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RHOMBICS - Are They Really Worth It?

Every amateur always wants a little bit better antenna than the one at his present installation. Occasionally, he will think that a rhombic would really fit the bill, if only there were enough space, height, etc. After thinking about this for a time, he looks over what reference material there may be immediately available, then goes about his business to think about antennas another time.

Many amateurs, SWLs and others think of the rhombic as the Rolls Royce of antenna systems, the absolute ultimate, or the panacea for the problem of elusive DX. It is unfortunate that more information on this antenna is not more readily available to the average person. The *ARRL Antenna Book* contains some information, as does the E&E *Radio Handbook*; but substantive information is usually available only in exotic sources and when located is often in such terms as to be unintelligible to anyone without an EE degree.

Confronted with the choice of antenna structure to erect on my 5½-acre QTH, I

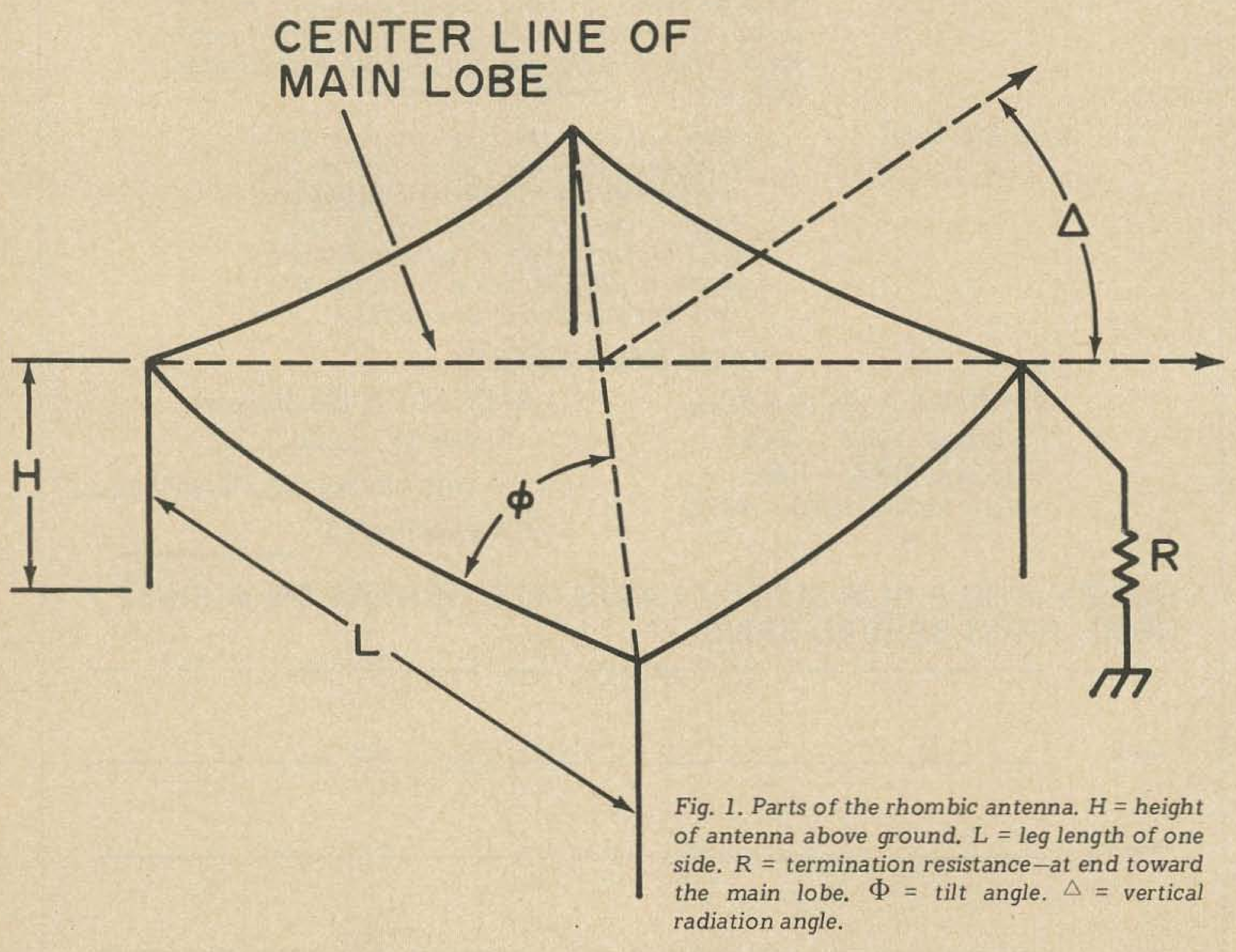
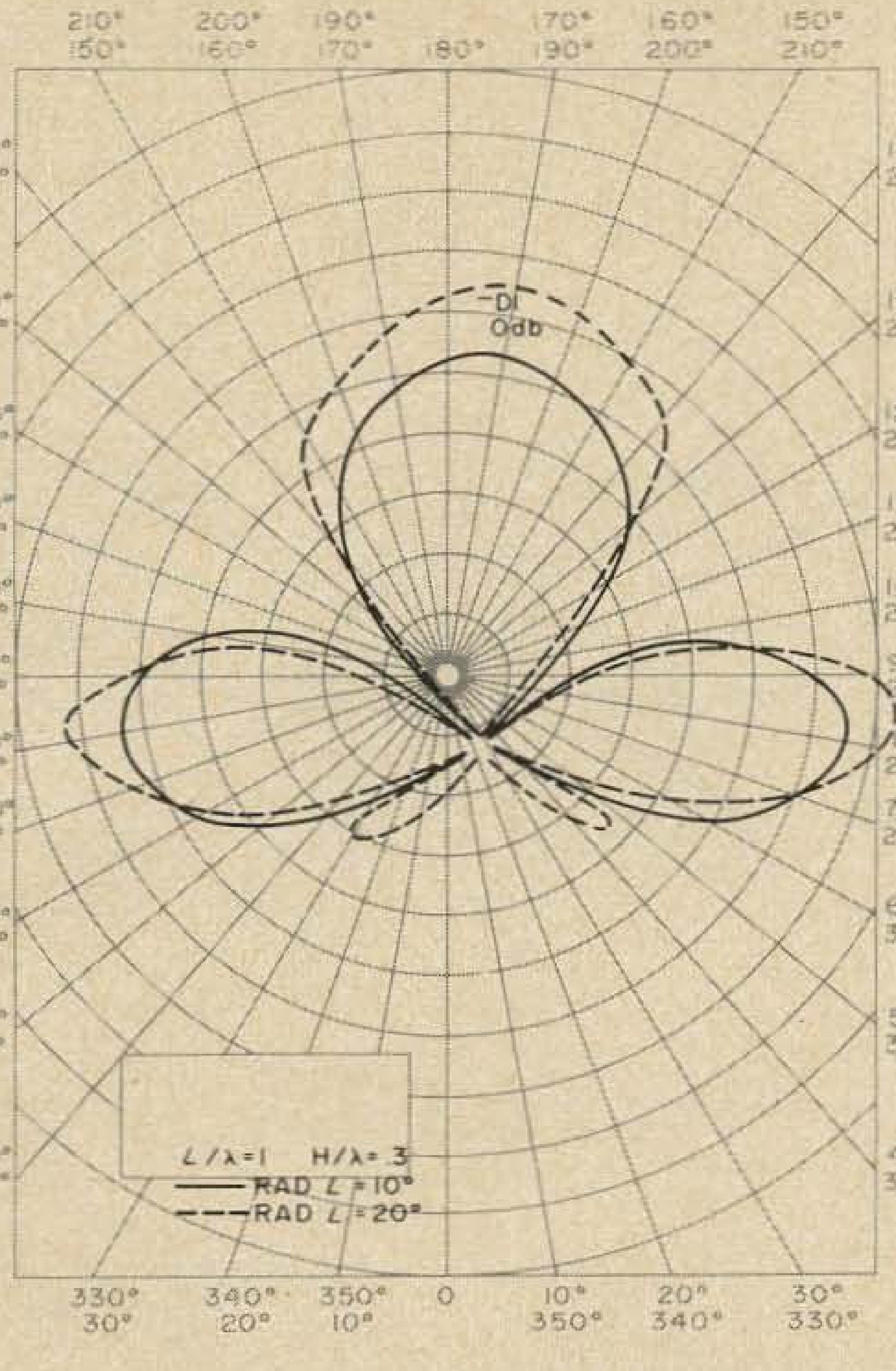
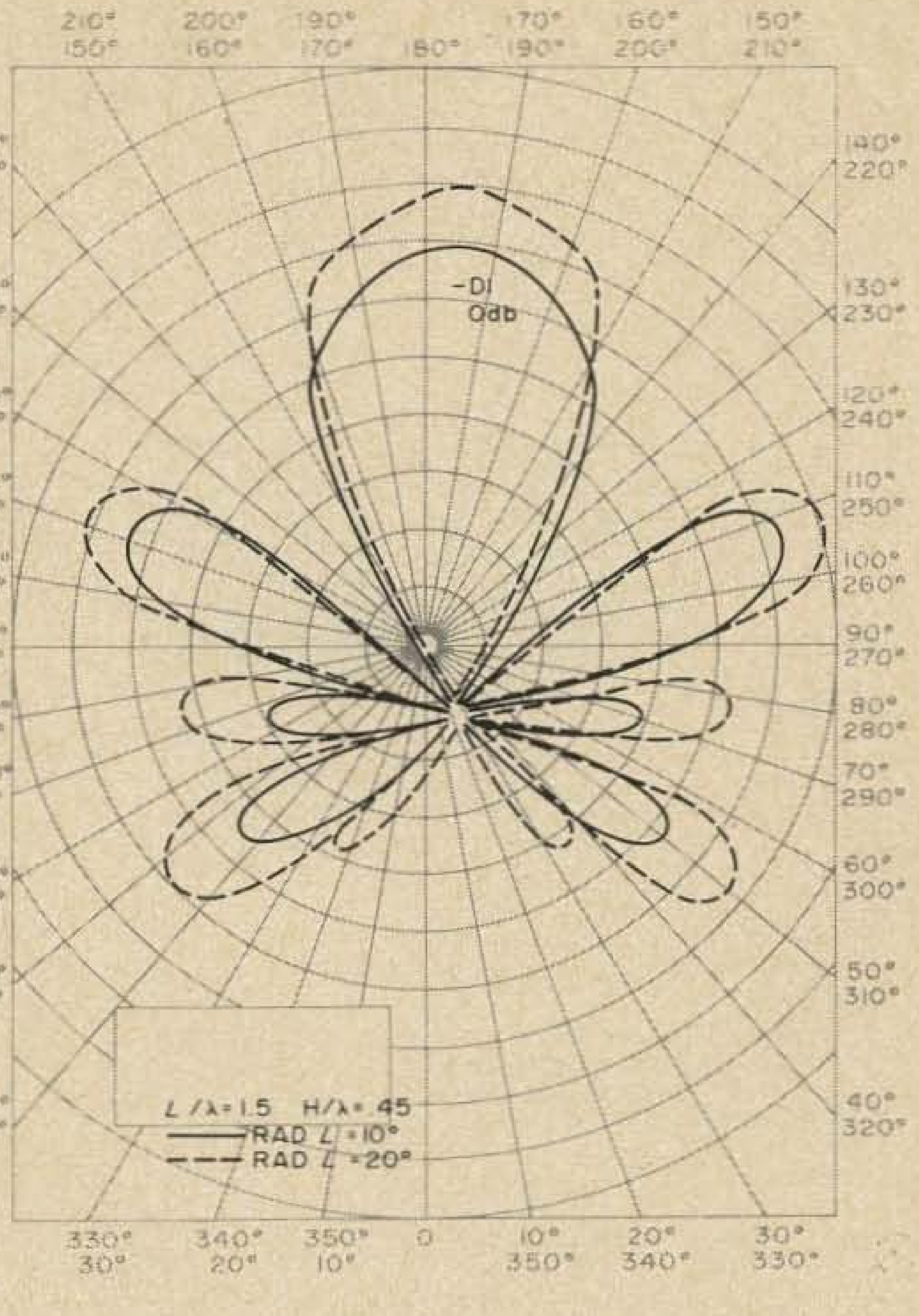


