PREDICTING ANTENNA PERFORMANCE

BY KEN "JUDGE" GLANZER,* K7GCO

PREDICTING an antenna's performance at a certain location entails many considerations such as the power level, height, ground terrain and conductivity, to mention just a few. Some antenna sites appear to be exceptional and often are. Sometimes they are just average or even below average for no apparent reason. How and by whom the location is evaluated is another consideration. Many times, skilled operators with low power transmitters consistently outperform other operators with higher power and higher gain antennas. The conclusion often drawn is that the skilled operator has a better location.

Side by side comparisons of signal strength, where skill is not a factor, can tell a true story in many respects. Amateurs are constantly comparing signal strengths in contacts and over a period of time a general overall performance level can be determined. One of the so-called "acid tests" that has proven valuable is who gets the DX station first in the "pile-ups." However, when the competition is the keenest a power factor sometimes creeps in and again invalidates the comparisons. Sometimes even the best of friends will hold out a bit on each other so even they aren't sure how they really compare.

* 202 South 124th Seattle, Washington 98168.

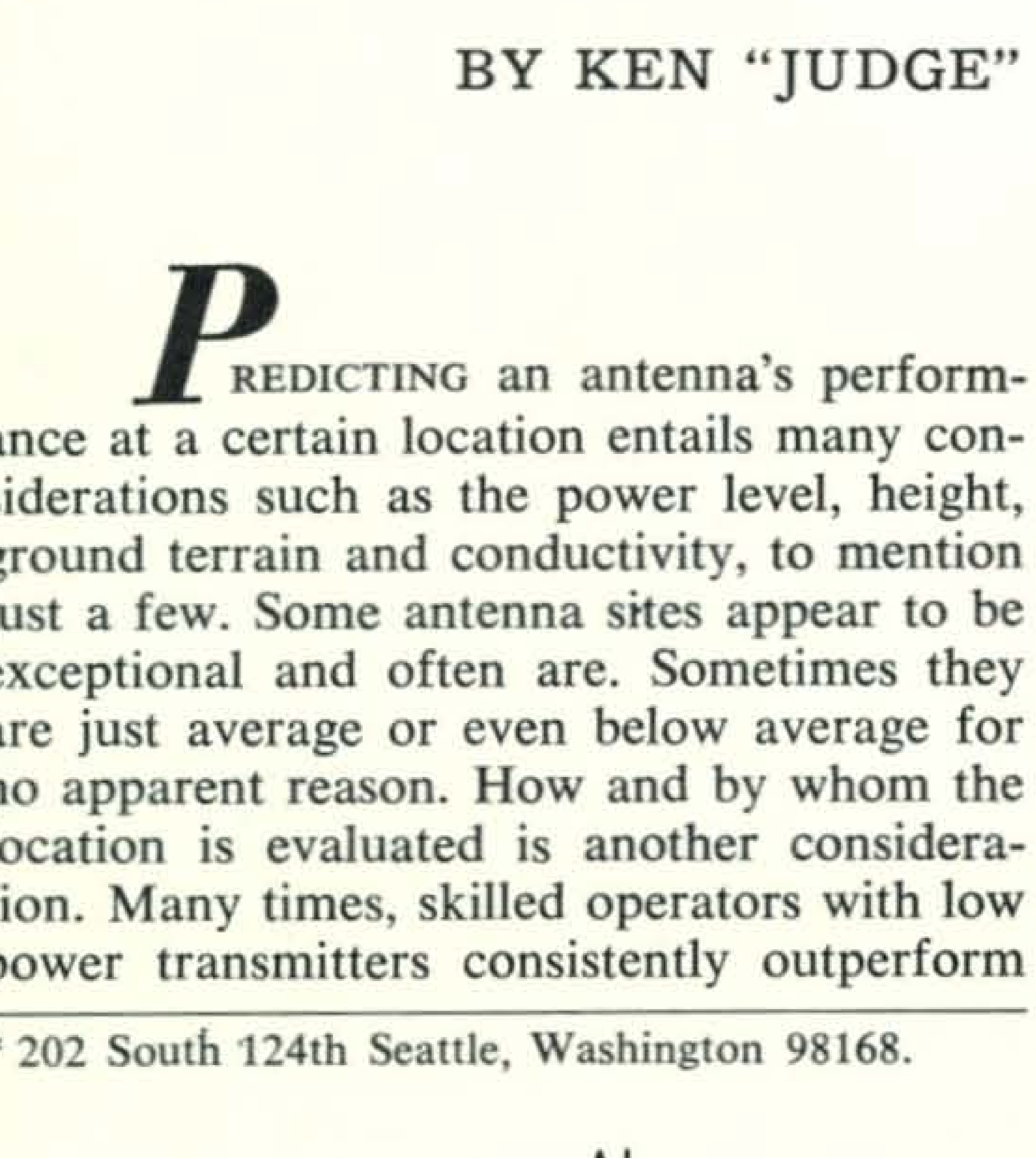

Fig. 1—Free space patterns of several collinear dipoles having 10 db gain. In A, circle #1 as viewed from the end of the dipoles shows the vertical gain pattern of a single dipole. Circle #2 is the vertical gain pattern of collinear dipoles with a 10 db gain showing an increase, but no change in directivity. In B, the top view of the collinear dipoles, the horizontal patterns for the single dipole (#1) and the colinear (#2) with 10 db gain are shown.

Pattern Importance

The importance of the free space vertical pattern cannot be over emphasized and it is the least understood. Far too much emphasis is placed on the gain of an antenna which, while it is certainly important, does not give the most important characteristic of the antenna. This can best be illustrated by the following example. The patterns of typical dipole configurations are illustrated in fig. 1. Assume that several collinear dipoles are all fed in-phase and their "line of sight" gain is 10 db over a single dipole. As illustrated in fig. 1 the horizontal pattern is a much sharper "figure 8" but the vertical free space pattern (H plane) is *still* the same as a single dipole, a circle. Although the antenna has 10 db gain, it has no vertical directivity and this is a serious disadvantage except for high angle radiation on the lower frequencies.

Now assume a number of dipoles are again fed in-phase but stacked one on top of each other until a line of sight gain of 10 db is again obtained as illustrated in fig. 2. The beam width of the horizontal "figure 8" is unchanged despite the 10 db gain. The *vertical* pattern is now a very sharp "figure 8" as a result of the vertical stacking. Both configurations have the same gain but the performance of the two antennas will be substantially different at 1000, 5000 or 15,000 miles away. The antenna with the vertical stacking will have the stronger signal at a distance because most of the energy is concentrated into the lower angles of radiation. Whenever a gain figure is quoted some description of the vertical and horizontal patterns should also be given.

