G. E. Smith W4AEO
1816 Brevard Pl.
Camden SC 29020

MONO - BAND LOG - PERIODIC ANTENNAS PART I

For the past three years I have been testing Log-Periodic fixed beam antennas at this QTH. They have given excellent results – however they do require considerable acreage. This article describes smaller single band Log-Periodics which require less space than multi-band types but still retain the good forward gain, directivity, and the swr remains relatively flat across the entire band for which they are designed. They are easy to construct, are quite inexpensive and require no tuning or complicated impedance adjustments.

The original L-Ps used here were for multi-band operation on 20, 15 and 10, having 12 to 17 elements. This single antenna operates about equally well on each of the three bands. The measured gain was from 8 to 13 dB depending on their size (boom length), number of elements and its apex angle.

Figure 1 illustrates a typical Log Periodic covering the frequency range 14 to 30 MHz for operation on 20, 15 and 10. Most of these used here for different directions are 12 to 30 meters in length (boom length). They are mounted 12 to 15 meters above ground. The material cost is quite reasonable because of the wire construction, generally running from $12 to $25 each.

I have since designed and tested other Log-Periodics for 40, 20 and 15; 15, 10 and 6; 20 and 15 only; and more recently mono-band L-Ps for 40, 20, 15 and 10 which will be described. To date I have assembled and tested many of these for various frequency ranges and for various directions. All have been of the horizontal doublet type Log Periodic (DLP) configuration with the exception of one vertical mono-pole Log-P for 80, using radials for the ground plane or counterpoise.

Since over-the-air testing of the original Log Periodics generated considerable interest, many inquiries were received during QSOs and also by mail and phone calls inquiring if single or mono-band L-Ps are practical to reduce overall length for those primarily interested in single band operation. The answer is yes, and a mono-band L-P will still retain a gain of 8 to 10 dB in the forward direction (compared with a ½λ horizontal doublet at the same height), and the swr is relatively flat across the band.

Number of Elements Required

At least 12 elements must be used for a Log Periodic having a 2 to 1 bandwidth or one octave frequency spread, i.e., for operation on any frequency between 40 through 20; 20 through 10, etc. An L-P for a single band or a limited frequency range requires only 5 to 6 elements. I have even had good results using only 4 elements to cover the complete 20m band, 14.0–14.35 MHz. However there is an advantage from using an odd number of elements from a mechanical

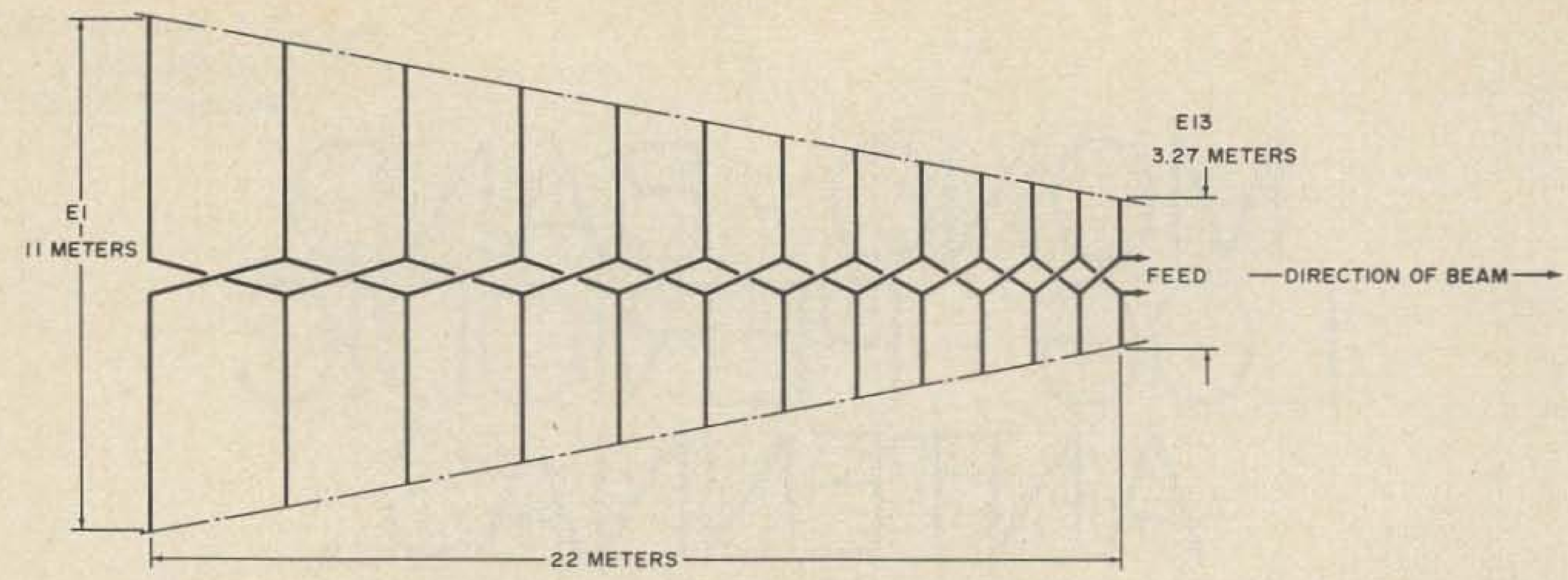

Fig. 1. Typical 2:1 bandwidth log periodic antenna, 14 to 30 MHz, for 10, 15 and 30 meters. $\alpha = 11^\circ$.

standpoint, as will be explained later. Therefore these L-Ps for mono-band operation all use five elements, as illustrated by Fig. 2.

