# The Guywire Pyramid

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*Space has always been an amateur's headache especially when it comes to erecting antennas for 160 and 80 meters. Described here is a full-wave, tuneable 80 meter antenna which occupies an area only 42 feet square.*

THERE'S no doubt about it: The best antenna for 80 is a horizontal half-wave dipole at a height of a quarter wavelength. This means in practical terms, a 125 feet line some 60 feet up in the air. In spite of the vastness of this country but few of us can afford this ideal. It not only requires a piece of real estate just a bit larger than the average lot but also two fair sized masts or towers. Anything less than that is a compromise between practicability and efficiency.

### Compromise

All right, so we settle for a little less. We use a trap dipole that may just fit the length of our lot. We get by with two 24 foot poles, or we run a line from the top of our beam tower sloping down to the highest point we can find at the other end. Or we think up any odd shaped concoction resonating on 80, as long as it stays within the limits of the available space and height. And we get out all right, particularly when our rig is of the full gallon variety.

Do we realize, however, what this compromise is costing us? We are wasting a lot of precious r.f. energy in a very inefficient radiating system. In the first place is the antenna so close to ground that its terminal impedance is down to 30 ohms or less. But the handbooks tell us that the impedance of a half-wave dipole is 73 ohms, so how could we go wrong with our 75 ohm coax cable? Well, we just happened to overlook the fact that the 73 ohm figure is only correct for an antenna in free space or at certain heights above ground, the lowest of which is a quarter wavelength. This amounts to some 60 feet for the 80 meter band. The result is a substantial mismatch on our 75 ohm cable and thus increased line losses.

Then, the close proximity to ground means increased ground losses and less upward reflection. In addition overhead power and telephone lines, probably at about the height of our antenna and, to make matters even worse often parallel to it, sip up a goodly portion of the radiated r.f. juice. In doing so we aggravate our TVI, HiFiI and similar I sores by running the stuff right into our neighbors' homes.

Last but not least; our antenna is essentially a one frequency device. We may operate it over a couple of hundred kc without running into an objectionable s.w.r. but it is a fact that an antenna designed for say 3900 kc is quite a bit off resonance at 3550 kc. And the phone man who hops from around 3900 to 3290 in order to fulfill his MARS commitments is really in a spot. Again the result is a decrease in radiation efficiency.

The author had never given these problems much thought until he came to live in the States. During his 25 years of licensed hamming in PAØ land he built and used many 80 meter antennas that approached the ideal. The higher suburban homes over there, at least two floors plus an attic topped by a high pointed roof, didn't need much in the way of a mast on top of them to provide tie points at a desirable height. The near non-existence of overhead power and telephone lines created an ideal low-loss environment for antennas.

While serving my five year term as a resident alien, which may ultimately lead to U.S. Citizenship and a ham ticket, I am "grounded". That's not much fun for an oldtimer but it has one big advantage; plenty of time otherwise spent on just "being on the air" is now available for the study of specific ham problems and can be devoted to some creative thinking and experimentation in this field.

Immediate incentive for an attack on the 80 meter antenna problem were the complaints of a fellow ham living on a rather small lot, almost fenced in by overhead power and telephone lines. No matter what antennas he tried he just did not seem to get out satisfactorily on 80. And to complicate his problems, he prefers phone work and is also a MARS member so that he has to hop from the high end of the band to lower-than-the-low end.

An additional stimulant was the consideration that 80 is gaining in importance and will continue to gain during the coming years. While old Mr. Sun is gradually losing his freckles, conditions on the DX bands deteriorate and the maximum useable frequency is approaching our low frequency bands. This may bring us quite a bit of DX on 80 provided we have an antenna capable of doing the job. The Guywire Pyramid may well be it.

### Research And Development

In his search for a solution to the aforementioned problems the author was inspired by an existing antenna type that has a number of desirable features: the inverted V-shaped dipole. A good article on this antenna appeared in *QST*.[1] The inverted V requires only one pole and occupies less space than a horizontal dipole but the distance between anchor posts is still some 100 feet.

