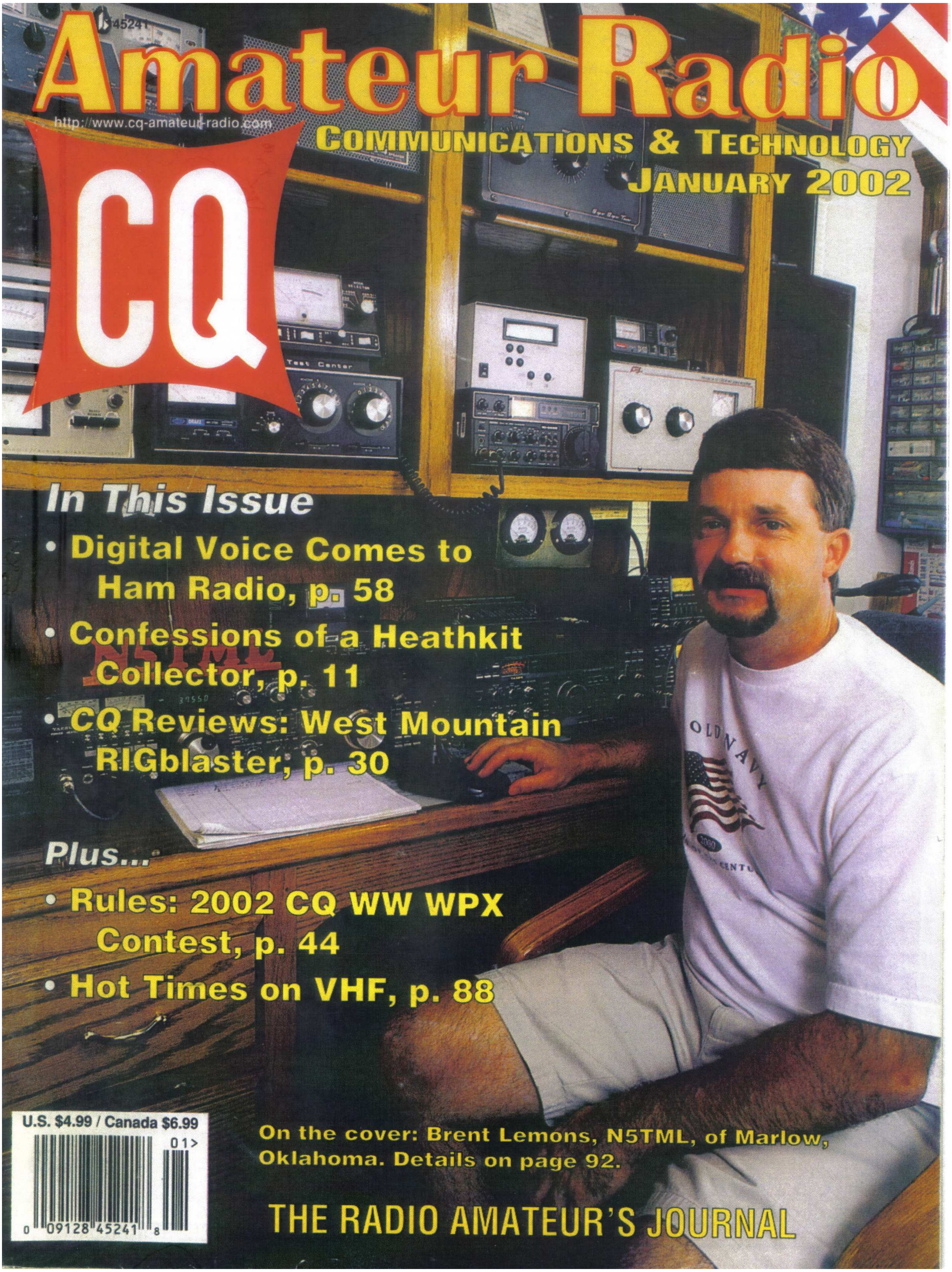
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On the cover: Brent Lemons, N5TML, of Marlow, Oklahoma. Details on page 92.
THE RADIO AMATEUR'S JOURNAL

PY3CEJ's "Underwater" 160 Meter Vertical
Is it a 1/4-wave or a 1/2-wave antenna?