Since high pine and cedar trees are used as "masts" to suspend the various antennas, the height above ground has generally been limited to 12 to 15 meters. Due to the arrangement of the trees, it was not practical to try a horizontal double type (DLP) on 80 as the height would have been limited to 12 meters, which is insufficient to realize full gain. For operation on 80 the vertical mono-pole L-P configuration mentioned above was tried. Since only ¼λ vertical radiators are used for this antenna, less height was required. Further, the vertical type gives a lower angle of radiation, better suited for longer haul circuits. This antenna is not described here; however the data on bandwidth, etc., obtained from the 80m test was sufficient to provide information to give the various dimensions for the horizontal DLP configuration for 80, should anyone have the space and support height (at least 19 meters) to use one to advantage. The listed swr readings for 80 were from the mono-pole type, but should be about the same for the doublet L-P.

All of the other mono-band Log Periodics for the higher bands were tested at a height of 12 to 15 meters above ground and a recommended minimum height is given for each band in the Table.

Theory of Operation

The theory and design of Log-Periodic antennas is rather complex. As this information and the design formulas have been presented in several amateur publications, it will not be repeated here. The best article on design formulas was "The Design of Log Periodic Antennas" by A. E. Blick VE3AHV, in the May 1965 issue of *73 Magazine*. Although this primarily covered VHF L-Ps for the 50–54 MHz band, the formulas hold for HF as well. The dimensions of the Log-Periodic antenna are such that the electrical properties repeat with the logarithm of the frequencies.

In effect, these antennas are a broad band unidirectional end-fire array. For those more acquainted with the yagi, you might consider the five element mono-band L-P illustrated by Fig. 2 as having a ½λ driven element (#2), a longer driven reflector (rear element #1) and three shorter driven directors, elements #3, 4 and 5. These are fed by a two-wire open center feed line which is in turn fed at the forward or short element end as shown.

It will be noted that transposition takes place between adjacent elements. Further for a single band it is possible to space the elements so that the main element, #2, is approximately ¼λ from the shortest forward element, #5. This simplifies the method of feed or impedance match at the feed point as will be explained later.

From the formulas given by K4GYO in his article on L-Ps in the October 1967 issue of *73 Magazine*, it is noted that the design of Log-Periodics is not simple. As all dimensions for element lengths and element spacings are given by this article, no math is required if these dimensions are followed.

Feed Method

The easiest method of feeding the monoband Log-P is by means of a 4:1 balun with the high impedance balanced input connected directly to the center open wire feeder at the short element or input end, then to coax to the shack. The latter can be any required length.

It was found that the impedance at the center of the ½λ element #2 is in the order of 30 to 33Ω as measured with an Omega Antenna Noise Bridge. The ¼λ open center feeder between element #2 and the short element feed point acts as an impedance transformer with the feed point being in the order of 200 to 300Ω which is easily matched by the balanced input of the 4:1 balun, and in turn to the coax. On 40 the swr across the band measures as follows:

7.0 MHz	–	1.05:1
7.1 MHz	–	1.05:1
7.2 MHz	–	1.01:1
7.3 MHz	–	1.1 :1

The swr for the 10, 15 and 20 meter equivalent mono-band L-Ps are similar to those on 40.

Although an 80m mono-band DLP has not been tried, the equivalent mono-pole configuration mentioned above gave the following swr readings:

3.5 MHz	–	1.2:1
3.6 MHz	–	1.2:1
3.7 MHz	–	1.1:1
3.8 MHz	–	1.2:1
3.9 MHz	–	1.4:1
4.0 MHz	–	1.25:1

This will illustrate the broad-band nature of the Log-Periodic (even for a single band type) which is an excellent feature of this type antenna.

Another simple method of feeding a mono-band L-P is by a tuned feeder from the shack end to the input of the L-P. This eliminates the expense of the 4:1 balun. However, a "match box" or other tuner is required between the set and the tuned line. For a multi-band L-P, the 4:1 balun is simpler as the tuner requires retuning when shifting bands, making it necessary to adjust two or three additional controls. This is not objectionable for single band operation, but is a nuisance if you shift bands frequently. If not already on hand, the tuning unit will probably cost as much if not more than a 4:1 balun.

Test Results

Most of the testing on the mono-band Log-Periodic here has been on 20 and 40. Both give a very consistent 10 dB gain in the forward direction. The one for 20, beamed at 150 degrees, was used for several months, keeping test schedules at noon several times a week with my friend YV5DLT in Caracas. Most of the original 20-15-10m L-Ps had also been thoroughly tested with this station. He has been of great assistance in giving very accurate evaluations of these antennas. During the years we have been testing these, I have kept the same non-gain antennas used as "standards," for comparison with the L-Ps. By this procedure we have been able to obtain very accurate comparisons.

Most of the testing on the 15m L-P was also conducted with YV5DLT and other South American stations with similar results to those on 20.

