

# “HUFF-DUFF”

## Your Own High Frequency Direction Finding Antenna

BY WILLIAM ORR, W6SAI

**H**UFF-DUFF (High Frequency Direction Finding) was widely used by Allied and Axis powers to locate submarine and aircraft high frequency transmissions, obtain a bearing on the signals and thus “pin-point” the location of the enemy vehicle. It was a good idea, but the design and installation of practical direction finding stations throughout the world proved to be a formidable task. After the war, when much air and marine traffic was transferred to the VHF bands, high frequency radio direction finding lapsed into obscurity except for location of clandestine transmissions. Modern direction finding equipment is beyond the ability and cost of today’s active listener, but some of the simpler techniques developed for aircraft location during the “thirties” can be applied today with good results. The Adcock direction finding system is one device that can be built, at little cost, to provide the user with interesting direction finding techniques. This article covers the construction and use of such an instrument.

### Early Direction Finding Attempts

The use of a radio wave for direction finding was well-known to Marconi, and this early radio pioneer developed equipment that was used by the Italian Navy to locate the approximate line of direction to a radio signal source. The U.S. and British Navies built and used RDF (radio direction finding) sets based upon Marconi’s design for many years, but it was not until 1938 that compact RDF equipment came into use for aircraft spotting. Many RDF installations were in use in Europe and Australia to aid civil aviation, but, aside from transoceanic flights, the U.S. employed other means that made the use of direction finders unnecessary.

With the coming of World War II, the need for high frequency direction finding accelerated development of new equipment in the U.S. and many simple ADF stations were installed along the airways operated by the U.S. Air Forces and served for aircraft rescue purposes. The ultimate transfer of most aircraft traffic to the VHF/UHF region during the late “forties” made obsolete most RDF stations, and gradually they were dismantled. Today, most RDF stations in the U.S. are operated by the military and the Federal Communications Commission for the purpose of spotting unauthorized radio transmissions. The FCC monitoring stations are located at Allegan, MI; Anchorage, AK;

Belfast, ME; Douglas, AZ; Ferndale, WA; Fort Lauderdale, FL; Grand Island, NE; Kingsville, TX; Laurel, MD; Livermore, CA; Powder Springs, GA; Sabana Seca, PR; and Waipahu, HI.

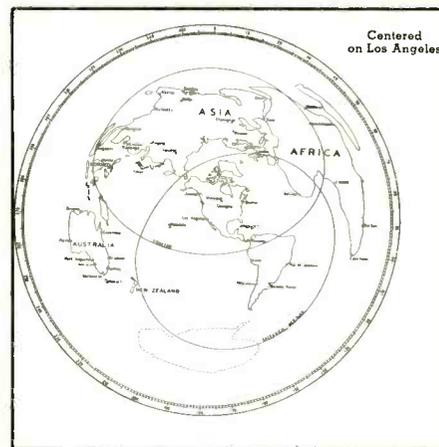
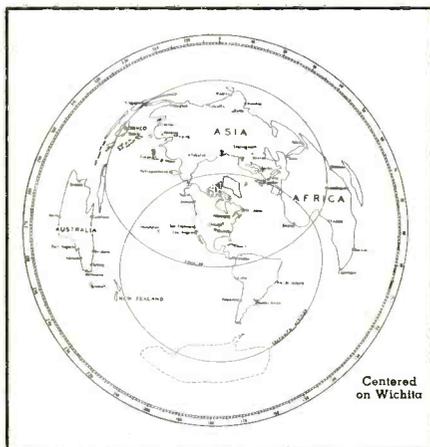
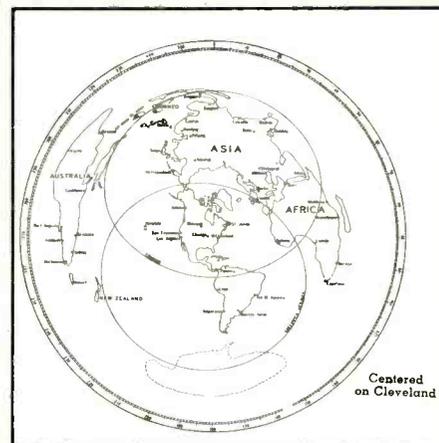
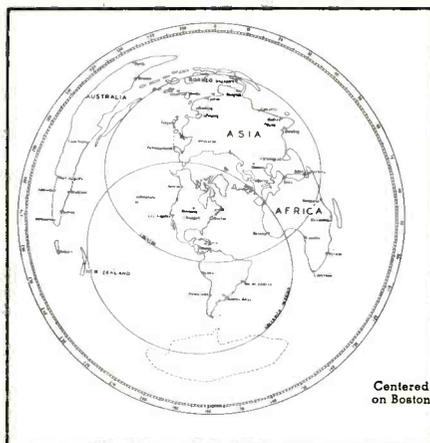
### How RDF Is Used

