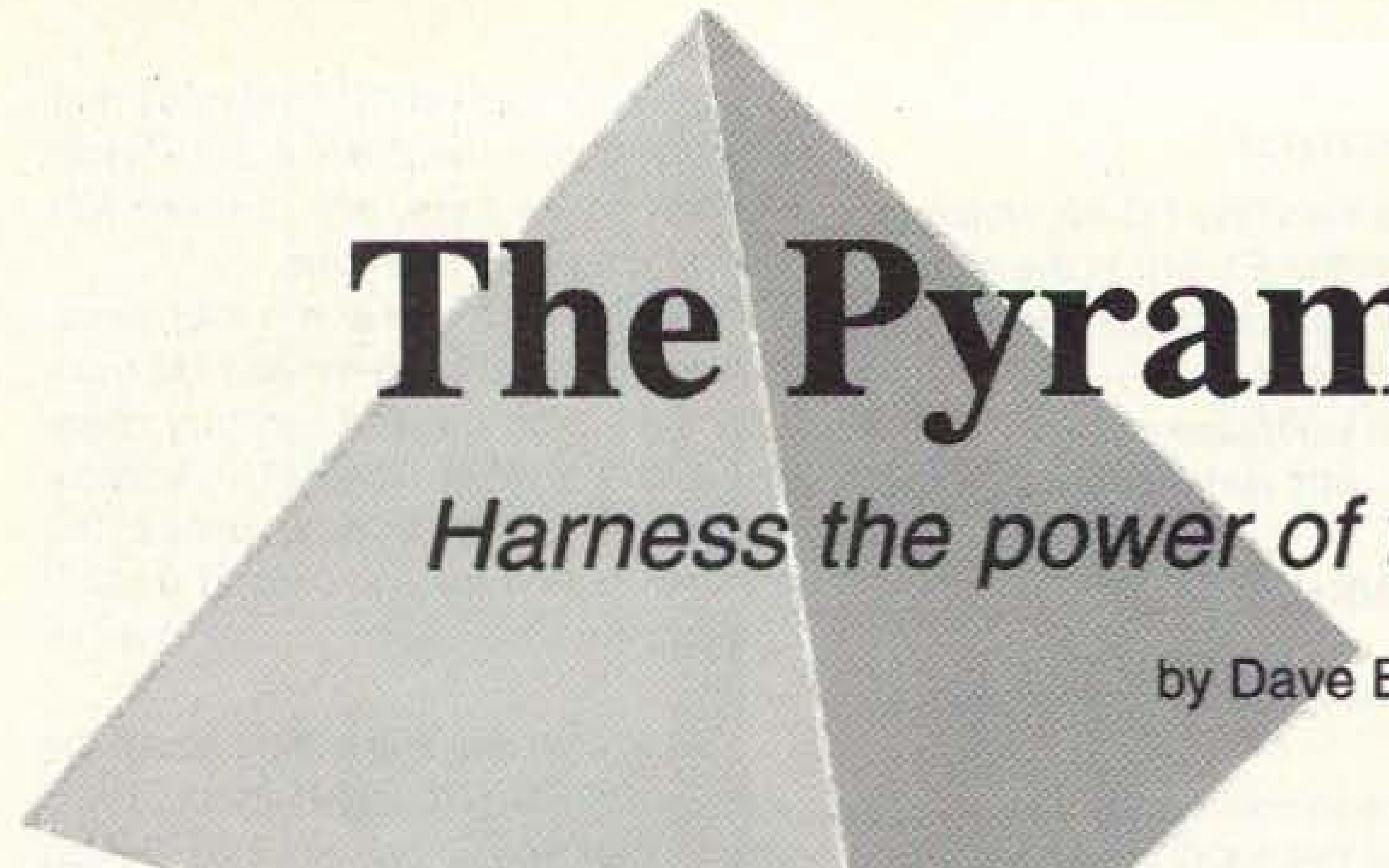

The Pyramid Antenna

Harness the power of this 10 meter workhorse.

by Dave Brown W9CGI

Do you believe in "pyramid power"? I do. But not the kind where you have to sit under a pyramid, or put things under it. In fact, I would not even recommend that in this case, as the effects of RFI on the human brain are just beginning to be understood. It is best and safest, therefore, to *not* sit under or to close to *any* antenna. The pyramid I am about to tell you about grew out of my continuing experiments with all types of antennas.

I became a ham originally because I found antennas, and that invisible link or transfer of power from a physical object to thin air, absolutely fascinating. I think you will find this antenna, the "Pyramid," interesting in construction and concept, easy to build, and quite rugged. That last part always has been interesting to me, as when I do build a winner from a performance basis I hate to be repairing it all the time—instead of *using* it on the air! This one, like a bridge, has inherent structural ruggedness.

Why a Pyramid?

That's a fair question, considering I have never seen anything that looks quite like my antenna. The design sort of evolved from trying to get an idea from paper to the sky. That is true of many antennas I have used over the years, and I'll own up to the fact I am not an antenna engineer by trade. I get antennas that work, and work well thank you very much, quite like Edison got inventions. I derive concepts from others' ideas and articles to be sure, and often times an antenna like this one truly is revolution by evolution. I started off by wanting to try the extended ideas of the bi-square, or extended dipole. This is nothing more than a regular dipole with an extra 1/2 wavelength added to the driven side of it. I learned years ago when I first used it that PVC tubing is the way to go whenever possible to do the "plumbing" (forgive the pun) on any of my antenna projects. It is strong, easy to cut, and many of the joiners you require for a particular configuration already exist as the 45 degree ELL, the 90 degree elbow, and of course the TEE. The mechanical construction of the Pyramid is nothing more than the proper collection of these with the correct lengths of 1/2" PVC tubing. A word of warning to those of you who do not do any amateur home plumbing or repairs: All plumbing items and pipe refer to flow, and therefore to *inside* diameters. Electrical conduit, on the other hand, is measured by *outside* diameter. This can be a great convenience when intermixing the two for antenna projects, but can be quite confusing to someone trying all this for the first time. The 1/2" tubing used to build the Pyramid is actually nearer to 7/8" *outside* diameter.

When you are trying to visualize my antenna, I'm sure that it might help you see something just a bit bigger, and stronger, than the 1/2" implies. To further explain why this Pyramid, like all Pyramids, is a joining of several triangles along their sides: It has long been known in the structural trades that the triangle is the *strongest* natural shape known to man. Thus, when you unite several of them, as in the side rails of older bridges you still see, you end up with a very strong truss or support.

