BEVERAGE ANTENNA ARRAYS

Two Approaches

Don Moman, VE6JY and John Bryant

ON THE MOVE AGAIN: MOMAN

Much of the following discussion on beverage construction and remote antenna switching has recently been put into practise at my new antenna farm. As hinted at in my article for *Proceedings 1992-1993*, "Listening to a Dream", I have moved a little further out of town onto 80 acres ideal for antenna farming. At present I have two beverage arrays; one full rosette in the center of the property and one half array at the west boundary. The second site allows longer

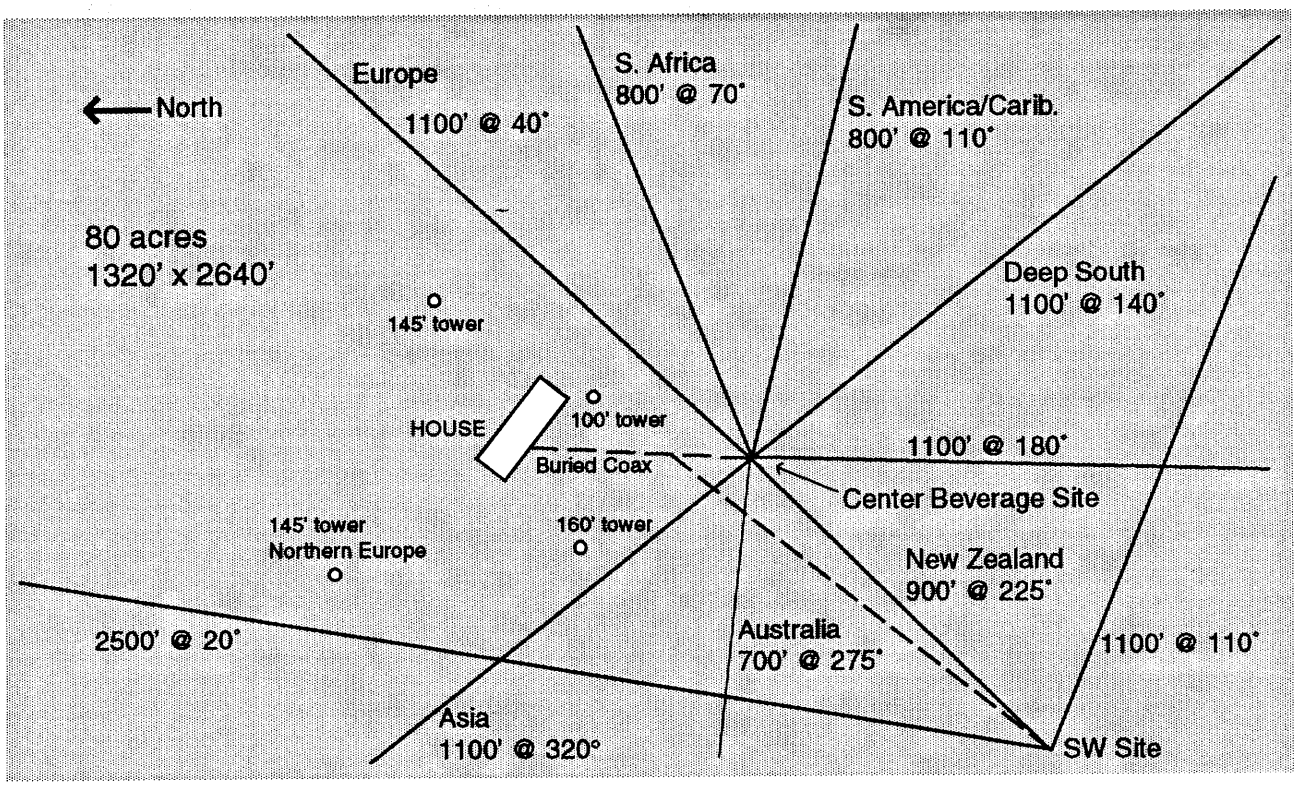

Figure 1. Beverage layout at VE6JY

beverages into Europe, Africa and South America. Some of these may become remotely reversible and steerable in the future. The first site is 450 feet away from the radio room and has 8 beverages centered at 40, 70, 110, 140, 180, 225, 275 and 320 degrees. Length varies between 700 and 1100 feet. The second site is 1400 feet away and will contain several more beverages, although not all of them are completed. The longest is 2500 feet long at 20 degrees, great for hearing Yellowknife, NWT on 1340 kHz but not much else so far. Feedlines are RG-8, RG-11 and CATV hardline. Only a few of the beverages have been properly terminated but I will finish that task this summer. Most of the beverages have their own impedance matching transformers, constructed when researching matching techniques, for *Proceedings 1992-1993*.

A Sony AN-1 active antenna is mounted at the convergence of the eight beverages at the first site, about fifteen feet above ground. I am certain there is some interaction between the AN-1 and the beverages, because the Sony has never worked better! It makes an ideal omnidirectional choice for casual listening and scanning. The beverages can then be selected to further improve the signal and determine the direction of signal arrival. This can be quite useful as it has been my experience that signals often arrive at other than their direct bearing. I used this beverage array on a daily basis throughout this past winter. Obviously certain paths are Long Path, like 60 meter Africans at 1700 UTC in the winter but many other paths can be quite skewed from either Short or Long Path bearings. This is most common on European

signals, which often come in best at 70, 120 or even 150 degrees. This is directly related to geomagnetic disturbances which disrupt the normal polar route. This past evening the northern lights were incredible, WWV indicated major to minor storming and the BBC on 3955 was S9+ on the southern beverage but barely listenable on the "proper" 40 degree beverage. At this latitude (53 north) a skewed path is very common. This has prompted me to add several beverages to fill in various gaps. One remaining gap is at 90 degrees, which may be useful under certain conditions.