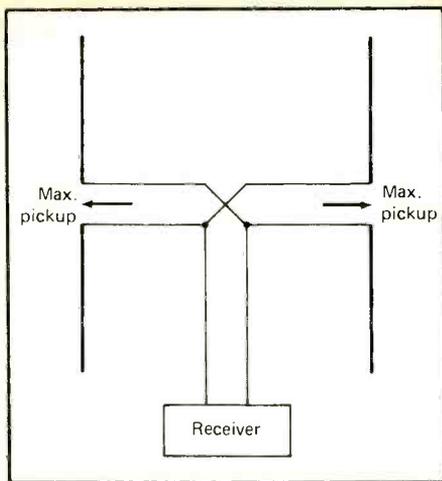
Radio transmission between two points usually follows the shortest path consistent with its reflections back and forth between the earth and the ionosphere. This path is known as the *Great Circle route*, which is the shortest distance between two points on the surface of a globe. This route commonly appears as a curve on a regular map. The Great Circle route became widely publicized in 1927 when Col. Charles A. Lindbergh

made his historic transatlantic flight from New York to Paris. The maps published in newspapers showed “Lucky Lindy” flying far north, grazing the tip of Greenland en-route to Europe. Why didn’t he fly a direct line from New York to Paris? Actually, he did, but on a regular map his route was distorted into an arc that took him close to the Arctic regions.

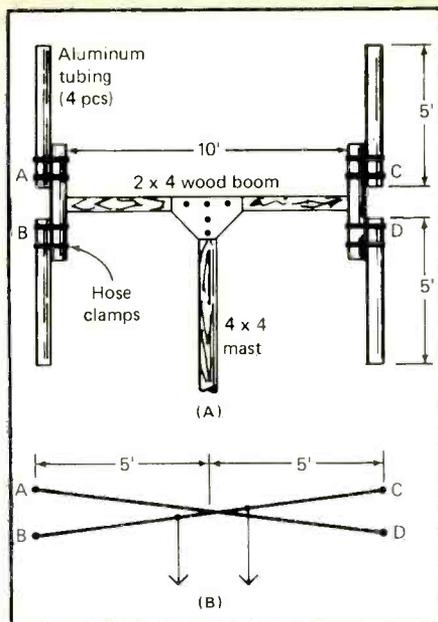
Four Great Circle maps are shown (Figures 1-4) that quickly reveal Great Circle routes from four locations in the U.S. to other world points. Notice the apparent distortion of the continents on the maps. But a ruler laid between the point of origin (the center of the map) and any point in the world will instantly give the line of direction to that point. Note that a Great Circle map

Figures 1-4: Great Circle Charts for the United States. (Charts courtesy of Radio Publications, Inc.)





**Figure 5:** The Adcock direction finding antenna. If spacing between elements is small compared to wavelength of received signal, the antenna provides a figure-8 pattern having deep nulls. Bearing errors caused by down-coming horizontally polarized waves can be substantially eliminated with this simple array.



**Figure 6:** Top—layout of Adcock array  
Bottom—connecting harness made out of 300-ohm line.

for one location will not work for another location.

A Great Circle map, in addition to being useful for navigation, is used to determine the line of direction of a radio signal. With a map and RDF equipment, the listener can locate a line of direction between his receiver and a distant radio station. Or can he?

