# The Tri-Band Birdcage

BY GEORGE COUSINS*, VE1TG

*The G4ZU Bird Cage in a previous issue of CQ inspired VE1TG to create this 3 band birdcage for 10, 15 and 20 meters.*

AFTER moving from Ontario to the Annapolis Valley of Nova Scotia in November 1959, the first problem was to find a place to live, and the second was to get back on the air. With winter coming on, the antenna problem had to be solved in a hurry, so between the trees appeared a scandalous conglomeration of long-wires, doublets and other arrays, mostly for 20 meters. Of course with my good friend VE1GA only four houses away across the field, it wasn't long before I was very conscious of the results he was getting with his 3-element wide spaced beam. The difference was that he is a permanent resident while I am a transient, so a beam was considered a bit too much for me to invest in. A good compromise seemed to be the cubical quad, so work was begun, with the XYL's clothes pole in mind for a support.

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[1]Bird, D., "The G4ZU 'Bird Cage' Ariel," *CQ*, April 1960, page 40.

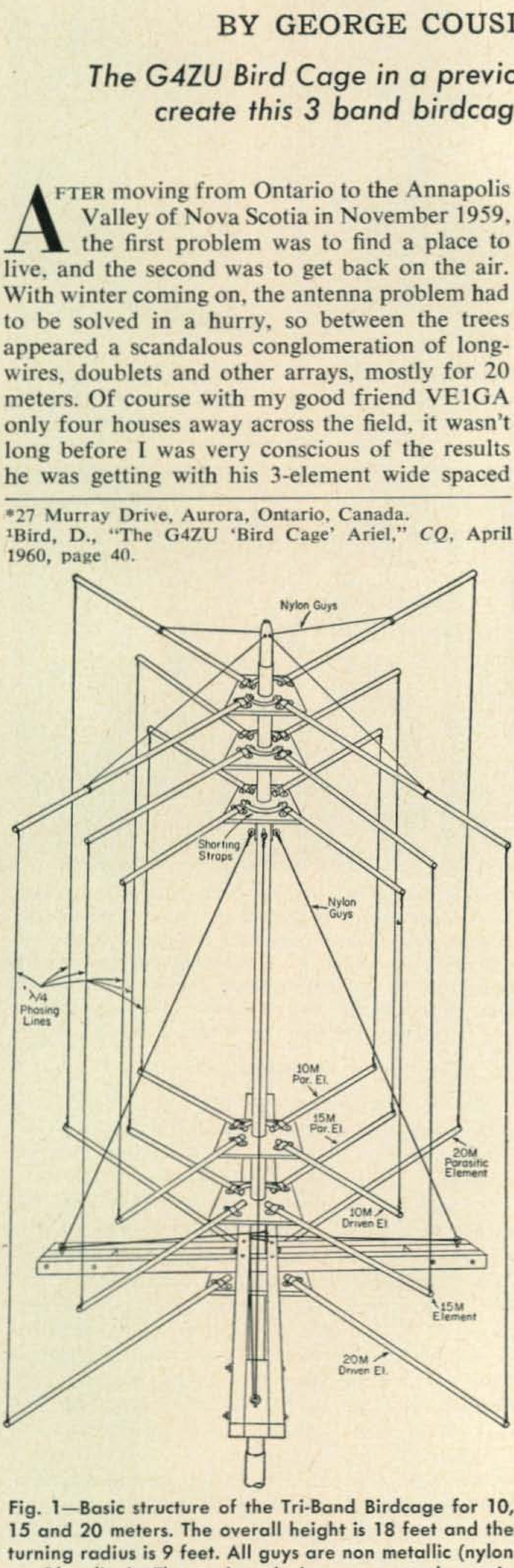



Fig. 1—Basic structure of the Tri-Band Birdcage for 10, 15 and 20 meters. The overall height is 18 feet and the turning radius is 9 feet. All guys are non metallic (nylon or Glass-line). The tuning devices are not shown in the drawing.

Two quads were built during the winter but didn't survive. Finally came spring, and with it a copy of *CQ*, complete with an article on the G4ZU Bird Cage[1]. This looked so interesting I was sold on it before I was half way through the article. The birdcage was constructed from the article for 20 meters only and was duly propped up against the clothes line pole.