The technical and theoretical aspects of beverage antenna have been well covered in past issues of *Proceedings*. Some of the more practical aspects will be discussed here especially dealing with remote feeding and switching, with ideas that are applicable to both weekend DX'pedition or permanent beverage installation, big and small. While the word "beverage" will appear many times, please keep in mind that most of the discussion on wire, feedlines and remote switching schemes could be equally applied to other types of wire antennas.

WIRE: MOMAN

For permanent installations, a steel cored wire with a higher conductivity coating is desirable. Since the majority of RF energy flows on the surface of the conductor, the core material need not be an especially good conductor. The ideal wire is copperweld -- a copper covered wire with a steel core. The steel adds a great deal of strength and reduces the stretch, which occurs when using pure copper wire. Copperweld is very stiff and springy and not pleasant to work with. It's not all that common to find locally, although I do see one ad in a amateur radio magazine for a supplier who has 14 gauge copperweld for 7 cents per foot. A similar type of wire is the "electric fence" wire which is galvanized instead of copper covered steel. It also is stiff and springy but is common in most parts of the country at farm supply stores and is quite inexpensive at about one cent per foot in 1320 foot rolls. It's very strong and can be pulled tight enough to span 300 to 500 feet with minimal sag. While you're at the farm supply store, you might stock up on the various types of plastic insulators you'll need to complete the installation. They also offer fiberglass stakes that could be used to hold up the wire. However, they are quite expensive and only three to four feet high. Perhaps they can be ordered in "giraffe" size?

Unfortunately, none of the above wire types are well suited to beverage expeditions. There you want something easy to work with that can quickly be rolled back up on the reel. Insulated wire is best so the additional task of installing insulators can be avoided, at least for a weekend type of installation. Stranded wire is better as it is less likely to kink and break. Soft, insulated, stranded "hookup" wire in the 18 to 22 gauge size is nice to handle but may be fairly expensive. Surplus stores and amateur radio flea markets may often have suitable wire available. I was lucky to find a number of reels of teflon insulated, 22 gauge stranded wire at a local surplus shop for only 5 dollars for 2000 foot roll. This insulation, besides being very tough and light, makes the wire easier to retrieve because of the slippery nature of teflon.

