Do you want a beam? Are there a few things lacking in your plan, such as a tower and the necessary bucks to complete it? Well, NZ5A may have just the answer for a lot of us.

The Yard Yagi

A Fixed 5-Element Wire Beam for 15 Meters

BY ROBERT S. LOGAN*, NZ5A

When I was invited to be a guest operator during a DX contest at N3BB's super-station in the dry, scrubby, cedar-covered hills south of Austin, I heard New Caledonia for the first time. My mind's eye pictured an operator in mufti, sweating with great dignity in the jungle somewhere, or an Albert Schweitzer maybe, puffing on a pipe between QSOs, taking a few hours off from his healing craft and methodically working the world. On this end the vision included several tired, middle-aged boys on the edge in central Texas in a small room stuffed with redundant radios, the room set off from the garage, and the garage itself laced with cables snaking up the cedar-covered hill to a nest of towers set in granite.

In a word, to me the mere sound of *New Caledonia* was romantic. And to be truthful, hearing it stirred up a little jealousy in me because in 30 years of hamming at *my* various stations, I had never heard a single FK8—not in Denver, St. Louis, Chicago, or in Dhahran as HZ1AB, or at 4U1ITU in Geneva during a wonderful week of business and pleasure at a younger age.

The jealousy, mild as it was, continued until a few weekends ago on a Sunday afternoon of another DX contest, as I tied down the last wire on the antenna described here and ran upstairs from the backyard to check the final SWR. I turned on the TS-520 and boom! There was an FK8 right on the frequency where I had left the rig the day before. I thought, what the heck, I'd give him a call and see how the thing worked. He came back on the first call, gave me a second or so of his time, and then ran off a long string of sixes. I couldn't believe it: The Yard Yagi worked like a champ, or more precisely, like a plaque winner.

I couldn't leave. The tools on the patio table would have to wait to be picked up later. I just sat there for half an hour, switching back and forth between my inverted-V dipole and this new beam, watching the S-meter go from below S3 to S7 and above. I was hearing nothing but background noise on one and New Caledonia booming in from the other, very clear, very steady, very Schweitzer.

After sitting there for half an hour, I realized that jealousy of naturally good DXers can be eased a little bit by human endeavor, but romance, thank goodness, is a permanent blessing of amateur radio's charisma. The Yard Yagi may bring a little romance back into the operation of little-pistol stations adrift in a jungle of restrictive covenants that seem to limit DXing opportunities.