One of the 40m mono-beam L-Ps is beamed south, and almost daily tests have been made with my friends W4QS and K4FBU in Florida over the past year. I use a good 40m doublet as the "standard" which is at the same height as the 40m L-P. A coax switch allows instant switching between these antennas. The doublet is horizontal (not an inverted V) and is in the clear. It

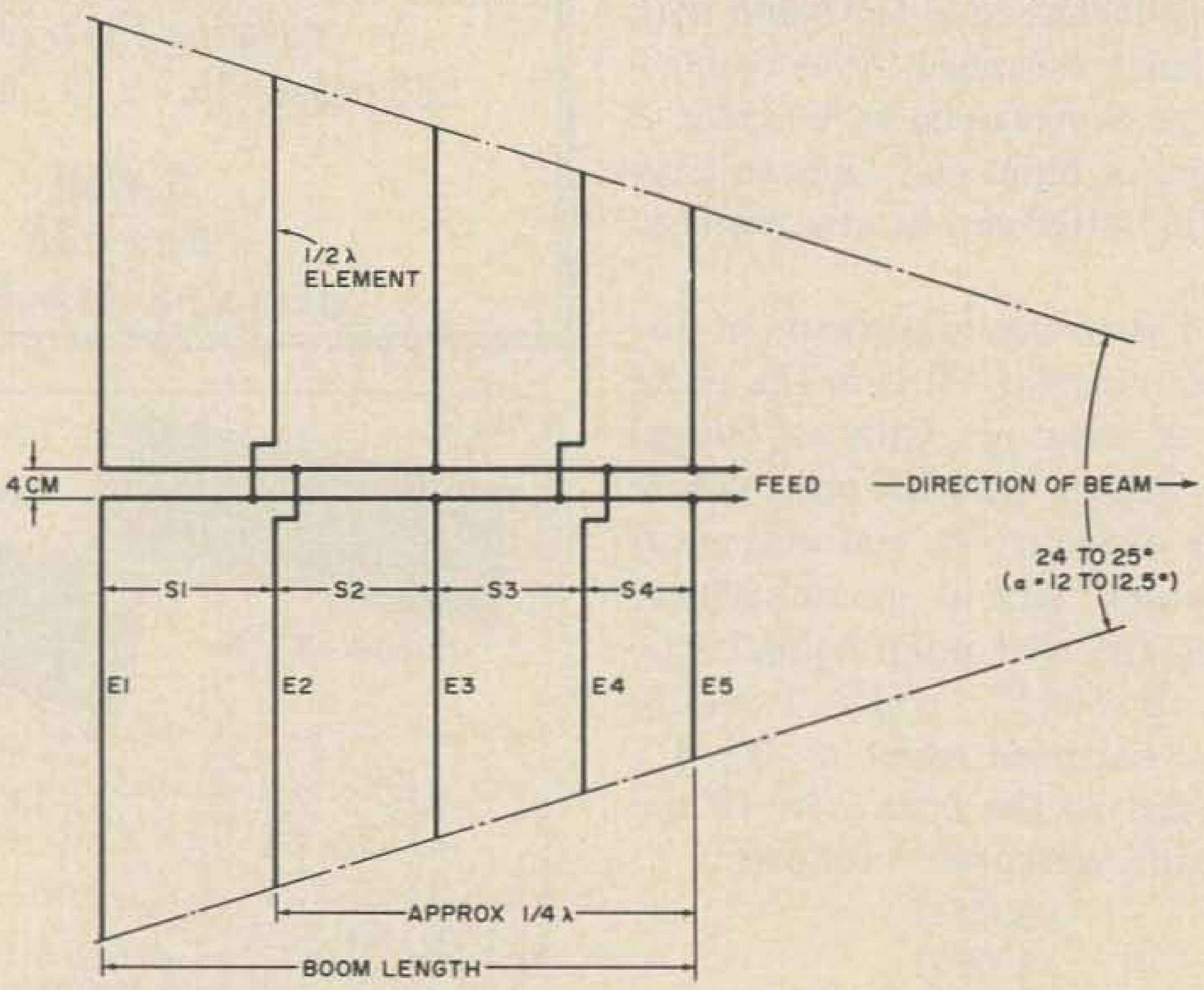

Fig. 2. W4AEO mono-band 5-element log periodic.

Table I

Band MHz	28.0–29.7	21.0–21.45	14.0–14.35	7.0–7.3	3.8–4.0	3.5–40	Notes
E-1	5.33	7.10	10.67	21.34	39.62	42.67	
E-2	5.10	6.86	10.06	20.12	37.79	40.84	
E-3	4.27	5.67	8.53	17.07	33.83	35.36	
E-4	3.73	4.97	7.47	14.93	27.43	30.48	
E-5	3.20	4.42	6.25	12.95	23.77	23.77	
S-1	1.07	1.43	2.13	4.27	7.92	9.14	
S-2	0.99	1.31	1.98	3.96	7.32	8.23	
S-3	0.92	1.22	1.83	3.66	7.01	7.32	
S-4	0.76	1.00	1.52	3.05	5.49	5.79	
Boom Length	3.73	4.97	7.47	14.94	27.74	30.48	
S2 +3 +4=	2.67	3.54	5.34	10.67	19.81	21.34	
Wire needed (Elements)	26.5	34	48	92	167	178	Note 1
Wire needed (Center feeder)	9	11.5	16.5	31	57	63	Note 1
Total wire	35.5	45.5	64.5	123	224	241	
Min. Ant. hgt.	10.6	12	12	12–15	20	21	Note 2
Opt. hgt.	21	21	21	43	40	43	Note 3

Note 1. These measurements include extra length for connections, etc.
Note 2. Telescoping TV masts suggested for higher bands.
Note 3. A height of 2 ½λ better for multi-hop paths.

