Ingenuity is not dead or even missing. KA0RUM, a recently licensed amateur, delves into the mystery of wire antennas and comes out a winner.

An Easy-To-Build All-Band Vertical Antenna

A Driven, Phased Array That Needs No Radials

BY PHIL MORGAN*, KA0RUM

Many years of antenna experimentation by amateurs have produced an endless parade of designs in various publications and reference materials. Licensed only three years, I have shared the bewilderment of hundreds of new amateurs confronted by this myriad of schemes and information.

To dispel my confusion I began to study as much authoritative material on antennas as I could find. Much I did not understand, something else I share with most fellow amateurs I'm sure, but some of it began to soak in and from this study emerged the antenna described here. It's a compromise design, to be sure, but it has many attributes, notably:

1. Operates on all HF bands plus 160 meters
2. Low radiation angle
3. Gain
4. Moderate steerability
5. Compactness
6. Inexpensive and easy to construct

The only limiting factor is the need for a couple of 45 foot (13.7 meter) high supporting structures such as towers, masts, houses, or as in my case a couple of tall trees.

Through my reading I came to realize there are only two basic designs from which all antennas are derived. The variations are endless, some simple and some complicated, but all relate back to either the dipole or the simple end-fed wire. Most end-fed variations can be difficult to match and can lead to problems with feedline radiation and RF in the shack. So what remained, in my opinion, was the old-fashioned dipole. However, obtaining low radiation angles with a dipole at the