The bottom elements were 2½ feet off the ground, but having no tower this couldn't be helped, so the thing was tuned up where it stood. All the methods tried, failed to bring the s.w.r. down under about 2:1. Deciding that the elements must be too long, we tried all sorts of capacitor arrangements, to no avail, so a pi-network coil from a surplus transmitter was placed in series with the coax and the s.w.r. came down very smoothly to 1.05:1.

The thing was pointed south and a tentative CQ sent forth on c.w. A PY7 came back immediately with a 5 8/9 9 report, so there was great rejoicing in the VE1TG shack. Considering the generally poor conditions on 20 at the time, this was considered to be pretty good.

The problem of rotating had to be solved. A hole was dug about 4 feet deep in the back yard and a piece of water pipe 6 feet long was inserted. The cage was placed on top of this, leaving the lower elements about 2 feet off the ground. It could be rotated with one finger, so a motor was considered unnecessary at this time.

### Tri-Band Cage

After a tower was built, the cage was examined critically and immediately the thought came to mind; why not a tri-bander? So away we went, and this is the result.

Figure 1 shows most of the construction details. The mast is a 20 foot section of 2" o.d. aluminum irrigation tubing with a very thin wall and very light weight. A piece of 2" × 2" clear pine is turned down and driven into the tubing, making a solid wood insert a little longer than the length of the pipe, and so creating much greater strength than either would possess alone.

The elements were cut from lengths of 65S-T aluminum tubing, using 1" o.d. for the 20 meter elements, and ¾" o.d. for the 15 and 10 meter elements. The 20 meter elements were 0.052 wall and the others were 0.035. By careful planning and checking to see what stock lengths are available, the elements can be cut with very little waste. Don't throw away any extra pieces; you may be making Gamma or T matches before you're through and they will come in handy. The phasing lines are made of #12 wire with solder lugs on the ends, which are then bolted to the elements. The aluminum should be cleaned before the lug is tightened into place. I also coated the whole joint with clear plastic which is available in most hardware stores. The lengths which I eventually ended up using are:

20 meters—elements 8'8" Phasing lines 17'
15 meters—elements 5'8" Phasing lines 11'7"
10 meters—elements 4'4" Phasing lines 8'8"

The phasing lines are only approximate lengths and should not be cut until the points mentioned later are understood. There are 8 elements and 4 phasing lines required for each band.

Six mounting plates are required for the elements. They are cut from ⅝ or ¾ plywood, and should be primed and painted before mounting. The 20 meter plates are 1½' square, and the others are 1' square. Two inch diameter holes are cut in the center of the plates so that they will fit tightly over the mast. The plates are eventually bolted to the mast using non-rusting hardware and angle shelf brackets. Remember the spacing requirements for each band. The best method is to mark out the spacing required between the top plates and then bolt them in place on the mast, remembering to keep them in line with each other so that the elements will also be in line when they are fitted. The mast can be laid across two boxes or saw-horses while this is being done. By placing the top elements near the top of the mast, there will be about two feet of mast left at the bottom for fastening to an extension shaft.

The elements are fastened to the plates at right angles to each other using water pipe straps bolted to the plates. This is shown in Fig. 1. A brass wood screw is also run through the element into the wood to prevent the element from turning or slipping out. Remember to fasten shorting strips of copper braid or other suitable material to the top elements. Select two adjacent elements for the driven element and short them together. Do the same for the parasitic element. Do not allow the shorting strips or the elements to touch the mast, and remember as you proceed with the other bands, to keep the same relationship between elements all the way down.