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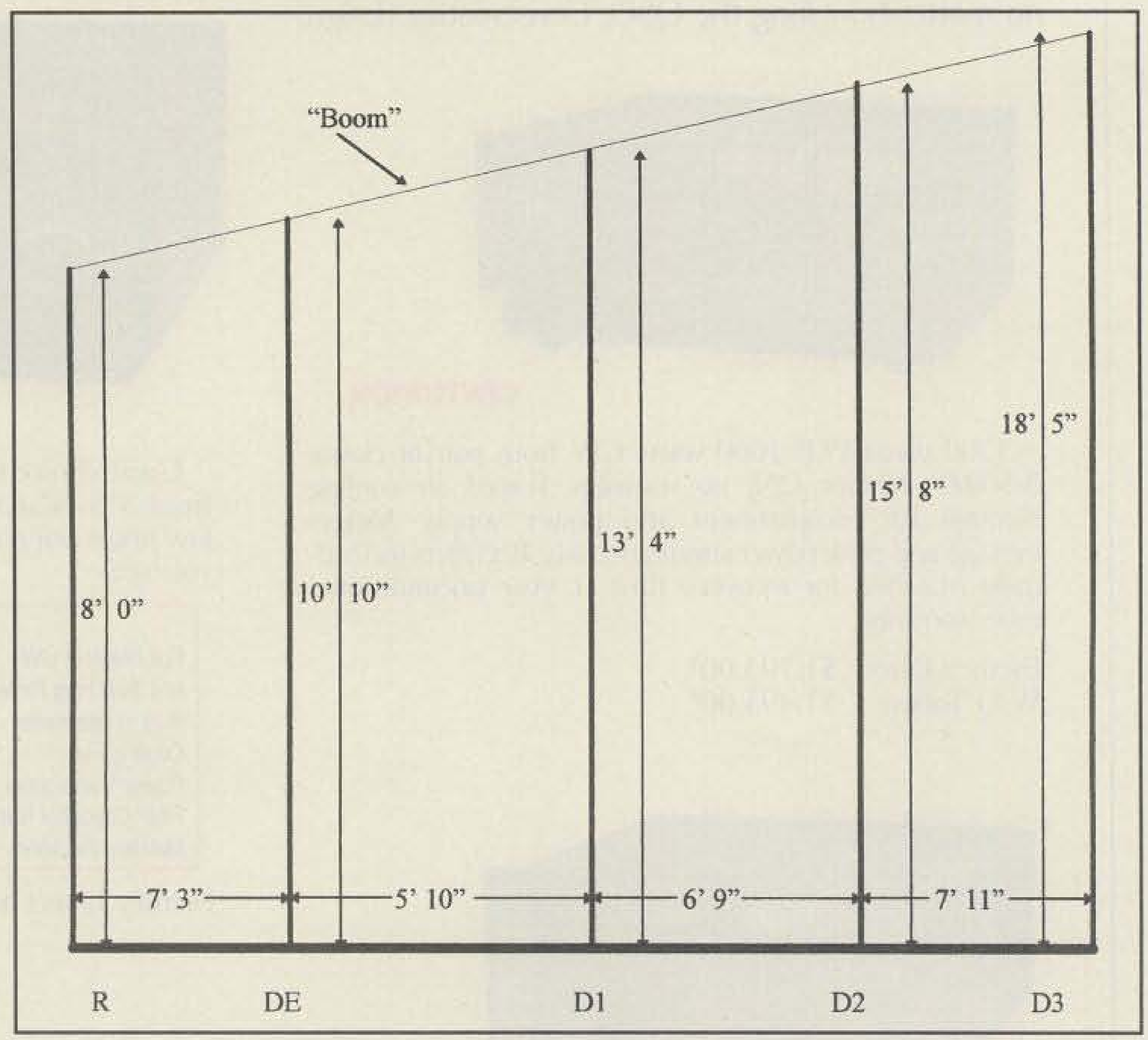

Fig. 1– Side elevation view of the Yard Yagi showing horizontal and vertical placement of the elements. The angle of 20 degrees is not drawn to scale.

The Yard Yagi

The Yard Yagi is a five-element, optimum-spaced fixed wire beam for 15 meters. In my case, the beam is tilted upward at a 20-degree angle and pointed at a heading of 245 degrees, giving about 10 dB of gain toward the South Pacific and Australia/New Zealand from my home in central Texas. The upward tilt seems to add "punch" to the signal.

The tilt of 20 degrees also happens to support my other habit of radio astronomy and Jupiter monitoring. At this angle, for radio astronomy, the beam points approximately to the plane of the ecliptic, given the theoretical half-power points of the vertical beamwidth (that is, the E plane) of the antenna. For amateur radio the angle seems to make up for the lack of height, for no beam the highest point of which is 18 feet should be able to work New

