Here's an interesting project that will add hours of fun to your operating time.

A Log-Periodic Quad Array

BY JAMES W. FISHER*, W8KJN

While I was designing a fixed-direction log-periodic array for receiving Arabic-language broadcasts from the Middle East, it occurred to me that a quad configuration might be substituted for the opposed bays of a conventional log-periodic. Gain should be greater than that of a log-periodic dipole array (LPDA) of the same boom length, and only slightly less than that of a two-bay conventional log-periodic of the same boom length. The idea appeared to offer mechanical and operating advantages.

- Only two high supports are required
- The width of the largest loop is somewhat less than the length of the longest element in a LPDA
- The quad is widely regarded as a good performer under marginal band conditions

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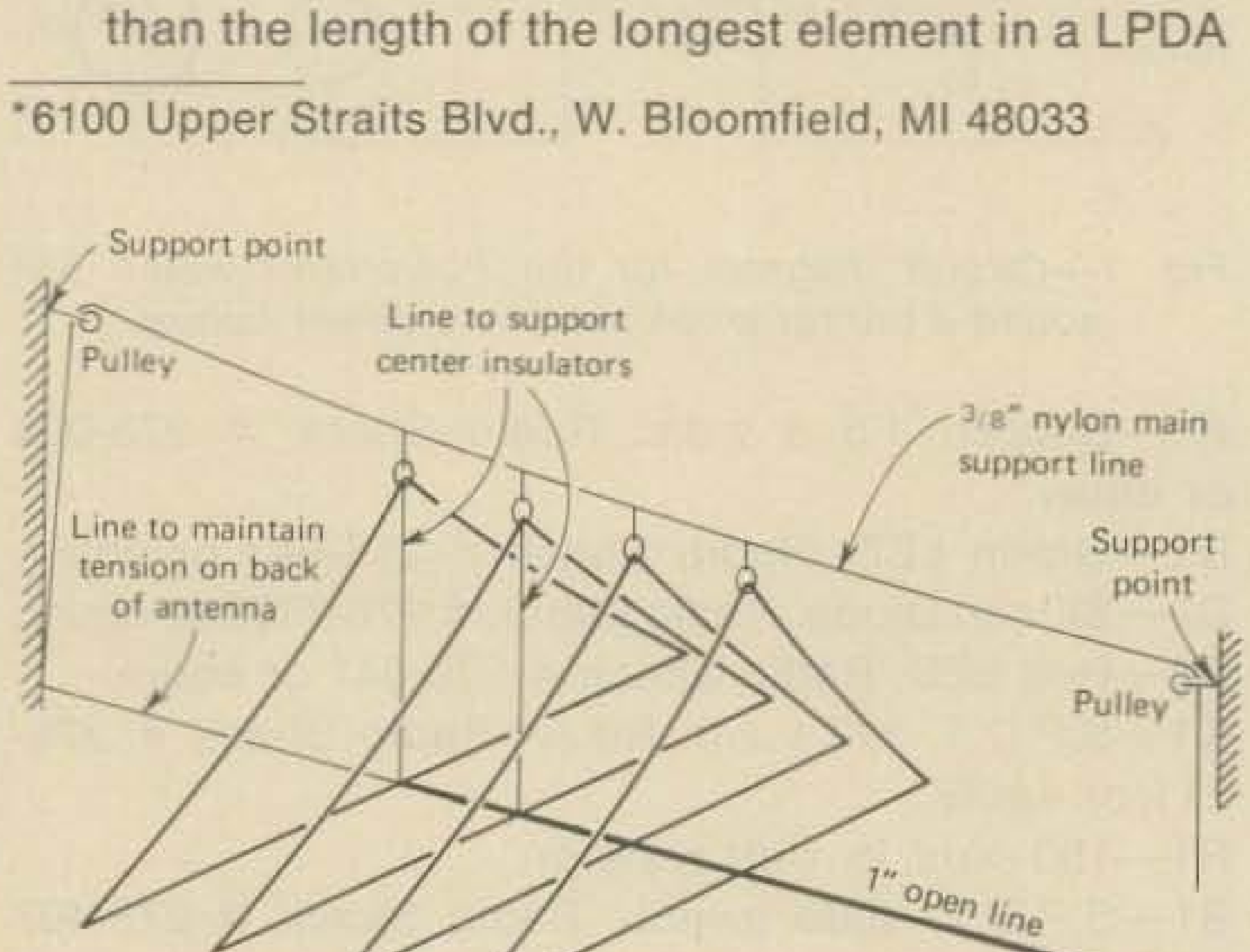
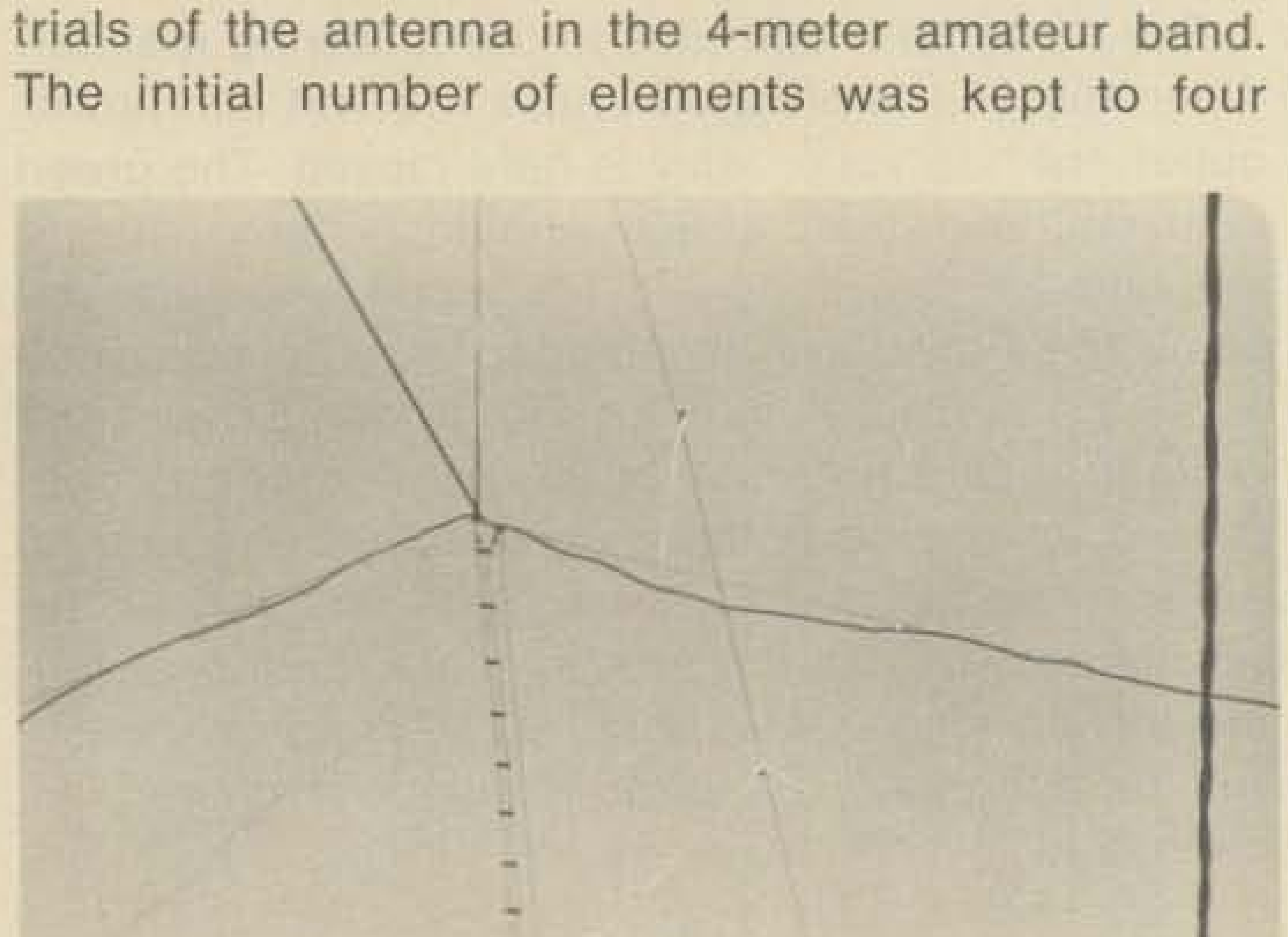


