Notes on The 10 Meter Vertical

OLIVER P. FERRELL*

IT IS A VERY common practice for the new Ham, and some oldtimers as well, to try to get out on 10 meters with a vertical half-wave antenna. At first glance, the vertical appears to have several advantages. It is very simple to erect, since the length need not be over 17 feet, it can be made to radiate equally well in all directions or azimuths and is fairly easy to tune.

After erecting the vertical at some random height, most amateurs find it works out pretty well on the ground wave—a few find it works on some "short-skip," but not on the DX. Some find it works erratically on DX and on short-skip, while unfortunately, many find it very poor on both. Since the rest of the locals appear to work the DX with other types of antennas the vertical becomes a worthless hunk of wire. However, 9 chances out of 10, it isn't the vertical itself that is totally at fault, but is probably due to the Ham, who neglected to give a little more thought to some simple applications of the "angle of radiation."

Angle of Radiation

The angle of radiation is not a mystic quantity, determined experimentally by trial and error. It is a finite relationship of ionospheric wave propagation and great circle distances. On the 10 and 11 meter bands this relationship is exceedingly elementary and should be fully understood beforehand by anyone attempting to use these two bands.

On occasions of 10 and 11 meter short-skip it has been possible to fully establish two factors. They are: (1) the short-skip is caused by an abnormal E layer condition, where the reflecting medium is almost invariably 110 km in height. (2) most of the contacts are made between the ranges of 300 to 900 miles. A few single hop contacts have been made out to as far as 1400 miles, but generally working beyond 900 miles calls for an antenna that is fairly well in the clear and the use of power measured up in the hundreds of watts. From these two parameters it is possible to determine quite accurately the minimum and maximum angles of radiation.

The minimum working angle of radiation for working out on short-skip could be considered in the terms of an arc several minutes above the horizon. But, with the power output employed by the amateur, few stations can claim a working minimum angle of 3 degrees, while the general run is about 4 to 5 degrees. At angles below 3 degrees the ground scatter and absorption become important attenuating factors which normally do not interfere with higher angles of radiation.

For an angle of radiation of 5.5 degrees, which is equivalent to a range of 900 miles, or the distance between New York City and St. Louis, we find approximately 40% of all short-skip contacts. During an intense sporadic E burst, 10 meters has been known to open from 300 miles. This range will determine the maximum angle of radiation and is equal to exactly 24 degrees for a 110 km layer height. Therefore, any type of antenna that radiates above 24 degrees to any appreciable amount is, to follow the classic expression, a "cloud-warmer."

Any Ham who managed to get a crack at radar sitting during the war is probably familiar with the number of lobes of vertical radiation as the height of any antenna is increased. The vertical half-wave is particularly notorious at this practice of radiating a considerable portion of its energy at extraneous and sometimes worth-

Note: This discussion of the lobe patterns for the 10-meter vertically polarized antenna is based upon an average ground. This is considered to be a mixture of sand and loam. The moisture content of the immediate ground will affect the dielectric constant and earth conductivity. Radiation over very wet earth generally results in the vector ratio accentuating the higher angle lobes. In contrast, radiation over sea water tends to accentuate the lower angles of radiation.

