Plain Talk About Rhombic Antennas

The Story of Some Experiences with Haywire Diamonds

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FOUR years ago, shortly after Bruce announced the development of the rhombic antenna, we put up an experimental antenna of this type with the idea of working Asia. As we see it now, everything was wrong with the project except the antenna itself. We had picked the wrong time and the wrong place. Asia simply wasn't willing. There were no signals. As a result of that experience our interest in the general subject of directive antennas fell off to a mere nothing—and stayed there.

Then, in 1934 we stuck up a directive array for the 60-mc. band and found, much to our astonishment, that nice fat signals could be had with it from stations a hundred miles away at times when the signals *were actually inaudible* on a normal half-wave antenna. This experience gave us a big jolt because the apparent gain was out of all proportion to normal expectations. We became heavy beam-backers overnight. Ever since, we have had a pronounced leaning toward directive antennas. We have used them whenever circumstances permitted and we have looked longingly at every tree, roof, and chimney within a half mile, mulling over all the possibilities.

One big problem with any array is to decide in what direction to shoot it. This difficulty was solved recently upon hearing that Brother A. G. Hull in Sydney, Australia, had grabbed off a license and was on the air. The other big problem, to which we have never found a ready solution, is to decide just how big an array is needed to give worth-while gain. It is one thing, we have discovered, to wade through the many technical treatments of directive antennas, visualizing a great stretch of flat, swampy ground with the various wires strung up in the blue over it. Gains can be computed so readily then, and it is not at all difficult to think in terms of the R point gain per hundred feet of wire. It is a horse of a different color to stand out on the only available piece of ground—sloping, bumpy, chuck full of trees, smeared with buildings, poles, wires and miscellaneous junk—and then to wonder what might happen to this textbook antenna under those circumstances.

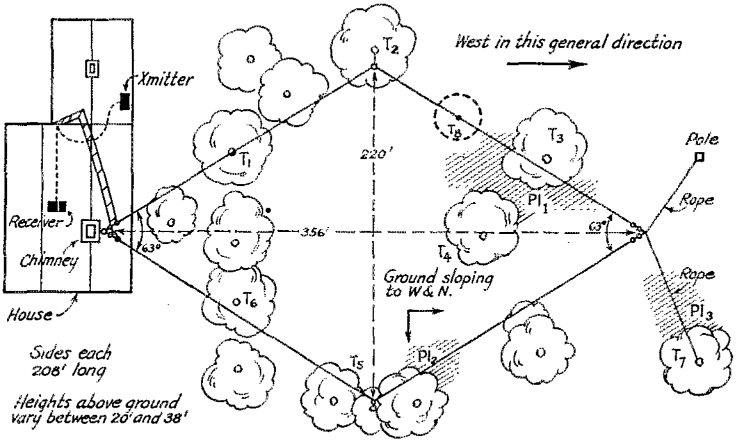

FIG. 1—THE LAYOUT AT W1JPE SHOWING THE NEW 3¼-WAVE RHOMBIC ANTENNA

The original rhombic antenna discussed in the text was suspended between the chimney and cherry tree T4. Its dimensions were exactly those used for the W1SZ rig shown in Fig. 2. The antenna shown does not actually have the clean lines and symmetrical shape indicated. The wire wanners irregularly through T_1, T_2, T_3, T_5, and T_6. Also, the height varies between 20 and 35 feet. The shaded areas $Pl_{1, 2}$ and 3 are dense patches of poison ivy—shown in practice to be important factors in antenna construction and adjustment. The rope between the 40-foot pole and T_7 allows small changes in the setting of the antenna. T_8 is the stump of a 40-foot tree which the authors removed by throwing a rope over it, then swaying it at its resonant frequency. The antenna works.

Anyway, we got out the compass and a measuring tape and made a crude plan showing all the chimneys and trees of the surrounding territory. On this we superimposed models of all the antennas we could think of. Study of the layout of the many trees around the place revealed chiefly that the guys who planted them had very little knowledge of directive antennas and still less consideration for the possible needs of future radio amateurs. The outcome, anyway, was a decision to string up a rhombic antenna of such dimensions that the transplanting of a few

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maples would be unnecessary. The presence of several choice 50-foot trees in the wrong places dictated that the wire would have to be threaded through two of them and wrapped around another but, we thought, that very circumstance would at least permit us to discover what does happen when such departures from the ideal are made.