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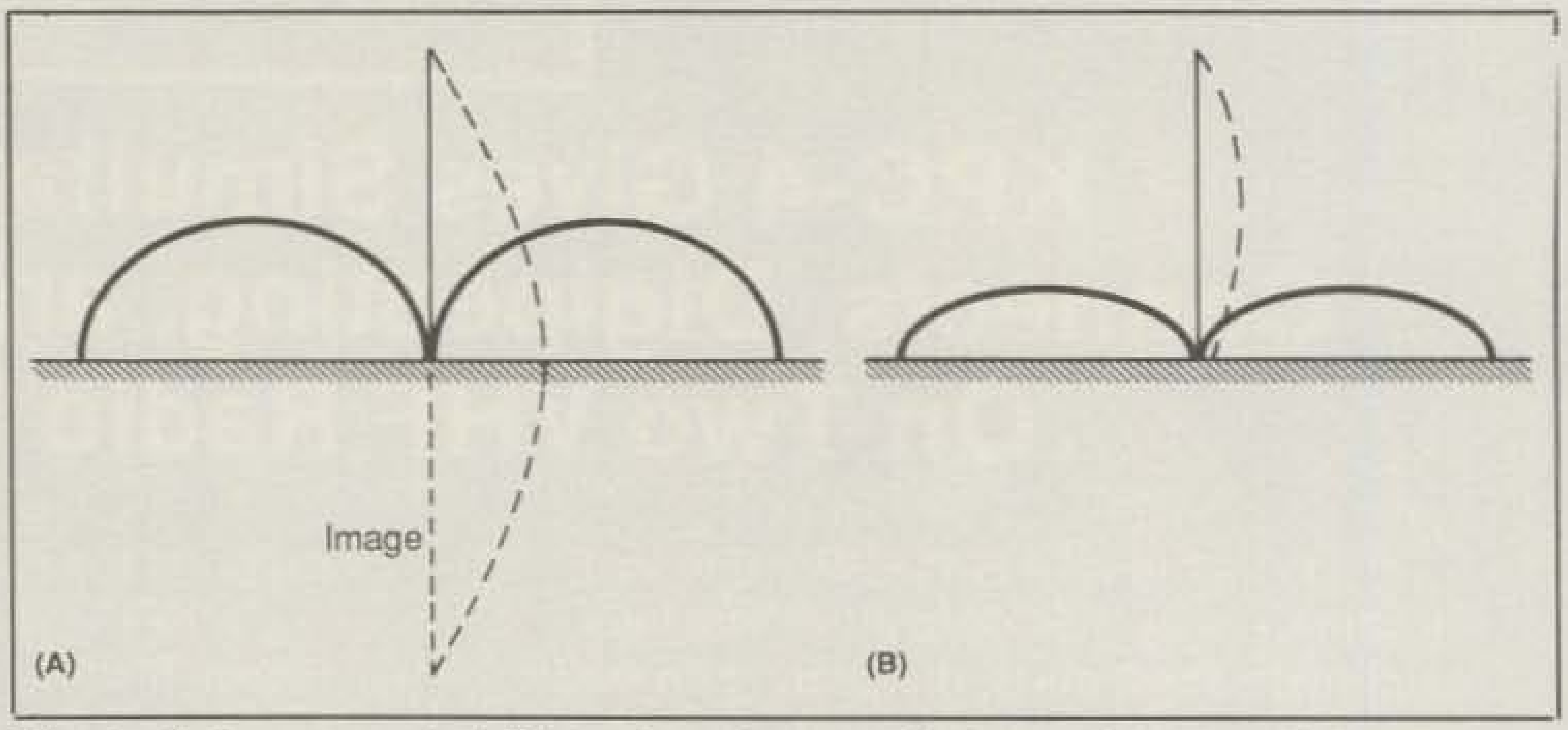
