Practical Miniature Antennas For 80 Through 10 Meters

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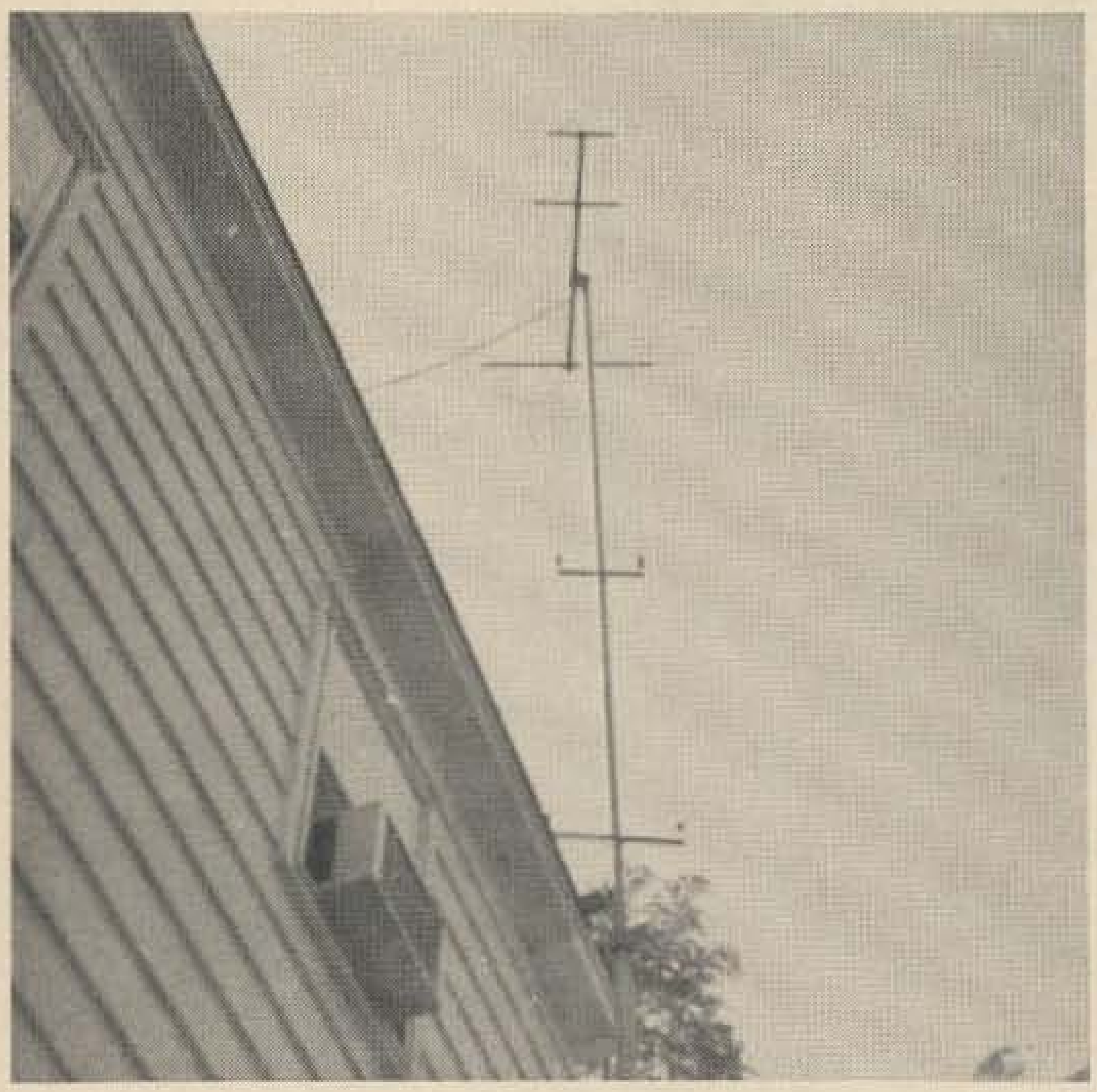

Equipment miniaturization has become common-place in Amateur Radio with the advent of modern transceivers and kilowatt linears that can fit in a shoe box. This article carries the miniaturization idea one step further, however, and describes *antennas* that are only 1/20th conventional size and, amazingly enough, have almost imperceptable losses, — 1 1/2 dB, compared with full size half waves.

