Francis A. Spelman WA7CUS
4317 Northeast 56th Street
Seattle, Washington 98105

John Spillane W7UGV
2010 N.W. 60th St.
Seattle, Washington 98107

The Ferris Wheel Antenna for 160- and 80-Meters

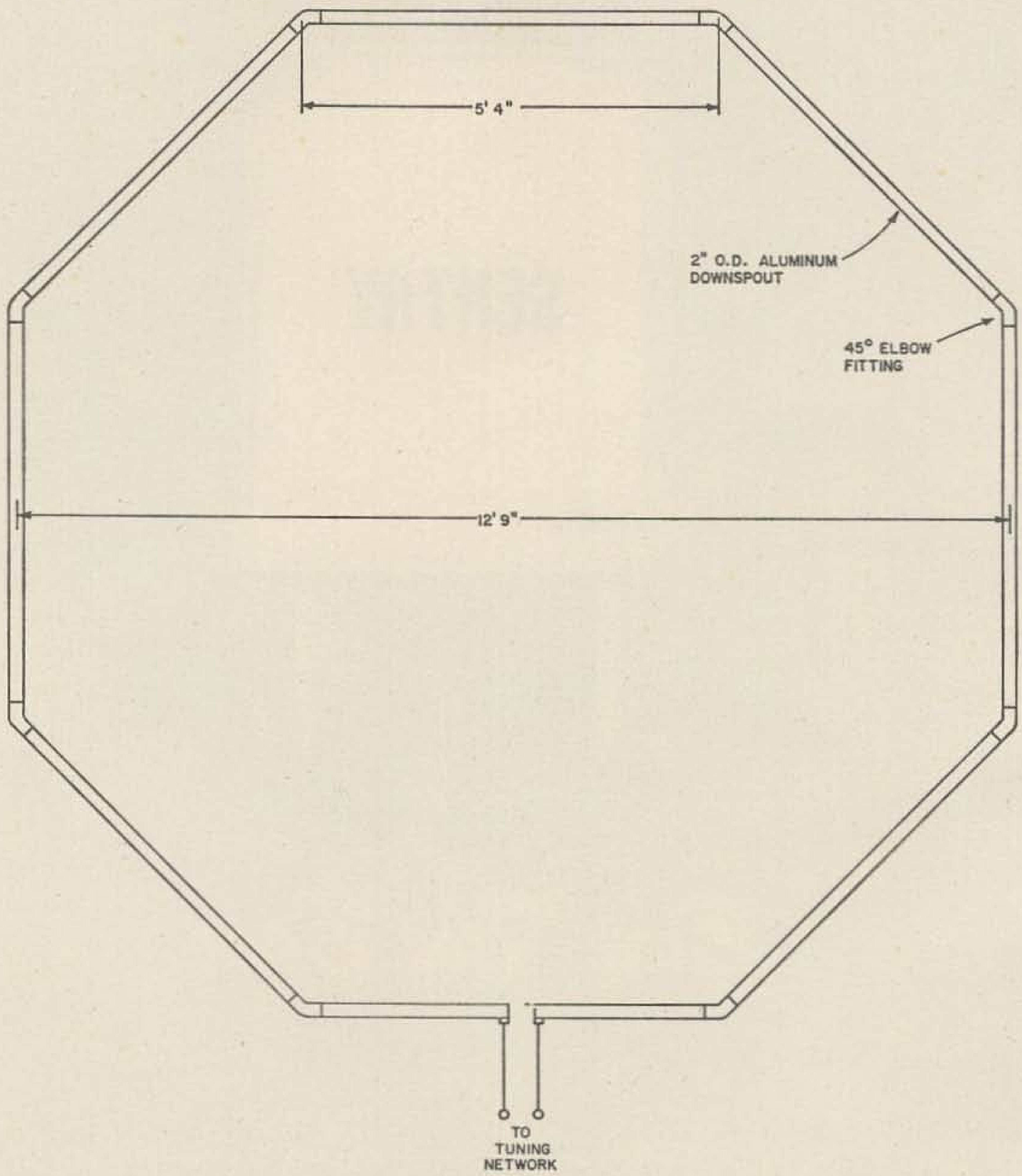


Fig. 1. A Ferris Wheel antenna cut for 160 and 80 meters. This antenna exhibits good efficiency with small size at relatively low height above he ground.

