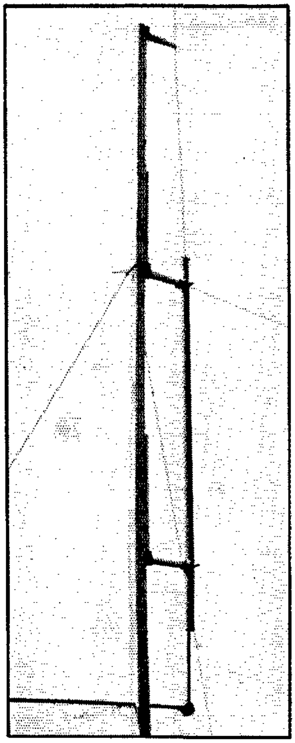
The Coaxial Vertical Radiator

An Improved Half-wave Antenna System for Low-Angle Radiation

BY JOHN J. LONG,* W8ABX



The coaxial antenna installed at W8XAI, mounted on stand-off insulators on a wooden pole. This installation uses a commercial ⅞-inch concentric feed line. The lower quarter wave section of the antenna through which the line runs is two-inch tubing. Less expensive arrangements can easily be devised for amateur work. A portion of the ground screen is just visible at the bottom.

THE antenna to be described was first used, so far as the writer knows, by the Western Electric company for their new ultra-high-frequency police transmitters. Although the antenna gives exceptional results, very little information has been available on why it works as well as it does. The explanation to be given later is simply that of the present writer. The results, however, are real — so real that any one wishing to operate on 5 or 10 meters will do well to put up such a rig.

Briefly, the antenna is a simple half-wave vertical dipole with the power fed into the center by running the concentric-line feeder up through the lower quarter-wave section of the dipole. This can be done by any number of mechanical arrangements, and two such arrangements, used experimentally at W8XAI and W8PK, will be described. W8PK operated on five meters and W8XAI on 31.6 Mc.

At W8XAI, a ⅞-inch isolantite-insulated coaxial line was used to feed the dipole. A piece of two-inch copper tubing was soldered to the end of the line by placing a disc of copper at the top, as shown in Fig. 1. The upper quarter-wave section was mounted on an insulator, and consisted of a piece of quarter-inch brass tubing. The whole assembly was mounted on insulators as shown in the photograph. The antenna power was 100 watts, and tests were made with different members of the WHAM staff and other listeners in Rochester, 16 miles away, to get information on how this antenna compared with a "J" type antenna which was formerly used. The new type of feeder system was so superior to the old that the improvement was very impressive.

The end-fed "J" type antenna is shown in Fig. 2, while the type used at W8XAI is shown in Fig. 3. This antenna feed system was quite unsatisfactory. On one test, the half-wave antenna was disconnected from the feeders and practically the same signal strength was reported as when the antenna was on, showing that the feeders were radiating considerable energy all by themselves! It so happened that the feeders were in a very unfavorable spot for doing much radiating, so most of the power was being wasted in heating the shielding on the building.

Ground Screens

We have been reading about the theoretical half-wave antenna erected over perfectly-conducting earth for so long, and never seeing one in operation, that we were pretty well disgusted with the theoretically-perfect antenna. It looked beautiful on paper but there just didn't seem to be any perfectly-conducting earth on this particular globe. We had some copper screen left over which was used for shielding our transmitter building, and which was supposed to be the last word in conductivity. We said, "Why not set up a piece of synthetic perfectly-conducting earth under our half-wave antenna and see what happens?" A test was made by placing this copper screen directly under the antenna, and reports at once showed that the theory was right, but that the earth as we know it was not so hot.

It is a simple matter to place a good ground screen at least a half wavelength in radius under a five- or ten-meter antenna. We wish it were as simple in the broadcast band!

Five-Meter Results

Before we get to the cracker barrel opinion on what happens with a vertical "J" antenna, let's see what W8PK did with a five-meter antenna built along the same lines.

He did not have a rigid piece of concentric line available so he made up the rig shown in Fig. 4.

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The concentric line consisted of a piece of low-grade No. 14 rubber-covered house wire pulled through a length of quarter-inch brass tubing. A piece of ⅞-inch copper tubing was soldered to the end of it, and the top quarter-wave section was an extension of the inner conductor. The whole assembly was suspended from the top by a regular antenna insulator.

