What You Should Know About Telescoping Towers

WILLIAM I. ORR, W6SAI

Assistant Editor, CQ

First — What NOT to DO

Working on a beam antenna closely resembles the task of building a boat in the basement. If one is not careful during the building of the boat, the day may come when it is necessary to tear out the side of the house to get the boat out of the basement. The analogy applies more closely to a beam antenna than one would think, once the beam is built and placed atop the tower. If one is not careful during the building and tuning of the beam antenna, the day may come when it is necessary to take the antenna down to make some minor repair, or tuning adjustment. To the sorrow of many Hams, getting the beam antenna down to the ground from the top of a thirty or fifty foot tower is no easier a task than getting the proverbial boat out of the basement.

This homely little simile was brought forcibly to my attention during an attempt to adjust a stacked 15 over 20-meter dual array. After the monstrosity had been struggled to the top of the tower, measurements indicated that inter-action between the two beams effectively detuned them both so that they were practically useless.

What to do? Hang by my heels fifty feet in the air, retuning the beams, my family (anxiously) and neighbors (hopefully) waiting for me to drop to a sudden end? In addition, every Ham well knows—by the theorem of *IPOIO*[1] that the wind will start blowing in heavy gusts the moment a foot is placed on the top rung of the tower, no matter how mild the climate at ground level may be.

1. Liscum Diven, "IPOIO," CQ, April 1952, p. 49.

GOING—GOING—GONE. The wide spaced three element twenty meter beam of W6FHR gracefully descends from the operating height of fifty feet to a resting height of 22 feet. The motor driven tower can actually drop the beam below the level of the house roof, when the tower is fully retracted. The fifty foot steel tower stressed to withstand the heaviest winds is guy-less and entirely self-supporting. The 25 foot boom is rotated by a surplus "prop pitch" motor, mounted atop the boom. Two selsyn drives are attached to the antenna system. One indicates the heading of the antenna, the other indicates the extended height of the tower. When the 20 meter band is dead, W6FHR shunt excites the tower as a top loaded vertical antenna for 40 and 80 meters!

The only answer was to lower the whole array, make the necessary adjustments on the garage roof, and then to raise it into position atop the tower once more. This looked like a dismal project that would take up at least two good week-ends, that might otherwise be spent working DX, or something equally profitable.

The job was finally done (actually requiring three weekends, during one of which EA9DD was worked by all except W6SAI), and involved a tremendous amount of physical wear and tear. After the completion of this little chore, some serious thought was devoted to the problem of designing a new antenna set-up that would lower the antenna to the vicinity of the ground to permit adjustments to be made with ease, perhaps at the top of a step-ladder.

A Solution

The first thought was to place the antenna and rotator on a little car that would run up a track bolted on the side of the tower.[2] This would necessitate an un-guyed tower, or one with removable guys. It would also involve some rather close tolerances between the track and the car, plus quite a bit of machine work. In addition, it would be impossible to rotate the antenna at any intermediate elevation, since the tower and track would block rotation of the beam. Since quite a bit of time and money would undoubtedly be expended on the proposed tower, it was felt that rotation of the beam at any chosen altitude was a "must." Just off-hand, I could think of any number of interesting experiments that could be run with a beam that could be elevated as well as rotated. As a final down-to-earth clincher, when the beam is dropped to a low altitude, nothing is visible to the neighbors. The antenna would only be run up into the air when in use. I was convinced and "Project Telescope" was started.

The tower-track idea was eventually dropped and a form of telescoping tower, made in concentric sections, that could be raised and lowered by mechanical or hydraulic means took its place. This system possessed three important advantages:

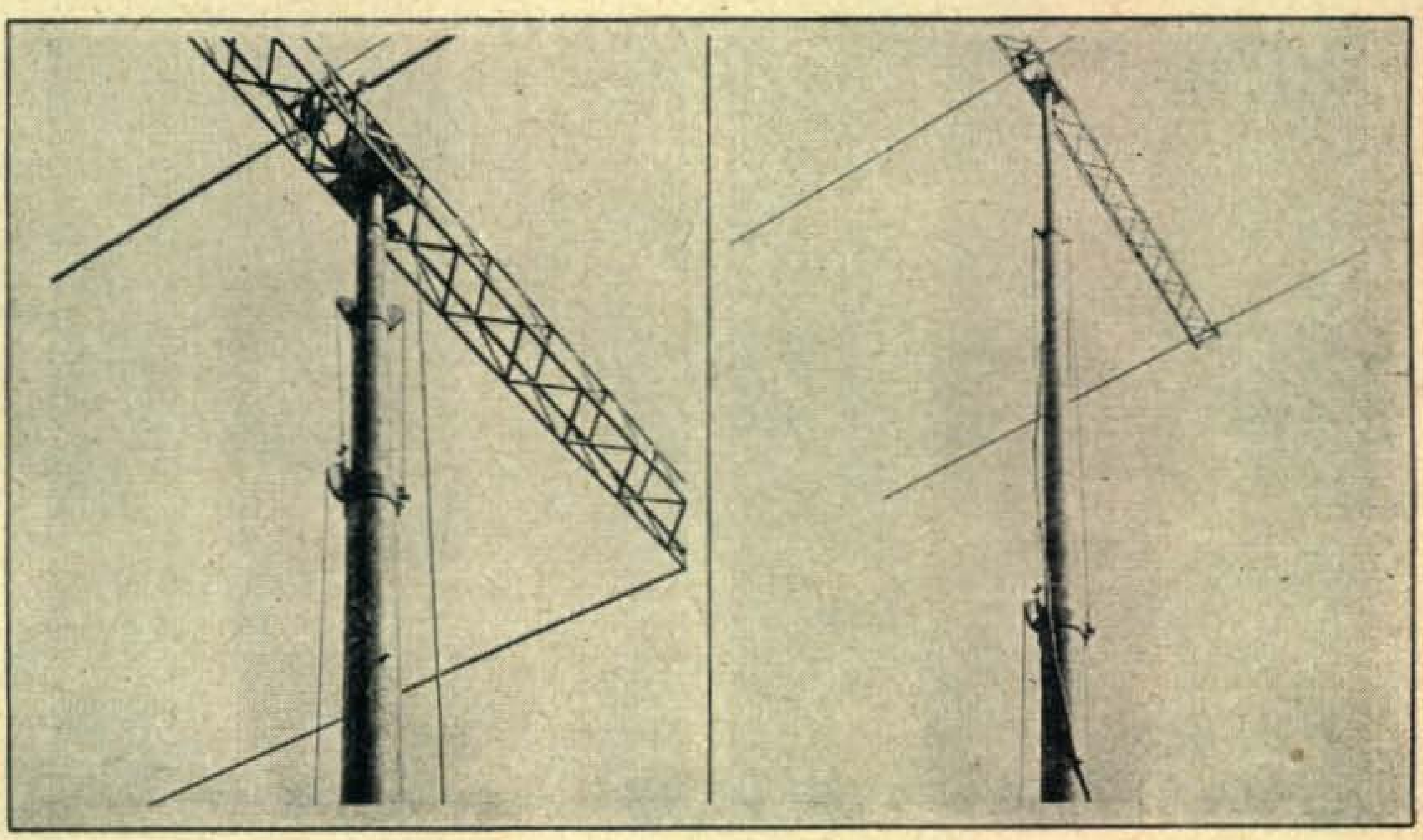
1. As the beam descended, the tower would "shrink," leaving no residue above the beam to antagonize the neighbors.
2. The beam would always be at the "top" of the tower. This solves the problem of turning the beam at various altitudes.
3. If the proper material is chosen for the tower, the required tolerances would be automatically "built-in" the purchased material, thus saving a lot of expensive hand finishing.

Considerable attention was given to the idea of operating the tower hydraulically by means of water pressure. This idea proved to be impractical, as the tower sections would have to be chromium plated and sealed to prevent leakage. ("Put a sprinkler head at the top of your tower and water your petunias as the beam descends," helpfully suggested W6LGU.)

A great deal of weight was given to the opinions of W6FHR, a structural engineer, who had been toying with just such a tower design for some time. We finally joined forces and decided the tower should have the following general specifications:

1. The tower should be made of relatively inexpensive material, such as steel pipe. The construction and assembly should be considered low precision work. This would keep cost to a minimum.
2. The tower should have a minimum height of 18 feet, and should "expand" to a height of 50 feet.
3. The tower should be self-supporting, and no guys should be needed. It should have a safety factor of 100% in a 70 m.p.h. wind, assuming a wind load of 15 pounds per square foot on a 4-element 20-meter beam.
4. The tower should be designed in excess of all local building codes.