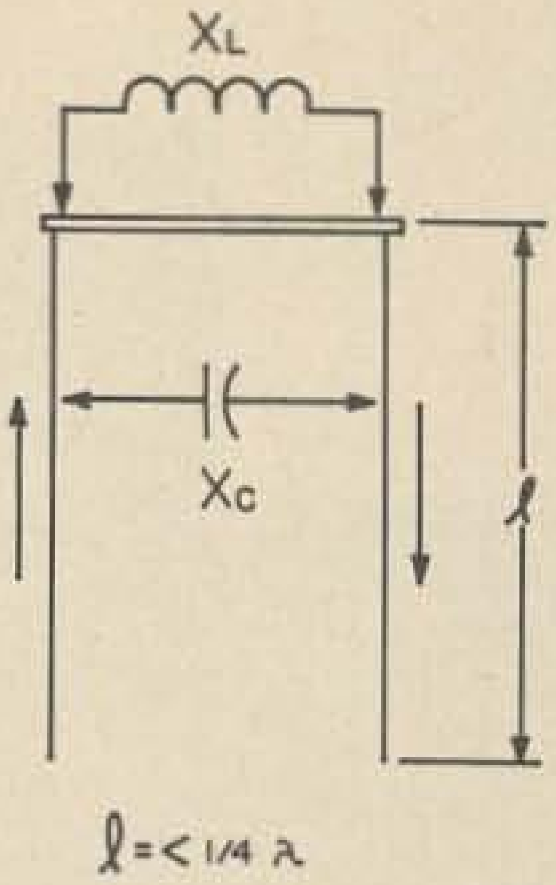

Fig. 1. The inductive reactance of a short copper element and the capacitive reactance of a $1/4\lambda$ section of open-wire line are combined to form a resonant antenna system.

Theory

The theory involved is quite simple: The *inductive* reactance of a short copper element and the capacitive reactance of a 1/4 λ section of open wire line are combined to form a resonant antenna system. See **Fig. 1.**

Since the open-wire line carries currents 180° out of phase and the wires are separated by only .024λ, there is very little radiation from this section. All radiation, therefore, takes place from the short copper element.

Losses

Reducing the size of an element lowers the radiation resistance considerably. An element only .024λ long, the length used here, shows a radiation resistance of only 0.5 Ω. However, the efficiency of the radiator remains better than 98% since the ohmic resistance of the short 3/4 inch copper elements average less than 0.008 Ω. I^2R losses in the open-wire line section are shown graphically in **Fig. 2.** If the line is made of at least #16 wire, the losses are small averaging slightly over −1 db.