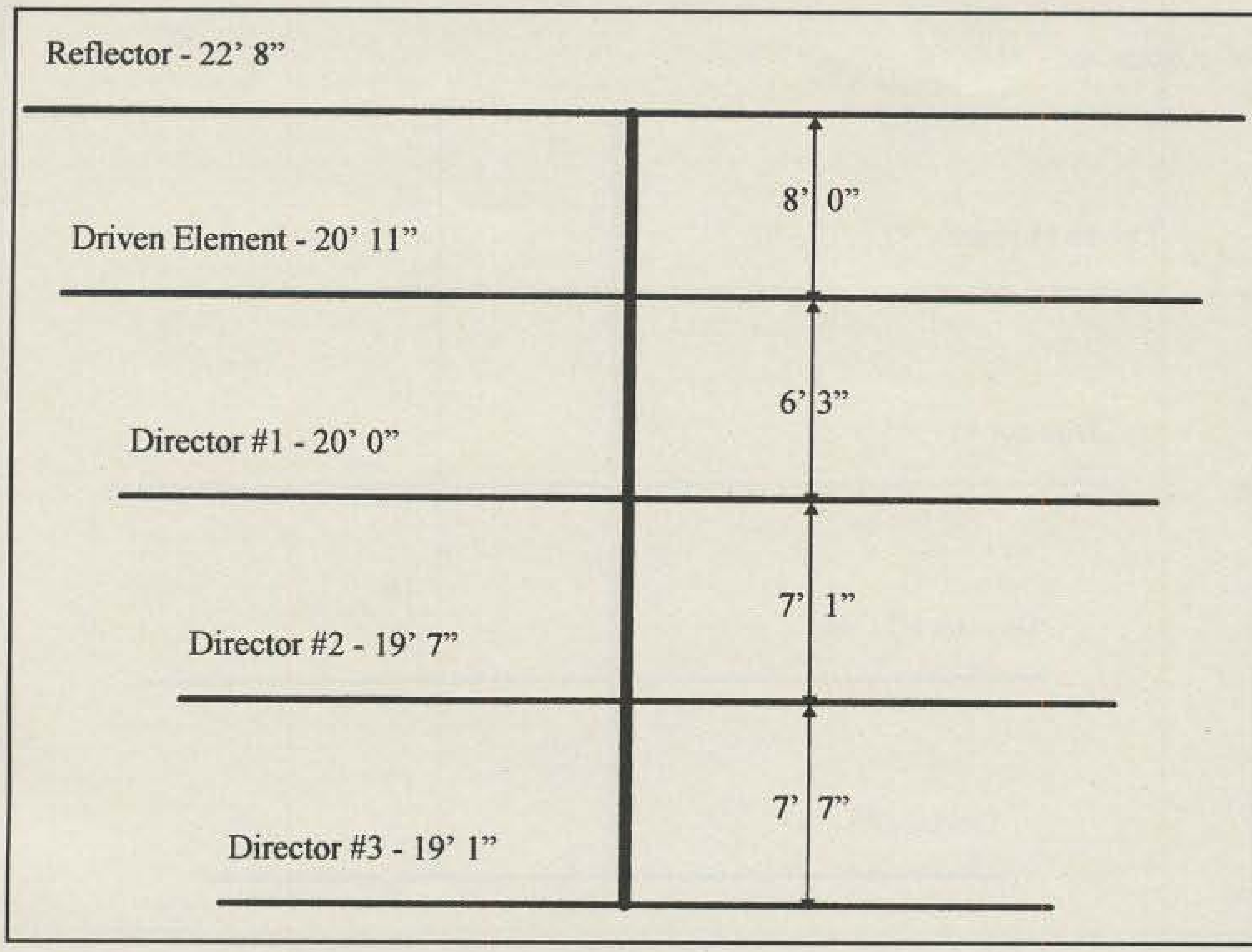

Fig. 2– Top-down view of the Yard Yagi showing element lengths and spacings in feet for 21.010 MHz. The elements and boom are not drawn to scale.

Caledonia and others in that area with such ease while running only 5 watts.

Other angles may work better or worse, but I did not experiment with that characteristic. It seems to me, logically, that any tilt angle should be no greater than 45 degrees, because ballistically speaking, that angle gives the longest throw for a given charge. However, artillery theory may have little to do with RF.

