Environmental concerns affect everyone equally. Here's one that may be doing double duty by raising additional havoc with our antennas.

Acid Rain and Your Antenna

BY RICHARD A. GENAILLE*, W4UW

Rain can be a pain in the antenna, to put it politely, and many amateurs have had their antenna systems affected by it whether they realize it or not. What is even worse is that some, or maybe many, of us have had antenna problems made worse due to acid rain! If you have ever experienced the detuning of your antenna during rainy weather, whether it be a beam or a wire type of antenna, then perhaps the following information will help you to understand what is happening and what you might be able to do to alleviate the situation.

Antenna Problems

My basic antenna system, which has been up for over 20 years, consists of a steel flagpole, turnover mast upon which is mounted a TH6DXX beam. The mast itself is configured as a vertical folded unipole and is used on both the 160 meter and 80 meter bands. A wire, two half waves in phase, horizontal antenna was used for 40 meters for many years until the opening of the WARC bands, at which time experiments were made with wire multiple dipoles to cover 40 meters and the WARC bands.[1]

After experiencing severe detuning problems with the multiple dipoles because of rain, I installed a delta loop, which I now use on 40 meters and the WARC bands and which does not appear to detune as significantly as the dipoles. I attribute this to precautions used in the construction of the delta loop which can be applied to other wire antennas and which I will describe later. These precautions may be useful in solving problems of antenna detuning due to icing, which some pundits see as changes in the antenna's dielectric constant.[2] I might mention that the resonant frequencies of my TH6DXX beam appear to lower during periods of rain, but detuning of the vertical mast on 160 and 80 meters is negligible.

I endured my rain-induced problems with my multiple-dipole antenna system until I got curious as to what could be done to alleviate the situation. When my multiple-dipole system was first installed, the maximum SWR at the target frequencies of 7.1, 10.125, 18.08, and 24.89 MHz was no higher than 1.1! The amount of shift occurring during heavy rain lowered the dipole frequencies by about 56, 129, 418, and 234 kHz, respectively, for the aforementioned band frequencies. You don't have to do much arithmetic to realize that these changes might cause your antenna to resonate at other than the frequency of choice. I think that most operators using wire antennas will find that their antenna tuner settings will change from what they had logged in dry weather as opposed to a rainy day. I can just imagine the problems encountered by those amateurs who live near a salt-water environment.