Although the Guywire Pyramid is closely related to the inverted V as will be shown later its development and operation can probably be best explained by starting out with an antenna we are all familiar with: the folded dipole. This antenna is illustrated in fig. 1A. The arrows indicate the direction of the r.f. currents during one half cycle and the dots are placed at the "hot ends" or high voltage points of the antenna.

By pulling the wires of the folded dipole apart we can form a rectangle with sides 1/3 and 1/6 wavelength long, as shown in fig. 1B. Next, by squeezing the centers of the long sides together and giving the system a half-turn twist at the intersection we form the skeleton bowtie of fig. 1C. Finally by bending this bowtie at the intersection, until the intersecting lines form angles of 90°, we arrive at fig. 1D, a pyramid with a square base, measuring $1/6 \times 1/6$ wavelength.

This pyramid shaped antenna has some interesting properties. Its terminal impedance, depending on the height above ground, ranges from 60 to 100 ohms. Radiation is mainly off the slanting wires. As can be concluded from the current distribution, the horizontal sections carry comparatively small currents that are equal in magnitude and opposite in direction so that the fields tend to cancel. Radiation from the horizontal sections is therefore negligible. At high angles with respect to ground, the antenna is substantially omni-radiant; at lower angles radiation is strongest in the direction A-B, weakest in the direction C-D, as indicated in fig. 1D. Because the radiating wires are angled their coupling with overhead power and telephone lines is much less than is the case with horizontal antennas.

The *Q* of the Pyramid is lower than that of a single wire inverted V. With other full wave loop systems, such as the Quad element, the Pyramid shares the characteristic of having no "end-effect". As a result the total wire length approaches the natural wavelength, provided the high voltage ends (in this case the horizontal sections) are sufficiently remote from ground and other objects. The area occupied by this full-wave antenna is extremely small and only one mast is required. Because of its shape the antenna may double as guywire system for its supporting pole. Thus it was christened the Guywire Pyramid.

By observing fig. 1D the relationship with the inverted V dipole will be obvious. In fact, the Pyramid can be defined as consisting of two shortened inverted V's, placed at right angles and connected in series. With the inverted V, the Pyramid shares the advantage of having its terminals at the top of the pole, offering a convenient support for the feedline.