Fig. 1—General layout of the author's log-periodic dipole array. A pulley system is used to permit easy raising and lowering. Although the array was designed for only 6-10 MHz, construction parameters are provided for 2-32 MHz.

While I have seen two-element quad arrays with both elements driven, I have not found any literature describing multi-element driven quad arrays in a log-periodic configuration. After doing some thinking about the position of the current loops on the elements fore and aft of the phase center, and the effect on current distribution of the lower Q of the loop, I decided that such an array was worth a try.

Initially, I constructed a four-element array with a frequency coverage of approximately 6-10 MHz. The primary objectives were to provide an antenna for regular listening to and recording of Middle Eastern broadcasts and to provide for on-the-air trials of the antenna in the 4-meter amateur band. The initial number of elements was kept to four



Looking Northeast. The feedpoint of L1, the support and back tension lines of L1 are in the foreground.

TABLE I. Array Dimensions

Element	Length	Length/2	Length/6	Spacing
1	167'6"	83'9"	27'11"	
1-2				10'0"
2	142'6"	71'3"	23'9"	
2-3				8'6"
3	121'0"	60'6"	20'2"	
3-4				7'3"
4	103'0"	51'6"	17'2"	
4-5				6'2"
5	87'6"	43'9"	14'7"	
5-6				5'3"
6	74'6"	37'3"	12'5"	
6-7				4'5"
7	63'6"	31'9"	10'7"	
7-8				3'9"
8	54'0"	27'0"	9'0"	
8-9				3'2"
9	46'0"	23'0"	7'8"	
9-10				2'9"
10	39'0"	19'6"	6'6"	
10-11				2'4"
11	33'0"	16'6"	5'5"	

To date, only elements 1 through 4 have been constructed and tested. Dimensions *length/2* and *length/6* are for constructing a LPDL. *Length/2* gives the length from the feedline to the low insulators.

partly to facilitate measurement of resistance and reactance at the fundamental, and harmonic and subharmonic frequencies, and partly because the four-element array has performed so well that I haven't had much incentive to expand it.

Design Considerations

For the experimental antenna, the following parameters were chosen:[1]

f_1 (lowest frequency): 6MHz

Circumference of largest elements: 1005'/6=167.5' (quad driven-element formula)

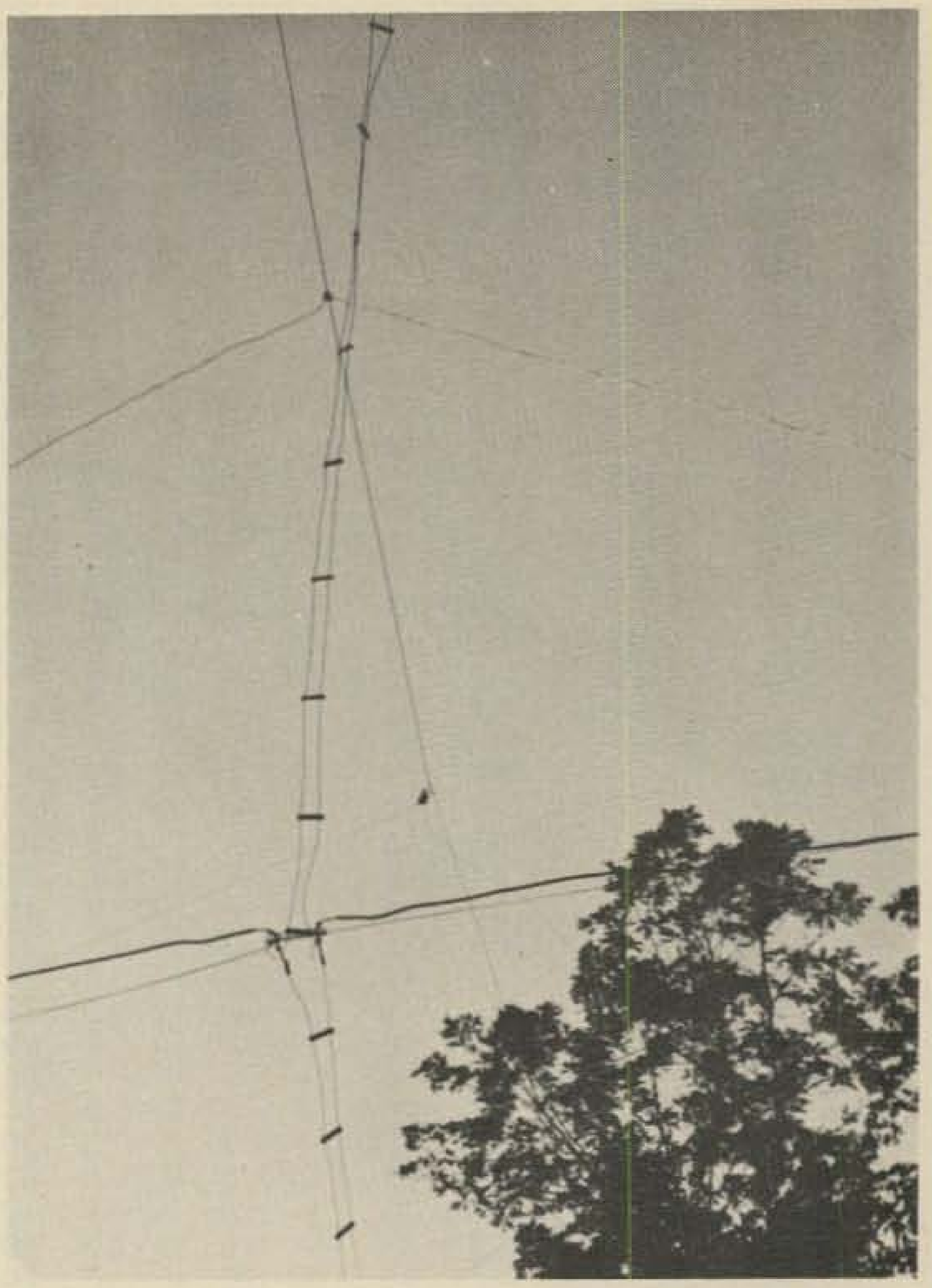
Spacing of two largest elements: 10 feet (chosen to keep array length reasonable)

(Ratio of spacing and element size): .85

Boom length to theoretical apex: approximately 64'

Table I shows the calculated dimensions for eleven elements, corresponding approximately to 6-30 MHz; however, only the four largest elements have been constructed to date.