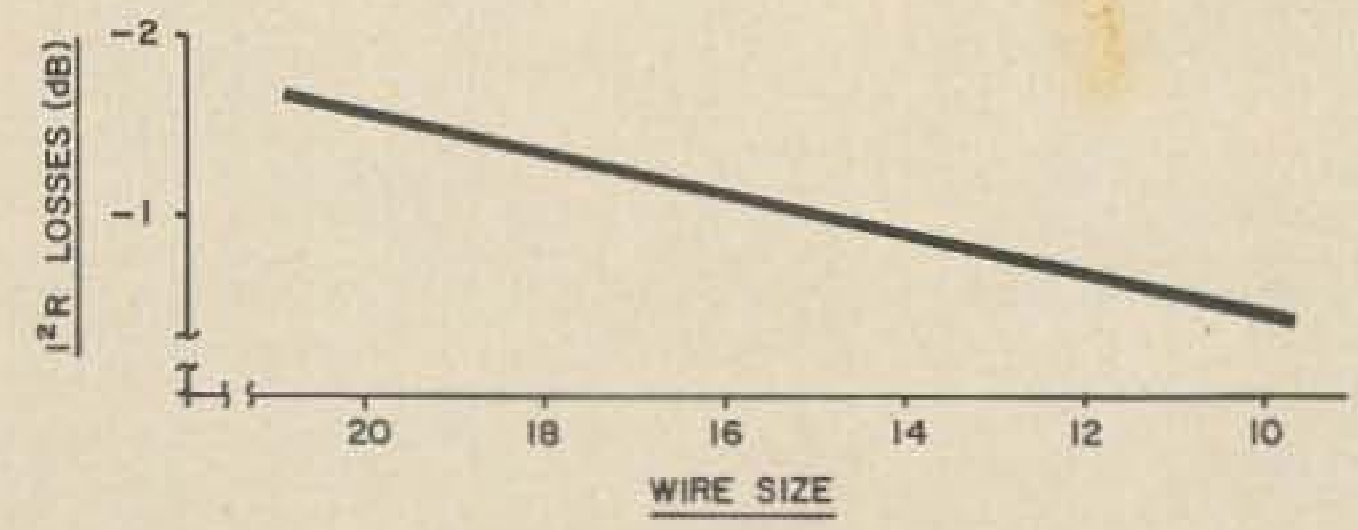

Fig. 2. Short antenna average I^2R losses vs. line wire size.