2. Anderson and Anderson, "Lower that Beam," CQ, June 1949, p. 28.



Right hand photo — The tower fully expanded. Left hand — A close-up of the tower in a retracted position. The cable drive system and pulleys may be seen, as well as the mounting plate for the 25 foot antenna boom. The antenna is a wide spaced 20 meter array, fed with a gamma match, and RG-8/U line. Special high-stress pulleys and aircraft-type cable are used as the erecting force. The two pulley bushings are located in the center of the photograph.

5. The tower should have a special fixture at the base, so it could be taken down at a later date, if desired.

6. It should be fool-proof in operation, and designed so as to be jam-proof.

The biggest design battle occurred over the problem of whether or not to use guy wires. If one or two sets of guy wires were added to the tower, it would be possible to construct the tower out of much lighter material. In fact, a braced structure of one-inch tubing could be built, sort of on the order of the Eiffel Tower. Strong arguments were advanced by the "guy the-tower" school of engineers, the strongest of which was the monetary savings involved in this type of construction.

After much discussion the problem was boiled

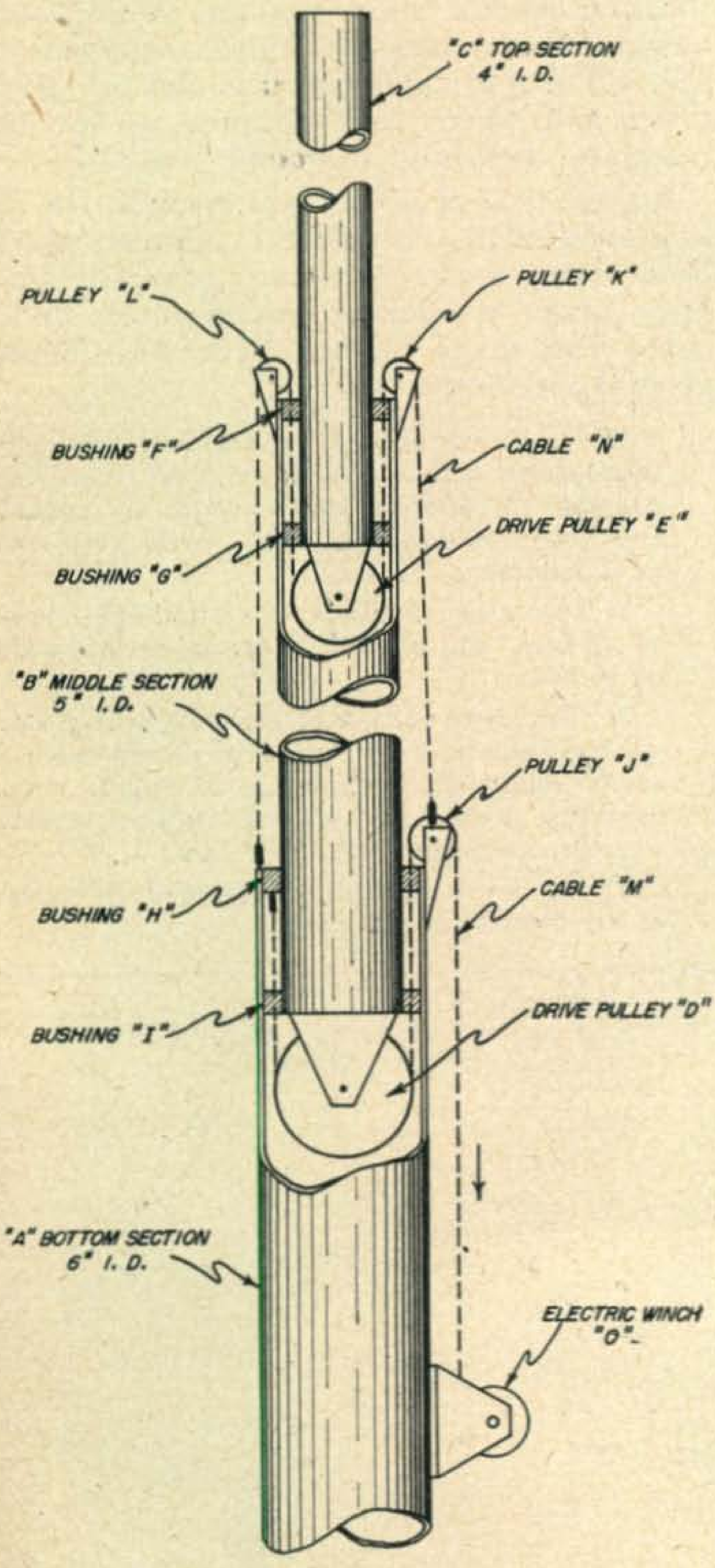


Fig. 1. Mechanics of the tower. See text for all details on operation.

down to the simple decision to restate just what we really were looking for. What was the so-called philosophy of the design? Just what were we trying to achieve?

"The idea is roughly like this," stated W6FHR. "What we want is a structure that will cause the antenna to be raised and lowered at will. It must be 'clean' in appearance, and not look like a rat's nest to the neighbors. It must take up a minimum of ground space, and above all, it must be strong; I hate to lay in bed at night during a windstorm and wonder when the darn antenna is going to crash about my ears! I don't want a cheap TV-type mast that has to be held up by a bunch of 'antennas' tied to it. Sure, a guy-less tower costs more, but the amount of money put into the antenna is a small fraction of the money the average Ham puts into his station as a whole! I want a tower that's going to last for fifty years, not one that might flop over if a guy-wire corrodes on me!"

