Here's an all-band, no-tune, no-trap antenna based on moving the feedpoint (with the flick of a switch) to achieve a perfect match on every band.

The Motorized Clothesline Antenna
An Impedance-Tuned Antenna System

BY ROBERT VICTOR,* VA2ERY

Remember Archimedes? He was the guy who jumped up out of his bath and went running down the hallway soaking wet yelling "Eureka!" That did not mean "Where are all the bloody towels?" but rather, "I've found it!" What he'd discovered while slipping into his bath was a way to measure the volume of an object by dunking it into a tank of water, leading to the concept of specific gravity we still use today.

Archy discovered a bunch of other stuff, too: pi, the screw, and the inclined plane, to name a few. When he wasn't busy practicing science with rubber duckies, he was a philosopher and is quoted as having once said, "Give me a spot on which to stand, and I can move the entire Earth."

This brings me to impedance-tuned antenna systems, and more specifically, the Clothesline. The Clothesline is an all-band, no-tuner, no-trap, no-loading-coil HF antenna that can cost as little as twenty bucks or so to put up and will outperform almost any other multiband dipole you can name.

I developed it by finding a different angle, a different "spot" to stand on, if you will, that allowed me to see a new approach to a conventional concern: how we match an antenna to a feedline. Here's the low-down on impedance tuning and more specifically, the Clothesline antenna.

Impedance Tuning

Look at the diagram (A) in fig. 1. It shows a half-wave of radio energy distributed along a length of wire cut for a half-wave at that frequency. If this wire were 132 feet long, we would say the antenna is resonant on 80 meters. Why resonant? Because if we impose a signal of 3.5 MHz on this antenna, we wind up with the maximum voltage points at the ends. This will be the case for any resonant dipole; the voltage will be at a maximum at the free ends.

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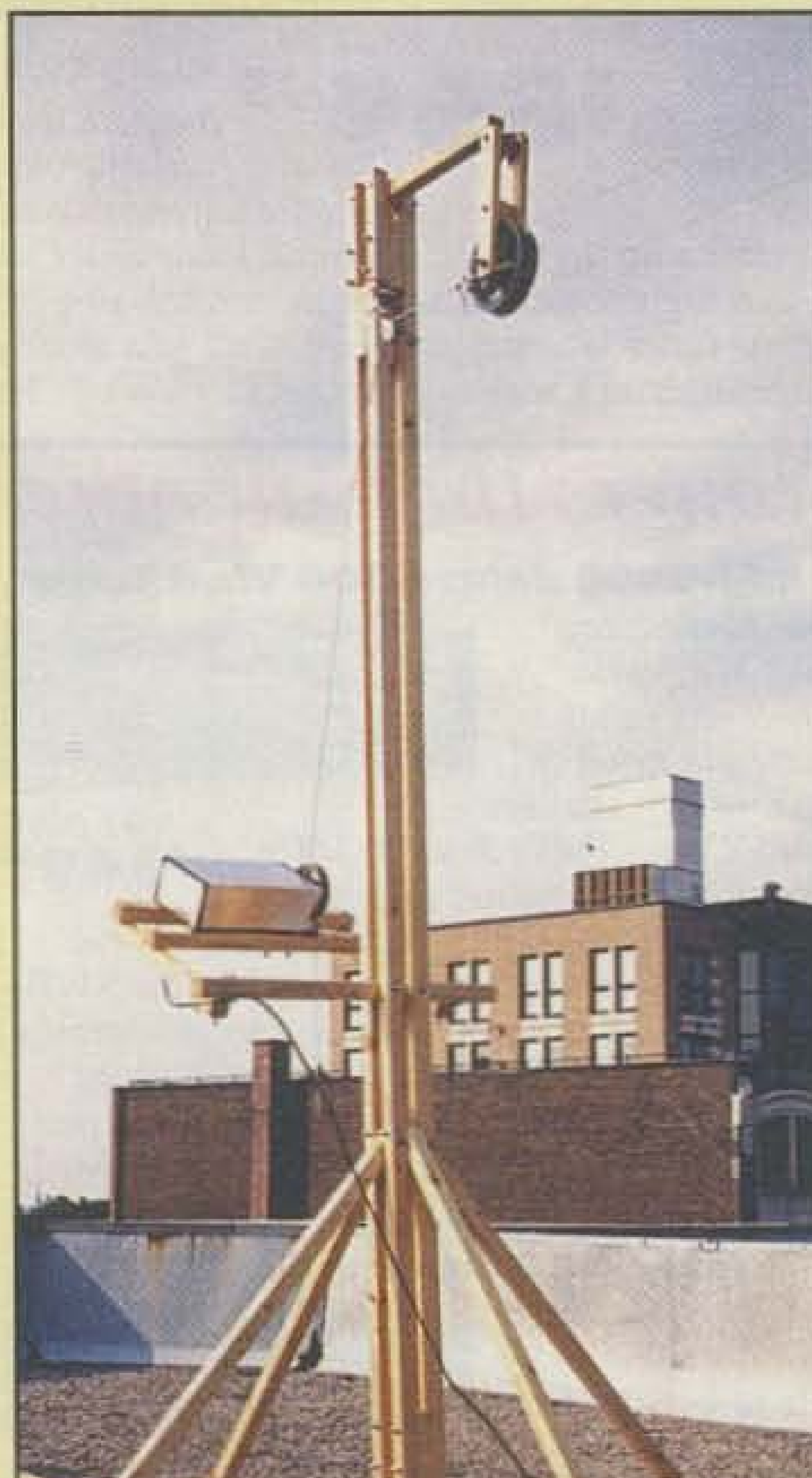
†"The Clothesline Antenna," QST, July 1998, p. 56.



Mini-tower and drive unit at one end of the motorized clothesline antenna. The unit is self-supporting on the author's roof. (Photos by the author)

The impedance at any point along an antenna is the ratio of voltage to current at that point. At our feedpoint, in the middle, the voltage is lowest and the current is highest, so that's our point of minimum impedance—about 50 ohms in this case. (Actually, the nominal feedpoint impedance of a dipole is 72 ohms, but let's just call it 50 ohms for the sake of this discussion.)