All measurements are expressed in meters.

should be as efficient as most doublets. When my friends receive me S-8 to 9 on the doublet, they invariably report at least a 10 dB increase on the L-P; and often "20 over 9." These are consistent day-after-day reports. The "S" meter at this end also confirms this increase in received signal in the forward direction.

Three of the 10m L-Ps aimed in different directions have been used here for monitoring the AMSAT Oscar 6 satellite 10m downlink. These were compared with a 10m vertical ground plane about 10 meters above ground. It was found that when the satellite comes over the horizon in the beam width of one of the L-Ps, acquisition could be had about 5 minutes earlier on the L-P than on the vertical. As Oscar 6 approached an overhead or near overhead pass, the vertical is better. Then as it passed over, the L-P in the other direction could copy it a few minutes longer than on the vertical.

I wish to point out that the beam width of the L-Ps tested here are usually wider than a yagi, being about 100 degrees in width. This is good for a fixed beam which may be beamed for a certain part of the country or for those interested in DX from a certain continent.

On 20 my northeast Log-P seems to cover Europe quite well. The 150 degree beam covers Caracas and the east coast of South America. The south beam, South and Central America, and the west beam W6s, Australia and others to the west.

I can certainly recommend the Log Periodic for anyone having the space. From the dimensions in the table it can be seen that mono-band L-Ps for 10, 15 or 20 are entirely practical. Considering the gain possible for the moderate expense involved, it is felt that hams have been overlooking a good bet by not making more use of these very excellent antennas. 10 dB gain in a desired direction for $15 to $35 is not bad compared with the price of a linear having the same gain. This gain is also quite evident on the received signal. Further, it seems to have a diversity effect on receive when QSB is bad. As 3 to 5 dB is generally considered a fair antenna gain on 40 (2 extended ½λ in phase or a two element yagi) the 10 dB possible from a mono-band L-P is certainly worth considering.

Next month the step-by-step construction of a mono-band L-P will be presented along with mounting and testing details.

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G. E. Smith W4AEO
1816 Brevard Pl.
Camden SC 29020

MONO - BAND LOG - PERIODIC ANTENNAS PART II

Last month the theory and design of single band Log-Periodics was discussed and element lengths were presented for five-element L-Ps for the HF bands 80–10m. This month we will conclude the article with the method of construction, erection and tune-up of these antennas.

Construction

Figure 3 illustrates the homemade 1.5 x 7.5 cm Lucite center insulators. These support and space the two-wire center feed line which feeds the elements and separates or positions the five elements. These can also be used as end insulators for elements 2, 3 and 4. Egg-type insulators are used for elements 1 and 5 as will be mentioned later.

W4ITS has been experimenting with L-Ps lately and suggests that pieces of ½ in. (std) plastic water pipe serve well for insulators and are less expensive and easier to construct.

Figure 4 illustrates the completed monoband L-P supported between four masts, showing the method of using two nylon catenary side lines for supporting the elements. This sketch is shown looking down on the complete system.

My lastest Log-Periodics are constructed entirely of aluminum wire which is used to reduce weight and cost. This is No.15 aluminum electric fence wire which can be purchased at Sears and is much less expensive than any copper antenna wire. The use of aluminum wire is important for weight reduction of my L-Ps since they are all supported by high trees. If masts were used, No.14 or 7/22 copper antenna wire could be used; however it is quite a bit more expensive.

Assembly

First cut and drill the Lucite per Fig. 3. Three of the center insulators (4-holes) and six of the end insulators (2-end holes) will be required for elements 2,3 and 4.

Next cut two wires slightly longer than the overall length given in the table last month for the two-wire center parallel feed line. Thread the three center insulators on one end of the two wires (close spaced holes).

Select two trees, posts or other rigid supports separated by a meter or two greater than the final length of the feed line. These