FEEDLINES: MOMAN

At mediumwave and the lower shortwave frequencies the choice of feedline is not critical. Losses are not high unless the cable run is extremely long. Coax can be either 50 or 75 ohm, both will work well. Suitable types include RG-58, RG-59, RG-6 or the larger diameter RG-8 or RG-11 cables. The thinner types are obviously more suitable for temporary and DXpedition installations. For direct burial and longer life under any conditions, RG-213 would be a good choice. For a first class installation on a budget, an ideal choice would be 75 ohm CATV coax. Roll ends are often cheap or even free from cable TV installers. I was lucky enough to spot an ad in a local newspaper for a giveaway item - 7 large cable reels. These make handy picnic tables or workbenches but much to my surprise, I found they still had anywhere from 100 to 800 feet of half and three quarter inch CATV hardline still on them! This type of hardline is ideal, it uses a solid aluminum jacket covered with a tough plastic coating designed for direct burial. This type of cable also has a very sticky substance just under the jacket, which prevents water from migrating under the jacket should a small nick occur. These are referred to as "self healing" types of hardline. Bare aluminum CATV cable such as that used for overhead cable TV wiring is not suitable for burial, as the exposed aluminum may not survive long in some types of soil.

Connectors for CATV coax are expensive but alternatives are available from your local plumbing store for a dollar or two. Half inch 75 ohm CATV hardline with the jacket removed, is exactly the right size to take a half inch copper compression fitting. The barrel of a PL-259 coax connector is also this exact size! Bare enough of the center conductor to solder into the center of the PL-259 and you have a solid, reliable RF connection good into the VHF region.

REMOTE ANTENNA SWITCHING: MOMAN

Designing the whole system for maximum flexibility in receiving has been an ever increasingly complex task, as the number of beverages grow. In addition to the SWL aspect, amateur radio contesting with multiple transmitting and simultaneous receiving needs has to be figured into the antenna switching system. The system that John Bryant describes in his article is perhaps the most basic and at the same time, a very flexible approach. One relay per antenna, one control wire per relay allows multiple beverages to be connected together, occasionally providing a combination that

my case where I have 8 or more beverages. Flipping toggle switches to see where the signal peaks is not nearly as convenient as rotating a switch. If possible, the switch could be set up so the indicator also shows where the beverage is pointing.

Because of the number of beverages and the distance involved, I have used a somewhat different technique. Four conductor telephone type wire is quite inexpensive compared to other types of control cable so my system is built to switch up to 8 antennas using just 3 wires plus ground. Each additional wire will double the number of antennas so I could expand to 16 antennas using only 4 wires plus a ground. One could expand the system even further without additional wires by using steering diodes and/or zener diodes along with both plus and minus DC voltages as well as AC. However, this can get a little tricky and I have an aversion to using diodes around RF, since they can rectify and create mixing products.

My system is modular in construction with each SPDT relay in its' own box. I used weather proof diecast aluminum boxes with BNC connectors. This allows for easy modification and maintenance. BNC connectors are easy to mount and work with but they had an unexpected advantage that I discovered last season. Some of the beverage transformers in my initial system had SO-239/PL-259 connections. The tension in the wires is significant and the wires can build up quite a vibration, which travels down to the matching transformer. This vibration would loosen the ring on the PL-259 and back it off, causing all sorts of noise due to the lack of a solid shield connection. BNC's with their twist lock action gave no problem at all.

Most general purpose low power relays are quite suitable for use as low and medium frequency antenna switches. I use small 26 volt military surplus relays, the type that are hermetically sealed in a small metal can. This should prevent oxidation of the contacts from a harsh climate out there. Isolation between the adjacent contacts in the relay can be measured using a signal source and an attenuator. Isolation decreases with increasing frequency, but most common relays provided at least 50 db at 5 MHz and 60 to 70 db at medium wave frequencies. In the interests of maintaining a sanitary beverage pattern, each matching transformer is switched between two adjacent beverages. In this way, the lead-in to each transformer input can be kept to a minimum. Again, this makes repairs easy. By adding more units the system can be expanded. Certainly this system or any of the ones described here are not limited to switching beverage antennas. I would be comfortable using these for any type of HF receiving antenna and even up to 100 watts for transmitting, more if larger relays were used.