If you are someone who grew up think-

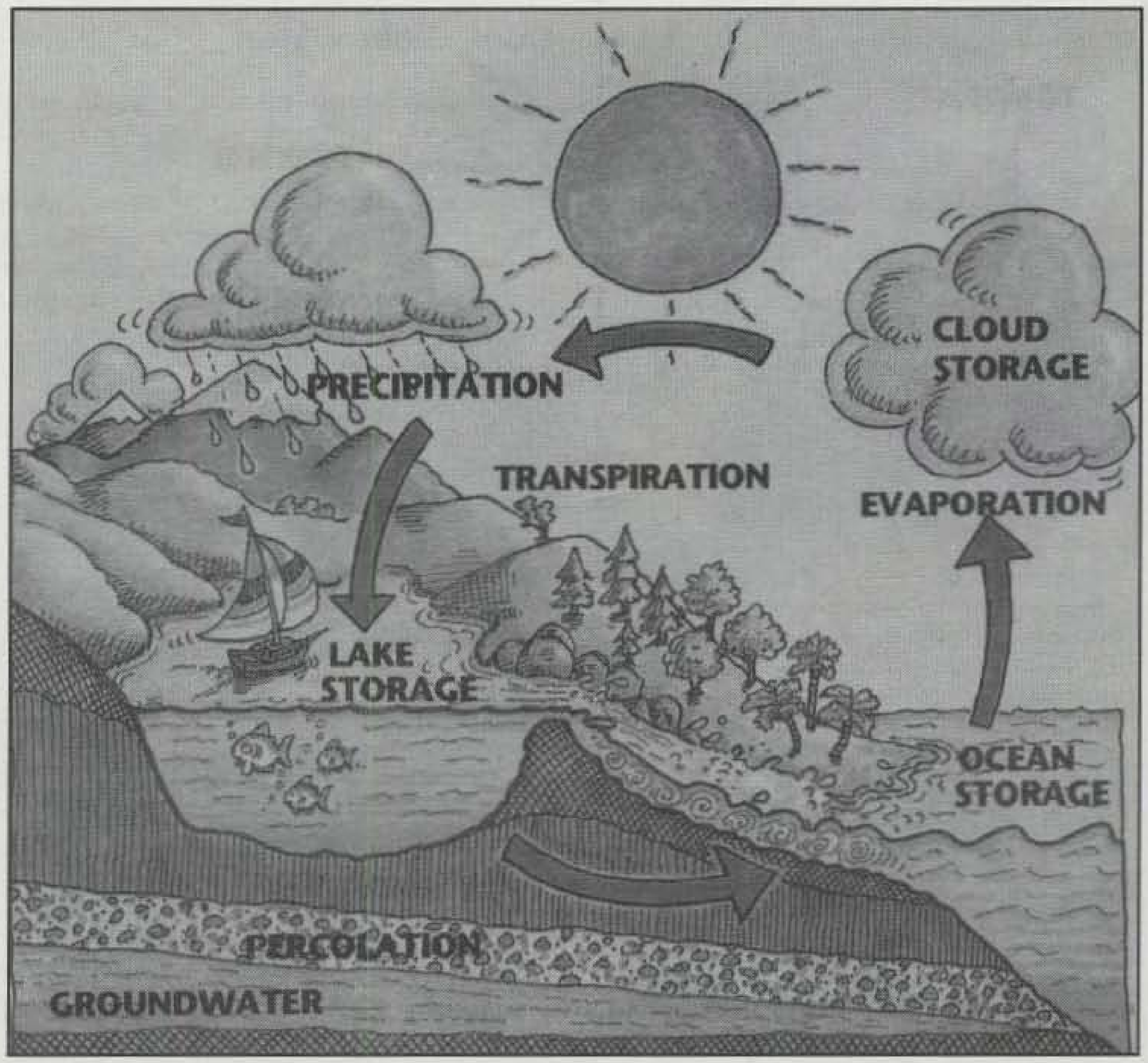

Fig. 1– The hydrologic cycle. Water evaporates. It travels into the air and becomes part of a cloud. It falls down to earth as precipitation. Then it evaporates again. This repeats over and over again in a never-ending cycle. This hydrologic cycle never stops. Water keeps moving and changing from a solid to a liquid to a gas, over and over again. Precipitation creates runoff that travels over the ground surface and helps to fill lakes and rivers. It also percolates or moves downward through openings in the soil to replenish aquifers under the ground. Some places receive more precipitation than others. These areas are usually close to oceans or large bodies of water that allow more water to evaporate and form clouds. Other areas receive less. Often these areas are far from water or near mountains. As clouds move up and over mountains, the water vapor condenses to form precipitation and freezes. Snow falls on the peaks. (Reprinted with permission from "The Story of Drinking Water," American Water Works Association, copyright 1990.)

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ing of rain as being clean and pure, that you could catch it and drink it "raw," you should think again. And snow cones? Forget it! I have lost my naivete in recent years, and am beginning to look at rain water in a different light. I hope that some of what follows will make many amateurs curious about their own situations, do some basic investigation, and get some local help to determine whether or not they have a problem with acid rain, and with suggestions offered in this article, reduce or eliminate "wet antenna syndrome"!

Cool, Clear Water!

Some years ago several articles that grabbed my attention appeared in my local newspaper. One of these, in September 1991, was by-lined "Forsyth May Have Most Acid Rain." Another, in November 1992, was actually a question posed by a local resident to the newspaper's answer man. It asked, "How do you get acid rain off the exterior of a car?" In both cases an explanation was given regarding what could be called acid rain. I should mention that Forsyth is a county in North Carolina, and the article dealt specifically with this state. Other states may have their own problems. I learned that acidity is measured on a pH scale, with 7.0 being neutral. Water is alkaline above that mark and acidic below it. For a definition of pH I would suggest that you consult your dictionary, which when all is said, tells you the same thing. It was said in the newspaper article that rainfall acidity in various areas in the county ranged from 3.4 (lemon juice is about 2.0) to 5.23, with a mean of 4.21 among six monitoring stations. It seems that winds from the south and west blow pollutants from as far away as Birmingham, Alabama and Tampa, Florida, as well from other areas, to this area. This means that wherever you are located there is a good possibility that pollutants are coming to you from places other than your own area, and your rain may not be as pure as you think.

