Structural Stresses in Antenna Supports

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The mechanics of structural stresses in masts and towers take an awful lot of math and physics in order to get the exact answers. Here's a simplified discussion of the problem which should help us to erect bigger and better sky-hooks.

THOSE SKY-HOOKS of varied and sometimes devious design that we see supporting all types of antennas throughout the country can be beautiful of appearance, but hazardous in structure. There are several types of supporting structures, among which are wooden masts, pipe masts, wooden latticework towers, steel towers, and telephone poles. Each of these has its particular characteristics as to stresses and strains, all of which must be taken into consideration when designing and constructing.

To begin with—a structure of any kind to support antennas must be considerate of the neighbors. They are in themselves the first potential hazard to your antenna support if they wish to protest. Should they make a protest, the next enemy of your structure is the building code and the building inspector in your locale. If you get by the first two hazards, the next enemy is the elements, especially wind of high velocity.

We have placed these events in the above order because the average ham just builds his structure and erects it in his enthusiasm to get on the air. Fortunately, the majority have enough "structural engineering feel" and common safety sense to build their mast or tower strong enough and guyed well enough to withstand most of the shocks to which such structures are exposed. However, certain pertinent facts should and *must* be given lots of thought.

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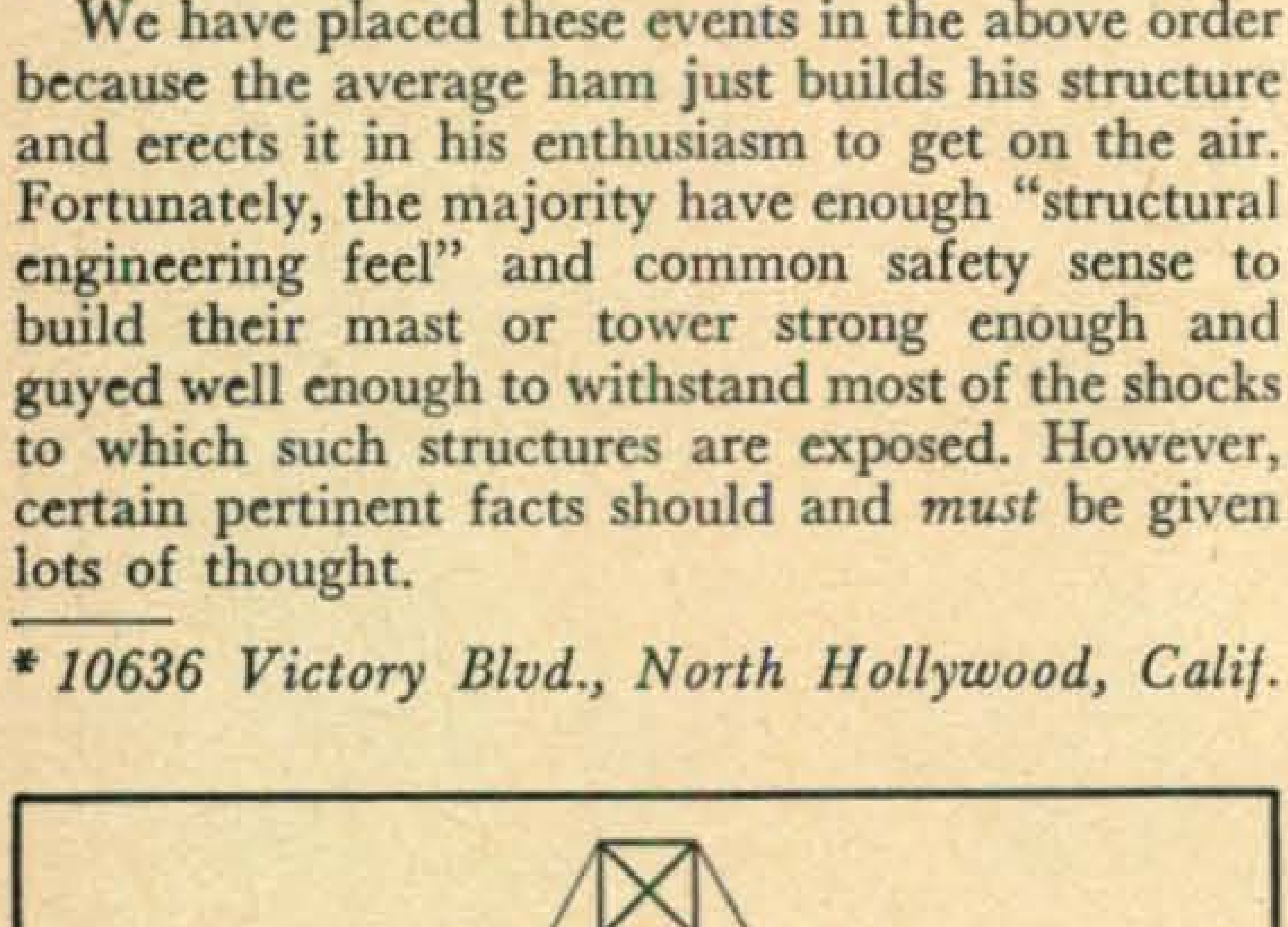