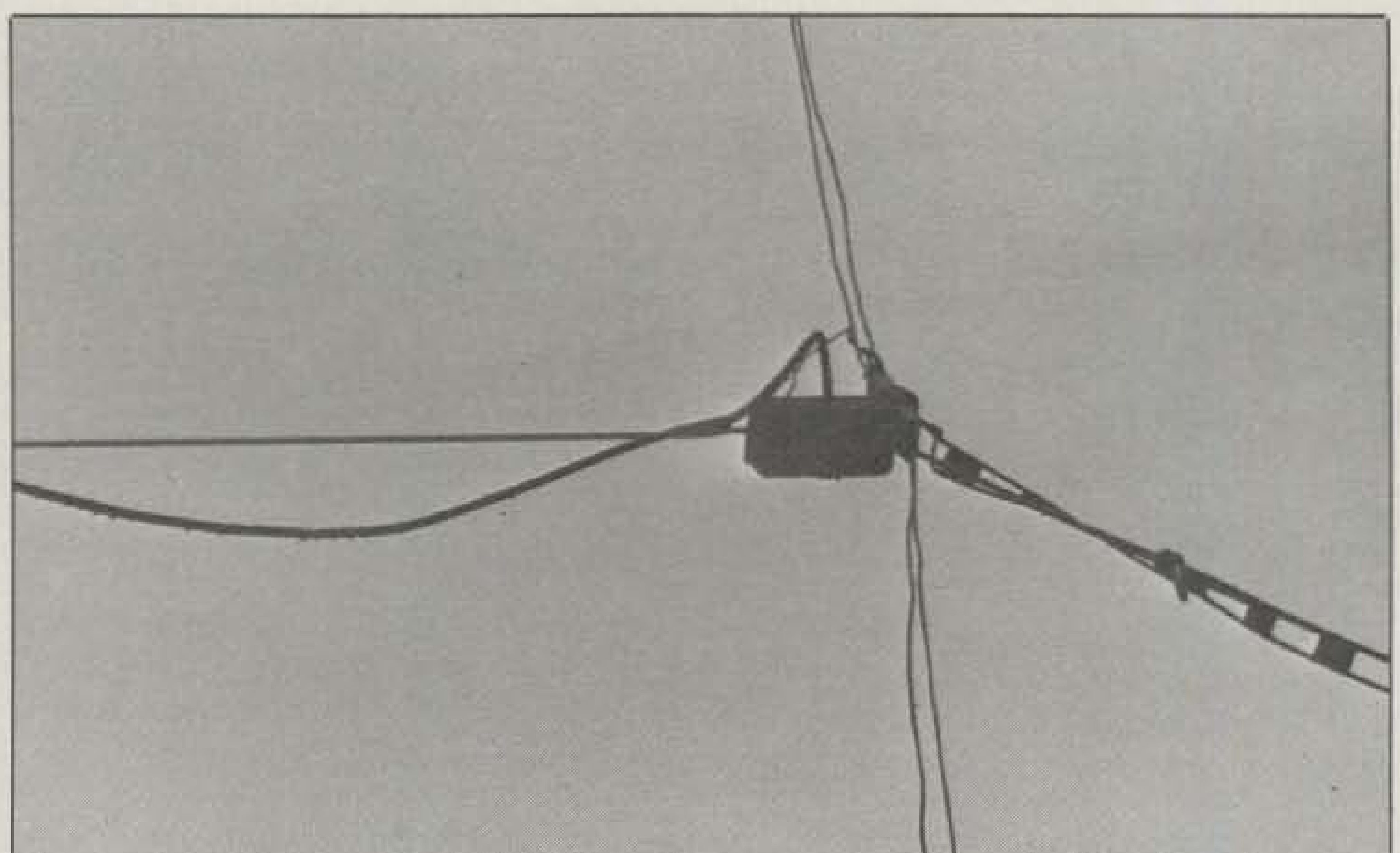
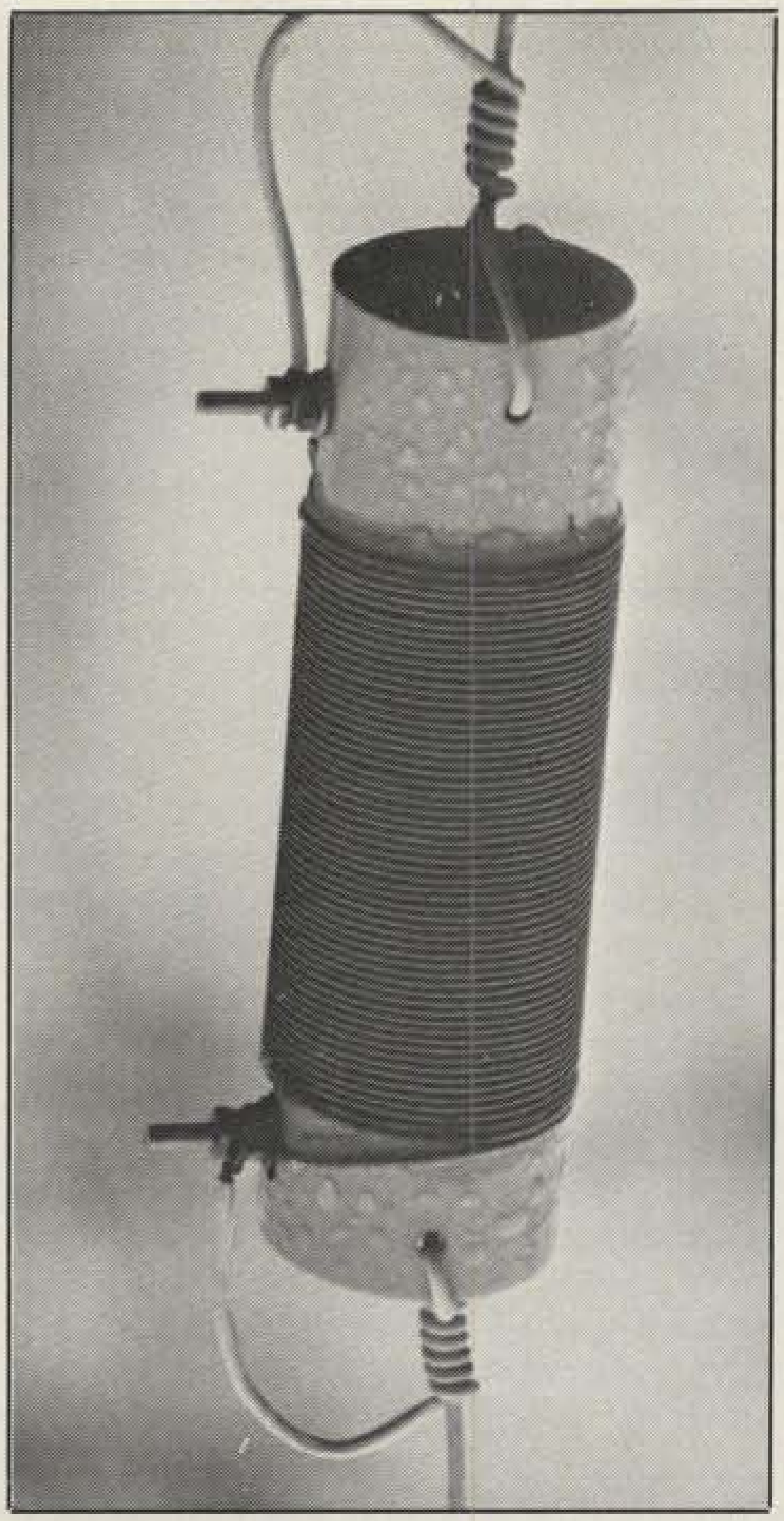