Now look at (B) in fig. 1. Here we have the same piece of wire, only now we have voltage curves shown for not only the base frequency, but for a couple of harmonics as well. Let's say the base frequency is 80 meters and the harmonics are 40 and 20 meters. You can see that the voltage peaks for the base frequency are at the ends as before, and the minimum is still in the middle. Voltage peaks for the harmonics are also at the ends (because they're harmonics), but the minimums, which identify the 50 ohm feedpoints, are all over the place.

To run an antenna like this on more than one frequency, we have three choices: (1) live with the mismatches at different frequencies (such as by using a tuner); (2) adjust the feedline to match the different impedances at each frequency (by using multiple feedlines for instance); or (3) physically move the feedline to the right 50 ohm impedance-matching point for each frequency.

An impedance-tuned system allows you to match your feedline to your antenna by adjusting the feedline to match the antenna feedpoint. The Clothesline antenna lets you do this by using the third choice above—moving the feedline to any point you wish along the antenna.

The Clothesline

The Clothesline is a folded dipole with the ends run over pulleys. A folded dipole operates just like a conventional dipole in terms of length vs. frequency, but has a 300 ohm impedance when fed in the middle. It has some advantages over a regular dipole: It has a lower angle of radiation and it's much quieter

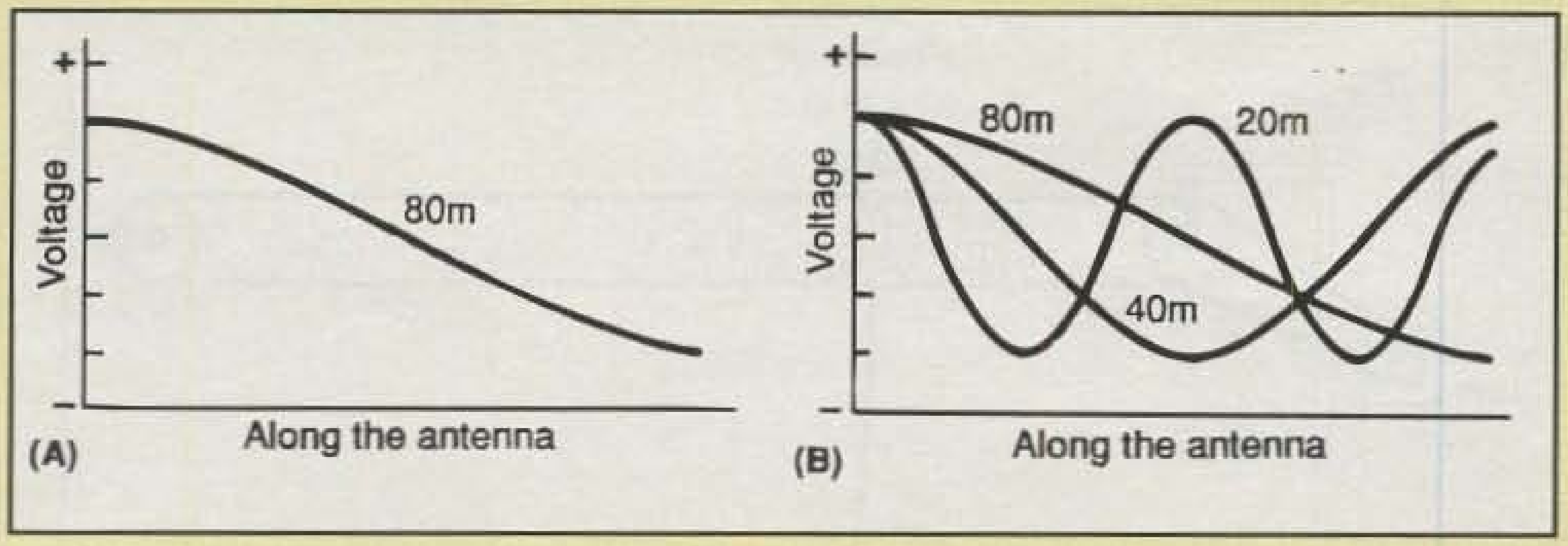
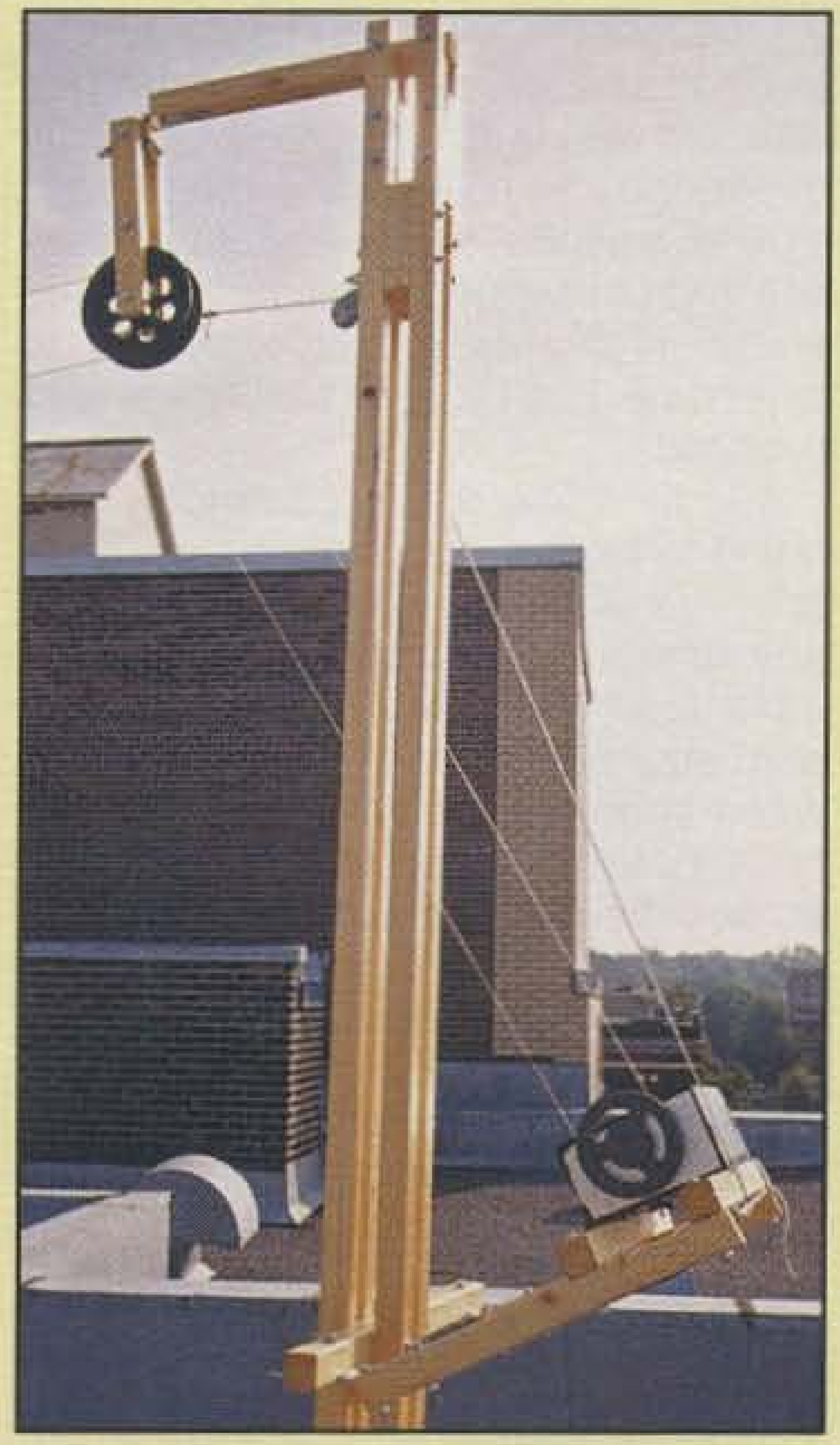