At my location the Yard Yagi is designed and constructed so the reflector is 8 feet off the ground and the No. 22 black wire elements march up step-by-step in a smooth angle to the third director at a little over 18 feet in height. The complete antenna is high enough on the reflector end to avoid getting tangled in someone's windpipe, but low enough at the last director to be below the roof level of my two-story house.

With trees in front and back yards, all a neighborhood vigilante can see from the street, if it's the right time of season and in just the right sunlight, are nicely painted wooden poles on the fence. I'll wrap climbing vines around the poles on some future weekend and call it a trellis, in case anyone should ask.

Design

Bearing and Direction. The first step in the design process is to understand the layout of your yard in terms of available supports and bearing. In my case, I knew that my west side yard measured 24 feet from fence to house and that a beam between the two supports would yield a generally south to southwest major lobe.

I then took a bearing on the North Star at night, and using the house plot and a simple hardware-store compass, I laid out more exactly where the fence line and side of the house pointed. It turned out that a beam between the two supports would be aimed at 245 degrees—right at all those exotic calls of the South Pacific and off Australia's northern coast. I concluded that a beam in the side yard on the west side of my house could probably yield good results and interesting times.

Element Lengths and Spacings. A side elevation view of the Yard Yagi showing vertical height and horizontal placement of the five elements is given in fig. 1. A top-down view with element lengths and spacings in feet for 21.010 MHz is shown in fig. 2. The antenna is cut for that low a frequency because I like to work DX CW at the low end of the band and monitor Jupiter emissions at 20.990 MHz.

For those who want to scale the antenna to other frequencies or bands, fig. 3 shows another top-down view of element lengths and spacings with dimensions in wavelengths. For example, to scale the antenna to 20 meters, divide 934 by the frequency on which you wish to operate and multiply the resulting length by the decimal wavelengths shown in the figure for the various elements and spacings.

As an illustration, let's calculate the length of a driven element for a Yard Yagi cut to 14.025 MHz. One wavelength at 14.025 MHz is:

$$1 \text{ wavelength} = 934/f \rightarrow 934/14.025 = 66.6'$$

A driven element for the Yard Yagi at the same frequency is:

$$DE = .47 \text{ wavelength} \rightarrow 66.6' \times .47 = 31.3' \text{ or } 31'4"$$

Remaining elements and spacings can be calculated in similar fashion. Remember to convert final calculations to inches by multiplying the decimal portion of the number by 12 and rounding to the nearest whole number. In the above example, for instance, 31.3' becomes 31'4".

Vertical Heights and Horizontal Spacing of Supports. Once all dimensions of the antenna are calculated, lay out a simple drawing showing the physical heights and horizontal spacings of element supports of the antenna as it will be placed in your actual location.

