Notes on Ethereal Adornments

Practical Design Data for the Single-Wire-Fed Hertz Antenna

By L. G. Windom*

The use of the linear Hertz radiator fed by a single-wire line has been restricted in amateur work because of lack of data on its design and adjustment. This article explains how these systems may be completely designed on paper. The antenna may then be erected with the assurance that the voltage and current distribution on both the radiator and feeder will be correct. —EDITOR.

SOONER or later in the course of amateur development, one must have some sort of antenna, skyhook, or as you like it. In the earlier stages it consists generally of merely "a" antenna, then later after much deep (?) thought, it is "the" antenna. These few notes concern themselves only with that much-cussed atrocity, the single-wire-fed (cross-breed, voltage-current) Hertz. This type has the advantages of simplicity, ease of erection, very

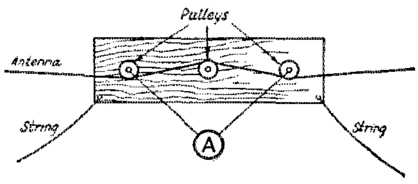

FIG. 1. — THE TROLLEY ARRANGEMENT USED TO PLOT THE CURRENT DISTRIBUTION ON THE RADIATOR

The same length of wire is maintained between the two outer pulley wheels which are connected to the ammeter. This effectively shunts the ammeter across a length of wire which causes a definite percentage of the current to flow through the meter. The position of the trolley is controlled by the two strings which allow it to be moved in either direction. Its position along the antenna during the tests described was determined by means of a transit.

high efficiency and, as will appear later, can be designed on paper and erected without the usual pruning operation.

The information herein contained is due to the efforts of John Byrne of the Bell Telephone Laboratories, ex8LT, W8GZ, W8ZG, W8DKJ; Ed. Brooke, also of the Bell Telephone Laboratories, W2QV and ex8DEM; and Jack Ryder, W8DQZ, under the direction of Prof. W. L. Everitt of the Department of Electrical Engineering, Ohio State University. The writer acts solely as a reporter and all credit is due the above-named men.

Interest in the single-wire-fed Hertz antenna for amateur work started mainly with an article by Williams, 9BXQ, in the July, 1925, *QST* followed by several, others including the re-hash in the July, 1926, issue. It is perhaps best to disregard all this previous material in relation to the

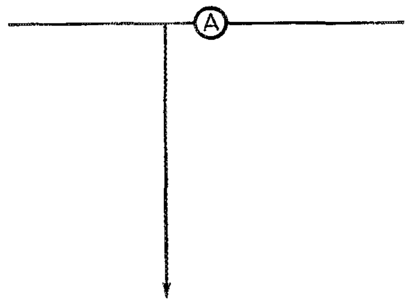

FIG. 2. — THE COMMONLY-USED METHOD OF DETERMINING THE FUNDAMENTAL OF THE ANTENNA IS TO INSERT AN AMMETER IN THE CENTER OF THE RADIATOR AND ADJUST FOR MAXIMUM CURRENT

This system is not satisfactory and the results obtained are very misleading.

single wire feeder system and start from the beginning.

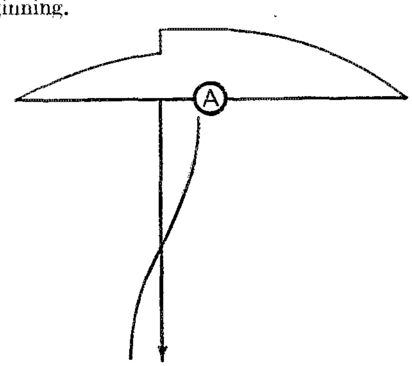

FIG. 3. — WHEN THE CURRENT IN THE CENTER OF THE RADIATOR WAS MAXIMUM IN THIS PARTICULAR CASE, THE CURRENT DISTRIBUTION WAS AS SHOWN

This is by no means a satisfactory condition, although it would be considered as such if only the ammeter readings were being considered.

Byrne and Brooke erected a special experimental station at W8XJ (Ohio State University),

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consisting of a transmitter shack, a very stable oscillator and necessary ethereal equipment to vary the antenna in all possible ways. Measure-

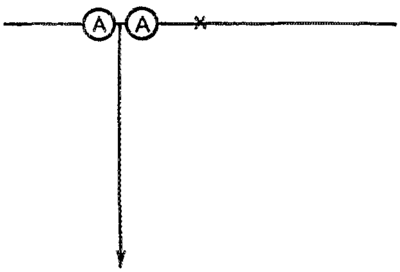

FIG. 4.—THIS SYSTEM OF DETERMINING THE FUNDAMENTAL EMPLOYS TWO AMMETERS PLACED CLOSE TO EACH OTHER WITH THE FEEDER CONNECTED AT THEIR JUNCTION

The ammeter normally located at the center of the system is dispensed with entirely.

ments were made by means of meters placed on trolley arrangements (Fig. 1) by which they were shunted across a portion of the antenna and readings taken at predetermined points through the aid of a transit.

