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A Survey of Direction Finding Techniques and Antennas

The field of radio direction finding (RDF) is actually almost as old as wireless or radio itself. And in this electronic age where global-positioning technology can easily tell us our location anywhere on earth with great accuracy, it is easy to overlook the tremendous service which RDF, even in its simpler forms, has rendered to mankind over the years.

Its applications range from locating distressed ships at sea, to helping pilots return their plane safely home, to finding sources of radio interference, to locating pirate radio stations, and even to zeroing-in on enemy transmitters in wartime. And we mustn't overlook the fun amateur radio operators have with their hidden transmitter hunts as they search for the "fox."

In scientific research, RDF techniques have helped us come to understand such vagaries of radio wave propagation as the fact that some signals depart from great-circle paths, what vertical angles waves are arriving from, and from whence come the strange echo signals that have perplexed radio operators from time immemorial (well, for a long time, anyhow). All in all, RDF is a very interesting field with much to offer the radio enthusiast.

A Brief History of Radio Direction Finding

Directional antennas have been around ever since the late 1800s when Hertz, who first demonstrated electromagnetic waves, used the dielectric lens and the parabolic-dish reflector antenna. (What? You thought the dish antenna was recent technology?!) Later in the 1800s, Marconi also utilized parabolic reflectors for some of his wireless systems. In 1900 Zenneck, the "German Marconi," experimented with directional antenna designs but, for some reason, discontinued what looked like promising work in this area.

Dunlap, in his *Radio's 100 Men of Science*, says "Many are mentioned as the 'inventor' of the radio compass, among them Fessenden, Pickard, John Stone Stone, Capt. H. J. Rounds, Francis W. Dunmore, Percival D. Lowell, R. L. Rose-Smith, and Bellini-Tosi, but generally Kolster is credited with having built a practical device; that others had observed and realized the directional properties of wireless is conceded."

Unfortunately, early receivers were so insensitive that RDF techniques were effective only up to a few miles. However, once the triode vacuum tube was discovered, much more sensitive receivers were possible. Subsequent to this improvement the systems of Bellini and Tosi, and of Pickard, were heavily utilized in early RDF work.

Bellini and Tosi, following up on work by Artom, had developed an RDF system (fig. 1A) utilizing two crossed, fixed-position loops connected to a "radio-frequency transformer with a rotatable secondary winding." This transformer, called a "goniometer," coupled the signals from the antenna loops to the receiver.

The goniometer had a rotatable secondary winding which, when rotated for the loudest signal, indicated the direction of a line which intersected the location of the transmitting antenna. However, it was impossible to say in which direction along this line (toward which of the line's ends) the transmitting antenna