Although the previous example is an extreme case, even minor improvements in the vetrical free space pattern appear to give beneficial results. An example of this is the quad antenna. The quad has proven itself to be an effective DX antenna yet its actual line of sight gain is slightly over 4 db. The horizontal pattern is noticeably wider than the average 3-element beam. The quad is actually a stacked array of two half waves in phase spaced one quarter wavelength apart. This is far from optimum spacing, however, the vertical pattern sharpens beneficially and is the principle reason for the good performance of the quad. An eighth wave at each end of each half wave is bent down or up and results in a slightly broader horizontal pattern. The sharper vertical pattern is obtained at the expense of the horizontal pattern and is a step in the right direction for effective long haul communications.

Another example of this is the popular "ZL Special" 2-element all driven array. The horizontal pattern is a cardioid of about 4 db gain. Yet the antenna is outstanding on long haul communication. The answer again is to be found in its vertical pattern. Vertical patterns are much sharper in all-driven arrays, another being the 8JK array. The 8JK array is an effective antenna on the low as well as the high frequencies as a result of the sharp vertical pattern.

Ground Conductivity

Another important factor in an antenna's performance is the ground conductivity. When an antenna works over a perfectly conducting ground the reflected component (equal in amplitude) combines with the free space pattern and reshapes or alters the pattern with definite lobes and nulls. The new lobes are 6 db stronger than the free space pattern in the vertical plane.

Locations where the antenna works over salt water have always proved to be outstanding due to the high conductivity. In such areas vertical antennas have proved to be outstanding performers and in many cases even better than horizontals. Antennas working over salt water (liquid copper) approach ideal laboratory conditions in nature about as close as possible. The angle of radiation patterns over perfectly conducting ground are closely duplicated in many respects.

Vertical Antennas

Vertical antennas that are ¾ wavelengths long or less always have one radiation lobe close to the ground or water regardless of their height above ground. The reflected component of a vertically polarized wave suffers no phase reversal (in an ideal case) upon reflection and therefore is in-phase with the direct component, forming a lobe next to the ground. At higher angles where the reflected component is out of phase with the direct component a null is formed in the vertical pattern.