There was one caveat I learned after the first attempt to build a 10 meter version of the Pyramid: The heat of summer *does* cause PVC, a plastic, to sag somewhat. Not wanting to find out the hard way how far the sag would go before breakage would result, I built the first version of the 10 meter Pyramid with a few more webs for the spiders to walk on and the birds to try to avoid. On the backside, as you will see, this also led to a very convenient place to run a nice centered feed down to the reflector element and keep the electrical construction well balanced side-to-side. The use of tubing at the corners nicely takes care of a place to run the feed for the driven element as well. Consider if I had merely run the feed down the center tubing at the front, and done the reflector "feed" down the center back to a normal reflector element—voilà—a standard 2 element yagi beam. Admittedly it would look different, but that is all it would be.

Bend Here—Tuck There

Bending the driven element as I did into the Pyramid was for two reasons. The first was the simple fact that if you do not do so, even on 10 meters, you would wind up with the bi-square about 33 feet long. That puts you out of the VHF "plumbing" league, and right back to unwieldy and usually unsteerable wire antennas. My Pyramid had to "steer" like a yagi, but beat it in performance. After all, it was my newfound and totally accidental love for QRP on 10 meters that led to the Pyramid in the first place. "Folding in" the ends of the bi-square allows the width to become about 16-1/2 feet, and back to what I consider manageable yagi-type antenna sizes. The electrical reason to bend the ends in did not come to mind until I began a rather vigorous evaluation of the antenna against my usual 10 meter antenna (a three-element home-brew yagi), and a reference dipole also made up into PVC for strength and weathering. Just as any other time you bend/fold an antenna element, both the feed impedance and the pattern of radiation are going to change. When you start bending things around in an intentional manner as I did, you can only hope the other changes are going to be ones that are favorable. I'm happy to report these certainly were very favorable. Bending cut the apparent beamwidth by about half as compared to the bi-square out straight, and to about a third as compared to my dipole! Now that does *not* make it like the razor-sharp VHF/UHF antennas I have built, but it sure puts a lot of gain in the direction you want it to go. It makes an ideal contest antenna for me, as the apparent beamwidth of about 20 to 25 degrees at the major lobe, and no nasty minor lobes, lets me put everything "on-target," and still not be so narrow as to miss half the fun going on. This 5-watt fetish I seem to have caught only since getting the use of 10 meters (I was a 30-year Tech licensee, with absolutely no interest in the other HF nonsense and quibbling), and needing an antenna like the Pyramid to make up mostly for the other guy's killer-watts. On a quiet band devoid of the horsepower hogs, I managed even before the Pyramid to get my WAC in a month, the 1,000 mile-per-watt club in two months (Paraguay, S.A. with 100 mW), and lots more fun. It is much easier now with the new antenna, much like having about six elements up there without all the hassle and mechanics that would require. By the way—it only goes up 16.5 feet in the air for you non-climbing amateurs!

Build It—Hang It—Get It On

See Figure 1. The actual construction is best covered by the pictures and drawings, but I will verbally walk you through it as well. One cardinal rule: PVC pipe is *great*. It will give you a lot of fun, it is inexpensive

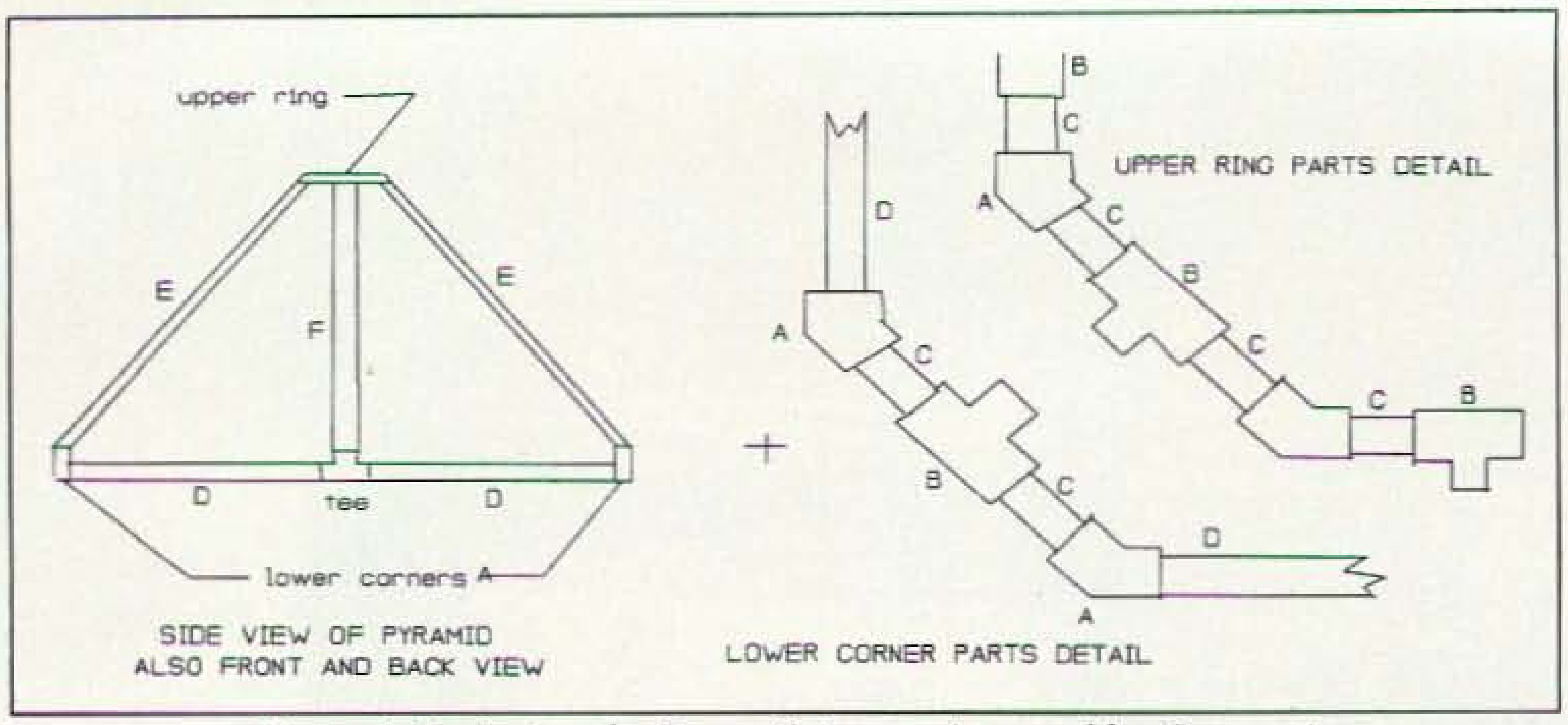

Figure 1. Beginning the Pyramid Antenna's assembly. (See text.)