When current flow in a relay coil is interrupted, a back voltage or EMF is developed. This voltage can be quite high and although it's not likely to harm anything with the sizes of relays we're using, it's a good idea to suppress this switching transient as much as possible since it can produce an annoying pop in the receiver each time you switch antennas. A diode connected across the coil with the polarity such that it conducts only on the back EMF will help.

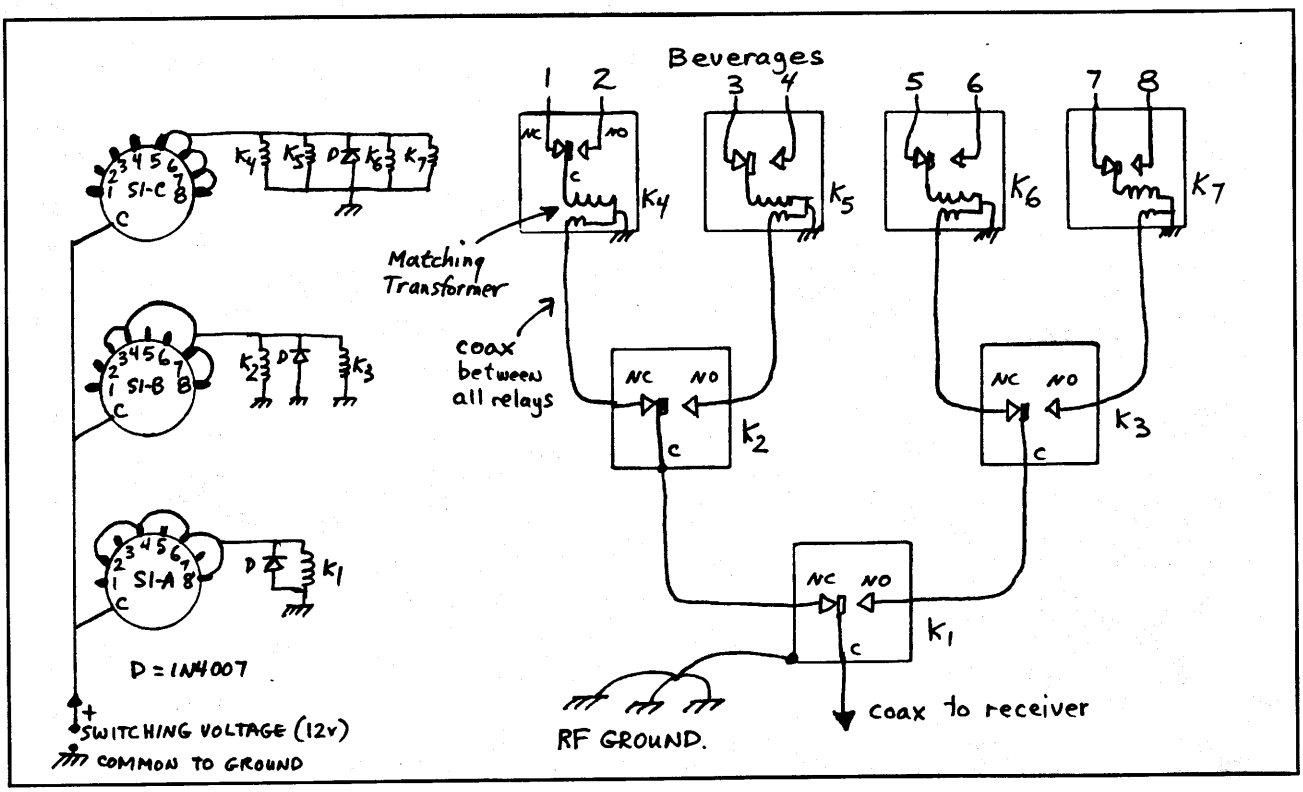

Figure 2. Switching 8 antennas using 3 control wires

Another type of switching that I have experimented with in the past is the rotary type, which can be driven by low RPM motors or rotary steppers. A common and inexpensive source of 12 volt 4 position rotary steppers is found in old 8 track players, as they were used to change tracks. Disadvantages of this type of switching are the larger control conductors needed due to the higher power necessary to switch, and lack of nearly instantaneous A/B comparisons. Also without some sort of indexing scheme, it can be hard to determine the position of the switch. They are better suited for adjusting the termination resistor value, something I intend to experiment with in the future. With proper coupling and isolating components, ratcheting type stepper switches could be driven directly using the beverage wire as the conductor, thus saving a great length of control cable (figure 3). This same technique can be used to send DC over a coaxial line at the same time RF is flowing back into the receiver, such as is usually found in an active antenna. This technique can also be used for remote relay switching in beverage systems. You could, for example, change the length of the beverage by switching in or out additional segments of wire. Such a system is described by ON4UN, John Devoldere, in his book on *Low Band DX'ing*[1].

The value of capacitors and inductors is not critical. The capacitor serves to block DC but pass the RF. A .1 uf capacitor has a reactance of 1.6 ohms at 1 MHz so its' effect as a series resistance is negligible. The inductor serves the opposite purpose; it must pass DC and block RF. A 1 mh inductor has a reactance of 6280 ohms at 1 MHz, again a small shunt resistance in a 600 ohm (approximately) system. The small wire used in the inductor may cause a problem if you are trying to pass enough DC current to drive some larger relays. Inductors used for 12 volt DC power line filters on car stereos would be a good choice, providing they have enough inductance.

If you are using the Mini-Circuit type wide-band RF baluns, care must be taken not to exceed the power handling capability of their extremely small core and windings. C2, C3 and L2 serve to bypass DC around the transformer. If a more robust transformer is used, it would be simpler to install a single .1 uf capacitor in the ground lead of the transformer.