Fig. 1– Half-wave vertical (B) produces lower radiation angle and maximum current point at higher elevation than does quarter-wave radiator (A). No radial system is required for the half-wave vertical to operate effectively.



The phase control relay box is mounted at the feedpoint of one dipole and controlled by 12 volts switched at the operating position.



The 80 meter resonator is constructed of 1½ inch (3.75 cm) PVC pipe and close-wound with No. 18 insulated hook-up wire. No. 8 hardware secures the ends of the coil and the antenna elements.

The all-band phased array installation at KAØRUM. The top support is nylon rope stretched between the tops of two high trees. The bottoms of the dipoles are weighted by concrete blocks with screen-door springs to relieve wind stress. Feedpoints are held apart by additional nylon cords pulling away from the center of the array.

lower HF frequencies requires supporting structures too high to be practical for many amateurs. Getting an 80 meter antenna up the necessary ½ wavelength would call for a tower or mast approximately 130 feet (39.6 meters) high, 65 feet (19.8 meters) high for 40 meters.

For most of us the answer to this problem has been the ¼-wave vertical in one of its several variations. But proper performance of the ¼-wave vertical does require radials of sufficient length and numbers for adequate current-gathering capacity. Recommended lengths are usually at least ¼ wave long for the lowest design frequency of the antenna, and this can take up a lot of space, a commodity in short supply on the average city lot.

There *is* a vertical antenna that does not need radials to perform well, possesses even better radiation angle than the ¼-wave vertical, and needs no complicated matching device to link it to the transmitter. I am referring to the simple ½-wave dipole stood up on its end in the vertical format (fig. 1).

Realizing that an 80 meter ½-wave vertical would also require a mast or tower an impractical 130 feet (39.6 meters) high, I began to search for a loaded, shortened dipole antenna to reduce this height.[1]

"Lo-and-behold," there was Bill Fanckboner, W9INN, with just such a design in his "space saver" dipole which measures only 46 feet (14 meters) long and can be used on all bands, 10 through 80 meters. Employing a combination of loaded and parallel dipoles with a common feedpoint, Bill has created an antenna which resonates naturally on the 15, 20, 40, and 80 meter bands and, with a transmatch, works very well on *all* of the HF bands.

My variation, described here (fig. 2), differs in that it resonates on 10, 20, 40, and 80 meters and is 5 to 6 feet (1.5 to 1.8 meters) shorter by virtue of the 80 meter elements being folded back on themselves. This narrows the operational bandwidth on both 40 and 80 meters, but this is of no importance when used with a transmatch and low-loss feeder.[2] It also operates very well on 12, 15, and 30 meters with the use of a transmatch.

My support-structure height requirements now were down to about 45 feet (13.7 meters), and a nylon rope thrown over the top limbs of a tall tree in my front yard did the trick. This antenna performed remarkably well on all bands, and substitution of 450 ohm twin feeder for the coax allowed operation on the 160 meter band.[3]

Next I began looking for an inspiration on how to improve my new baby. Turning to the *ARRL Antenna Book* section on driven arrays,[4] I learned how to turn the simple vertical dipole into a driven array with the capability of radiating either endfire or broadside.

