Radio FUNdamentals

THINGS TO LEARN, PROJECTS TO BUILD, AND GEAR TO USE

The End-Fed Long Wire Revisited

Frank Lucas, W3CRA (later W8CRA), was one of the all-time top DXers. He was the first of the pre-WW II American operators to achieve DXCC. At the peak of his career his equipment was modest—a homemade receiver and transmitter (600 watts) and an "end-fed, single-wire Hertz" antenna.

More recently Howy Bradley, W2QHH, the world's top QRP operator, worked over 360 countries with an end-fed long-wire antenna. Unlike Frank, Howy had to compete with 3-element Yagis and quads in order to achieve his impressive record. Other DXers have had luck with a long-wire antenna, and a lot of them are showing up on the 10 meter band.

This leads to an interesting conclusion. If you can't erect a beam, the DX experts suggest that a long-wire antenna has a lot going for it!

How long is a "long wire" antenna? Well, as far as 20, 15, and 10 meters go, a wire over a wavelength long may be considered to be "long." This indicates that a 160 meter Marconi (about 135 feet long) works as a long, end-fed wire antenna on the higher bands, provided it is properly fed. It looks as if an antenna of this type is perhaps the proverbial "all-band" antenna—something often sought but seldom found.

Many amateurs are in the position I was in when I was first licensed. I lived in a two-story house with my station in a corner of my bedroom. The peak of the house roof was about 25 feet above the ground. Somewhat over 100 feet away was a nice tree which I estimated to be about 30 feet tall. I could easily climb the tree to the 25 foot level and string a #14 hard-drawn enamel-coated copper wire from the tree to the peak of my roof without getting anyone excited—except my mother, who watched nervously as I clambered about the roof (fig. 1).

Once I achieved a good ground connection (which wasn't easy), I used the antenna on several bands—160, 80, and 20 meters. I didn't work 40, as there was a big DXer on that band a few blocks away, and when he was on the air, my little receiver folded up. At that point in time the 15 meter band didn't exist, and only a few hardy souls were exploring the 10 meter band. However, on the bands I used, the single-wire antenna worked very well.