**4609 North Broad St., Phila., 40, Pa.*

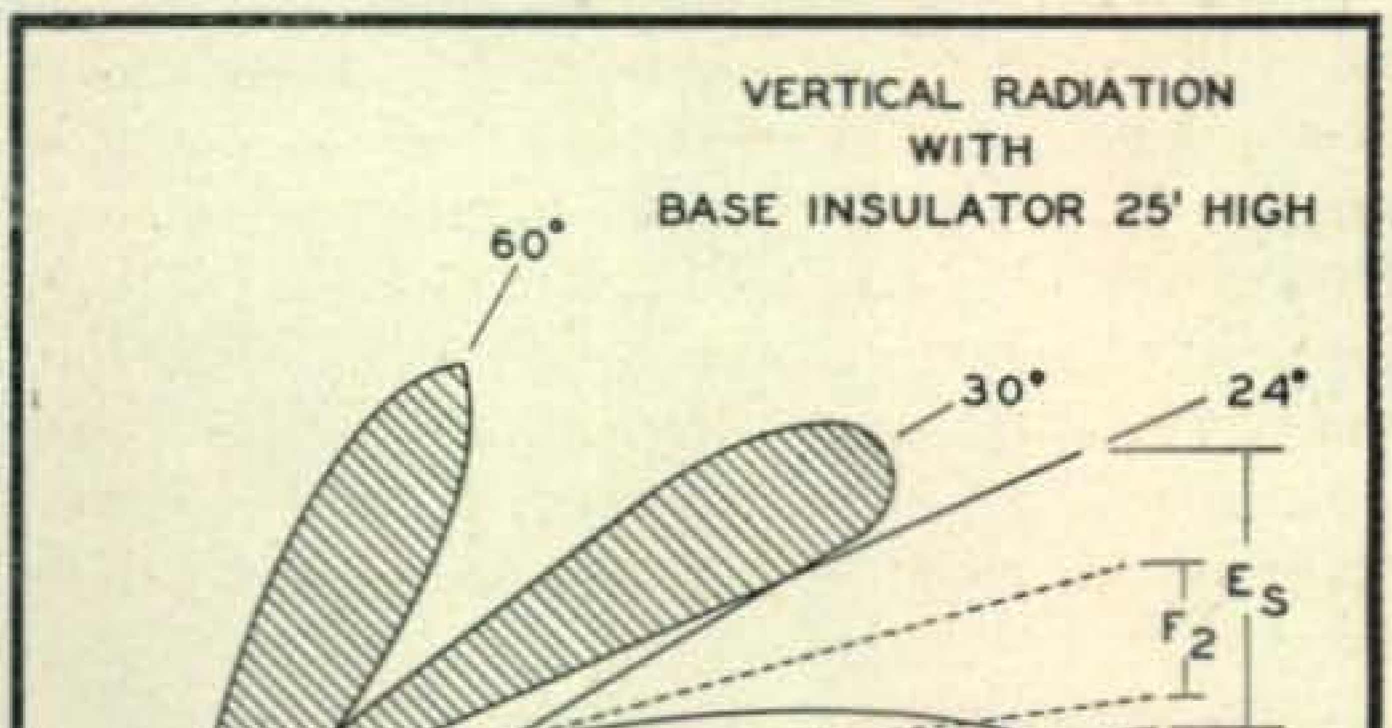

Fig. 1. Relative power radiated vs. the angles of radiation for a 10 meter half-wave vertical antenna with the base 25 feet above ground level.

less angles. Few Hams have the facilities for getting the vertical much above a nominal height of 30 to 40 feet (height of base insulator). This height persists even today because of the stigma of "line of sight" communication when considering the erection of 10 meter antennas. Actually, the facts of the angle of radiation belie this time-worn hypothesis.

In *Fig. 1* is shown the relative power radiated vs. the angles of radiation for a 10 meter half-wave vertical antenna with the base 25 feet above ground level. Obviously, this radiator is doing much in the way of keeping several clouds very comfortable. A lobe of fair size occurs at 60 degrees. This corresponds to a short-skip hop amounting to about 80 miles — an impossible ionospheric condition on 10 meters. A second major lobe is radiated at 30 degrees. This corresponds to a range of about 210 miles—a short-skip condition which occurs very seldom. At the most useful angles of radiation, this vertical at this particular height radiates the least amount of power.

If we drop the antenna down about 9 feet to where the base is exactly one-half wave above ground level a very interesting thing happens. The 60 degree and 30 degree lobes combine at 40 degrees and the relative power radiated at this angle is approximately 50% of the total energy. Many verticals erected near this height above ground appear to work out on the longer reaches of short-skip. This condition is portrayed in *Fig. 2* where it can be seen that a certain small percentage of the power is now being radiated between 5 and 15 degrees. This corresponds to working from 450 to 900 miles.

