This article describes some construction ideas for those interested in the esoterica of log-periodic antennas.

Log-Periodic Antennas in VHF and UHF Amateur Service

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The log-periodic antenna grew out of a formal mathematical exercise. The theoretical configuration consists of two interlocking logarithmic (equiangular) spirals.

A rudimentary practical approach to construction is to lay the antenna out in a planar configuration where the "element" pattern is repeated in geometrically increasing steps. A workable realization of the log-periodic antenna is accomplished by constructing a series of antenna elements whose lengths and spacings are governed by strict mathematical formulas.

The log-periodic yagi combines the frequency independence of the log-periodic antenna with the gain and directivity characteristics of the yagi. —K2VG

Unlike the case of the yagi, log-periodic antenna principles and design theories were not developed by any one scientist or pair of researchers. Early experiments were done at the University of Illinois and also by the well-known Dr John Krauss, W8JK, at Ohio State. Smith, of the Cleveland Institute of Electronics, also engaged in extensive design and testing of log-periodics. However, none of this work was done with the amateur particularly in mind, so few practical construction articles exist in the literature. This article will attempt to bridge the gap.

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The ham bands at v.h.f and u.h.f. are under attack from many quarters today and unless operation becomes much more active, in proportion to the total ham population, they may be lost for good. In addition, operation must not be concentrated in any one small portion. This is an invitation to shrinkage. Since, for example, no single antenna of the more familiar types can cover the 420-450 MHz band satisfactorily, it behooves us to develop a skywire that can put us anywhere in the band at will.

The log-periodic and its derivative, the log-periodic yagi (or *periodic cum parasitic)*, is a practical answer. It gives more gain per unit length of boom than a classical yagi.

One thing that will not be done in this article is belabor the reader with esoteric theory, log tables, etc. Suffice it, then, that it can be shown that a series of driven dipoles can be arranged and interconnected such that, at any frequency from lowest cut-off to the highest in a given band, a small group of elements will constitute a resonant area. See fig. 1.

As the transmitting or receiving frequency is changed, so is the resonant area without introducing the need for physically or electrically changing the feed system. Furthermore, the log-periodic may be operated on its third, or even fifth, harmonic with no degradation of efficiency. Thus, a log-periodic based on 144-148 MHz will perform nicely over the 432-444 MHz range and, if set for cut-offs at 140 MHz and 150 MHz, will cover the entire ¾ meter band.

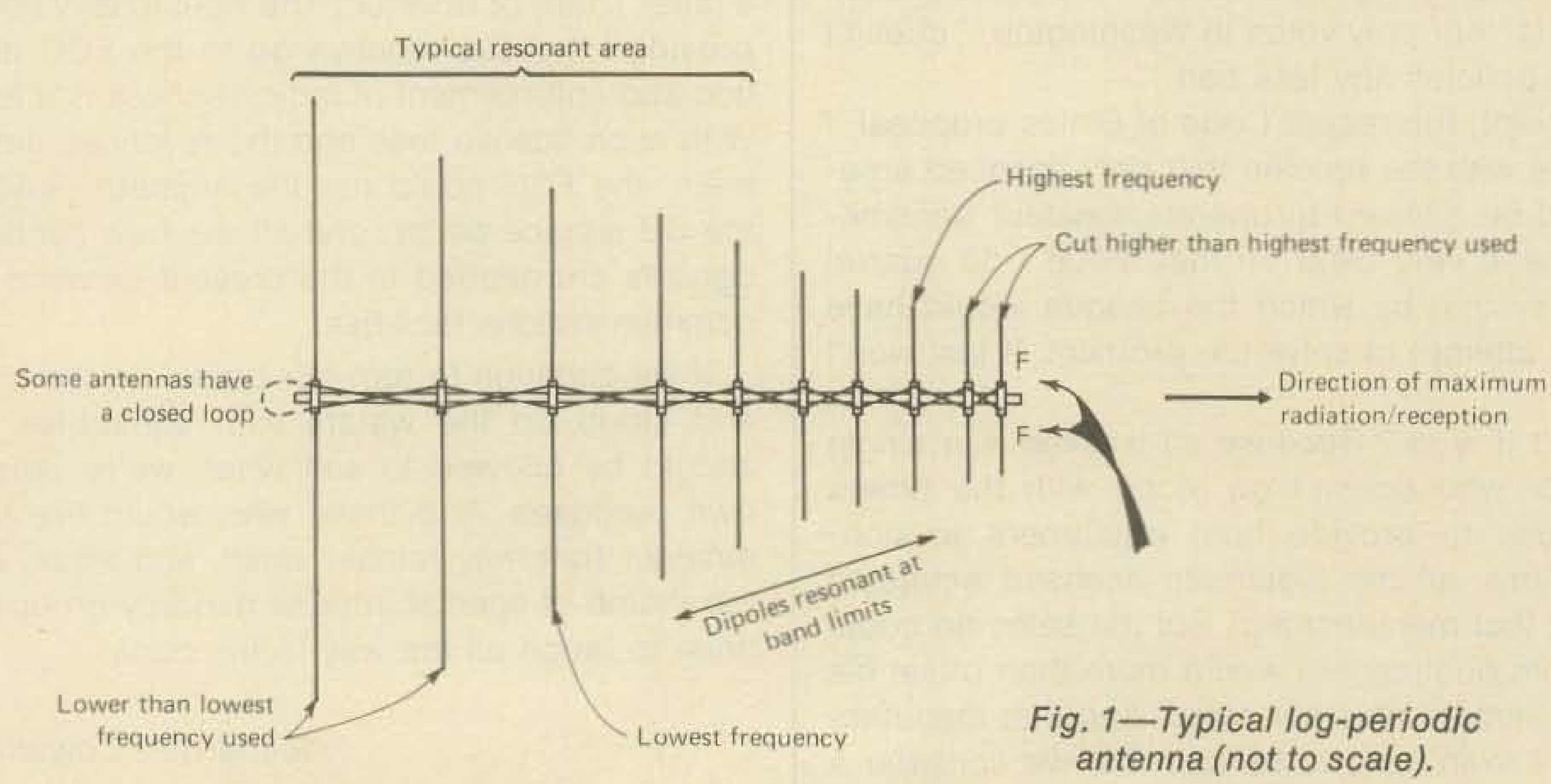


Fig. 1—Typical log-periodic antenna (not to scale).

There are two basic configurations of log-periodics and two basic ways of feeding them. Fig. 2 shows the resulting beam patterns when (a) the log-periodic is a "straight wing" and (b) when it is a "swept wing" type or veed to 60 degrees. Note the virtual disappearance of the side lobes in (b). However, the side lobe energy must reappear elsewhere. It does, not only in a sharper front lobe, but in the form of an undesirable back lobe. It will be shown later how to attenuate the back lobe with a parasitic reflector and by terminating the feed path along the boom.

Incidentally, there is a third configuration, namely a "wedge" or "arrow" arrangement of the two log-periodics, but we will keep to the promise of simplicity in this article.

The second area of interest, feeding the antenna, can be handled in two ways. See fig. 3(a). Here the element pairs are insulated from the boom and cross-connected by a phasing line, with feeder attachment at the front or small end. The boom is placed at ground potential by direct attachment to the grounded mast. Fig. 3(b) is another story. Here, two booms are used and directly attach to the element pairs without insulating blocks, half to each boom. Thus, the booms are integral parts of the feed system. Feeders are still attached at the front end but the booms must be insulated from each other at the feed end and from the grounded mast. For static discharge, a shunt or spark gap is placed from the boom to the mast, details of which will be discussed later. (The system of feeding a twin boom log-periodic with coax by running it through one boom from back to front as an impedance transformer and balun, and then hooking the inner conductor to one boom and the outer to the boom run-through, is not recommended for u.h.f operation).

