to developments in HF digital radio is to provide the field—as they are starting to do—with a vast and inexpensive testbed for analysis of waveforms, error control coding, routing techniques and adaptive networking in general. Testbeds for commercial and governmental networks, even though they may involve some hardware that is not yet available to hams, are almost always expensive and time consuming to set up, and data collection and analysis can also be complicated and expensive, since it's done by people on payrolls. Amateurs work for fun and for free, and can provide far more data than a commercial or governmental network can ever hope to get. I'd like to see the ARRL continue to take the lead in organizing our efforts in the emerging HF digital field.

2. Although I don't know much about the status of its availability for amateur use (which probably depends a lot on governmental and the big manufacturers' strategies), it would put amateur digital HF experimentation in a very effective position if hardware to perform automatic link establishment (ALE) according to the new Federal Standard 1045 became available soon at a reasonable price.

I hope these remarks will be useful.—*Ken Wickwire, KB1JY, 232 North Road, Apt 17, Bedford, MA 01730*

Comments on Measuring the Mass of the Earth

In the September 1991 issue of *QEX*, Dr. H. Paul Shuch discusses interesting applications of EME (Earth-moon-Earth) measurement data in determining, among other things, the mass of the earth. The article also illustrates how imaginative teachers can motivate their students (and readers of *QEX*) by applying common knowledge in unusual ways. However, there are some minor errors in the article regarding the earliest accurate measurement of the Earth's circumference which I wish to correct.

On page 9, first column, third line from bottom and the top of the second column, Shuch states that "one of the earliest accurate measurements of the Earth's size (circumference) involved observing that, on the day of the Equinox at local noon in Alexandria, a stick placed vertically in the ground cast no shadow," and a stick similarly positioned in Athens (some supposedly known distance to the north) cast, at the same time, a shadow of appreciable length. Actually, I believe the description given by Lancelot Hogben in his two books is the correct version of the procedure used by Eratosthenes (BC 276?-195?) in measuring the Earth's circumference.[1,2]

First, I quote from A History of Mathematics[3] regarding the individual responsible for the measurement discussed by Shuch: "Eratosthenes was a native of Cyrene who had spent much of his early life at Athens. He achieved prominence in many fields when, in middle life, he was called by Ptolemy III to Alexandria to tutor his son and to serve as librarian of the university there. Today Eratosthenes is best remembered for his measurement of the earth—not the first or last such estimate made in antiquity, but by all odds the most successful."

According to Hogben, during the time of Eratosthenes "it was common knowledge that the noon sun's zenith distance at Alexandria on the summer solstice was 7.5 degrees. It was also on record that its image was then visible at noon on the water surface of a deep well in Syene, near the Aswan Dam of today and just on the Tropic of Cancer, whence its midsummer noon zenith distance was zero. [Note the different spelling of "Cyrene" and Syene" in these two references.] Since Alexandria and Syene lie nearly on the same meridian, it thus appears that a great circle arc of about 7.5 degrees separates them. Either from records of the mean time of route marches over level desert country or from crude maps made by the Egyptian temple surveyors for tax allocation, Eratosthenes know that the intervening distance is, in Anglo-American linear measure, about 520 miles." Knowing the distance between Alexandria and Syene, Eratosthenes estimated the Earth's circumference to be 520 × 360 / 7.5 or about 24,960 miles.

Thus, the second reference point was not at Athens, as Shuch states, but at Syene, "just on the Tropic of Cancer" and near the First Cataract of the Nile at the Aswan High Dam. As Hogben explains, the distance between Alexandria and Syene was known to a fair degree of accuracy. In comparison, the distance between Alexandria and Athens was much less likely to be accurately known because of the intervening Mediterranean Sea, and therefore this distance was probably not used in the calculations.

Shuch refers to the shadow measurements being made during the "...day of the Equinox..." But according to Hogben, the measurements were made during the summer solstice when the sun was directly over the Tropic of Cancer, and that is why the noon zenith distance at Syene was zero (because Syene is located on the Tropic of Cancer). Also, Shuch states that "Alexandria...is near the equator), but it is actually at the latitude of about thirty-one degrees above the equator. For comparison, the border between Alabama and Florida is at a latitude of 31 degrees, and you would hardly call that latitude "...near the equator!" For an additional comparison, Entebbe and the northern part of Lake Victoria (both in Uganda, Africa) lie almost directly on the equator and near the same meridian passing through Alexandria.

Because of the reliance placed on the technical accuracy of *QEX* and its archival value and so the errors discussed about will not be repeated, I believe it is important that the above corrections be brought to the attention of your readers. —*Ed Wetherhold, W3NQN, 1426 Catlyn Place, Annapolis, MD 21401*

You're absolutely right, Ed, the two cities in question

[1]Lancelot Hogben, *Mathematics for the Million*, W.W. Norton and Company, Inc, 1943, Fig 7, p 348.
[2]Lancelot Hogben, *Mathematics in the Making*, Crescent Books, Inc, 1960, pp 124-126.
[3]Carl B. Boyer, *A History of Mathematics*, 2nd edition, John Wiley and Sons, Inc, 1991.

were indeed Alexandria and Syene, and the experimenter in question was certainly Eratosthenes himself. I'm pleased to note that I caught the error myself and took action to correct it—see QEX *December 1991 Corrigendum.*

The one detail about which we disagree is how Eratosthenes knew the distance from Alexandria to Syene. I'm inclined to believe your source, regarding route march times over level desert. However Cornell's Professor Carl Sagan, in his pop-science book Cosmos, *states that Eratosthenes actually hired a surveyor to pace off the distance. I choose to accept this source only because it underscores the futility of pacing off the distance to Athens! Cosmic Carl is also the source of my statement about the lengths of shadows cast by sticks in the ground. Thanks for being so observant, Ed. It's nice to know somebody actually reads my articles.*—H. Paul Shuch, N6TX, Professor of Electronics, Pennsylvania College of Technology, One College Avenue, Williamsport, PA 17701

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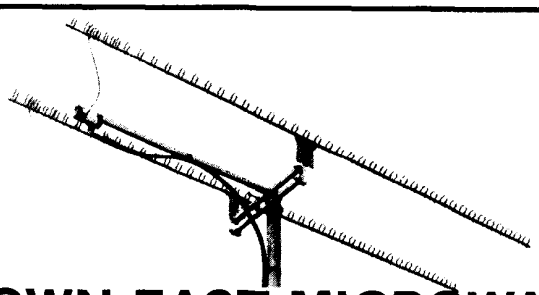

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