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VHF Signal Diffraction

—why the highest antenna may not be the best

My QTH is down in a hole in the ground, and while it's not a big hole, it is still sufficient to cause problems on two-meter simplex when I try to communicate on RTTY with friends in Amarillo.

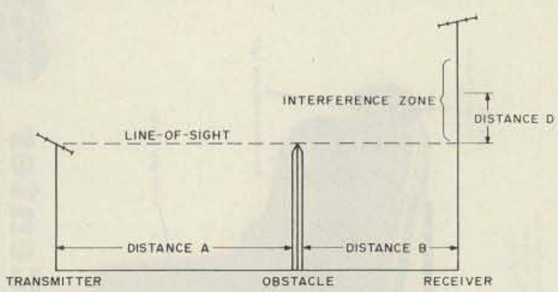

Fig. 1.

Having contemplated and rejected the "Superman approach,"[1] I searched for other solutions. As I climbed up my tower to recover last year's quad (which the West Texas wind had turned into a three-and-one-half-element birdcatcher), I happened to carry my handie-talkie with me. I tried in vain to hit the repeater from the top of my tower and then sadly started the climb to the ground. I had descended but a few feet, however, when the little transceiver squalked to life. "What gives?"

As it turned out, I was able to communicate with the Amarillo repeater, some twenty miles away, from a point not at the top of my tower, but somewhat lower down.

Never one to look a gift horse in the mouth, I mounted the new antenna on the side of the tower where the signal was strongest and then repaired to my desk and home computer to find out what in the

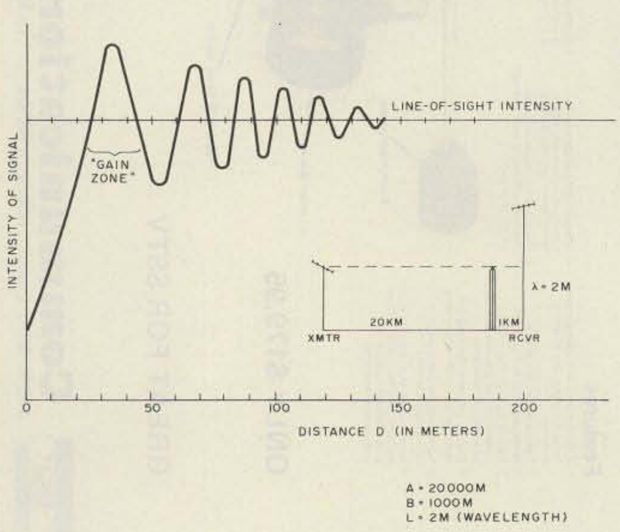

Fig. 2.

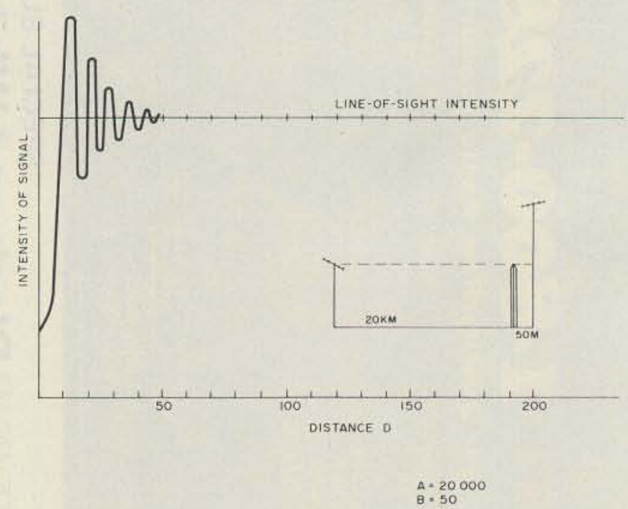

Fig. 3.

world was going on. What I learned may be of benefit to other hams in similar situations.

The answer I arrived at has to do with a phenomenon known as "diffraction" which many VHF operators have encountered in one form or another, often while driving in urban areas. Fundamentally, what happens is that when a light or radio wave front passes by a sharp, straight edge, the waves "interfere" with each other. See Fig. 1. This interference can take place in either a "constructive" or a "destructive" manner, causing the waves either to reinforce or destroy each other. At the places where reinforcement takes place, we realize an increase in signal—gain, if you will.

Oh, well, ho-hum. I guess that is what is happening on my tower. The top of the tower happens to be in a place where the interference is destructive, thus attenuating the signal from the repeater, while only a few feet down the tower the interference is constructive, resulting in readable signals. So, no problem; I will just lower the antenna into the zone of constructive interference and be done with it.

"What did I just say?!" Lower an antenna? Waydaminute! Back to the old APPLE, quick. Any old physics book will do. The APPLE models the system nicely and results in the very interesting graph shown in Fig. 2, which displays signal strength as a function of the distance, D. (See Fig. 1 again.) The horizontal line depicts the line-of-sight strength of the signal. Wow! I can, by proper placement of the antenna, realize a gain over the line-of-sight path. This gain is theoretically about 1.4 dB, and under marginal conditions this could make a difference.