Feed-line impedances have deliberately been omitted at this point since they will be picked up later in this article. However, it is significant to note that in the case of log-periodic antennas, there is no substitute for a balanced feed. Open wire lead is best, with the balun at the shack end, not at the antenna end.

Let us now examine how log-periodics do the work of extracting signal voltage from the intercepted wave front over a broad frequency range. In the author's opinion, talking from a receive-mode viewpoint lends toward more clarity than talking from the transmit-mode viewpoint.

One might think that all that is needed to cover a given bandwidth is to make the rearmost pair of elements resonant at the lowest desired frequency, advancing by stages to the frontmost pair, resonant at the highest desired frequency. Not quite! Fig. 1 shows that log-periodics are resonantly active over several element pairs at once for each operating frequency. So provision must be made for sufficient pairs resonating below and above the desired bandwidth to accommodate this phenomenon.

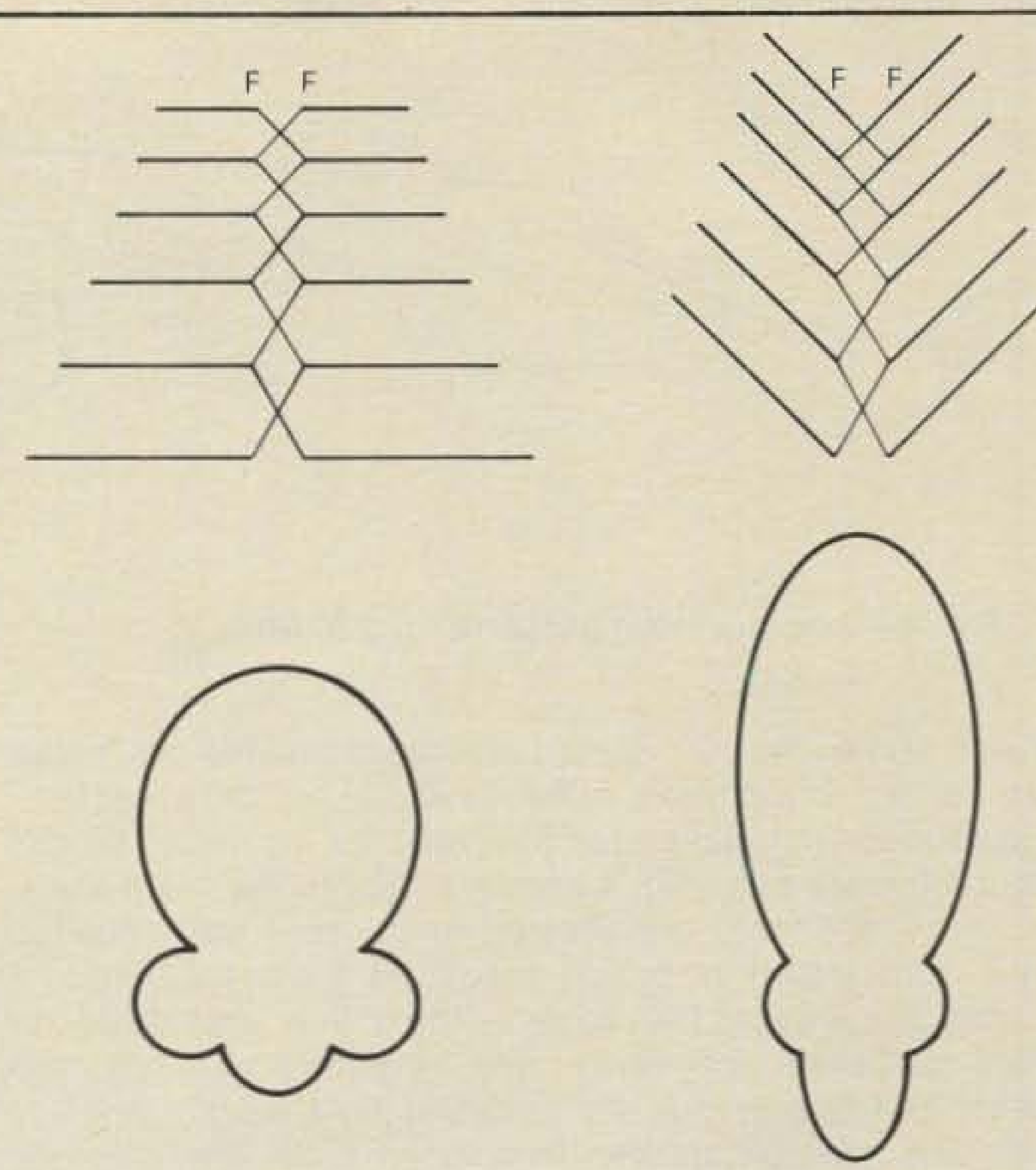


Fig. 2—E-plane polar plots. In (a), 90° elements; in (b), 60° elements.

Then there is the requirement of smooth transfer of resonant areas throughout the antenna's bandwidth. This graduation of element lengths and spacings is logarithmic, not arithmetic. Scientifically "pure" log-periodics are designed with constant reference to log tables.

We now move to practical amateur applications. A log-periodic yagi for 1¼ meters, a dual-bander for 2 and ¾ meters and a "lopsided lippy" (a combined vertical and horizontal "whirling bedspring" array) for ¾ meters will be considered.

Gain features in this article are based on the author's estimates only and may be reasonably expected, but are certainly not guaranteed. These antennas are intended for good, reliable terrestrial communication, where gains in the 11-15 dB range are ample. They are not intended for moonbouncer hotshots looking for 25 dB paths.

Recall that a log-periodic may be married to a yagi to form a *periodic cum parasitic,* resulting in broader band coverage and more gain per unit of boom length than the conventional yagi. Let us now select a configuration to build.