Fig. 1, showing wind loading, anchorage, and guying on a 50-foot tower. Explanation is in text.

The simplest way to approach the engineering problem involved is to consult a Structural Engineer. Your city Building Inspector will help you with your design problem, too—if you can find one who is sleepy enough not to realize what he is doing and has nothing else to do at the moment. Both the Engineer and the Inspector have facts and formulas as well as figures at their command which are at your disposal in the design of your particular type of structure. These formulae and pertinent information are all contained in the Code Book of Building Specifications. Stresses and strengths of various kinds of wood are also contained in this helpful book.

The Telephone Pole

The latticework tower of wood construction, believe it or not, is considered by the Engineer and Building Inspector to be the poorest kind

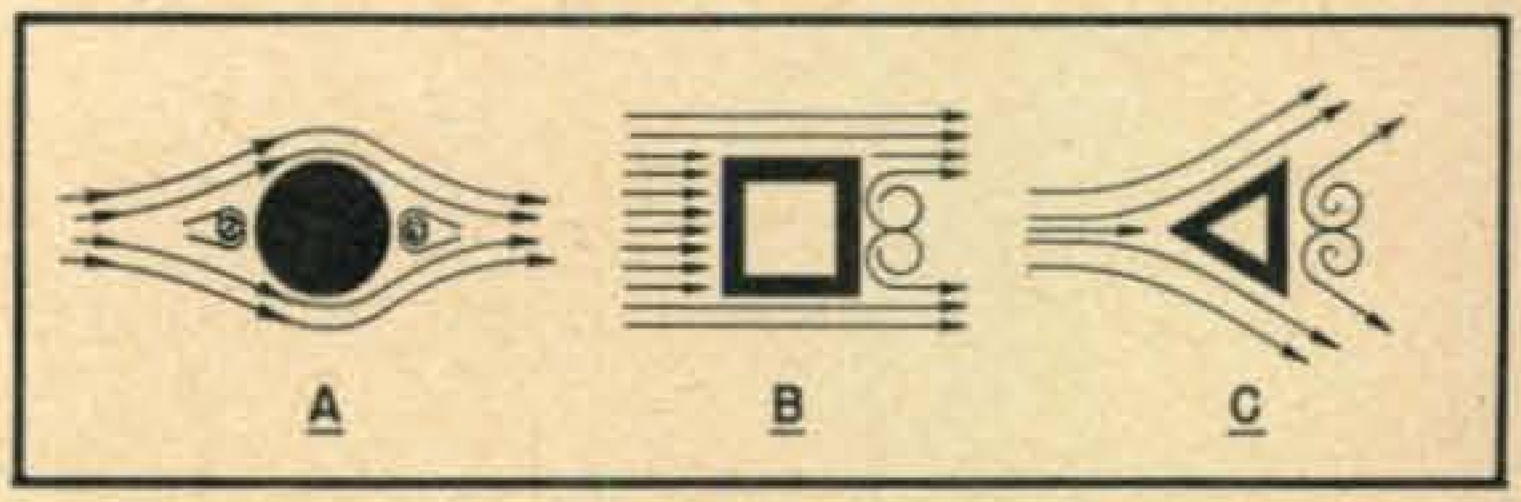

Fig. 2. Note how the wind follows around the telephone pole in "A," creating burbles front and back which cancel each other. In the square tower at "B," the structure receives the full blast of the wind, plus the burble at the rear which causes additional stress due to the vacuum formed. The triangular tower at "C," though it has a burble at the rear, cuts the wind better on the front face, with consequently less thrust.