A recent article describing the use of loop antennas in Viet Nam[1] led the authors to plan and build the Ferris Wheel antenna described below. The Ferris Wheel is compact, inconspicuous, inexpensive, portable (if desired), broadband, and reasonably efficient. Its radiation characteristics are quite good—in fact the Army Limited War Laboratory found that a vertical loop antenna surpassed a low dipole in terms of radiated power[2]. Since the lower bands, particularly the 2 MHz and 4 MHz bands, are transmitted with low-hanging amateur antennas, the Ferris Wheel seemed an ideal antenna for low-frequency work. The antenna is good for both short and long skip, since it has good radiation characteristics at both low and high angles. The Ferris Wheel is an ideal field-day antenna, since it requires virtually no support on a calm day, and only minimal

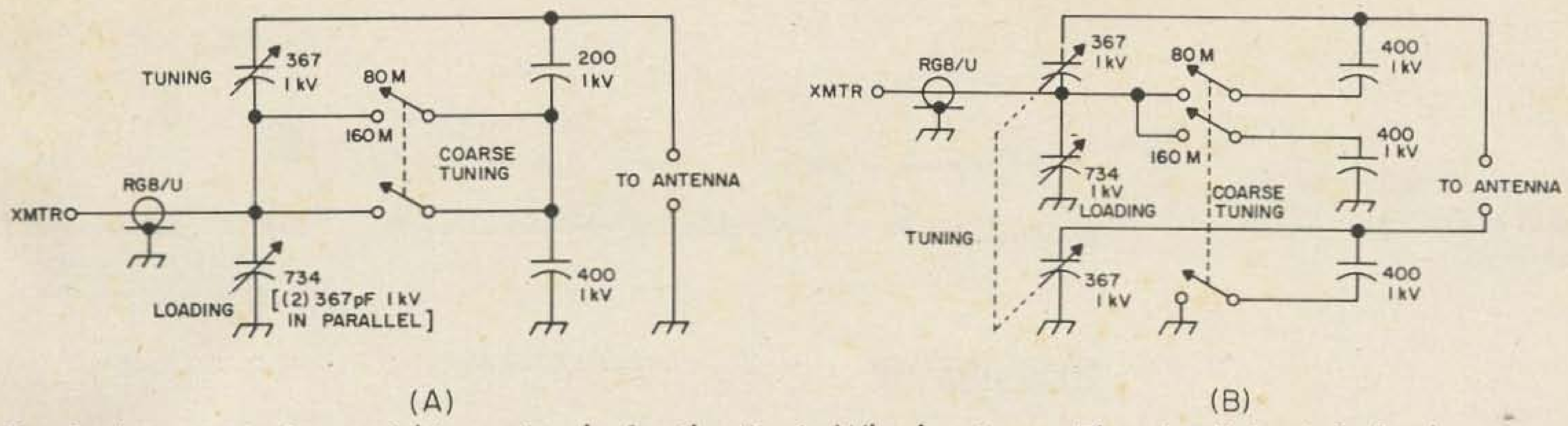


Fig. 2. Antenna tuning matching networks for the Ferris Wheel antenna. The circuit in A is for low-power applications; the circuit in B for high power.

support on a blustery day. Finally, as a permanent antenna, the Ferris Wheel is quite sturdy, the model built here having survived both small-craft and gale warnings with no ill effects.