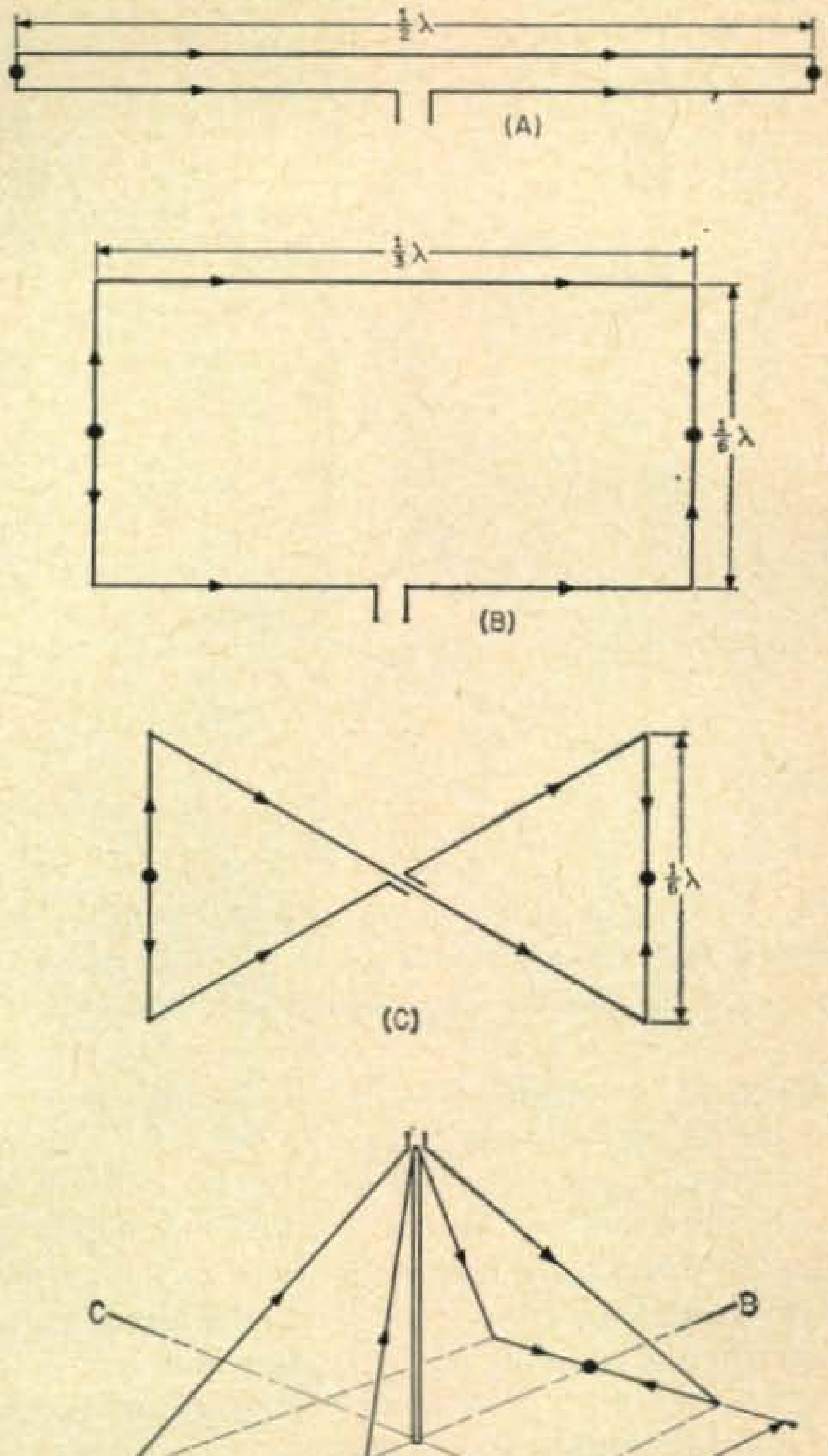


**Fig. 1—Evolution from the folded dipole (A) via the rectangular loop (B) and the skeleton bowtie (C) to the Pyramid (D). Arrows indicate current flow and the dots indicate the high voltage points. The similarity between this antenna and the inverted V may be seen from (D).**

A quick calculation shows that such an antenna for 4 mc would occupy an area of not more than $42 \times 42$ feet and that the height would be about 40 feet, assuming that the horizontal sections are 10 feet above ground. As accidental touching of the "hot ends" of a fired-up antenna cannot be considered to be conducive to longevity the horizontal sections of the Pyramid should be at least 10 feet high above ground.

### Tuning

Figure 2A shows, schematically, how the resonant frequency of such an antenna can be reduced. Single wire stubs connected to the "ends" do the trick. The fact that these ends, i.e. the centers of the horizontal sections of the Pyramid, are easily accessible enables us to build in a tuning feature.

[1]Glanzer, K., "The Inverted-V-Shaped Dipole", *QST*, Aug. 1960, page 18.