of structure, while a telephone pole is considered best. This is among the wood structures, mind you. To qualify the statement—it is almost physically impossible to figure a safe top load for the lattice tower. The same goes for shear stresses from earthquakes. There is no practical formula for wind resistance or top loading. This is because of the criss-cross characteristic of the construction. The Building Inspector, then, will figure wind resistance on a "flat plate" basis. This is actually an advantage, since it does not allow for the spaces between, which, of course, cut down resistance considerably.

A tapered tower has a distinct advantage over one of straight construction. The taper has the effect of getting greater stability; it presents less surface to the wind at the top and lowers the center of thrust, thus lowering the point of guying.

The triangular lattice tower is even better than the four-sided model from a construction and wind loading standpoint. In addition, if you taper it, you have tops in lattice tower construction with wood as a material. Steel, of course, takes precedent over all as the ultimate in structural material for durability and lasting qualities. It probably becomes cheaper in the long run, too, because of this.

Now what about guying? First we must know what the wind pressure is going to be on our tower. The Building Code for a 50-m.p.h. wind says 20 pounds per square foot, flat plate loading. That's the maximum figure for a margin of safety. In most cases the actual code says 15 lbs. per sq. ft. from 1 to 30 feet of height and 20 lbs. per sq. ft. from 30 to 60 feet of height.

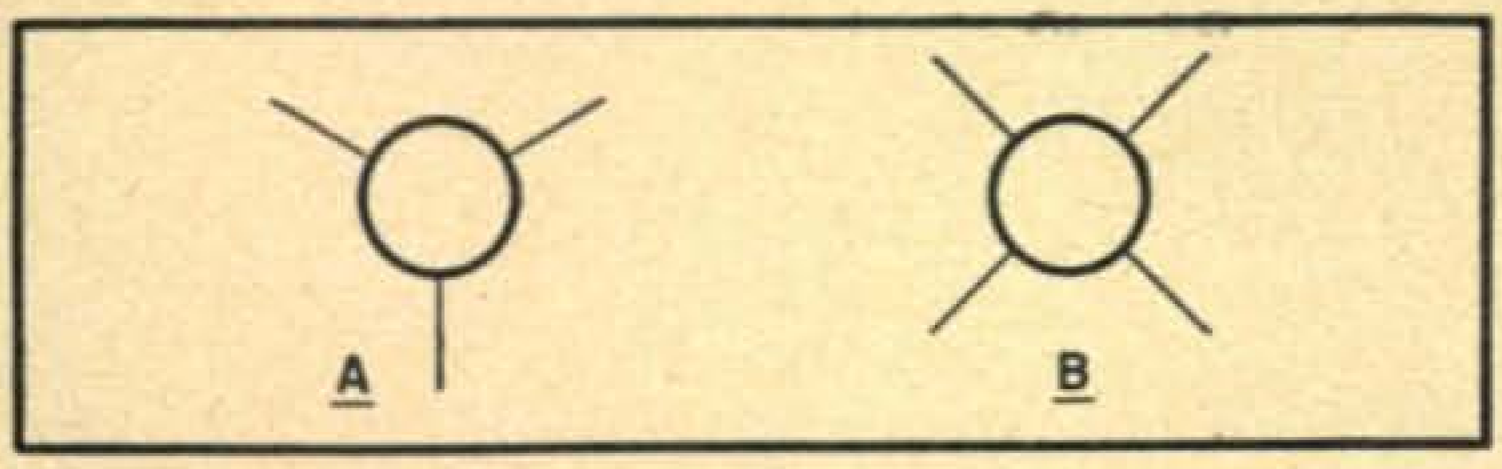

Fig. 3. Through three guys, as at "A," are usually sufficient, the use of four, as at "B," gives better strain distribution.

If you want to figure the actual wind loading on your particular tower, the following formula can be used.