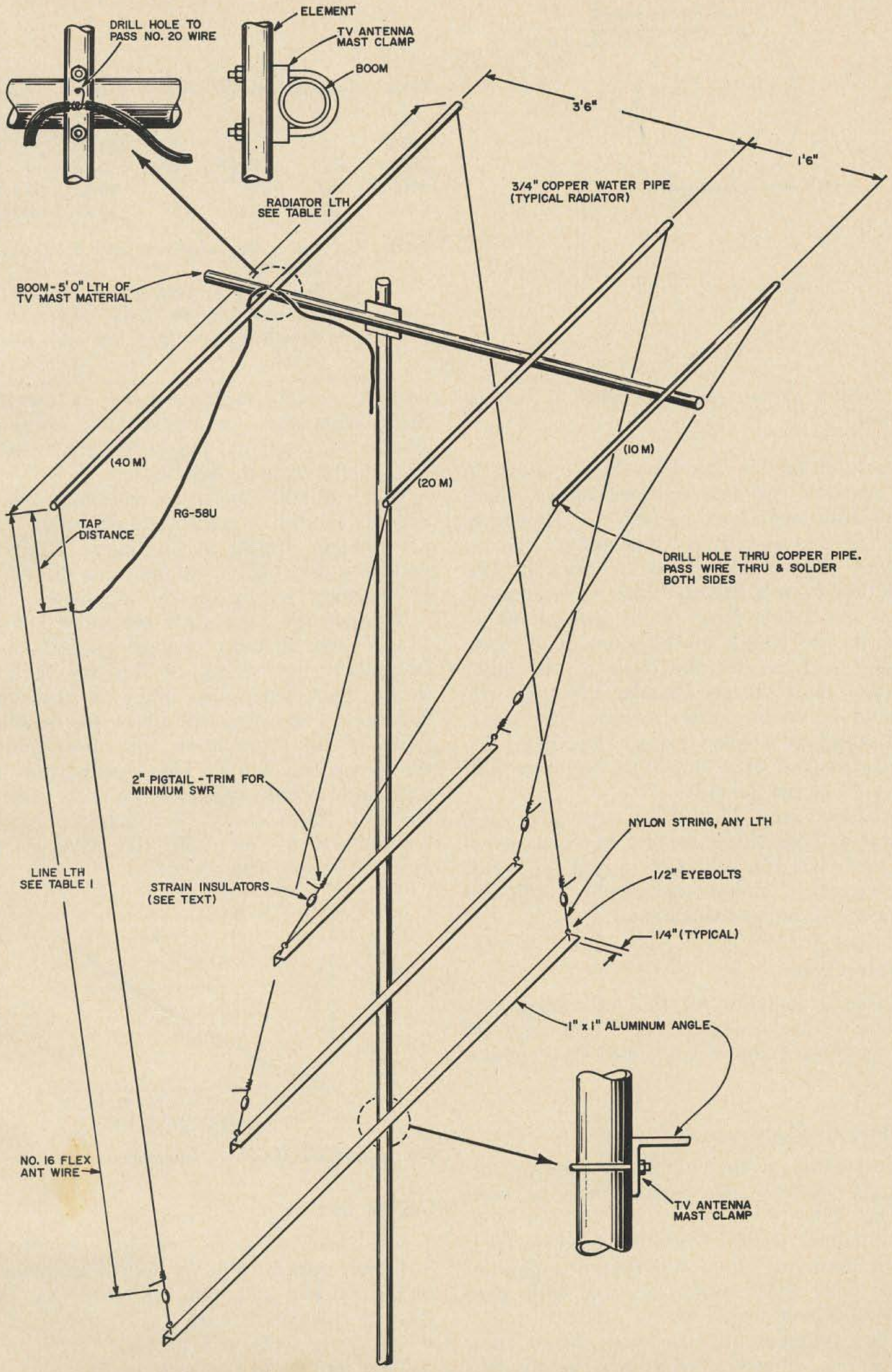

Fig. 4. Construction Details

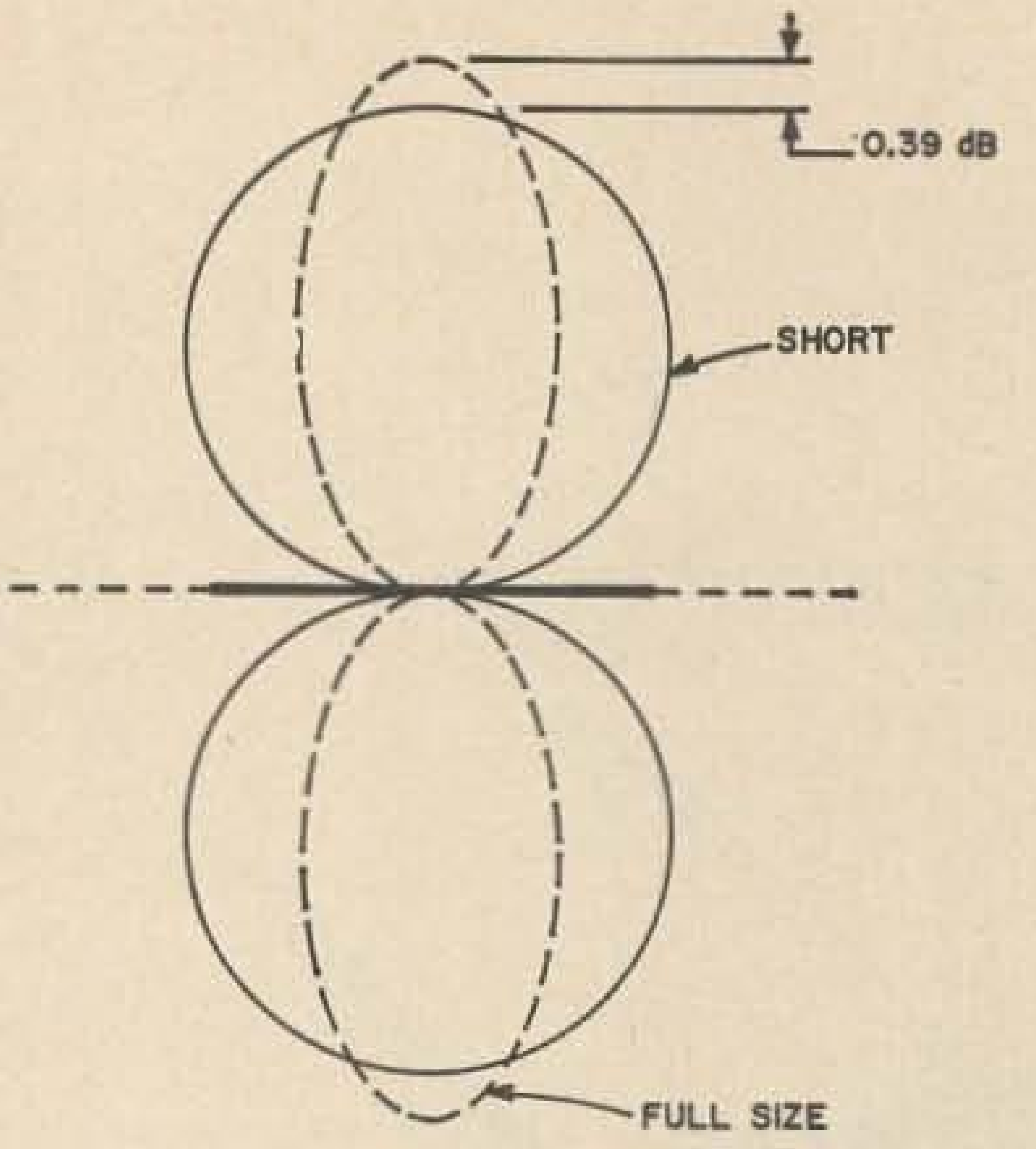

Fig. 3. Field pattern comparison short vs. full size element.