Fig. 1– (A) This graph shows the voltage distribution of an 80 meter signal on a 132 foot wire antenna. Note that the positive and negative peaks coincide with the ends of the antenna. Normally we would feed this antenna right in the middle, where the curve crosses zero. (B) Here's the same antenna with signals for 40 and 20 meters added. There are voltage peaks at the ends for each band—the antenna resonates—but the zero crossing points for 40 and 20 are nowhere near the middle.



The motor frame (lower right in photo) is hinged to permit tensioning of the drive belt. Tension is set by either shortening or lengthening the counterbalance lanyard.

on receive, both great for DX. The Clothesline uses these to advantage and more. Since we actually have a proper match on the base band and all harmonics, we have a perfect match at all times and so can dispense with the tuner or traps and the associated losses that would otherwise be the case for most multiband dipoles.

The one disadvantage of the Clothesline (and hence the motivation to create a remote drive) is that you have to go to the antenna to tune it. Since I invented the Clothesline and first described it a couple of years ago in *QST*†, I've received feedback from hundreds of hams who use it as their main antenna and don't find this a concern. It is true also that you can get one up in the air like this for about twenty dollars and get better performance than any other multiband dipole will give you, so your bang-for-the-buck is tremendous. (If you're planning on putting up *any* dipole, you should consider a Clothesline. It will only cost a couple of dollars more and open up all the other bands for the price of a yank on the feedline. Note, too, "all the other bands" includes any harmonic of 160, 80, or 40 meters, which includes 6 and 2 meters!) However, I think I felt a responsibility as the antenna's inventor: I just had to try a motor drive...

Driven to a Motor Drive

Much of what is described here applies to a non-motor-driven Clothesline, so I recommend you read this even if you're going to put up a manual version. Also keep in mind that I mention 40 meters as my base band, but you can put up one for 80 or even 160, if you have the space. If you decide to put up a motorized Clothesline, or already have one up that you want to drive remotely, you'll have some decisions to make. Here are some of the items I dealt with in executing my own installation, and the results of my experiments.

I'd already observed that the antenna seemed to peak on receive when properly adjusted for a particular band. I figured a remote drive might allow me to listen for that peak when tuning and help me position the antenna. This meant the drive had to be electrically quiet. I felt that getting a DC motor to run without generating an earful of hash would be tough, but on the other hand, an outdoor AC motor poses safety concerns and is frequently ruled out by electrical or building codes.

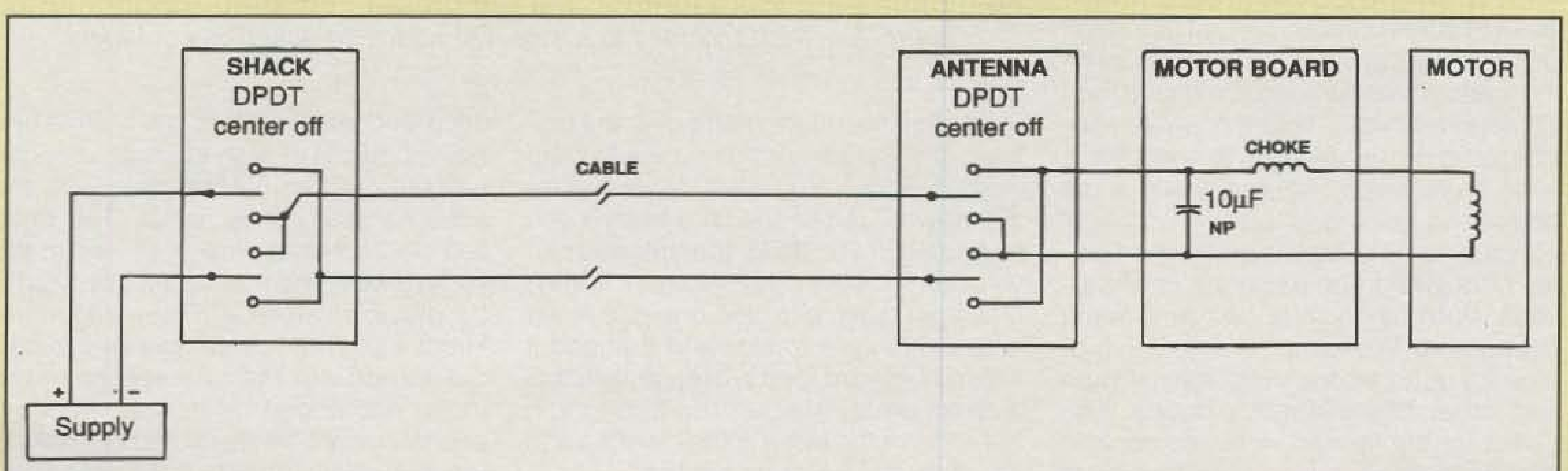


Fig. 2– Schematic of the control circuit for the motorized Clothesline antenna, providing control from either the ham shack or the antenna itself.