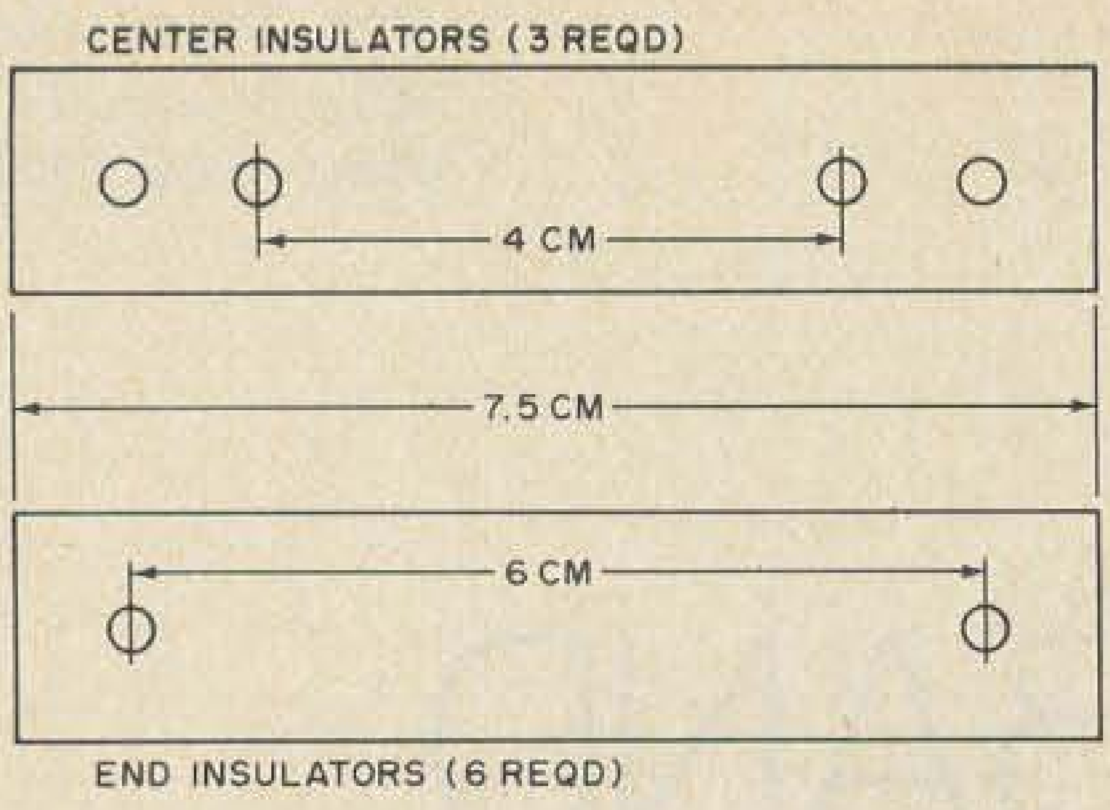


Fig. 3. The centered end insulators are made of Lucite approximately 6 mm thick. All holes are made with a No. 29 drill.

should be at least 1.5 meters above ground between which the two-wire center feeder can be strung and pulled tight.

With the two-wire feed line secured to and made tight between the two supports, mark a starting point (about 30 cm from one of the end supports). This can be indicated by a piece of plastic tape or masking tape secured to each of the two parallel wires (or a quick-drying paint smear can be used). This will be the starting point or the location of the No.1 rear (longest) element. Note: An egg-type insulator will be used as the center insulator for the rear element 1 and the forward element 5. Lucite is not suited for these two end elements as there is more strain on these than elements 2,3 and 4.

Starting at the marked point which will be the center connection for element 1, measure along the parallel feeders with a steel tape to obtain the first spacing distance (S1) between elements 1 and 2. Now slide a Lucite center insulator to this point. The other two insulators must be forward of the element 2 center insulator. Using a short length of No.18 or 16 tinned copper hook-up wire, secure the Lucite center insulator or spacer to the two parallel feeders as illustrated in Fig. 5. Make certain the Lucite spacer is square or at right angles to the feeder and that the tension is equal on both wires. After the first spacer is secure, proceed to the next.

Measure the second spacing distance (S2) which will be the distance between element 2 and 3. Slide the second Lucite spacer into position and secure, being sure the third spacer is forward of the second.

Now measure S3 and secure the third spacer, then measure S4 or the last spacing between E4 and E5 and mark with tape or paint. This will be the location for the egg center insulator for the short forward element 5 and also the feed point.

Measure a length of antenna wire for the longest rear element 1. Since this is in effect a doublet, the length on either side will be one-half the length given in the table. Allow sufficient length on both ends for securing to the center and the end insulators.

The two-wire center feeder line will be attached across the center (egg) insulator of element 1. The feeder can be spaced or fanned out to about 8 cm at the center which will give greater spacing. This gives better mechanical stability to the two parallel feeders and there will be less possibility of these two wires becoming twisted or shorted in a wind. The lower bands, 40 or 80m L-Ps, may require one or two extra Lucite spacers to reduce the possibility of shorting in a high wind. A spacer every 2 meters may be necessary. These will generally not be required after element 2 or 3. None should be required for 10, 15 or 20m L-Ps.

Next, measure the two wires for element 2. As this element will be transposed at the Lucite center insulator, leave at least 30 cm extra on the center ends, beyond where they are secured to the end holes. This extra length or "dress" will allow for the transposition below the Lucite insulator.

Measure and cut element 3. This element is non-transposed at the center.

Measure and cut element 4. This will be transposed as per element 2.

Measure and cut the shortest forward element 5. This is non-transposed and also uses an egg center insulator as used for element 1.

The two-wire parallel center feeder can now be removed from the two end supports and for the moment can be laid on the ground. We now have the center feeder spaced by the three Lucite insulators for elements 2,3 and 4, and it is ready to be connected across the two egg insulators at elements 1 and 5. The two-wire feeder should be 30 or 40 cm longer at each end (beyond the rear and forward marked

