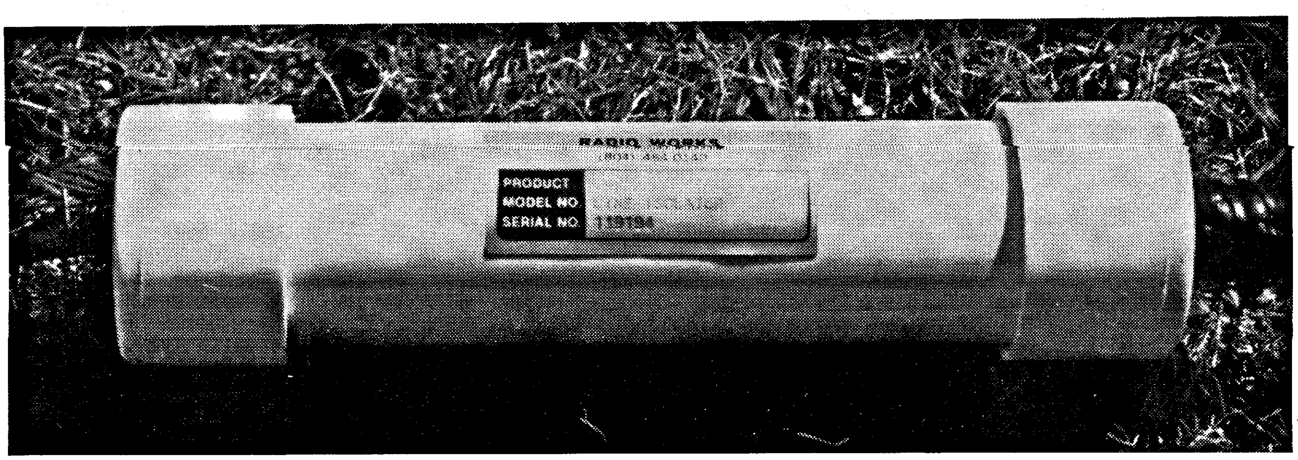
The quality of construction is very high throughout. The antenna uses thick-wall PVC tubing for the balun and Line Isolator housings, 7 x 22 ga. hard-drawn stranded copper antenna wire, glass-filled ABS copolymer insulators, stainless steel hardware, and low loss RG-8X coaxial cable for the center vertical radiating element.

The Radio Works publishes full specifications and bandwidth charts for its current-type baluns and Line Isolators, and it is clear that the firm is proud of the performance and construction of these items. The balun for the Carolina Beam is a special unit that cannot be interchanged with another design. However, it has features similar to other Radio Works' 4:1 Current-Type© baluns: double-cored and wired in a cross-coupled "X" pattern for exceptional output balance and symmetry; a massive toroidal ferrite core; high winding inductance; high feedline isolation; hand assembled and tested to exceed specifications; filled with foam potting compound; and L-C network compensation for a wide bandwidth.[3]

According to Jim Thompson W4THU, president of The Radio Works, the L/C network is a very important part of the balun. The circuit compensates for some of the compromises imposed by this design, and vastly improves the bandwidth and the reactive nature of the balun.

The (SWR) of a Radio Works' balun is typically less than 1.1 : 1 from 3.5 MHz to 28.0 MHz, and rises to about 1.4 : 1 at 1.8 MHz. I believe this nearly flat response is part of the reason for the good performance of the Carolina Beam on the SWBC bands.

What is a Line Isolator? It is a current-type device that operates as an RF choke in series with the outer braid of the coax cable and prevents RF current (transmitted or received) from flowing along the outer surface of the feedline's shield (i.e. *below* the Line Isolator). The Line Isolator has no effect on the signal carried by the cable and does not introduce a reactance that could adversely affect system matching.[4] This unit allows the center vertical element of the Carolina Beam to function both as feedline and vertical radiator. According to The Radio Works, the Line Isolator is much preferred over a coiled-coax type of choke, which is useless below 14 MHz because inductance is too low.



Line Isolator for Carolina Beam antenna

The center vertical element of the Carolina Beam is a key to its good low angle response. The Radio Works catalog states that

> "The Carolina Windom has popularized radiating feedline sections that improve low angle vertical radiation. Extensive computer analysis has shown that improvement in vertical patterns can be applied to other antenna types. The technique is called "VERT", Vertically Enhanced Radiation Technique... [antennas using VERT] have the advantage, increasingly, as the propagation favors longer propagation paths. Daytime, high angle operation will show little difference."