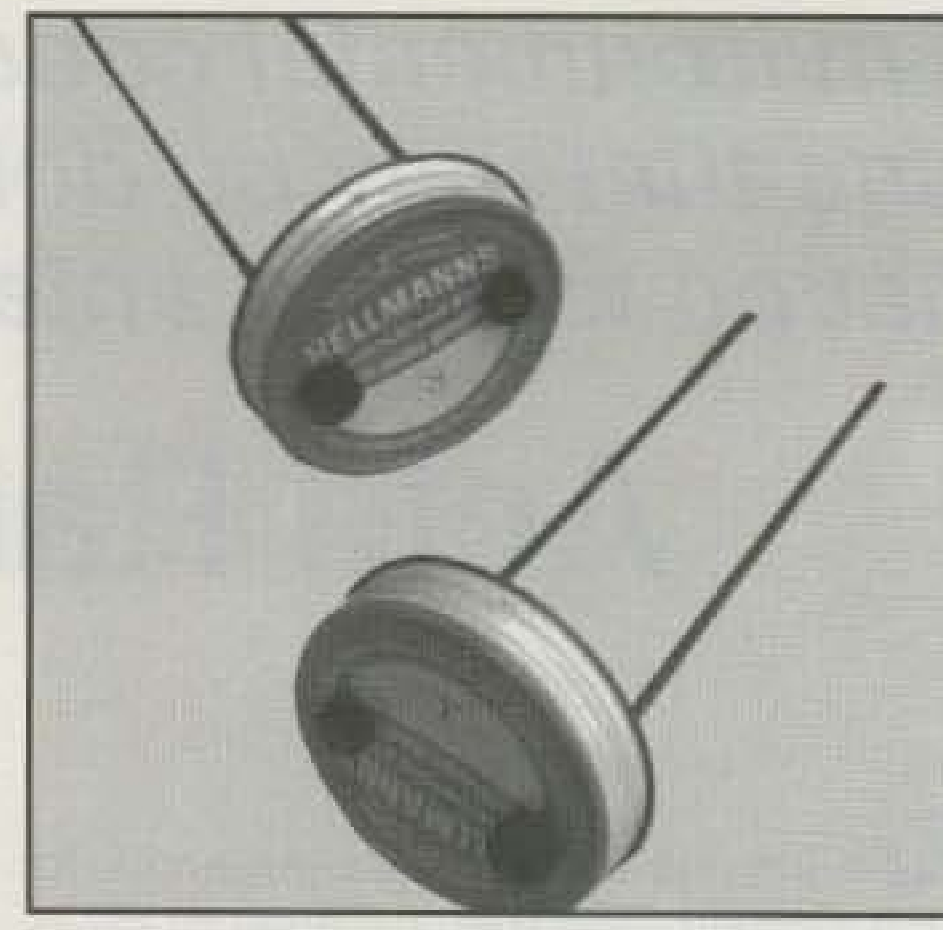


Photo 1– Simple test probes for home water analysis.

How do these pollutants get mixed in with your rain? Take a look at fig. 1, which shows the hydro-logic cycle. If you study this sketch and then look at your local weather channel on TV and see the movement of various fronts and moisture, it isn't difficult to determine that if the moisture passed over Chicago or Los Angeles, or most any other major industrial area, on its way to you, you could get a good dose of rain loaded with pollutants. The pollutants will more than likely be sulfur dioxide and nitrous oxides, which undergo chemical reactions in the atmosphere that turn them into nitric and sulphuric acids which then fall back to earth with rain. Your chances aren't very good anymore that you will have rain that is clean and pure fall on you. So much for the childhood myth of good, clean rain!

Out of curiosity, I collected some rain

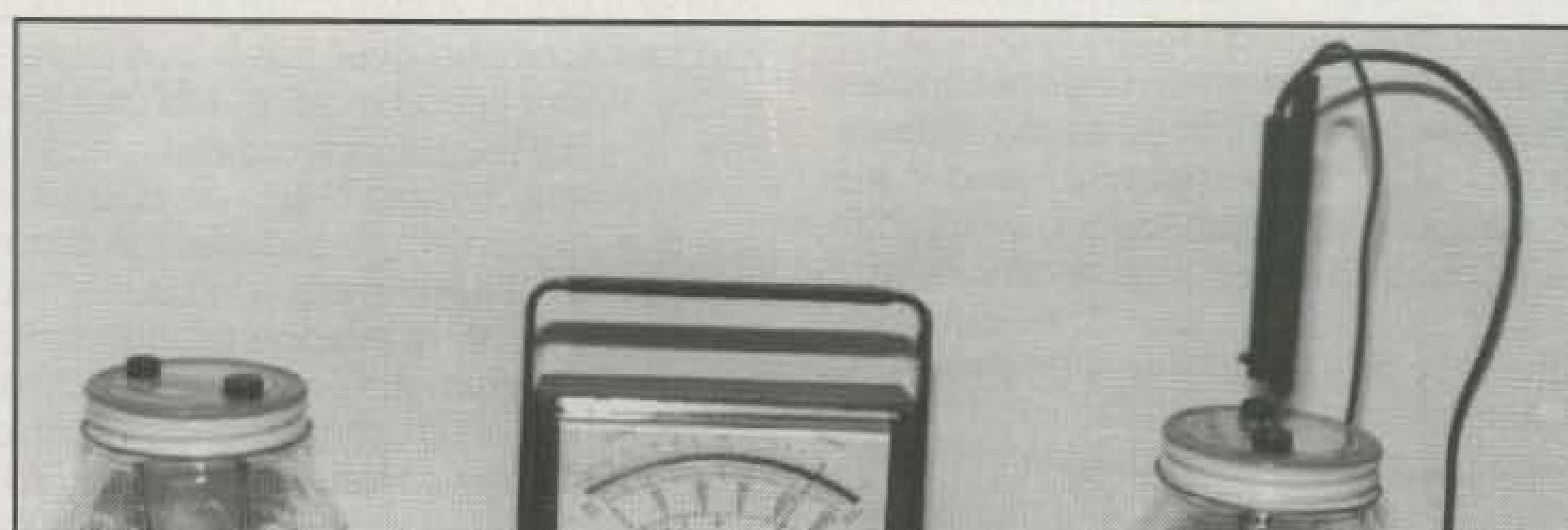


Photo 2– Testing rain and tap water at W4UW.