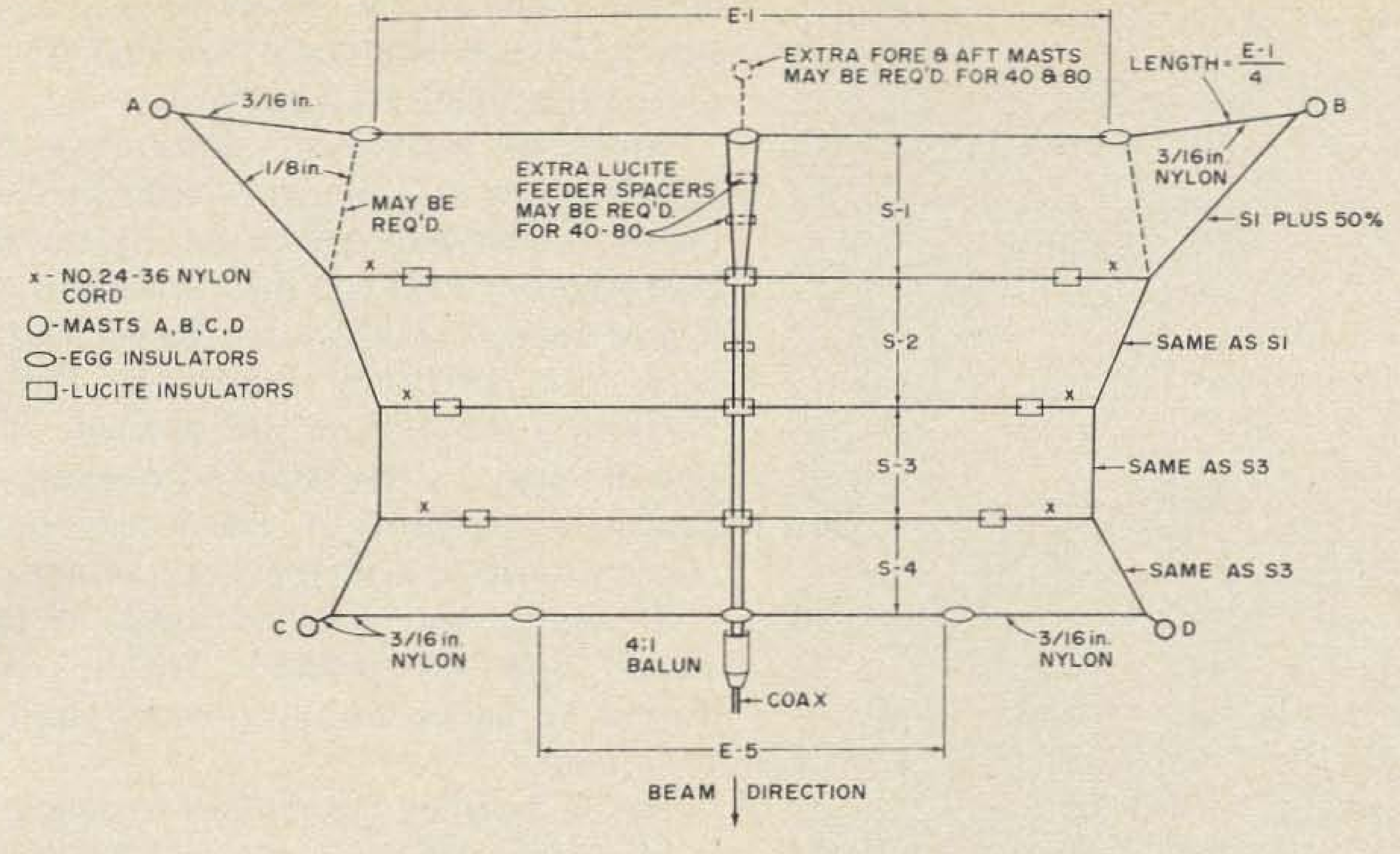


Fig. 4. Basic layout of the L-P antenna once the insulators and supporting ends have been attached.

points). These extra lengths leave sufficient length for wrapping to the center of elements 1 and 5. After wrapping, the extra length is cut off. We now have the center feeder connected to the five elements.

Regarding transposition of every other element, note that the odd elements 1, 3 and 5 are *non-transposed* while even elements 2 and 4 are *transposed.*

We are now ready to assemble the entire antenna. It is assumed that the four masts, trees or other supports to which this beam is to be suspended and aimed in the desired direction have been selected or erected.