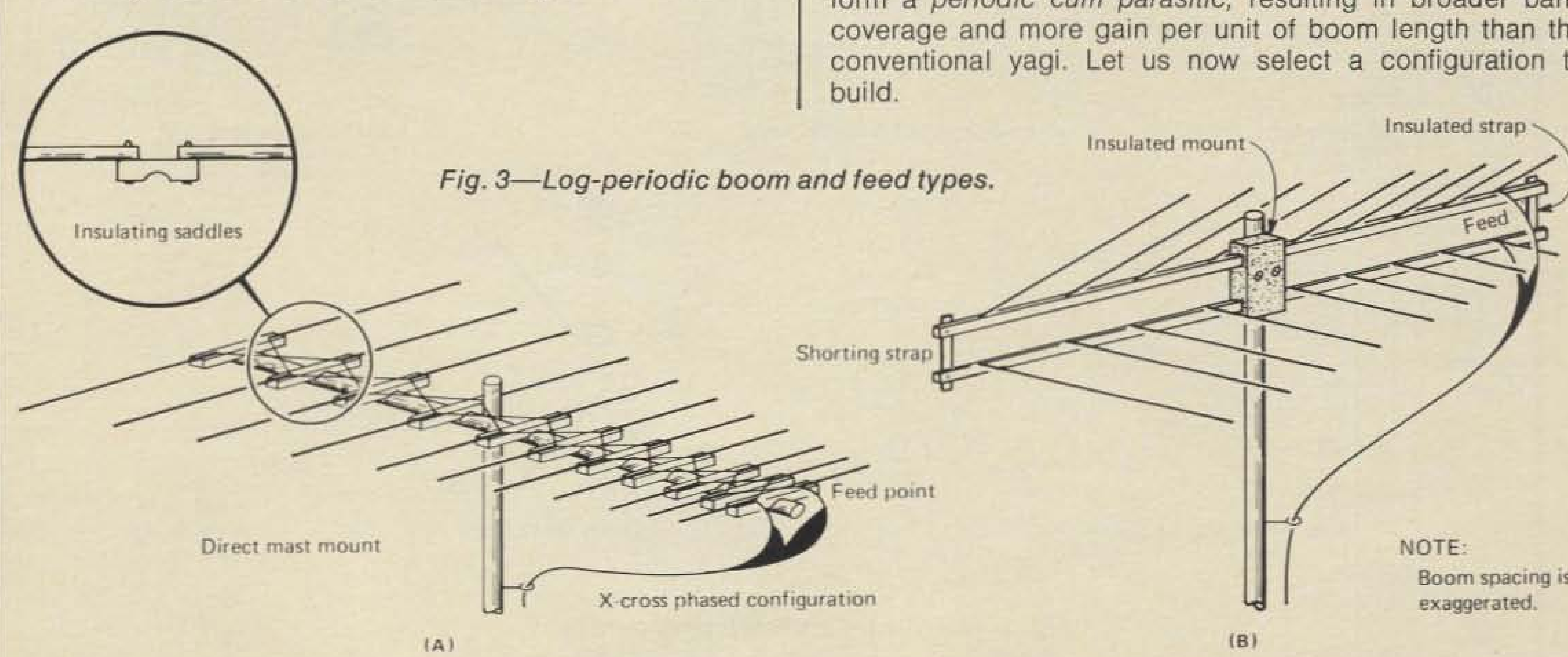
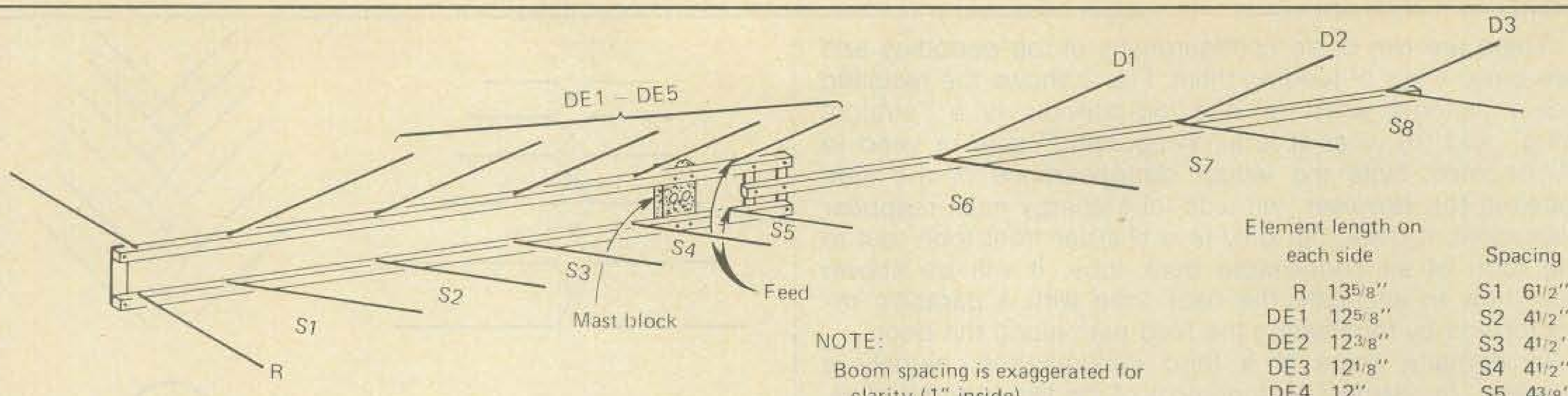


Fig. 3—Log-periodic boom and feed types.



Element length on each side		Spacing	
R	13⅝"	S1	6½"
DE1	12⅝"	S2	4½"
DE2	12⅜"	S3	4½"
DE3	12⅛"	S4	4½"
DE4	12"	S5	4⅜"
DE5	11⅞"	S6	11"
D1	12¼"	S7	13"
D2	12"	S8	14"
D3	11¾"		

NOTE:
Boom spacing is exaggerated for clarity (1" inside)
Twin booms 28" ea
Auxiliary booms 41" ea
Elements ⅜ Ø

Fig. 4—Log-periodic antenna for 220 MHz.

It was shown that 60° swept elements provide the better beam pattern. In addition, a twin boom is not only mechanically stronger but eliminates the need for insulating blocks at each element pair. Fig. 4 shows a "lippy" for 1¼ meters. Note that the booms are shorted at the rear but insulated at the front (feed) end and insulated from the mast. A reflector, not swept, five driven dipole sets and three directors comprise the array. The directors are not split between the booms but are mounted on a single auxiliary boom and cleated to the twin booms by the phenolic straps. Fig. 5 details mounting hardware required, which is common also to the two-bander to be later described.

Do not be misled by the fact that directors 1 and 2 are longer han the foremost driven elements. The log-periodic yagi is a member of the traveling-wave antenna family. A received wave enters the beam at the third director, travels rearward to the reflector end, reverses and returns forward, reverses again, etc. The first two directors reinforce and enhance the longer driven elements. They do not adversely affect or "block" the driven elements shorter than themselves. Of course, up to a point, the more directors in a log-periodic, the higher the gain, and as many as eight or nine could be used before reaching the point of little or no return for the metal and hardware involved. We use three for reasons of compactness without a great sacrifice of gain.

However, higher gain and, more important, lower wave angle, are better achieved by stacking two moderate length beams, rather than one extra-long single bay. Stacking heights for log-periodic yagis need not be so large to obtain maximum capture area as those of yagis. For example, best stacking height for an 8-over-8 yagi is just under 1.8 wavelengths, but a "lippy" of the size shown here will work very well at only 0.75 wavelength and, in this case, as little as 40 inches. Gain for a two-stacked is about 13.25 dB over a dipole. TV ladder line of 450 ohm impedance, *not* the narrowly-spaced 300 ohm variety, makes a fine stacking harness.