It is unfortunate, but many times constructional difficulties do not permit the erection of the vertical 10 meter half-wave at its most effective height. That is, with the base only 4 to 6 feet above ground level. This is illustrated in *Fig. 3*. At this low height a very small minor lobe is found at about 80 degrees. The power lost here is only 7 to 8%. Contrastingly, the arc between 5 and 24 degrees is now filled in by the maximum radiated power and in the absence of minor lobes presents a solid front at all the important angles of radiation.

Using the Vertical on Long Range DX

Fortunately the problem involving the use of a vertical half-wave for 10 meter DX is not as complicated as it might at first appear. Here the propagation of 28-30 mc signals must depend upon the F_2 layer, which varies in height from 260 km to 390 km. The height variation can only slightly be anticipated. The maximum height and maximum density of the F region occurs one or two hours after the wave path sub-solar point. Or in other words, the maximum is a few hours after midday at the midpoint of the working path. This phenomenon has been observed by 10 meter DX men and is illustrated monthly in the *CQ* Prediction Charts.

Some years ago the R.C.A. Riverhead Receiving Station made a number of tests on 10 meters in conjunction with the reception of 7 meter trans-Atlantic television signals. These observations included the determination of the signal angle of arrival or radiation and since they are still applicable to this topic they are illustrated in the graph form in *Fig. 4*.

Although the height of reflection varied from 282 km to 378 km, a line of mean range versus angle of radiation may be drawn. The maximum angle of radiation will be directly related to the intensity of F region ionization. Referring to data collected during the last sunspot maximum we find that the minimum F layer skip distance, which is inversely proportional to the maximum ionization, was about 1100 miles. This corres-

