Some Notes on Ground Systems for 160 Meters

Getting a good ground system for a quarter-wave antenna isn't easy, when the job has to be done on an ordinary city lot. The experience of W1TX should be helpful to others seeking an answer to installing an effective radiating system on 160 meters.

Because of the wavelength dimensions, practical considerations make the grounded antenna the rule on the 160-meter band. Thus a natural question arises — what constitutes an effective grounding system for that band in an average amateur location? The question was settled years ago for an ideal installation [1] and the results are briefly summarized in the *Antenna Book* [2]: The grounding system should consist of 120 radials at least a half wavelength long, spaced uniformly around the circle like spokes in a wheel. But who among us has the space or facilities to put in such a monster? What to do when everything has to fit into an ordinary city lot?

Roy Fosberg, W1TX, faced this problem and decided to see what he could do about it. His setup is typical of the average, although the details of what can be done will naturally vary from one spot to another. Experiments and measurements were carried out over a period of about a year and a half, with results that have been interesting and beneficial, although in some respects a little hard to account for. The following information is offered not in the thought that duplication is either possible or necessarily optimum, but rather to indicate trends that should offer guidance to those who want to make their 160-meter antenna systems as effective as possible.

The physical layout at W1TX is shown in plan in Fig. 1. The grounding system consists of both driven rods and radials, the arrangement being dictated by the availability of space plus actual observation of the effect of adding rods and radials successively. The antenna itself, an inverted L a quarter wavelength long over-all, remained

[1] Brown, Lewis and Epstein, "Ground Systems as a Factor in Antenna Efficiency," *Proceedings of the I.R.E.*, June, 1937.

[2] *The ARRL Antenna Book*, Chapter 2.

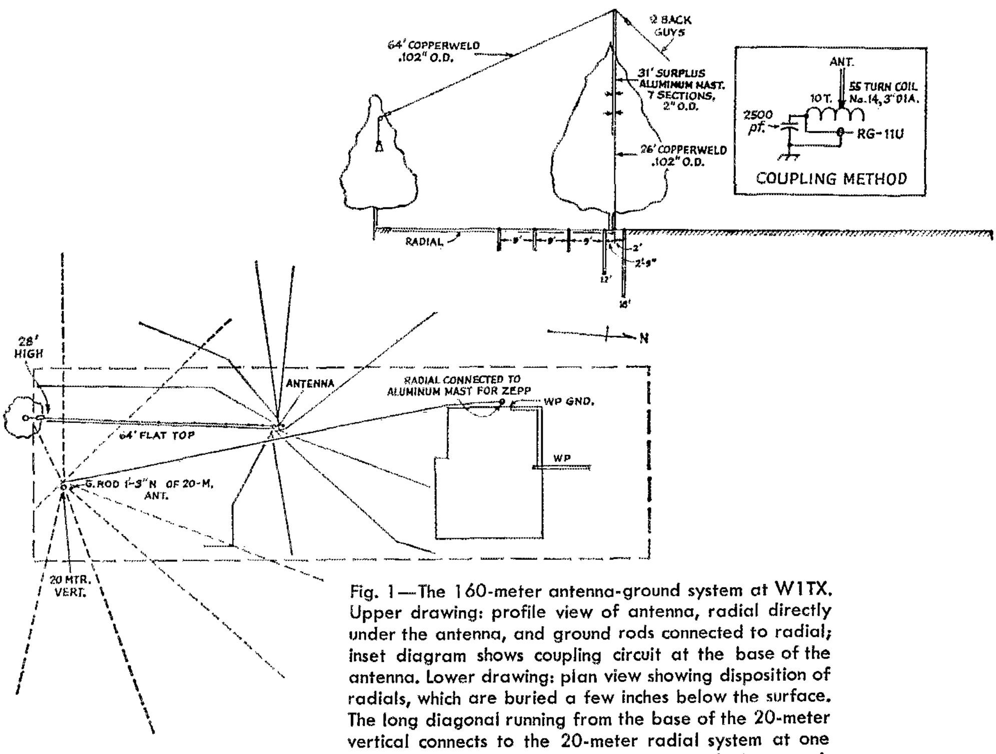


Fig. 1—The 160-meter antenna-ground system at W1TX. Upper drawing: profile view of antenna, radial directly under the antenna, and ground rods connected to radial; inset diagram shows coupling circuit at the base of the antenna. Lower drawing: plan view showing disposition of radials, which are buried a few inches below the surface. The long diagonal running from the base of the 20-meter vertical connects to the 20-meter radial system at one end and to the grounded aluminum mast at the house end. It is also tied into the 160-meter radial system where it crosses the radial running in the "5-o'clock" direction.

the same throughout the tests, so it can be assumed that any change in the ground system that resulted in an increase in the r.f. current at the base of the antenna, for the same d.c. plate input to the final, improved the radiating efficiency.[3] Antenna current therefore was used as the criterion. Because of the length of time over which the tests were conducted, the several r.f. meters used were periodically checked for calibration. As W1TX is associated with the local power company and has access to the necessary equipment, the 60-cycle ground resistance for various configurations also was measured.