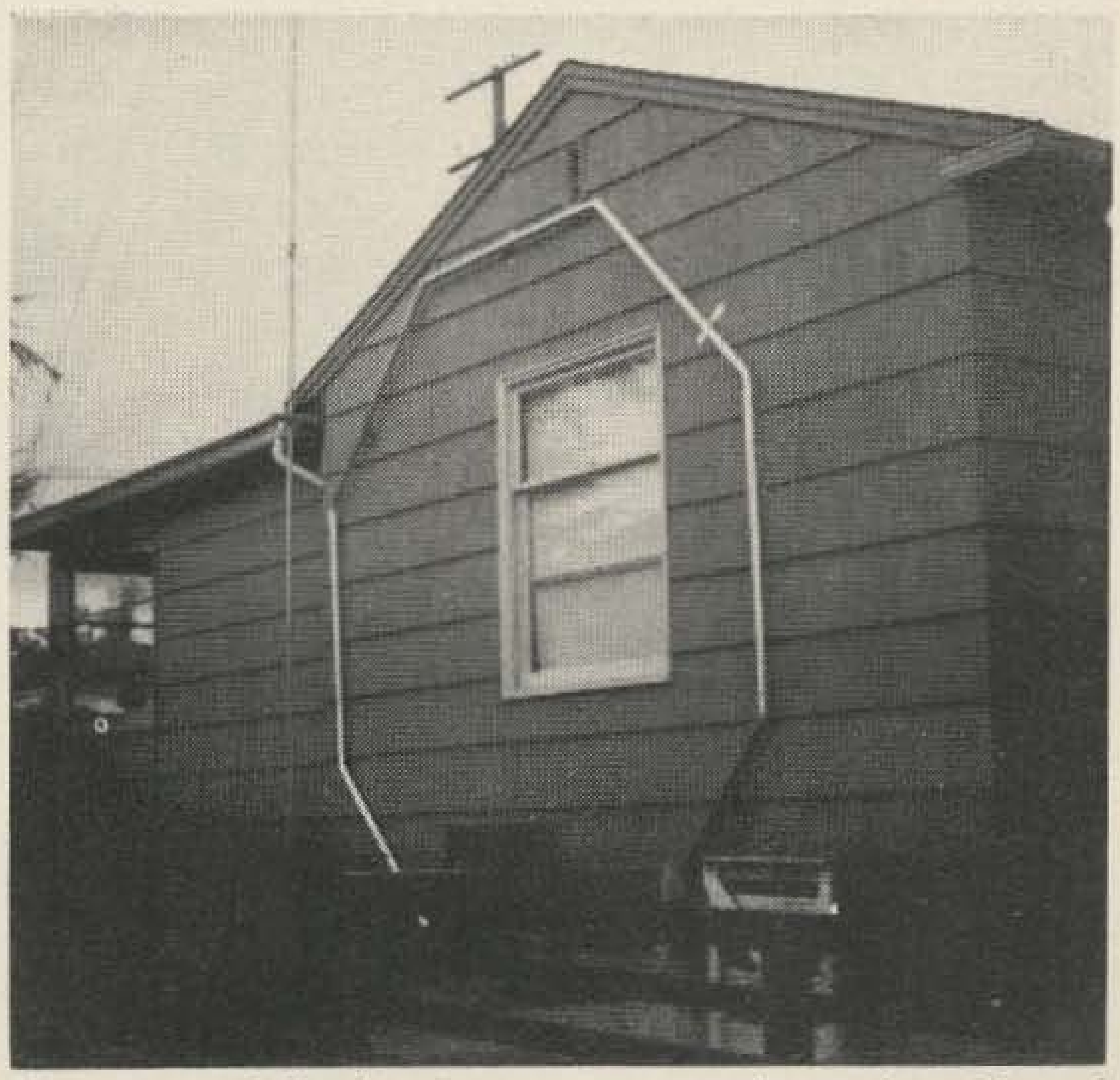
The Ferris Wheel antenna (**Fig. 1**) is a loop antenna mounted vertically upon the ground. Since the radiation resistance of a loop antenna is very small (see **Table 1**), the conductor forming the loop must be made as large as possible in order to achieve reasonable (if disadvantageous) efficiency. In order to reduce loss resistance, we selected 2-inch aluminum downspout as the conductor of the Ferris Wheel. Obviously, we used unpainted, bare aluminum.