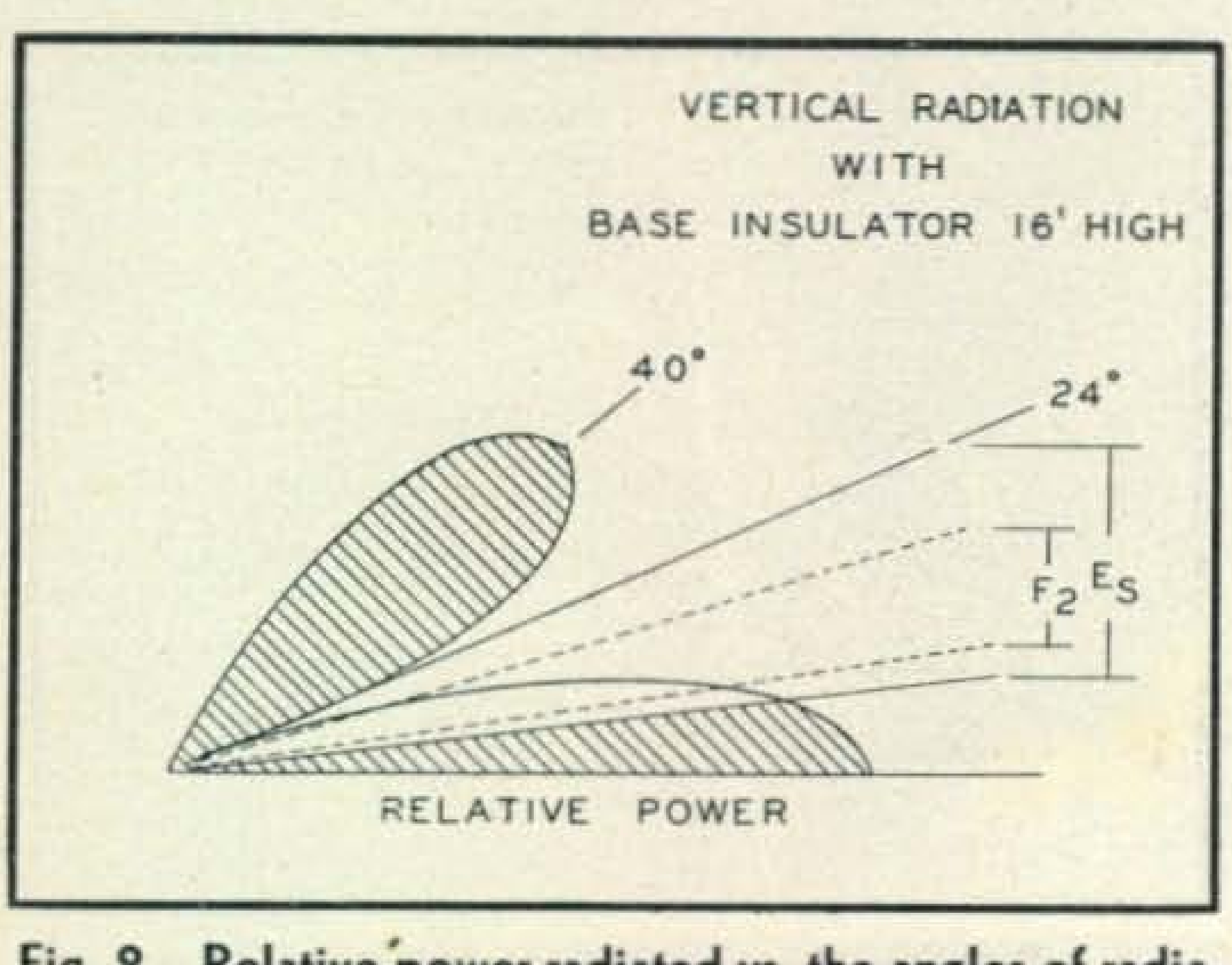

Fig. 2. Relative power radiated vs. the angles of radiation for a 10 meter half-wave vertical antenna with the base 16 feet above ground level.