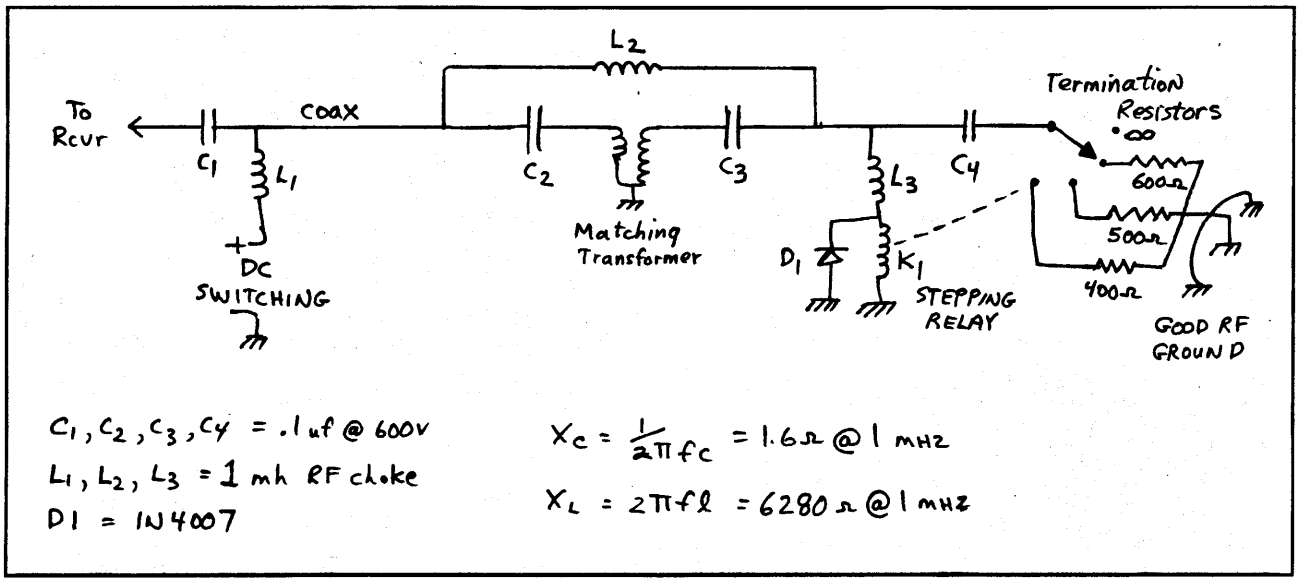

Figure 3. Basic DC switching and isolation techniques

I look forward to much more experimenting with this array, as I plan to improve the RF grounds at critical points, add termination resistors to all the wires and fill out the second SW site with even more beverages. Even at this stage, using the array has been very rewarding. Later this year, I hope to reinstall the log periodic at about 90 feet here at the new site, and it will be most interesting to compare the log with the beverage array. The results might even make an article for a future *Proceedings.*

A HALF-WAGON WHEEL OF BEVERAGES: BRYANT

Most of us have a dream antenna system we suppose we could never afford. My dream had always been to have a permanently mounted 'wagon wheel' of Beverage antennas, with me DXing away at my favorite rig in the middle. I knew it was an impossible dream; I could never afford the thousands of feet of antenna wire and coaxial lead-in, much less the land to put it on. Over the past three years, I've found that I was wrong on all counts.

My first discovery was that antenna wire wasn't as expensive as I thought. I learned that many amateurs use smooth galvanized steel wire -the kind manufactured for electric fences - for Beverage wire. It turns out that RF currents flow on the surface of antenna wires and that steel wire works just as well as copper for most receiving antennas. I was still suspicious until I saw Bill Tippett's (WOZV) system he described in *Proceedings 1991*. Bill used electric fence wire drawn very tightly with posts and insulators at 100' intervals. 2500' rolls of electric fence wire sell for less than $30 at most farm supply stores. Some of the electric fence insulators are pretty nifty, too.

Next, I discovered an excellent source for coaxial lead-in: Davis RF (P.O. Box 230, Carlisle, MA, 01741 Phone 508-369-1738 or 1-800-484-4002, Ext. 1356) sells 52 ohm coax with excellent spec's for 17 cents/ft. in 500 ft. rolls.

I also learned that Beverages of about 450 to 500 feet are about optimum length for 60 and 90 meter DXing. I had always imagined needing much longer antennas. I now know that even 'mini-Beverages' of as little as 150' will exhibit some directional characteristics.

REMOTELY SWITCHED BEVERAGES: BRYANT

My real revelation was seeing Bill Tippett's antenna switching system while we were visiting in Colorado. Bill had a wagon-wheel system in a field next to his house. Five Beverages came together at the center of the field and were individually switched by a home brew system into one single coax lead-in, which then ran the 600' or so to his basement shack.

I had always supposed that Beverage switching systems had to be very elaborate to keep the antennas from coupling together and destroying directionality. NOT SO! Bill used 12 volt DC 'reed' switches from Radio Shack and ran a 6-conductor cable out to the switches to throw them ON or OFF. The gizmo was mounted in a plastic box. Bill switched the signals coming in directly from the Beverages and then had one ferrite toroid-based impedance matcher mounted right before the signal entered the coax lead-in. At first, I couldn't believe that so simple (and cheap) a system would work! It did. Each of the antennas exhibited very individual characteristics and, since Bill regularly 'worked the world' on 160 meters, the system was obviously a good one.