Construction of the four largest elements of this array results in a boom length of 25'9". Open-wire feed with 1" spacing is used for the feedline, and is cut to the full theoretical length of the array, from the longest element through the apex, to maintain the periodicity of antenna impedance throughout the full operating range of the antenna. Additional elements could be added with little difficulty. The open feedline is terminated at the array apex with a 4:1 balun, and a 5-ohm coax is used from there to the operating position.



Looking southwest. The feedpoint for L3 is in the foreground.

As quad performance is very similar whether the loop is square or triangular, the triangular shape was chosen for mechanical convenience. An appropriate generic name for the antenna is log-periodic quad array (LPQA); since the antenna as I have constructed features triangular elements suspended from the element apex, it can be described as a log-periodic delta loop (LPDL); with the horizontal run at the top, it could be called a periodic delta quad (PDQ).

The polarization of the array is determined by the feed point. I feed it at the bottom; fed there or at the top, it is horizontally polarized. Fed from the side, it would be vertically polarized. Also, if the elements are fed at corners, one insulator per element could be spared; this could be done with an LPDL by feeding it at the top of each element.

If the array is designed for as much as a 2:1 frequency range, individual elements will show multiple resonances within the operating frequency

[1]see Rhodes, "The Log-Periodic Dipole Array," *QST*, November 1973, for terminology and formulas for standard LPDA's.