I thought I would need lots of torque to overcome the resistance of the pulleys and wire to shuttling in and out; my experience with the hand-driven version told me that the weight of the feedline and consequent tension on the antenna might need a little oomph to overcome. Finally, reversibility was also required.

It looked like a DC gearmotor was going to be the practical choice. They are reversible, can be had with almost any amount of torque, and have the advantage that they are built with standard-size output shafts, a consideration when shopping for pulleys and drivebelts. I'd just have to deal with the hash as best I could. I bought a new gearmotor from Dayton Gearmotors. The unit I selected offered 50 inch-pounds of torque at 28 rpm, giving me about a half-foot per second of wire travel at the pulley, which sounded just about right.

The easy way to control this motor is to use a center-off, double-pole, double-throw (DPDT) switch right in the shack, which I did. However, as I also wanted to be able to run the motor while I was right at the antenna up on the roof, I added a second switch there. The schematic (fig. 2) was the result.

This setup is simple and achieves both local and remote control. Having motor control locally on the roof made adjustment of the antenna and feed setup a breeze. When was the last time you threw a switch and the feedpoint came to you?

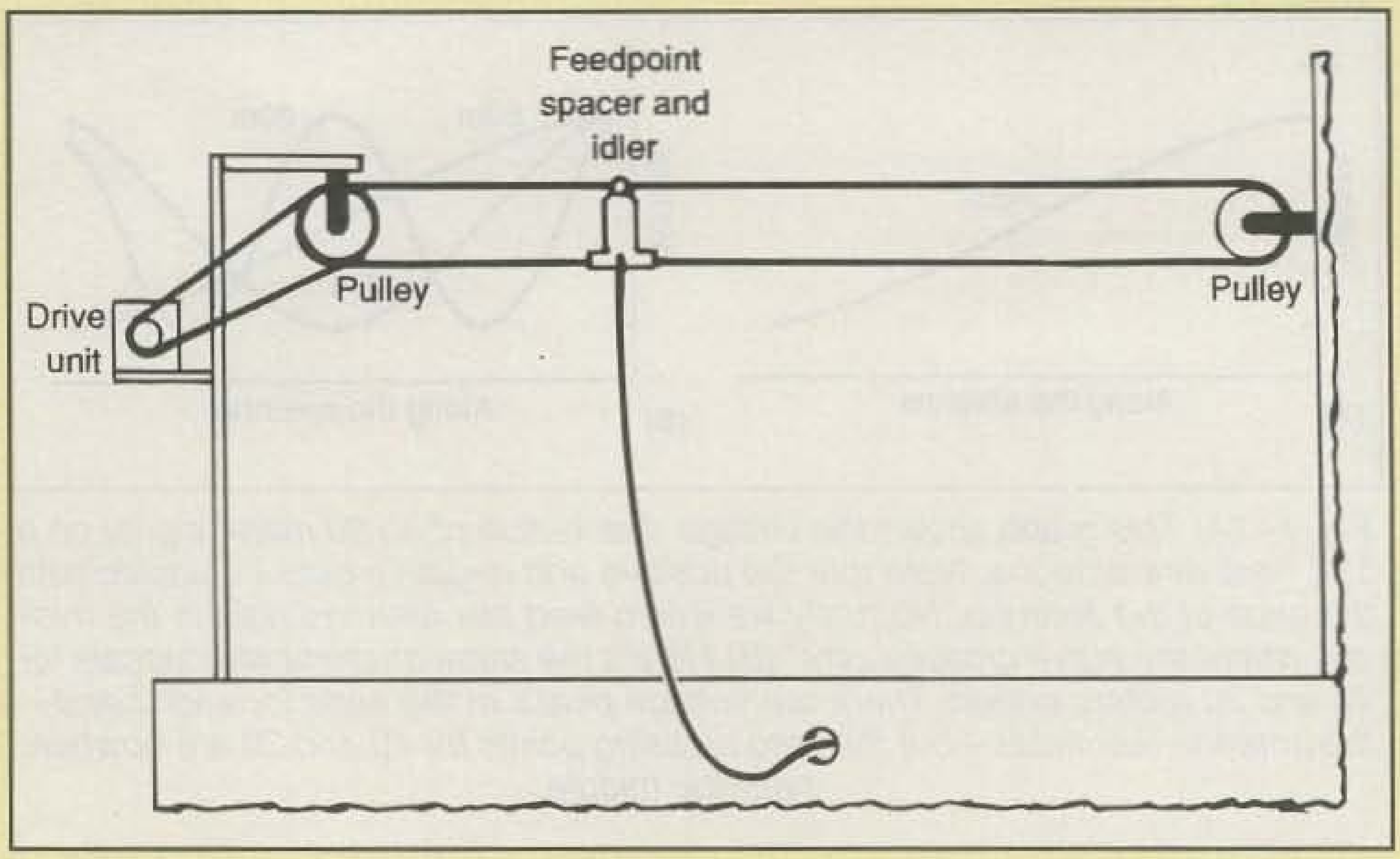
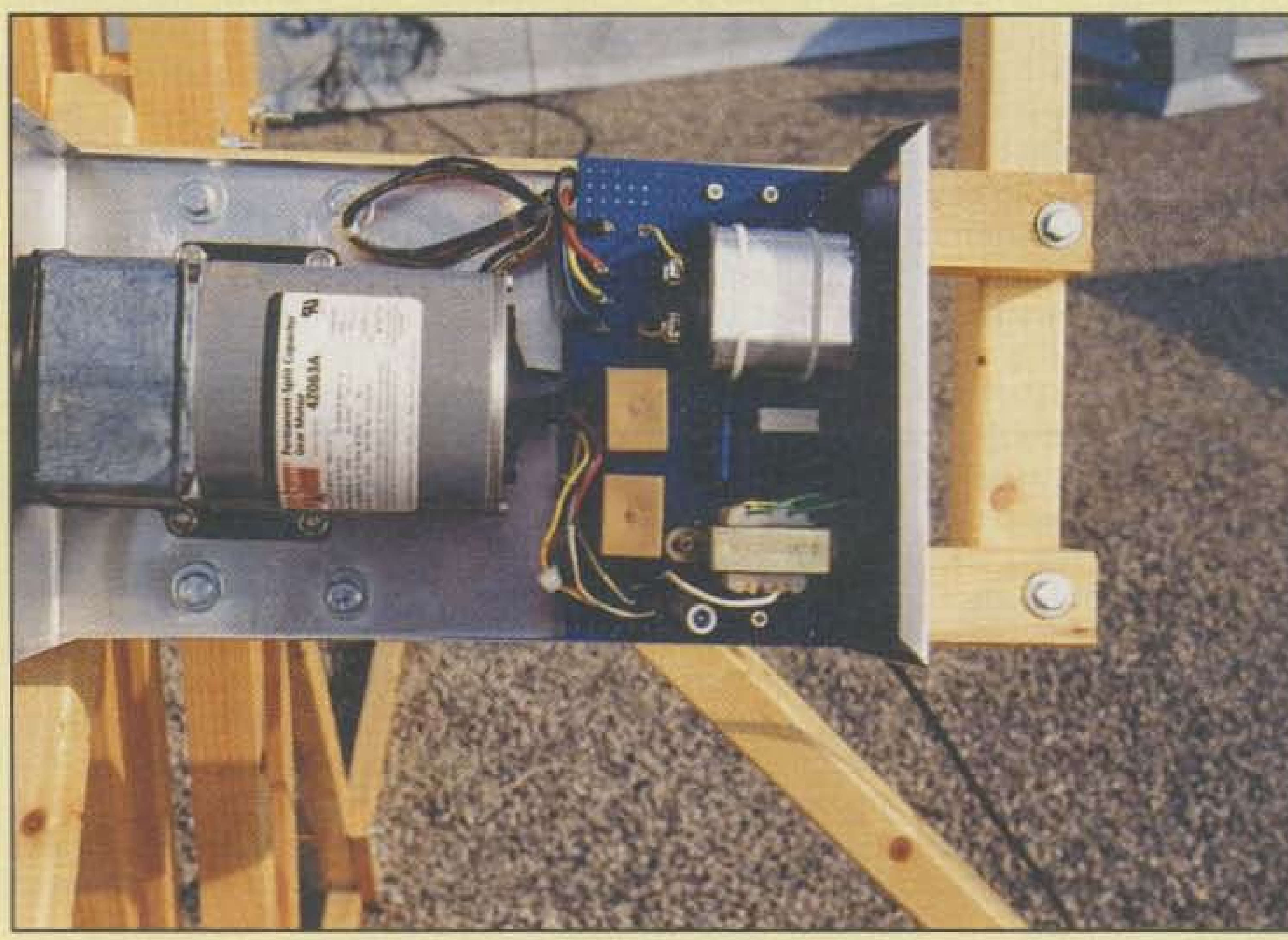