A forty-foot circumference loop antenna, made of 2-inch aluminum downspout, will have reasonable (17.5%) efficiency at 2 MHz and better (70.7%) efficiency at 4 MHz. Conveniently, aluminum downspout is sold in 10-foot sections. Since radiation resistance is proportional to the square of the area of the loop[3,4,5], an octagonal shape was chosen over a square shape since the octagonal has 20% more area for the same circumference, and thus, the radiation resistance is 44% greater. Additionally, five-foot lengths of downspout are much more convenient to handle than ten-foot lengths in a portable installation, and 45-degree elbows are readily available while 90-degree elbows are not. Both elbows are listed in catalogs, but the 90-degree elbows are generally missing from the local dealers' shelves.

The capacitive tuning network (**Fig. 2A**) is simple to make and to tune, and it will handle powers of several hundred watts. The values shown tune the antenna within the 160-meter and 80-meter amateur bands. For higher power operation, the balanced network of **Fig. 2B** may be used. Tuning this network is more difficult, but by no means impossible.

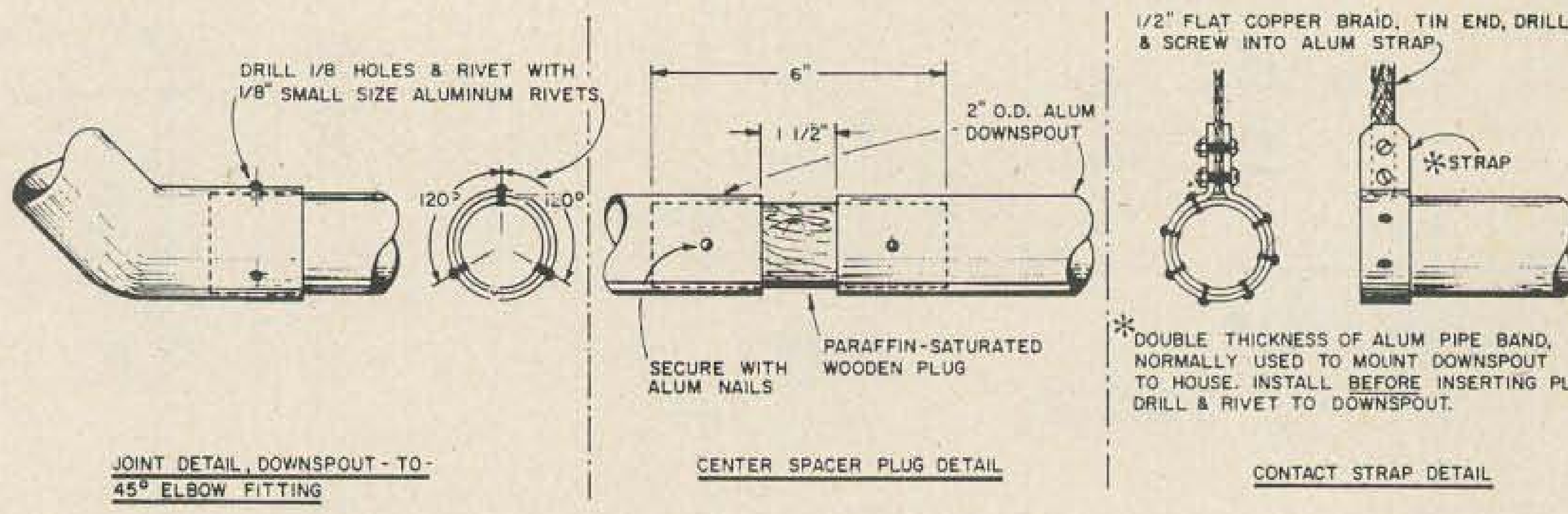
The Ferris Wheel antenna has given excellent results, both on 160-meters and on 80-meters. One evening, on the first try made on that band, we made a contact of 400 miles on 160-meters, and we had several contacts on 80-meters, ranging from 3 to 600 miles.