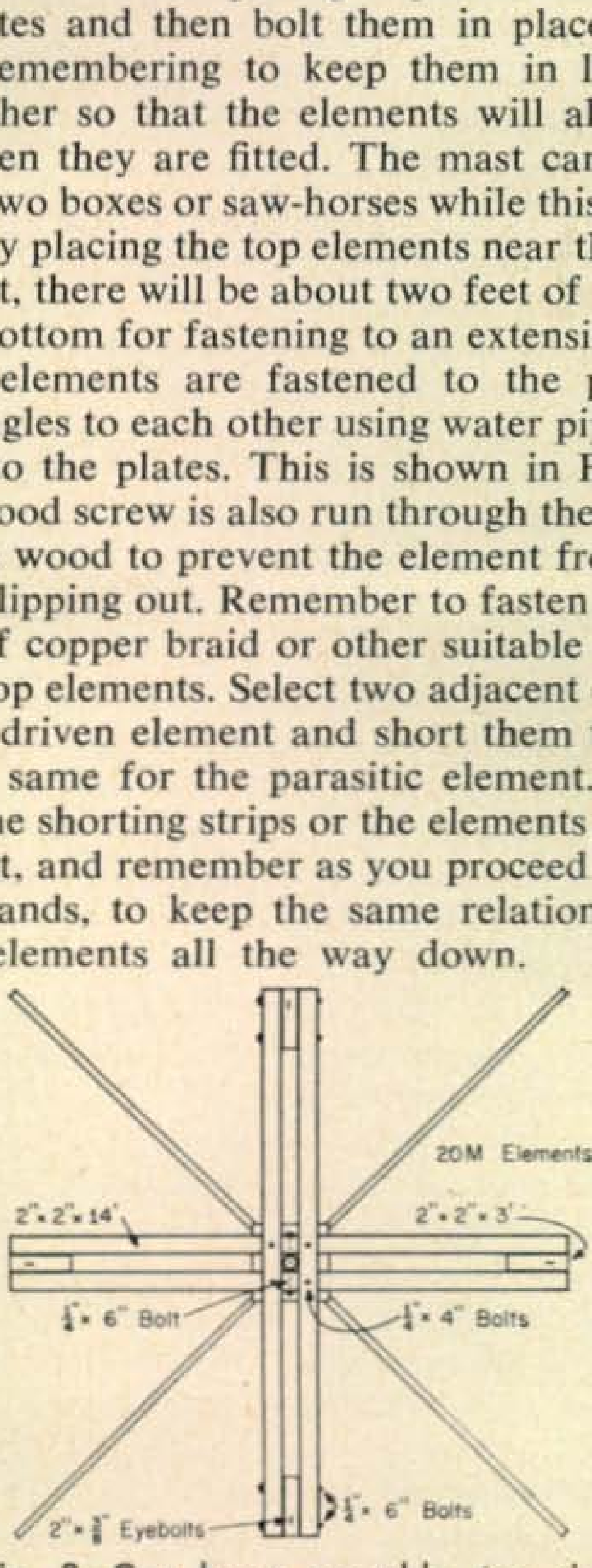



Fig. 2—Guy boom assembly, top view.

Not having much faith in a 9' length of tubing suspended from only one end, I extended the wooden insert out the top of the mast by a couple of feet and then ran guys from the top of this extension to the outer regions of the 20 meter top elements. These guys are nylon here, but in any case should be non-metallic and of a material which is reasonably free from stretching or contracting when the weather changes. So far these guys have prevented any sag or bending in the elements.

Providing all has been done carefully, the top elements should be in place by now, and all lined up with each other. Now the phasing lines can be connected to the top elements and the bottom plates can be slipped on the mast. Install the bottom elements on the plates, but if you are going to tune it up on the ground don't bolt the bottom plates yet, as you will have to adjust the lengths of the phasing lines to bring the elements into the required resonance, and this will naturally mean having to move the position of the bottom plates. When this is all done, the plates should be bolted into place so that the phasing lines are stretched tightly between their appropriate elements.

If you intend to tune it up on top of the tower, cut the phasing lines for the lengths in the above table and bolt everything in place. This is what I did, so read on and see how it turned out for me; then make your own decision. An awful lot will depend on how easy it is to work on top of your tower or whatever you are going to stand the antenna upon. I found the tuning did not vary enough to worry about between ground level and 32 feet in the air. However this will depend on location and surroundings so should be left to the discretion of the builder. Everyone will have his own pet ideas but remember—be sure you can reach the 10 and 15 meter lower elements when you have it up there! If you can't you had better do at least preliminary tuning on the ground, and take your chances on how it will work up there. Here again a lot will depend on the design of the tower and also on how long a reach you have.

### Raising The Antenna

After spending many hours reading articles on antenna construction, I notice very little is ever said about how to get the things up in the air. In this case it depends on the design of the tower, height, and facilities available. When the antenna is completely assembled on the ground you will have something resembling an overgrown porcupine and just about as easy to grasp. As soon as you decide to build the antenna (if you do) start cultivating friends—you'll need them for the Great Day. Also if at all possible I would suggest you try to tailor your tower to the needs of the antenna. Visualizing lots of fun when the big day arrived, I built the tower with a 3 foot square top and and with a platform about 4 feet down from the top. In this way three men can work at the top with lots of safety. This is a good thing to point out to your friends when request-