In addition to the I^2R (heat) losses in the element and line outlined above, there is an additional loss, termed the directivity loss, that results from shortening the radiator. This is illustrated in **Fig. 3.** The radiation from a full size half-wave element forms the classic figure eight pattern. However, as the length of the element is made smaller and smaller the ovals of the eight become more nearly circular although the general radiation pattern remains the same. The result is a loss in the immediate forward direction of −0.39 dB, and some "filling out" along the sides.

Summarizing: The directivity plus I^2R losses in these short element antennas average −1 1/2 db when compared with full size elements, a loss that could hardly be detected in the received signal!

Construction

Table 1 includes all the information required to size antennas for 10 through 80 meters. **Fig. 4** shows suggested construction details.

Additional Construction Notes

Horizontal arrangements are shown, although, vertical polarization could be used just as well.

Individual coaxial feeds are used on each band; however, one could design a parallel single feed that would function with very little additional loss.

Tap distances for use with 52 Ω coax are shown; however, feed lines of any impedance, balanced or unbalanced, can be used by merely tapping down on the line. Series capacitors are not required since the system is resonant and a purely resistive load is offered to the feed line.

Table I

Band	Length		Tap[2]	B.W.[3]	Loss[4]
	Radiator	Line[1]			
10M	10"	8'3½"	3"	245 Kc.	−1.3 db
15M	15"	11'1½"	4"	215 Kc.	−1.4 db
20M	20"	16'8½"	4½"	140 Kc.	−1.5 db
40M	40"	33'1"	7"	80 Kc.	−1.7 db
80M	80"	62'10"	12"	50 Kc.	−2.0 db

Notes: (1) Adjust line length for SWR 1:1 (see text)
(2) 52 Ω tap
(3) Bandwidth at SWR 2:1
(4) Includes line I^2R losses and 0.39 db directivity loss. #16 line wire size assumed.

Good quality moisture resistant end insulators should be used since extremely high r.f. voltages appear at this point. High impedances and higher voltages are the effects of standing waves on the open-wire line.

Because the capacitive reactance (of the 1/4 λ line section) changes rapidly with frequency, the tuning of the line is quite sharp. The dimensions given in the table, if followed closely, will place the resonant point of the antenna at the *lower* end of the respective band. The construction details show short pig-tails on each side of the line. These should be trimmed one-quarter inch at a time until the SWR is 1:1 at the operating frequency.

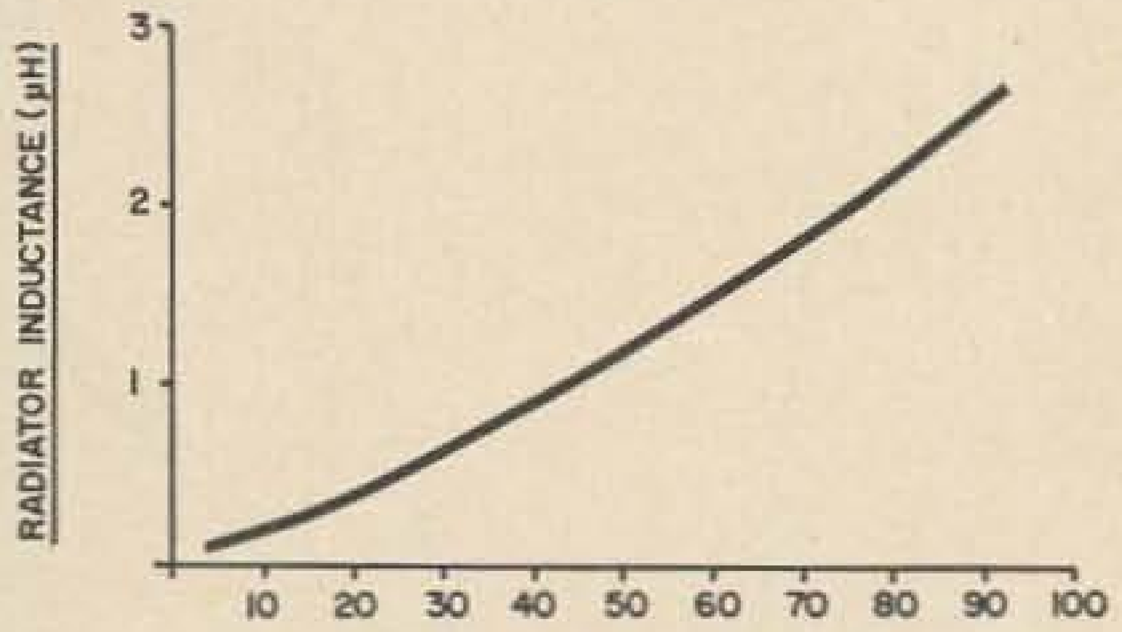

Fig. 5. Radiator length vs. inductance.