The key to success with the Ferris Wheel is to maintain low resistance in all joints and connections. To achieve this we force-fit each joint between the downspouts and elbows, and then drilled three holes, approximately 120-degrees apart, and then riveted each downspout-to-elbow joint (**Fig. 3**) with aluminum rivets. The rivets were inserted with a hand riveter, available for about $5.00 at either a harware store or Sears. Aluminum rivets must be used to avoid future electrolysis and corrosion at the joints. At the feed point, an inch-and-a-half was removed from the center of the five-foot downspout, and a paraffined wooden plug was inserted in the downspout as a spacer (**Fig. 3**). Connection was made to the feedpoint with



The Ferris Wheel antenna mounted to the side of WA7CUS's house.

Fig. 3. Construction details of the Ferris Wheel antenna.



double aluminum strap (available to affix the downspout to a house) riveted to the downspout as shown in **Fig. 3.** Half-inch tinned copper braid was screwed to the tabs on the aluminum strap (**Fig. 3**) and used to tie the loop to the tuning network inside the shack. The joints were all sprayed with Krylon (after riveting and attaching the braid) for weather protection. The loop was fixed to the side of the house with five aluminum straps, each made of a pair of downspout straps, and the loop was spaced 1¾-inches from the house with square, painted, wooden spacers.

The total time of erection of the Ferris Wheel antenna is less than five hours, including the hacksawing, cutting, fitting, drilling and riveting. The above time includes searching for spacer wood in a basement junk heap, spacer carving with a dull knife, but not paraffin treating, spacer painting, and construction of the tuning network. The network had been built before the antenna was raised. Tuning network construction is straight-forward (although number 14 wire should be used to make all connections), and is left to the imagination of the reader.

The radiation pattern of the Ferris Wheel antenna is directional in a horizontal plane, and is vertically polarized. Both the horizontal pattern and the vertical pattern are shown in **Fig. 4.** The patterns shown are those of a vertical loop, resting upon a perfectly conducting earth. The patterns do not differ substantially from those of a small vertical loop in space, and thus imperfect ground has little effect on the loop, as long as the loop is close to the ground. Patterson's article points this out, and a few moments analyzing a loop antenna and its image due to a ground plane will substantiate the result. Tests made on the antenna at 3.96 MHz within the state of Washington confirm the theoretical pattern.

The Ferris Wheel is a broadband antenna. Using the network in **Fig. 2A,** we found that once the antenna is tuned midband on the 75-meter band, VSWR remains with 1.6:1 throughout the band. But the Ferris Wheel is easily tuned, and with the aid of a VSWR bridge, it can be adjusted rapidly. Patterson's article shows a VSWR bridge built into the tuning unit, and for installations where the antenna is not at arm's reach from the transmitter, a bridge built into the tuning unit would be most convenient. Since the feed point can be anywhere on the loop, the antenna feedpoint can be placed convenient to the transmitter. Initial tuning (within 2:1 VSWR) can be made by tuning the antenna to maximum signal output in the receiver (AVC off). Final tuning is done with transmitter RF power.