Fig. 1. Parts of the rhombic antenna. H = height of antenna above ground. L = leg length of one side. R = termination resistance—at end toward the main lobe. Φ = tilt angle. △ = vertical radiation angle.





considered a number of different designs, including the rhombic. It was confusing to see terms such as *tilt angle*, not the tilt of the antenna in respect to the ground, but the "tilt" of the geometrical figure in relation to a square – a tilt angle of 45° would result in a square; 0° and 180° would produce a straight line, see Fig. 1.

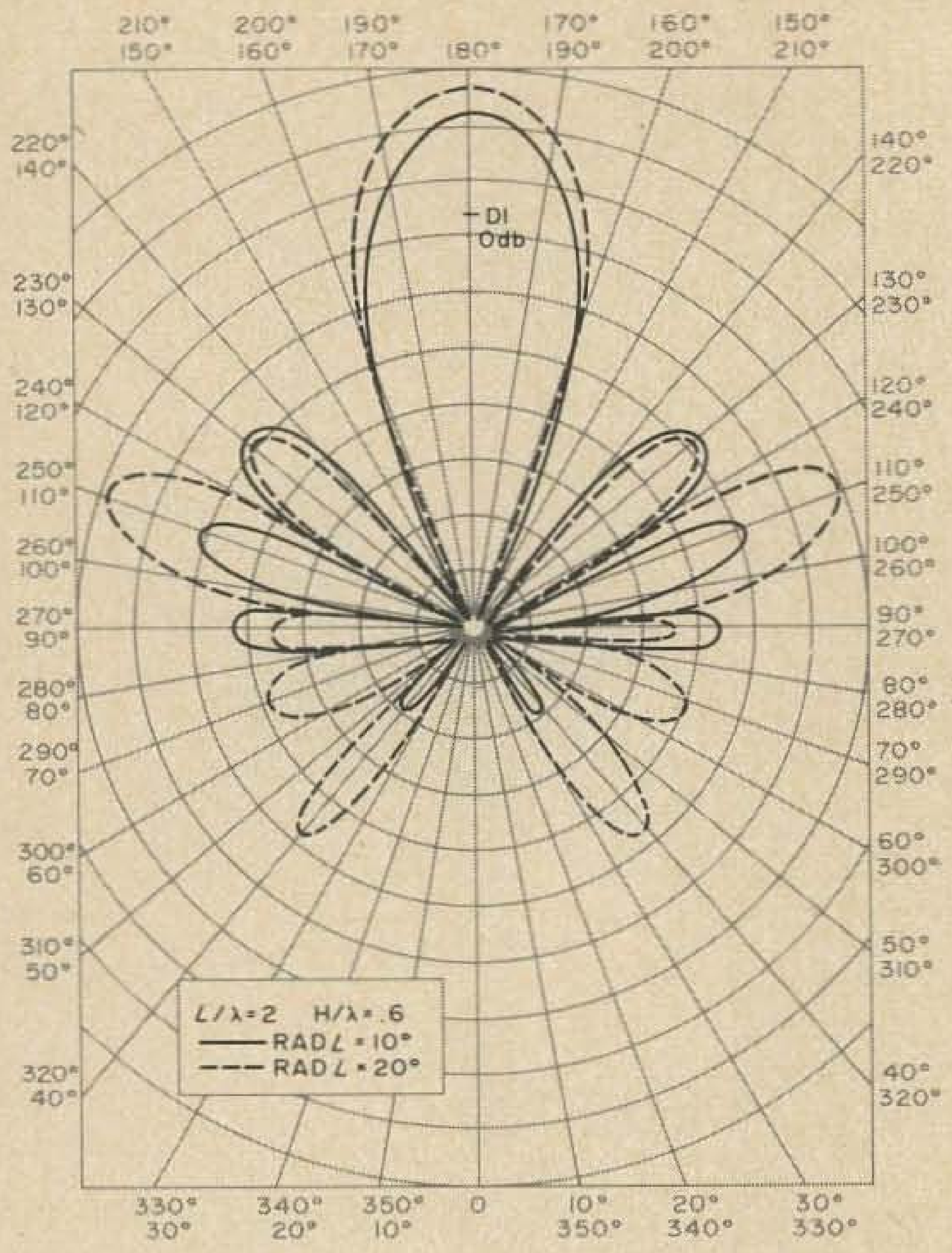
H = height of antenna above ground
l= leg length of one side
∅ = tilt angle
R = termination resistance – at the end toward the main lobe.
△ = vertical radiation angle