We shall skip now a hectic day of scrambling over slate roofs; climbing trees; threading wires through branches; getting smeared in poison ivy; unscrambling wires and ropes tangled in tree tops. These matters were important enough at the time but, like most experiences of the kind, faded into insignificance once the whole procedure was shown to be justified. And this particular procedure *was* justified. The antenna, from the very word go, functioned in a manner which we should have believed quite impossible.

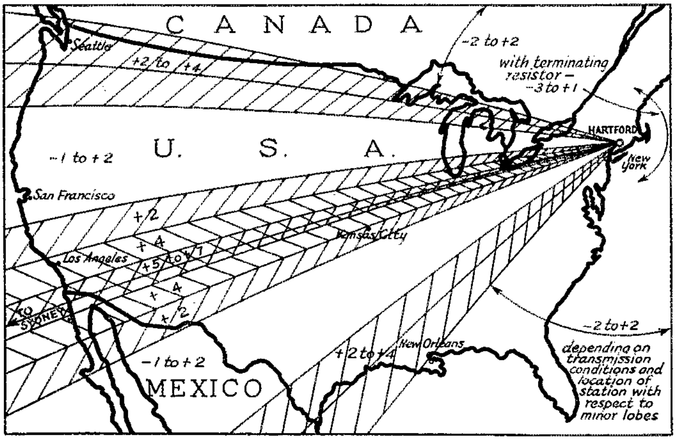

FIG. 3—A SKETCH DIAGRAM PRESENTING A VERY APPROXIMATE SUGGESTION OF THE RECEPTION PERFORMANCE OF THE HAYWIRE DIAMOND

The losses and gains indicated are R points measured on the a.v.c. meter of an HRO receiver. The comparison antenna was a conventional half-wave affair with a 75-ohm transmission line. The figures given are averages of several hundred measurements made over a period of two weeks. Though this diagram represents the performance of the antenna shown in Fig. 1 it differs only in minor respects from that obtained with the W1SZ antenna.

The gadget we ended up with had the general shape of a diamond with sides 144 feet (approximately 2¼ wavelengths) long. The wire was about 30 feet above ground most of the way with a couple of excursions down to about 20 feet. The far end, strung up in the cherry tree T4 of Fig. 1, was terminated with several pieces of "Ohmspun" (a non-inductive resistance element manufactured by the States Company, in Hartford) totalling 700 ohms (d.c.). An ordinary 6-inch feeder with 14-gauge wire was attached to the station end of the antenna and draped over the ridge, down the wall and through the window and a couple of doors to the transmitter. A double-pole double-throw relay served to switch the antenna to feeders running into another room where the receiver and operating controls are located.

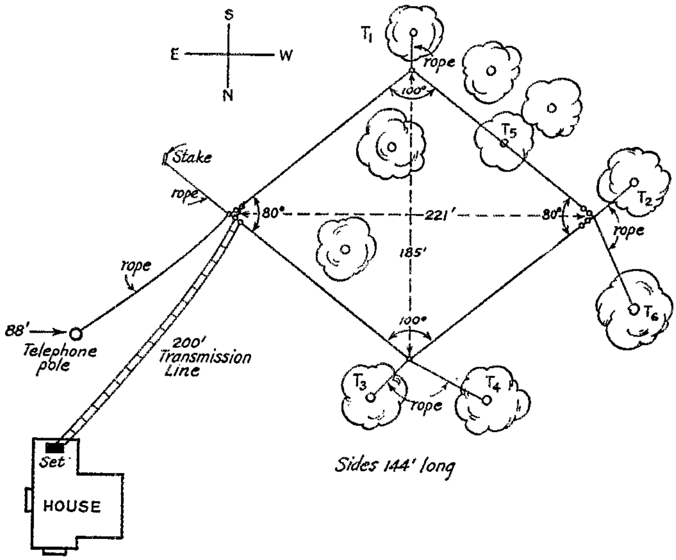

FIG. 2—A BIRD'S-EYE VIEW OF THE W1SZ DIAMOND

The clear spaces on this diagram indicate dense underbrush, brambles and a forest of second-growth trees. The antenna itself is 40 feet high at the station end and approximately 60 feet at the other points of suspension. The location of the trees used for support allows slight changes in the direction of the antenna but any change is, of course, a half-day's job. The antenna is ordinarily operated without any terminating resistor. The comparison antenna consists of two phased vertical half-waves mounted on the telephone pole.