	Hardness	Alkalinity	Turbidity	pH	Date Collected
Rain	0	0	0.47	4.55	21 Feb. 1993
Tap	30	16	0.32	7.28	23 Feb. 1993
Snow	0	0	0.33	4.35	25 Feb. 1993

BASIC ANALYSIS OF LOCAL WATER

(Note: pH of 7 is neutral.)

ELEMENTS IN PPM (parts per million)

	Rain	Snow	Tap
Na (Sodium)	<2.0	<2.0	7.83
K (Potassium)	<1.0	<1.0	1.66
Ca (Calcium)	<1.0	<1.0	4.91
Mg (Magnesium)	<0.5	<0.5	1.37
Ni (Nickel)	<0.05	<0.05	<0.05
Fe (Iron)	<0.10	<0.10	<0.01
Cu (Copper)	<0.05	<0.05	0.06
Zn (Zinc)	<0.10	<0.10	0.259
Mn (Manganese)	<0.01	<0.10	<0.01
Pb (Lead)	0.012	<0.0025	<0.0025

(< = less than.)

Table I– pH and elements found in local water.

water in a clean, empty mayonnaise jar and tap water in another jar. I fabricated two sets of probes from the jar tops and some insulated jacks which then had lengths of tinned copper wire soldered to them as shown in photo 1. The probe assemblies were screwed onto the jars as shown in the test setup shown in photo 2. What I was trying to do was see if I could read some resistance between the probes due to the tap water or the rain water. If you look at the meter pointer you will see that there is an indication of resistance, which is also indicative of current flow in the ohmmeter. This unscientific test rather surprised me, since I was not expecting to get a reading using tap water. The local water department allayed my fears by telling me that the tap water was slightly alkaline and therefore would pass a small current. What was interesting was that the rain water passed more current due to its acidity. Not to worry, the water department said, "The tap water is fit to drink!" Try this test for yourself and worry, too!

With my curiosity whetted (no pun intended) I decided to have the Winston-Salem Public Works Department, Utilities Division do a check on my tap water, rain water, and water melted from collected snow. One of the chemists at one of the water treatment plants in Winston-Salem not only analyzed my three samples of water, she also provided me with a copy of "The Story of Drinking Water" published by the American Water Works Association. This publication, while not a college textbook, should be required reading for anyone who has ever taken a drink of water. The results of the water analysis should be of interest to everyone. You should be able to obtain such information from your Utilities Division at no charge.

The figures in Table I show how my tap

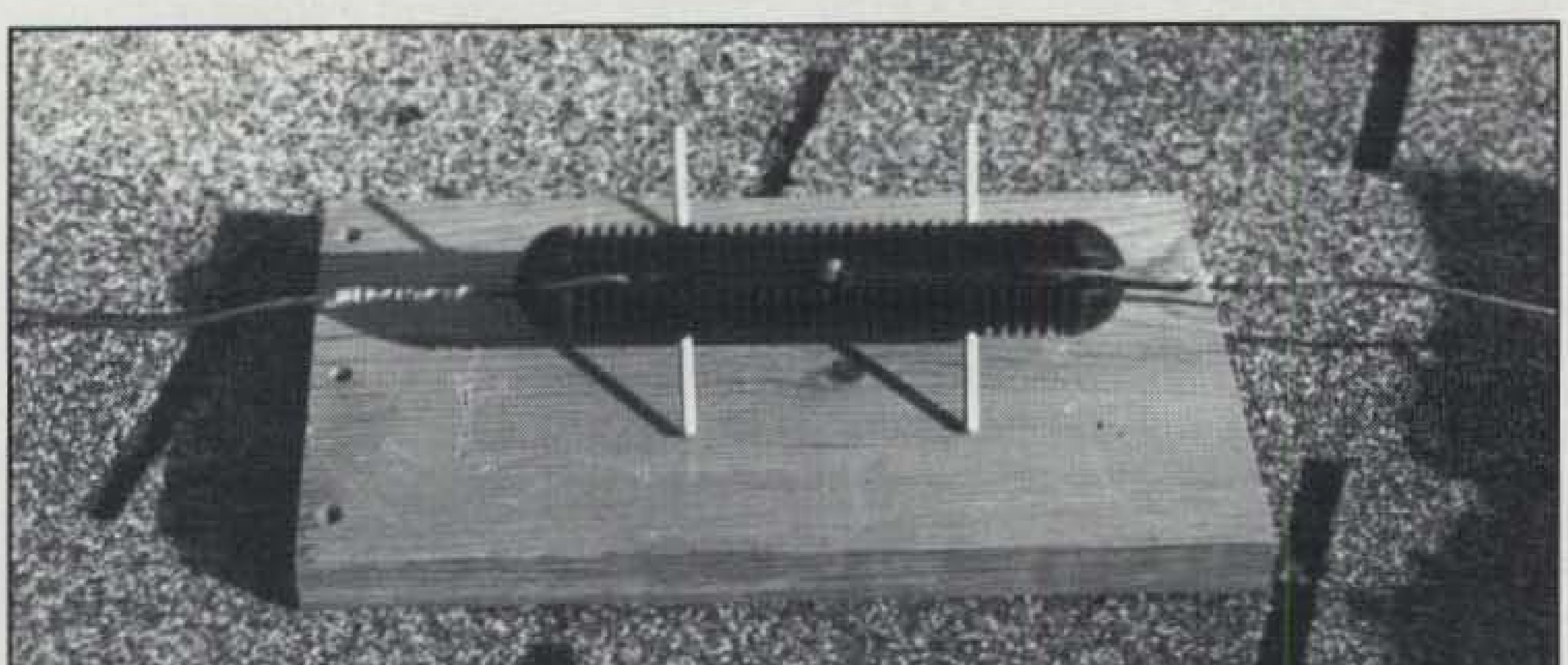


Photo 3– Modification with dowel centering pins.