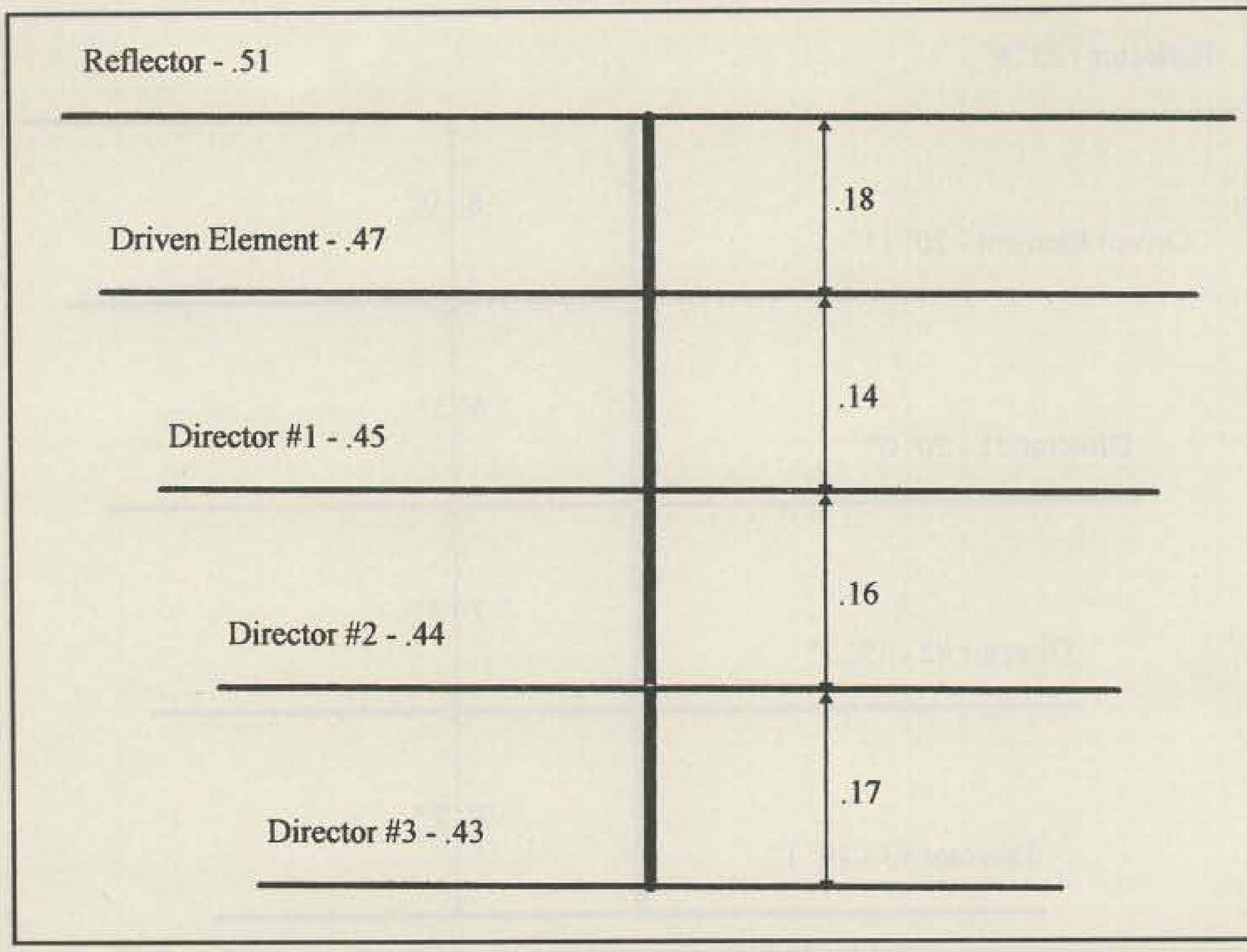

Fig. 3– Top-down view of the Yard Yagi showing element lengths and spacings in wavelengths. One full wavelength equals 934/design frequency. The elements and boom are not drawn to scale.