$F = 1.28(.0028) \times A \times V$

where

F = force in pounds per square foot.

A = area in square feet.

V = velocity in feet per second.

Note: 1 mile per hour equals 1.48 feet per second.

The figures you arrive at will be interesting—and appalling. But it will be a revelation, for it will give necessary, practical information on guying. It is interesting to note that a 15-foot lattice tower of proper design and anchorage does not require guying. A 50-foot tower requires guys at both top and center.

Let's take a look at *Fig. 1* for a moment. In a hypothetical case, if you have an arbitrary wind load on the center guy wires of 1,000 lbs., the engineer adds at least half that figure again as a safety factor to compensate for tower weight off balance, and upon the angle "*B*" of the guy with respect to earth, and the placement of the guy above center on the tower. In this case the engineer used the figure 1,730 pounds. *That is the pull on the guy "A" in the diagram.* In order to cancel the weight pull, there must be as much or more weight in the concrete "dead man" to which the guy is fastened. In this case it would be almost a ton at each of the guy anchors. The same weight anchor should be at each of the corner feet of the tower! Think what the pull must be on the top wires. Is it any wonder, then, that antennas and towers can come crashing down in 35 to 40 m.p.h. gusts?

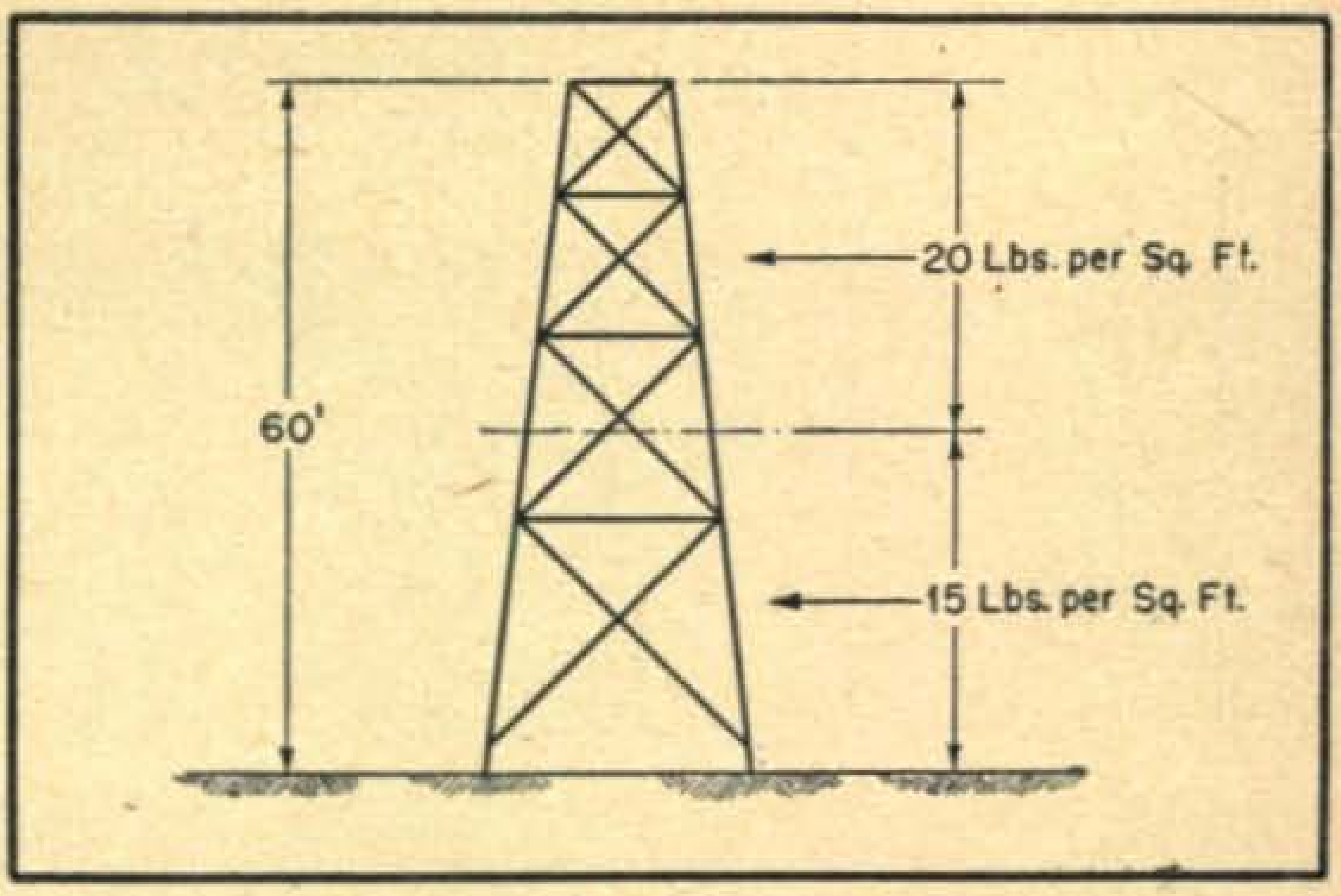

Fig. 4. How wind pressure is distributed on a "flat plate" basis in a fifty m.p.h. wind.

Wind loading is only one factor to be considered in structure. In addition, there are shear, compression, bend, top loading, and vertical or column loading. In figuring top or column loading, the weight of the beam in total, pipe connector and rotating motor, must all be taken into account. In figuring wind loading, the largest flat area of the boom surface should be used.

For a moment let's go to the other extreme and look over some of the characteristics of the telephone pole. An advantage a telephone pole has over a tower is that the pole requires no guys, provided at least 15% of the total length is in the ground. The engineer figures 18% for a safety margin.