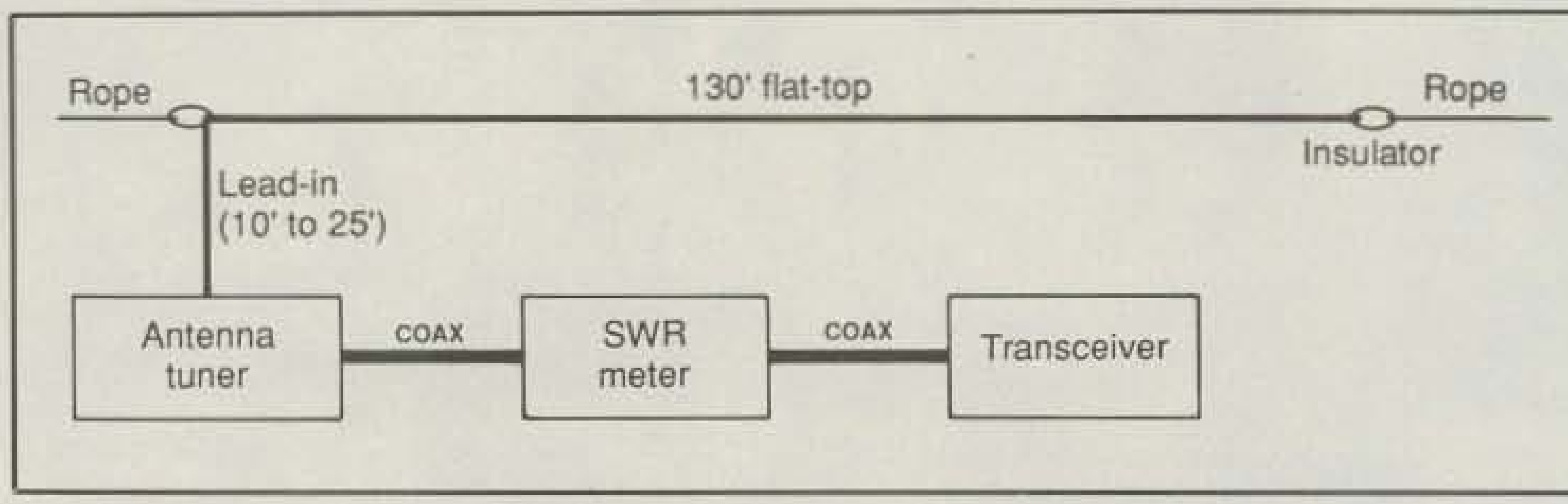

Fig. 1–A practical end-fed, single-wire antenna for coverage of all bands between 160 and 10 meters. Antenna tuner is required, and in all cases a good ground is vital. Quarter-wave radials can be used on the higher bands, as discussed in the text. Antenna is 25 feet above ground.

After a few years I reluctantly took down the wire and put up a tower and a 2-element Yagi. But the long wire did a superlative job during the time it was up, and the cost was right!

I still run across operators using a long wire, and some of the 10 meter signals from this simple antenna are outstanding! It is a fine antenna for an apartment dweller who can run a thin wire out to a nearby tree. If the wire is #20 or smaller, it is very hard to see when it is up in the air! And small-diameter wire is quite rugged. I had an end-fed wire antenna at my beach home for many years, and it remained aloft in spite of heavy storms that blow in from the Pacific along the northern California coast. (My best DX with this wire was to have Father Moran, 9N1MM, answer my CQ one fine, frosty fall morning!)

A Close Look At The End-Fed Antenna

I think it is worthwhile to take a close look at this inexpensive and effective DX antenna. The old timer built his end-fed antenna by cut-and-try, aided by bits of information gained by the commercial services who often used this antenna for backup to their curtain arrays. Today's amateur is luckier. The modern computer-assisted antenna analysis program of K6STI (Brian Beezley, 507 ½ Taylor St., Vista, CA 92084) can be used in an investigation of this antenna.

As shown in fig. 1, this antenna is fed at one end with a short wire that drops down to reach the transmitter. An antenna tuner, SWR meter, and a good ground return are required at the transmitter to make the antenna work properly. Since a good ground is difficult to obtain in the HF region, a single quarter-wave radial ground wire is used for each band. These radials are made up of insulated wire and may be run about the room, near the baseboard. They make sure the equipment is at RF ground potential so that you won't "get bit" when you pick up the mic or key the transmitter! Their real purpose is to establish the feedpoint ground for the antenna. Without them, the ground return is liable to be the power line, and that can cause numerous difficulties, including TVI!

The horizontal portion of the antenna is 130 feet long, and the lead-in portion is from 10 to 25 feet long. The flat top does most of the radiating, but the lead-in contributes its bit.

The radiation pattern is more complex than one would imagine. Generally speaking, the antenna is omnidirectional in nature, with enhanced lobes and minor nulls branching out from the sides of the wire. The pattern changes from band to band, as the computer printouts illustrate.

The long wire picks up a signal over a physical distance of several wavelengths (depending upon the band in use) and seems to boost the average level of the received signal, as compared to a dipole or ground-plane antenna, particularly those DX signals arriving at low angles.

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Band	Gain (dBd)	R	X	Series Reactance
40	0.5	105	−570	100 pF
20	1.4	115	−190	100 pF
15	2.4	150	+ 56	1 μH
10	3.3	425	+290	2 μH

Table I– Gain for each band using the end-fed, single- wire antenna shown in fig. 1.

One reason for this is that the radiation pattern of the long wire is both horizontally and vertically polarized in a complex mix. The gain over a dipole is achieved in the main lobes; it is not large, but it increases as the frequency of operation is raised. In the case of the antenna shown in fig. 1, the gain for each band is shown in Table I.

Patterns of the End-Fed Wire

On 160 and 80 meters, operating against a good ground, the antenna pattern is virtually omnidirectional. On 40 meters the pattern resembles a fat figure-8, with the pattern in line with the wire (fig. 2).