The various graphs show different placements of the knife edge in relation to the transmitting and receiving stations. They show clearly that it may be possible to place an antenna in such a position that it can take advantage of the gain "offered" by an obstacle such as a hill or building and thus allow communication over paths which would otherwise not be productive.

The graphs are based on a wavelength of 2 meters, but since they were computed using formulae developed for light waves, they must be used mainly as a guide. There should be a slight difference in the way light and radio waves behave, although it should not be large. It is possible, by a judicious placement of the base of the antenna tower, to maximize the size of the zone of constructive interference.

Examination of the graphs also shows that there is more than one zone of constructive interference where gain is realized over the straight line path. One would have to be careful to place the antenna in the zone of greatest signal. The graphs show also that there is no use going any higher on the tower after a certain point is reached. Instead, moving lower on the tower may bring you into a zone of constructive interference and thus allow you to carry out communications over difficult paths.

The graphs are shown for several representative situations. The computer program takes advantage of the HIRES capabilities of the APPLE, but could be modified for other machines. The mathematics of the situation are not entirely trivial and require numerical integration of Fresnel integrals. ■

```
   3  X1 = 0;Y1 = 0
   4  HGR
   5  HPLOT 279,53 TO 0,53
   6  HPLOT 0,159
  15  INPUT "HOW FAR IS IT FROM TRANSMITTER
      TO OBSTACLE ";A
  20  INPUT "HOW FAR IS IT FROM OBSTACLE
      TO RECEIVER ";B
  25  INPUT "WHAT IS THE WAVELENGTH ";L
  30  FOR L0 = 0 TO 250
  40  V = L0/SQR(B•L•(A + B)/(2•A))
  50  GOSUB 1000
  60  PRINT L0; TAB(12);V; TAB(25);(X + .5)↑2 + (Y + .5)↑2
  70  GOSUB 2000
  75  NEXT L0
  80  END
1000  X = 0:Y = 0
1010  FOR I = 0 TO V STEP V/200
1020  X = X + COS(3.14159/2•I•I)•V/200
1030  Y = Y + SIN(3.14159/2•I•I)•V/200
1040  NEXT I
1050  RETURN
2000  IT = (X + .5)↑2 + (Y + .5)↑2
2010  X1 = L0
2020  Y1 = 158 – 158•IT/3
2030  HPLOT TO X1,Y1
2050  RETURN
```

Program listing.

References

1. "Predicting Radio Horizons at VHF," *QST*, June, 1978.
2. Jenkins and White, *Fundamentals of Optics*, 3rd edition, McGraw-Hill, New York, 1957.

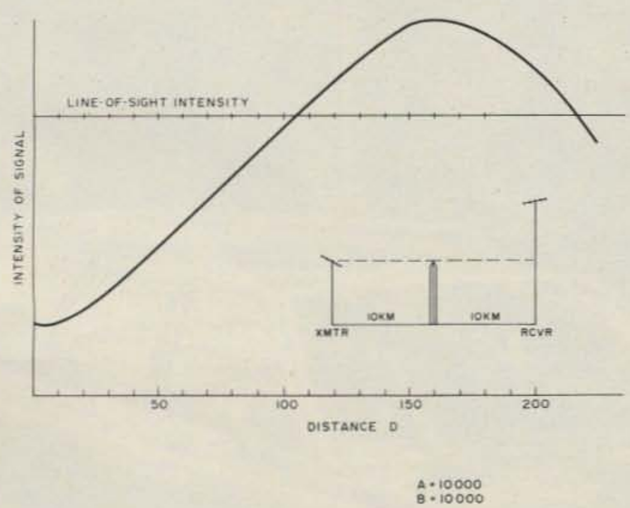

Fig. 4.

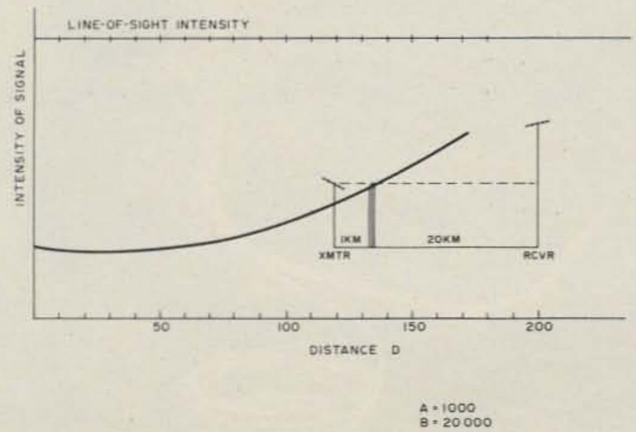

Fig. 5.