A normal half-wave radiator with a single-wire feeder was erected, using a meter at the center of the radiator for tuning purposes, and with the feeder some 6 feet off the center as in Fig. 2.

Tuning for maximum current at the center of the antenna with this arrangement resulted in

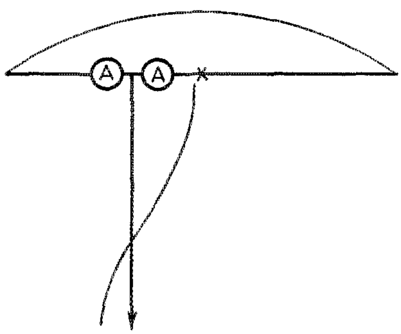

FIG. 5.—IN THE TEST WORK, THE TWO AMMETERS AND FEEDER WERE PLACED ON THE ANTENNA AT A RANDOM POINT AND THE TRANSMITTER FREQUENCY VARIED UNTIL THE READINGS OF THE AMMETERS WERE THE SAME

It was then found that the current distribution was as indicated.

a greatly distorted current curve on the antenna and a bad standing wave on the feeder as indicated in Fig. 3. Note that this is the usual method of tuning employed by amateur stations.

Obviously this wasn't according to the theory, so different lengths and feeder positions were tried—with the same discouraging results. Now let's write this on our cuffs or where you will—*the method of tuning a single feeder Hertz by means of an indicator at the center of the antenna is wrong and should not be used.* True, there are some means of so doing, but they are more likely to lead one astray, even when you know what you are doing. From the above it was apparent that the first requirement was to hammer the current curve on the antenna into shape. Then, as says the movie sub-title, "came the dawn." Just where the glimmer came from I never knew, but most amateurs have a few spare ideas stored away somewhere. The meter in the center of the antenna was taken off and tossed into the lake—it wasn't their meter, so they could afford the procedure. Nevertheless, that step is essential to results—discard all indicators at the center of the antenna—the neighbors will feel better and the fire department will have fewer false alarms.

Next, two *equal reading* ammeters were placed in the antenna at a random point—any place between center and end—and the feeder connected between them as in Fig. 4. These meters should be as close together as possible. Also, one

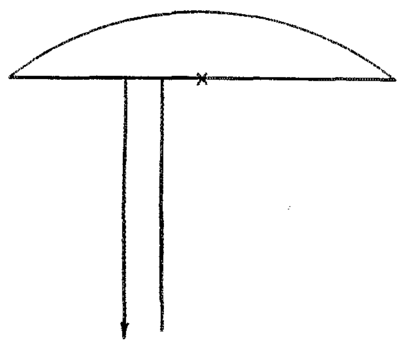

FIG. 6.—AFTER THE RADIATOR DIFFICULTIES HAD BEEN CLEARED UP, THE POSITION OF THE FEEDER WAS SHIFTED AND THE CURRENT DISTRIBUTION ALONG IT MEASURED

When the proper position was located, there were no standing waves upon the feeder and the radiator showed excellent current distribution as indicated. These conditions are independent of the length of the feed line which when properly adjusted will not cause any damaging radiation.

meter could be used by changing it from one side to the other of the feeder and plotting two frequency-*vs.*-current curves.

The transmitter was then tuned (frequency varied) until the two ammeters read exactly the same. The current curve of the antenna was again taken, and the result was a perfect current distribution as shown in Fig. 5.

Different lengths of antenna were tried and when adjusted by this method always gave a perfect current distribution curve. Such is only possible at the fundamental, hence *this method is the proper one for determining the fundamental of a single feeder Hertz.* A number of tests were run, and it was found that for the average amateur antenna the fundamental was approximately 2.07 times the length in meters, i.e., $\lambda = L \times 2.07$.[1]

Next the feeder was given a massage. Starting with it at the center, current curves were plotted (curves on the feeder) as it was moved outward. Again by the grace of the Wouff-Hong the standing wave on the feeder began to disappear. At a very definite point, the feeder curve became a straight line. Beyond this point standing waves again appeared. This procedure was repeated for a number of various antennas, and it was found that this magical position of the feeder from the center was a fixed ratio, and that, given any antenna length, we can compute the proper feeder point. This formula being: Distance of the feeder from the center equals the antenna length times

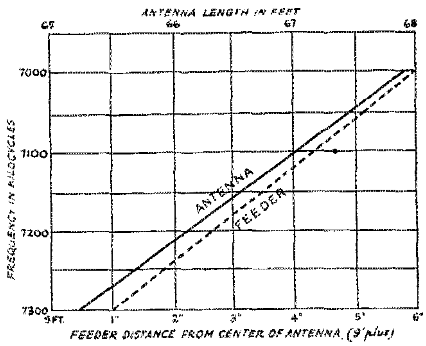

FIG. 7. — IN ORDER TO SIMPLIFY THE PROBLEM OF DESIGNING THIS TYPE OF SYSTEM, THE ABOVE CURVES ARE GIVEN

They cover the dimensions of the feeder and radiator for fundamental operation in the 7000-kc. band. One has but to decide upon the frequency at which operation is desired and then pick the values for feeder and radiator length directly from the chart. For the higher frequency bands, the radiator may be operated at a harmonic frequency; the feeder position will still be correct.