On all higher bands nulls exist in the azimuthal pattern, but these should not be taken too seriously. In real life they tend to be obscured and usually show up as a 6 to 10 dB drop in signal strength. Reflection from a rough, imperfect ground and reflections from nearby objects often smooth out the nulls, and the antenna becomes omnidirectional for all practical purposes.

The 20 meter pattern is shown in fig. 3. Note that it is not symmetrical, the lobes radiating from the far end of the antenna being slightly stronger than the lobes at the fed end. Minor lobes are down about 3 dB and six nulls show up, each down about 16 dB. In real life these nulls may not be observable.

The 15 meter pattern shows additional side lobes and nulls, but the nulls are less pronounced (fig. 4). The pattern is becoming more irregular. Finally, on 10 meters many lobes exist and are shown to be about −3 to −8 dB below maximum field strength. On this band the antenna is nearly four wavelengths long, and power gain in the main lobes, as compared to a dipole, is about 3 dB (fig. 5).

As I said before, the pattern is a complex mix of horizontal and vertical radiation. The nulls, in addition, are affected by the positioning of the lead-in wire. But these computer printouts provide a good view of the theoretical pattern of this long-wire antenna design.

Feeding the End-Fed Antenna

The impedance at the lead-in point falls in the range of 100 to 150 ohms on the 40, 20, and 15 meter bands. It is about 450 ohms on the 10 meter band. It is reactive on all bands unless the lead-in wire is pruned to reduce reactance on one band. Table I gives an idea of the computer-derived input impedances. A real-life antenna which sags a bit and is surrounded by other objects will depart somewhat from these figures.

In any event, an antenna tuner such as a "Transmatch" should do a satisfactory matching job. To make things a little easier, the reactance of the antenna can be tuned out by placing a variable series reactance of the opposite sign in the lead-in. Suggested values are shown in the table.

The radial quarter-wave ground wire, one for each band, is essential. I didn't know this when I erected my first end-fed antenna many years ago, and I had RF running all over the house. I had the choice of curing the problem or going off the air permanently after my father got "bit" by RF when he turned on his bedside reading light! A single radial cut to 16.5 feet for 20 meters and strung out along the baseboard of my room cured the problem.

Longer End-Fed Antennas

Do you have space for a longer wire? Good. The limiting factor in a long wire is the height above ground and the allowable sag.

As far as the higher frequency bands go, the exact length of the long wire is not an important factor. Make the wire as long as you can and get it up in the air as high as possible. Sensible rules. Antenna reactance at the feedpoint can be tuned out with either a series inductor or capacitor, and the resistive component can be matched with most popular tuners. An SWR meter and radial ground wire are all-important.

In a future column I'll discuss the V-beam, a simple antenna made up of two long wires in V-configuration, fed at the