This passionate appeal convinced even the hardest skeptic—the guyed tower was cast into limbo, and we went ahead with our original design. Finally, with a sigh of relief we shipped the blue-prints off to the sub-contractor for fabrication of the tower.

A few weeks later a large, flat-bed truck pulled up in front of the house. The driver, a cigarette clinging perilously to his lower lip, vaulted over the door of the cab and accosted me. "Hey, Bud, where do you want this here tower put?" Encouraged by the friendly kibitzing of the five man erection crew that was standing by, he backed his truck to the prepared tower base, and gently lowered the tower into position.

Springing into action, the five man team heaved as one, and slowly the tower reached a vertical position. The retaining plates were put in place, and excited hands lifted the three-element twenty-meter array to the prepared mounting atop the tower. The coaxial and motor drive cables were plugged into place, and when all was ready, the green "UP" button on the tower control box was pressed, and tower and antenna rose majestically in the late afternoon air. It was a great moment.

General Design of the Tower

This telescoping tower is made of three sections of seamless steel line pipe, which conforms to *A.P.I. 5L Spec., Grade B.* This pipe is smooth, uniform and resistant to corrosion. It is about 30% stronger than ordinary iron pipe, and its concentricity is much truer. Each section of pipe is 21 feet long. The base section is 6" I.D., the center section is 5" I.D., and the top section is 4" I.D. An overlap of three feet is allowed at the two center joints, and the bottom section of the tower is embedded seven feet in the foundation. This makes the total overall height of the fully ex-

[*Continued on page 50*]