A second "space saver" dipole was built and I tuned it to match the first one. The nylon support rope was then strung between the tops of two tall trees, and the second antenna was hung with the center feeds separated and connected by 33 feet (10 meters) of 450 ohm twin line (fig. 3). The balanced feeder from my transmatch was attached at a spot exactly halfway between the antennas and brought away from the feedpoint perpendicular to the plane of the array for a distance of about 30 feet (9 meters) before running off toward my shack.

Using Radio Shack parts, a simple control can be constructed to invert phase. A double-throw, double-pole, 12 volt relay (fig. 4) with points rated at 10 amps is mounted in a weatherproof plastic box

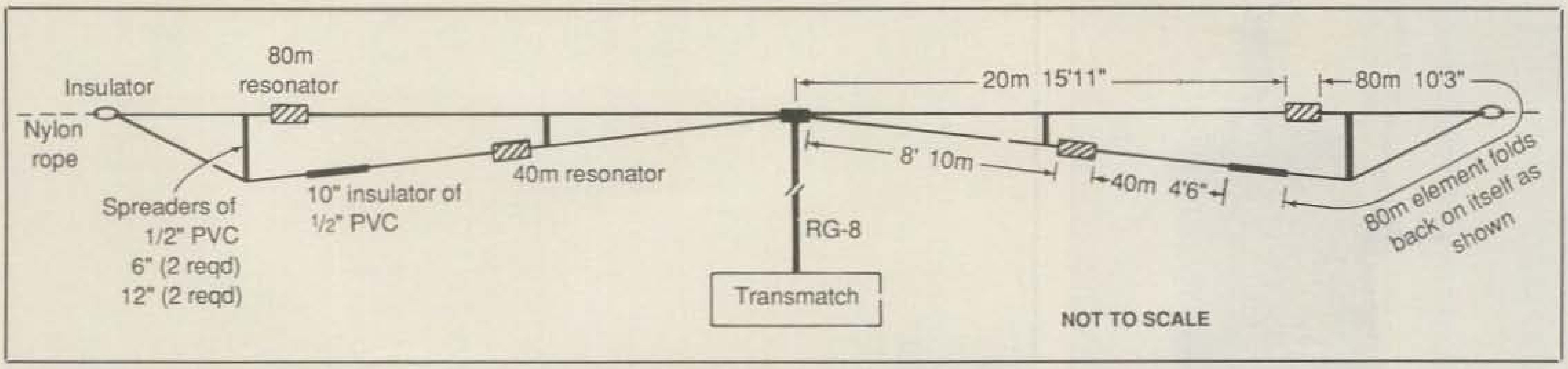


Fig. 2– The KAØRUM version of "Space-Saver" dipole is only 40 to 41 feet (12.2 to 12.5 meters) long and is naturally resonant on 10, 20, 40, and 80 meters. With a transmatch it will tune all HF bands with good effectiveness.

at the feedpoint of one antenna. A 12 volt plug-in power supply provides the energy, through a push-button switch at the operating position, to change the array from 180 degrees to 0 degrees phase difference, thereby altering the radiation pattern.

As most amateurs are aware, by virtue of the placement of the amateur bands in the spectrum, the same 33 feet (10 meters) of separation which works out to ⅛ wavelength at 80 meters is also ¼ wavelength on 40 meters, ⅜ wavelength on 30 meters, ½ wavelength on 20 meters, ¾ wavelength on 15 meters, ⅞ wavelength on 12 meters, and 1 wavelength on 10 meters. With this in mind, a quick glance at the H-plane patterns in chapter 6 of the *ARRL Antenna Book* will give you some idea of the radiation patterns available on all the different bands with switchable 0 and 180 degree phasing. There is also a bonus of some gain, differing in amount depending on the phasing and frequency used.

Construction of the shortened dipole is pretty straightforward. Approximate wire lengths are given in fig. 2. Tuning may vary in accordance with personal preference and local conditions. The 40 and 80 meter sections will interact, so check resonance frequency of both elements each time you adjust either one. All materials for these antennas are readily available from your local hardware and electronic-supply stores.