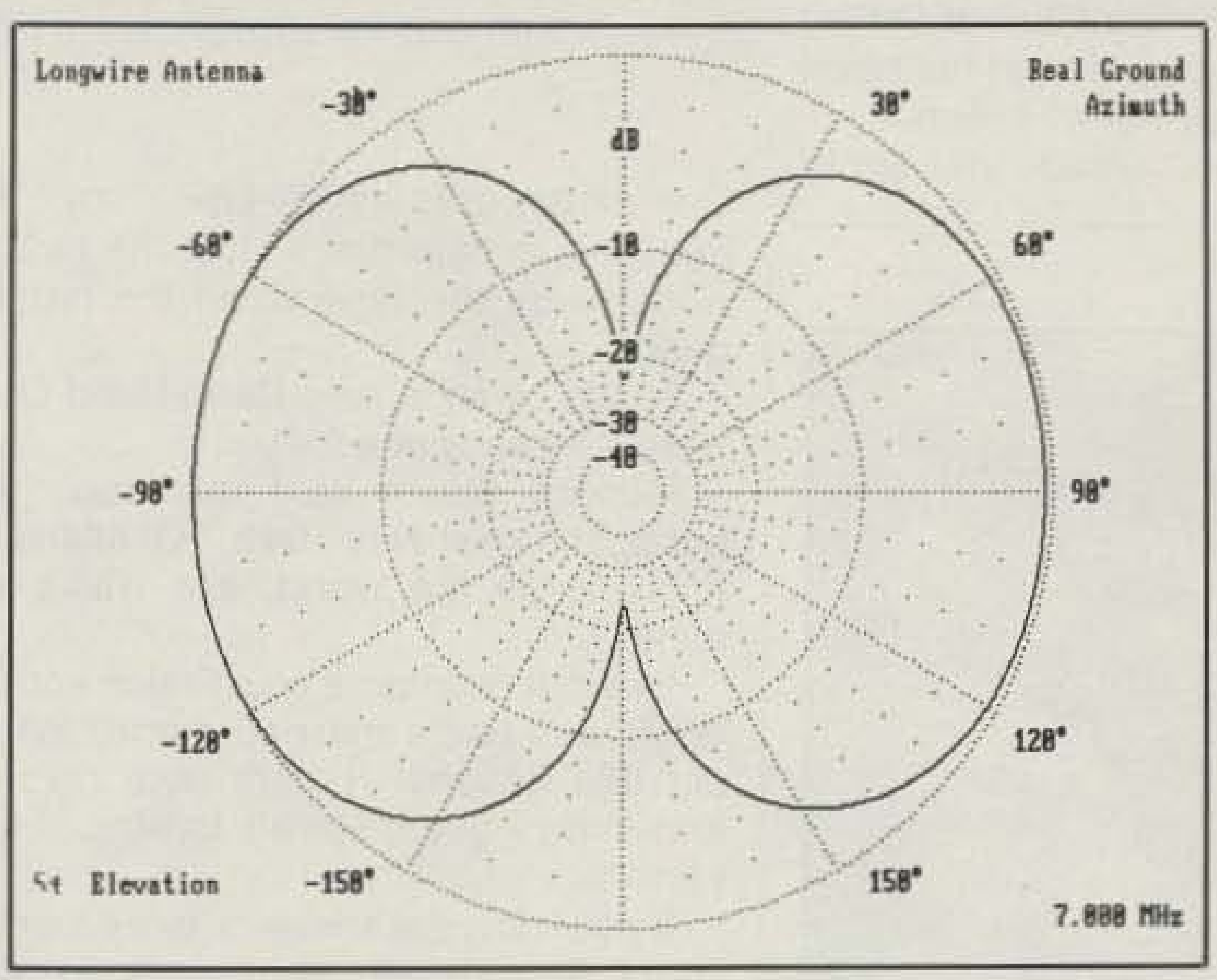

Fig. 2– Computer-derived 7 MHz field pattern of the long-wire antenna of fig. 1. Wire runs from −90 degrees to +90 degrees (right to left) and is fed at the right end. Strong nulls exist at right angles to the wire.