Telephone poles for lights or communications are usually exempt from building permit. This is not to say that for an individual a permit may not be required or the Building Inspector consulted before you erect one. But telephone and light poles have been used by the thousands for many years, and their safety is well established. They will stand a heavy top load (almost a half ton with 700 lbs. legally allowed), far more than the average ham will ever use. They are also treated to withstand weather and underground livestock.

Psychological Considerations

With a telephone pole the ham is allowed two swell arguments for its erection. The neighbors are used to seeing and living with telephone poles. Their objections will not be as pronounced as with other types of structures. In case they do make a kick to the building inspector and he orders the pole down, it can be pointed out by comparison that other services are then violating the Building Code. There you have him, for he won't try to argue the point with the local light and telephone company. After all, their poles are on public property and therefore present a greater hazard than the one on your private estate!

There are two additional ways to circumvent the neighbors making a kick to the City Building

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V.H.F.—U.H.F.

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Connecticut. The 210-foot tower raises the effective height of the antenna to about 400 feet above sea level. The antenna itself is similar in general appearance to the familiar FM Pylon, and measures approximately 40 feet, top-to-bottom. (You've gotta make 'em big, even at u.h.f.) The antenna has a rated power gain of approximately 20 over a dipole, and is omni-directional. Horizontal polarization is used. A specially-developed r.f. transmission line is used to minimize feeder losses.

The picture-carrier transmitter is expected to put out close to a kilowatt on peaks, and the f.m. sound-transmitter runs at about half this power. Emissions are in accordance with present-day low-band TV standards. Both transmitters utilize a number of relatively small tubes (4X15ØAs), effectively operating in parallel, to achieve this output. The antenna gain boosts the effective radiated power to over 15 kw.

The purpose of this experimental installation is to explore the possibility of commercial utilization of the available u.h.f. channels. Special receivers will be installed in typical home locations in the area to be served by the new transmitter, and numerous mobile and fixed-point field strength surveys are planned to provide propagation data.