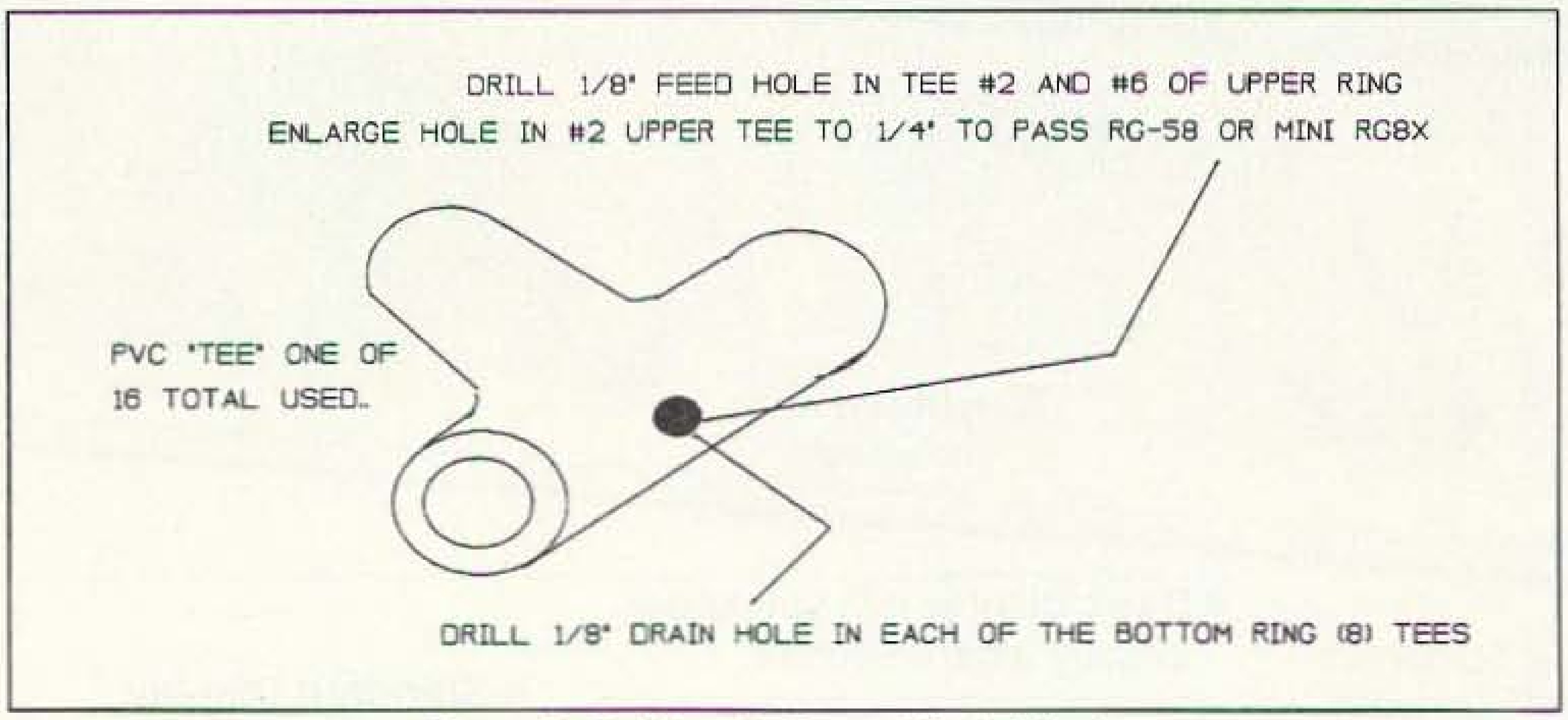

Figure 2. Drilling the Pyramid's "T" holes.

construction material, and is quite forgiving in all but one way: Whenever you get ready to glue two parts together (cement, to be technical), *make sure you mean to do it!* This stuff puts epoxy to shame. The process you are using actually bonds the two pieces by fusing, so it is not just a glue joint. When you are done, you will have a one-piece antenna. I can't impress that often or strongly enough. The materials and cement are quite safe to use if you follow the directions, and by all means do pre-fit *everything*, no matter how sure you are that your cut and gloop shot will work. Begin by cutting all the parts except the four I will cover later: the shorter uprights at the center of the sides. The easiest parts are the corner uprights, part "E," because all you do is buy them, bring them home in their full 10-foot-long glory, and use them—no cutting required.

Next, you do cut some tubing, and I recommend using a hacksaw or backbow saw with fairly fine teeth. Something you would use on metal tubing or aluminum will work fine. Use of a saber saw in this day of electrical aid and abetting is quite all right, but not necessary. There are not all that many cuts to make. In order to practice your cuts, we'll start on something simple but necessary. Try very hard to keep the cuts 90 degrees, or a cut straight across the tubing. This eases matters a lot when you go to put them into the joiners later. Take one piece of tubing and clamp it firmly, but gently, into a vise or firm clamp. Then proceed to demolish it by practicing your cutting and making 24 pieces that are two inches long. I will admit that absolute accuracy in the length is not required, but in order to end up with a nice symmetrical antenna, neatness *does* count.

Now that you are a real pro at cutting (hey, there *is* a knack to it), we can move on to the only other cutting required. (See, I told you this was also an easy antenna. Just remember the GLUE thing, OK?)

Take eight pieces of PVC tubing and cut the store length of 10 feet down to eight feet long. If you already considered yourself capable of cutting the 2" pieces above, then yes, you could have cut them out of the two-foot pieces that are coming off these 10-foot pieces and saved buying one piece. I just want to be sure you are comfortable working with PVC, and offer the information that you can do it either way. When you are finished, you will have the eight necessary pieces marked "D" in the drawings. Right now I will tell you that no matter how neatly you saw, the edges are going to end up rough, and the hole inside somewhat plugged. Sand all edges smooth and clean out that hole carefully with either a box cutter, an X-acto knife, or the sharp edge of a common screwdriver. Do each one *as you finish cutting it,* or sure enough, you will miss one, and later that becomes critical.

Now you get your first try at playing in the glue pot, but I'll let you get your feet wet slowly. That is a joke, and it pays to keep the cement *off* of you and *on* the pipe, though my skin does not seem to mind small amounts accidentally spilled if it's cleaned off quickly. This is not, I am happy to say, like working with some of the super-glue which, if it hits your skin or you put your fingers together, makes you "welded" for life!

It likes the PVC a lot, but your hands are reasonably safe. Do pay very close attention to the can directions and, of course, keep it away from your eyes and the like. Begin the actual assembly by picking up eight of the 45-degree "L" pieces, part "A," and cementing them to each of the eight pieces you just cut to eight feet long, part "D." If you follow the can directions at this stage you can't go very wrong. Be sure the part is seated well, and follow the 1/4-turn instruction to help that, like screwing a nut onto a bolt. By the time you've done one I'm sure you will be impressed with how fast the cement sets up.