Experiments with 2, 3, and 4 element vertical beams on 20 meters over a period of

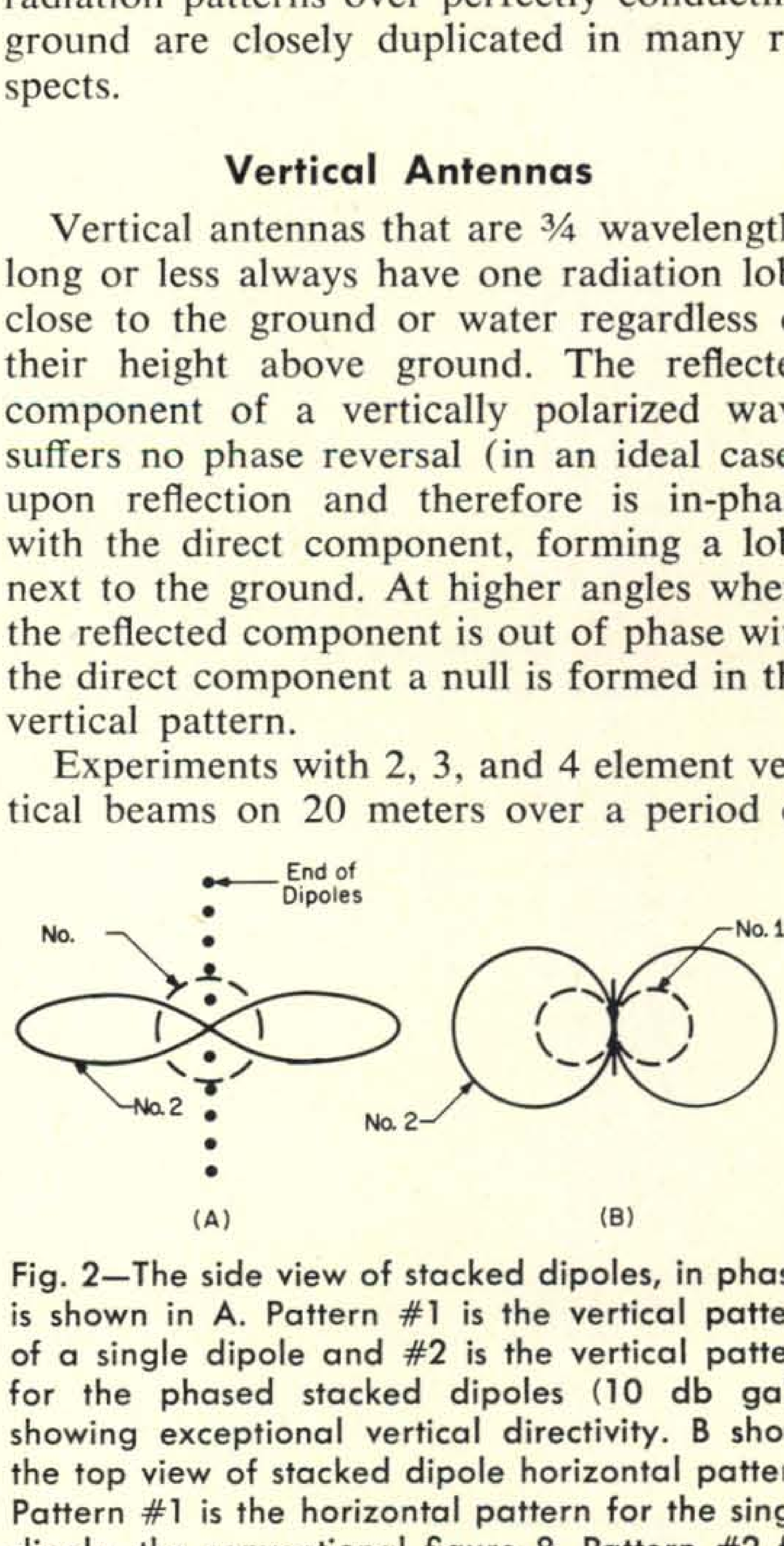

Fig. 2—The side view of stacked dipoles, in phase, is shown in A. Pattern #1 is the vertical pattern of a single dipole and #2 is the vertical pattern for the phased stacked dipoles (10 db gain) showing exceptional vertical directivity. B shows the top view of stacked dipole horizontal pattern. Pattern #1 is the horizontal pattern for the single dipole, the conventional figure 8. Pattern #2 for the stacked dipoles is also a figure 8 with the same beam width but higher gain.

Fig. 3—The antenna view from W7YGN. This has proven to be an outstanding antenna site with Puget Sound below for a ground plane. The view is northeast with the Space Needle looming up in background. Weak DX stations have been heard here when not heard elsewhere in Seattle. Directly north is the antenna sight of W7FA.