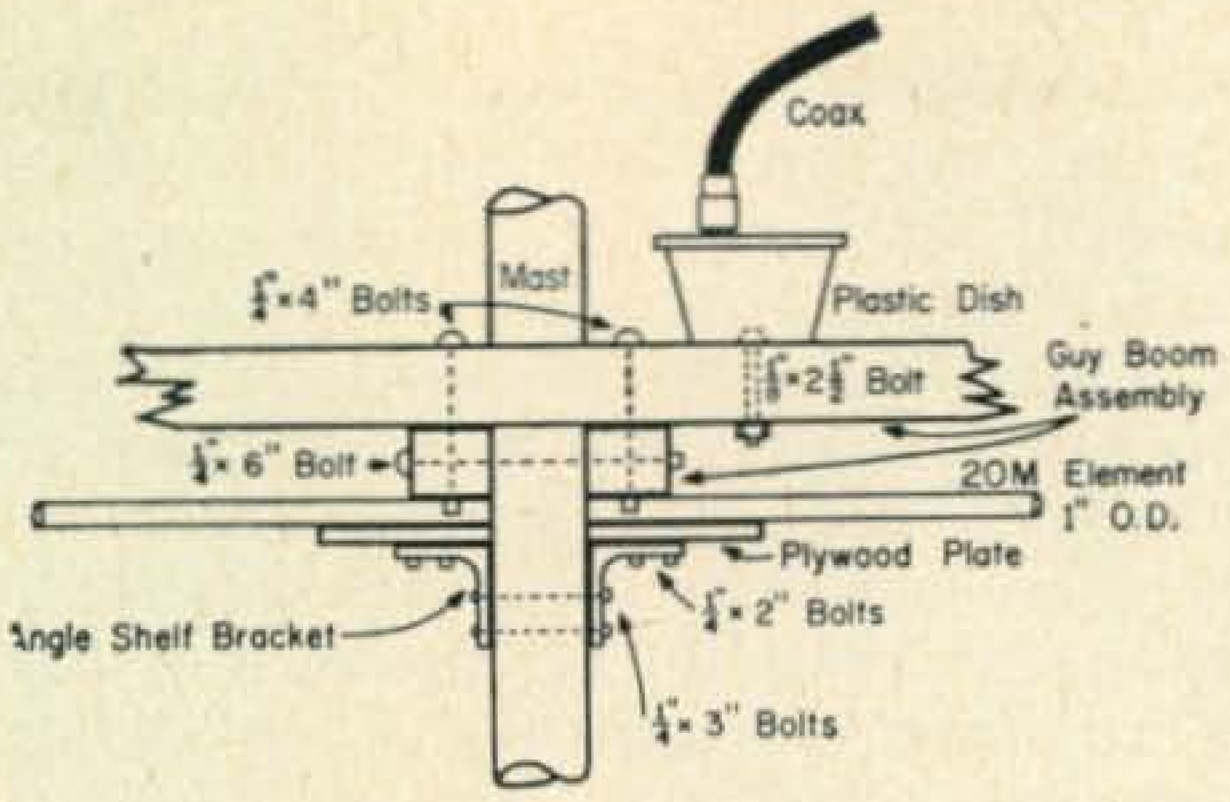



Fig. 3—Details of the guy boom and twenty meter element mounting assemblies. The plastic box contains the gamma capacitor.

ing volunteers for the raising. Even with this, there is a bit of fun in store when you get three men and an antenna all struggling away on top at the same time.

We raised the antenna all in one piece, completely assembled, by sheer manpower. Don't do it! We bent one element (one of the very top ones, of course) and also put a dent in the mast. Luckily both of these faults were remedied without too much trouble but they could have been a lot worse.

Further experimenting has proven that the easiest way to accomplish the task is one of the following:

Method 1—Mount a gin pole at the top of the tower, complete with a small block and tackle, and rig a rope sling around the mast in such a way that it can be raised vertically. The gin pole should be high enough so that the mast will clear the top of the tower and the base can be then swung into place.

Method 2—Release all the plywood plates except the top one. Slide them all up to the top of the mats in a tight group, and then proceed as before with the gin pole. The difference is that you now have about 18 feet of mast to grasp and also all your elements will be at one end—an important point when you're trying to keep an eye on all 24 of them at once!

Method 3—Remove the plates and elements as complete units. Stack them at the top of the tower in the correct order. Run the mast up through the inside of the tower and through the plates also. Bolt the top plate, slide the mast up, bolt the next plate, slide the mast up, *etc.*, until the elements are all in place.

