a new look at the W8JK antenna

This old standby provides interesting possibilities for the new bands

The W8JK antenna or "flat-top beam" was adapted for Amateur use and described in *QST* in 1938[1] by John D. Kraus, W8JK. This antenna was widely used for several years but has now been largely superseded by the Yagi, which has higher gain for a given size.

In 1970, 32 years after his original *QST* article, W8JK described a 5-band rotary beam antenna with several modes of operation.[2] In mode 1, having the highest gain, the antenna consists of a pair of vertical W8JK antennas stacked horizontally. Whether by design or chance, the same issue of *QST* contains a description of a device called "The Ultimate Transmatch,"[3] which is a considerable aid in making the basic W8JK an attractive antenna.

In this article the W8JK antenna is compared to the widely-used 3-element Yagi, and it will be shown that, despite its lower theoretical gain, the W8JK is in several respects the better antenna.

the W8JK antenna

The basic W8JK antenna is shown in **fig. 1**. It consists of two closely spaced dipoles fed 180 degrees out of phase. The original W8JK article refers to this as a single-section antenna if the dipole length, L, is a half wavelength and as a two-section antenna if L is a full wavelength. In fact, the antenna operates well and with no abrupt change in properties over a frequency range such that L varies from less than a half wavelength to more than a full wavelength, so that this distinction appears unnecessary. In the original article and elsewhere[4] more complicated varieties of the antenna, and end-fed as well as center-fed versions, are discussed. However, only the basic antenna is dealt with here.

Operation of the W8JK antenna is as follows: the individual dipoles tend to radiate as they would in isolation; that is, with no radiation off the ends and maximum radiation at right angles to each dipole. However, because of the out-of-phase feed to the dipoles, radiation cancels in the upward and downward directions. The cancelled radiation is not lost but appears elsewhere, primarily in both directions along a line joining the centers of the two dipoles.

Antenna gain depends on both element length L and spacing d, but neither is critical. If a lossless antenna is assumed, very close spacing should produce the highest theoretical gain, but such spacing also results in very low radiation resistance, and conductor losses cannot then be neglected. In practice, spacings of about one-eighth wavelength seem to be opti-

By Frank Regier, OD5CG, Department of Electrical Engineering, American University of Beirut, Beirut, Lebanon

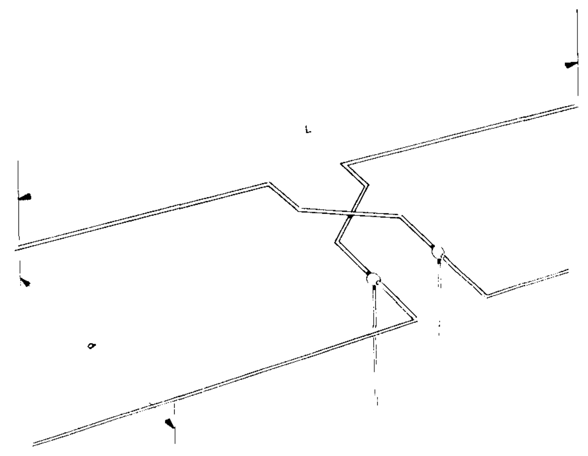

fig. 1. The basic W8JK antenna, consisting of two closely spaced dipoles fed out of phase.

mum. The spacing should not be reduced to much below this figure but can be increased to a quarter wavelength with very little reduction in gain.

Antenna length is subject to the same constraints as in the case of a simple dipole: length should not be reduced much below a half wavelength because of reduced radiation resistance, and gain increases with length up to a maximum at one and a quarter wavelengths.

The gain of a basic W8JK antenna with eighth-wavelength spacing and half-wavelength elements is about 4 dB in free space. This figure increases gradually to about 6 dB at twice the design frequency, and to a maximum of about 7 dB at 2.5 times the design frequency.

the Yagi antenna

The familiar 3-element Yagi antenna is shown in **fig. 2**. This antenna is similar to the W8JK in that its

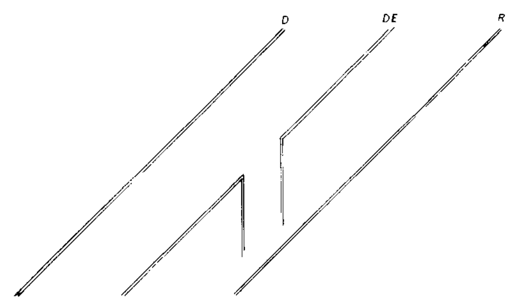

fig. 2. Three-element Yagi antenna. Energy from the driven element DE is picked up and reradiated by reflector R and director D.

gain results from the cancellation of radiation from the various elements in some directions and addition in others. It differs, however, in how power is applied to the various elements. In the W8JK antenna both elements are fed directly. In the Yagi only one element is fed directly, and the others behave simultaneously as receiving and transmitting antennas, receiving power from the driven element and re-radiating it with an amplitude and phase determined by the length of the element and its spacing from the driven element. This method of supplying power to the parasitic elements makes the Yagi easy to feed, but the critical dependence of the phase of radiated power on element length makes the Yagi a narrow-band antenna, operating as intended only near the design frequency. At frequencies far removed from resonance, the parasitic reflector and director receive and re-radiate little power, and the pattern of the antenna is not very different from that of the driven element alone.