Ground Resistance vs. Ground-Rod Depth

It is not to be expected that the r.f. resistance of a ground rod will follow the same pattern as the 60-cycle a.c. resistance, when the depth of the rod is increased, because radio-frequency currents do not penetrate the earth as deeply as do 60-cycle currents. However, for moderate depths it is probable that the trend is the same in both cases. The following table is typical of 60-cycle resistance *vs*. depth, using a 5/8-inch diameter sectional galvanized steel rod:

Depth, ft.	*A.C. Res., ohms*
2	400
4	325
6	175
8	70
10	47
12	40
14	37.5
16	36
18	29

The soil was dry when these measurements were made. Similar measurements after a rain showed values of the order of 1/3 less resistance at depths of 10 feet or more. The difference between dry and wet was more marked at the shallow depths, being of the order of four times as high, dry, at 4-foot depth.

Increasing the number of ground rods with spacings as shown in Fig. 1 caused the total 60-cycle resistance to decrease, as would be expected. This also was generally true of the r.f. resistance, as indicated by the change in antenna current, but there were exceptions.

[3] This was confirmed by field-strength measurements made at distances of several wavelengths from the antenna. The relationship between antenna current and field strength was linear. The field-strength meter was calibrated against a standard signal generator.

Hints on Ground Systems

As result of the series of tests, which are not reported here in detail, W1TX offers the following conclusions:

"1. With a bit of meticulous planning, a 160-meter antenna system can be installed on a 50- by 160-foot lot to give a good account of itself. In my case, with a quarter-wave inverted-L antenna and a ground system of four radials and five ground rods, 80 QSOs with foreign stations were made with 50 watts input during the 1962–1963 winter period. These included VP8, VK and ZL.

"2. One to five ground *rods* of the sizes and locations shown in Fig. 1 installed in the plane of the antenna ranged from 80 percent higher efficiency for one rod to 19 percent higher for five rods, as compared with the corresponding number of *radials.*

"3. It appears that from about eight units (rods or radials) upwards, radials are slightly more efficient than rods.

"4. If radials are to be used, at least twelve are recommended as well worth the effort of installation. Beyond twelve, the improvement *per radial* is small. (Scrap No. 12 or No. 14 house wire from which the insulation has been stripped makes a relatively inexpensive radial ground system.)

"5. If ground rods are to be used they should be connected to the ground system one at a time and their effectiveness checked. Rods in some locations were found to be of no benefit, and some actually were detrimental

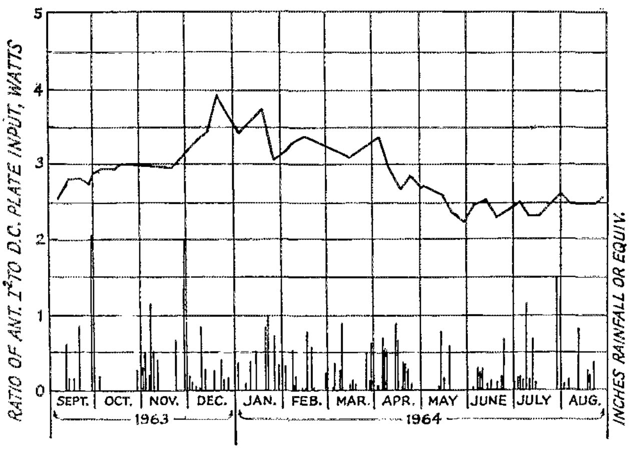


Fig. 2—Seasonal variation of antenna relative efficiency. Weather-bureau data on precipitation are also plotted. The ratio from the winter high to the summer low is almost 3 db.

to the effectiveness of the ground system.

"6. Ground rods are recommended to be a minimum of 10 feet long. Six-foot, ⅝-inch diameter threaded galvanized sectional rods coupled together as driven make ideal 12- or 18-foot rods which can be driven rather simply with a 10-pound hammer."

Seasonal Variations

Early in the experimental work it was found that the ground resistance, as indicated by the relative radiating efficiency, varied over a period of time. (Relative radiating efficiency is defined here as the ratio of the square of the antenna current to the d.c. input to the final stage.) The state of soil moisture offered a possible reason for this, so after the final ground/radial system shown in Fig. 1 had been arrived at, the system was left alone and the efficiency was checked at regular intervals. These measurements were continued over a year — from the beginning of September 1963 to the end of August 1964.

The results are shown in Fig. 2. Precipitation data obtained from the local weather bureau are plotted on the same graph. If there is any correlation between efficiency and equivalent rainfall it is certainly not readily discernible. The efficiency definitely was highest during the cold season and was low throughout the summer. The same behavior had been observed earlier, and was the reason for running the tests over a complete year without changing the antenna system. No tie-in has been observed between the actual wetness of the ground and the antenna efficiency.