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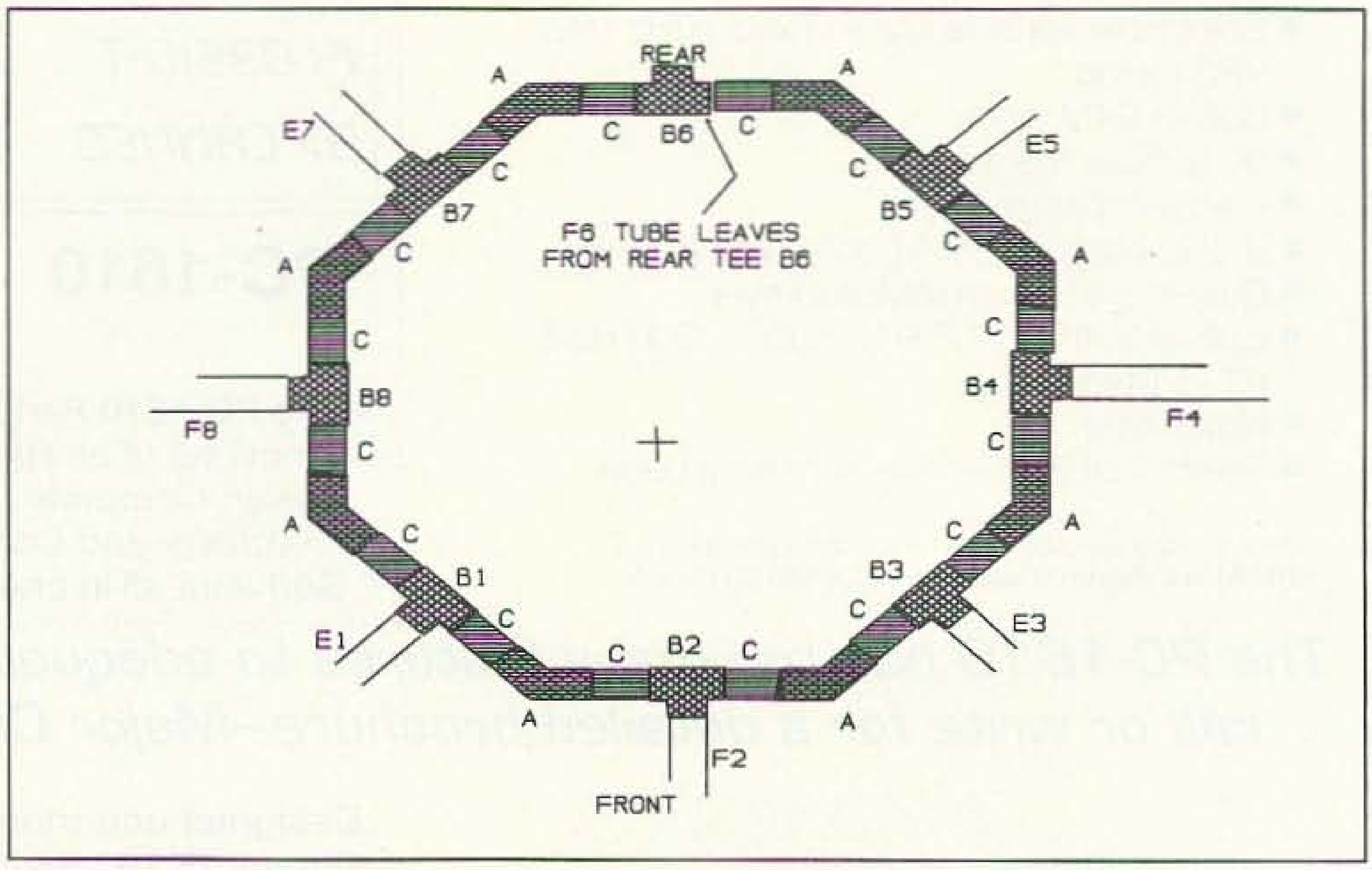

Figure 3. Pyramid's upper ring detail.

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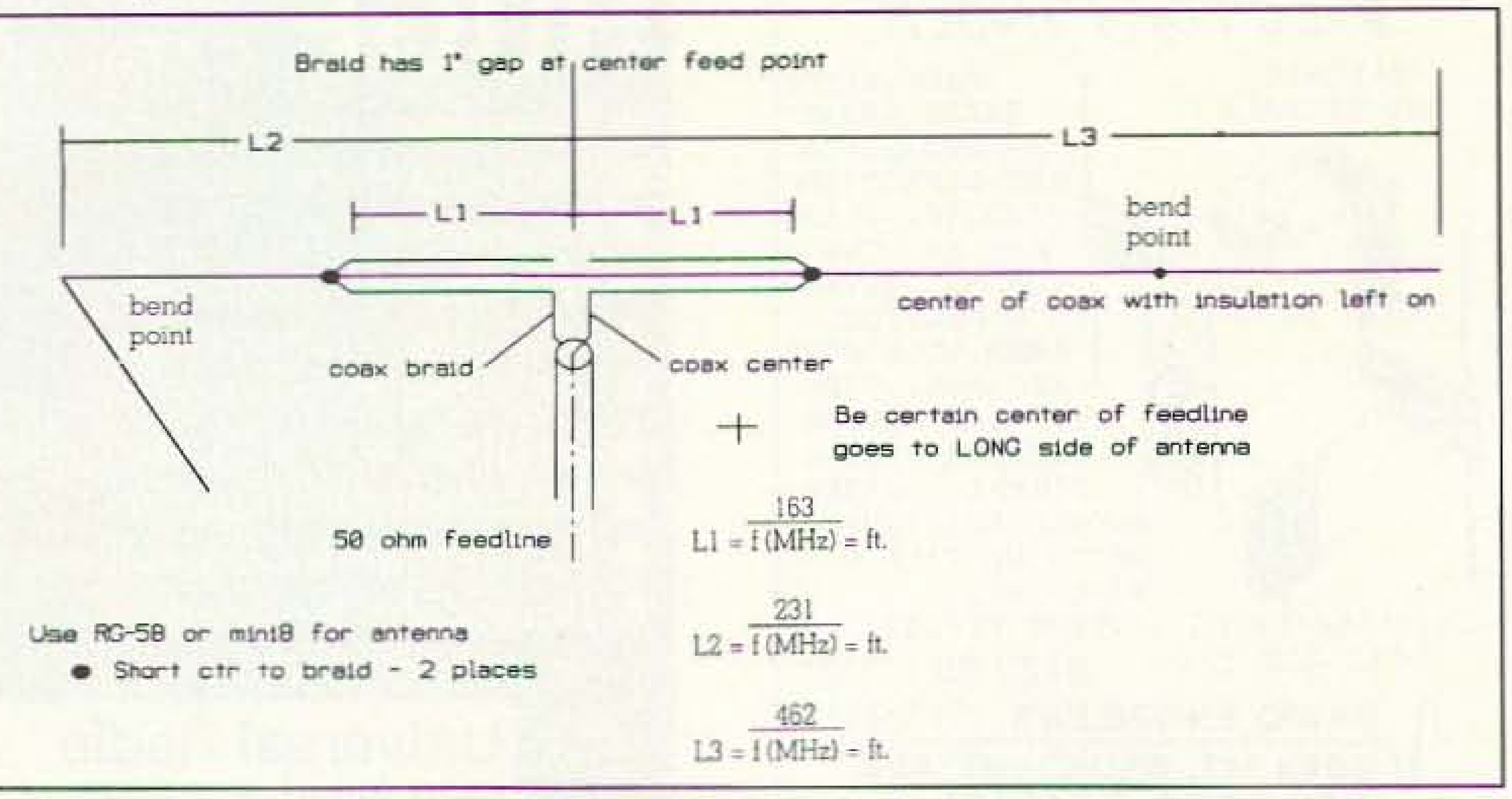