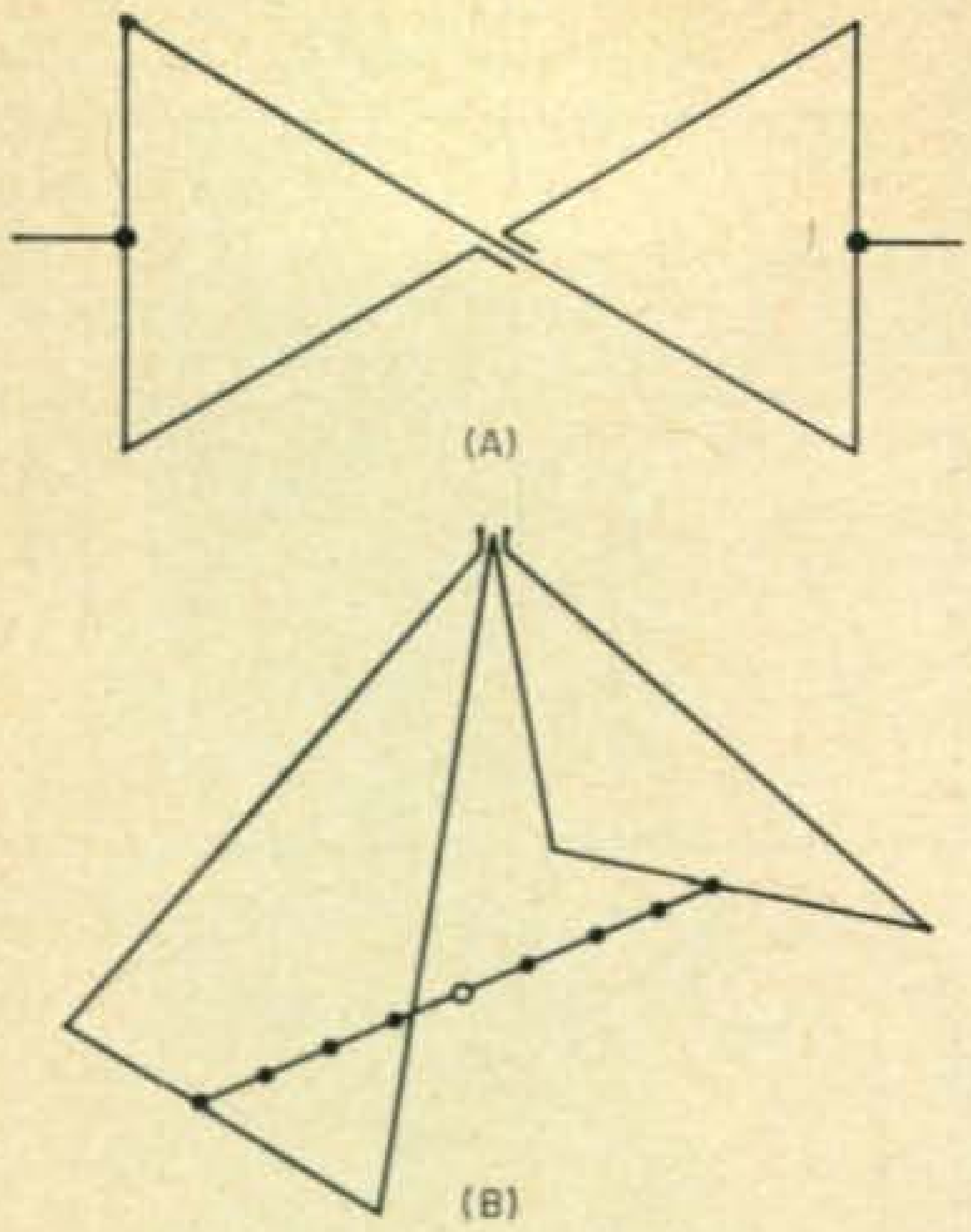


Fig. 2—Addition of the tuning stubs (A) on each end lowers the resonant frequency. A tuning stub line, shown in (B), permits adjustment to spot frequencies.

A practical solution, offering as many spot frequencies as we want is shown in fig. 2B. The line interconnecting the centers of the horizontal sections is broken by insulators at predetermined points. By simultaneously shorting out one or more sets of insulators from each end, the antenna can be lengthened step by step. In this manner a frequency range with a ratio of 1.2 to 1 can be covered. On 80 meters this would be from 4.0 to 3.3 mc.

The stubs not only reduce the resonant frequency but also the terminal impedance. Measurements have shown that over the full range, the impedance will vary from around 90 ohms at the highest frequency to around 50 ohms at the lowest. The fone man might therefore prefer a 75 ohm feedline whereas a 53 ohm line would suit the bug artist better. The all around operator had better flip a coin and live with some mismatch at one end of the band or the other. This slight mismatch is more than made up for by the fact that the antenna is resonant at our operating frequency.

### Construction Details

There is little sense in trying to give a clear cut recipe for the construction of an antenna of this type. Your site may call for some modification in the shape. If a pyramid with a 50 × 30 feet base would fit your lot better, by all means go ahead. And try to keep the horizontal sections at the short sides in this case. The shape and the environment will influence the resonant frequency as well as the impedance. So will the height. The only way to arrive at the correct dimensions is by measuring the frequency. This is not difficult. A grid dipper, the cut-and-try method and a little ingenuity is all there is to it.