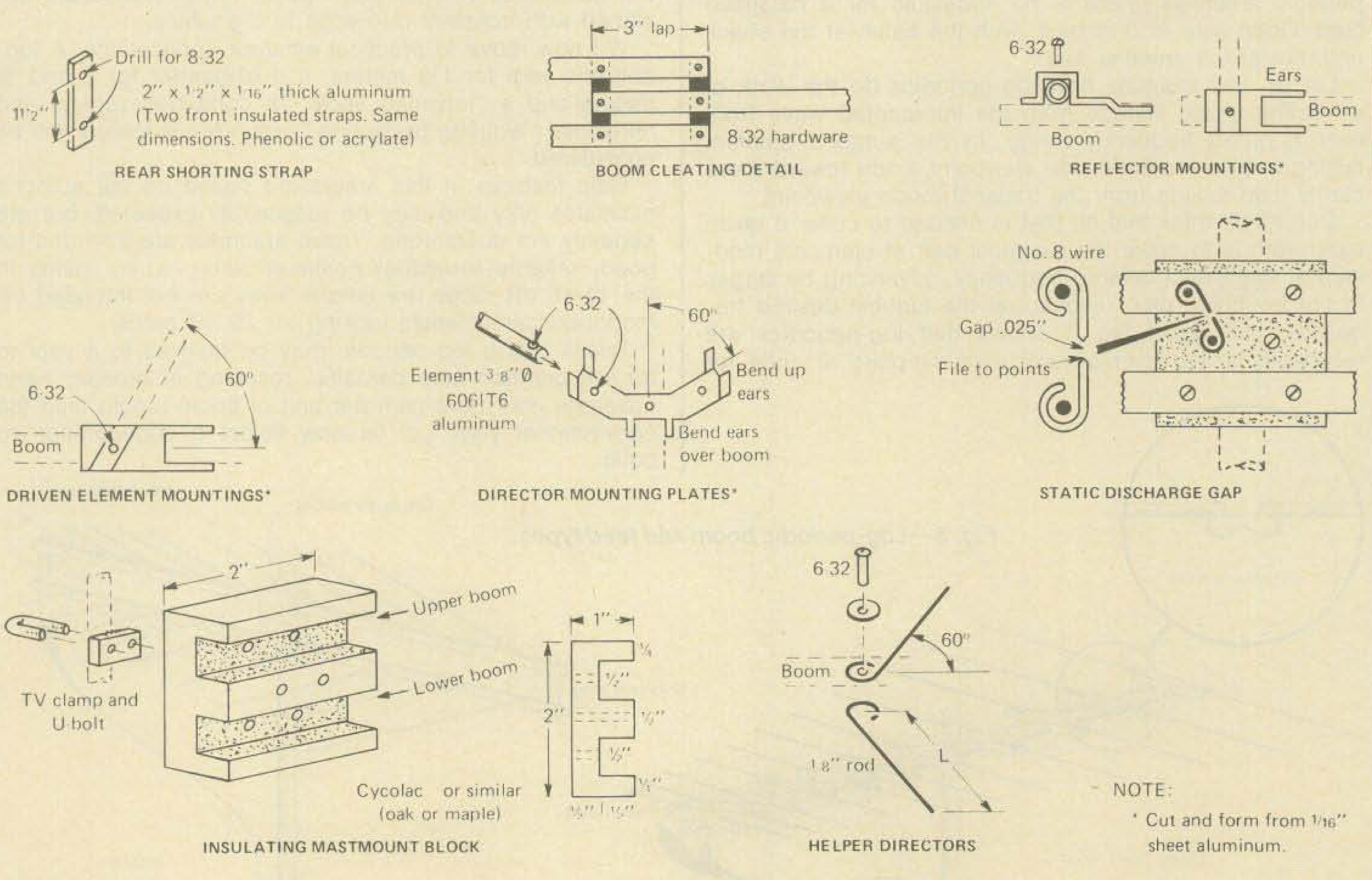


Fig. 5—Hardware and mounting details.

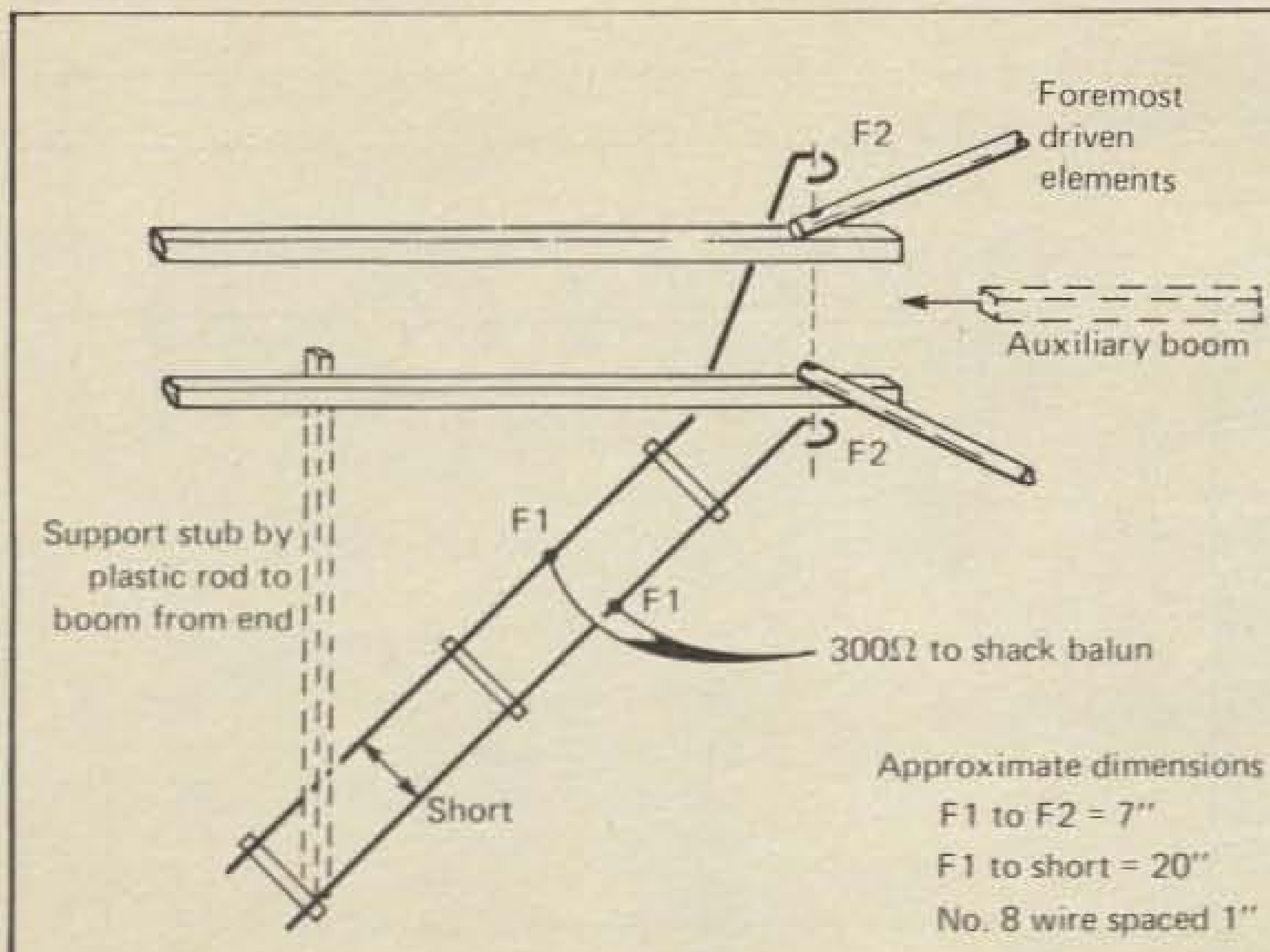


Fig. 6—Matching stub for 1¼ meter antenna.

Run 300 ohm twinlead (Beldon Permohm) from the harness midpoint to the shack through a 6:1 toroidal balun and then through a short length of coax to the rig.

By the way . . . just a short word about the absolute minimum s.w.r. fetish seen in some publications. Modern 50 ohm equipment will work into an almost infinite s.w.r. without burning the gear up or losing all of the signal. The amateur at the other end of the QSO couldn't possibly tell by ear or S-meter whether the s.w.r. is 1:1 or 3:1. Log-periodic yagis contain reactive impedance components and purists may wish to add a stub to attempt to tune it down. Rough starting points are shown in fig. 6. The leg of the stub to the upper boom must be an inch or so longer but this will not upset tuning.

Now let us construct antenna number two (fig. 7), for dual operation on 2 and ¾ meters. Here we have the straight-across reflector, six pairs of driven elements and two directors for two meters; in the third harmonic mode, for 420 MHz. Four additional directors are interspersed on the auxiliary boom. They are made of #8 semi-hard drawn wire whose inner ends are curled under holding bolts and washers. This "lippy" is fed directly with 450 ohm open wire line (with no tuning stubs). Stacking height should be 66 to 72 inches, should you wish to build two bays. Gain to be expected from a single bay is 11 dB on two meters and as much as 14.5 dB on ¾ meters.

