Improving Earth-Ground Characteristics

Do you live in an area where tons of fulgurite are all that's left in your backyard every time a storm passes through? Try this idea and gain some protection, too!

By Roger Hoestenbach,* W5EGS

Several years ago I moved to my present dry, desert QTH which has a rather unusual soil problem – *there is none!* The *terra firma* is solid rock upon which the builders have hauled in just enough soil to grow a few blades of grass. The trees and shrubs have to be planted in holes which have been drilled with jackhammers or dynamited. The resulting soil resistivity is in the vicinity of 12,000 ohm/cm. In discussing this problem with other hams, I've found that my situation is not as unique as one might imagine. Perhaps the grounding techniques described here may benefit you, if you're in similar circumstances.

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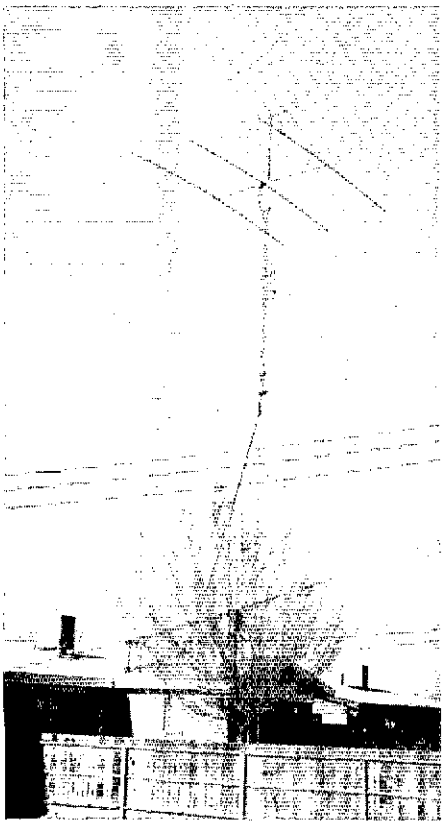

A neighbor's eye view of W5EGS' 70-foot "lightning" rod. Know what that little box on the roof of the house is? For those that don't live in an arid climate, that gadget is called a cooler, and it works, too!

My station location has a lot going for it from an amateur radio viewpoint. The highest point in the county is located a quarter-mile away. There are no large trees, few power lines, and low housing density. However, I was told the lightning-strike rate was high and damage from direct strikes quite common, due primarily to difficulties encountered in obtaining a satisfactory ground for lightning protection. The neighbors were amused when I announced that I was contemplating erecting a 70-foot tower in my backyard. The only ones that encouraged the installation were probably hoping it would act as a lightning rod to protect *their* property. I not only needed a good ground to aid in lightning protection, but I needed a good rf ground that would act as a conductor instead of a lossy dielectric. I am an avid DXer and, for me, a low controlled angle of radiation is a must. My research led me to the "ground screen" recommendation in the *ARRL Antenna Book*: Why not utilize a simplified, buried version of this technique with some method of effectively connecting it to earth ground? I hoped the resultant ground resistance would be in the vicinity of one ohm or less.

The Earth Ground

Resistance to current through an earth-ground path is based on three factors: (1) the actual resistance of the ground rod and the metallic connection to it, (2) the contact resistance between the ground rod and the adjacent earth, and (3) the resistance of the surrounding earth. The first factor should be almost negligible, since copper rod used for grounding purposes is of sufficient size and cross section that the resistance value is small. The second factor can be a problem if the earth isn't tamped properly around the ground rod or if the surface of the rod is contaminated with grease, paint, oxides or some other insulating cover. The third factor is the most critical and the one that deserves the major effort.

A ground rod driven into the earth radiates current in all directions. It can be thought of as being surrounded by layers of earth, all of equal thickness. The layer of earth nearest the ground rod has the smallest surface area so it has the greatest resistance. The next layer has a larger surface area and less resistance, and so on. Eventually a distance from the ground rod is reached where the inclusion of additional earth layers does not add significantly to the resistance of the earth surrounding the ground rod. Elaborate test equipment is available to measure analytically this optimum distance and the exact earth resistance, but the average radio amateur has neither access to this type of equipment nor the need to define these parameters to such an exacting degree. Instead, let's attack the basic problem: the conductance, or lack of it, of the earth layers within the critical distance. Public and private utilities have recognized this problem for years and use a method known as "soil treatment" for dry sand, dry soils, rock and other ground (soil) conditions. The soil treatment consists of mixing salt into the surrounding earth layers. I used this basic idea and expanded on it somewhat in order to improve its effectiveness.

As shown in Fig. 1, I started by

digging a hole with an 18-inch diameter and a depth of four feet. In the center of this hole I drove a 3/4-inch Copperweld ground rod as far into the earth as I could. A handy "driving" tool can be made from pipe that will barely pass over the rod. I took a threaded piece about 12 inches long and screwed a coupling and hex-head barstock plug onto the upper end. I placed this over the ground rod to prevent mushrooming the top while pounding on the pipe with a sledgehammer. After installing the ground rod in the hole, I inserted a plastic water pipe in the hole and filled the hole with a chemical mixture containing the following items: *bentonite*, a clay-like soil commonly used by farmers in earthen tanks to increase their ability to hold water without loss due to seepage (this material swells when wet and packs the mixture in the hole under adequate pressure to make up for poor tamping); *gypsum*, a popular product in the building industry which is used in the making of Sheetrock and plaster of Paris (this material gathers moisture and holds it in order to remain stable, and prevents loss of conductivity due to drying out); *rock salt*, the low resistance additive.