A combination of method 1 and 2 was tried out when we had to lower the antenna in order to straighten out the top element and it worked out fine. The gin pole also serves to support the antenna while you're taking a breather and getting your support problems straightened away. You'll need a rest by this time and something has to hold the thing up!

### Guying

Before tuning or anything else you must make sure the thing will stay up and I for one have little faith in a structure this high, standing there all by itself, in the winds we get around here. Guys there must be, but in such a way that they will not interfere with the rotation of the antenna. This can be quite a problem, in a closed loop system such as this.

The solution here, shown in fig. 2, was to install two wooden booms at right angles on the mast itself, as low as possible, without interfering with rotation. Mine are mounted just on top of the lower 20 meter elements, and each boom is made up from two lengths of 2″ × 2″ × 14′ lumber, with a piece of 2″ × 2″ × 3′ at each end. The center point of the boom is bolted through the mast and the ends are fitted with eye bolts. The guys should be non-metallic. I used a new type of plastic clothes line with a tensile strength of 750 lbs. Each guy is fastened to the mast just below the top 10 meter element and is then taken out to the end of the boom where it is passed through the eye bolt and run back in to the mast at the bottom. It is tied here and by adjusting the tension on each of the guys, the mast can be held straight.

### Feeding

Separate coaxial cables are used to feed the three sections of the antenna. Though originally intended, I understand, to match 52 ohm, I decided to use the 72 ohm RG-59/U which I had on hand and had no difficulty in bringing the s.w.r. down. Possibly the Tri-Gamma match mentioned in W6SAI's Quad Handbook could be made to work here, but personally I prefer the separate cables.

When it comes time for tuning, if you don't have an s.w.r. bridge and a grid dip meter, beg, borrow or buy them. Also enlist the aid of another ham. It is necessary to have one man at the transmitter and one on top of the tower.

First decide whether you want a director or a reflector. The original article called for a reflector but this has been changed now to a director. In any case get the grid dip meter to work and check the driven Element. I found that, even though I had cut the phasing wires so that the total element was theoretically longer than the low end of each band called for, the measured frequency of resonance was considerably higher than the upper band limits. This may be due to the proximity of other wires for the other bands, but in any case is not too much to worry about. Faced with this problem on the ground, the phasing lines can be lengthened to the extent necessary to bring the element into resonance at the correct point. However I was on the top of the tower by the time I discovered this, so changing the lines was definitely "out". Instead, a small coil of about 6 turns of #12 wire 2″ in diameter was made of B&W coil stock and inserted in the driven element. The coil was then carefully pruned while checking with the meter until the frequency of resonance was as required. I adjusted for resonance at the center of the DX phone band in each case. However as will be seen, the exact frequency of resonance is not too important.

Having resonated the element, the coaxial cable was attached. The outside shield of the cable was attached to the exact center of the small coil and the inner conductor was connected to a small gamma matching section. In the case of the 20 meter section, the gamma bar is about 30" long and the capacitor is a 75 mmf. I feel these values will serve as a good general starting point but would not necessarily always be correct. However this is no different than any other type of antenna matching arrangement.

With an assistant on top of the tower to tune the capacitor, the s.w.r. was quickly brought down to 1.1 on 20 meters. Checking across the band revealed a total swing of from 1.05 at the lowest point to 1.2 at the highest point, with no difficulty.

The 15 meter section was tuned in the same manner, as far as the driven element was concerned. Again it was necessary to use a small coil in the element. This one was constructed from 6 turns of ¼" copper gas line, 2" I.D., and close spaced. Again it must be realized that the necessity for these coils may not arise and even if it does, the size required may not be the same as mentioned here. However, it is well to know how the problem was solved here, in order to save time in another installation.

The 10 meter element was found to require a small coil of tubing containing 3 turns 2" I.D. and the spacing adjusted until resonance was attained. Figure 4 shows the gamma matches as they are here.