When is a quarter-wave not a quarter-wave? When it's half of a half-wave! This month we bring you an innovative 160 meter antenna designed by Alencar Aldo Fossá, PY3CEJ, translated from Portuguese, with some adaptations, by Antennas Editor Arnie Coro, CO2KK**.* —W2VU

Al Fossá, PY3CEJ, and his station in Porto Alegre, Brazil. Al operates exclusively SSB on 160 meters and has worked at least 260 countries on the band.

I have always used both dipoles and quarter-wave verticals for transmitting on the 160 meter band. For receiving, Beverages and long wires were my choices. In February 1999, when I moved to my new countryside home, I had the idea of doing something different for 160 meters, something that would work better for both receiving and transmitting.

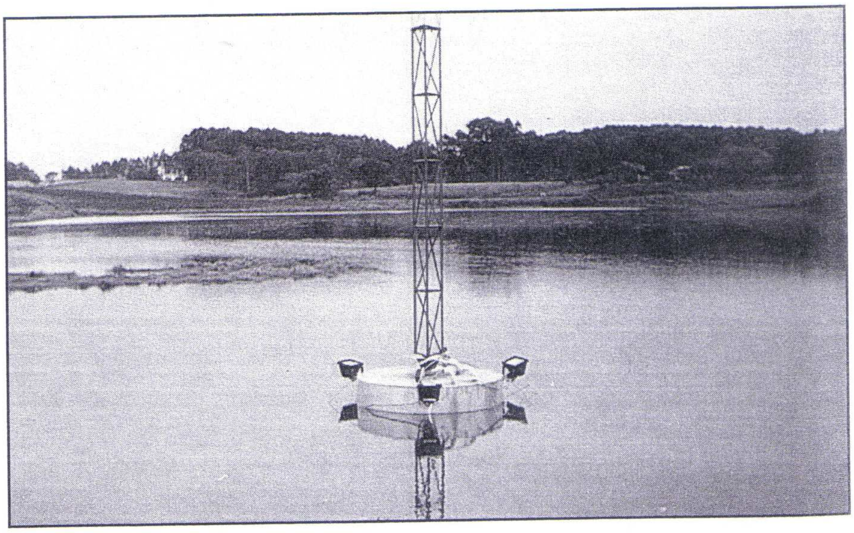
It is well known that the 0.25-wavelength vertical is a noisy antenna for receiving and that 0.5 wavelength dipoles show directional radiation. Because 160 meters is, after all, a medium-wave band with the prevalence of a strong ground-wave component, I decided to make use of a little creativity, hoping that the new approach would work in actual practice.

I decided to install the antenna *in* a small lake on my property, quite near to the house, as it is said that water is a good "mirror" for radio waves. Because I like both the dipole and the vertical, which jointly have provided me with 260 countries on 160 meters, I had the idea of trying to join what's good about both antennas, due to the fact that each new country worked was becoming more and more difficult. I calculated the length of a half-wave dipole for 1.848 kHz as 77.10 meters, with each leg being 38.55 meters long.

A quarter-wave vertical has its image below ground, so here is what I did: Rather than making this image a virtual one as in a classic vertical monopole above the ground, I decided to make it an actual *real physical image.*

During the summer, when the lake's water level was low, I contracted a local drilling rig owner to dig a 40 meter deep hole right at the base of the tower that is the "above ground radiator." The well-like hole was lined with a 40 mm diameter PVC pipe, with its two ends sealed. The tower's concrete base was then cast right next to the PVC pipe, locating the tower's base insulator very near the pipe's upper end and making sure the top of the base stayed above the lake's normal high-water point.

The tower's total length is 38.55 meters, and a heavy copper wire of exactly the same length was then intro-



PY3CEJ's in-the-lake antenna for 160 meters. Not visible here is the "mirror" wire in a PVC pipe that goes 40 meters underground, or underwater radials.