First tests were made in reception—the diamond being thrown on to the receiver with a double-pole double-throw switch in place of one of the various normal receiving antennas previously used. Gains or losses were measured with the "S" meter on an HRO and all references made to R's are, therefore, in terms of divisions on the "S" meter dial. Stray pickup from the wrong an-

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tenna at the wrong time was reduced by coupling the diamond to a tuned circuit and thence to a low impedance line (the arrangement is described later) and by using a 75-ohm line from the comparison antenna. The change-over switch was therefore in a low impedance circuit in both cases.

The use of "S" meter points to express gain or loss is doubtless far from ideal but we found it preferable to the conventional business of estimating signal levels by ear or, on the other hand to actual measurement of the field around the antenna—a process made quite impractical by the existence of dense woods in almost all directions.

To get back to earth, we found immediately that signals on the line of the beam were given such a lift that, while they were painfully weak on the comparison antenna, they were extremely strong on the diamond. That, of course, is the sort of sweeping statement that we are unable to avoid. It is the sort of statement with which antenna engineers might have little patience. From the ham operating standpoint, though, it states the case. The performance of the antenna on interfering signals was similarly striking. Frequently it would be possible to hear sixth-district stations on the beam with nothing more than faint heterodyne QRM. Switching to the half-wave comparison antenna would produce, on precisely the same frequency, a fourth-district station of similar strength and with similarly inconsequential interference. The 20-meter signals from W1JPE were bumped, along the line of the beam, anything from 2 to 6 R points (estimated by the various listeners). The VK's (20-meter 'phone) over the period of a week's testing, reported us variously as the "loudest first-district station," as "loud as the strongest W's from any district" and "three or four R points stronger than W1SZ."

The latter line of talk led W1SZ to throw up a similar antenna — not that it was all throwing. The location at W1SZ is even more thoroughly smeared with trees and underbrush than that at W1JPE. This circumstance, together with the fact that W1SZ decided to use copper-clad steel wire, led to many complications. A two-day struggle with the project leaves us with one firm recommendation—that if copper-clad steel wire must be strung above dense underbrush, it should be dropped into position from a blimp or other convenient type of skyhook. Threading the wire through the brush with the idea of pulling it up into position afterward is, quite definitely, the wrong idea.

To get back to cases, the W1SZ antenna also worked like a charm, bumping his signal along the line of the beam to such an extent that he now became a point or more stronger than W1JPE. The comparison antenna used at W1SZ is a pair of vertical half-waves in phase strung alongside an 85-foot telephone pole. It is an excellent antenna in the ordinary sense of the word but the

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new diamond ran rings around it in just as striking a fashion as did the diamond at W1JPE. The vertical antenna was, of course, preferable for work to Europe, South America, Canada, and some portions of the United States but, surprisingly enough, the diamond gave quite good general coverage in spite of the great gain along the direction of its main lobe. Using this antenna without a terminating resistor W1SZ has been able to maintain contact with VK3MR and other VK stations for 19 hours out of the 24—a performance, from this part of the world, which we have long considered an impossibility.

The point about all this rigmarole is that after reading all the idealistic technical material and after hearing vague rumors of results obtained by other amateurs we have at last had intimate experience with the rhombic antenna in ham dress. And since the experience embraces two installations under widely different conditions (both of them being similarly successful) we feel justified in trying to express our enthusiasm. Without any doubt, there are hundreds of hams with the space to put up a small diamond and the desire to pump a particularly heavy signal into some one corner of the world. Most of them would hesitate to do anything about it because they are faced, as we were, with the impossibility of discovering from any of the published material whether or not the thing would be worth while. The textbooks say that a rhombic antenna with sides 3¼ wavelengths long will have a power gain of 25 over a half-wave antenna at the same height. But this leaves many questions unanswered. Over what angle, for instance, is this gain likely to be noticeable; what happens to it if the location is covered with trees; and what if the wires are actually tangled in the branches, and if the height of the wire is less than a half wave and variable along the length of the antenna—what then? What happens if the ground is irregular or sloping? And what happens to the performance if the terminating resistor is left off?

Answers to these questions, based on our own experience, go about like this: Over an angle of approximately 5 degrees the apparent power gain over a half-wave antenna in reception, particularly on DX signals, is likely to be very much more than the theoretical value—this probably resulting in cases where the vertical directivity of the antenna places the main lobe at the angle of arrival of the incoming signal. The height of the antenna above ground will influence the vertical directivity and the slight superiority of the W1SZ antenna over that at W1JPE leads us to suspect that the additional height at W1SZ has given him a lower angle of radiation in the vertical plane and, hence, a better performance on DX signals. The irregular ground and the irregular height at W1JPE has doubtless destroyed the clean form of the ideal main lobe, the effect appearing chiefly to be a slightly broader characteristic in both the horizontal and vertical planes.