Fig. 3– Drawing of the motorized Clothesline antenna showing connections of motor and feedline. The feedline must be long enough to reach from one end of the clothesline to the other.



Here's where the work gets done! The author used a borrowed AC motor for the prototype, then switched to a safer DC motor for actual use outdoors.

Construction

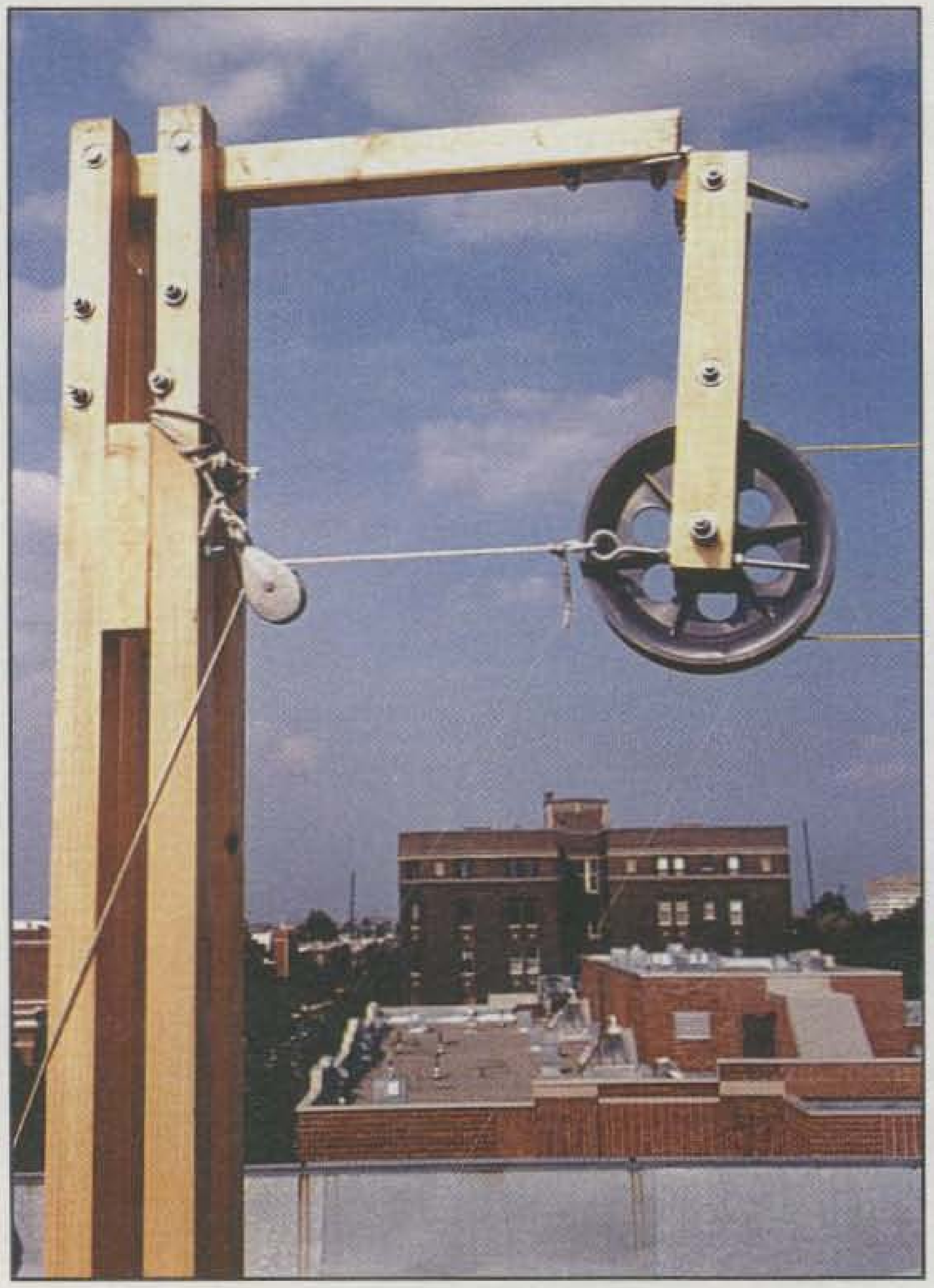
My apartment rooftop had no really convenient attachment points for the antenna or drive unit, so I wound up building the mast you see in the photos. It was constructed to address a few different concerns. There's lots of wind up on my apartment roof, so a free standing structure (as this had to be) needed a wide base to stay vertical. The roof itself isn't designed for any significant freestanding loads, so weight was minimized, and the long foot-pads float the whole shebang and distribute the pressure over a wide area, which I figured would avoid any stress leading to leaks.