Now, let us examine the "lopsided lippy" (fig. 8), a dual-polarized array for ¾ meters. At u.h.f., rotation of polarization of a signal may occur several times, even over fairly short distances. So a signal leaving a transmitting antenna in a horizontal mode may arrive at a receiving skywire in the vertical mode! It behooves the serious operator, therefore, to have switchable receiving capabilities, and even the means to simultaneously receive both modes.

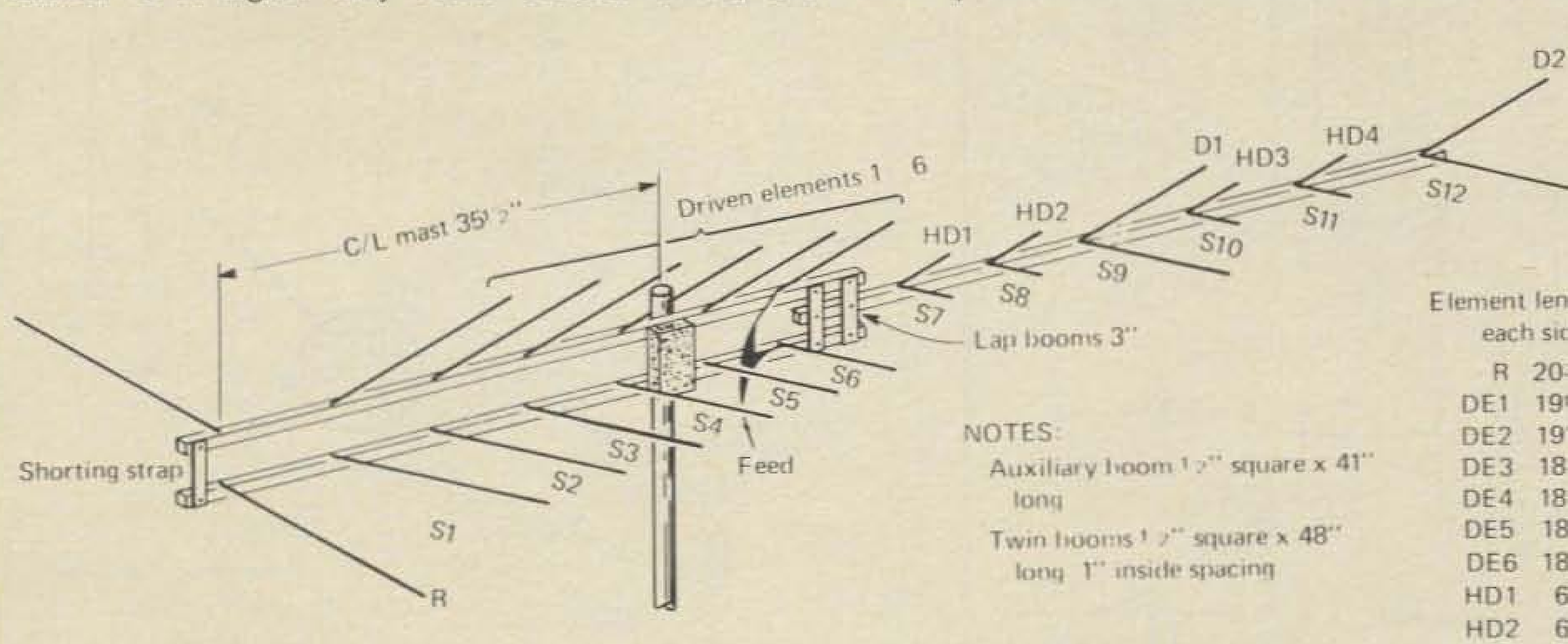
For transmitting, one can also experiment with vertical or horizontal emission over a given path and note comparative results. Fig. 9 shows a suitable switching circuit.

"Lopsided lippy" has four log-periodic yagi bays, each consisting of six driven elements and four directors, the last three of which are not swept, mounted on five-foot booms. The bays are "quaded" with approximately ¾λ vertical spacing and 1λ horizontal spread between vertical and horizontal pairs. The whole works is backed up by a 40 by 40 inch square of ½ inch mesh hardware cloth as a plane reflector. Separate vertical and horizontal feeders are brought into the shack. All elements are ⅛ inch rod, mounted as per the directors in the previous array. (See fig. 10).

And so we end our perilous journey through the logjam of logarithmic tables in an appropriate place: your own back yard. Sorry, apartment dwellers, but "the poor man's antenna test range" requires a minimum clear space of an 85 foot radius over an arc of 120 degrees. Suburbanites, however, should not find such a pie slice hard to come by. It need not be flat, only open.

Figure 11 shows a home-brew layout for testing the "lippies." It is limited to two meters and above, as lower frequencies require much longer shots from antenna to signal pickup sites. Using a theodolite, a stadimeter, a compass, a golfer's scope or whatever you can beg, borrow or steal, lay out as accurately as you can, an arc (a in fig. 11) with a radius of 67 feet from the chosen point of the test antenna mounting rig. Drive stakes at 0° (360°), 30° and 60° each side thereof. Make sure that for at least three wavelengths at the lowest frequency to be tested (20 feet at 2 meters) behind this arc and up to arc B, there are no metallic objects, dense foliage, etc.

Temporarily mount the test antenna on a jig of plastic water pipe or anything nonmetallic that can swivel the antenna 180°. The antenna must be supported a minimum of one wavelength above the ground. Point the antenna at the 0° stake. Hook up a low power transmitter (five watts is plenty) through appropriate instrumentation (s.w.r. meter, reflectometer, bridge, wattmeter, etc.) to the antenna. Keep the feedline between the instruments and the antenna ½ wavelength above ground. Dispatch an assistant with a field strength meter and folded fan or cage dipole, cut to the middle of the desired band coverage, to the 0° stake.