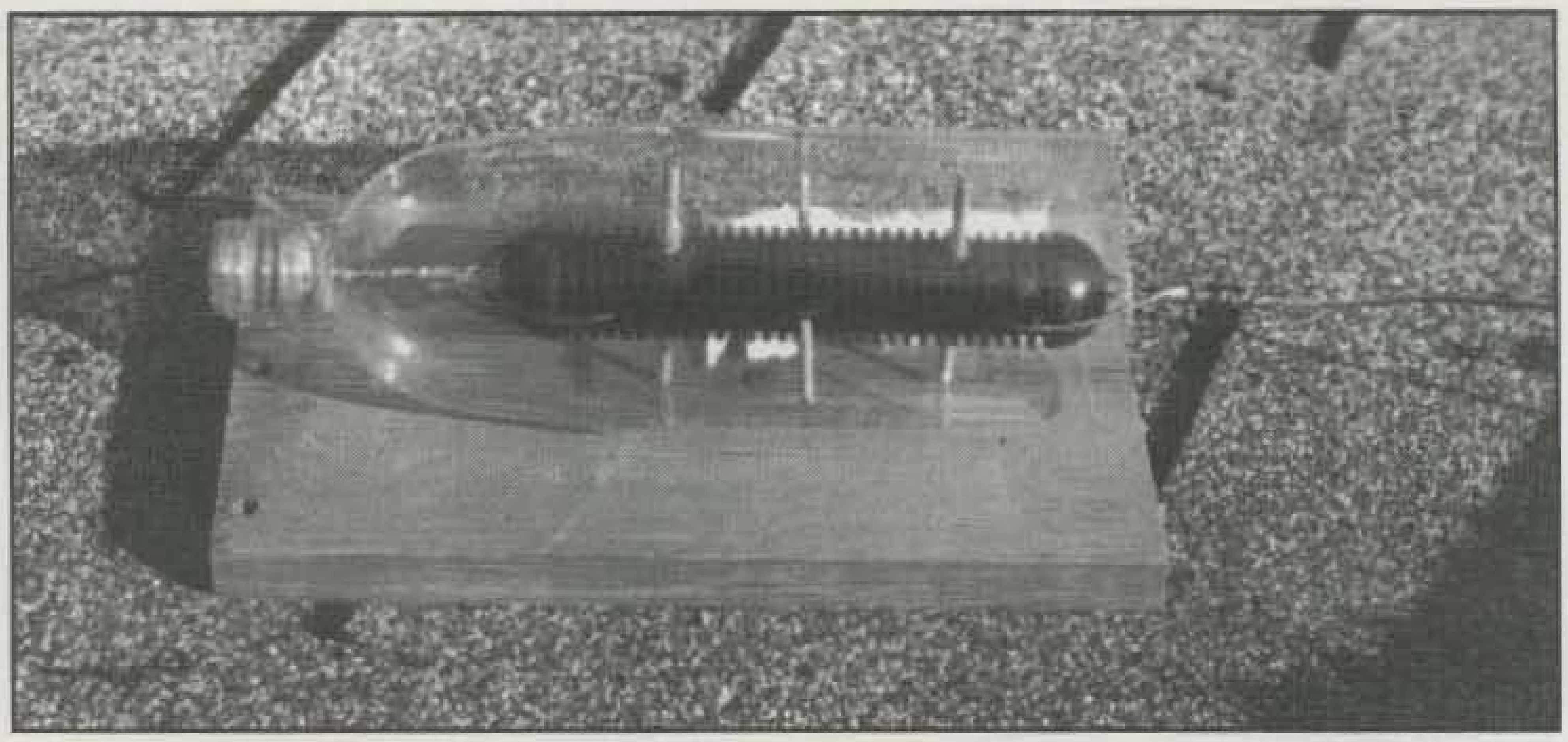


Photo 4– Modified insulator with "bootie" raincoat.

water, rain water, and snow water compared in regard to pH. One can see that the rain water and snow water are definitely acidic, while the tap water, which is river or reservoir water treated at the water treatment facility, is almost neutral. Table I also shows the makeup of each of the water samples in terms of the various elements. Note the level of lead in the rain water! You may think that the rain in your area is non-acidic, but your friendly water department chemists may have news for you! By the way, you will probably need to supply whoever tests your water comprehensively with at least 1½ pints of each liquid for them to work with, but check it out with them first.