I mounted the antenna drive-end pulley on a swing arm using a stock hardware-store hinge to permit tensioning the antenna to take up slack and to provide for counterbalancing against wind and other miscellaneous forces. The pulley for the far end went into another mounting, this one hinged to permit it to swing from side to side as well as up and down, so it would align itself automatically with the antenna.

I strung the antenna wire over the pulleys, and here's something you'll want to know about. You want to get any residual twist out of the wire before you hang it up. If you don't, the antenna can wind itself up like a two-element Slinky! One ham told me he tied one end of the wire to his lawn tractor and dragged it around his yard for a while; he said this worked great. Another (me) hung it in hunks over the edge of the building and shook it until his arms got tired.

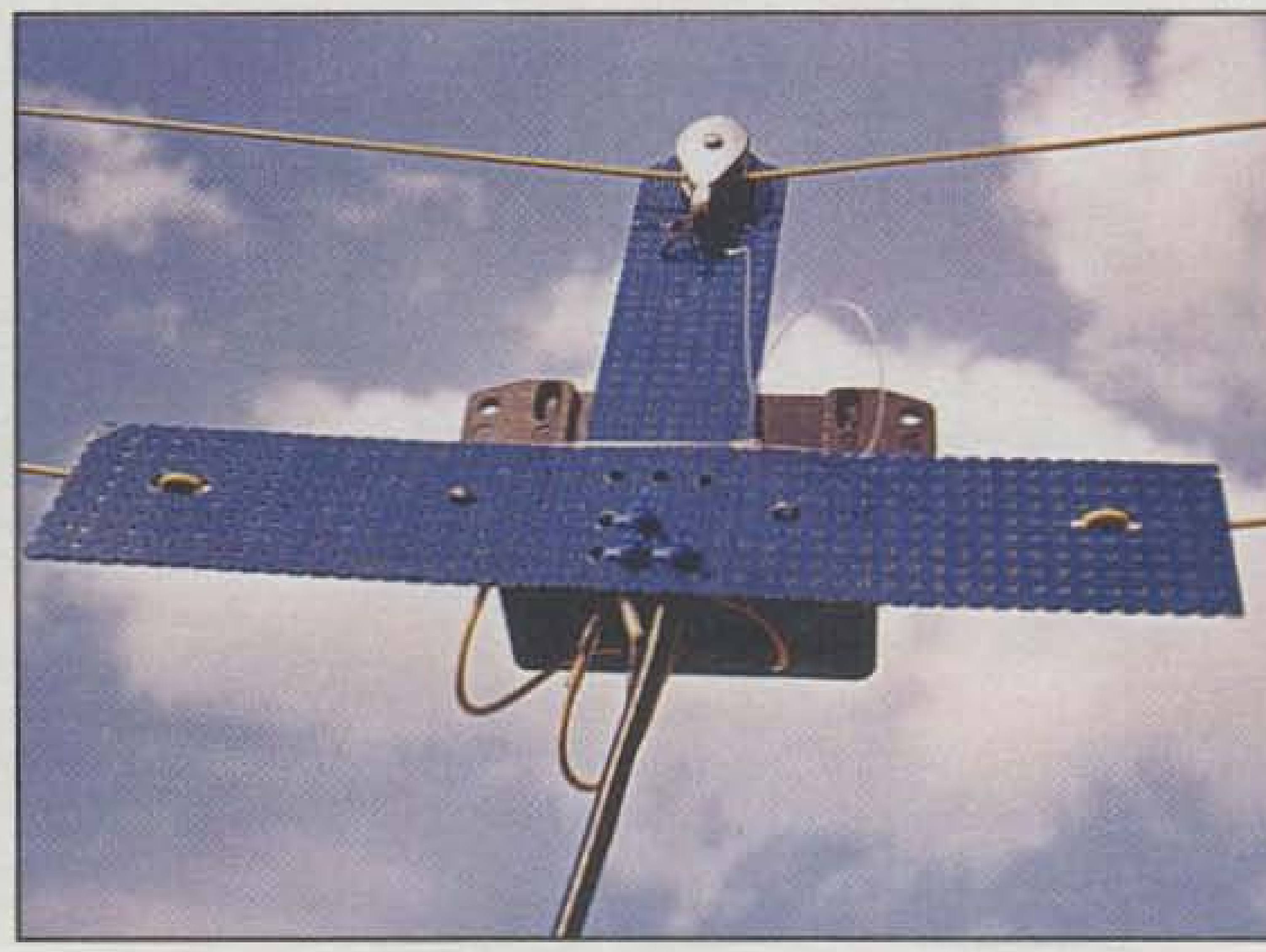
I chose to mount the motor on a swinging frame bolted to the mast about four feet directly under the antenna drive-end pulley. I then ran a drive belt fashioned out of high-strength monofilament from the motor pulley up to the antenna pulley (see fig. 3). The drive belt and antenna wire both ride in the same groove in the antenna pulley; a little playing with the motor alignment keeps them from contacting each other.

It turned out that the weight of the motor and enclosure served well as a counterweight for the antenna, making for easy adjustment of the drive-belt tension. As you can see in the photo, the counterweight line is attached to the motor frame. Simply lengthening or



← *The drive end pulley is mounted on a swing arm. This allows tensioning of the antenna and provides a counterweight to take up slack.*

Detail of the center insulator and balun. Note that the upper section is fitted with a pulley through which the upper wire runs. This helps distribute the weight of the feedline evenly and maintains a set separation between the sections. ↓



shortening this line sets the drive tension, after which it remains relatively constant even as the motor swings up and down due to wind forces on the antenna. If needed for proper antenna tension, additional weight can be hung from the frame.