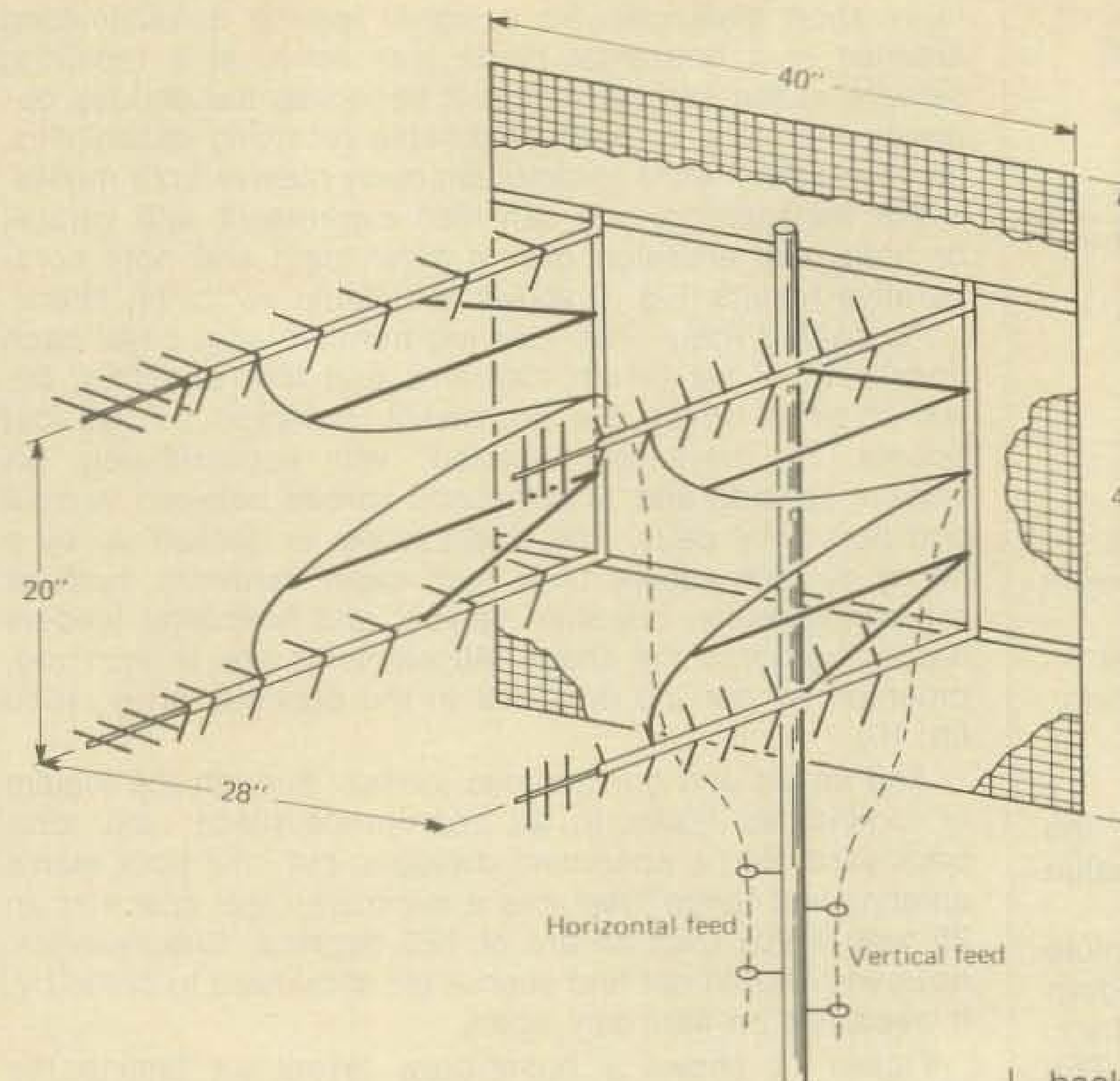


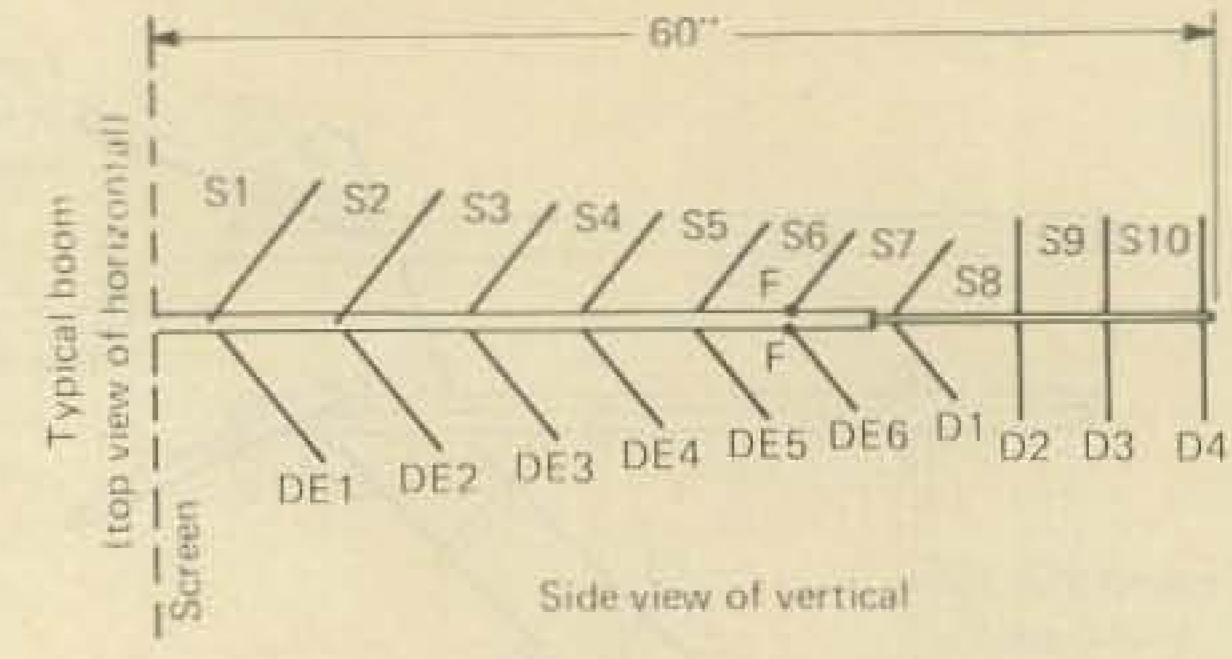
NOTES:
Auxiliary boom ½" square x 41" long
Twin booms ½" square x 48" long 1" inside spacing

Element length on each side	
R	20⅜"
DE1	19¼"
DE2	19"
DE3	18¾"
DE4	18⅝"
DE5	18½"
DE6	18⅜"
HD1	6⅜"
HD2	6⅜"
D1	18¾"
HD3	6¼"
HD4	6⅛"
D2	18½"

Spacing	
S1	10½"
S2	7½"
S3	7"
S4	7"
S5	6½"
S6	6½"
S7	5"
S8	6"
S9	6"
S10	7"
S11	6"
S12	7"

Fig. 7—Dual band log-periodic antenna for 2 and ¾ meters.





Element lengths (1/8 Ø)		Spacing	
DE1	6 9/16" each side	S1	6"
DE2	6 3/8" each side	S2	4"
DE3	6 3/16" each side	S3	4"
DE4	5 13/16" each side	S4	3 1/2"
DE5	5 5/16" each side	S5	3"
DE6	5 1/8" each side	S6	3"
D1	6 3/16" each side	S7	6"
D2	11 3/4" entire	S8	8"
D3	11 1/2" entire	S9	10"
D4	11 3/8" entire	S10	11"

Fig. 8—The "lopsided lippy."

If the antenna is so equipped, and it has not yet been done, tune up a matching stub for minimum reflected power first; then try for maximum forward power. If the stub settings are not the same, use minimum reflected settings. Then have your assistant read the field strength at 0°. Have him move 30° to the left; read; move another 30° to the left. Then move and take readings at 30° and 60° to the right. This will give a rough plot of the nose of the beam (the *E*-plane).

Now swivel the antenna 90° to the right and take readings for the side lobes. Then swivel the antenna the remaining 90° and take the back lobe readings. Plot the front-to-back ratio. Purists may wish to experiment with sliding reflector inserts at this stage.

You now have some idea of the *E*-plane pattern, not to the exact "dB down" figure, but at least *relative* front-to-back and front-to-side ratios. These tests can, of course, be repeated for reciprocal receiving test readings by hooking up the transmitter to a folded dipole and reading out the data on a calibrated field strength meter and attenuator; but this requires lugging the transmitter out to range stake zero.

Figure 12 shows a lashup which takes less room but is for impedance matching only. It requires erecting a wooden mast. (If, however, you have a side of your house, without metal fittings, gutters, downspouts, etc., at least 25 feet high, you can cantilever a receiving dipole from it.)

The test antenna, whether intended for vertical or horizontal polarized operation, must be pointed straight up in the air or nearly so, with the reflector a minimum of one-half wavelength above ground.