### Pitfalls In RDF

It is tempting to think the high frequency radio wave travels a Great Circle route as it passes from continent to continent. But high frequency waves reflected from the ionosphere are often altered during their path from transmitter to receiver. The alterations greatly increase the difficulty of locating the direction of origin as deviations of 10 to 20 degrees from the direct path are common, and deviations larger than this have been observed on occasion. The cause of these deviations have been linked with the ever-changing structure of the ionosphere, as well as by auroral activity.

Luckily, most deviations are of short duration and are, in general, much less than 20 degrees, and it has been determined that a number of observations made over a period of time can result in good determination of a line of direction between transmitter and receiver.

### The Adcock ADF Antenna

Simple loop antennas have been used for many years for low frequency (below 500 kHz) direction finding. The deviations of HF signals due to action of the ionosphere, however, make the loop useless for HF observations. This was realized very early in the game, and in 1919 an English patent to Adcock was granted for an improved HF di-

rection finding antenna system which would eliminate the errors inherent in the loop system. The Adcock elements responded only to vertically polarized waves and were insensitive to horizontal polarization. This was the result of a discovery that, regardless of the original wave polarization, the reflected wave had a great degree of vertical polarization, which exhibited less of the directional fluctuations that did the horizontally polarized portion of the wave. The Adcock ADF system has been in use for many years and only in the past few decades has it been surpassed by more exotic and expensive ADF antennas. The Adcock array is cheap and easy to build and provides a good introduction to the listener to the art of radio direction finding.

### Building An Adcock Antenna

The simplest Adcock antenna consists of two vertical antennas, connected together and to the receiver tuner via a two-wire transmission line (Figure 5). The spacing between the antennas must be small compared to the wavelength of reception and antenna length need only be long enough to provide adequate signal pickup. The Adcock antenna described in this article was designed to operate over the 10 MHz to 18 MHz range in order to keep size and spacing to a reasonable size. Spacing is about 0.1 wavelength at 10 MHz, or approximately 10 feet. For convenience, each vertical element is made 10 feet long. This is a good compromise between element length and signal pickup.

The interconnecting, two-wire transmission line can be made out of TV-ribbon line and runs from the antenna to a tuner located near the antenna. Coaxial line is run from the tuner to the station receiver.

As with any directional antenna, it is important to make sure that signal pickup is only by the antenna and that the feedline is immune to pickup. More on this important feature later.

The tuner transforms the balanced Adcock two-wire feedline to the unbalanced line which runs to the station receiver. The reason that the two-wire ribbon line is not run directly to the receiver is that a balance to ground must be maintained in the line. It must be short, and it must drop down directly below the antenna. The tuner, in fact, is placed directly below the antenna to allow a good balance to be maintained in the transmission line. Placement of the coaxial line from tuner to receiver is not critical, nor is the length of the line.

The antenna elements can be made up of 10-foot sections of light aluminum tubing, cut in half. They are mounted to a support board with hose clamps or U-bolts. The board, in turn, is mounted to the end of the support boom L-shaped angle plates. The boom is 2" x 4" on edge, ten feet long. The assembly is shown in Figure 6. When the wood framework is completed, it should be given a coat or two of paint or shellac to protect it from the weather.

For ease of assembly, the boom can be temporarily mounted to a short section of TV mast, so that it is held about six feet in the air. This makes it convenient to work on the antenna.

A length of 300 ohm ribbon line is used to connect the antenna elements. Make sure that you have a half-twist in the line so that the upper section of one antenna is connected to the lower section of the other, as in the drawing. Make the line as short as possible, consistent with good workmanship.

Finally, find the center point of the line and clean the insulation from the wires for about an inch. You will solder the feedline on at this point. Wrap the joint with vinyl electrical tape when you finish it to make it waterproof.

### Installing The Adcock Array

The antenna is now complete and ready to mount on a supporting structure. The bottom tips of the elements should be at least 10 to 15 feet above ground level. This places the boom of the antenna about 15 to 20 feet in the air. A guyed slip-up TV mast will do the job, with a light-duty TV rotator at the top of the mast. The control cable from the rotator should be taped closely to the mast so that it will not interact with the ribbon feedline, which drops down from the center of the antenna.