I recommend this setup, or something similar, no matter how or where you mount your own Clothesline. You're going to need some way of establishing and maintaining drive-belt tension and antenna tension, and you need to do so in a fashion such that changes in one don't affect the other. An alternative is to put the swing-arm pulley and counterweight on the far end of the antenna, while establishing drive tension to a fixed pulley at the near end.

Center Insulator and Feed-Point Attachment

The center insulator you see carries an idler pulley that rides along the top run, spaced vertically from the antenna wire tie-offs to match the diameter of the end pulleys. This spreads the weight of the insulator, balun, and feedline equally between the top and bottom runs. Because tension is constant throughout the loop, the weight is shared perfectly, and the antenna runs remain perfectly parallel, even at low tension, no matter the position or motion of the feedpoint. This is important to conserve the folded dipole shape. If you don't do this, the runs will flop around and therefore your match will vary.

Once the whole shebang was up in the air and the motor was ready to run, I made an interesting discovery. With ball-bearing pulleys and the feedline support system, the antenna, even under high tension, rolls like a breeze. A motor with a quarter the power of mine would have driven the system with ease.

The balun you see in the photos is a home-wound 6:1 and matches the 50 ohm coax to the feedpoint impedance of around 300 ohms. Here you can get away with a more common 4:1 balun, but make or buy a 6:1 if you can as it will do a somewhat better job. If you use a 4:1, consider using 75 ohm coax as feedline for a better overall match.

Operating with the Clothesline

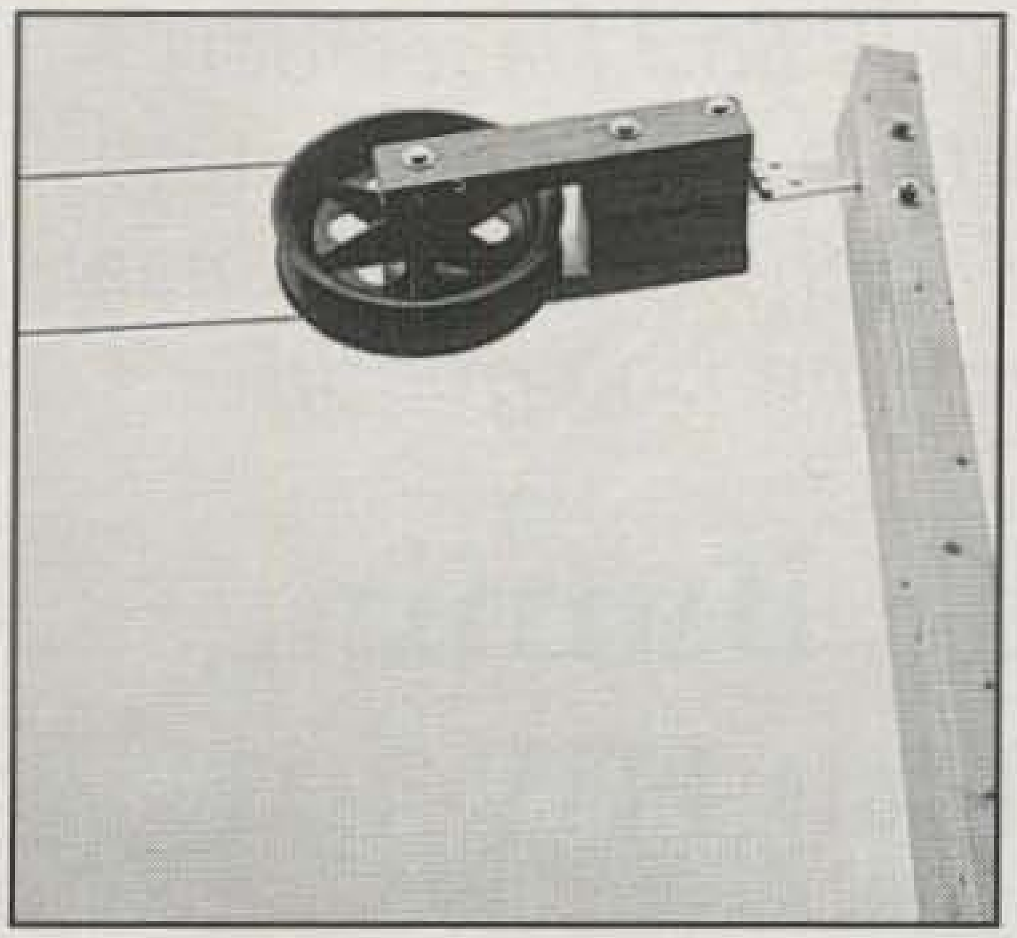
There's a word that describes operating a motorized Clothesline—*Fun!*

My first experiments involved that oh-so-desirable quality of being able to peak the antenna on receive, and sure enough this works 100%. Throwing the switch to reel the antenna this way and that, while listening to either signals or noise, produces a smooth, reliable slope and peak of activity in the phones. Hit the peak and you're tuned! I checked this over and over on all bands, and it works like a charm.