Variations on the 3-element Yagi include: a) an increase in the number of directors, leading to improved forward gain (additional reflectors, being in a low-field region, would have little effect and are rarely used), b) interlacing elements for various frequency ranges, and c) the addition of traps in the various elements to cause resonance at several frequencies. This is a useful procedure but requires compromise spacing at the different frequencies.

a comparison

Although a 3-element Yagi has more gain in free space than the W8JK, there are at least three respects in which the latter is the better antenna. These are: noncritical construction, bandwidth, and operation at low elevation.

The noncritical nature of the W8JK results from the fact that, unlike the Yagi, it does not depend on resonance for its symmetry; and, provided symmetry is maintained, element length and spacing are relatively unimportant.

Its large bandwidth, too, results from the nonresonant nature of the W8JK antenna. This bandwidth is such that operation is possible over at least a 2.5:1 frequency range. Operation over such a range does require the use of an antenna tuner or transmatch and a tuned transmission line, since antenna impedance does change with frequency.

antenna height

We turn now to the question of operation at low elevation. It is a matter of great importance, and in fact the major point of this article, that the basic principle of operation of the W8JK antenna remains valid even at very low elevations, whereas under the same conditions the behavior of a Yagi degrades to that of

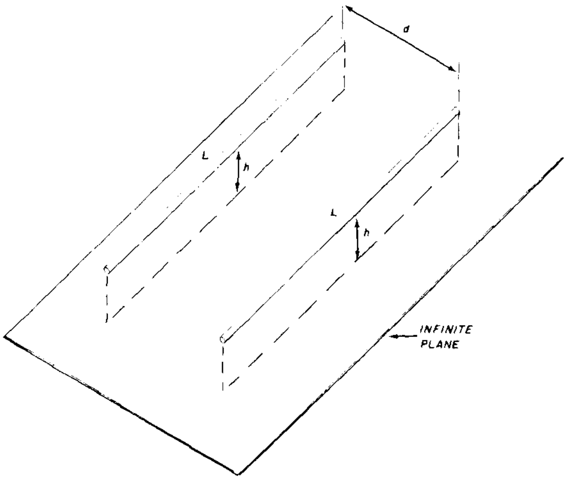

fig. 3. Basic W8JK antenna spaced at a height *h* above a ground plane. Although reflection from the ground plane takes place and the angle of radiation is raised, symmetry is retained, and the basic principle of operation — cancellation of radiation in the vertical direction — remains valid.

a simple dipole. This means that at low elevation the W8JK is a more effective antenna than the Yagi. To see why this is so, consider first the W8JK (see **fig. 3**). The presence of a nearby ground plane will affect the antenna impedance, but with a tuned feed line and a transmatch this is easily compensated.

The important point is that, because symmetry is not disturbed by the ground plane, the fundamental principle of operation — cancellation of radiation in the vertical direction — remains valid. Considering next the Yagi (see **fig. 4**), we find that the nearby ground plane will severely detune both director and reflector and interfere with their excitation by the driven element. These two parasitic elements therefore become ineffective, and performance degrades to that of a simple dipole near ground.

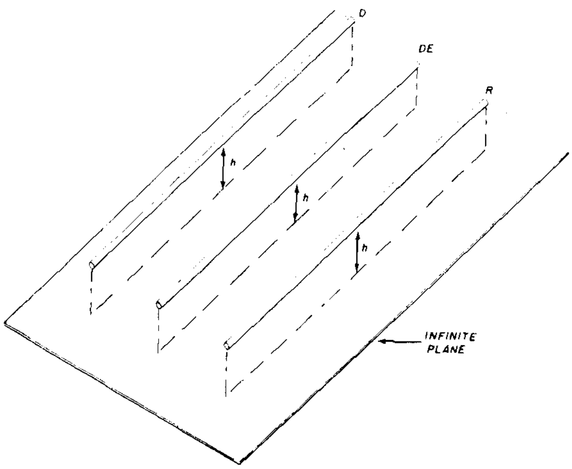

fig. 4. Three-element Yagi antenna at a height *h* above a ground plane. If *h* is small, director D and reflector R are detuned and improperly excited and are thus ineffective. The resultant radiation pattern is that of the driven element DE alone — a dipole above a ground plane.