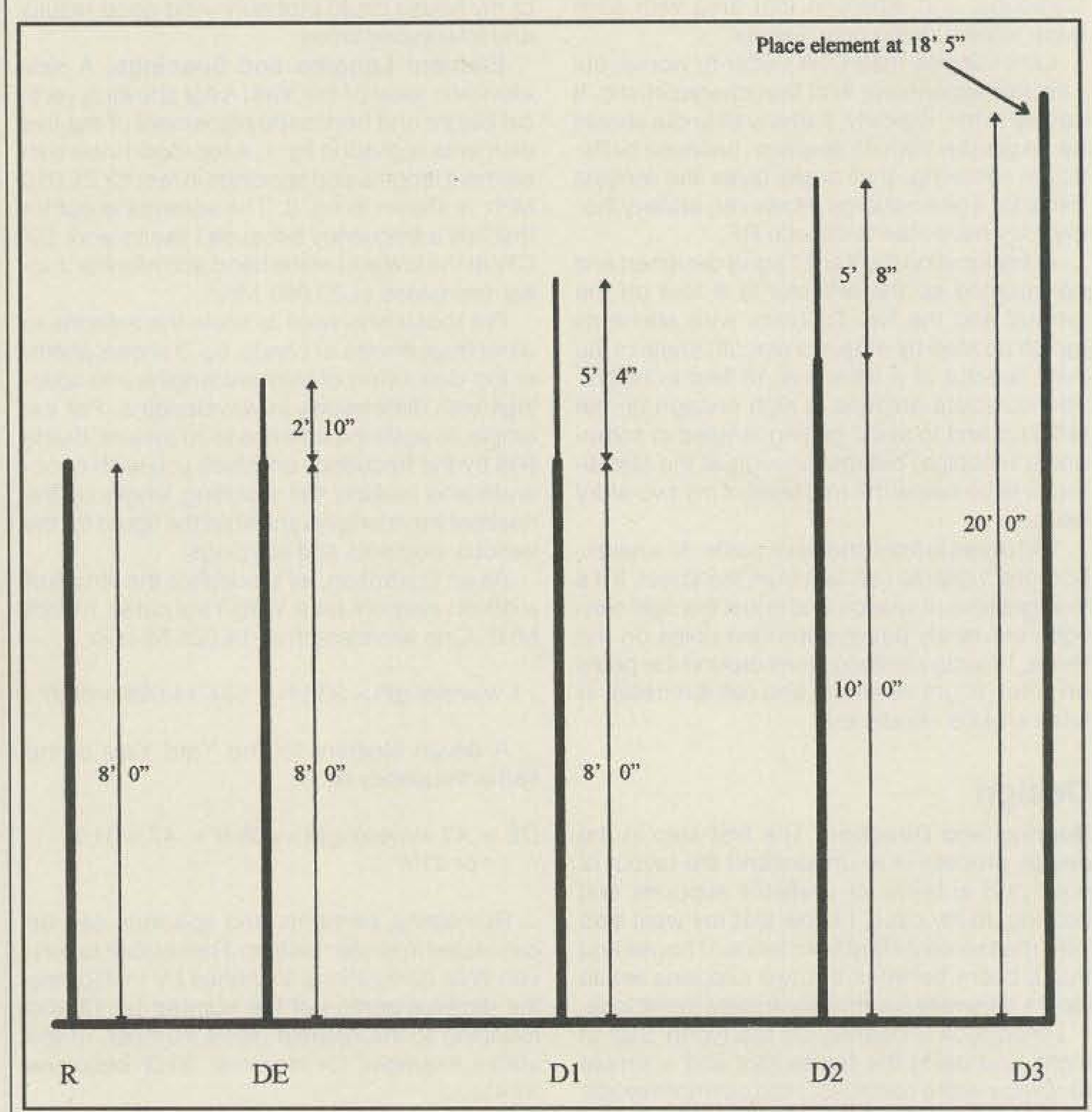

Fig. 4– Physical construction of element supports. The Reflector support is a single 2 × 4 × 8', while the Driven Element and Director #1 are 2 × 4 × 8' topped by a 1 × 2 × 8' cut to the lengths shown. Director #2 is a 2 × 4 × 10' topped by a 1 × 2 × 8' of appropriate length. Director #3 is a 20' length of cyclone rail fencing or two 10' TV antenna masts. The other ends of the elements are tied to eyehooks in the side of the house at the same heights and spacings as the supports.

The Reflector Baseline. Begin by setting the reflector baseline vertically and horizontally. Mark a point for the reflector and draw out the vertical and horizontal lines intersecting the point. With an architect's scale, mark off the vertical line to 8 feet or whatever height is convenient for your location. This is the height of the reflector from ground. The bottom point of the vertical line from the reflector becomes "ground level" for the remainder of the antenna. Extend the "ground level" line the length of your paper. If you don't have an architect's scale, you can substitute a regular ruler and do a little interpolation to determine element lengths and spacing. For example, you may decide that 1 inch on the ruler will stand for 2 feet of antenna length or spacing or height. Then 2 inches on the ruler indicates 4 feet, 2.5 inches indicates 5 feet, and so on.