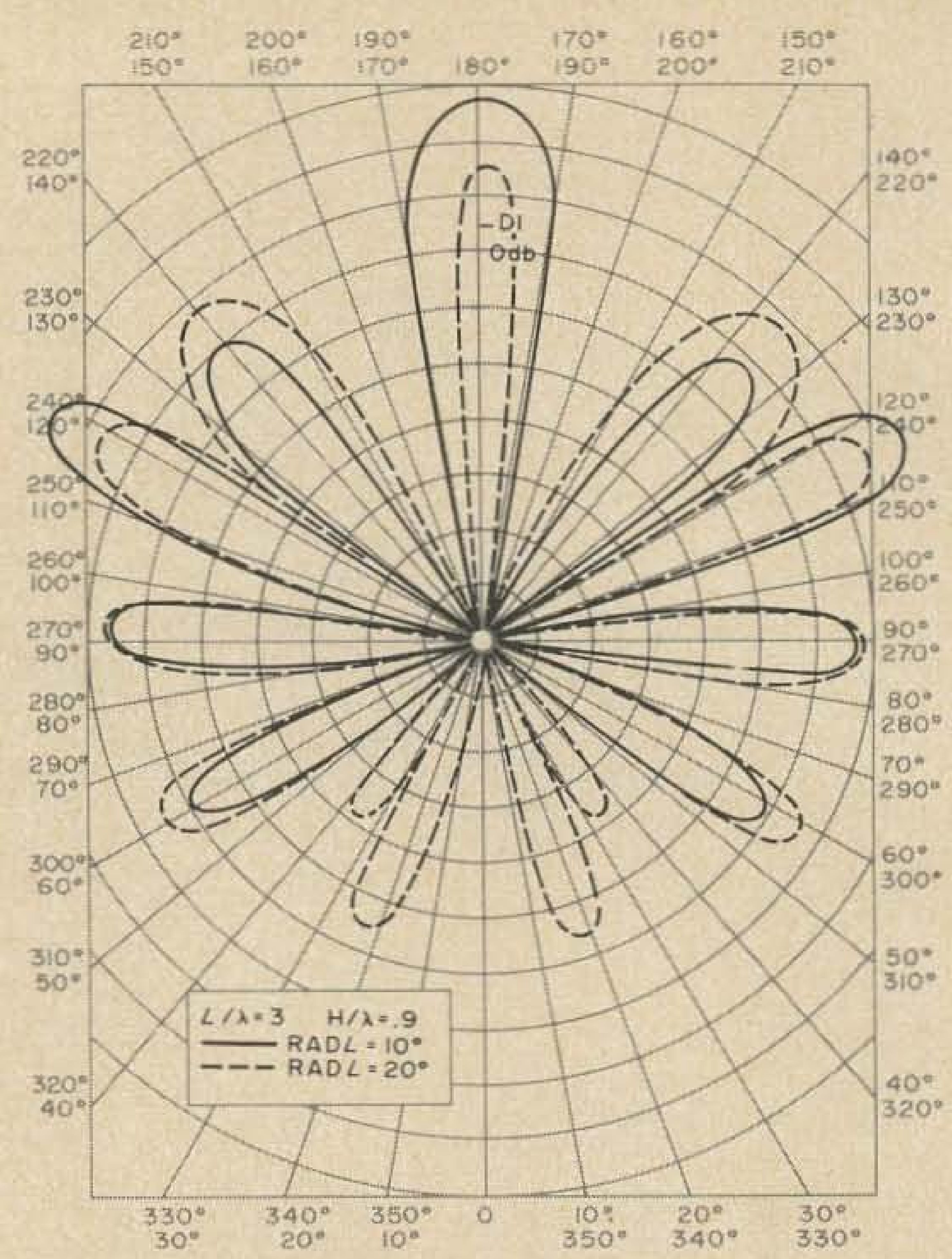
This information, coupled with complicated mathematical calculations immediately discourages all but the most determined of the fraternity. It is possible, fortunately, to calculate theoretical radiation patterns for a given set of parameters; we'll get to these in a moment.