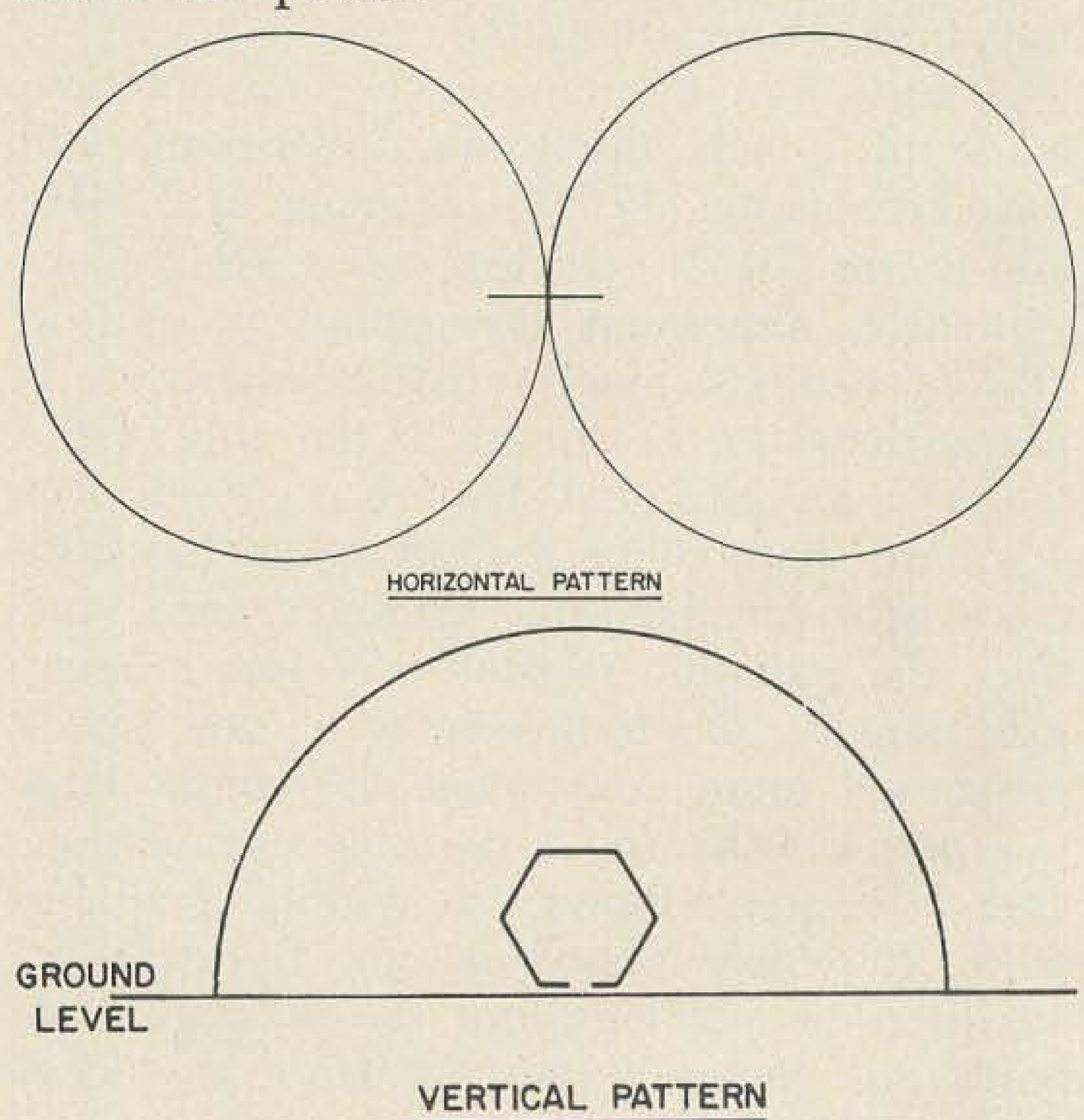


Fig. 4. Patterns for a small vertical loop antenna, resting on a perfectly conducting earth. Tests made by the authors appear to confirm that the Ferris Wheel antenna pattern closely resembles this theoretical pattern.

Since our initial tests on the Ferris Wheel antenna were made using force-fit joints between the downspouts and elbows, and during those tests we had good results from distant (12 miles) stations during the after-

Table 1. Comparison of antenna size, frequency and efficiency.