The directors are tuned by the use of wire stubs on each element. In my case the 20 meter stub is 4½ feet long, the 15 meter one is 36 inches long and the 10 meter one is 24 inches long. This will give a good starting dimension in

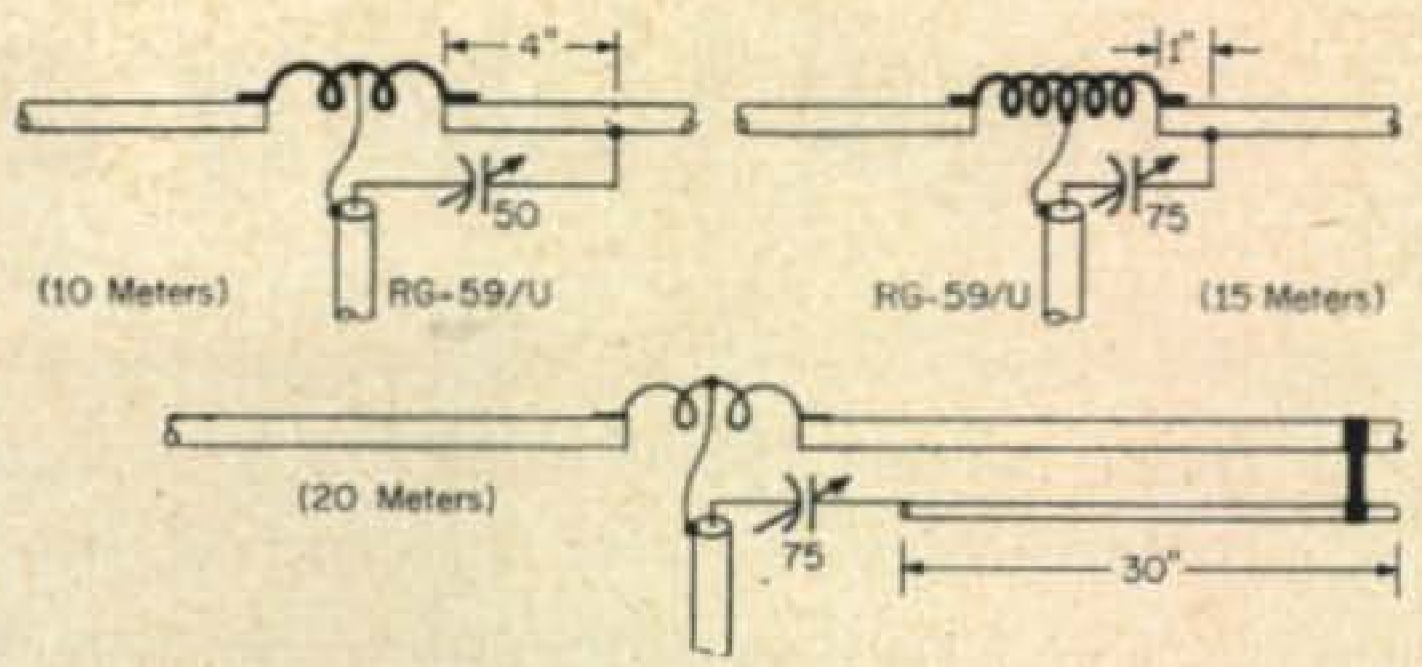


Fig. 4—Specifications for the gamma matches for each band. The coils are wound on a 2" i.d. While the exact number of turns will vary with individual installations, as will the feed points, the measurements used will provide some idea for a starting point. 10 M-3t ¼" copper; 15 M-6t ¼" copper; 20 M-3t #12. The gamma bar for 20 meters is a ¾" tube.

each case. The final adjustment is done by any of the methods shown in antenna handbooks. I used the grid dip meter to set the directors for a frequency about 5% higher than the driven elements and then enlisted the aid of another amateur who lives a few miles away. Using his receiver and "S" meter the stubs were then given a final adjustment. The eventual lengths are very close to those given above.