Radio Works' products that incorporate the VERT principle include the Carolina Windom, the Carolina Beam, Vertical Radiating Dipole, and Dipole/2 antennas.

The Carolina Beam comes with a fifteen page users manual that contains sections on installation, troubleshooting (from the perspective of ham-band transmitting), coaxial cable lengths, weatherproofing, and performance (general comparisons to a Carolina Windom and halfwave dipoles).

To help keep the vertical elements at the ends from swaying in light breezes, I attached two 1-lb. lead weights at the bottom of each wire. I also use 12" long, screen-door springs between each support rope and the antenna end insulators, which should help the antenna to survive moderate wind storms.

PERFORMANCE

For performance comparisons, the Carolina Beam was erected between tall cedars at a height of approximately 50 feet in the 100 ft., flat-top orientation. The axis of the antenna runs NW-SE, giving a broadside directionality that nominally favors Australia/South Pacific and Europe/Africa. In practice I have found the antenna to work well in all directions, but directionality increases on the higher (daytime) bands.

My home is located on a small island in a good-sized lake. Some antenna texts indicate that the far-field radiation/ reception patterns are affected by ground conductivity changes such as those from bodies of water. The performance of my antennas may be enhanced or changed by the surrounding lake.

Initially the Carolina Beam was compared to my other DXing antenna, a terminated (500Ω) 300 ft. "mini-Beverage" that is coax-fed through an impedance matching transformer and separate ground system. The mini-Beverage is directional off the far end at 260 degrees true north and performs very well for reception from Papua New Guinea and Irian Jaya. The main downfall of the mini-Beverage is noise pickup from nearby homes.

For tropical band stations located "down the barrel" of the mini-Beverage, signal strengths on the Carolina Beam are usually somewhat less. However, reception is often better due to less noise. During quiet conditions with threshold-level signals the mini-Beverage outperforms the Carolina Beam, but only for tropical band Papua New Guinea and Irian Jaya stations. In all other directions and frequencies the Carolina Beam is a better performer—often by as much as 5 S-units—especially on the higher frequencies.

A more realistic antenna for comparison is a 100 ft. randomwire, typical of what many shortwave listeners use. The following chart compares reception between the Carolina Beam, a 100 ft. randomwire (inverted-L), and an impedance-matched 100 ft. randomwire (using the same matching transformer and separate ground system as the mini-Beverage described earlier). The 100 ft. randomwire was connected directly to the 500Ω input of a Drake R8 receiver, and the other antennas were directed to the 50Ω unbalanced input via a coax switch. Both randomwires were erected 25 ft. high. (Note: refer to the article "Impedance Matching for Simple Wire Antennas" elsewhere in this edition of *Proceedings 1994-95* for details of improving reception with matching transformers.)

The charts on the following pages show that the Carolina Beam sometimes made the difference between hearing or not hearing a particular station. (Note the randomwire entries marked *barely audible* or *not audible*.) This was true more often on the higher frequencies, where the Carolina Beam's gain and low-angle reception out-performs a simple randomwire. "QRM" in the charts is used in the SWL sense of the term: local man-made sources such as light dimmers, powerline hash, and other RFI, rather than adjacent or co-channel stations.

The Carolina Beam and the two randomwires had approximately the same performance on the 25 meter band; on every other band the edge went to the Carolina Beam, sometimes by a significant margin.

I expected the Carolina Beam to be a good DXing antenna due to its low radiation angle, but I did not expect the lower noise levels. This was a pleasant surprise! A further reading of The Radio Works catalog revealed information I had overlooked previously: the Line Isolator can often reduce noise at the receiver:

> *Here is one explanation for the noise reducing action of the 4KV-LI [Line Isolator]. There may be very low level RF current flowing through or along the surface of the ground (earth). Fast rise-time pulses created by motors, switches, leaky insulators, etc. produce RF energy that we hear as noise. Several houses in a neighborhood are connected via the power lines. Unfortunately, improper grounding of household systems is more the rule than the exception. A complicated electrical network is established. RF (noise) current may be flowing between houses or electrical power ground systems as our modern household noise makers seek a path to ground.*