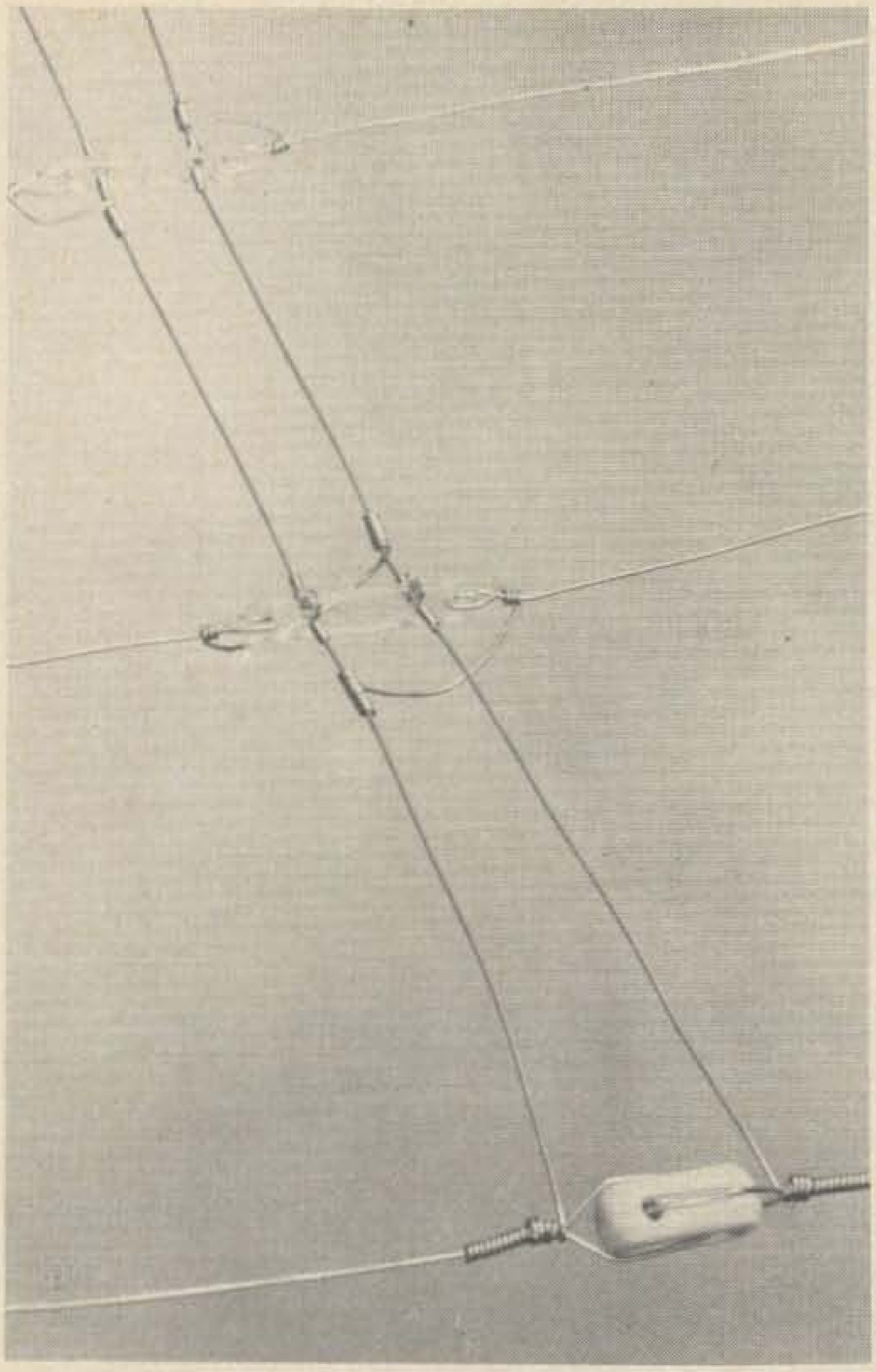
The entire antenna will first be temporarily assembled between the four masts at a height of approximately 2 meters. This height is suggested as the system can be stretched at the low height between the four masts to clear the ground and can still be reached for making the connections between the elements and the center feed line. If the beam is to be for 80m it may be necessary to assemble it approximately 3 meters off the ground, using a stepladder.

With the five elements and the two-wire center feeder laying on the ground in the desired aiming direction, string the two catenary side lines (A-C and B-D) fore and aft between the supports.

Next add the end insulators to the five elements and to these tie on the nylon support cords. Egg-end insulators are used for the rear and forward elements 1 and 5; Lucite end insulators for elements 2, 3 and 4.

Stretch element 1 between supports A and B and element 5 between C and D. Now, by having the two side catenary lines stretched between the masts (line 1 between A and C; line 2 between B and D) at a working height, it is fairly easy to adjust the tension between the elements and the side lines so they (catenary side lines) will take on the proper shape illustrated in Fig. 4. While making these adjustments, it is suggested that the nylon cords between elements 2, 3 and 4 end insulators and the catenary lines be tied to the catenaries with an easily untied knot, as it may be necessary to adjust these several times for proper weight and tension distribution so the side lines will take on proper shape. This is the only "cut and try" procedure required for assembling this type L-P.

Care should be taken at this point to keep the elements parallel with each other, i.e., the end separation between the elements should be equal to their center spacing distances, S-1, S-2, etc. There will be some



This is a mock-up showing three elements to illustrate proper connections to the forward or aft egg center insulators (non-transposed). The following element using the Lucite center insulator is transposed and the third insulator is non-transposed. These mock-up elements were only spaced 25 cm so the three types of center connections to the feed line could be illustrated in a single photo.

sag to elements 2, 3 and 4 unless their supporting cords to the catenaries are very tight. Some sag in these elements seems to have little if any effect on the antenna's performance. It is probably better to have some sag than to put too much strain on the end cords and in turn the side lines. Allow some "give" to reduce possibility of damage during an ice storm.

There will also be some fore-and-aft sag to the center feeder due to the weight of the two-wires and the center insulators (especially if copper wire is used). The amount of feeder sag will also depend on how tight the rear and forward elements can be tightened between their supports, as they support the weight of the center feeder. If copper is used for the center feeder, it may be necessary to also have two additional fore-and-aft supports, especially for 40 or 80.

After all mechanical adjustments have been made at a convenient height, it should "hang" or be stretched in exactly the same configuration it should have when raised. If it now appears satisfactory, the element end cords can be firmly secured to the side catenaries. After these are secured with a non-slip knot, a few wraps of masking tape should be applied to either side of the element cords to keep them in position.

If copper wire has been used, all joints should now be soldered. The 4:1 balun should be added to the forward short-end feed point.

Before hoisting the antenna to position, it is suggested that an swr check be run. Connect a short length of coax to the balun and read the swr across the band every 100 kHz.