The rhombic is a "travelling-wave" antenna, contrasted with the more common "standing-wave" or resonant antenna, such as the dipole. A travelling-wave antenna is non-resonant at any particular frequency, being useful over a wide band of frequencies. As a result, the impedance of the antenna does not vary nearly as much as it does on a standing-wave antenna. Calculating the impedance variations of a rhombic, it is theoretically useful over about a 5:1 frequency range. Other factors enter in, however, so that commercial users find that the practical useful range is over about a 2:1 frequency ratio.

The average rhombic weighs in with a characteristic inpedance of around 800Ω. Antenna experts found that this impedance can be lowered by using multiple conductors on the legs. These conductors are together at both ends of the antenna, but separate as they go toward the sides, where they will be a meter or so apart. The capacitance will vary in a manner which maintains a constant impedance. At the sides, the center wire will appear to be outside the upper and lower wires, because each wire is of identical length. Most commercial users have a 600Ω antenna.

A properly built rhombic system contains the terminating resistor at the opposite end from the feed point. This resistor gives the system the characteristic front-to-back ratio, the big selling point of the rhombic. The resistor should be matched to the characteristic impedance of the antenna and should be capable of dissipating half the power





applied by the transmission line (which, naturally, should also match the antenna impedance). At amateur power levels there is no great problem in building a resistance network to take the heat, but commercial users use "dissipation lines" rather than fixed resistors.

The average radiation efficiency of a terminated rhombic is around 67%. This compares with the radiation efficiency of a dipole at substantially 100% – but remember the power dissipated in the termination resistance.

It would be possible to use reams of polar coordinate paper calculating radiation patterns for rhombic antennas at various tilt angles, leg lengths, heights, etc. Probably a computer could be programmed to spew forth thousands of these in a few minutes. For the purposes of this discussion, we will look at ten patterns obtained from the same antenna. The patterns start at a leg length of 1λ and go to 4λ; the height starts at 0.3λ and goes to 1.2λ. This is the same antenna operating at several frequencies with the radiation patterns given for 10λ and 20λ radiation angles.

Note: the diagrams contain ticks on the major axis for 0dB gain in relation to isotropic and for 0dB gain for dipole, identified as 0dB and DI respectively.