The mixture, as homogenous as possible, is tamped firmly into the hole and a 6-inch dirt cap placed over the top of the mixture so grass can grow over the spot where the hole was dug. The watering pipe is charged with a saturated solution of brine. The salt over a period of years leaches further into the surrounding earth, increasing the effective inclusion of the surrounding earth layers. Connecting several chemical vats in parallel to form a ground system can reduce the combined resistance to a fraction of an ohm.

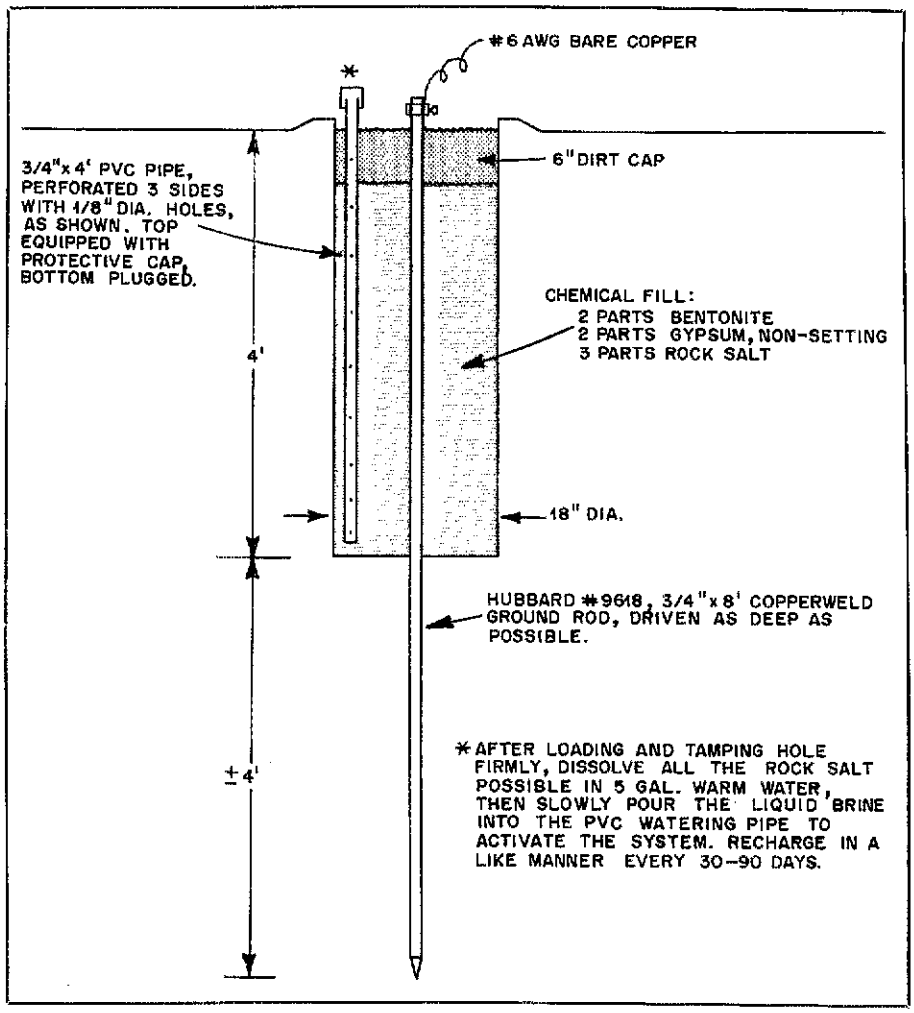

Fig. 1 — Drawing of a method for improving earth-ground characteristics. Dimensions are those used by W5EGS.

The Radial System

My house is located in the center of a 60- by 120-foot city lot which made it convenient to locate the tower near the midpoint of the lot and run sloping V-beams to the back corners of the yard for 40 and 80 meters. I think it is generally agreed that the ideal ground radial or screen system (at least for verticals) is about 120 wires, each at least 1/2 wavelength long, extending radially from the base of the antenna and spaced equally around a circle. Such a system should be the practical equivalent of a perfectly conducting ground and have negligible resistance. Assuming all this to be true, I slit the lawn with a Ditch-Witch trencher at roughly 3-degree intervals and installed as many radials of varying wavelength as I could. I used over 2600 feet of No. 6 AWG soft-drawn bare copper wire. I also ran one continuous wire around and bonded the water, gas, phone, electricity, sewer and radial ground systems all together. I then located seven chemical grounds as described above, at randomly selected spots in the network.

The Results

I have been using this installation for 12 years now with respectable reports. I run QRP cw and only 1000-watts PEP on ssb to a TH-3 tribander and the two V-beams. I've worked over 200 countries and garnered well over 80 awards, so the system does work! All the antennas are fed with grounded baluns and switched to ground in the shack when not in use. The tower has taken hundreds of direct hits from lightning and none of these has caused any damage to date. The strikes hit a steel pipe cap on the top of the mast and splatter horizontally in several directions, producing a spectacular display that is quite frightening the first few times it's observed. I have yet to observe even any little molten beads of metal on or near the pipe cap as a result of those hits. Additionally, during a thunderstorm the high levels of ionization in the atmosphere produce multiple flashes of corona discharge from the pipe cap edges at regularly recurring intervals. This phenomenon is also quite spectacular. QST

Strays

STOLEN EQUIPMENT

□ Stolen on Aug. 20 in San Francisco from auto, Tempo transceiver, serial no. 5728 and Western Electric T-T pad. Reward. Shel Kurtzmán, 19436 Topham Street, Tarzana, CA 91356, tel. 1-213-344-0878.

□ Taken during QTH break-in, Swan 500 C, serial no. I 486 739; Swan 117-XC, serial no. 0 16466 and Swan VX-2 VOX. Elmo V. Boswell, WØPXW, 443 S. Prince Lane, Springfield, MO 65802.