Even though the antenna is only 2–3 meters above ground, the swr readings taken at this height will not be too far off from one taken after the antenna is raised to maximum height. This procedure would probably not be accurate for a yagi or other narrow band, high Q beam, as there would be too much ground effect. An L-P, being a low Q broad band antenna, seems to be less affected. It is suggested that the swr readings be recorded for comparison with the final swr test which should be run after the antenna is raised to its final location.

Another interesting test while the antenna is at a workable height it to excite it with sufficient power to get an rf indication at the element ends, using a small neon bulb or a "sniffer" to check the voltage distribution on the elements and center feeder.

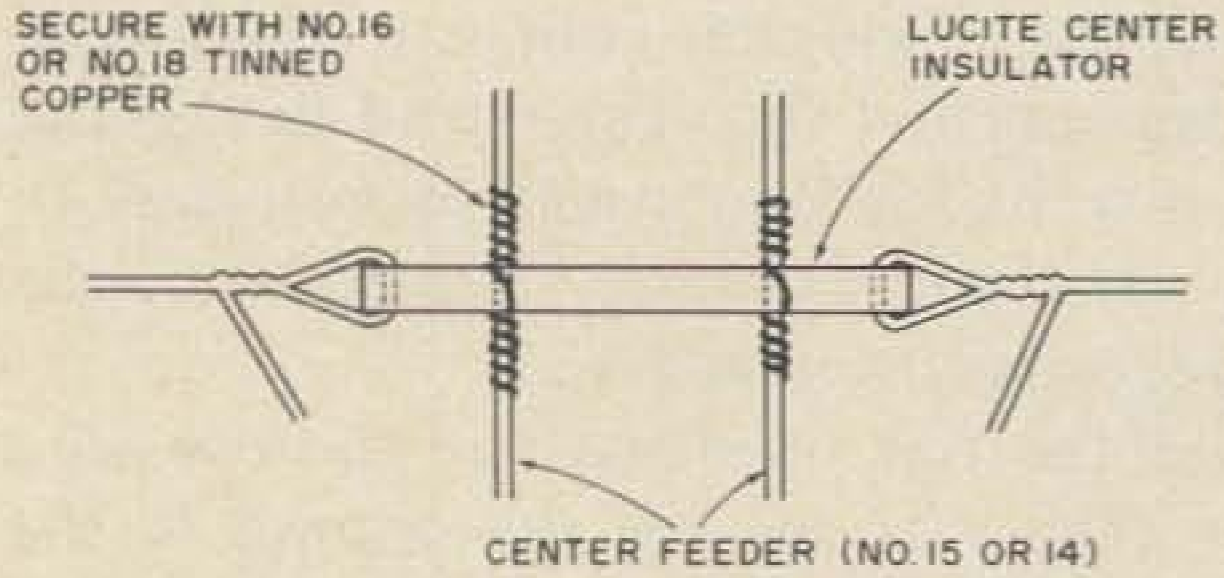


Fig. 5. Method of securing the center insulators to the center feeders.

Rf will be practically nil on the rear element 1 (reflector). The second element will be quite "hot", as it should be, and rf will generally diminish on the three forward elements. At the high end of the band, 3 may become the "active" element and 2 the reflector. This simple voltage distribution test is especially interesting on a long 12–17 element L-P for 20-15-10 when testing on each of the three bands.

If the low elevation swr is less than 1.5:1 and relatively flat across the band, the coax to be used can be connected and the beam raised into place for on-the-air tests.

Some have inquired as to how these L-Ps stand up under icing conditions and during high winds. Although all of my L-Ps, including those for 20-15 and 10 are suspended by high pines and cedars, I have had no problems to date. The first L-P installed in 1970 is still up. It and several others have been through three heavy ice storms. Although they sagged almost to the ground from ice buildup, none broke. The nylon line used for their support evidently has enough "give" under the load to prevent snapping. As soon as the ice melted, they returned to their normal height. The only antenna I have lost here during an ice storm was an 80m doublet – but so far, no L-Ps. They have also been through several high winds successfully.

There have also been inquiries as to whether the mono-band L-P can be designed for a higher gain than 10 dB. The gain of a Log-Periodic is determined by several variables as were outlined by Reference 5. Of these the ∝ angle (½ the apex angle), the "boom length" and the number of elements, are important factors. The smaller the apex angle, the longer the boom length and more elements (up to a point) gives greater gain.

Some of the large fixed commercial and military hf Log-Periodics give gains up to 14 dB. One manufacturer produces a modified type L-P only 60 meters in length which has an advertised gain of 17 dB.

Working with these variables is more complex and lengthy than can be presented here. Without a programmed computer, the designing of an L-P by the formulas can become quite involved. I have, however, worked out a graphic design method for L-Ps which requires absolutely no math except for simple division. By using this method, any 3 to 30 MHz, VHF or UHF L-P can be designed on paper in less than an hour, where several days were required before. My largest 17-element 20-15-10m L-P, which is 30 meters in length, giving 12 to 13 dB gain, was generated by the graphic method.

I am now assembling an experimental "Long-John" mono-band L-P for 20 which will have seven or nine elements and should give 15 dB gain. If this gain is realized, I plan to add a second identical L-P to give two side-by-side (co-linear) in phase beams to obtain an additional 3 dB or a total of 18 dB. I have tried this previously with a temporary dual L-P and was able to get the additional 3 dB gain by phasing. If this works out over a test period, I will be glad to pass on the information.

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