TABLE II. RESISTANCE AND REACTANCE OF ARRAY, 2-32 MHz

MHz	*R*	*Xc*	*X_L*	*MHz*	*R*	*Xc*	*X_L*	*MHz*	*R*	*Xc*	*X_L*	*MHz*	*R*	*Xc*	*X_L*	*MHz*	*R*	*Xc*	*X_L*
2.0	low	—	10	8.0	70	—	—	14.0	20	15	—	20.0	30	—	—	26.0	30	—	—
2.1	low	—	5	8.1	75	—	—	14.1	20	10	—	20.1	40	—	—	26.1	35	—	—
2.2	low	—	10	8.2	100	—	—	14.2	20	10	—	20.2	45	—	—	26.2	35	—	—
2.3	low	—	10	8.3	100	10	—	14.3	25	5	—	20.3	55	10	—	26.3	35	—	—
2.4	5	—	10	8.4	90	15	—	14.4	30	5	—	20.4	50	15	—	26.4	35	—	—
2.5	5	—	15	8.5	75	15	—	14.5	30	—	—	20.5	40	20	—	26.5	35	—	—
2.6	15	—	20	8.6	45	15	—	14.6	50	—	—	20.6	35	20	—	26.6	40	—	—
2.7	25	—	25	8.7	40	15	—	14.7	95	5	—	20.7	25	20	—	26.7	40	—	—
2.8	40	—	45	8.8	35	15	—	14.8	70	20	—	20.8	15	20	—	26.8	45	—	—
2.9	250	—	70+	8.9	30	15	—	14.9	30	20	—	20.9	15	10	—	26.9	45	5	—
3.0	250	30	—	9.0	30	10	—	15.0	30	20	—	21.0	20	10	—	27.0	40	10	—
3.1	40	15	—	9.1	25	10	—	15.1	35	10	—	21.1	15	10	—	27.1	40	15	—
3.2	20	10	—	9.2	20	10	—	15.2	40	10	—	21.2	15	10	—	27.2	40	15	—
3.3	15	5	—	9.3	20	10	—	15.3	50	15	—	21.3	20	10	—	27.3	40	15	—
3.4	5	—	—	9.4	20	10	—	15.4	55	15	—	21.4	20	10	—	27.4	30	15	—
3.5	5	—	—	9.5	15	5	—	15.5	45	20	—	21.5	20	5	—	27.5	30	15	—
3.6	low	—	—	9.6	15	10	—	15.6	40	20	—	21.6	25	5	—	27.6	25	20	—
3.7	low	—	5	9.7	10	10	—	15.7	30	20	—	21.7	25	5	—	27.7	25	20	—
3.8	low	—	5	9.8	10	5	—	15.8	20	20	—	21.8	25	5	—	27.8	25	10	—
3.9	low	—	10	9.9	low	5	—	15.9	25	20	—	21.9	30	—	—	27.9	20	15	—
4.0	10	—	10	10.0	10	—	—	16.0	20	15	—	22.0	25	—	—	28.0	20	10	—
4.1	15	—	10	10.1	15	—	—	16.1	20	10	—	22.1	30	5	—	28.1	25	15	—
4.2	low	—	15	10.2	10	—	—	16.2	20	10	—	22.2	30	5	—	28.2	20	15	—
4.3	15	—	15	10.3	15	—	—	16.3	20	10	—	22.3	30	5	—	28.3	20	10	—
4.4	25	—	20	10.4	20	—	—	16.4	20	10	—	22.4	30	5	—	28.4	20	10	—
4.5	25	—	30	10.5	20	—	5	16.5	25	5	—	22.5	30	5	—	28.5	15	10	—
4.6	35	—	40	10.6	20	—	5	16.6	25	5	—	22.6	35	5	—	28.6	15	10	—
4.7	50	—	55	10.7	20	—	10	16.7	30	—	—	22.7	35	10	—	28.7	15	10	—
4.8	90	—	70+	10.8	20	—	15	16.8	30	—	—	22.8	35	10	—	28.8	10	10	—
4.9	250+	—	70+	10.9	35	—	10	16.9	40	—	—	22.9	35	10	—	28.9	10	5	—
5.0	250+	—	70+	11.0	40	—	30	17.0	50	—	—	23.0	30	10	—	29.0	15	10	—
5.1	250+	20	—	11.1	40	—	45	17.1	70	5	—	23.1	35	10	—	29.1	10	5	—
5.2	250+	20	—	11.2	80	—	70+	17.2	65	10	—	23.2	30	10	—	29.2	10	5	—
5.3	190	15	—	11.3	135	—	70+	17.3	50	15	—	23.3	30	10	—	29.3	10	5	—
5.4	140	10	—	11.4	250+	—	50	17.4	40	15	—	23.4	30	10	—	29.4	10	5	—
5.5	110	5	—	11.5	250+	—	25	17.5	40	15	—	23.5	25	10	—	29.5	10	5	—
5.6	120	—	—	11.6	100	30	—	17.6	40	15	—	23.6	25	10	—	29.6	10	5	—
5.7	130	—	—	11.7	50	25	—	17.7	40	15	—	23.7	25	10	—	29.7	10	5	—
5.8	150	—	5	11.8	35	15	—	17.8	40	15	—	23.8	20	10	—	29.8	5	5	—
5.9	250+	—	5	11.9	25	10	—	17.9	35	15	—	23.9	20	5	—	29.9	5	—	—
6.0	250+	—	—	12.0	30	10	—	18.0	40	20	—	24.0	25	10	—	30.0	5	—	—
6.1	250+	15	—	12.1	30	5	—	18.1	35	15	—	24.1	25	10	—	30.1	10	—	—
6.2	250+	20	—	12.2	30	—	—	18.2	35	20	—	24.2	25	10	—	30.2	10	—	—
6.3	145	20	—	12.3	35	—	5	18.3	30	15	—	24.3	25	10	—	30.3	10	—	—
6.4	90	20	—	12.4	45	—	15	18.4	25	15	—	24.4	25	5	—	30.4	10	—	—
6.5	75	20	—	12.5	60	—	30	18.5	25	15	—	24.5	20	5	—	30.5	10	—	—
6.6	60	15	—	12.6	95	—	50	18.6	25	15	—	24.6	20	5	—	30.6	10	—	—
6.7	50	15	—	12.7	170	—	55	18.7	20	15	—	24.7	20	5	—	30.7	10	—	—
6.8	50	10	—	12.8	250+	—	—	18.8	20	15	—	24.8	20	—	—	30.8	10	—	10
6.9	50	5	—	12.9	250+	25	—	18.9	15	10	—	24.9	20	—	—	30.9	15	—	10
7.0	70	10	—	13.0	140	30	—	19.0	15	10	—	25.0	20	—	—	31.0	15	—	5
7.1	80	10	—	13.1	90	30	—	19.1	20	10	—	25.1	25	—	—	31.1	20	—	10
7.2	75	10	—	13.2	50	30	—	19.2	15	10	—	25.2	25	—	—	31.2	20	—	10
7.3	70	15	—	13.3	40	25	—	19.3	20	10	—	25.3	25	—	—	31.3	20	—	10
7.4	50	15	—	13.4	30	25	—	19.4	20	10	—	25.4	25	—	—	31.4	20	—	10
7.5	45	10	—	13.5	25	20	—	19.5	20	10	—	25.5	25	—	—	31.5	25	—	10
7.6	40	10	—	13.6	25	20	—	19.6	20	5	—	25.6	25	—	—	31.6	25	—	10
7.7	40	10	—	13.7	25	20	—	19.7	20	5	—	25.7	30	—	—	31.7	25	—	10
7.8	40	5	—	13.8	15	15	—	19.8	25	—	—	25.8	30	—	—	31.8	30	—	10
7.9	40	—	—	13.9	20	15	—	19.9	30	—	—	25.9	35	—	—	31.9	25	—	10
																32.0	30	—	10

NOTE: R indicates measured resistance in ohms. *Xc* indicates measured capacitive reactance in pF. X_L readings indicate that the array displays inductive reactance; the X_L shown is the approximate pf by which the cariable capacitor in the bridge is less than the fixed capacitor. The readings should not be considered exact, but do provide useful general indications. Some of the measured reactance may be due to the few inches of coax used to connect the balun to the bridge.