FREQUENCY	STATION	CAROLINA BEAM	100 ft. w/Matcher	100 ft. Hi-Z
2325	VL8T Australia	S-6	S-6 + strong QRM	S-6 + strong QRM
2340	Fujian PBS, China	S-5	S-5 + strong QRM	S-5 + QRM
2485	VL8K Australia	S-5 + slight QRM	S-5 + QRM	S-5 + QRM
2500	WWV	S-6	S-5	S-5 + QRM
3220	CPBS1, China	S-8	S-5 + QRM	S-5 + QRM
3245	AIR Lucknow	S-5	S-2	S-3 + strong QRM
3250	PBS, Pyongyang	S-7	S-4 + QRM	S-4 + strong QRM
3255	BBC, Lesotho	S-5	S-3 + QRM	S-4 + QRM
3260	PBS, China	S-5	S-3 + QRM	S-3 + strong QRM
3265.1	RRI Bengkulu	S-5	S-3	S-4 + QRM
3300	R. Cultural, Guatemala	S-7	S-5	S-5 + QRM
3320	PBS, Pyongyang	S-7	S-5	S-5 + QRM
3330	CHU, Canada	S-6	S-4	S-5 + QRM
3335	BCC, Taipei	S-4	S-2	S-2 + QRM
3395.1	RRI Tanjung Karang	S-5	S-2	S-3
3915	BBC Singapore	S-7	S-5 + QRM	S-6 + QRM
3925	R. Tanpa, Japan	S-7	S-5	S-5
3981.1	Unid. stn. (China?)	S-5	S-5 + QRM	S-4 + QRM
4740	R. Yunost, Tajk.	S-4	S-1	S-3 + QRM
4753.3	RRI Ujung Pandang	S-7	S-6	S-7
4770	V. of Nat. Salvation	S-6	S-5	S-6
4800	LNBS, Lesotho	S-5	S-5	S-5
4815	R. China Int'l., China	S-4	S-4	S-4
4840	V. of the Strait, China	S-4	S-2 + QRM	S-2
4860	R. Moscow? Russia	S-4	S-4	S-4
4875	V. of Jinling, China	S-6	S-5 + QRM	S-5
4915	Guangxi PBS, China	S-6	S-5	S-5
4920	R. Quito, Ecuador	S-3	S-2	S-2
4970	RTM Kota Kinabalu	S-5	S-5	S-5
4991	R. Ancash, Peru	S-4	S-2	S-2 + QRM
5000	WWV	S-7	S-7	S-7
5975	BBC, Antigua	S-9	S-8	S-8
6060	R. Australia	S-8	S-6	S-6
6165	R. Nederland, Neth. Antilles	S-7	S-5	S-5 + QRM
6195	BBC Singapore	S-6	S-5	S-5 + QRM
7250	R. Moscow	S-9	S-7	S-6 + QRM
7355	WYFR, USA	S-7	S-5	S-4 + QRM
7412	AIR, Aligarh	S-4	S-2	S-2 + QRM
7425	WEWN, USA	S-6	S-4	S-4
9515	BBC, Sackville	S-5	S-3	S-3 + QRM
9580	R. Australia	S-9 + 20db	S-8	S-7
9650	DW, Germany	S-6	S-6	S-6 + QRM
10000	WWV	S-9 + 10db	S-9	S-9
11625	Vatican R.	S-2	S-1	S-2 + QRM
11680	China R. (Fr. Guiana)	S-9 + 20db	S-9 + 20db	
11695	R. France Int'l.	S-4	S-4	S-4 + QRM
11760	R. Havana	S-9	S-9	S-9 + 5 db