Searching For Answers

Some time ago in a question-and-answer column in another publication a question was asked regarding the SWR increasing greatly and the operation suffering when ice accumulated on a wire antenna. The response was that when ice coats an antenna, the antenna's dielectric constant changes because of the thickness of the ice on the antenna, and so does the resonant frequency. I believe that the response told only part of the story and that the antenna should have been considered as a system complete with insulators and supporting medium. I also believe that rain or snow, acidic in nature, might have more effect on the shift in resonant frequency due to the effective lengthening of the overall antenna because of wet or iced-over insulators rather than the coating of ice on the antenna wire. Remember that in the case of a half-wave dipole antenna, the impedance at each end of the dipole is theoretically infinite. What this means is that if you have an insulator between the ends of the dipole wires and the supporting rope or wire, you had better be darn sure you use high-quality insulators—ones with a high dielectric constant and a low dissipation factor and a long path.

The supporting catenary for my multiple-dipole antenna was the 40 meter dipole which utilized a popular, black plastic insulator at each end. I believed that the weak spot on my antenna system might be the insulators, since I could not bring myself to believe that rain, even acid rain, could cause as much shift in the resonant frequency of my multiple dipoles by the wire just being wet! As an aside I should mention that with a multiple-dipole system adjustments are usually made on the lowest frequency dipole first, since these adjustments have a considerable effect upon the higher frequency dipoles. Consequently, any changes to the lower frequency dipole due to ice or rain would detune the other dipoles without even considering the effect of the ice and rain on the other dipoles.

To prove what I suspected, I decided to provide some protection for my end insulators on the 40 meter antenna. I did this by covering them with empty, plastic soft-drink bottles of the liter size to keep them dry. As shown in photos 3 and 4, ⅛ inch holes were drilled at three points on the plastic insulator, and short pieces of ⅛ inch dowel, treated with water seal, were pushed through the holes such that each end sticking out of the insulator was the same and sufficient in length to position the insulator in the center of the plastic bottle. A cork was fitted into the neck of the bottle, and the support wire end of the antenna was fed through a hole in the cork. A bead of solder was placed on the wire coming out of the cork to keep the protective cover from sliding off the insulator. Silicone sealer could also be used around the cork. The antenna was reinstalled and I patiently waited for it to rain. It did. In fact, it rained many times and eureka! The change in resonances of the multiple-dipole system was negligible. There were no large changes as mentioned earlier in this article. Photos 5 and 6 show typical installations using the "bootie" covered end insulators.

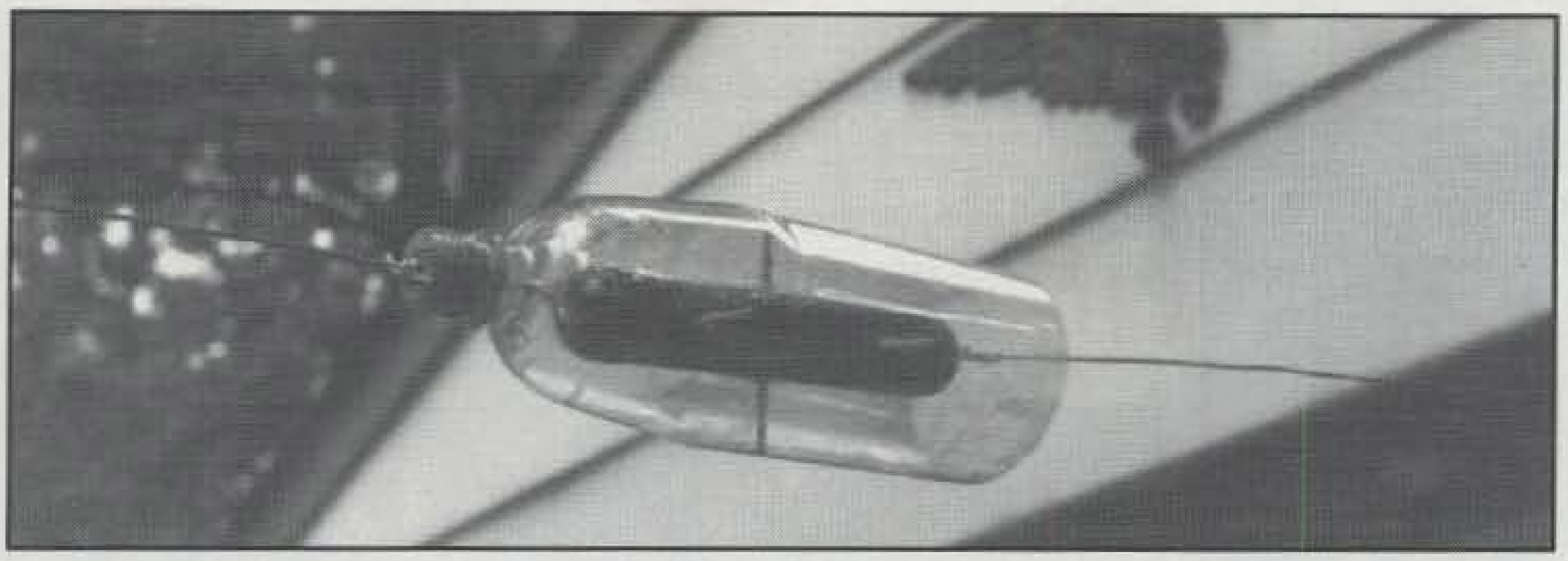


Photo 5– "Bootie" protected end insulator used for horizontal antenna.