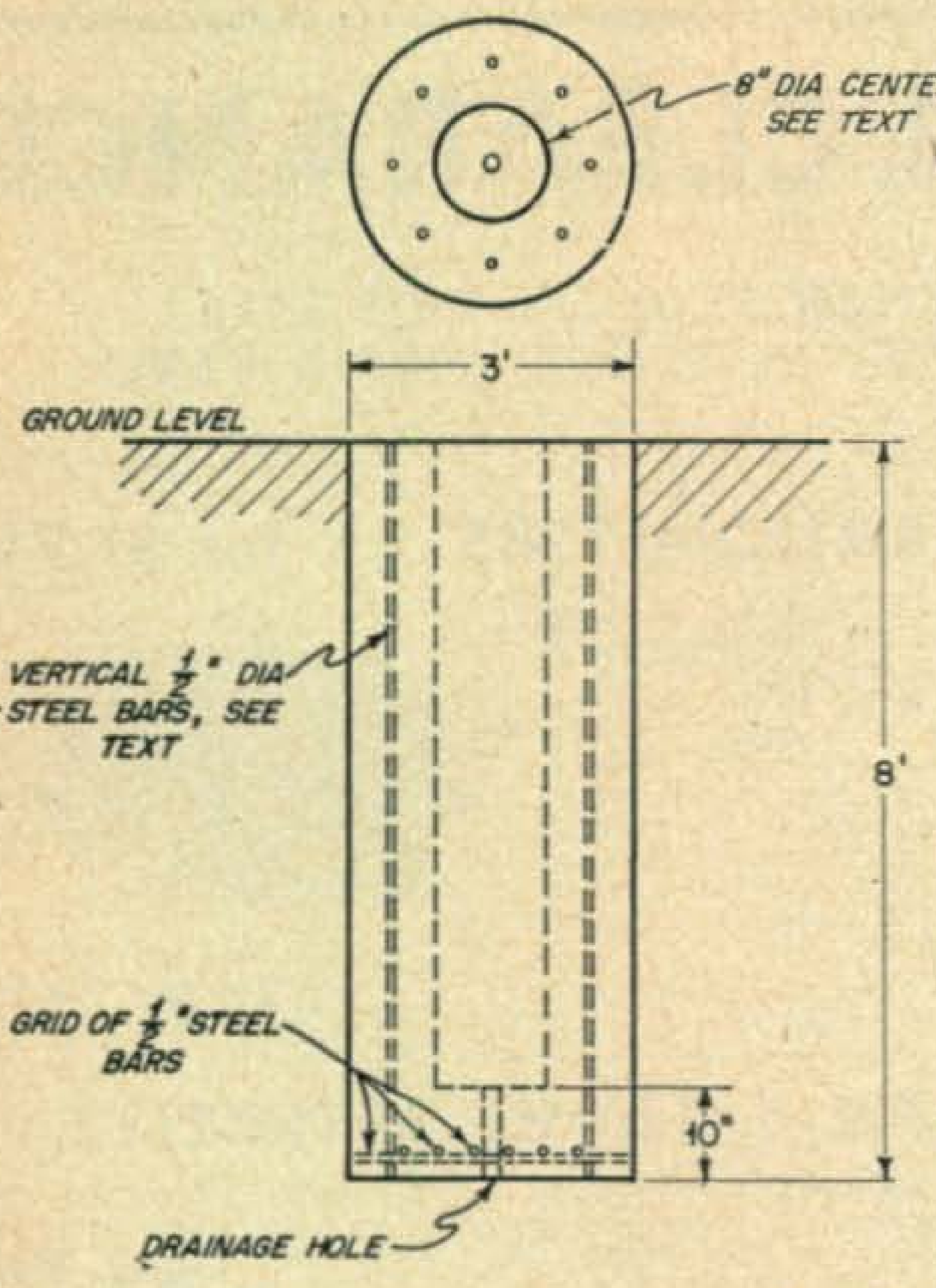


Fig. 2. Suggested base mounting hole.

tended tower 50 feet. When the lattice boom[3] is mounted on the top of the tower, the elements of the antenna are exactly 51½ feet above ground.

A clearance of ¼" exists between the telescoping tubes and in this space is strung the tension cable that raises the tower. The cable is 5/32" diameter, 7 x 19 aircraft control wire. It works at about 30% of its maximum safe load. The top end of the large tube, both ends of the center tube, and the bottom end of the top tube are all shimmed to provide a close slip fit between the tower sections. The circular shim, about ¼" thick, may be turned out on a lathe, and held in final position on the tower with *Allen* set screws.

In order to keep the three sections of the tower aligned for proper cable action, the two moveable sections of the tower are keyed by a ½" x ¼" key, extending the full length of the tubes. A corresponding keyway is cut in the top bushing of each moveable tube section, just large enough to pass this keyway.

The Drive Mechanism

An electric winch *(O)* winds up the main drive cable *(M)*. An upward lift is exerted on the drive pulley *(D)* mounted on the inner section of pipe *(B)*. The far end of the drive cable is clamped to fixed bushing *(H)*. The bushing *(I)* slides with the center pipe section. A separate cable section *(N)* and pulley-bushing assembly *(K, E, L, F, G)* elevates the top section *(C)* when the center section moves. Special jam-proof high strength pulleys are used in this "lift-yourself-by-your-bootstraps" operation.