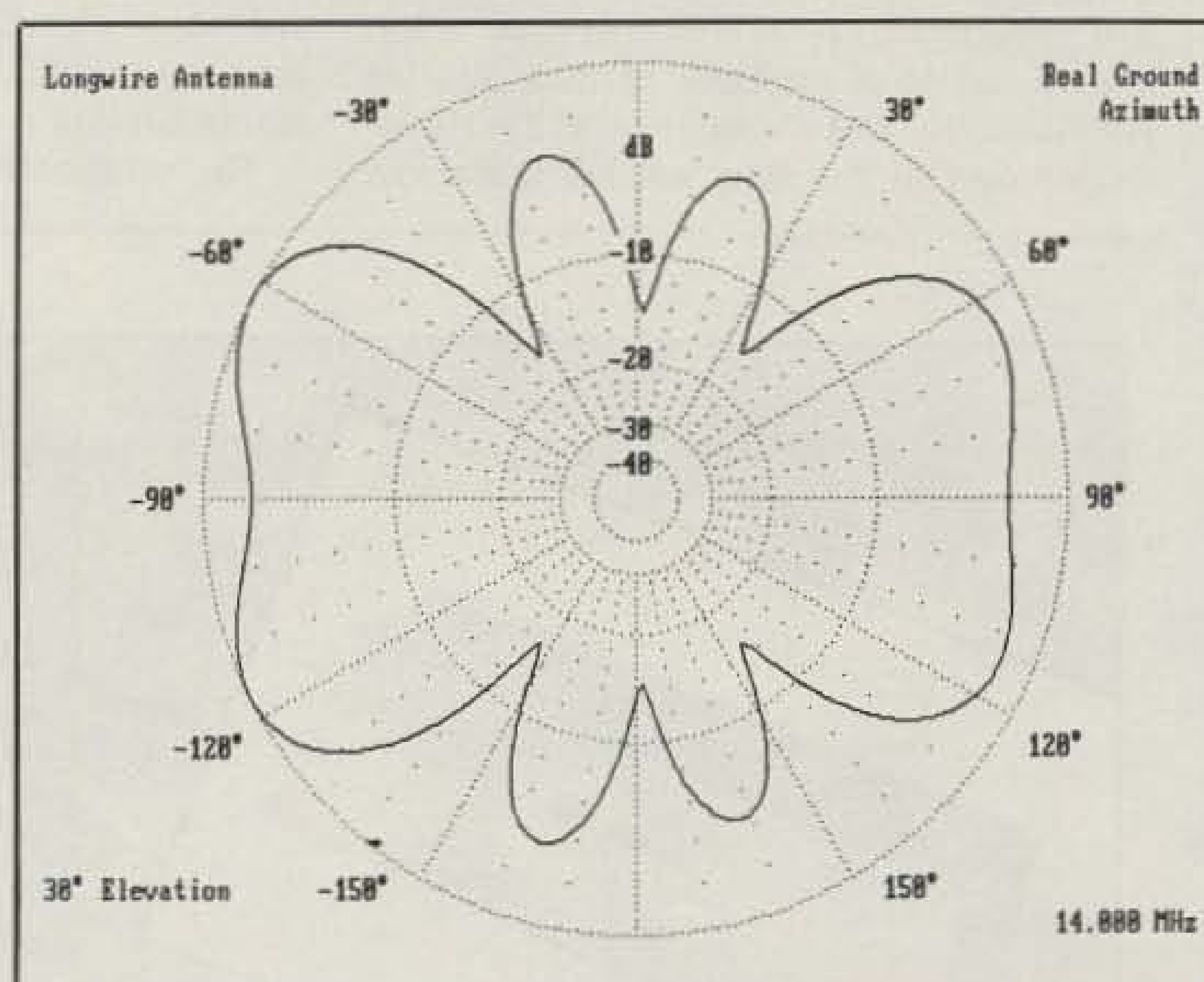

Fig. 3– Fourteen MHz pattern of the long wire. Multiple lobes exist on this band, and pattern is slightly stronger off "free end" of the antenna.