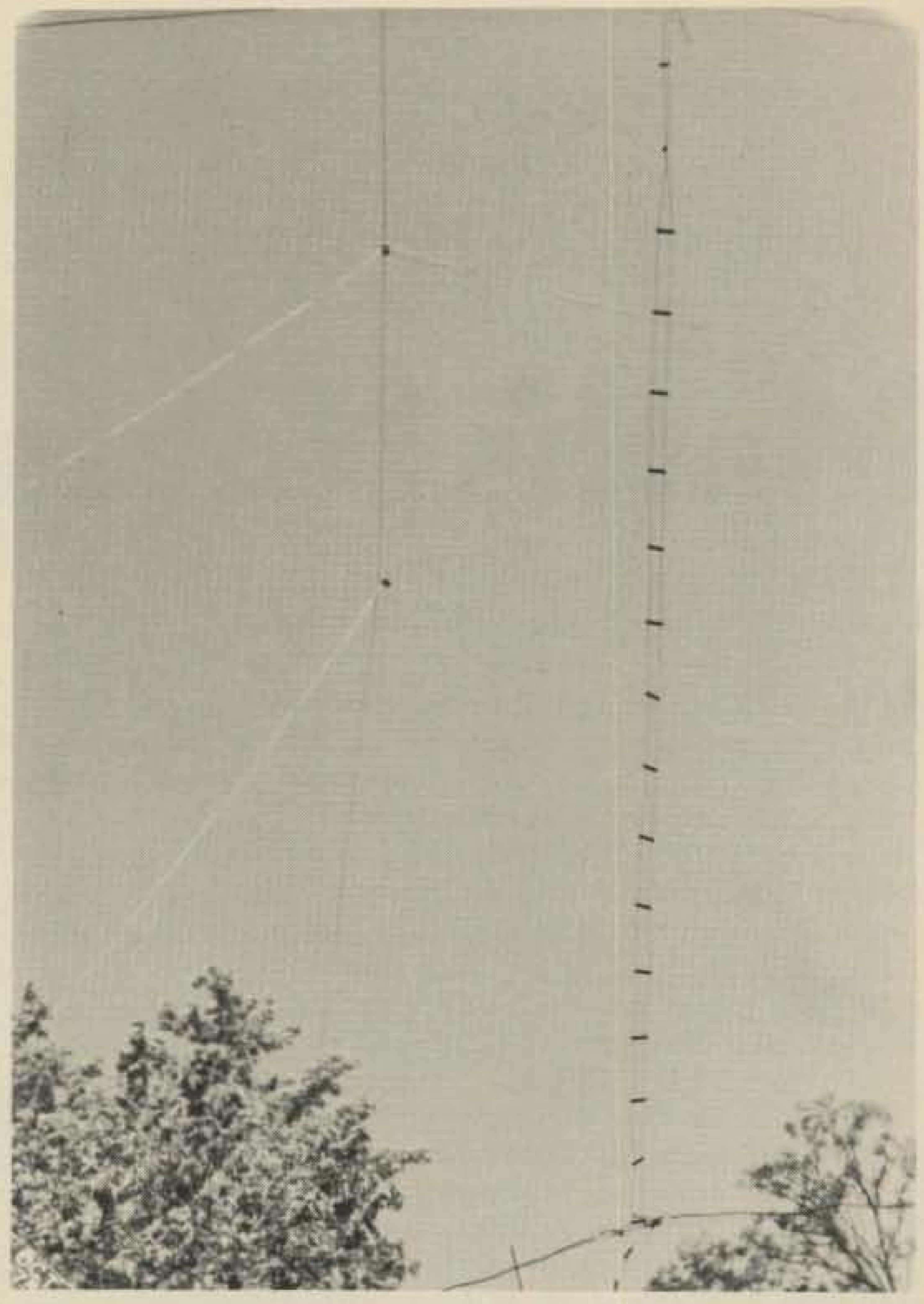
range. This is an important consideration, as the figures for resistance and reactance for 2-32 MHz show definite resonances at half the fundamental frequency and at harmonics. Several approaches could be taken:

- High-pass or low-pass filters could be used in the transmission line or elements;
- The transmission line and element impedance could be chosen to minimize power transfer at undesired resonant areas;
- The relative spacing constant and   could be chosen so that radiation from the various parts of the array would combine to reinforce desired patterns;
- The frequency range of individual arrays could be kept under 2:1, and separately-fed higher-frequency arrays could be interlaced within lower-frequency arrays, just as 10- and 15-meter quad arrays are interlaced with 20-meter arrays. As an alternative to separate feeding, the interlaced elements could be brought to a common feedline;
- The frequency range of individual arrays could be kept under 2:1, and each "element" could be composed of open-wire twinlead with one loop complete and the other broken directly opposite the feedpoint, essentially combining two arrays on the same feedline.