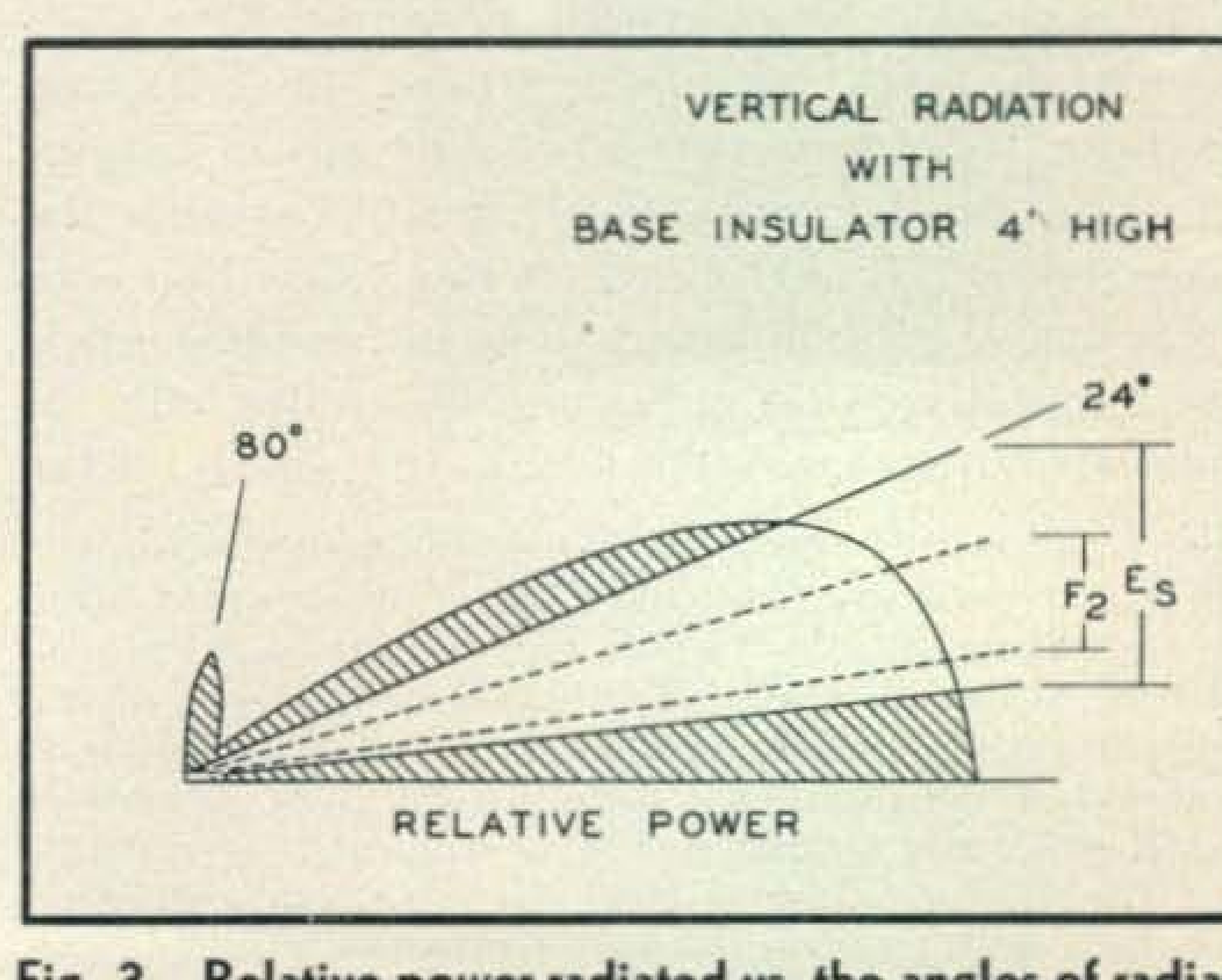

Fig. 3. Relative power radiated vs. the angles of radiation for a 10 meter half-wave vertical antenna with the base 4 feet above ground level.