FREQUENCY	STATION	CAROLINA BEAM	100 ft. w/Matcher	100 ft. Hi-Z
11795	DW, Germany	S-6	S-5	S-5
11805	R. Moscow, Kazan'	S-3	S-2 + QRM	S-2 + QRM
11826.8	RFO Tahiti	S-7	S-5	S-6
11930	VOIRI, Iran	S-5	S-5	S-5
11940	R. Jordan	S-9	S-7	S-8
11945	UAE R., Dubai	S-8	S-7	S-7
11950	Kazakh R.	S-7	S-5	S-6
11960	HCJB, Ecuador	S-7	S-7	S-6 + QRM
12040	Unid., rel. pgm.	S-2	barely audible	barely audible
12060	R. Moscow (Armenia)	S-3	barely audible	not audible
13595	WJCR, USA	S-8	S-7	S-7
13605	R. Australia	S-4	S-2	S-4
13675	UAE R., Dubai	S-7	S-6	S-7
13700	R. Nederland (Flevo)	S-9	S-8	S-9
13740	VOA, Ohio	S-9 + 5db	S-9 + 5db	S-9 + 5db
15000	WWV	S-9 + 10db	S-7	S-7
15029.6 USB	RFPI, Costa Rica	S-3	barely audible	barely audible
15050	AIR, Delhi	S-6	S-3	S-4
15155	HCJB, Ecuador	S-9 + 10db	S-8	S-9
15168.9	RFO Tahiti	S-7	S-5	S-6
15220	R. Moldova Int'l.?	S-3	not audible	barely audible
15230	R. Japan	S-8	S-5	S-4
15240	R. Australia	S-9	S-5	S-6
15245	R. Moscow (site?)	S-4	barely audible	barely audible
15310	BBC, Oman	S-6	S-4 + QRM	S-5
15345	VOFC, Taiwan	S-9	S-5	S-4
15355	R. Japan	S-9 + 10db	S-8	S-9
15360	BBC, Singapore	S-5	barely audible	barely audible + QRM
15365	R. Australia	S-8	S-5	S-6
15390	BBC, Ascension	S-9	S-5	S-8
15400	VOA, Greenville	S-8	S-5	S-6
15435	R. Jamahiriya, Libya	S-5	S-2	S-3 + QRM
15445	R. Pakistan	S-5	S-3	S-4
15460	R. Moscow, Krasnoyarsk	S-6	S-3	S-5
15490	R. Moscow, Tula	S-5	S-3	S-4
15505	R. Kuwait?	S-5	barely audible	barely audible
15475	Africa Numero Un	S-4 + QRM	S-2 + QRM	QRM only
17760	R. Pilipinas, Philippines	S-5	S-5	S-4
17775	KVOH, USA	S-7	S-7	S-7
17790	BBC, Ascension	S-6	S-6	S-6
17795	R. Australia	S-6	S-6	S-7
17845	R. Japan	S-7 mixing w/VOFC	S-7 Japan only!	S-6 Japan only!
17890	R. Moscow, Irkutsk	S-6	S-5	S-5
18640	unid. FAX xmsn.	S-4	S-1	S-3
21455 USB	HCJB, Ecuador	S-2	barely audible	S-2
21475	VOA, Philippines	S-7	S-4	S-5
21480	R. Moscow, Petropavlovsk	S-9 + 10db	S-8	S-9

A well installed vertical antenna will have two ground systems. One is at the antenna and the other is at the radio equipment end of the coax. We have different ground systems at each end of the coax feedline. A voltage gradient probably exists between the two grounds. The differential voltage between these two grounds will be conducted directly by the coaxial feedline and coupled to the station receiver. We hear the result as noise. The 4KV-LI [Line Isolator] isolates the two ground systems from one another and reduces the noise pulses that may be flowing along the coax. This is, of course, only one explanation. The capacitive coupling between coax and ground also will have a similar effect.[5]

The above explanation applies directly to a vertical monopole with a ground connection. All antennas, however, form an electrically complicated system affected by other antennas, local RFI, transmitting/receiving equipment, antenna feedlines, ground system(s), and nearby metal objects. The Line Isolators sold by The Radio Works have negligible loss and are worth experimenting with in any coax-fed antenna system.

In an urban or suburban environment the noise level is the limiting factor in DX reception, and the Carolina Beam is an unusually quiet—and unconventional—antenna. I have not directly compared the Carolina Beam to a delta loop antenna, but going from memory it seems to be as quiet an antenna as the 60 meter band delta loop I have used.

Ontario DXer and *Proceedings* author Tony Ward purchased a Carolina Beam after hearing of my good results. He is in the fortunate position of DXing with a number of longwire antennas about 500 feet long, which are lengthy enough to be considered true Beverage antennas (unterminated) on many frequencies. How does the 100 foot Carolina Beam compare with a Beverage, usually considered the ultimate antenna for the serious SWBC DXer? Surprisingly well, according to Tony:

> "The Carolina Beam is performing well, even at its low (25 feet at the house, 35 feet at distant end) elevation. I would expect this in a vertical array. It occasionally equals my longwires on the evening long-path, but has never beaten them (ie the best-performer on a given station) so far. If you had no room for long-wires it would be considered a superb choice for a single antenna. On the morning path (when my antennas have to work off their feed-ends — it is normally the best performer on 60 & 90 meters by an S-unit or more. Some mornings saw it bring in Indians inaudible on any longwire... I am well pleased.
>
> Because of the peculiarities of my location I can run longwires radially from North around to South towards the east. This means I can direct them towards the evening long-path (NE, SE etc) but they must work off the fed-end back at the house on the morning Asian short-path to west and northwest. I currently have 4 (soon to be 5) of these unterminated long-wires up, and they are all about 500 feet in length.
>
> The overwhelming advantage of the long-wire is its extreme simplicity, and great directional performance. The Carolina Beam was originally installed in its long mode, with two 16 ft. and one 22 ft. vertical elements. The 16 ft. element closest to the house as less than 10 ft. from aluminum siding, and I could not see it performing fully to spec. I recently reversed the antenna, which allowed me to dangle a now 32 ft. vertical element from the top of the tree at the back of the house — a 50 ft. support. The shortened horizontal extent of the antenna in this format carries the housewards (west end) 16 ft. vertical a further 20 ft. away from the siding, while keeping the 22 ft. driven vertical on my own property. Preliminary results confirm the expected improvement in low-band performance. At sunset tonight, for example, Ghana on 3366 was slightly stronger on the Carolina Beam than on the best longwire. Stations now runs neck-and-neck with the Carolina Beam — not bad at all for a single antenna versus four others to choose from.
>
> Daybreak monitoring shows that the Carolina Beam maintains its advantage into Asia on mornings when low-angle signals are arriving. During the daytime it makes an excellent all-purpose receiving antenna on the higher frequencies, sometimes with the edge, other times not (as expected). Low angle late afternoon Asians are often better on it (Delhi 9910, Korea 15575) but most signals are coming in at fairly high angles, where almost any antenna will work.
>
> Tonight I tuned Radio New Zealand on 15115 at about 2300, 45 minutes before my local sunset. The best antenna was the 75 degree longwire — working off its rear without a doubt — by about 2 S-units. A recheck at 0120 showed a dramatic reversal of the situation. On the longwire the signal was a watery S3-4, with occasional peaks to S6. On the Carolina Beam however the signal was a perfect S9+10 to 20dB. This is on the R8, pre-amp off. Presumably the propagation was low angle, and particularly suitable to the Carolina Beam. The Carolina Beam had the edge up and down the band on many stations at different distances, but the advantage was most spectacular on RNZ. The sucker's paid for itself!

One further comment is important. Long-wires are desirable because of directional gain, good signal/noise ratio, extreme simplicity, AND the less-often mentioned but rather important factor of resistance to short-term fading. Long-wires often seem to hear better because signal strength gathered along their appreciable lengths is steadier and less choppy. I notice this diversity effect in favour of the long-wires, even when the Carolina Beam leads in peak signal strength. But the Carolina offers excellent performance for its size, and for situations in which there is a one-antenna limit, it's unbeatable."

FINAL COMMENTS

Some weeks after my comparison testing, I lowered the antenna to take close-up photographs. I was surprised to discover that the Line Isolator was filled with a considerable amount of water! I thought I had thoroughly waterproofed all connections and seams with the supplied Coax Seal© but I clearly missed something. I drilled two small holes in the lower cap of the Line Isolator to drain the water, and then plugged the holes. The owner's manual recommends complete weatherproofing, and they aren't kidding. I do not know if the unit was waterlogged during my comparison tests, but dry Line Isolators and baluns are certainly preferred! I later discovered that water had entered the unit where the coax exits the top of the Line Isolator. VERY liberal application of Coax Seal© is my recommendation.

The excellent low-angle reception pattern of the Carolina Beam has been emphasized in this review. However, the antenna's horizontal element also contributes to its all-around performance. Unlike Tony Ward, I prefer the 100 ft. long configuration for best tropical band performance at my location. I have switched between the two lengths a number of times and continue to like the 100 footer below 5 MHz. Fortunately it is a ten minute job to reconfigure the length of the Carolina Beam.

The Radio Works company would be wise to advertise this antenna in the SWL community, perhaps after "tweaking" the antenna to our frequencies of interest. At $99.95 the Carolina Beam is an excellent value. It's ironic that the best commercial antenna I've ever used for SWBC DXing—the Carolina Beam—is an amateur radio antenna!

REFERENCES

[1]The Radio Works Inc., P.O. Box 6159, Portsmouth, VA 23703. Phone: (804) 484-0140; fax: (804) 483-1873. A price catalog and a 128 page Reference Catalog are available together for $6.00 postpaid (inquire directly for pricing to Canada and foreign addresses). The Reference Catalog is particularly useful to antenna experimenters; it contains a wealth of "how-to" information, antenna construction and maintenance tips. Highly recommended!

[2]The ARRL Antenna Handbook, 14th Ed., American Radio Relay League (ARRL), Newington, CT 06111; "Multielement Directive Arrays", pg. 6-13.

[3]The Radio Works Inc., *loc. cit.*

[4]The Radio Works Inc., *loc. cit.*

[5]The Radio Works Inc., *loc. cit.*