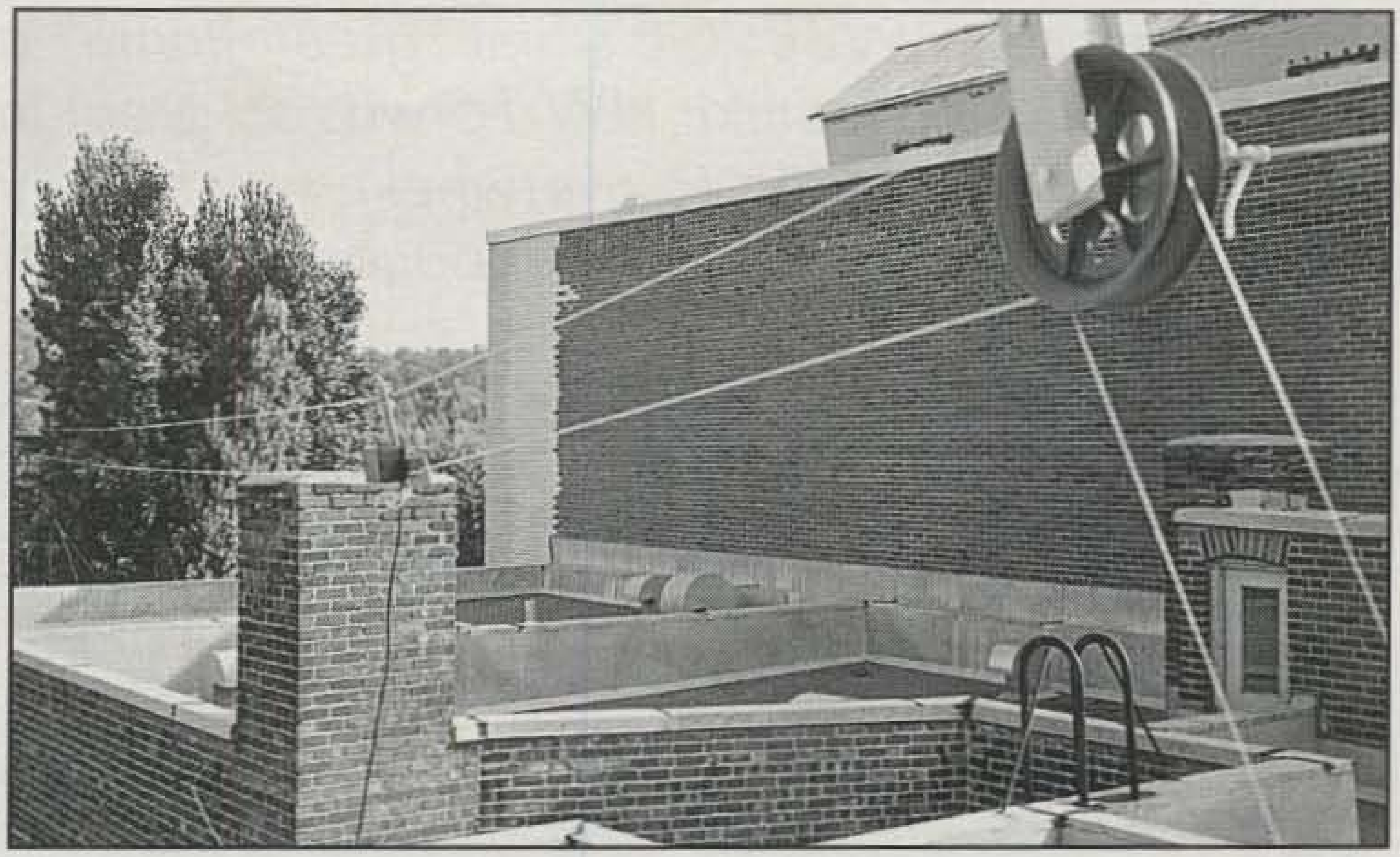
The theory says that bands higher than the base band (in my case, 40 meters) have more than one feedpoint. I had confirmed this with manual positioning of the feedpoint; now the motor drive reaffirmed it with push-button ease. I noted no difference in the tuning slope or other behavior among the multiple feedpoints on higher bands, which suggests that they're reacting just as normal dipole center-feedpoints would.

There may be some directional effects in the selection of feedpoints. Selecting an off-center point that places the long end of the antenna towards the transmitting station seems to improve performance in that direction. What with QSB and the like, it's hard to be precise, but I would say that I can improve reception (and presumably transmission) by two to four S-units with this technique when my contact lies in a direction favored in this manner.

Being able to pick the best point for



The pulley at the far end of the antenna pivots both side-to-side and up-and-down, automatically aligning itself with the antenna.



The whole shebang! Note that the runs are kept perfectly parallel. This is maintained by sharing the feedline weight between the top and bottom runs, as well as by the variable tension hinges at each end.

reception while tuning the antenna on the fly is great fun, and it has really helped with some of the iffy ones. It brings back the days when having tuning savvy was better than good looks! I feel like I'm getting these benefits on transmit as well, although I'm not sure how I'd be able to prove it.

Just like any other antenna, you likely will have to trim the Clothesline a little once it's up in the air. When you do, keep in mind that you're adjusting many bands at once. Take SWR readings for all the bands on which you want to operate, and figure out what kind of adjustments you need to make *on average* to get things in order. Being able to flip that switch and take readings makes this very easy to do.

One more note on the switches: If you look closely at the schematic, you'll notice that the motor won't work if both switches are in the "off" position. Here's how to set them up: For normal operation you leave the switch at the antenna "on" and use the switch in the shack to control the motor. When you want local control at the antenna, flip the antenna switch "off," then go back and flip the shack switch "on," and you'll have control from the switch at the antenna when you go back outside.

And So...

Motorizing my Clothesline has been worth every penny and minute of effort. I have a trap-and-tuner-free multiband antenna that tunes at the flip of a switch, replaces four other dipoles with associated feedlines, remote switches, and maintenance, is many dB quieter on receive, has a lower angle of radiation, and offers some directional and directable gain on most bands. It's rather more attractive and discrete, too, compared to all those other wires, feeds, and supports.

The tunable nature of the motorized Clothesline has permitted me to experiment with and optimize feed strategies, feed position, trim length, and noise pickup. I never really thought about this in the beginning, but this experimental facility has turned out to be one of the antenna's most valuable assets. I can't imagine how another antenna could have talked to me in such volumes, in so little time. My log book and 100 watts have smiles for miles.

Above all, the Clothesline is fun! Tuning the Clothesline has brought back those days when, as kids, we would peak preselectors, tweak trimmers, and sometimes even use a cupped palm held *just so* over a ganged capacitor to bring in the weak ones. It's so satisfying to just flip a switch and trim up the Clothesline and know that my antenna is perfectly tuned for that day, that band, and that contact. Ham heaven. ■

Another Approach

Remember back when I said that we can solve the impedance tuning issue two ways, by either moving the feedline or adjusting the feedline impedance? The Clothesline uses the first method, while a new antenna I've developed takes the second route—adjusting the actual feed impedance to match the antenna at different frequencies. This antenna, which is designed for portable HF rigs such as the Yaesu FT-817, is called the Miracle Whip, and it's being sold commercially by the company I work for, Miracle Antenna (I'm the Chief Designer). The antenna plugs into the back of the rig, covers HF and VHF, works DX off a tabletop (without a ground) and is only four feet tall! If you're interested, see our website at <http://www.miracleantenna.com>.