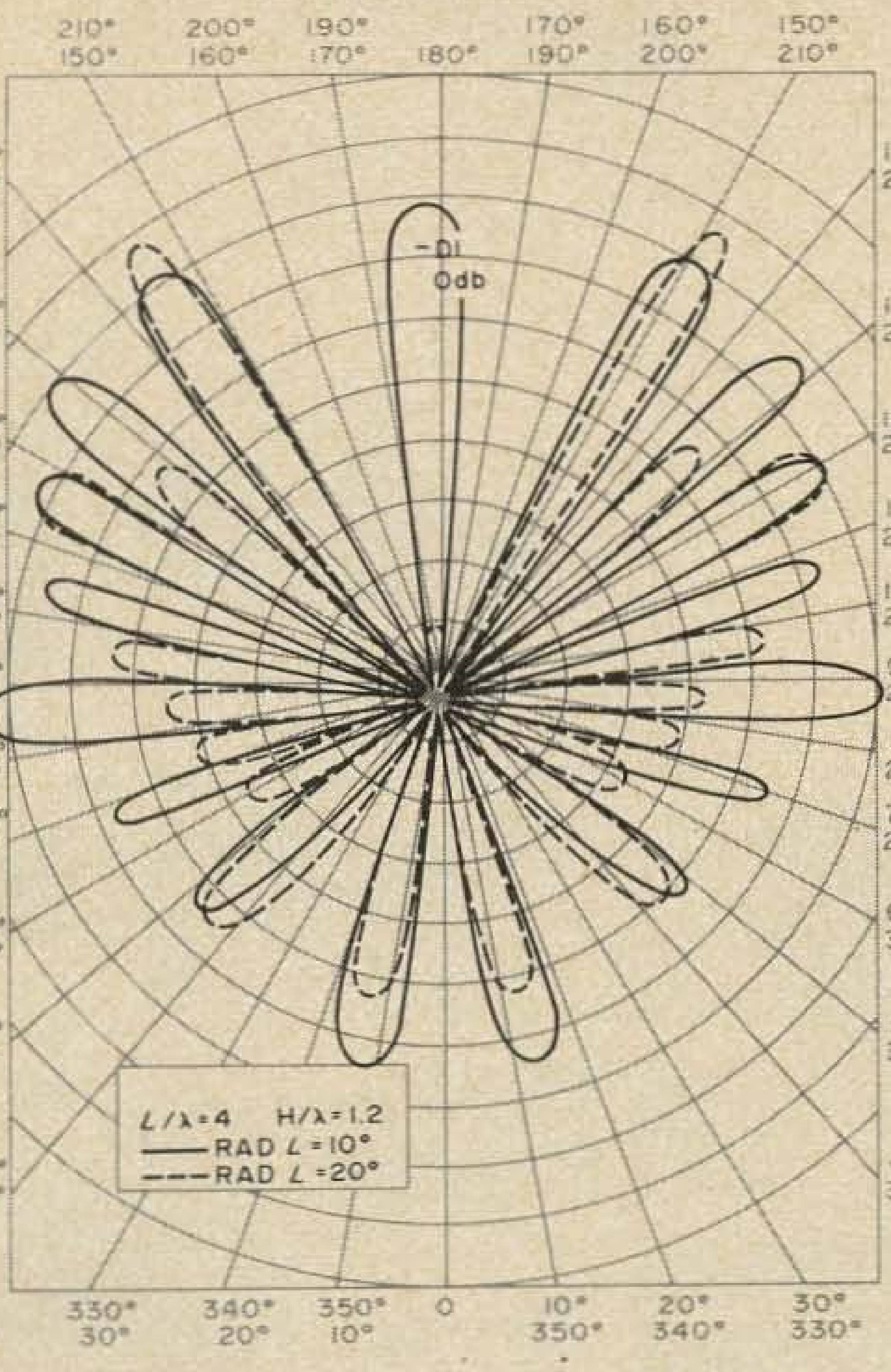
Disadvantages

1. Radiation pattern shows considerable change over frequency range.
2. Very poor front/side ratio.
3. Power lost in terminating resistor.
4. Antenna cannot be rotated for typical amateur use.
5. So what if you want to make a contact within 400 miles?
6. System requires enormous quantity of real estate.
7. Four supports are essential.