I developed my own switching system based on Bill's but using double pole single throw relay switches which are 'normally off' (RS part #275-248) as shown in Figure 4. As you can see, when the relays are OFF, the antennas are grounded to prevent static buildup and to reduce antenna interaction. When a relay receives 12 volts from my indoor control box, it switches the RF from that antenna to the 'bus' going through the impedance matcher to the coax lead-in. The entire switching system cost me less than $15 for the indoor control box and 6 control switches and about $20 for the outdoor box, perf mounting board and five relays. It works like a charm and, as far as I can tell, there is no coupling between antennas. Each antenna exhibits very distinctly different and distinctly directional reception patterns.

Besides saving a great deal of money on expensive coax, switching Beverages remotely also can allow you to arrange Beverages most efficiently on your land. I live on a semi-rural 'ranchette' site that is about 450' square. My house is in the middle of the site. (Figure 5)

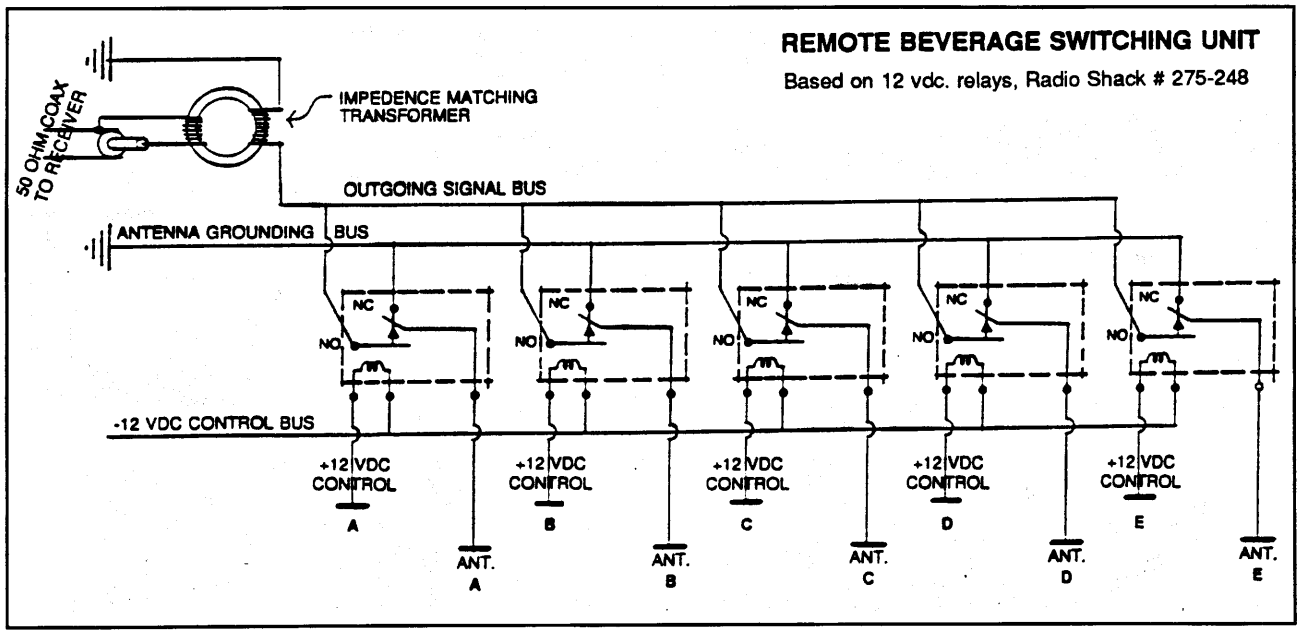

Figure 4. Remote Beverage switching unit

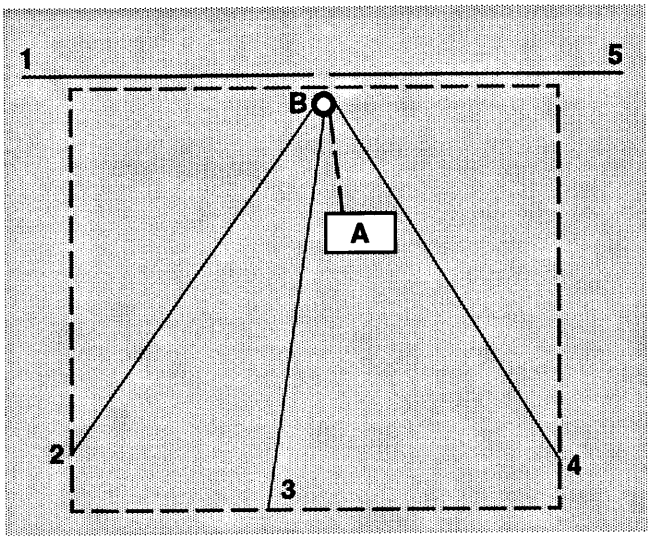

Figure 5. **A**=House **B**=Beverage Switching Site **2,3,**& **4**=450 ft. unterminated Beverages **1** & **5**=750 ft. terminated Beverages on the fence line

As you can see, by leaving Beverages 2,3 and 4 unterminated, I can cover dawn Long Path to Asia and evening Short Path to Europe with Beverage 2. I aim right at evening Long Path to Asia, Short Path to southern Africa and dawn Short Path to East Asia with Bev. No.4. I cover dawn Short Path to central and south Asia with Bev. No.3 which is also my best Latin antenna. Beverages 1 and 5 run on the fence line and point at mid Pacific and western/central Africa respectively.

THE AMERITRON REMOTE COAX SWITCH MODEL RCS-8: BRYANT

Several months ago, I learned that the Ameritron Corporation (Ameritron: 921 Louisville Road, Starkville, MS 39759; (601) 323-8211; Fax: (601) 323-6551. RCS-8V costs $149 w/SO-239s, $169.95 with Type-N connectors. They also have a 4-position remote switch, the RCS-4, priced at $134.50. Prices per Feb. '94 *QST*) manufactures and sells a very nice remotely controlled coax switch which will handle up to five transmitting or receiving antennas. The unit sells for under $200 and works much like my home-brew system. The remote switch itself is remarkably well built and uses five large relays mounted directly on a glass PC board. The switch is a COAX switch, so input to the switch box must be via 52 ohm coax. For us, this means using an impedance matcher at each Beverage and then a short run of coax from each matcher to the switch.