The boys on "five" said it was as loud as a beam job that he spent considerable time building — minus the trouble of having to go out and turn it whenever he wanted a different direction. The thing puts an R9 signal into W8ABX, 18 miles away, on five meters. The beam job never did that. Maybe he didn't have the beam operating at maximum efficiency, but that is the point — there are plenty of beams that are not working to the utmost! Just because the signals get weaker when the antenna is turned in the opposite direction is no sign that it is working efficiently in the direction at which it is pointed.

There was some doubt about the length of the lower quarter-wave section, but it was found by using a sliding sleeve on the outer tubing that the length was the same as that of the upper section, and came out exactly as calculated. Forty-eight inches for 56.5 Mc. will give you some idea of the lengths for other bands.

Why It Works

Now for some guessing: Apparently a vertical "J" type antenna with a vertical quarter-wave "Zepp" type matching section at the end of the half-wave antenna has voltage which is out of phase in each side 180 degrees. But looking at it

This is a description of the new Western Electric antenna developed for u.h.f. police work. Installed at short-wave broadcasting station W8XAI, its performance was so evidently superior to the old "J" type that the hams on the staff just naturally had to give it a workout on amateur bands, with the results recounted in this article. It should be excellent for 5-meter work, since it is designed to give more intense low-angle radiation than it is possible to achieve with the more conventional forms.

from the antenna's angle, the feeder becomes part of the antenna if it does any radiating itself.[1] If this setup is operated above a ground, it is a ¾-wave antenna. A ¾-wave antenna has a very husky lobe of high-angle radiation and a weak lobe of practically horizontal radiation. This is so when the antenna is above perfectly conducing earth! Wasting all of the main part of the radiation in a high-angle lobe is not good "ham radio" at these frequencies. Anyway this new method of feeding is doing its stuff, so why worry with theory which is only correct when figured over perfectly-conducting earth — of which there is none!

To check the idea, a vertical dipole was supported from a concentric line out of the attic window at W8ABX as shown in Fig. 5, thereby

[1] At 56 Mc. in particular, it is doubtful whether a line with 6-inch spacing can be considered to be at all near the non-radiating condition. This spacing begins to approach the 1⁄40th wave spacing which, with out-of-phase currents, forms an effective radiating system. See p. 18, *QST*, May, 1938.

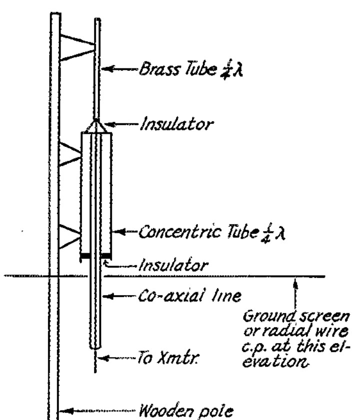

Fig. 1 — The coaxial antenna at W8XAI. Its performance is markedly better than that of the resonant-line fed antenna (Fig. 3) formerly used.

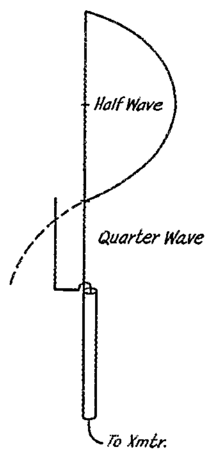

Fig. 2 — The "J" antenna, showing a "net" standing wave on the matching section, because of current or phase unbalance. Radiation from the matching section will tend to raise the angle of radiation.

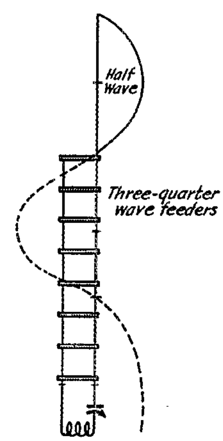

Fig. 3 — The old W8XAI antenna, used before the coaxial antenna was installed.

eliminating the vertical matching section. This antenna gets better reports than were ever obtained with an end-fed job.

Remember this: An antenna with power being fed into it is not the same as a theoretical antenna in free space. If the feeders radiate any energy which will interfere with the radiation pattern of the antenna itself no one can tell what is happening without making an elaborate field-strength survey. This is not being done by the average ham.