Tune the stub as above for minimum reflected power. This antenna is for 220 MHz and 420 MHz only. Two meters would require at least a 35 foot mast. ■

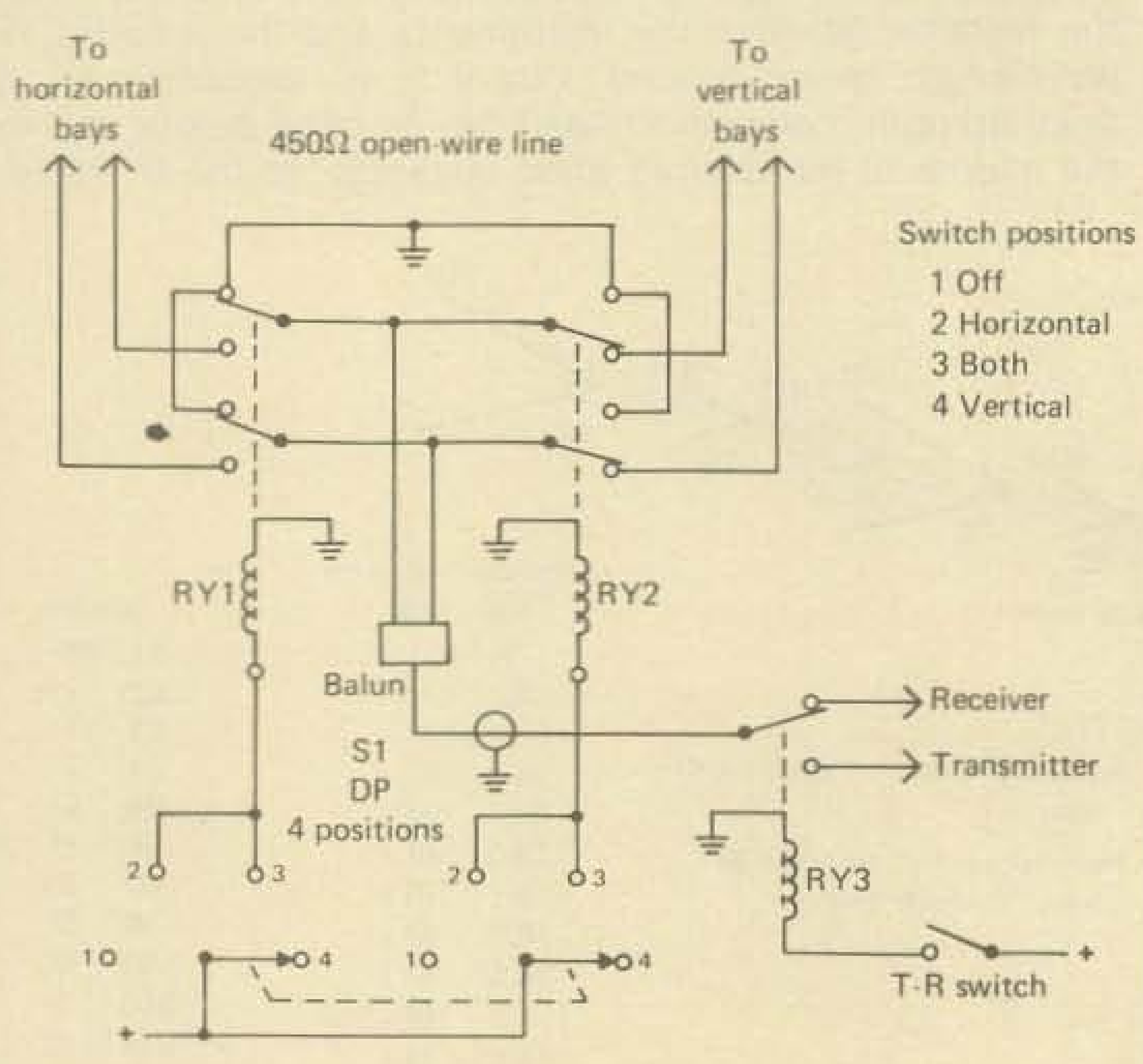
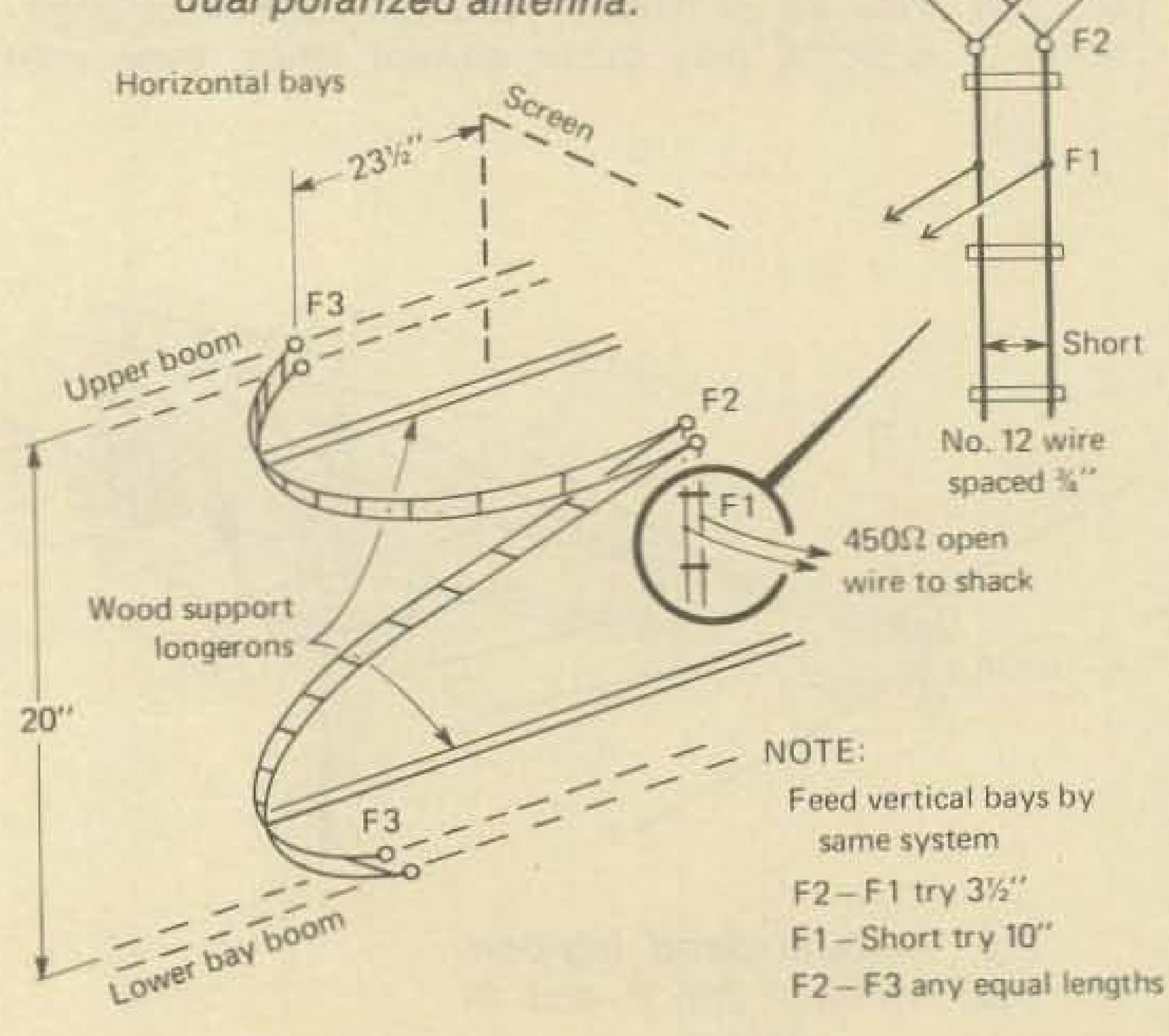


Fig. 9—Dual polarization feed system.

Fig. 10—Feed harness for ¾ meter dual polarized antenna.