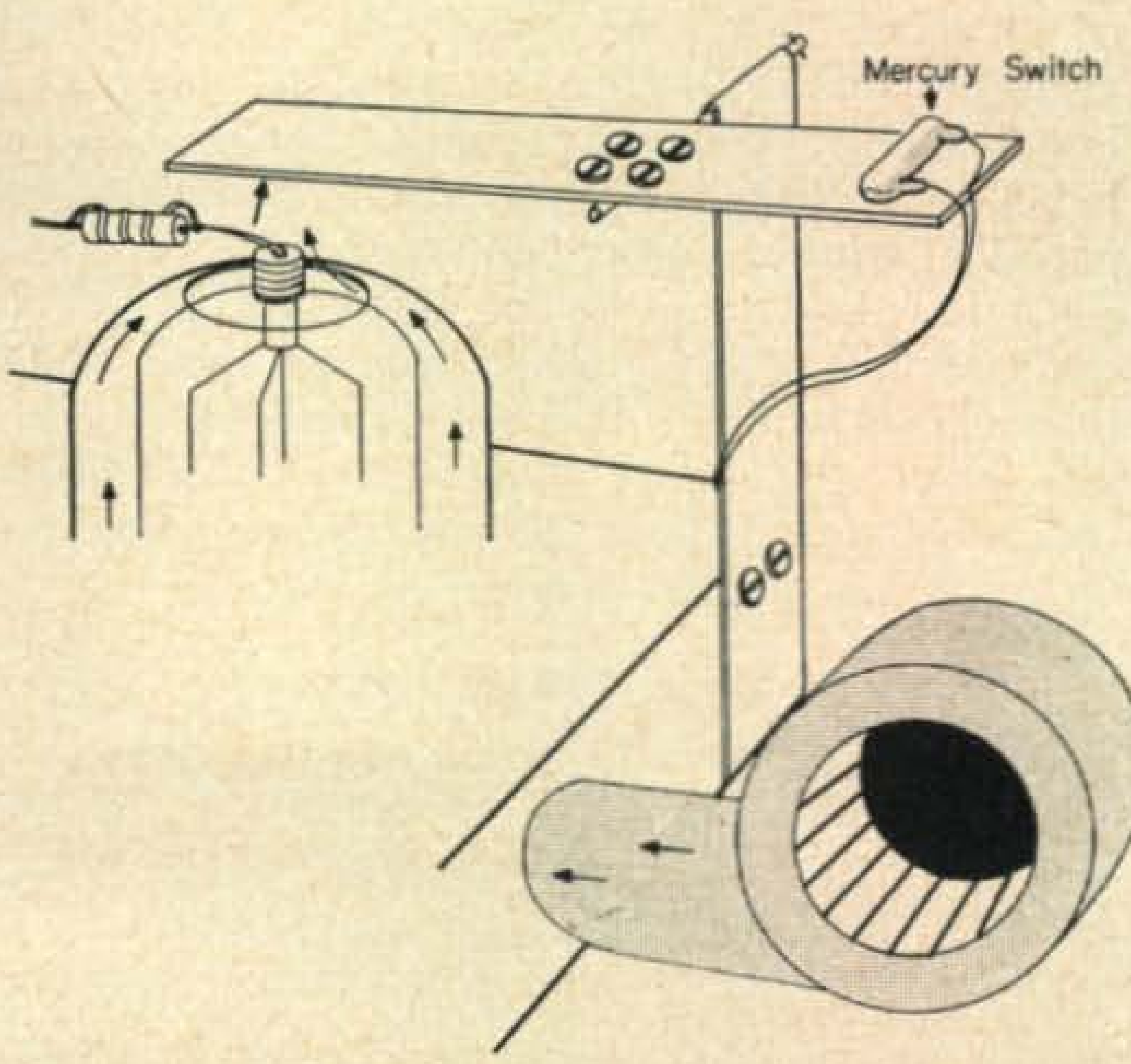
I would like to say a most heart-felt thanks to the fellows who gave so much of their time and labor to help put the thing into operation. These include VE1GA, VE1ZL, VE1ABJ, VE7AFT/1, VE1AGL and Joe Kyte, Jack Rooney, Ray Ortman and Bob Hawes of the Royal Canadian Air Force. The latter four aren't hams yet, and so I am even more grateful to them for the unselfish effort and the hours spent helping to get the antenna completed. ■

# Air Blower Safety Switch

BY E. ROBSON*, VQ4ERR

WHAT happens to the high powered final tube when the blower fails? Many of these modern, high efficiency tubes are extremely temperature sensitive and require some sort of protection. The sketch illustrates a simple homemade device that uses the air stream flowing around and up the tube to lift a light plastic strip on which is mounted a mercury switch. The plastic plate can also be used to trigger a microswitch. When the plate is pushed up, the switch is wired to apply the high voltage to the final. When the air supply fails the plastic plate drops down and the mercury switch shuts off the high voltage supply.

It takes a little time to balance the plastic strip so it falls gently onto the tube cap when there is no air supply. The air column must be strong enough to push up the plastic strip. With a small mercury switch the weight distribution on the pivot is ⅔ to ⅓. The pivot is a piece of tubing slid over a bolt which is fixed to the




metal post. I'm in the process of constructing a miniature switch to fit directly in the air stream. Any ideas? ■

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