25 and the product divided by 180; i.e., feeder distance from center =

$$\frac{\text{Length of antenna (feet)} \times 25}{180}.$$

These figures are for number 14 copper wire — the size having a slight effect — until for number 24 wire the factor 25 above becomes 30. The absolute factor for any size wire is thus easily computed. Also it was found that *the position of the feeder has no effect on the fundamental of the antenna.*

Recently at W8XJ, Ryder of W8DQZ has found that these formulas hold true for feeders up to 1200 feet in length (that being the longest distance available) and that the only losses were those of resistance. The 1200-foot feeder had an

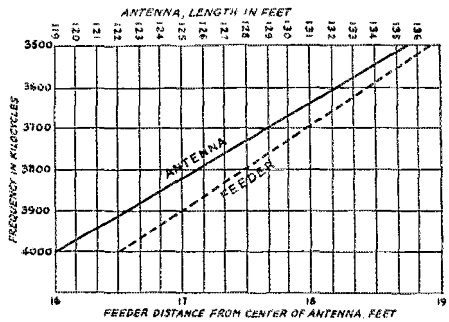

FIG. 8. — THESE CURVES ARE SIMILAR TO THOSE GIVEN IN FIG. 7 EXCEPT THAT THEY APPLY TO SYSTEMS HAVING THEIR FUNDAMENTAL FREQUENCIES IN THE 3500-KC. BAND

If a 14,000-kc. system is to be designed, these values may be divided by 4 or those given in Fig. 7 may be divided by 2.

efficiency of over 85%. Anyway, it isn't usual practice to put your antenna in the next state. Hence, we can say that *the feeder length has no effect*, for all normal operation.

Constructing an antenna by these two formulas and tuning to the predetermined fundamental by a good accurate frequency meter, we secure current distribution on the feeder and antenna as in Fig. 6, which is about as perfect as can be desired. The feeder efficiency for the average runs well over 95%.

Next, antennas for the 14,000- and 3500-kc. bands were tried and the formulas given found to hold true for all waves. A single feeder Hertz will work well at its harmonics — in fact just as well as at the fundamental, for the reason that the feeder connection will continue to be approximately at the correct distance from the voltage nodes. We can, therefore, build the antenna for the lowest frequency (highest wave) to be used and then work at harmonics for the other bands, or else use separate antennas. At W8ZG a 7000-kc. antenna has been working very effectively on 28,000 kc.

To save time and computation, graphs covering the 7000-kc. and the 3500-kc. band are given in Figs. 7 and 8. By choosing the frequency you desire to operate on, the antenna length and feeder positions are at hand. For a half-wave 14,000-kc. band antenna divide the figures of the 7000-kc. graph by 2.

The feeder is tapped directly on the plate inductance of the transmitter at such a point as causes the tube to draw normal input — i.e., the feeder tap is moved from the filament toward the plate end until the tube draws normal operating current. It is not advisable to push it out to the limit, as this tap on the inductance has an

[1] This agrees quite closely with the figures obtained from a number of sources and given on page 49 of the October, 1928, issue of *QST*. Rearranging the formulas for the general problem of determining the length of wire in feet needed to give a certain fundamental wave length in meters, we get:

Length in feet = Desired fundamental in meters × 1.56

or Length in feet = $\dfrac{468{,}000}{\text{Desired frequency in kilocycles}}$

— *Editor.*

effect on the efficiency of the transmitter beyond a certain point. In addition, you can spoil a good note by such excessive coupling. The formulas are for average operation using inductances about 4 inches in diameter. For 28,000 and 14,000 kc., one turn from the filament; for 7000 kc., two or three turns; and for 3500 kc., five or six turns are ample, depending, of course, on the total number of turns used. A ground should be used on the filament circuit as a protective measure.

As a summary, the following steps should be

(Continued on page 84)

Notes on Ethereal Adornments

(Continued from page 22)

taken in erecting and operating a single-feed Hertz antenna:

1. Choose the frequency on which you desire to operate.

2. Construct the antenna by following either the two formulas given above or the graphs. If you are more meticulous you may follow the entire procedure outlined.

3. Tune the transmitter to the fundamental (the chosen frequency) by means of an accurate frequency meter. Leave it there. A Hertz must be operated as near the fundamental or a harmonic as possible to secure high efficiency. Operating away from the fundamental or harmonic throws the whole system off.

Always remember the station is no better than the operator or the emitted signal, so before you tell us how rotten the antenna is, take the other factors into account.