It may be, of course, that this behavior is associated with some pecularity of the local soil. New England soil has notoriously poor conductivity, and it has long been accepted that the northeast section of the country is poor ground-wave territory in the broadcast band. If the conductivity drops very low in the winter, when such moisture as there is in the crust is usually frozen, it may be that the rod/radial system tends to act like a counterpoise rather than as a ground. Under such circumstances the losses could be lower than in summer, when the earth dielectric has high-enough conductance to make it lossy. This is only speculation, however, and it would be interesting to see what similar measurements made in other sections of the country would show. QST

"Nothin' On"

BY JOHN G. TROSTER,* W6ISQ

CLICK, click, click, snap, snap.

"Cq cq cq cq cq cq cq . . . cq cq cq cq cq . . . cq cq cq cq . . . cq cq cq cq . . . cq cq de de W6ISQ W6ISQ W6ISQ W6ISQ k k."

"Cqcqcqcqcqcq . . . cqcqcqcqcq . . . cqcqcq-cqcqcq . . . cqcqcqcqcq . . . cqcqcqcqcqcqcq . . . cqcqdedew6isqw6isqw6isqkk."

"CQCQCQCQCQ . . . CQCQCQCQCQCQ . . . CQCQCQCQCQCQ . . . CQCQCQCQCQ . . . CQCQCQCQ . . . CQCQDEDEW6ISQW6ISQ-W6ISQW6ISQKK."

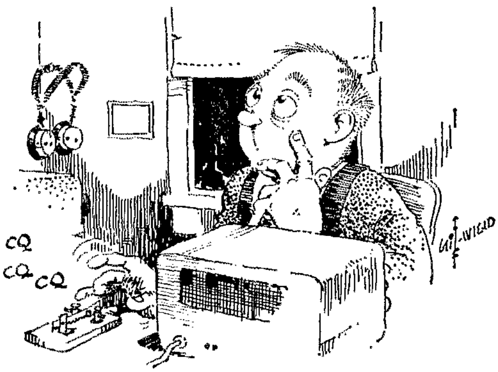
"C q c q c q c q c q . . . c q c q c q . . . c q c q c q c q . . . c q c q c q . . . c q c q d e d e W 6 I S Q W 6 I S Q W 6 I S Q K."

"C Q C Q C Q C Q . . . C Q C Q C Q . . C Q C Q C Q C Q . . . C Q C Q C Q C Q . . . C Q C Q D E D E W 6 I S Q W 6 I S Q W 6 I S Q k."

"Cq cq cq cq cq . . . cqcqcqcqcqcq . . . cq cq cq cq cq cq . . . cqcqcqcqcqcqcqcqcq . . . cq cq cq cq cq cq . . . cqcqcqcqcqcqdedeW6ISQ W6ISQW6ISQW6ISQKK."

"CQCQCQCQCQCQCQ . . . CQCQCQCQCQ CQ . . . c q c q c q c q c q . . . cqcqcqcqcqcqcq . . . . c q c q c q c q . . . CQCQCQCQCQCQ . . . c q c q c q . . . cq cq cq cq cq cq . . . cq cqcqcqcqcqcq . . . C Q C Q C Q C Q C Q . . . c q c q c q c q . . . CQ CQ . . . cqcqcqcqcqdede W6ISQ W 6 I S Q W 6 I S Q k."

"C Q C Q C Q C Q C Q . . . C Q C Q C Q . . . C Q C Q C Q . . . C Q C Q C Q C Q . . . C Q C Q C Q . . . CQCQCQCQCQ . . . C Q C Q C Q C Q D E W 6 I S Q W 6 I S Q W 6 I S Q K K."



"Cqcqcqcqcqcq . . . C Q C Q C Q C Q . . . cq cq cq cq . . . CQ CQ CQ CQ CQ . . . c q c q c q c q . . . CQCQCQCQCQCQCQ . . . cq cq cq cq . . . c q c q c q c q . . . CQCQCQCQ CQCQCQ . . . c q c q c q . . . cqcqcqcqdede w6isqw6isqw6isqk."

"C q c q c q . . . C Q C Q C Q . . . c q c q c q . . . C Q C Q C Q C Q C Q . . . cq cq cq cq . . . CQ CQ CQ CQ CQ . . . cqcqcqcqcqcq . . . CQCQCQCQCQCQCQCQDEDEW6ISQW6ISQ W 6 I S Q W 6 I S Q W 6 I S Q w 6 i s q W 6 I S Q w 6 i s q . . p s e p s e pse pse kkkk."

"&%#$ %&#"

Snap, snap, click, click, click.

"I thought you were going to work your radio tonight."

"Naaaaahhhh — nothin' on." QST