Boom Length and Element Spacing. Next, using a protractor, mark a point at 20 degrees or whatever tilt angle you wish to set from the reflector point, and then draw a line through the reflector point and the angle point you just marked. This line becomes the "boom" of the Yard Yagi. Again with an architect's scale, mark off the distance of each element along the "boom" according to the element spacings calculated above. There should be five points, including the reflector, spaced on the "boom"; these represent the five elements.

Vertical Height and Horizontal Spacing of Supports. Next drop a vertical line from each element to the ground line. These vertical lines indicate the vertical height of the element supports, and at the intersection with the ground line, the horizontal distance along the ground for each support. With an architect's scale, measure the distance along the ground line from the reflector to the driven element and convert the measurement to feet. Continue marking off distances from the driven element through Director #3.

Be sure to measure the distance between supports along the *ground line*, not on the boom. Since the boom is tilted, it represents the hypotenuse of a triangle, and the distances between elements on the boom are longer than distances between supports on the ground. If you dropped vertical lines from the elements to the ground line, you should have proper spacings, because after all, the supports are set on horizontal ground, not tilted in the air, as Pythagoras might have noted long ago if he had been an amateur tinkerer.

There! You now have the electrical and physical characteristics for a fixed, optimum-spaced 5-element wire Yagi with significant gain and directivity, including substantial front-to-back ratio. All that's left to do is to build it according to the dimensions.

Construction

Measuring Ground Differential. There is a difference between the ground level at the foundation of a house and the ground level away from the house—say, at the fence. Landscapers introduce that differential on purpose so rainwater and sprinkler water drain from the house. Therefore, remember to measure the difference between ground level at the house (if you use a house as one tie-off point, as I did) and ground level of the fence (if you use a fence as the other tie-off point), and then add that difference to the lengths of the supports nailed to the fence.

I had to add 18 inches to the support heights at the fence, since ground level at the house was that much higher than at the fence! Of course, being acutely aware of all that surrounds me at all times, I came to realize ground differential as a fundamental scientific phenomenon only *after* I had securely nailed the first two element supports to the fence and pulled the elements tight. The wire slanted up from the fence to the eyehooks on the house—thus, discovery of the ground differential! The ground differential at your location may vary.

Constructing Element Supports. The supports on the fence for all elements but Director #3 consist of various lengths of 1" × 2" pine furring strips and 2" × 4" pine boards, each 8 feet long, assembled in combinations as shown in fig. 4. For Director #3, a 20 foot length of cyclone fence railing is used as a support, since the combination of furring strips and pine boards at that height was not as stable as it should have been during strong thunderstorms and wind. If you are not near a hardware store that sells fencing supplies, two 10 foot sections of lightweight TV antenna masting from your nearest hardware or discount department store will provide an equally stable support. Remember to add the ground differential to the final calculated height of the fence supports. Since it will almost certainly vary from one place to another, the ground differential is not shown in fig. 4.

Once the wooden supports are cut to the correct lengths and nailed or screwed together in the correct combinations of total lengths, paint them with good-quality exterior primer and paint. Choose a color that blends in with your surroundings.

The final step in the assembly of supports is to drill 1/4 inch holes at the appropriate place on top of the furring strips and through the cyclone-fence railing. These holes allow the wire elements to be passed through them and tightened from ground level. The other ends of the elements will be tied to stainless-steel eyehooks screwed into the side of the house at calculated heights and spacings.

Preparing The Elements. The elements should be cut to the lengths given in fig. 2, or as calculated for your desired frequency. The driven element is a conventional split dipole fed with 50 ohm coax. No matching network or device is required for this configuration of Yagi. All other elements are single, continuous lengths of wire. I used No. 22 black wire for the elements, but any other wire size able to support itself without breaking is sufficient. Wire of No. 26 or 28 gauge is likely to break from falling branches, flying birds, or plain stress or fatigue, so try to avoid very thin wire. No. 22 black wire seemed to be a nice compromise between invisibility and strength.