3. Orr and Abrahams, "A Lattice Boom for 14 Mc. Antennas," CQ, April 1951, p. 21.

Driving Mechanism and Control Circuit

Attached to the tower, about four feet above ground level is a worm drive unit, with a 30:1 reduction. The use of a worm provides a one-way action, that allows force to be transmitted to the cable to raise and lower the tower, but prevents the weight of the tower on the cable from acting through the gear reduction unit to turn the drive shaft. It is possible to erect and lower the tower by means of a crank on the worm drive, but it is a long task, particularly for the usual "out of condition" Ham. It is much better to couple a 1/3 h.p. electric motor to the worm gear, and let it do the hard work. If the motor is used, and limit switches are mounted at the top and bottom limits of tower movement, the tower may be remotely controlled from the operating position.

The Mounting Base for the Tower

The completed tower weighs slightly less than 1,000 pounds. The center of gravity (when the tower is contracted) is only about three feet above ground level. This greatly simplifies the installation problem.

If it is possible to pick up the tower with a crane, a simple mounting base, such as shown in *Fig. 2* may be used. A hole three feet in diameter and eight feet deep is needed. In many localities, this is the standard diameter of a sanitary cesspool, and a sewer contractor can dig such a hole with his automatic machinery in a few minutes. A patchwork of ½" diameter steel foundation bars is laid at the bottom of the hole. Seven steel bars, eight feet long, are then arranged in a circle of about 2 feet in diameter. Two other bars are bent, forming a 2-foot circle, and are wired to the vertical bars, forming a crude cage, *Fig. 3*. This cage is lowered into the hole to provide internal reinforcement for the concrete to be poured later.

[*Continued on page 52*]