The control box in the shack is also very well made with LED's which light to indicate the antenna in use. The antenna selection switch in the Ameritron unit is a rotary switch. This limits you of course, to having only one antenna active at a time. My home brew system, using 5 SPST in the shack, allows you to have any or all antennas active at the same time.

If you would like absolutely maximum antenna isolation and would rather not build your own switching system, the Ameritron RCS-8 is very nice.

DO YOU REALLY NEED THIS: BRYANT

If you can string several mini-Beverages on your property (or that of friendly neighbors), I'd strongly recommend that you at least invest in a homebrew system similar to one of those covered in this article. My now three year old 'new' antenna system has improved my DXing ability more than any new receiver ever has! After Tippett's *Proceedings 1991* article convinced me that Tropical Band signals often can and do follow the Long Path, I put up my half wagonwheel. In less than one season, I logged all but two of the twenty-some All India Radio transmitter sites. I heard Tropical Band Subcontinentals VERY REGULARLY and very well from late October until early March rather than the 'normal' 6 to 8 week midwinter 'Subcontinental Season.' Almost 100% of those receptions were Long Path on the Beverage pointing southwesterly. Even on those few occasions when Long Path signals were only equal to Short Path signals 'over the Top', the Long Path was significantly quieter. I should note that after two wonderful Indian Long Path seasons (91-92 and 92-93), the 93-94 season has been very disappointing on 90 meters. Short Path seems to be dominating this season and signals from the Subcontinent seem to down generally.

The single greatest advantage of a multiple Beverage array similar to ours is the significant improvements in signal-to-noise ratio. Directional antennas only 'see part of the sky' and therefore only part of the noise. My current system lets me maximize signals and minimize noise.

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[1]Devoldere, John. ON4UN *Low Band DXing.* ARRL 1987, pp II-120