Forms for the 40 and 80 meter resonators are of 1½ inch (3.75 cm) rigid PVC pipe with 6 inch (15 cm) outer circumference. The 80 meter resonator form is 6½ inches (16.25 cm) long, with 60 close-wound turns of number 18 insulated hookup wire. For the 40 meter resonator use a form 4½ inches (11.25 cm) long and 30 turns of wire. I use a couple of coats of clear acrylic on the coils to help them resist deterioration from the weather. The two spacers which separate the ends of

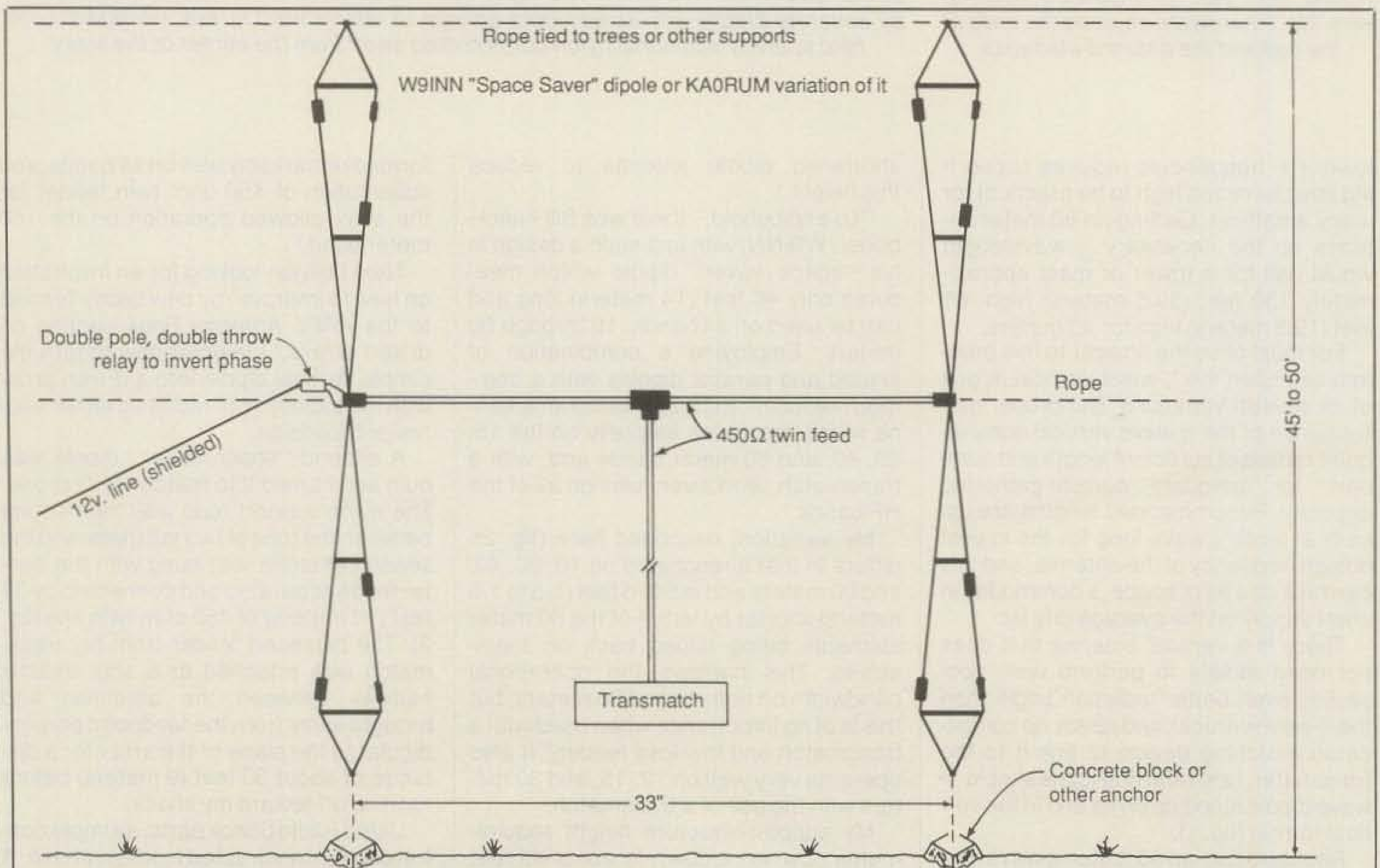


Fig. 3– As used at KAØRUM's QTH this array of two shortened dipoles can be switched between 0 and 180 degrees phase difference to alter radiation patterns. Gain ranges from 0.2 dB to 4.9 dB over a single dipole. Multiple lobes show up at higher frequencies.