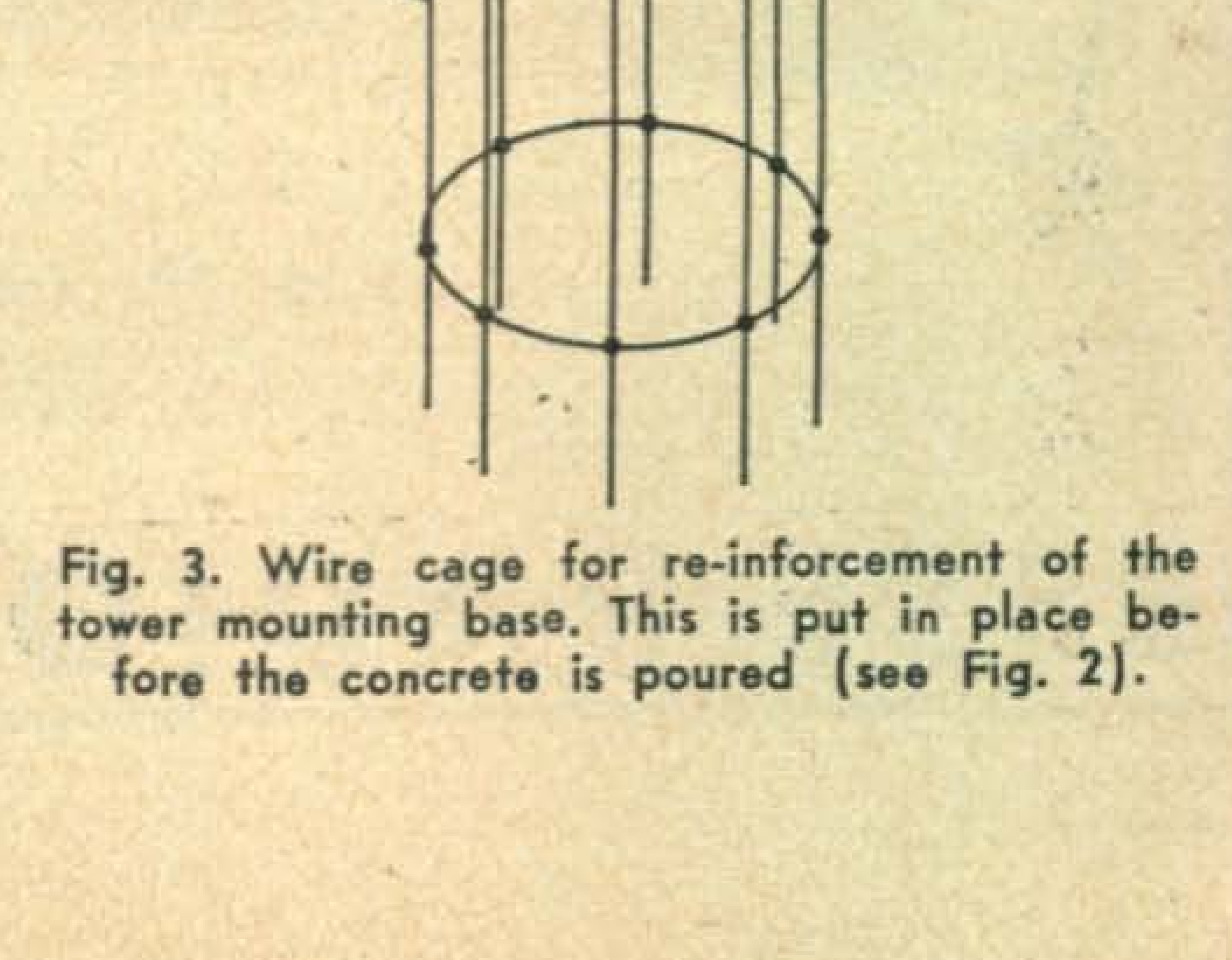


Fig. 3. Wire cage for re-inforcement of the tower mounting base. This is put in place before the concrete is poured (see Fig. 2).

TELESCOPING TOWERS

[*from page 49*]

It is next necessary to make an inner core, or form, about 8 inches inside diameter which can be dropped inside the cage, to provide the central hole for the tower. The best bet is an 8-foot length of eight inch thin-wall steel tubing. This is lowered into the hole, and aligned in a true vertical position by means of a few sticks of wood, and some wire stays.

When all is ready, the cement should be slowly poured into the area surrounding the central pipe. When the cement nears the top, the retaining bolts with their wooden template (to be described later) should be put in place, and the cement poured around the retaining bolts. The retaining plate should rest just above the top of the 8-inch pipe, clearing its top lip by perhaps ½ inch or so. The cement should be allowed to harden for six or eight days before the antenna is placed in the mounting base.

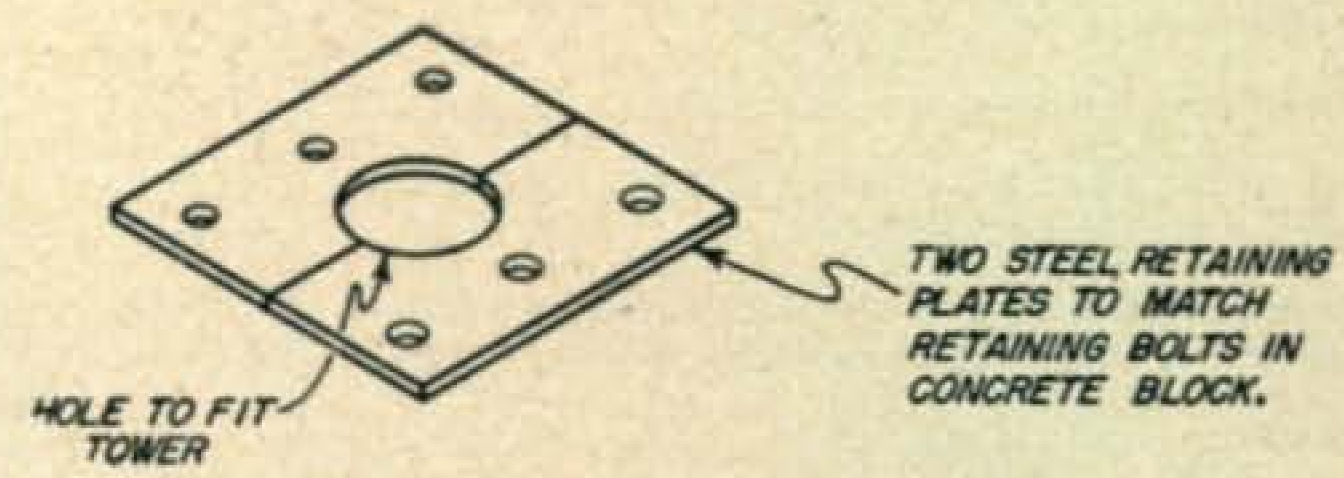


Fig. 4. Tower retaining plates.