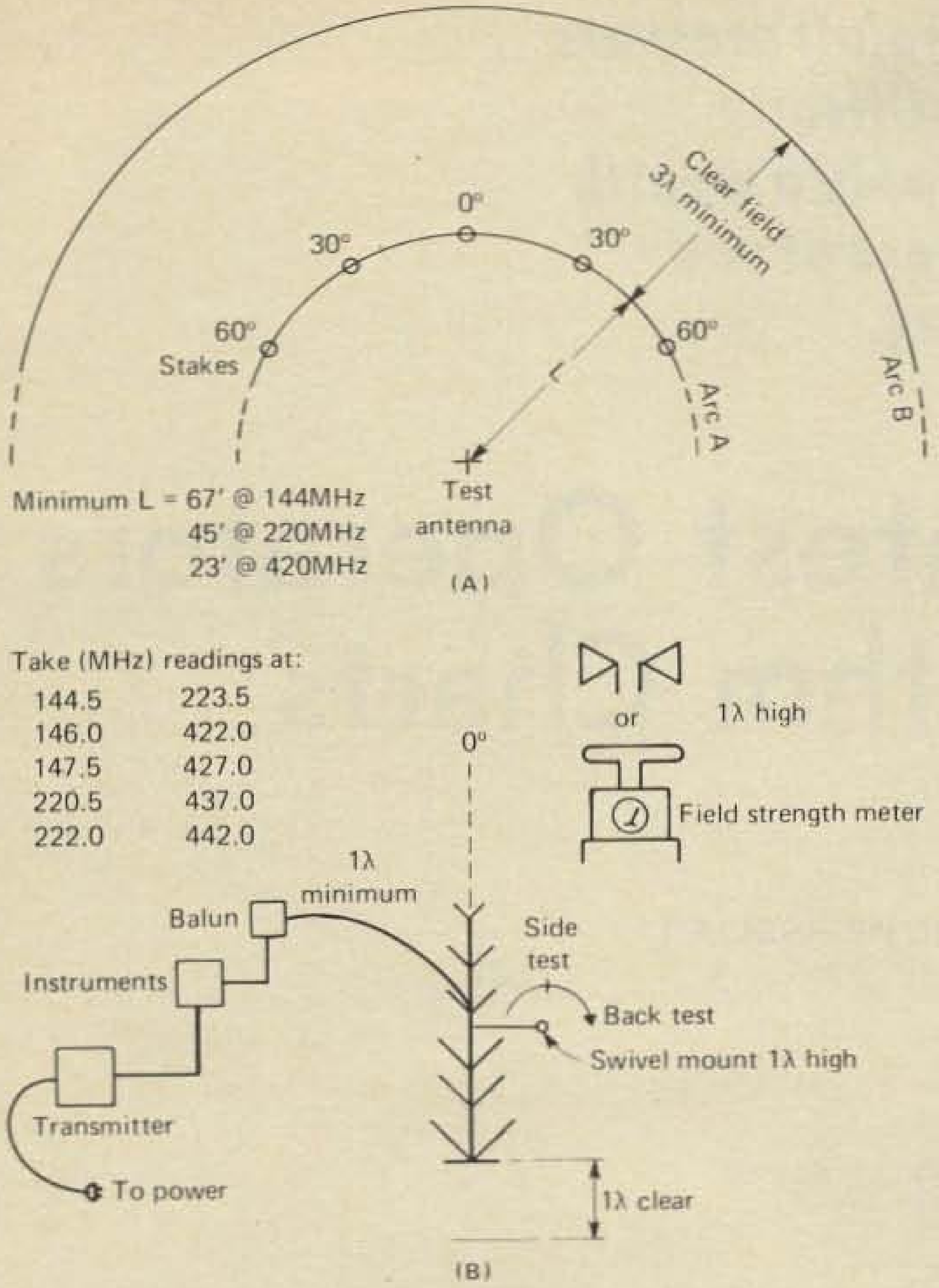


Fig. 11—Set-up for pattern test.

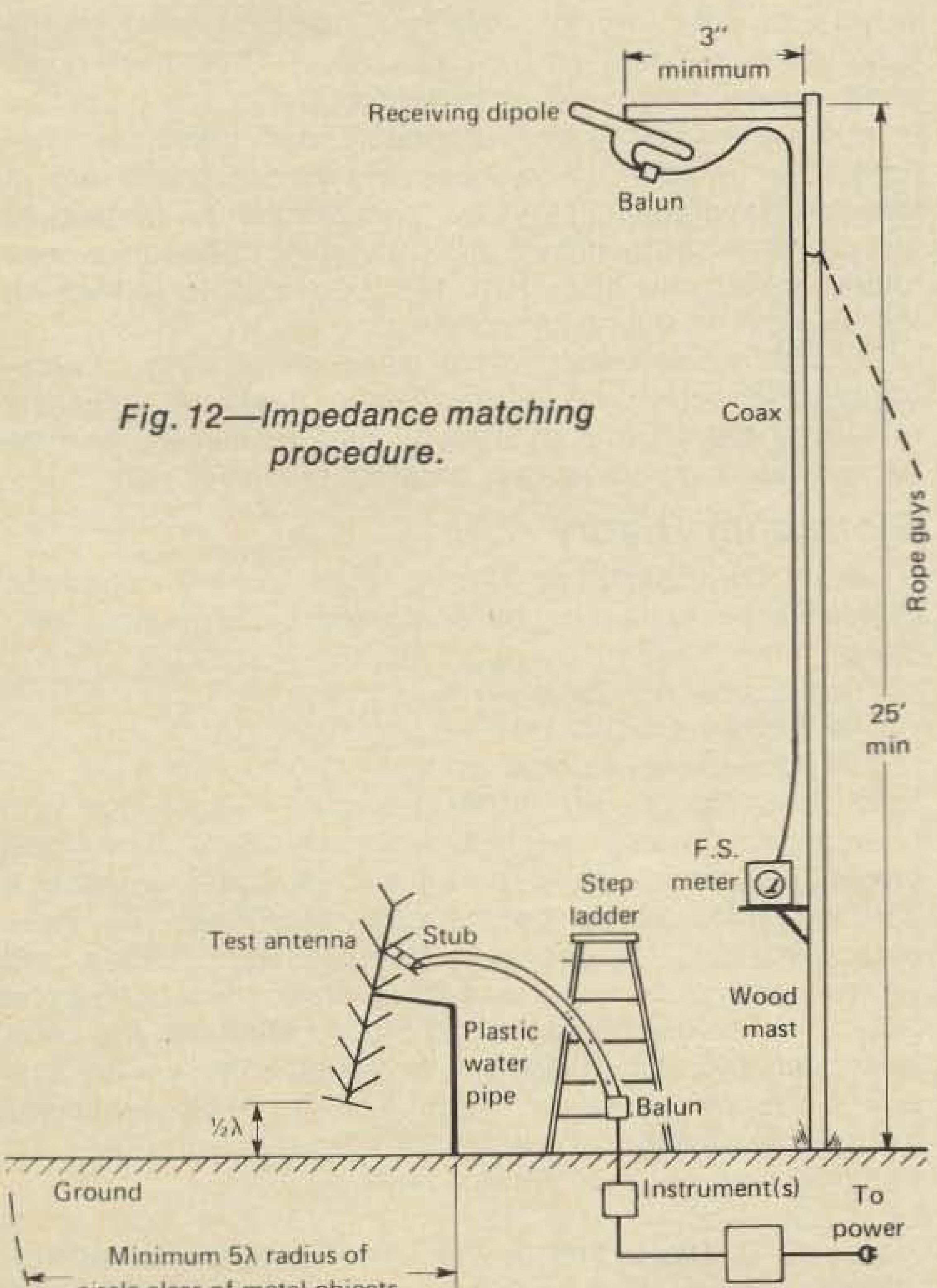


Fig. 12—Impedance matching procedure.