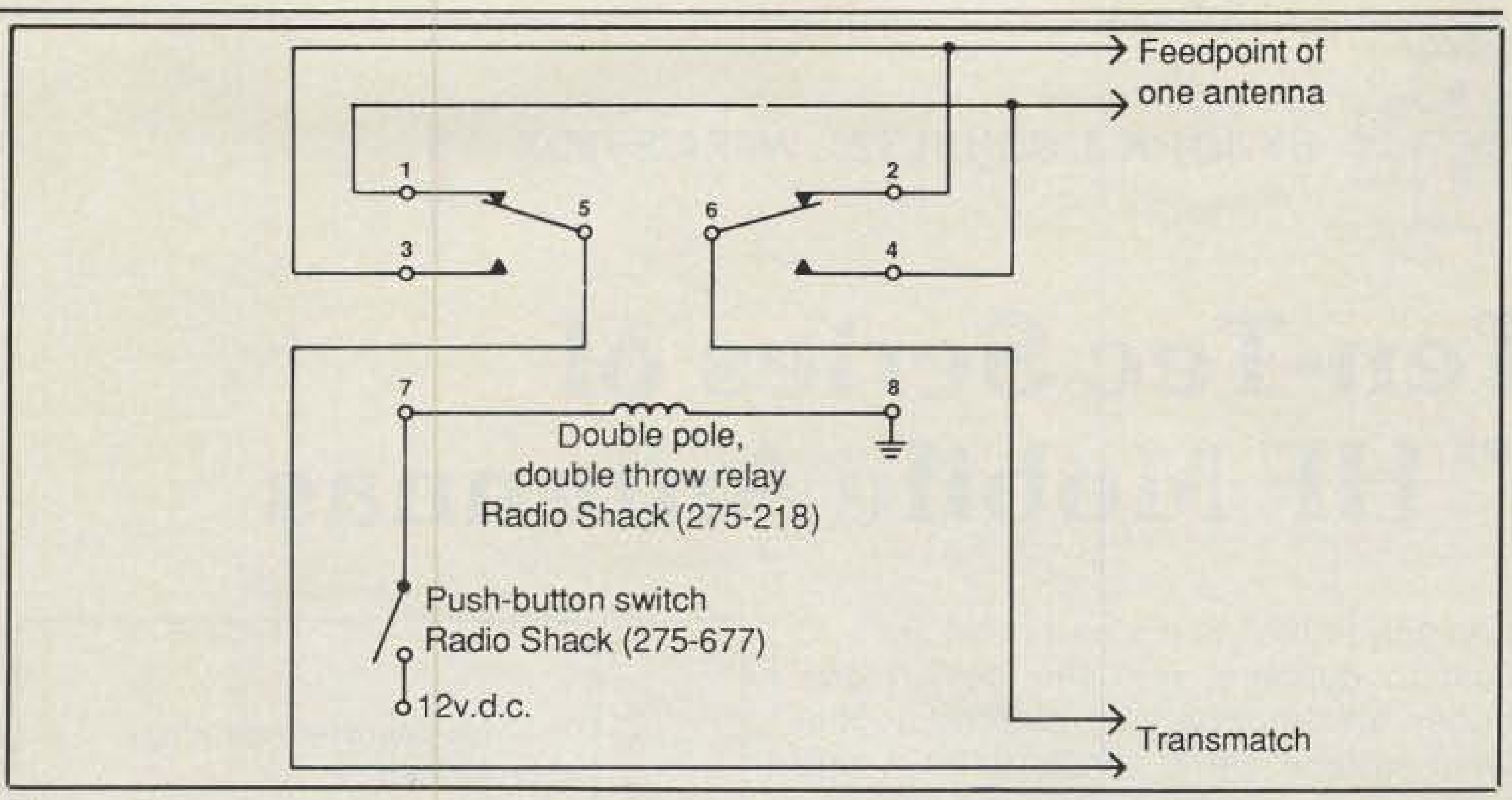


Fig. 4– Phase switching relay is mounted in plastic box (Radio Shack 270-220) at feedpoint of one dipole. Twelve VDC is supplied from plug-in battery eliminator (Radio Shack 273-1652) through single-pole switch mounted at operating position.