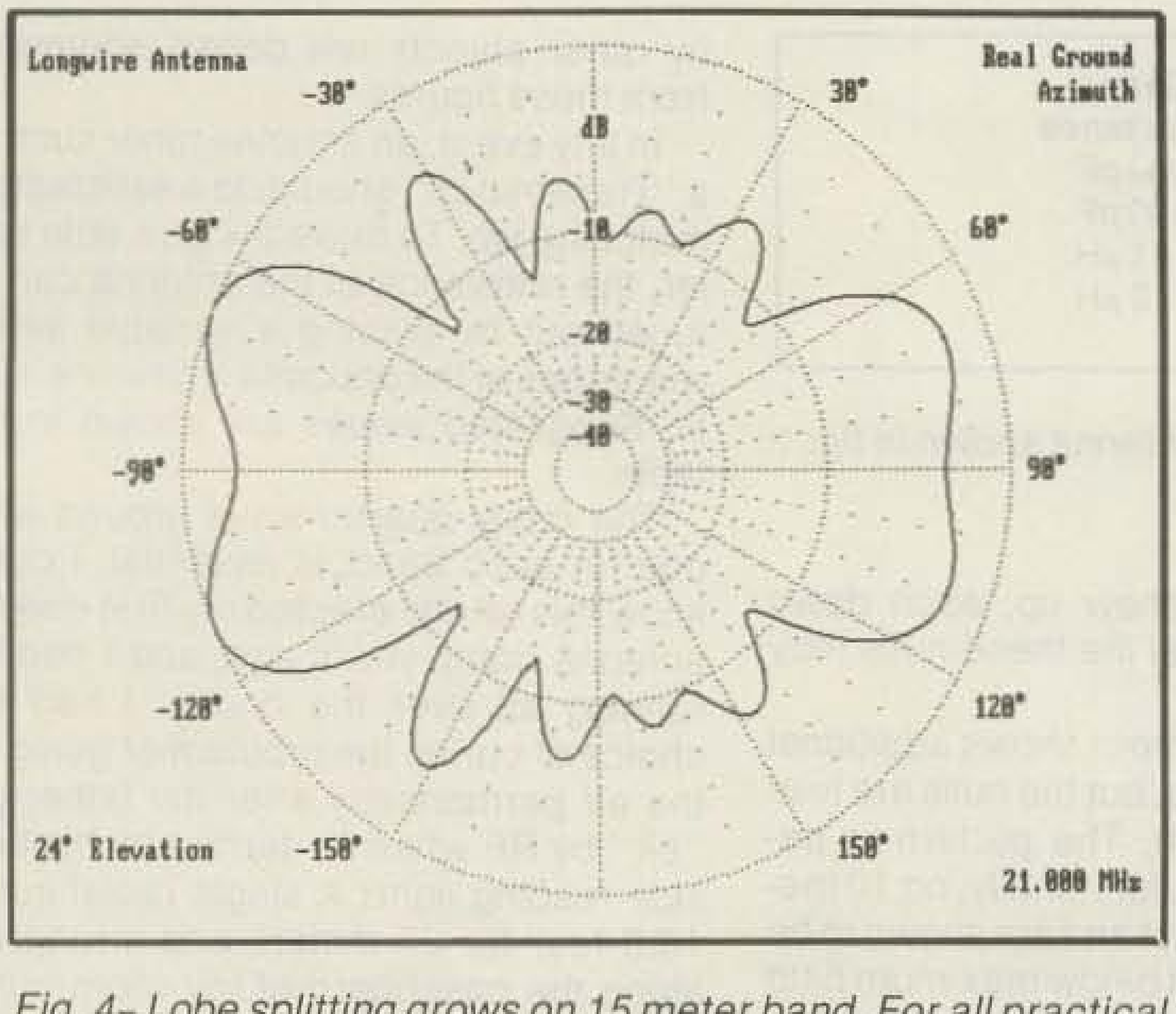

Fig. 4– Lobe splitting grows on 15 meter band. For all practical purposes, however, the user will find the antenna nearly omnidirectional as uneven ground and reflection from nearby objects tend to fill in the nulls.