The following should therefore merely be seen as an example plus some practical hints. There are some minimum requirements such as the height of the pole and the height of the horizontal sections. The higher the whole system is, the better the efficiency, with a minimum of 40 feet for the top, and for reasons mentioned earlier, a minimum of 10 feet for the horizontal sections. These sections should also be kept away as far as possible from high fences, overhead power lines and other conductors.

Assuming that a tower or pole of at least 40 foot height is already available at the center of a 42 × 42 feet area the bill of goods really does not amount to much:

Two lengths of 125 ft antenna wire (for a target frequency of 3900 kc).

Eight antenna insulators.

One coax receptacle mounted on a plexiglass plate.

One coax cable 83 ft long (75 or 53 ohms, make up your mind and take your pick).

Four ten foot poles with braces (this item might be deleted).

Some guywire (plastic clothline with nylon core is just fine).

The first step is to survey the area and determine which are the best sides for the horizontal sections, keeping in mind that the more they are in the clear the better. At the same time try to determine if there are any existing poles, fence posts or walls that may be utilized as tie points for the corners of the Pyramid. Otherwise we'll have to place the ten foot poles as shown in fig. 3A or, if more space is available, four anchor stakes as pictured in fig. 3B.

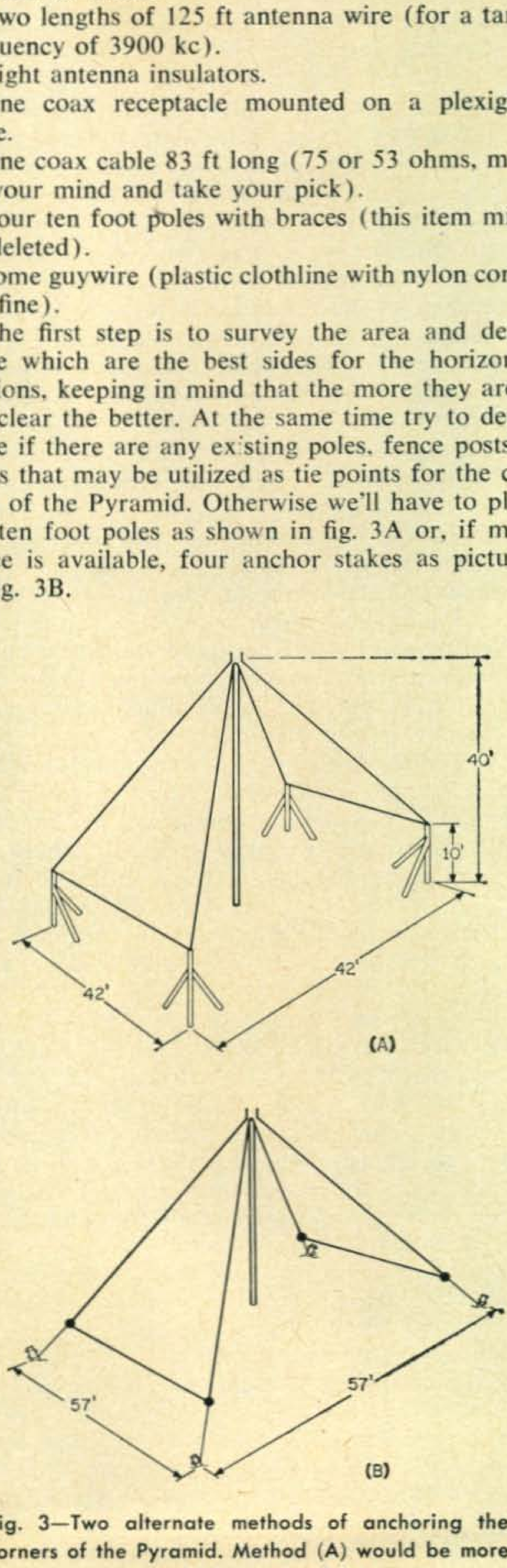


Fig. 3—Two alternate methods of anchoring the corners of the Pyramid. Method (A) would be more suitable for a small lot.