Figure 4. Pyramid's bazooka feed detail.

Five-minute epoxy, my foot! This stuff is, for all practical purposes, instant. It is for that reason I want you to follow along with me slowly and work your way up to the final assembly, where things can get really complicated unless you really appreciate the speed at which this cement works. Into the opposite end of each "L," cement a two-inch section of tubing. This will use up eight of your "C" parts, and at this point you should have eight assemblies of C-A-D sequence.

Now that you have become an expert gluer-upper, we can tackle another eight-to-eight assembly that is also non-critical, and is the miniature of what you just did with the eight-foot tubes. Take eight more of the 45-degree "L" pieces and cement them to eight of those two-inch pieces you cut off first.

One more easy step: Take eight more two-inch pieces and cement them into the other end of the 45-degree "L," part "A," just completed. Now, put the lid on the cement and *put it away* for now. That is for your own good, I promise.

Take 10 of the "T" part "B" pieces and drill 1/8" holes in the back of them directly opposite the larger opening (see Figure 2).

Enlarge one hole to just over 1/4" to pass the RG-58 feedline you will add later. This becomes "T" number 1 in the drawing. In the next assembly paragraph, use a second of the drilled "T" parts as number five. All the other "T" parts in the upper ring are undrilled (six, total).

Next, we need to do a little practice assembly, and since the top of this Pyramid is just a mini-version of the bottom, we will begin by assembling the top ring. Note: Assemble—do not cement. Press-fit a "T" onto one end of the eight 45-degree "L" part "A" just done, and then press-fit another into the opposite end of the "T." Continue alternating "T"s and 45s with two straights until you form a complete circle. The whole thing should be just flexible enough to fit the last pieces together without distorting or stressing the overall circle too much.

If you follow the diagram, you will end up with a circle of parts in a B-C-A-C B-C-A-C sequence all the way around, and have eight "T" parts "B," eight "L" parts "A," and 16 straight two-inch pieces, parts "C." Do the assembly on a flat surface and leave the "T" pieces heading straight out from an imaginary point at the center of the circle (for now). Be sure you have the numbered "T" parts (one and five) where they belong in the ring.

Now you can go for broke and assemble the lower ring. It goes very much the same as the upper ring. The exception is that the "L" 45-degree "A" parts now have parts "C" and "D" in each in place of the much smaller upper ring C-A-C combinations, so a bigger ring will result.

The easiest way to assemble the lower ring is to first find an open area in the shape of a square about 20 or more feet on a side. (Two-car garages are great, but I don't have one, either.) Any flat open area will do. By *press-fit only,* assemble the lower ring, following the diagram shown in Figure 3. I found it easiest to put the eight-foot pieces into a "T" and build each side, and then assemble the corners. Any order is all right, just *don't glue things yet.*

Mechanical to Electrical

Do the first cut on your feedline by cutting a piece of RG-58 to exactly 13.0 feet long. This is 1/2 wavelength at 10 meters, in coaxial rather than free-space terms. Continue on to the dipole.

Now is the time to build the "real," or electrical, parts, of the antenna. You can see by Figure 4, and the references to the two other antenna articles listed at the end of this article, that I have at last found a matching device for dipoles that works, is super-easy to do, requires *no* setting, and has *never* ended up with higher than 1.2:1 SWR on any I have made. Re-checking that one even proved that I just plain did not measure accurately. Do it right the first time and you will have no problems, I assure you. Taking just the outer insulation off the dipole center, then splitting the braid, and lastly soldering the feedline to it is admittedly delicate work, but just take your time and follow my sequence of doing it. First look over the diagram carefully and study it until you are sure just what is being done, and are familiar with all the dimensions. Then cut the insulation as shown, move inward and cut and remove the center one-inch of braid and solder the feedline to the feed point. The ground braid side of the feedline solders to the braid on the shorter end of the bi-square. The center conductor solders to the braid on the longer side of the antenna. Follow the diagram closely, as this is the easiest place to reverse something and end up with a dud instead of a winner.

When all that is done, half of the electrical work is done—the hard half. For the reflector element you can use copper wire in #14-#18 gauge, just like light-duty house wire. #10 or #12 is usually used for houses nowadays, but is a bit heavy, and does not work a bit better—I tried it! If the wire has a coating or insulation you will have to remove an inch or so at the reflector feed point in order to solder the reflector feed wire to it. Another good wire material is TV twinlead. Run from the hub at the center of the upper hub down the back center tube "F" part. Then solder another piece of twinlead as shown that is one wavelength in length on either side. That is fed out the back tubes of