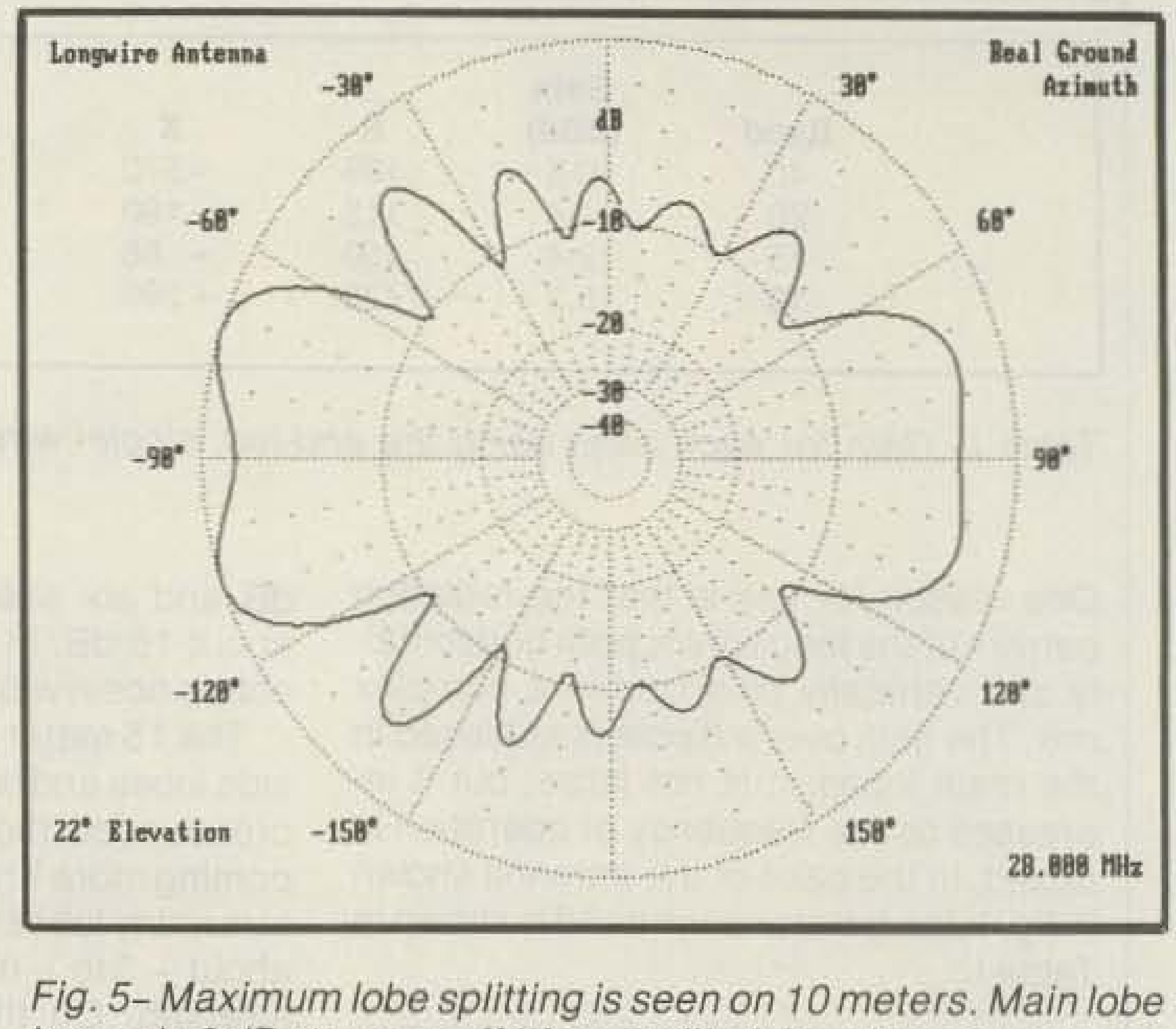

Fig. 5– Maximum lobe splitting is seen on 10 meters. Main lobe is nearly 2 dB stronger off "free end" of the wire as compared to fed-end (right).

apex. This is another inexpensive gain antenna design!

The Center-Fed Long Wire, Coming Up!

It may be more convenient to feed the long wire in the middle rather than at one end. No problem. However, moving the feedpoint makes a difference in the current distribution in the antenna. As an example, look at a wire one wavelength long. There is a reversal of current as shown by the arrows in fig. 6.

The input impedance at the center of this antenna on 20 and 10 meters is quite high, on the order of 2200 ohms on each band. A balanced line and antenna tuner are required to feed the antenna. If the line is cut to a multiple of odd quarter wavelengths, the impedance at the transmitter end of the line will be quite low (about 72 ohms for a 400 ohm line).

There are interesting versions of the center-fed antenna which will be discussed in a later column. Until then, see you on the low end.