We next roll out the antenna wires in U-loops with the ends near the center pole and their bases in the directions where we planned the horizontal sections. Then we string two insulators on each leg of the loops, securing them in place with a couple of twists at 1 and 42 ft from the ends. Now we are ready to complete the top construction as shown in fig. 4. One set of wires is interconnected, the other set goes to the coax receptacle. Picking the right ends now will avoid a lot of headaches later on.

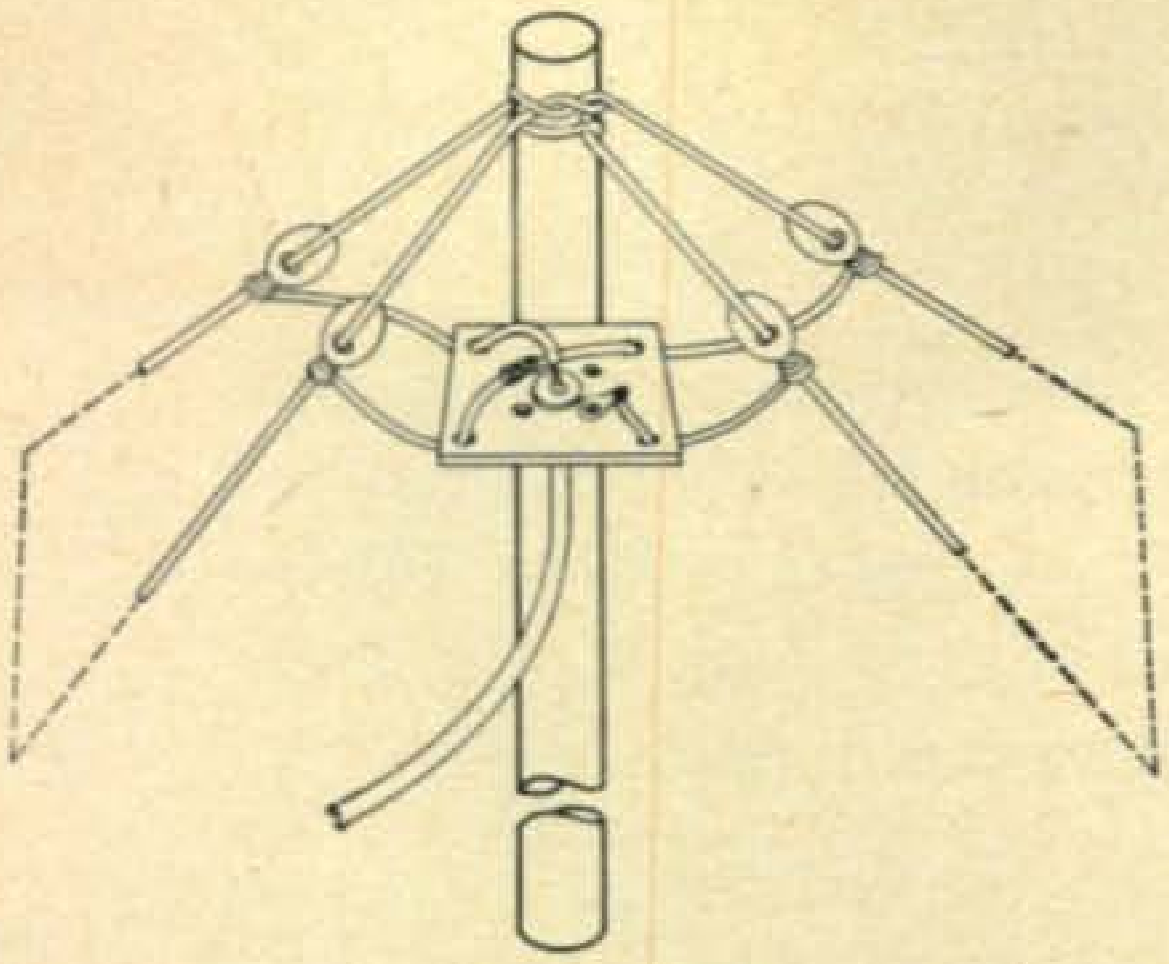

Fig. 4—Construction details of the Pyramid peak.