A practical solution for horizontal dipoles—which virtually eliminates resonance changes caused by rain, snow, or ice—is to fold over each end of the dipole. As long as the center portion is not shorter than a quarter wavelength, the dipole will perform satisfactorily. To retain normal characteristics each end should be folded down the same amount and no more than 1/8 wavelength. An insulator covered with a "bootie" is used at the bend point on each end of the dipole to connect to the supporting rope or wire. The idea is to place the insulator at a point on the antenna where the impedance is much lower than at the very end.

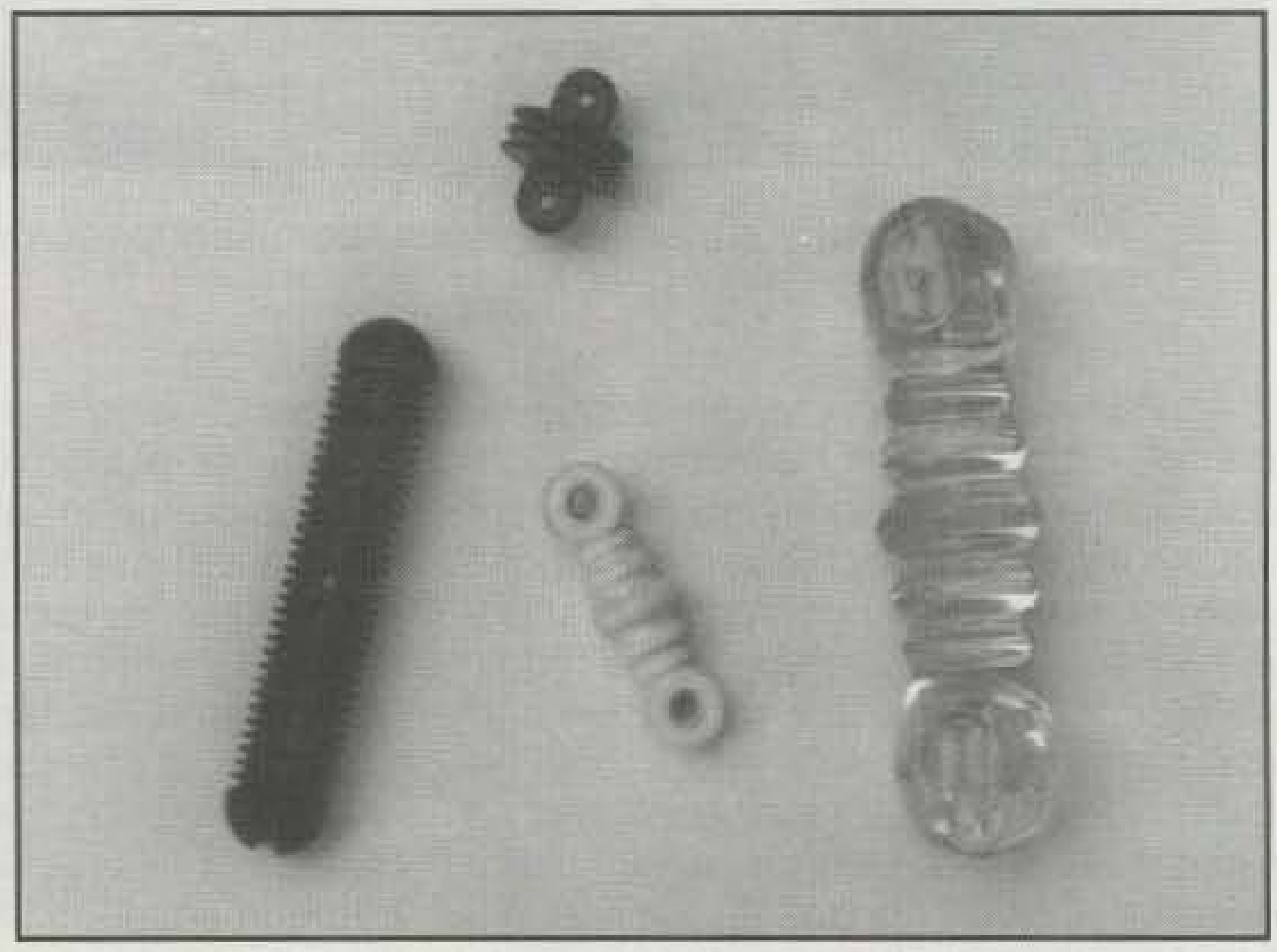
While I am not overly fond of plastic insulators, putting a "bootie" over them seems to solve the problem. In looking closely at plastic insulators that have been exposed to weather, I find them all to have had their surfaces affected, which probably helps to make them not look like insulators when acid rain covers them, but just an extension of the antenna wire.