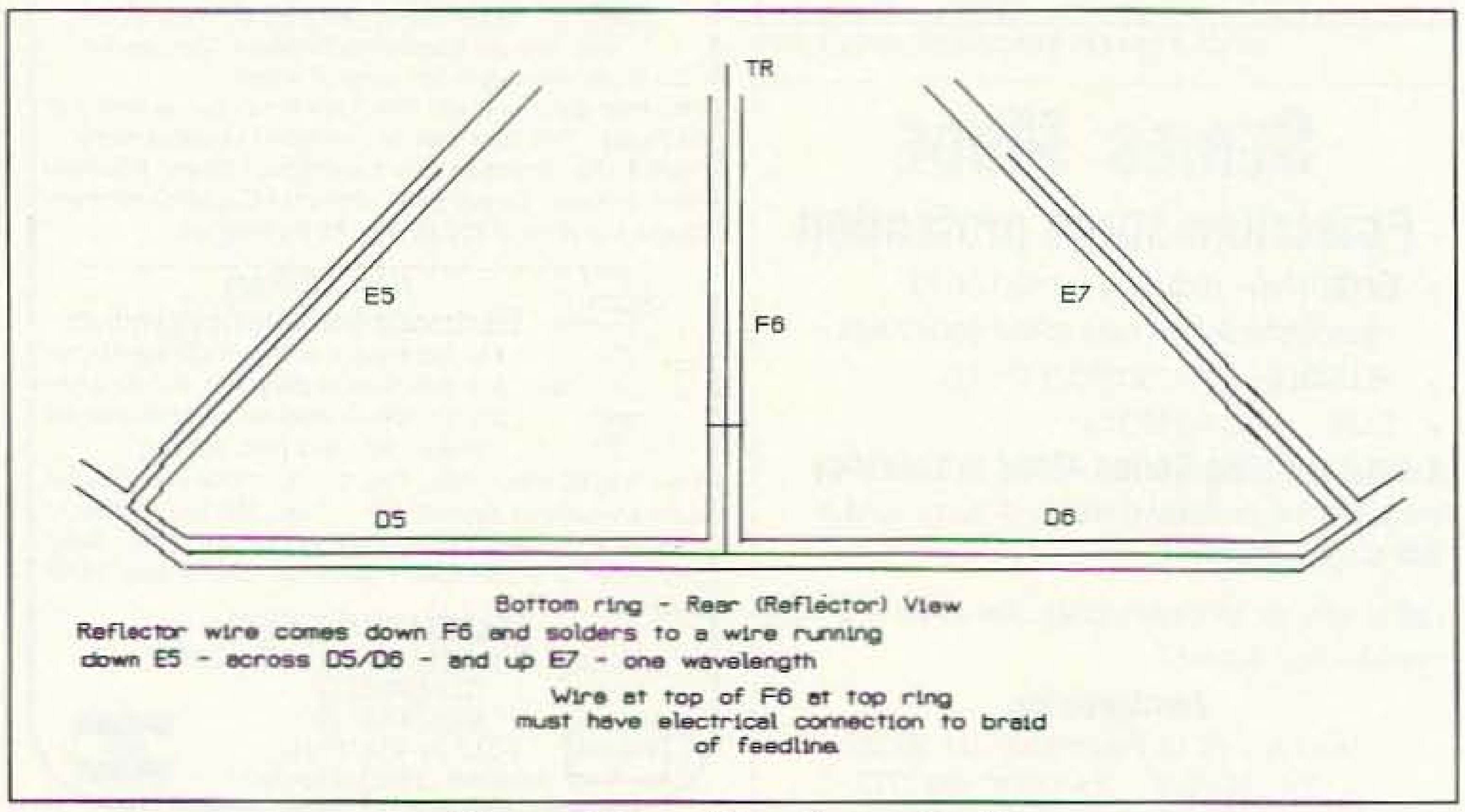

Figure 5. Pyramid's reflector detail.

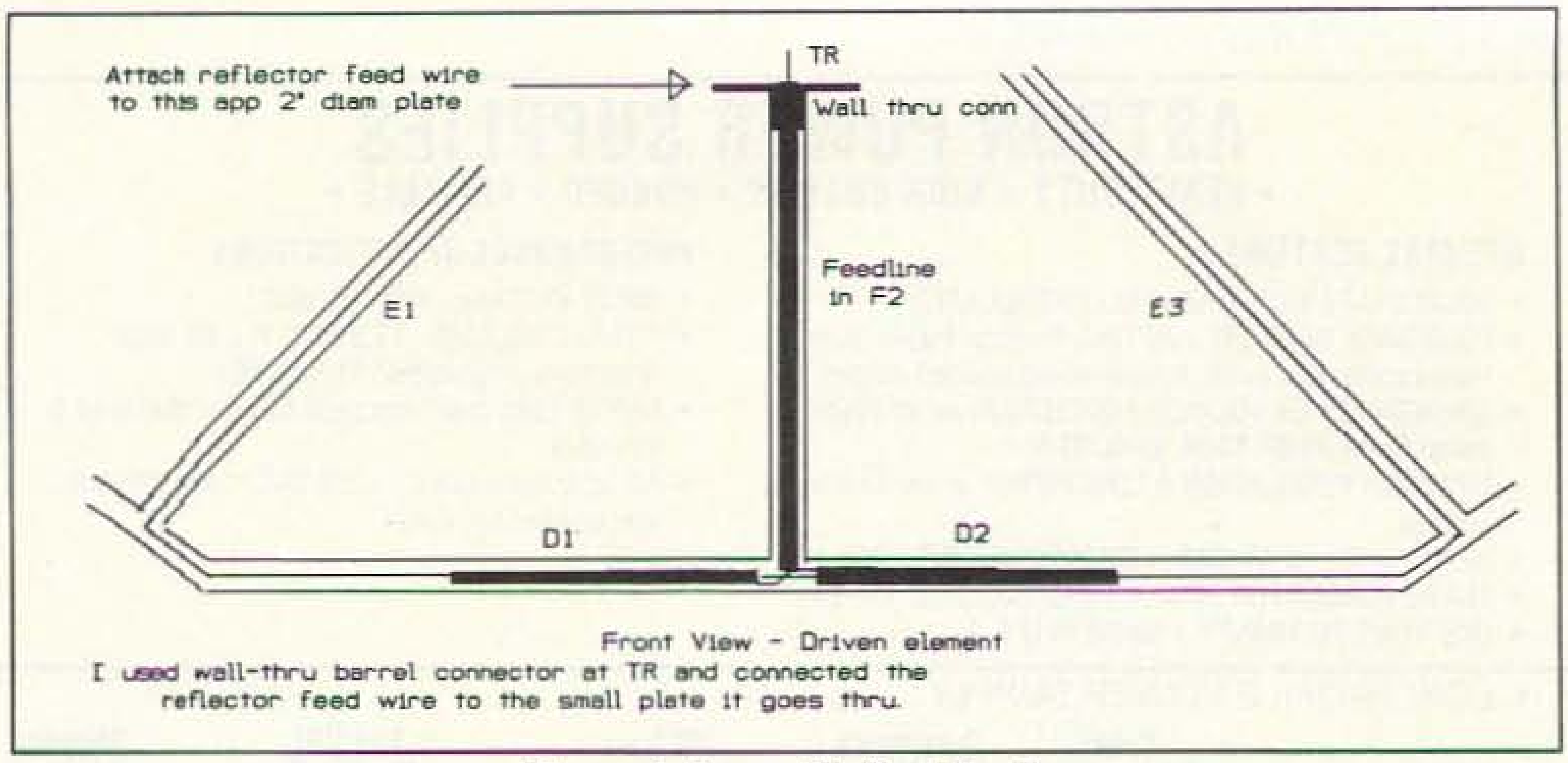

Figure 6. Pyramid's feed detail.

the lower ring, turns, and continues about two-thirds or more of the way back up the back corner tubes. The shape is like a large triangle, not quite closed at the top, and fed at the bottom center (see Figure 5).