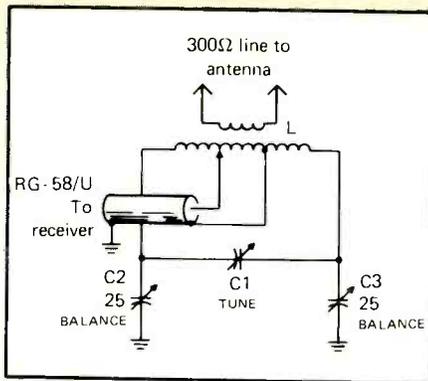
The feedline should be kept well clear of the mast in order not to upset the direction finding ability of the antenna. The antenna tuner is placed at the foot of the mast, as discussed in the next section.

### The Antenna Tuner

A schematic of the antenna tuner is shown in Figure 7. The tuner resonates the antenna to the frequency range of reception

and also provides balancing controls to obtain a proper null. The easiest way to check out tuner and antenna is to temporarily bring the station receiver out to the antenna site and connect it to the tuner with a short length of coax line. The coil taps and tuning capacitor are adjusted for maximum signal strength on a strong signal in the frequency range under investigation. The taps and capacitor setting are logged across the operating range and a table made up so that you can preadjust the tuner after the receiver is returned to the operating position.

The last step is to adjust the two balancing capacitors in the tuner. A strong, nearby station whose location is known should be used for this adjustment. The Adcock array is rotated until a sharp signal null is found. There should be two nulls, 180 degrees apart in antenna direction. Between the nulls is a broad area of maximum signal. Either null will work for the adjustment. The best null (weakest signal) spot is found and the balancing capacitors adjusted until the signal is nulled out. A very strong signal (40 dB over S9) should be nulled down to S2 or S1 on



**Figure 7: Adcock Tuner for 6-15 MHz**  
*C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>—midget variable capacitors*  
*L—10 turns #12e, 1/2" diameter, 1 1/4" long. Link is 3 turns of insulated wire wrapped around center of coil. Coax shield tapped to center of coil. Center conductor tapped 2 turns off-center. Adjust tap for best signal.*

the receiver meter. Adjust the main tuning capacitor as you null the signal; the adjustments are slightly interlocking.

Once you have a good null on your test signal, find other strong signals and attempt to get a good signal null on them. You may have to readjust the balancing capacitors a bit. You should be able to get good nulls on most signals over the range of the tuning capacitor.

To lower the frequency range of the tuner, add more turns to the coil. Both halves of the coil (measuring from the ground, or shield, of the coax tap point) should have an equal number of active turns, or you will lose your null adjustment.

Now, tune in signals at random and practice nulling them out by swinging the antenna back and forth. Once you have the hang of it, you should adjust your rotator so that the two vertical antennas lie in a plane that is true north-south (not magnetic north). If your control box on the rotator is calibrated up to 180 degrees, you can make readings directly from the indicator. (Some of the Ham-type rotators have this feature). Armed with a Great Circle Map and knowing the direction of true north, and a little expertise in making null readings, you should be able to draw a line of direction from your site to the distant station on the map. You will have to make a number of readings over the space of a day or two in order to get an average reading that will make sense.

### A Final Word

Listener direction finding is a new art and is still in the early stages of development. If you can find a colleague a few thousand miles away, you can practice on known stations to see if you can achieve triangulation on the signal. The process is not hard, but time and patience are required to obtain meaningful results. The key to good results are a ship-shape installation and good null balancing. It is unfortunate that the tuner must be located at the foot of the antenna installation, but those investigators who develop expertise can then extend the ribbon line and bring the tuner into the dwelling and place it at the receiver location. This makes rapid frequency change much more flexible. But this step should not be taken until the system is in a good, working condition with the tuner directly under the antenna. One problem at a time, please!

### Final Words On The Subject Of DF'ing

I am still experimenting with the Adcock array and don't know all the answers. I do know it is a lot of fun to play with. Sometimes it is possible to get startlingly accurate readings; other times the results are mush. But the problem of high frequency direction finding is so interesting and challenging, this simple antenna is a good introduction to the science of determining a line of direction to a distant station. If you build the array, let me know your results. Write me care of POP'COMM. Good Hunting!

PC

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