Trees, buildings and miscellaneous wires in the field of the antenna probably have a similar effect on the performance of the antenna, but the influence is very hard to detect. Not so long ago we should even have chopped down the family's pet trees to avoid contact between the antenna and branches or leaves. To-day we are of the impression that the matter is of precious little consequence—in the case of very long-wire antennas, at any rate.

Then there is the matter of the terminating resistor. Should facilities be available it would be possible to adjust the terminating resistor precisely and thus virtually eliminate unwanted signals from the rear of the antenna. And it would be possible, doubtless, to improve the radiation in the forward direction by establishing and matching the characteristic impedance of the system. With our particular antennas, access to the terminating resistor is had only after a half-day's work untangling ropes and wires from the trees. A program of cut-and-try adjustment with field intensity measuring equipment is, therefore, quite impractical. We have been left with the alternatives of connecting in a 700-ohm resistor, hoping for the best, or dropping the resistor out. The chief observation is that any terminating resistor, (accidentally we have tried 300, 500 and 800 ohms) simplifies feeding the antenna since, under those circumstances the system will take plenty of power without tuning the feeder. Elimination of the termination resistor makes it necessary to tune the feeders but the performance in the forward direction is quite similar. The terminating resistor, even if incorrectly adjusted, gives a drop of several R points to signals arriving from the rear of the antenna. The reduction in noise coming from the rear is also noticeable.

Our most recent experience with this type of antenna has been in the erection of a larger system (3¼ wavelengths on a side) at W1JPE in the attempt to blot out the W1SZ signal in Australia. The new antenna, though larger, is considerably more irregular in its various dimensions than the first version and probably because of that its performance is not quite what we had expected. The main lobe and the two first secondary lobes give us a performance in reception similar to that shown in Fig. 3. This chart, indeed, is the result of several hundred readings taken on the HRO "S" Meter while comparing the 3¼ wavelength diamond against a half-wave comparison antenna. It differs from the characteristic had with the 2¼ wavelength antenna only in the distribution of the minor lobes. It represents, in short, just about what one might expect from a very haywire diamond between 200 and 300 feet from tip to tip.

And so, after all these very general statements, we reach the point where we can suggest with all the emphasis we can command that any ham who has a hankering to pump big signals in one or two particular directions, and who has any chance at all to borrow or rent the space, is doing the wise

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thing if he cancels his order for two half kilowatt bottles and puts up a diamond instead. Don't mind the trees and the underbrush; don't mind the buildings and the clothes line—just string the thing up and shoot. Remember though, that it is quite ridiculous to use such an antenna for transmission while using a piece of wire around the picture rail for receiving. It is utterly impossible to exploit the possibilities of the antenna without a change-over switch or relay which will permit using the antenna for reception. The method of coupling the antenna to the receiver is also important. We suggest setting up a tuned circuit consisting of a 35-$\mu\mu$fd. midget variable condenser and an 8-turn coil of bare wire one inch in diameter, coupling this with a 2-turn link to the terminals of the receiver. The feeders from the antenna should then be clipped across about the middle four turns of the coil. A somewhat similar arrangement, shown in Fig. 4, is suggested for the transmitter.

Possibly the most important feature of all is that the rhombic antenna operates effectively over a very wide frequency range. It is the one type of directive antenna that functions without

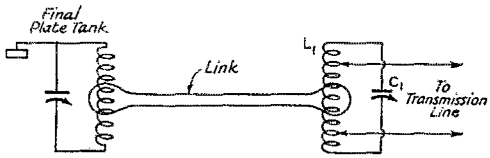

FIG. 4—THE ANTENNA COUPLING CIRCUIT USED AT W1JPE

L_1 and C_1 are similar in size and rating to the coil and condenser used in the plate circuit of the final amplifier. The coupling of the two-turn link and the setting of the taps on L_1 are varied until the desired load is obtained.

the need of any adjustment or change on, say, the 40-, 20-, and 10-meter bands. Further, as the frequency is increased the vertical angle of radiation is decreased. Result—a hot performance on three bands. In practice the W1JPE antenna is an absolute whizz on 28 mc., even giving greater gains than those had on 14 mc. Time and again we have had thoroughly satisfactory 'phone contacts with stations along the line of the beam at times when the signals simply did not exist on the normal antenna.

It is all rather hard to believe.

Briefs

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