Retaining Devices

When the tower is in a vertical position in the base, the area around the tower may be filled with sand, which should be wetted down and packed into place. The retaining plate should be bolted into place, and the tower is ready for operation.

The tower retaining plates are cut of ¼" sheet steel stock. When placed together, they have a hole cut through the center with a torch that will just pass the outside diameter of the tower. Each section of retaining plate has three 1" diameter holes cut in it to anchor the plate to the retaining bolts sunk in the concrete form. After the retaining plate has been made, a wooden template of the sections should be made of ⅜" plywood. The retaining bolts are bolted to this template before they are sunk in the concrete, thus insuring a proper fit between the bolts and the retaining plates.

Tower Maintenance

The tower requires a very minimum of upkeep. Before it is erected, the complete tower should be given a good coat of red lead paint, then a final color coat that will blend into the surrounding objects. A gray-blue is very effective at de-emphasizing the tower to the neighborhood. The erecting cable, the two top tower sections and the pulleys and gear drive should then be given a liberal coating of grease.

Results

The beam has been deliberately left up in high winds with no signs of vibration or deflection of the tower. Exceedingly interesting results have been obtained on both short-skip and DX contacts when the beam has been elevated and depressed. For extreme DX work (The W6-Europe path) it has been found that the maximum height of 52 feet is best. As the beam is slowly dropped from this height, the Europeans become more hollow-sounding and drop off in signal strength. At 52 feet it is comparatively easy to work European phone signals through the east coast QRM. At a 30-foot elevation this is almost impossible. "Skip" to the east coast is also optimum at the full elevation of 52 feet. At this elevation, the main lobe of the beam is at an angle of about 18°. This is still a little high for optimum results to Europe, as the signals from that part of the world should arrive at angles between 5°-10°. However, an angle this low calls for a tower height of 70 feet or so—out of the question!

As the desired skip length decreases, the optimum height of the antenna also decreases. A height of about 40 feet is optimum for W8 and western W4 stations—a skip of about 1800 miles. A thirty foot height is deadly into the WØ and W5 areas. On short-skip within the W6 call-area, a height of 20 feet or so is optimum.

Local Effects and TVI

One of the most valuable features of the antenna is its uncanny ability to attenuate local signals. In the Los Angeles area on a busy Sunday, operation on 20 meter phone is almost impossible because of cross-talk between local high power phone stations. It is now possible to find a certain height at which particularly loud local signals may be greatly attenuated, possibly by a correct out-phasing of the direct and indirect ground waves. This ability alone makes the tower well worth its initial cost. Local signals that completely paralyze the receiver become merely a strong signal when the height of the tower is changed five feet or so.

Interesting results are also obtained with regard to TVI. The 1 kilowatt transmitter used with this antenna is 100% clean TVI-wise. The only problem is primary blanketing of nearby receivers. As the tower is run up in height, the blanketing effect slowly drops off, and is less severe at 52 feet than at 35 feet. At 35

[*Continued on page 54*]

[from page 53]

feet, even a high-pass filter on the TV set is not enough to completely free the screen of interference. At 52 feet a high-pass filter is not needed on a well-designed TV set. We have since found that maximum interference occurs when the antenna fires directly into the power lines.

There is no doubt that this power line affects the operation of the antenna. Loading of the transmitter and the SWR of the coaxial feed-line both fluctuate violently when the antenna fires into the power line. Checks with stations located in the line of fire of the beam when it is aimed at the power line report a very marked drop in signal strength when the beam lies in the plane of the power wires. The beam is located about 40 feet from the line.

Once a tower of this type is used, where variable height as well as rotation may be had at the push of a button it can easily be seen that elevation is as important as rotation of a beam antenna.

Editor's note: Because of the interest in this remarkable tower, W6FHR has made arrangements for the construction and assembly of this tower for interested parties. Information may be obtained by writing to Lewis H. Abraham, 11339 Gladwin St., Los Angeles 49, Calif.