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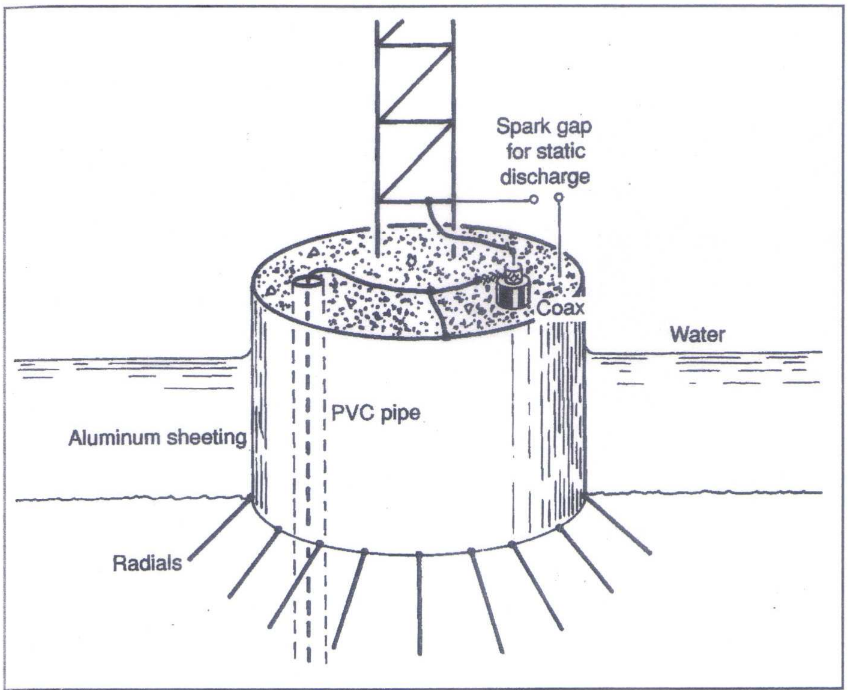


Fig. 1– Schematic of the base of PY3CEJ's 160 meter antenna system. The tower installed on the concrete base is 1/4 wavelength high and is used as the radiating part of the antenna. An identical length of wire is dropped into the sealed PVC pipe which goes 40 meters underground to form the image section of a half-wave dipole. Radials were added in the water to further improve signals.

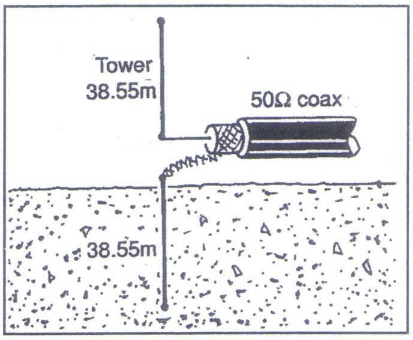
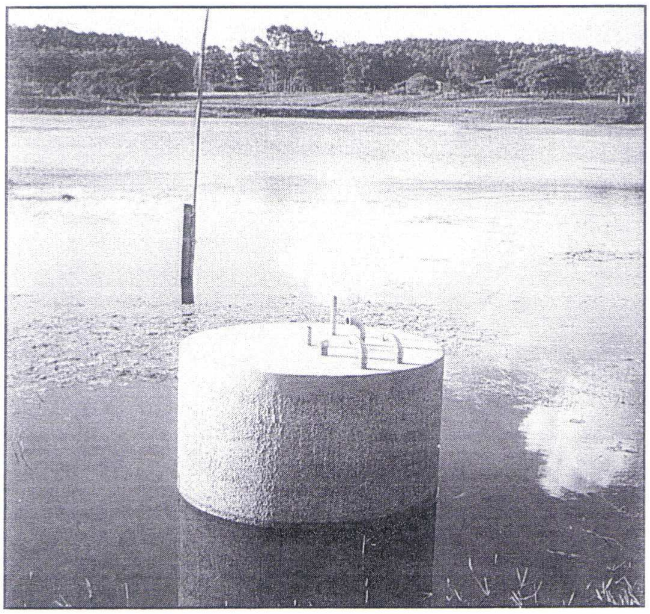


Fig. 2– Simplified view of the PY3CEJ system—one-quarter wave above ground and one-quarter wave below, fed in the center like any other half-wave dipole.