The way in which the top will be brought to the proper height and tied to the mast or tower depends on your facilities and is left to your ingenuity. To prevent the wires from becoming a tangled mess, the corner insulators should be tied to the corner posts with generous lengths of guyline before hoisting the top section in place. Make sure the antenna wires do not touch the mast or other antennas. Complete the construction by stretching the guylines and hooking on the coax cable.

Now check the resonant frequency with a grid dipper coupled to a coil of a few turns at the end of the coax cable. If the frequency is lower than 3900 kc we simply shorten the horizontal sections by cutting out a piece of each. A rule of thumb is 1½ feet per 50 kc. Too high a frequency can be corrected with single wire stubs connected to the centers of the horizontal sections, using the same rule of thumb. If we own an impedance bridge we may check the terminal impedance which should be in the range of 70 to 100 ohms. It can be measured at the end of the 83 foot coax cable which is a half-wave length at 3900 kc.

As the antenna is a symmetrical device the perfectionist might prefer a 1:1 ratio balun instead of the single coax cable described here.

As an extra we may throw in the spot frequency tuner, consisting of a line connecting the centers of the horizontal sections. For spot frequencies around 3900, 3700, 3500 and 3300 kc this line is broken by insulators at zero, 6, 13 and 21 feet from each end. Short tail ends, as shown in fig. 5, with

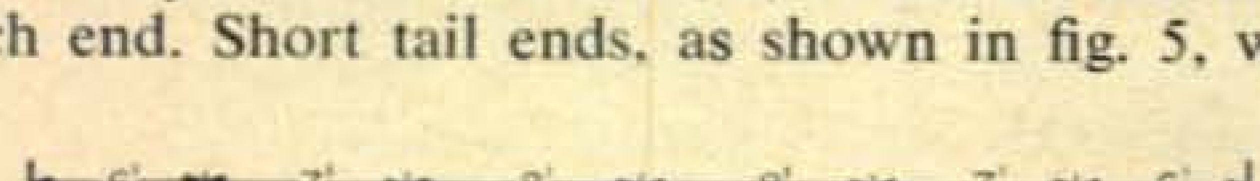


Fig. 5—A tuning stub line for 3900, 3700, 3500, and 3300 kc.

heavy duty alligator clips complete the job. If going outdoors on a wintry night to tune the antenna is considered incompatible with the American way of life, the real gadgeteer might come up with a remote control switching device for the stubs.

## Combination With Other Antennas

The problems encountered on 80 also pertain to 40, be it on a lesser degree. The Pyramid resonates on its second harmonic, but shows some undesirable characteristics. The horizontal sections will act as radiators and the terminal impedance will be very low. A workable solution is paralleling the Pyramid with an inverted V as shown schematically in fig. 6. To minimize interaction between

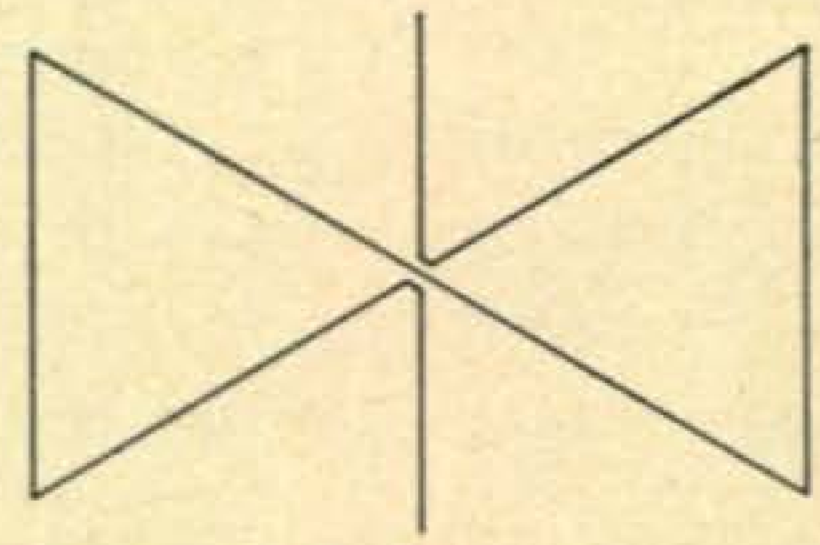

Fig. 6—A combined Pyramid and inverted V.