the 40 and 80 meter elements and which hold the parallel elements apart are made of ½ inch (1.25 cm) PVC pipe. Ordinary antenna insulators were used at the feedpoints and the ends to attach the ropes. In addition to the heavy nylon rope I used to support the two antennas, ¼ inch (6.25 cm) nylon cord was woven through the webbing of the twin-feeder for extra support. The bottom of each antenna was tied to a screen-door spring and to a concrete block for weighting. This spring relieves some of the stress from winds.

Both the original W9INN antenna and the shorter KAØRUM version can be ordered directly from the manufacturer already assembled and tuned. But if you prefer to build the variation described here and plan to use more than the normal 100 watt output of most of today's solid-state transceivers, you may want to acquire the sturdier and better insulated resonating units from the manufacturer.[5] My home-brew resonators have not been tested at powers higher than 100 watts.

How does it work? Well, much better than I dared to hope. Low-angle radiation gives good DX results even in this period of very poor propagation. Operating barefoot 10 through 80 meters with my ICOM IC-745 and a Heathkit SA-2060 transmatch, the signal reports to me by other stations using amplifiers are usually equal to or better than my reports to them. This array consistently outperforms my ¼-wave trap vertical and my 4-band ground-fed sloper. With this antenna system, even barefoot, if you can hear 'em you can probably work 'em. Many of my QSOs have expressed surprise when they discover I'm not using an amplifier. The limited 40 and 80 meter bandwidth of the single "space saver" dipole is not a problem with this array and transmatch combination.[2]

And, would you like another bonus? Try tying the two sides of the feedline together and connecting them to the single wire output of a wide-range transmatch.[3] You'll discover, as I have, a really fine 160 meter radiator which has helped me get my share of 59 reports right in there with the big boys and their amplifiers.

I have a more substantial nonmetallic support structure in the planning stage. You may have your own ideas for avoiding the instability of trees blowing in the wind. I call it the 80 meter jig. However, I would avoid use of a metal tower or mast if possible. Someone with more expertise than myself will have to speculate on the effect of a nearby metal structure on this system.

Total cost of this antenna system, as outlined, amounted to less that $90 including rope, feeder, wire, insulators, PVC pipe, 12 volt power supply and relay, etc. All was purchased new. But if you have a well-stocked junk box, you can probably build it a lot cheaper.

There is nothing new about this antenna. It uses information readily available in current reference materials in just a little different configuration. IT WORKS!

Thanks to Bill Fanckboner, W9INN, for his patience and helpful counsel in bringing this antenna project and report to fruition.

References

1. "Off-Center-Loaded Dipole Antennas," *The ARRL Antenna Book*, 1983, chapter 10, pages 5–6.

2. "The Conjugate Match and the Z_0 Match," *The ARRL 1986 Handbook For The Radio Amateur*, chapter 16, pages 10–11. J.M. Haerle, WB5IIR, *The Easy Way, HF Antenna Systems*, 1984, Overtones Inc., pages 1–11. W. Maxwell, "How Does a Transmatch Work?", Technical Correspondence, *QST*, March 1985, pages 45–46.

3. J.M. Haerle, WB5IIR, *The Easy Way, HF Antenna Systems*, 1984, Overtones Inc., page 96.

4. *The ARRL Antenna Book*, 1983, chapter 6, pages 4–14, chapter 8, pages 10–11.

5. W9INN Antennas, P.O. Box 393, Mt. Prospect, IL 60056, set of 4 resonators for one dipole: $40.

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