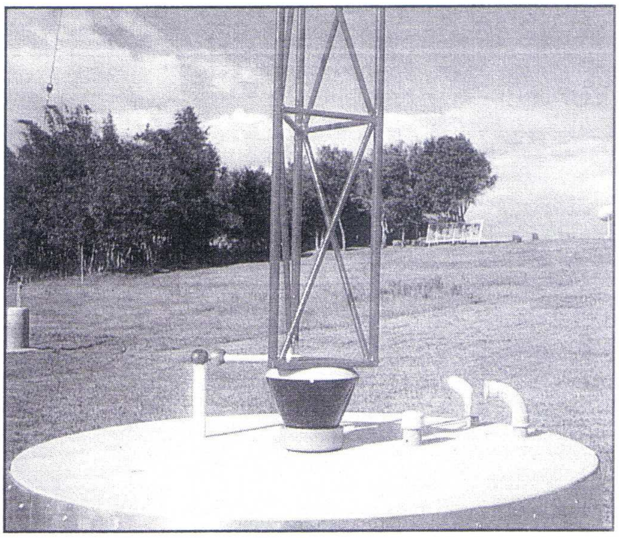
duced into the PVC pipe, effectively isolating the wire from ground, while at the same time having it behave as a perfect real image of the 0.25-wavelength tower radiator. The whole system's geometry was then of a half-wave dipole, one leg formed by the tower itself, and the other end formed by the copper wire placed inside the PVC pipe that ran into the ground 40 meters deep, of which 38.55 meters were "filled" with the copper wire forming the other leg of the vertical dipole. The antenna is fed via a buried coaxial cable that goes to the shack.

When the whole system was completed (notice that there are no quarter-wave horizontal radials installed, as in a typical vertical monopole system), I started calling CQ DX on 160 using the half above and half below earth "dipole." The first tests were good, receiving nice reports. Later, the first international QSOs got me 59+ reports from W8JI and IK7MCJ.

Reception with the new half buried antenna is different from that with the quarter-wave vertical, less noisy and better sounding to the ear, which usually gets tired of the typically high band noise level on 160 meters.



Concrete base before the tower was installed. Capped PVC pipe contains the 0.25-wavelength image wire.



Detail of the PY3CEJ system during the dry season. Note to the right of the tower the capped PVC pipe which contains the image wire, and the spark gap on the left side to help reduce built-up static charges and minimize the antenna's attractiveness to lightning.

The "True Image Vertical" and "Sea Gain"

Comments by Arnie Coro, CO2KK

Al's antenna is certainly unique because it uses a specially drilled well to house what could be described as a "real image" and not a virtual one of the "missing half" of what would otherwise could be described as a very well installed, by all engineering standards, quarter-wave vertical for 160 meters. The fact that the antenna's radial system is, at least during part of the year, submerged in a lagoon also adds significantly to its overall efficiency. I think that Al's idea of drilling the well and installing the "missing half of the half-wave dipole" into the well casing is something that should be tested at other locations, with the system's overall radiation efficiency carefully measured with high-quality instrumentation and standard field-intensity measuring procedures.

Vertical antennas are popular on 160 and 80 meters and enjoy considerable success because the installation of horizontal antennas at heights sufficient to provide low-angle radiation is next to impossible for the average amateur. Full-size quarter-wave verticals, or even better (my favorite), the 0.28-wavelength-high design, do need a very well installed and properly maintained ground system, which if laid on the ground is usually specified as 120 radials of 0.25 wavelength each. Elevated radials have, according to some authors, proven to be more efficient, requiring a much lower number of wires to achieve similar results.

Ground conductivity is a decisive factor when a scientific analysis of the antenna system radiation efficiency is analyzed. This is why some amateurs, with their stations installed in areas of high conductivity, achieve such nice results with their verticals.