Mechanical Considerations

Fishing lines were lofted over the two trees by a friend using a bow and a flu-flu arrow (the flu-flu has a high-drag "feather" area and provides adequate initial speed and distance without traveling long distances on the other side). The fishing lines were used to pull up the ⅜" nylon lines which support the array. As shown in fig. 1, a pulley system is used to permit easy raising and lowering of the array without scraping the end ropes back and forth over the support-point tree. The pulley system has been a success, but for maximum height, the pulley must be near the point where the line passes over the tree, or the pulley and the whole array can end up considerably lower than the highest point in the line passing over the tree.

In general, it will be necessary to suspend the top insulators from the nylon rope by varying lengths of light line, in order to keep the array shape linear. While designing the antenna, I calculated the lengths of line necessary to connect the corners of adjacent elements together, in order to simplify the job of keeping the whole array in shape. However, with only four elements, it has been just as easy to attach individual lines from the ends of the elements to the house, trees, etc. Also, array elevation problems have prevented me from using equilateral triangles for the elements, so the calculations would have been inaccurate.



The feedline is in the foreground. The apexes of L3 and L4 are above, looking up.

Having had some earlier problems with aluminum-wire connections in various other arrays, I decided to use copper-clad wire throughout the elements and feedline, and to solder all connections using a propane torch. The commercial open-wire twinlead used has a spacing of 1" and is relatively light, but the middle of the base of each element tends to sag unless considerable tension was placed on the corner insulators, putting the whole array under considerable strain. Therefore, a line was run from the top insulator down to the feedpoint insulator of the longer elements. Doing this alleviated the problem. The line currently used on the largest element is unnecessarily short and probably plays a large role in the high resistance noted at the array apex around 6MHz.

Resistance and Reactance of Experimental Four-Element Array

Table II shows the resistance and reactance of the array from 2 through 32 MHz, as measured just after the 4:1 balun with a Palomar RX Noise Bridge. The reactance is predominantly capacitive from 5

(continued on page 72)

Zero Bias (continued from page 5)

computers and the like. They're the first on the block with all the latest jargon and equipment that literally astounds and confuses their family and friends. They may be looked on as sort of odd by some people but still within the ranks of amateur radio they can find a "home and friends" who speak their language.

Then again, suppose you're not interested in world affairs or what's going on today on Mars. There are modes and aspects of amateur radio that are tailor made for your interests. The wonderful part of amateur radio is that you're not stuck with just so many channels, a few types of film, or only a copy of the inverted airmail stamp. It's all out there and more for as much or as little as you want.

I Think We've Made It

Some of you might also experience something new receiving your monthly copy of CQ. The February issue is likely to be available slightly before or around the same time as the January issue. Before you sit down and write irate letters or reach for the phone let me explain.

The January issue and the February issue were printed by two different printers with two different schedules. The February issue is on an earlier schedule to allow for newsstand distribution during the month of January. This meant that here at CQ we all went crazy trying to put out two issues at the same time with the February issue just a little ahead of January.

Editorial Responses

I've begun to receive some responses to my editorials which were aimed at calling both the FCC and the ARRL to task. Although so far they range about 50/50 for and against, I am heartened by the response. The anti letters seem to be a little strange in that they call me to account for fighting the best thing to happen to amateur radio since Mr. Maxim. Well, all I tried to do and will continue to do is speak out and fight against getting ripped off. There aren't too many people who seem to like getting ripped off by either government or private enterprise but if you are one of them . . . enjoy. I don't, and judging by my mail, many of you don't.

I can't promise to answer your letters, but I do like to receive them. So if you have anything to say about what I have written, either for or against, let me know.

73,

Alan, K2EEK

LPQA *(from page 51)*

MHz through 30 MHz, and is typically about 10 pF. A small neutralizing reactance would facilitate achieving a low s.w.r. against 50-ohm coax throughout the normal operating range (6-10 mHz) and at higher frequencies through 30mHz. The figures show resonance at 16 different frequencies, ranging from 2.95 MHz through 30.3 MHz, plus a near-resonant condition around 6.9 MHz.

In using these findings to design other versions of the LPQA, the impedances could be "managed" in several different ways:

- The impedance of the open-wire line could be varied;
- The array could be fed from a point other than the theoretical apex;
- The impedance of individual elements could be varied by using multiple conductors;
- A 1:1 or even 1:4 balun could be used in place of the 4:1 balun;
- An open-wire feed could be used with an antenna coupler;
- Operation could be based on loops open, opposite the feedpoint, as is the case with some quad arrays.