the two antennas the inverted V should run parallel to the horizontal sections of the Pyramid. Also, when operating the V, the Pyramid should be tuned to its highest frequency so that its second harmonic is well above 7 mc.

In constructing an inverted V for 40 the same procedure should be followed as described for the Pyramid, i.e. start out with 36 foot wires each side of the terminal, measure the resonant frequency and then readjust the length of the wires.

The terminal impedance of the inverted V is around 50 ohms, so that a 53 ohm coax line would be a good compromise for this antenna combination.

Combination with antennas for other bands is of course possible. During my experiments, successful results were obtained with a 4½ wavelength long inverted V for 20.

The added antenna might influence the resonant frequency of the Pyramid. It is advisable to run a check on that and readjust the wire length of the Pyramid if necessary.

## Results

The Pyramid has been in use at W8QEF for over six months. Invariably reports ranged from "edging over" to several S points better than a 30 foot high trap dipole at the same location. Only local stations in a direction through the "open" sides of the Pyramid reported slightly weaker signals.

During Field Day 1960 the Columbus Amateur Radio Association used a combination 75 meter Pyramid and 40 meter inverted V, resulting in a greater number of 75 phone contacts than on any previous Field Day. In this instance the Pyramid served as guywire system for a 40 ft steel mast that was topped by a 10 meter ground plane.

[*Continued on page 121*]

screen-grid terminal of the *rf* amplifier. If the capacitance is greater than .005 mf, replace it with one of this value. If the capacitance is found to be less, no changes are necessary.

The next stop is to obtain the B+ for the voltage divider. This voltage may be obtained from a separate supply, or from the low voltage supply contained within the transmitter.

The switching circuit that was mentioned earlier as shown in fig. 2. This circuit will appeal to those who use their television or radio as the modulator. In one position it's a modulator for the transmitter, in the second position the unit functions normally.

### Adjustment and Operation

Place a dummy load across the transmitter output, turn on the power and tune up the rig. If the plate current is greater than one-half its original value before the modification, the slider on $R_1$ must be adjusted for reduced screen voltage. If the plate current is less than one-half the original plate current value the slider must be advanced until a reading of one-half the original plate current is obtained. Make all adjusments with the slider resistor with the power off! The bands may be crowded but we would certainly miss hearing your voice; *exercise caution.*

### Precautions

If you are using an *ac-dc* audio amplifier make certain that the chassis is at ground potential by observing the polarity of the linecord. The polarity of the unit may be checked by holding one lead of a small neon bulb by the fingers and touching the other lead to the suspected chassis. If the neon bulb glows, reverse the plug in the wall outlet. With all precautions accounted for, connect the audio amplifier and the transmitter together thus completing the "operation."

Button up the transmitter and attach the microphone to the audio amplifier. Switch on the transmitter and amplifier. Tune up using heavy plate loading, advance the gain on the audio amplifier until occasional kicks of plate current are seen on the meter. These kicks of plate current are voice peaks and indicate that the transmitter is modulated. ■

## GUY WIRE [*from page 29*]

While the Guywire Pyramid does not pretend to be the best radiator for 80 it certainly has proven to be one of the best compromises between practicability and efficiency. The built in spot frequency tuner renders it a versatility that could only be matched by the old fashioned center-fed Zepp. Its additional low angle radiation might contribute to good DX results.

### Acknowledgment

I wish to express my appreciation for the cooperation of Lee Campbell, K8GVO who furnished the incentive and of Skipper Knowles, W8QEF who made her station, yard and time available for the many experiments. Thanks also to Dan Umberger, W8ZCQ, CARA Field Day Chairman 1960 for taking a chance with the Guywire Pyramid during Field Day. ■