420-Mc Activity in South Jersey

At the insistence of the members of the local "420" net, Ye Ed recently spent a very pleasant evening at the home of W2JRO, Camden, listening to the activity on this band. These boys have made surprising progress in the past few months. Solid S9 signals over distance up to 10 miles were the rule, not the exception. The only reason that we didn't hear more "DX" was that there wasn't any activity beyond the members of the net! Smitty's rig uses a pair of 316s in a line-controlled modulated oscillator. Plenty of r.f. was in evidence—enough to flash a neon bulb easily and light a "twin-lamp" on the 300-ohm ribbon feeding the 16-element beam. The biggest signal on the net frequency was W2WUP's. Walt was pushing a pair of 703s into a 24-element beam. W2OQS has his 316s boxed up in a solid shield-can to reduce radiation losses in the shack. He had also painstakingly trimmed most of the insulation from between the wires of the 300-ohm ribbon feed line! W2ZNB was in there with a pair of 6J6s running about 12 watts input. The most popular receiver was the APS13, practically un-modified. However, all the signals were plenty copyable on a very haywire super-regen which used a self-quenched 955 as the detector! The fellows are having a lot of fun on this band, and are looking for new fields to conquer. They admit that they have a long way to go; they want good r.f. amplifiers for the receivers, low-loss feeder systems, more power, higher-gain antennas, etc., just as much as the next guy, but in the meantime they are active on the band, learning a lot about how these frequencies behave.

From where we were sitting, it seemed to us that 420 mc looks like the only ham band where the fellow with a one-tube modulated oscillator and a super-regenerative receiver can get on the air, find some activity, and compete on nearly an equal basis with the other fellows on that band. The equipment we saw was certainly not fancy—there were no plumbing nightmares or precision machine-shop jobs in sight. The compact phased antenna arrays can be soldered together in a matter of minutes. In short, what are the fellows waiting for? This looks like the early days of the old five-meter band all over again! No TVI was in evidence—there's a big incentive!

Among those stations active in the Camden-Philadelphia area are W2s-OQS, JRO, ORS, PWP, QPC, PEN, RJQ, UNH, WUP and ZNB; W3s-GNA, AYG, IJO, KEA. If I missed any, let me know!

Six Meters in Review

There have been a few reports of ionospheric DX during the past month, but on the whole, conditions might be classed as relatively quiet. Sporadic E provided most of the excitement, and the early days of December brought almost nightly reports of "short skip." These were, in general, pretty spotty openings, and no records were established for activity or signal strengths. The MUF climbed tantalizingly close to 50 mc on several occasions, but, perhaps due to lack of day-time activity, very few long-range QSOs resulted. The automatic beacon transmissions of VE1QZ were logged on a few occasions (as reported in last months column), but to date Oscar has had bad luck in timing his listening periods to take advantage of the transient conditions that made these reports possible. He missed a QSO with W7QLZ on December 14 by a matter of minutes!

In other parts of the world, things were a little livelier, the South American reports showing frequent extended range contacts. KH6PP continued to prove that things are different in the Islands by knocking off a flock of ZLs on the evening of the 10th.

Things looked a little better for the Ws on December 31 when an excellent F-layer opening developed between the Hawaiian Island and the U. S. west coast. KH6PP worked K6BF and VE7DU (a new country for Gene) with very strong signals both ways, which held up for over an hour. Very few stations were active, at this time, so the opening almost passed unobserved.

We have little information on the status of the band during January. On the 8th, HC2OT broke through for QSOs with some of the W5s. We'll try to dig up more information on this one before next month! A big ionosphere storm scheduled for the weekend of the S.S. contest failed to materialize, much to the relief of the two-meter contestants!

See the RASO News Letter for more six meter notes, and keep those reports coming in. . . . . . See you next month 73 Brownie

ANTENNA SUPPORTS

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Inspector; join the AEC and enlist the neighbors' aid in erecting the mast or tower structure. When they know what the AEC stands for, they will be more than willing to help through a sense of importance. If there is one disgruntled neighbor who does make a squawk, being a member of the AEC presents a wonderful argument to the Building Inspector for leaving the tower or pole standing in the interest of good citizenship and public welfare. But—you had better be sure that your tower meets all mechanical and structural safety requirements if you want to convince him.

Wind loading is not so great on a telephone pole. In fact, 2/3 of the total factor values of the previous formula can be used in computing wind loading on a round pole. A glance at *Fig. 2* will show why.

Now the question regarding final placement of your supporting tower. If you intend to mount your tower on your house or garage roof, be certain the roof is sufficiently "beefed up" to support the added weight. The garage is the most logical of the two because it's easier to work on the rafters from the inside. Guying presents less of a problem too. When placing your guys *do not guy simply to the four corners.* It's a good way to lose your roof with wind loading on the tower. Come down three or four feet on the corners of the garage.