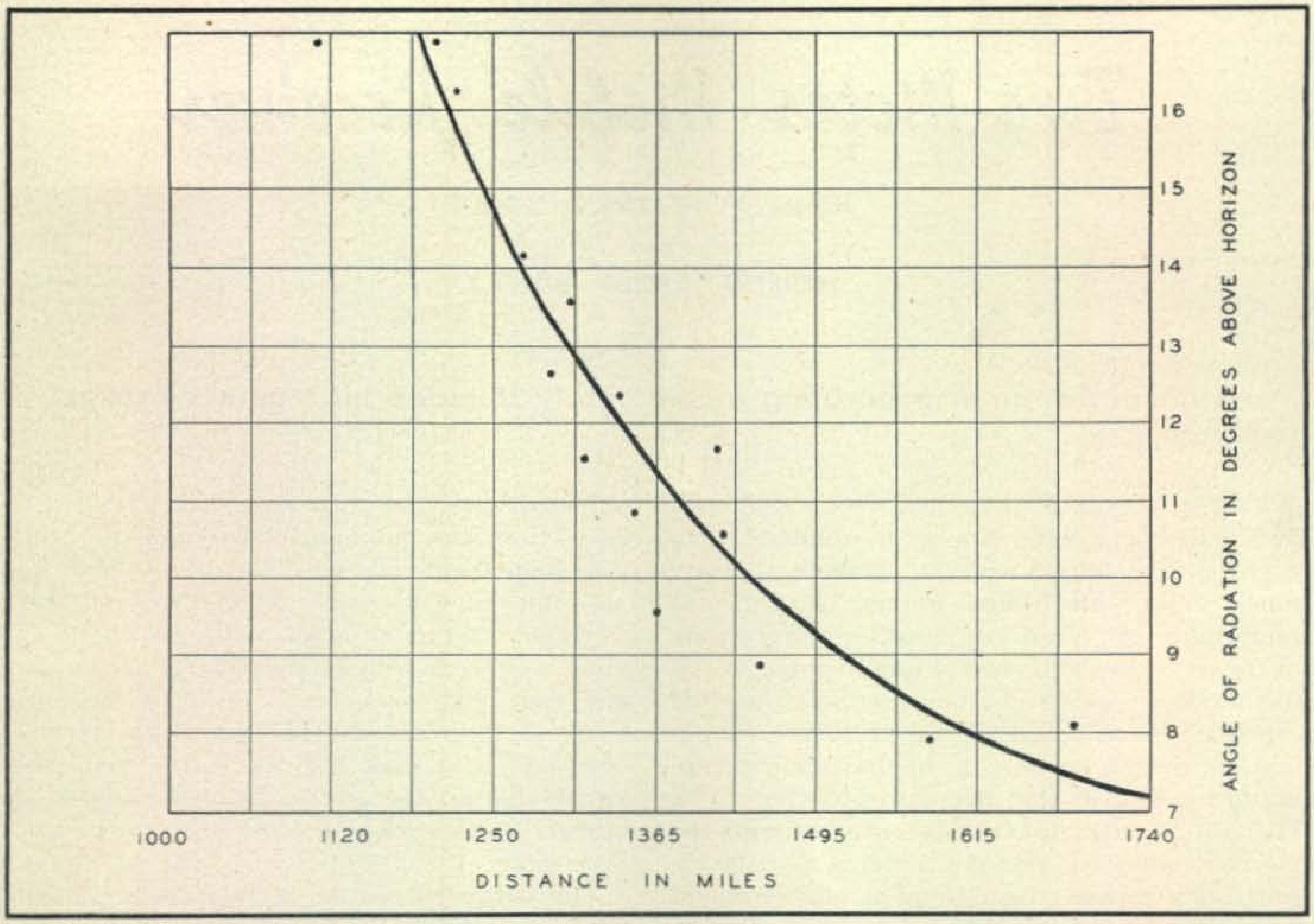

Fig. 4. Signal angle of arrival plotted against distance. Note that the minimum angle represents the maximum distance.

ponds to a general maximum angle of radiation of 17.5 degrees. This angle is illustrated in the *Figs. 1, 2* and *3* as the dashed line. The minimum angle of radiation should follow quite closely that of short-skip propagation. Possibly, there are frequent occasions where propagation does occur below 5 degrees, but it is the expressed belief that in working ranges beyond 1750 to 1900 miles, the propagation is by two or three hops. Employing the R.C.A. data the minimum angle is a little over 7 degrees; this is also illustrated in *Figs. 1, 2* and *3*.

Optimum Mounting Height

The vertical half-wave antenna does have an important place in 10 meter communication. If it were possible to put the antenna 100 or more feet above ground, many of the minor lobes would fill in the necessary angles for working either short-skip or DX. However, since most verticals have tended in the past to be antennas necessitated by space, time, and monetary expenditures it is well to keep in mind that for 10 and 11 meters the maximum power must be radiated between 5 and 24 degrees above the horizon. This can only be accomplished by keeping the vertical very low, with best results obtained when the base insulator is 4 to 6 feet above ground level.

There are two factors which can not be neglected in any discussion on 10 meter half-wave antennas. One of these concerns the circular pattern of the vertical antenna. For the average Ham this is a pure theoretical assumption. Every telephone line, house wiring line, building, guy wire and fence distorts the pattern till no two identical vertical antennas have identical horizontal patterns. This appears to be the reason for many verticals being placed as high as possible, but seldom above 30 or 40 feet. If it is impossible to mount the vertical low and with the favored directions in the clear, it will undoubtedly pay better to try some other type of antenna, unless you have several hundred watts of power to waste.

The second point concerns the term "ground." This does not represent a loose bit of wire insecurely wrapped around the nearest waterpipe. An efficient half-wave vertical antenna must be worked against an efficient ground. There are literally hundreds of excellent ways to obtain an efficient ground—starting from the 120 wire 3 degree radial system used by the broadcasting stations, down to driving several iron stakes in the ground directly below the antenna. This problem can be left to the ingenuity of each amateur, but remember the ground, to be a ground, must be direct and low-resistant.