Advantages

1. Impedance varies little over considerable frequency range.
2. Very high front/back ratio.
3. Power concentrated in desired direction.
4. Ideal antenna for point-to-point communications.
5. Antenna excellent for low-angle, long-distance communication.

Rhombic users have developed several variations of the system. For additional gain, it is possible to stack two rhombics. For use on more than 2:1 frequency range, it is possible to build a rhombic inside another rhombic, saving one support (the "nested"



rhombic); to suppress undesirable side radiation; two rhombics can be interlaced, adding gain to the main lobe and cancelling the side lobes. The radiation angle can be changed by tilting the plane of the wires away from the plane of the ground. See Fig. 2.

After considering the problem of where to point it and the various other problems, I decided not to build a rhombic, since I wanted a more flexible system. I ended up with a phased array, even though suitable for only one band, the side supression will be better and I really don't need the extreme front-to-back ratio.

The next time you think about an ideal antenna, remember the rhombic may have excellent forward gain, but it also has considerable side radiation (and reception) and is inflexible, which quality alone would make it questionable for most amateurs.

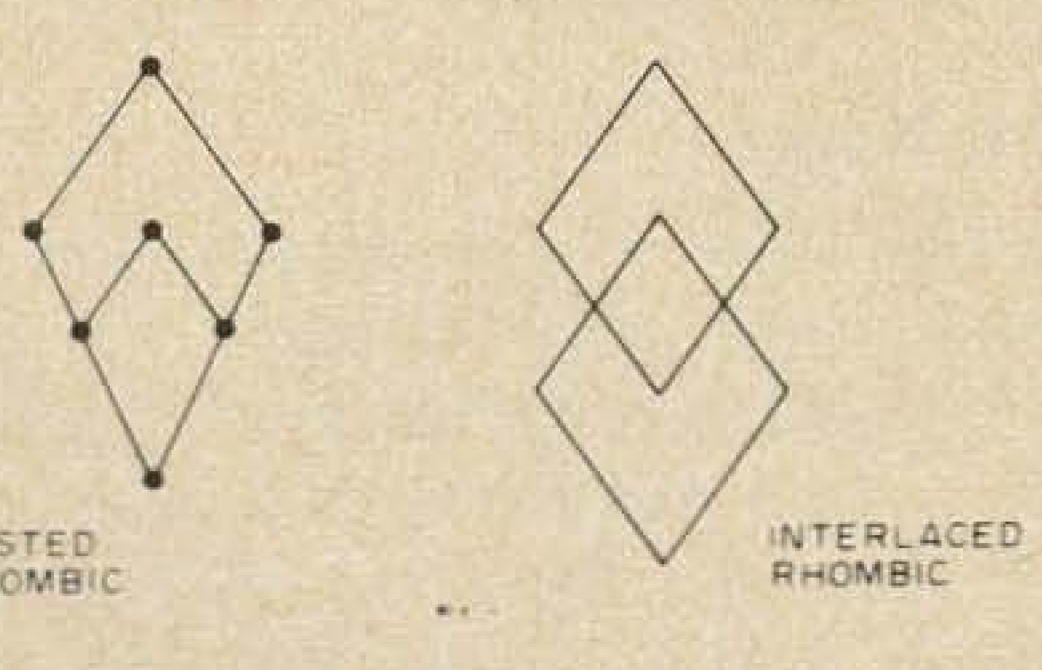


Fig. 2

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