Attach an insulator to the end of each element, feeding the element through the inside hole of the insulator and soldering the wire back on itself in a loop. Tie off a long "tail" to the outside hole of each insulator. These tails will be used to pull the elements tight and center them horizontally between the house and the fence, or whatever supports you choose.

Assembling The Yard Yagi. By now you should have constructed the supports and have them lying in the yard where you will assemble the Yard Yagi. Also, you should have prepared the elements and marked them so that when you reach for Director #1, that is, in fact, what your hand will find.

The first step in the assembly process is to screw the eyehooks in the wall of the house at the correct heights and spacings as shown in fig. 1, or as you calculated. Next, thread one long tail on the end of an insulator for each element through the appropriate eyehook and temporarily tie off the end to a stake on the ground so the tail and the element with it will not pull through the eyehook when you raise the other end of the element. Then thread the tail on the other insulator through the hole of the support assembled for the element and temporarily secure it to the bottom of the support. Leave the wire elements loose between the supports, letting them droop considerably in the middle, if necessary. You will tighten and center them later.

Remember to match the reflector with the reflector support, the driven element with the driven element support, and so on. It is easy to mix them up in the excitement of building! The smaller the tilt angle of the beam, the more one element support will resemble another, especially on the ground, because height differences among them will be smaller.

With the elements threaded through the holes in the eyehooks and supports, it is now time to raise the supports and nail them to the fence.

Begin with the driven element, since it must be centered between the house and the fence, and all other elements will be centered in line with it. Nail the driven-element support in place, and pull the tails tied to each end insulator so that the center insulator is centered between the eyehook on the house and the support on the fence. Tie off the tails securely at the bottom of the support and at the house.

Once the opposite ends of the driven element are about the same distance from the fence and the house so that the feedpoint is centered between them, raise the next element. Since you measured the horizontal distances along the fence for each support and marked a place for each one, the process can be completed very quickly.

Performance

Technically, the beam seems to perform as designed. SWR at the design frequency is 1.2 to 1. It rises slowly to about 1.5 at the top of the band with no matching device at all.

As for communication, the Yard Yagi works very well at my location. Although 15 meters is not open as frequently as one might desire, I can work about anyone I can hear. The beamwidth is quite sharp. Although stations on the fringe of the beamwidth are about the same strength on the beam as my dipole, stations much outside the Caribbean, northern South America, and southern California are stronger on the dipole than the beam.

For stations within the beamwidth, the difference in signal strength between the inverted-V dipole at 25 feet and the Yard Yagi at 18 feet at its highest point is never less than 3 S-units and is often as much as 4 to 5 S-units in favor of the beam.

I make no claim that the Yard Yagi produces 15 to 20 dB gain, as the increase in S-units would indicate. That large a difference is due to factors other than gain, as I know from extensive QRP antenna building and testing. For example, you can switch between a vertical and a dipole and quite often get as much as 20 dB difference in strength of a particular signal. The difference is due to the angle of arrival and the degree of polarization of the particular signal being received. So in addition to the normal gain that one gets from a beam antenna of a specific configuration, I think the fact that the Yard Yagi is tilted has much to do with its final overall "gain" over a simple dipole.

I can't wait to hear stations in Europe on the long path and work them! For a gain antenna that costs only a little wire, a little wood, and five eyehooks, the Yard Yagi is certainly an outstanding performer.

Now if I could just find a little land somewhere outside Austin with live oaks about 20 or 30 feet tall growing in a rough circle, a clear meadow between them and a little shack in the meadow, a little table in the shack with a nice radio on it, and my hand on that radio feeding switchable Yard Yagis—well, that sounds like another plaque winner to me! ■