I have not attempted to find the cause of shift of resonance of the beam during periods of heavy rain, but I suspect that trap end covers on the elements may be the culprits allowing water to leak into the traps.

Let me digress for a moment to mention that poor insulators can also cause problems in dry weather as I found out the hard way many years ago. When I first erected the turnover mast for my beam, I thoughtfully decided to use the mast as a radiator for the 80 and 160 meter bands. I accomplished this by configuring the mast into a folded unipole by fastening RG8 coax cable, with the inner conductor joined to the shield, to a bracket that extended out about 3 inches from the mast at the uppermost point of the mast (below the rotating mast supporting the beam). The line was run down to ground level parallel to the mast and spaced 3 inches from the mast with insulators at about 4 foot intervals. The bottom end of this coax was also shorted at the bottom end to form a flexible conductor and was fed into a remotely operated tuner at the base of the mast. The feedpoint impedance was relatively high on both bands. When doing the initial load tests on the vertical, I found that the SWR crept up slowly during full power application. I found this hard to believe until I thought about the insulators that I had used to space the coax line away from the mast. I had used a number of 3 inch long round steatite insulators from the top down and ran out near the bottom. I dug out some old nondescript insulators from the junk box and used them in the last two bottom positions. Those bottom insulators were very warm to the touch after a minute or two of full power to the antenna. Apparently, the dielectric factor was poor enough, at radio frequencies, to permit

Photo 6– "Bootie" protected end insulator used at bottom end of sloper or suspended vertical.

Photo 7– Some typical insulators. (The big Pyrex one may be hard to come by. Length is 7¼ inches.)



current flow and dielectric heating. After replacing the problem insulators with several made of quality material, the problem went away. You probably would never notice RF heating at the lower power levels of transceivers. The loss is there nonetheless, reducing useful radiated power.

Insulators

There are many new amateurs who may not pay attention to what they are using for insulating material. A local chap, relatively new to amateur radio, asked me to take a look at a KW antenna tuner that he had constructed from handbook diagrams and photos. He was having some trouble with it. I connected it up in my installation and tuned up into one of my antennas at low power. Everything seemed to work okay until I raised the power level. Then sparks flew and smoke rose. Disaster! In examining the unit I found "insulating" material used for keeping the variable tuning capacitors isolated from ground. The material looked as if it had been cooked somewhat, so I removed it. On one piece I found the word "Havoline." He had used the plastic from an empty motor oil container for his project. I suspect the dielectric quality of this material was not suitable for RF work. How would he have known? Nothing was said in the article describing the tuner that high RF voltages might be present most of the time, making it necessary to use quality insulating material. I have looked at a number of popular handbooks and found little, if anything, about insulators and their use in antennas systems. That's a pity, because with widespread acid rain more and more amateurs will be having trouble with their wire antennas.

Photo 7 shows several types of insulators which are available. The venerable glass insulator made by Pyrex does not seem to be readily available any longer except at fleamarkets, but certainly it is one of the finer ones. The white porcelain insulators, which I believe are available from number of sources, would be my next choice for moderate-size antennas. The plastic insulators would be my last choice, unless some sort of protective boot is installed over them. At low-impedance points, such as at the center of a dipole, the short insulator would probably be satisfactory as is. Some examples of good insulators are ceramics consisting of porcelain and steatite, iron-sealing glasses, and glass bonded mica or ruby mica, polyethylene, and teflon. Not all of these materials can be made into antenna insulators, of course. These materials have high dielectric constants and low dissipation factors at most amateur band frequencies. The dissipation factor of an insulating material is defined as the ratio of energy dissipated to the energy stored in the dielectric. Forget about PVC pipe, plastics, and wooden dowels (even those soaked in paraffin like in the old days). These materials weather poorly, and eventually the surfaces get pitted to the point where various contaminants in the air will adhere to the damaged surfaces and ruin the insulation effectiveness of the material. Even the popular 450 ohm ladder line should be replaced after some years of use.

Summary

While I am certain that the information regarding acid rain and the suggestions that I have provided for combatting the effects of acid rain on your antennas are far from complete, I cannot remember ever seeing this subject treated, probably because not many amateur operators have given it much thought. Now that it is on the table, perhaps additional information will be forthcoming from others based on their experiences with wet antennas. I sincerely hope so. Good luck!

And Finally . . .

My thanks to Kelly Stoltz, Chemist for the Winston-Salem, NC Public Works Department, Utilities Division for her help in understanding more about our drinking water and for providing the analysis of my rain, snow, and tap water.

Thanks also to the American Water Works Association for their permission to reprint the illustration of the Hydrologic Cycle From "The Story of Drinking Water."

Footnotes

1. Genaille, Richard A., "40 Plus WARC," *CQ*, October 1992, p. 42.
2. ARRL, "The Doctor Is In," *QST*, May 1994, p. 72. ■