Sea Gain

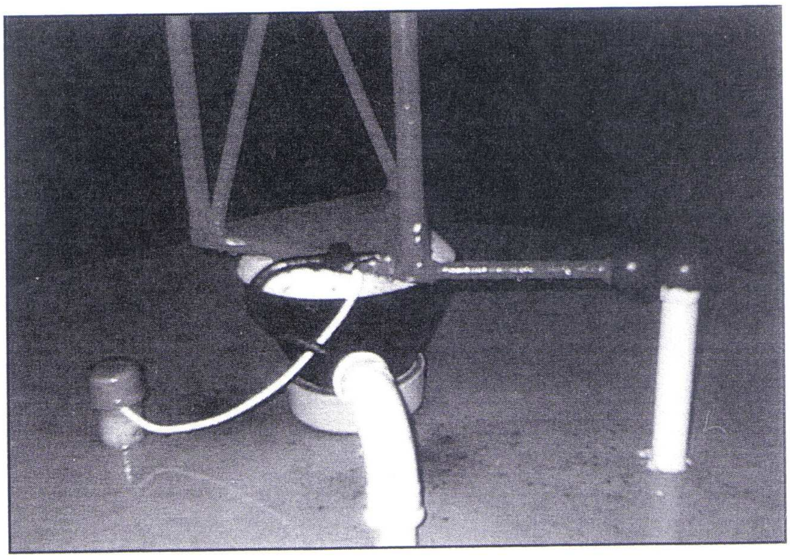
One additional and often overlooked enhancement that is quite noticeable on 160 meter band systems is the so-called *sea gain* that is present even when the station is located up to one or even two miles away from the seashore. Sea gain provides an *extra* boost to 160 meter signals, both for the ground wave and the skywave, even when the antennas used are far from achieving the radiation efficiency of a properly installed reference system, usually specified as a 0.25-wavelength-high vertical radiator working against the classic 120 0.25-wavelength radial system.

Testing the Brazilian "well image" antenna on the 80 and 40 meter bands should be something really interesting to do. If you decide to do it, please keep us up to date on your experiments!

—CO2KK

As I said, the first tests were good, but then it started raining heavily and the tower base flooded. I decided to add four radials, each 40 meters long, and I deployed them into the water, connecting them to an aluminum sheet that surrounds the base of the tower.

After this final addition of the four submerged radials, the antenna's performance improved fantastically. Water in



Close-up of the base with the lake full. The white cable connects the image wire to the shield side of the coaxial cable coming from PY3CEJ's shack.

Resources

For additional information, we recommend the following:

Brown, Lewis, and Epstein, "Ground Systems as a Factor in Antenna Efficiency," *Proc. IRE 25,* pages 753–787, June 1937.

Coro, A., " Eficiencia de los sistemas de radiacion en el rango de frecuencias de 0.5 a 2.0 megaHerz" ("Efficiency of radiating systems in the range of frequencies between 0.5 and 2.0 Megahertz"), unpublished manuscript available from the author.

Jager, K., "Effect of the Earth's Surface on Antenna Patterns in the Short Wave Range," *Int. Electrik Rundsch 24 (4),* pages 101–104 (1970).

Stanley, C., "Optimum Ground Systems for Vertical Antennas," *QST,* Dec. 1976.

contact with the radials seems to help transform the small lake into a 360-degree radial system!

The first QSO was with 7P8AA , who gave me a 59+ 10 dB report, and reception of his signal reached a similar level. Reception improved, and the SWR of the antenna showed a 1.0 to 1 ratio, and my FT-902-DM liked the antenna a lot!

Reports from Europe are now always 59+, and all this is using SSB. Here are just some examples: LA3XI, OH5LF, DJ7AA, G3PQA, and SP6KFH. From the USA and Canada I am also receiving many 59+ reports from stations such as VE2ENM, W3UR, K1ZM, K2KYH, W4NZ, and others.

I wrote this because I wanted to add a bit more to the medium-wave antenna systems knowledge base, which is a mysterious area of antenna theory and practice. Any suggestions, comments, and opinions about this system will be most welcome, as it is my belief that telling the public about our experiences, good or bad, is good.

At this writing, I am using the following equipment at my station: an FT-902-DM transceiver, an FL-2100Z linear amplifier, and something essential for 160 meter DX work—no less than three additional receivers, a Drake R4B, a Kenwood R5000, and a Collins 75A4. For low-frequency work it is important to eliminate mixer noise due to the Voltage Controlled Oscillator (VCO phase noise) and the Phase Locked Loop (PLL), so it is better to use receivers such as the Drake or the Collins, which generate the local oscillator frequency using a crystal. My future equipment, due to the option of having crystal oscillator injection, is the OMNI VI Plus from Ten-Tec, which shows optimum behavior on the low frequencies.