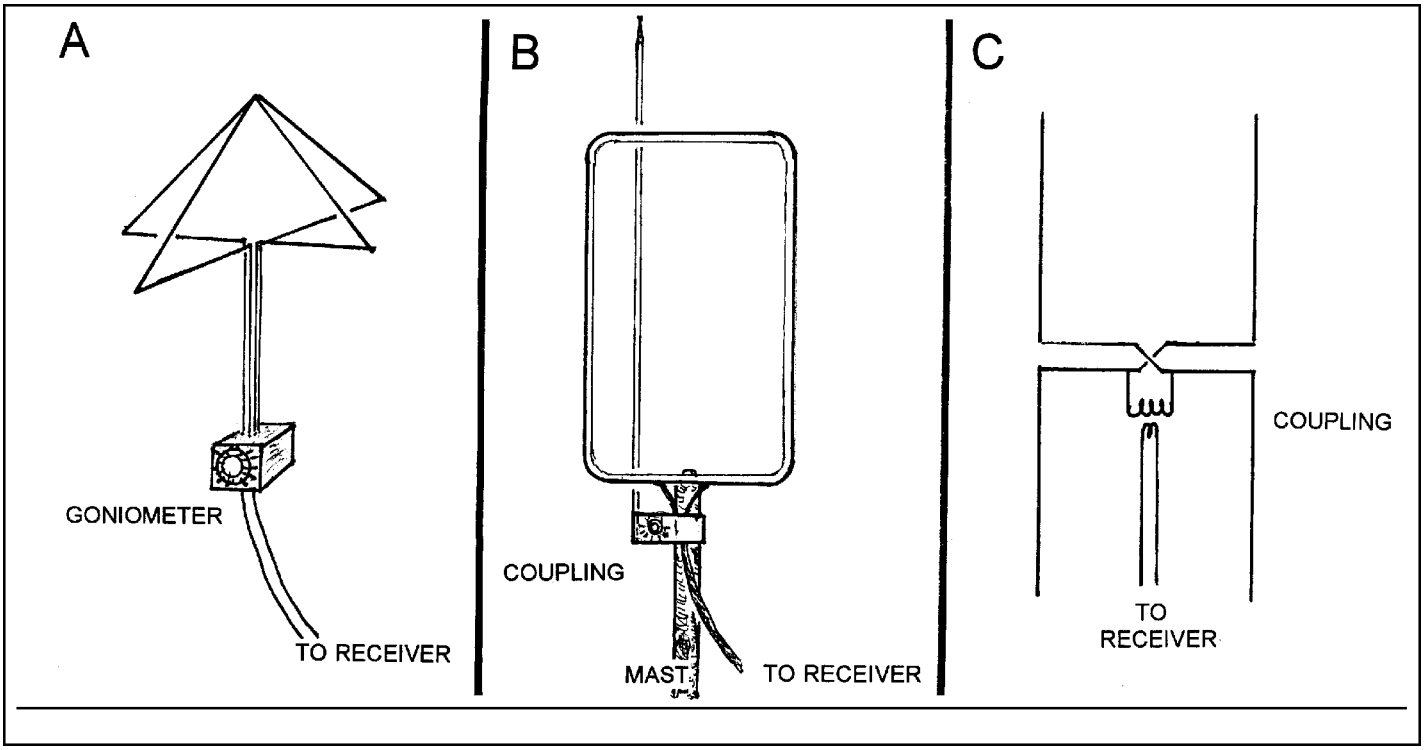

FIG. 1. *Three antennas which have been important in radio direction-finding. The Bellini-Tosi (A), the loop-plus-sense-antenna (B), and the Adcock (C).*

lay. Only by taking separate readings from two separate locations could the transmitting antenna's location be determined. Its location was the intersection of the two directional lines indicated by the goniometers.

Picard developed a loop-plus-sense-antenna (fig. 1B). Its cardioid (heart-shaped) response pattern gave a non-ambiguous, unidirectional indication of the direction from which signals arrived. This was a great advantage, and the design is still frequently utilized (see any *ARRL Antenna Book* for how to build one)..

During the first world war the wireless pioneer Fessenden worked out an RDF system using two widely separated loop antennas. By this means the British were able to locate German Zeppelins via the Zeppelin's radio signals, and report their positions to the British air force long before the Zeppelins arrived over England. The British were also able to RDF the movement of German battleships with such great accuracy that by monitoring a ship's wireless activity from their monitoring stations in Britain they were able to detect German ship movements while the ships were still *within the German ports*.

Subsequent to those earlier systems the Adcock antenna (fig. 1C) was developed to reduce signal polarization errors common on high frequency, and was heavily utilized in RDF work. Marconi had earlier developed an RDF antenna system composed of a number of inverted-L antennas radially spaced around a circle. The elements were sampled by a rotary switching arrangement, and the antenna producing the loudest signal was assumed to be pointing at the source of the signal.

A more recent RDF system which also uses rotary sampling of antennas arranged in a circle is the Wullenweber, or "elephant cage" antenna. This antenna covered a circle 900 feet in diameter, had a central, circular shield-screen 120 feet high, and 96 vertical antenna elements each over 100 feet tall!

More recently the Doppler effect has been exploited to produce some rather sophisticated RDF units. By sampling the signal from a set of several physically-separated antennas it is possible to determine the direction of wave arrival fairly precisely. We should note that position-indicating systems such as GPS and the older LORAN, although they are not strictly speaking RDF systems, are very accurate in helping locate one's position on the earth's surface.

Some Easy RDF Techniques

The loopstick antennas in most small AM receivers are quite directional. If you tune such a receiver to a radio station and then rotate the receiver horizontally, you will most likely find that the signal fades to a low level at two points in a complete rotation. These points are called "nulls," and they are quite narrow (i.e., you must position the radio precisely to null the signal). If the signal is strong you may not be able to get a good null due to the automatic gain control in the receiver. In this case try a weaker signal.

The nulls should occur along a line through the long dimension of the antenna's ferrite rod. Take a directional reading on one station at two widely separated locations. Plot these two directional lines on a local map, and the point where the lines cross will indicate the position of the transmitting antenna.

If you have a handheld transceiver or scanner operating on the VHF band or higher, you can RDF using just your body as the RDF accessory! Tune in the station you want to RDF, and hold the transceiver or scanner up to your chest. Standing upright, slowly turn in a complete circle. The signal will most likely fade as you face in the direction away from the transmitting antenna, and return to full volume as you face that direction.

On VHF and UHF many beam antennas are small enough to carry and manipulate easily by hand. With the typical beam you will rotate the antenna over your head while looking at your receiver's signal-strength meter for a maximum reading. Most beams have a fairly wide beamwidth, but they can give you a general idea of the transmitting antenna's direction.

RADIO RIDDLES

Last Month:

I said: "Antennas have been called by various names including 'skywires,' 'antlers,' 'signal grabbers,' and 'wings.' Heinrick Hertz called them 'conductors.' The British often use a different term for 'antenna.' What is that term? What is its origin?"

You probably guessed it correctly; the term is "aerial." This term originated from the fact that, for good reception, early wireless antennas had to be elevated high above the earth. "Aerial" means "high above the earth," thus the antenna was an "aerial wire." In time this was shortened to "aerial."

This Month:

Could RDF be used to track thunder storms?

You'll find an answer for this month's riddle, and much more, in next month's issue of *Monitoring Times*. 'Til then, Peace, DX, 73