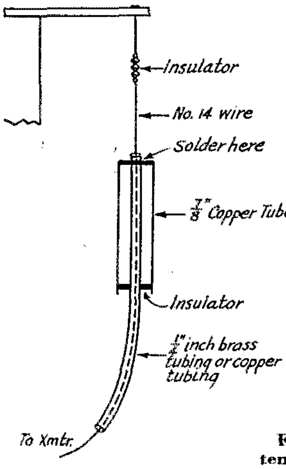

Fig. 4 — The 5-meter coaxial antenna built by W8PK, using materials easily available to the average amateur. This antenna gave a good account of itself as compared to a rotary beam.

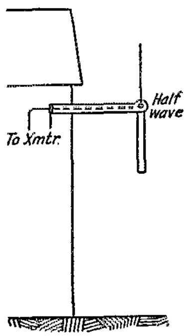

Fig. 5 — Vertical antenna with horizontal feed line as installed at W8ABX to check the effect of feeders. Results were definitely superior to those with the same type of antenna but with the feeder system vertical.

After all this talk you will probably say, "My antenna is the best one I ever tried." OK, but don't say we didn't tell you about the "theoretically-perfect" vertical half-wave antenna!

Editor's Note. — This article was written before the coaxial antenna had been described in print by its designer, Arnold B. Bailey, of the Bell Telephone Laboratories. Subsequently an article by Mr. Bailey appeared in the September, 1938, issue of *Pick-ups*, monthly publication of the Western Electric Company. The principle of operation is essentially as outlined by W8ABX, the intention being to eliminate radiation from the feeder system and, in the case of the common form of u.h.f. police antenna, from the grounded metal pole of which the top section is usually considered to be the radiating antenna. The inner surface of the quarter-wave tube can be considered to be an extension of the outer surface of the coaxial transmission line and does not carry current (except when power is coupled into it, as in the case of a nearby antenna). The outer surface, however, acts like the lower quarter-wave section of a vertical half-wave antenna; the current does not penetrate below the surface because of skin effect. The quarter-wave tube and the section of coaxial line it encloses can be looked upon as a high-Q circuit, so that a large potential difference appears between the lower end of the tube and the line proper. This is equivalent to placing a wave-trap in series with the lower end of the antenna and the outer surface of the concentric feed line, with the result that practically no power is transferred to the outer surface of the line itself; hence no current flows in it and it does not radiate. Tests carried out by Bell Labs have shown that an average signal-strength increase of 8 db results when the coaxial antenna is substituted for the ordinary "J."

It should be pointed out that, except for reduction of feeder (and pole) radiation the coaxial antenna is not a more "efficient" antenna, in the sense that it radiates more of the power supplied to it than does the ordinary half-wave dipole; it is, in fact, still a half-wave dipole. Its greater effectiveness lies in the fact that it eliminates stray radiation and thus permits the dipole to approach its theoretical performance in concentrating radiation along the horizontal. In other words, more of the radiated power will be pushed along the ground — the place where it is wanted in the case of normal u.h.f. work. Since low-angle radiation is desirable for long-distance 28-Mc. work, the antenna should also be highly effective for DX as well as local work on that band.

Incidentally, W8ABX's suggestion of using a ground screen under the antenna is well worth considering, particularly at these frequencies. Several of the WHAM gang have found such screens to increase materially the effectiveness of the antenna,[2] and at 56 and 28 Mc. the area to be covered is not large (a circle a wavelength in diameter at most). In a recent conversation, W8ABX suggested that a radius of 0.3 wavelength should be sufficient, since the current tends to concentrate at this point, and that tests had shown that going beyond this distance to a radius of a half-wavelength did not appreciably improve the results. — *G. G.*

[2] W8EBS reports that the use of a chicken-wire ground screen under his 10-meter rotary beam has improved the output very noticeably, making it better than the coaxial antenna, as would be expected. He also reports that the radiation angle could be changed to suit the station he was working, which also is according to the book. The screen should be a half wave below a horizontal antenna for lowest angle of radiation. Under a vertical antenna, the screen should be placed near the bottom of the lowest vertical element.—Author.

Strays

In your haste to see How's DX did you notice the dope on Regs? One concerns the Cairo Conference and the other clears up the technical difficulties of the FCC Regs.