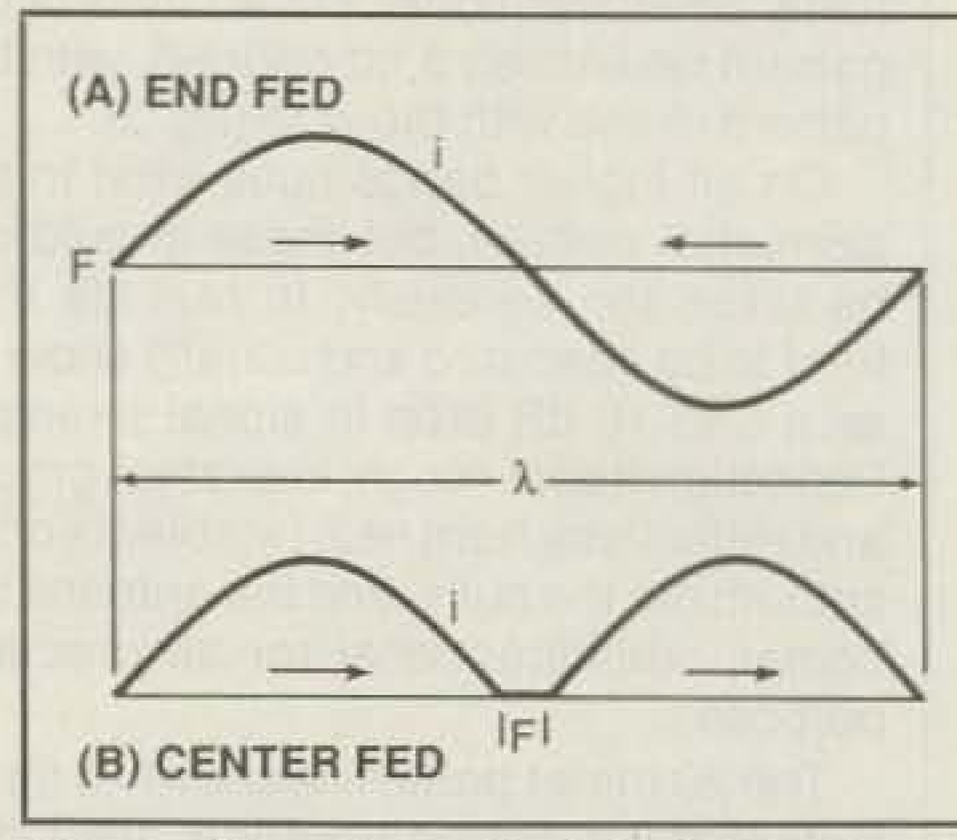

Fig. 6– When long wire is fed at the center (B), a current reversal takes place and half-wave sections shown here are in phase. This is the well-known "two half-waves in phase antenna." Compare currents with end-fed wire shown in (A).

The Dead-Band Quiz

The last Dead-Band Quiz gave two quotations about Ann. One quotation was from the book, and the other was from the made-for-TV movie version of the book *Tinker, Taylor, Soldier, Spy*, by John le Carre. Roddy Martindale, who worked "on the fleshy side of the Foreign Office" made the remark. After pumping George Smiley of the "Circus" for hours over an unappetizing dinner and getting nowhere, he flung this verbal dart at Smiley as they parted, jabbing him in his heart about Smiley's unfaithful wife, Ann.

Recommendation: Read the book! One of the greatest all-time "spy" stories! It is in paperback. Just the thing to while away the time when the band is dead.

Ready to try a new Dead-Band Quiz? Here's an easy one for you:

Richard Blaine said this about Ilsa Lund. The year was 1941: "Of all the gin joints in all the world, she walks into mine!"

By what nickname was Blaine known? What was Ilsa's married name? Where did this fictional remark take place? I know you'll get it. Here's looking at you, kid!

If you know the answers, write them on your QSL and send them to me at my address at the beginning of this column. The calls of the knowledgeable "winners" will be published in this column.

73, Bill, W6SAI