It follows from the above argument that there must be some critical height below which the W8JK outperforms the Yagi, and it would be interesting to know what that height is. In principle it should, of course, be possible to calculate the characteristics of both the W8JK and the Yagi as functions of height above a perfect ground. But, particularly in the case of the Yagi, this presents difficulties, and an experimental approach seems preferable. I am not in a position to carry out the experimental work, but I have found a reference[5] that seems to contain the essential results. In this reference it is stated that a 20-meter antenna, essentially equivalent to a W8JK, at 38 feet (11.6 meters) gave results comparable to a 3-element Yagi at the same height. When 10-meter antennas were compared at the same height, the 3-element Yagi was found to be superior. This would seem to imply that at an elevation of about one wavelength, a 3-element Yagi outperforms a W8JK, but that at a half wavelength elevation, the two are about equal. This would mean that the critical height is about a half wavelength, and that below that height a W8JK can be expected to outperform a Yagi.

Fig. 5 (from reference 4) shows the W8JK vertical radiation pattern at a height of 1/2 wavelength.

conclusions and remarks

The W8JK antenna has a number of desirable characteristics and makes a particularly good antenna in situations where only a low height is possible. An elevation of a half wavelength seems to be about the critical height below which the W8JK provides higher gain than a 3-element Yagi. Thus a W8JK at 20 feet (6 meters) should be about comparable to a 3-element Yagi at the same height on 21 MHz, poorer at higher frequencies, and better at lower frequencies.

Although the W8JK exhibits gain over at least a 2.5:1 frequency range, the antenna has an impedance that is a function of frequency and should be fed by a transmatch and an open-wire line of some sort.

In addition to the 10-, 15-, and 20-meter bands, the new Amateur bands at 10, 18, and 24 MHz can be accommodated. For example, an antenna with a length $L = 40$ *feet* (12 meters) and a spacing $d = 11$ *feet* (3.4 meters) should provide good performance on the Amateur bands at 10, 14, 18, 21, 24, and 28 MHz. In addition it should provide much improved reception on the 12-, 15-, 18-, and 21-MHz shortwave broadcast bands, where most listeners make do with a random length of wire, or at best, a dipole. If operation below 14 MHz is not required, the spacing can be reduced to $d = 8$ *feet* (2.4 meters), and the length L can be anything from 24-40 feet (7.3-12.2 meters).

In closing I might mention that my own experience in feeding a 30-foot-long (9-meter) W8JK with 8-foot (2.4-meter) spacing by means of a 40-foot (12.2-meter) length of 300-ohm TV twinlead has been better than might be expected. There has been no breakdown with 1200 watts PEP input, and although losses are no doubt somewhat higher than those of an open-wire line, the use of twinlead is extremely convenient. The main disadvantage of the twinlead is that it is necessary to cease operation during rainstorms because the input impedance of the feed line becomes erratic.

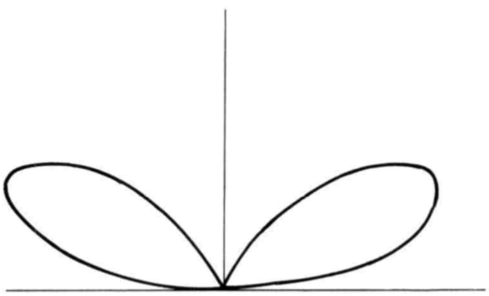

fig. 5. Vertical pattern of W8JK antenna at a height h of one-half wavelength. At other heights additional lobes may appear, but vertical radiation is always cancelled and radiation is at lower angles than from a dipole at the same height (from reference 4).

references

1. J. Kraus, "Directional Antennas with Closely-spaced Elements," *QST*, January, 1938, pages 21-23.
2. J. Kraus, "W8JK 5-Band Rotary Beam Antenna," *QST*, July, 1970, pages 11-14.
3. L. McCoy, "The Ultimate Transmatch," *QST*, July, 1970, page 24.
4. *The ARRL Antenna Book*, 13th edition, 1974, pages 139-143.
5. J. Alan Biggs, "Stacking and Folding the Triplex," *CQ*, June, 1948.

bibliography

Lawson, James L., W2PV, "Yagi Antenna Design," *ham radio*, January, 1980, page 22; February, 1980, page 18; June, 1980, page 32; July, 1980, page 18; September, 1980, page 37; October, 1980, page 29; November, 1980, page 22; December, 1980, page 30.

ham radio