Design Details

The inductance, L_R, of short lengths of 3/4 inch copper pipe is shown graphically in **Fig. 5.** The inductive reactance, X_R, may then be calculated from:

$$X_R = 2\pi f_{mc} L_R$$

The length of open-wire line, l° (degrees), required to furnish the necessary resonant capacitive reactance can be determined from:

$$\text{Cot}\ l^\circ = \frac{X_R}{Z_o}$$

The line impedance, Z_O, for various spacings is shown in **Fig. 6.**

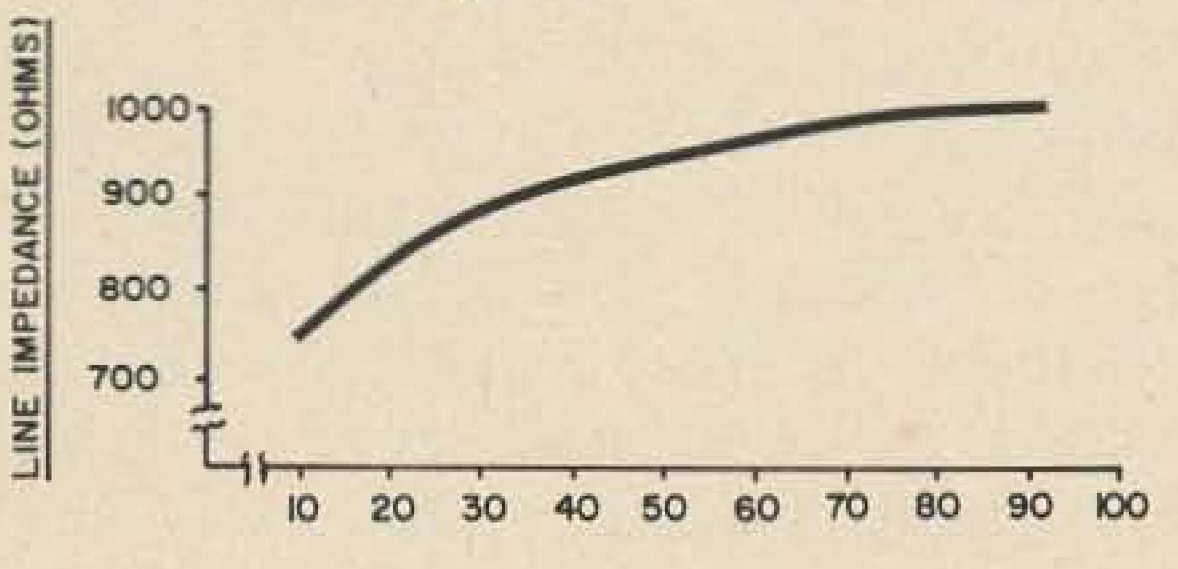

Fig. 6. Line spacing vs. impedance, Z_o, wire size #16.

Results

Tap distances, antenna "Q", and bandwidths were first calculated and then substantiated by testing. Unfortunately efficiencies were calculated but, lacking facilities to do so, were not checked under operating conditions.

Antennas for each of the bands have been constructed and used with results comparable to any of the full half waves used here at various times. Comparisons were run against a long wire (275 feet) antenna by switching between the two. In the direction of the maximum lobe of the long wire, the long wire outperformed the miniatures by 1/2 to 2 S units. In all other directions the miniatures were equal to or better than the longer wire. Both coasts are worked regularly on 40, 20 and 15 with reports ranging from S5 to S9.

Conclusions

Where space is available to mount them, full half waves have the edge, but if not, substitution of the minatures probably will not affect the results one way or the other, and then, you just might be able to raise the minature higher and that's a lot more effective than increasing it's length.

References

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Electromagnetic Waves and Radiating Systems—E. C. Jordan, Prentice-Hall Publisher.

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