Fig. 4—This is the antenna view at K7GCO. With equal antennas and power, signal reports have averaged 6 db higher than those of W7YGN. Lake is fresh-water. Horizon appears curved because the camera was tilted down. View is Northeast. To the southwest the land slopes up. This site has proven to be one of the most effective in the US as unusually strong signal reports have been received from Europe with simple antennas and 1 KW power on all bands.

Fig. 5.—This was the antenna view from W7FA. The salt water of Puget Sound below provided an excellent ground plane (liquid copper) and the signal strength reports were always outstanding. West Seattle is across the water and was the antenna sight of W7YGN. One end of a 75 meter folded dipole was connected to the 20 meter beam tower and the other end down on the beach for a "Slantindicular" polarization. This antenna gave outstanding results. W7FA was probably the only west coast station that heard ZL1ABZ from he Kermadec Islands on 75 meters on April 18, '58. This is the ultimate in antenna sites.

years by W7DND have shown that the 3 and 4 element beam's free space vertical pattern is apparently too sharp for effective communications. The sharper the free space vertical patterns the lower the main angle of radiation and less energy in the higher angles. omparison with K7GCO and with stations in Europe have confirmed this observation. Other facts may have influenced the results but every effort was made to make the comparisons as accurate as possible. The salt water bay next to W7DND's lot was not pure salt water due to the fresh water streams flowing into it. This results in a much lower conductivity but still much better than the highest ground conductivity.

Other tests at W7DND also show that stacked Lazy H antennas of horizontal polarization working over salt water apparently do not suffer from too sharp a vertical pattern. One reason may be that regardless of how sharp the free space vertical pattern may be with horizontal antennas there is never a lobe next to the ground due to the 180° phase shift suffered by horizontally polarized waves.

Horizontal antennas require height and/or stacking to develop a low angle of radiation and a sharp vertical pattern. Vertical antennas do not have to be high or stacked to produce a low angle of radiation or a sharp vertical pattern and this is a big advantage. An antenna's E plane pattern is generally sharper than its H plane pattern so a vertical antenna will generally have a much sharper vertical pattern than the same antenna horizontally polarized. Unfortunately. vertically polarized waves are attenuated more over lossy ground than are horizontally polarized waves. Vertical antennas are more prone to noise pick up which is also a major disadvantage. However, 2 and 3 element vertical beams over comparatively lossy ground have proven very effective. The "Twin Ten" array for 10 meters is an example of this.

The antenna site of W7YGN, shown in fig 3, appears to be one that couldn't be improved upon with the salt water of Puget Sound below. Although it has proven to be an exceptional antenna site, the one at K7GCO shown in fig. 4 seems to have the edge on all bands. The ground slopes down to the fresh water lake at about a 30° angle. The power lines in the antenna's field about 80 feet away do not appear to affect the signal but that would not be known conclusively unless extensive checks were made with the wires removed.

Generally speaking, a rule of thumb has been offered that if the obstructions do not cause a change in the s.w.r. as the antenna is rotated, their effect is negligible. The higher the gain of an antenna, the more effect a metallic obstruction will have on the antenna's major lobe as the reflections will be stronger and the beams tuning, phasing, *etc.*, becomes more critical. Obstructions on the same level and of the same polarization will have the greatest effect on the antenna.

Antennas are affected very little by other antennas that are resonant higher in frequency. The low frequency beams in a stacked array are virtually unaffected by the smaller beams. The smaller beam's vertical pattern is affected by the larger beams to some extent, and if they are mounted too close it will show a change on the horizontal pattern, s.w.r., resonant frequency and bandwidth. The larger beams act as a partial screen or ground or sky plane. The vertical radiation from a yagi is small and decreases with increased gain.

Radials

Radials under an antenna are most useful when the antenna has a high angle of radiation such as a horizontal dipole on the low frequencies. The major part of a yagi's vertical pattern doesn't reflect off the ground much closer than a 45° angle projected down from the antenna and all the way to the horizon. So the neighbors lot and house wiring, plumbing etc. have more to do with a beams's resulting vertical pattern than does the area immediately under the antenna. The pattern is scattered, twisted, deflected, reflected and absorbed so that any similarity between what it would be in an ideal case is small. The effect is more serious on a received signal as nothing can be done about it. When transmitting one can often make up for the disrupted pattern with high power or a high gain antenna. Generally the two balance out but several instances have been observed where one station always received better signal reports than others but had the most trouble receiving other distant stations due to low signal strength. High power was usually the answer but it can also be a receiver in need of alignment. Many questions will be answered some day when some one develops a way to see the r.f. field of an antenna. ■