Frequency	Section Length	Radiation Resistance	Loss Resistance	Efficiency	Circumference
2 MHz	5 ft	$7.5\times10^{-3}\Omega$	$3.53\times10^{-2}\Omega$	17.5%	40 ft
4 MHz	5 ft	0.120Ω	$5.00\times10^{-2}\Omega$	70.7%	40 ft
4 MHz	3.28 ft	$2.30\times10^{-2}\Omega$	$3.28\times10^{-2}\Omega$	41.3%	26.24 ft
7.3 MHz	3.28 ft	0.259Ω	$8.85\times10^{-2}\Omega$	74.5%	26.24 ft

noon on 75-meters, we concluded that a force-fit Ferris Wheel would make a useful field day antenna for the two dc bands. Performance is not deteriorated by resting the loop on the ground, so long as losses are not increased at the feedpoint (from moist earth, for example). For the initial tests, our loop was rested upon a wooden 4x4 on the ground, and the loop leaned against the side of a house. In the field, the Ferris Wheel could rest on the ground, and lean against a tree for support. The five-foot lengths of downspout slip easily into the back seat of a car, or into the back of a station wagon, and the elbows are simple to store and carry.

Table 2. Material required for the Ferris Wheel antenna.

Part	Quantity
Downspout, 2-in diameter, Aluminum, 10-ft. section	4 each
Elbow, 45-deg., 2-in. diameter, Aluminum	8 each
Strap, downspout mounting, Aluminum	14 each
Rivet, 1/8-in., Aluminum, small	70 each
Nail, Aluminum, roofing	12 each
1¾ x 1¾ x 24-inch unfinished board	1 each
Plastic spray, krylon spraycan	1 each
Paint, house (to match QTH decor), to paint mounting spacer blocks	As needed
Capacitor, variable, transmitting, 1 kV, 365 pF	1 each 1 each
Capacitor, ganged variable, transmitting, 1 kV, 365 pF each section	1 each
Capacitor, silver mica, 1 kV, 400 pF	1 each
Capacitor, silver mica, 1 kV, 200 pF	1 each
Switch, ceramic wafer, 2PST	1 each
Braid, tinned copper, 1/2-inch	6 feet

The Ferris Wheel antenna can be made for higher frequencies than 2 MHz and 4 MHz. **Table 1** lists radiation resistance, section length, and efficiency for a 2/4 MHz antenna and for a 4/7.3 MHz antenna. At higher frequencies, the advantages of a small loop are far outweighed by the advantages of other types of antennas, and so the calculations are not presented for frequencies higher than 7.3 MHz.

The Ferris Wheel is an inexpensive, simple, and effective antenna at 2 MHz and 4 MHz. It is easily erected for either a permanent installation or for field day. It can be made of readily available materials **(Table 2)** within an afternoon.

. . . W7UGV, WA7CUS

Antenna efficiency is given by

$$\text{efficiency} = R_r/(R_r + R_l)$$

where

R_r = radiation resistance = $3.12\times10^{4}\times(A)^2/(\quad)^4$ ohm

R_l = loss resistance = $6.25\times10^{-7}\times(s)(f)^{1/2}$

s = circumference in feet

f = frequency in Hz

The logic leading to the above formulas is found in reference 4, Chapter 12, Section 10; Chapter 5, Section 17.

References

[1] Patterson, Kenneth H., "Down-to-earth Army Antenna," *Electronics* (August 21, 1967), 111-114.

[2] *loc. cit.*, p. 114.

[3] *loc. cit.*, p. 113.

[4] Ramo, Simon, *et. al., Fields and Waves in Communication Electronics*, pp. 288-303, 656-657, New York, John Wiley & Sons, Inc., 1965.

[5] King, Ronold W. P., *et. al., Transmission Lines, Antennas and Wave Guides*, pp. 224-230, New York, Dover Publications, Inc., 1965.