The broad resonances above 24.7 MHz show the possibility of broadband arrays using elements which have a full-wave resonance at a subharmonic of the operating frequency.

The comparitively broad and noncritical tuning of the LPQA lends itself to the design of a wide variety of broadband directional arrays with good matches to readily available transmission lines.

Results

The array has been used for the past six months in monitoring SWBC transmissions from the Middle East. My receiver and tape recorder are operated by a timer, and I later remove the tapes and listen to them while commuting. This array has been far superior to the ones I had previously used—including a sloper and a bobtail bidirectional broadside curtain—in providing a strong, steady signal for tape recording.

On 40 meters, good results have been obtained in working European stations. I seem to be one of the earliest stations west of the Eastern seaboard to hear and work Europe. North American QRM, other than from VE1-VE2 and W1-W2 areas, appears to be attenuated to a worthwhile degree.

The design parameters chosen for this array were conservative. By increasing the and/or spacing, considerably higher gain can be achieved. Although the array is not small, it has not turned out to be troublesome to raise and maintain, except for getting the main support lines up and clear. Similar arrays for 80 or even 160 meters would not be unreasonable. For MARS use, or if additional hambands become available, the LPQA's broadband characteristics offer many advantages.

I would appreciate hearing from others who construct LPQA's. ■

The Powerlarm *(from page 47)*

larm is most useful. An intruder may pull the main switch to your house so that he can disconnect power being supplied to lights or various security guards which do not have a no-break power supply. A glance out the bedroom window to see if any other lights are visible will help establish whether the power outage is local or covers a neighborhood area. At any rate, you are forewarned.

The Powerlarm also serves a useful function when trying to locate a circuit breaker or fuse which controls a specific outlet you wish to disconnect in order to work on it. Plug the Powerlarm into the outlet and switch off the circuit breakers one by one until you hear the buzzer sound off. And if you plug the Powerlarm into the same receptacle as your deep freeze, you'll be able to tell when you've lost power to that unit. You may not notice for days that the external freezer panel light has gone out and that could mean the possible loss of all your frozen food and meats as the temperature rises above the safe deep freeze point.

The Powerlarm can be left plugged in permanently and dissipates about 3 watts power, the same as an electric clock. The Powerlarm can be easily assembled in an evening for a total cost of under $6.00. It only has to work once to pay for itself many times over. ■

On A Clear Day *(from page 46)*

that 'sneaky' — in your actions, I should say that you have been where things of great interest and dramatic impact have been occurring. Would you care to tell me what they were?"

"I guess you might say that I have been at the site of our newest 'repeater.' Now speaking of repeaters . . . we have a pretty active one in the basement. You might tell Thumbs what you told me about having to be up high to really produce, though. She doesn't know that."

"You mean she's . . . ?"

"Yes, she's! I have just come from the OB Ward. Several little feline offsprings have begun to appear there. There are certain traditional results from over-socializing on fox hunts, you know. You might say it was 'CFAR' all the way, too . . . Cute Felines Arriving Rapidly, Get it? When I left, things were what you in that 'Q Code' would call about 'ten four.' But things were happening pretty fast. She had an awful lot of help on that Fox Hunt. From what I saw, I think you'll be able to get on that other repeater and tell them that it looks like W9LC will soon be up to Ten *Twenty!"* ■

S.S.B. Theory *(from page 43)*

to the transmitter's abilities to reduce the carrier and unwanted sideband. Also, the terms "upper sideband transmission" and "lower sideband transmission" refer to which sideband the transmitter does not reject.

It is, however, not my purpose in writing this article to go into great detail about the actual makeup of single sideband systems. I do hope that, in presenting this alternate explanation, I may have shown that single sideband theory isn't completely senseless. ■

Multi-Band Traps *(from page 30)*

$jX_{in\,(1\,2)}\,f_{low} = -jK_m$ cotan $84^\circ = -jK_m\,(+0.105)$ ohms

Plugging in our respective K_m's for the two monopoles, we get,

$jX_{in\,(1\,2)}\,f_{low} = -j560.32(+0.105) = -j58.834$ ohms
$jX_{in\,(1\,2)}\,f_{low} = -j340.10(+0.105) = -j35.710$ ohms

Recalling that a linear antenna seems to act, at least in terms of its impedance behavior with frequency within a *single ham band,* like a series LC circuit, we see that we indeed obtain a capacitive reactance on the low frequency side of resonance like that predicted for such "circuit." At the high frequency band limit of 4.000 MHz, the frequency proportionality is now 4.000 MHz/3.750 MHz, so our analogue line length h° becomes $1.067 \times 90^\circ$, or 96.000 electrical degrees. Now equation (1.0-3.) tells us,

$jX_{in\,(1\,2)}\,f_{high} = -jK_m$ cotan 96.000°
$= -jK_m\,(-0.105)$ ohms

On the high frequency band limit the sign of