Sound Assembly

See Figure 6. It is now time to turn all these carefully cut and crafted pieces into a real working antenna. Take your time feeding the wires through the PVC tubes or kinks and cursing will result. I have found the old "tie a string to a fishing sinker small enough to drop through tubings, and then tie on the cable being pulled, and pull it" trick to work like a champ. If you are not a fisherman, and I'm not, it is still worth buying a sinker just for this job. It is the perfect size (you choose the right one), and shape (teardrop) to do the job. Now that you know all of the lower ring fits together, carefully take the driven leg "T" apart. Slip each half of the bi-square into the "T" open end and head each half out opposite ends of the "T." Be sure the shorter end goes out the direction of D1, and the longer end out the end in the direction of D2. Feed these parts of the antenna out through D1 and D2 respectively. Center the feed in the "T" between D1 and D2. When all is nicely centered, with no kinks, and a smooth-looking "Y" as in the feedline drawing, fill this "T" with RTV, a small amount at a time, working from the center outwards. This is your final weatherseal, so do it slowly and carefully. While the RTV is drying, go to the back center of the Pyramid to the "T" between D5 and D6. Run the reflector element through the correct D5 and D6 tubes. This will no doubt require disconnecting corners, so go all the way around the lower ring and disconnect all non-cemented connections. Remember, the first fit was just a trial fit. Now you are loading the antenna real parts into the tubes, and when reassembled the next time you will cement things together.

By the time you work the reflector wire through the back lower tubes and around the lower corners, through the correct "T" parts and up two more 10-foot PCV tubes that become "E" part back corners, the RTV should be dry. Leave the feed part of the reflector just lying on the ground and running toward the center for now. I found the next assembly to work for me after trying many different ways. Take any one of the 10-foot-long "E" tubes and lay it in the corner connecting the upper ring and the lower ring at point 1. You must now find a stable means to support the center ring about 3'4" off the ground. Small stepladders are just about close enough, or some kitchen stools, sawhorses, or whatever means you have to support the ring at this height. Now fit the #1 "E" tube into the "T" at #1 upper ring corner and cement it into the "T." *Do not* cement any other part(s) of the "T." Do the same at the corner "E" tubes at #3, #5, and #7 corners. You can cement any "E" tube into its "T" at each corner—but not other parts of the "T." This is very important, as the "T" parts of the upper ring eventually must slope downward at about a 30- to 40-degree angle, just as the "T" connections at all the lower ring points must slope upward. The exact amount you will next find out by actually forming the Pyramid. Take each corner 1-3-5-7 in turn and cement the "T" of that corner at the lower ring "T" point. Be careful not to spill any cement into the lower "T" fittings and thus welding the "T's" ability to rotate upward. When four corners are done, you will have a Pyramid top and sides, and as you reassemble the lower ring pieces, the lower ring will come back together. Go around the lower ring cementing *only* the corners at 1-3-5-7, and being sure the "T" at each of those corners slopes upward directly toward the upper ring. The tubes do bow a bit, so try to keep a line through the lower "T," a corner tube "E,' and its upper ring "T" as a straight line, as that removes a lot of twist stress when the antenna is later hung from the center of the top or upper ring. Leave the "F" tubes and center front/rear/sides "T" parts *not* cemented. Using the four remaining PVC tubes, make your "F" tubes by cutting them as follows:

Turn the "T" on the lower ring and the upper ring to face each other, much the same as you did the corners. Now measure between the open ends of the upper and lower "T," and add one inch. The add is for the 1/2" that goes into each "T" at each end of the tube. This is a careful measure-and-fit operation, but not critical. If it's just a bit short it will bow the Pyramid's base upward a bit at the center sides. If it's a bit too long, it will bow it downward. These tubes are mainly mechanical support to prevent sagging between the corners. Mine were cut to fit, and if you do all your other cutting carefully, that should work for you as well. Slip one of these over the reflector feed wire at the back center, and feed the other end out through the upper "T" at #6, where the second upper "T" with the hole is located. If twinlead is used, or larger gauge wires, etc., then you may have to enlarge this hole to suit, or solder a wire to feed through the hole onto the reflector feed. You are trying to reach the center hub, where these wires will ground the reflector to the mast, coaxial feedline shield, and all grounds. Do the same with the coax feedline through the front "F" tube running between the upper "T" #2 and the lower "T" #2 that got the RTV filling. This gets the feedline back up to the upper ring and the mast.

When all this is in place, begin cementing these "F" tubes in place, upper and lower, all around the Pyramid at locations 2-4-6-8. A word to the wise at this point: When fully assembled, it can be difficult to tell a cemented joint from a tight joint under tension from all the other parts—until the whole thing falls apart when it's 16 feet in the air!

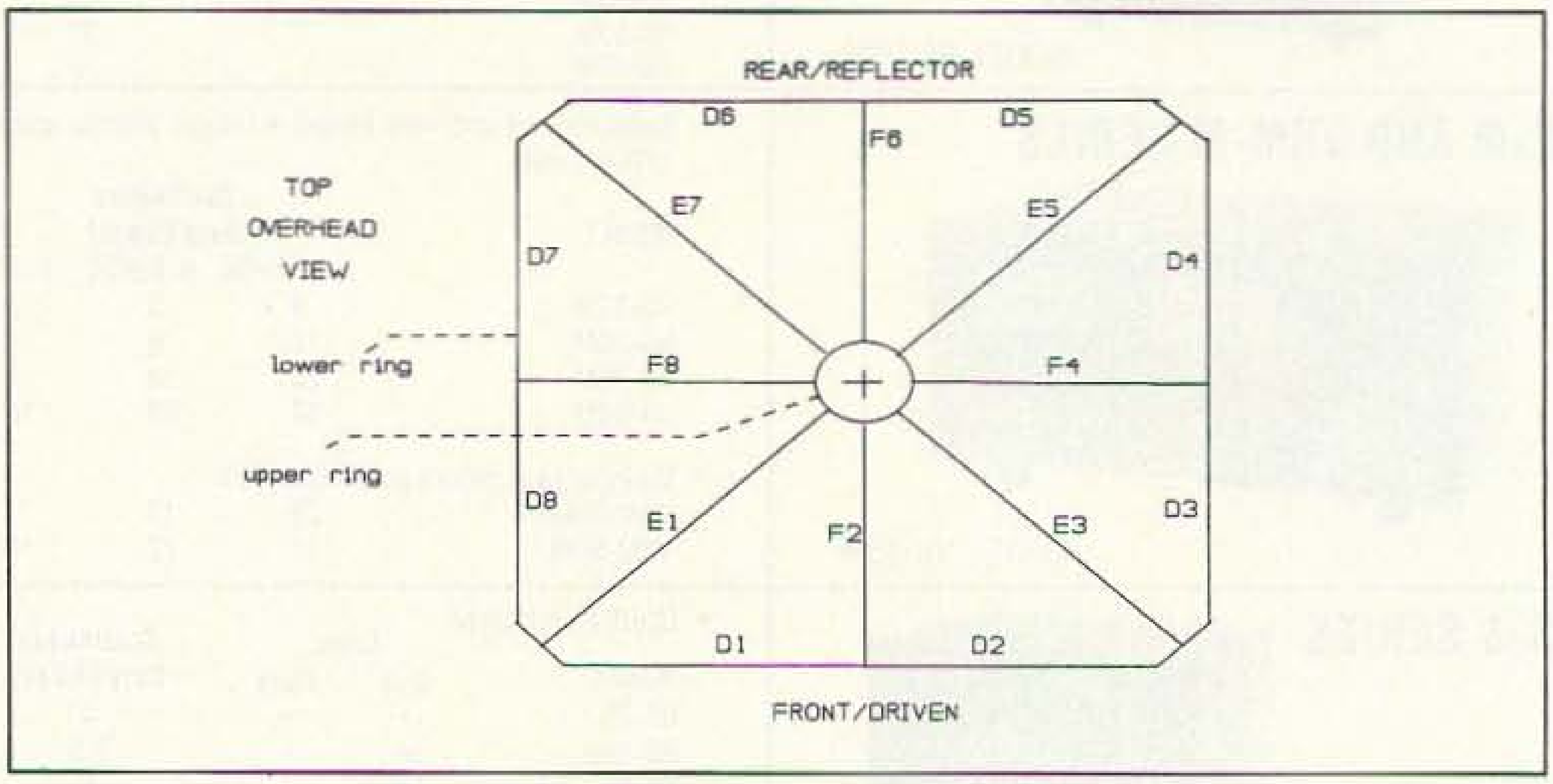

Figure 7. The Pyramid Antenna's overall design.

Do use some means to mark the outside of every joint you cement as you cement it. Tape you can later remove (black/red/yellow high visibility), or magic markers like that work really well. When you are finished and ready to raise the beast, you want to be able to do a walk-around-the-whole-thing inspection and find loose ends at a glance.

Assembly Tips

I discovered a few helpful hints on the final assembly trail, and hope they make assembly for you a lot easier than my first try (live and learn). When cementing the last of the bottom ring, give up any hope of the twist assembly method. Just coat the tube part, insert in joiner, and hold 15-30 seconds. The same holds for all the final assembly of the upper ring, which you can now do. Just coat all the way around the tube for about 1/2" that is going into the joiner, and insert the tube straight in, keeping the overall ring flat.

For those of you with machining and aluminum plate at your disposal, the mounting plate for the upper ring could be 1/4" aluminum plate. I have no such source, so 3/4" marine-grade plywood has done well for me for years. Use a piece 2" larger around than the ring's outer diameter, and give the wood several light coats of marine-grade varnish or other weatherproofing material. Rustoleum "Wood Saver" paint also seems to do well, but is a relatively new product, and I'm just now doing some testing on it myself. After the first few soaking coats of whatever you decide to weatherproof with (aluminum users skip on), drill holes to pass the legs of U-bolts that will wrap around each part "C" in the upper ring and through the plate (16 in all). These can and should be light-duty 3/16" variety U-bolts used throughout the TV antenna industry and available in most hardware and discount stores. Heavier U-bolts would have been fewer in number maybe, but harder to find and of a strength really not necessary. Using the lighter version U-bolts allows more distribution of the stress points where the antenna mounts, and spreads that stress when the wind starts blowing things around. To be sure, the antenna will bob around a bit in the wind, as overall it is quite light for its size. Not to worry, mine made it through 64 mph winds this year, and kept on tickin'. Mounting from the plate to the support mast is left to the user, but I found floor flanges to work very well. Take time to find aluminum types used in office/factory handrails and pallet shelves if possible. They don't rust, and tend to have higher collars on them. The latter I like to drill and tap holes at 120-degree spread around the collar and run into them 3/16" to 1/4" bolts about 1" to 1-1/2" long. This stops the obvious, "If I can screw it onto the upright mast, the wind can surely 'unscrew' it!" Take time to seal the plywood edges, if used, and whatever you do, do not use any kind of chip or particle board. The strength is just not there.

I hope you find the antenna as easy to build and as much fun to use as I have. At only 16.5 feet up (through the center line of the lower ring), or about 20 feet even at the center plate, it is quite a worthy performer. It took quite a bit of fiddling to decide how much reflector to use and where to run it, as well as the guts to try this type of a driven element, but I had all those years to evaluate all the smaller parts of this antenna. I even built scaled-down VHF models for the first time in my life, and hey, scaling does work—sort of. And if all else fails, and the band goes all quiet, you can always go sit under it (power OFF of course), and test the other theories of pyramid power.

If I can help you in any way, just drop me a line (14670 N. Cumberland Rd., Noblesville, Indiana 46060). Please include an S.A.S.E. and allow a few days for me to to digest your question and reply. 73

Parts List and Specifications

Type of pipe/tubing used: White PVC plumbing pipe; 1/2" Crestline (or equivalent), schedule 40, PVC 1120, 400 PSI. Black and gray are usually sold as electrical conduit. There is a tan PVC that is for hot water and is higher in cost, with no increase in value as used in this project. Overall, the white PVC cold-water pipe is the least expensive, and is more than sufficient for strength.

Cement used: Hercules brand, clear, PVC, medium body, medium set plastic pipe cement; up to 6" diameter; schedules 40 & 80.

Parts:

PVC tubing as above	1/2", white, app. 7/8" o.d.	17
PVC connectors	45-degree, ELL	16
PVC connectors	Three-way joiner, T	16
Can of cement	To join tubing and joiners	1
3/4" plywood	Marine if possible, app. 24" x 24"	1
Pipe floor flange	Minimum 1-1/2", four-hole mounting (to suit vertical support pipe coming from rotator	1
U-bolts	Aluminum or plated hardware, with legs long enough to encircle tubing and go through plywood mounting plate, app. 1-1/4"	8
Coaxial cable	RG-58, solid-center conductor	App. 50 ft.
RF connector	As appropriate to connect to lead-in to shack (BNC fittings were used, but PL-259 type are adequate)	1

Approximately a pound of care and patience (be sure to prefit and try everything before you glue—the glue works, fast)

References: Charles Whysall W8TV, "The Double-Bazooka," *QST*, July 1968. p.38.

John Schultz W2EEY, "The Double Coaxial," *73 Magazine*, June 1973, p.79.