A Super-Gain Antenna for 40 Meters

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This article gives briefly the results of a study to develop an antenna for the 40 meter band which would allow the hams to compete somewhat better with the foreign broadcast stations which practically take over the band in the evening and nighttime. In this respect the study was a partial success in that an antenna was developed based on the theory of super gain arrays, which rejects QRM from low angles. After some experimental work, a super gain antenna[1] was designed for the 40 meter band which is extremely simple, uncritical and offers large gain and QRM rejection factors.

The propagation studies and design work for this antenna were done at Dusina Enterprises in Melbourne, Florida.

Briefly, the antenna to be described has a forward gain of approximately 9 DB based upon engineering design data developed in the literature[2] and in addition to the forward gain has an average of 15 DB rejection against low angle QRM. Therefore, two hams both using this type of antenna array can gain an advantage of about 14 DB[3] improvement in signal strength and about 15 DB less QRM when communicating via high angle paths over short skip distances for an overall S/N improvement of about 29 DB. Short skip distances on the 40 meter band mean up to about 200 miles radial distance from the transmitter in the daytime and up to about 1,000 miles in the nighttime. These distances are selected from actual performance measurements on the array to be described.

The antenna is of the super gain class and consists of a single dipole antenna placed very close to and above a reflecting screen such as to limit the radiation to 90 degrees plus or minus 35 degrees approximately. The antenna is made in a very simple manner as follows. A 300 ohm TV type twin lead folded dipole is cut to the length 63 feet 2 inches plus or minus 1 inch and is fed in the center with RG 58 U coax or some other 50 ohm coaxial cable. This folded dipole antenna is suspended tautly seven feet above flat ground using three wooden poles or some other suitable support. If metallic poles are used, it is suggested that nylon cord be used for approximately three or four feet between the ends of the antenna and the metal pole so as to reduce the effect of capacitance on the ends of the antenna. On the ground directly below this antenna are laid three reflecting wires of a noncritical length sixty-five to eighty feet long. One wire is stretched along the ground directly below the antenna element. One of the remaining wires is laid along the ground parallel to the antenna but approximately six feet from the wire directly beneath the antenna. The third reflecting wire is placed on the other side of the antenna such that when the reflecting screen is completed there are three wires six feet apart, one under the antenna and one on each side forming a reflecting screen about eighty feet long by twelve feet wide. These reflecting wires are laid on top of the ground but they may be in the ground if desired. A slightly higher efficiency will result if they are placed on top of the ground, and the method used here over a lawn was to cut the lawn very low and lay the wires on top of the grass. When the grass grows back out, the wires will stay under the turf and not be

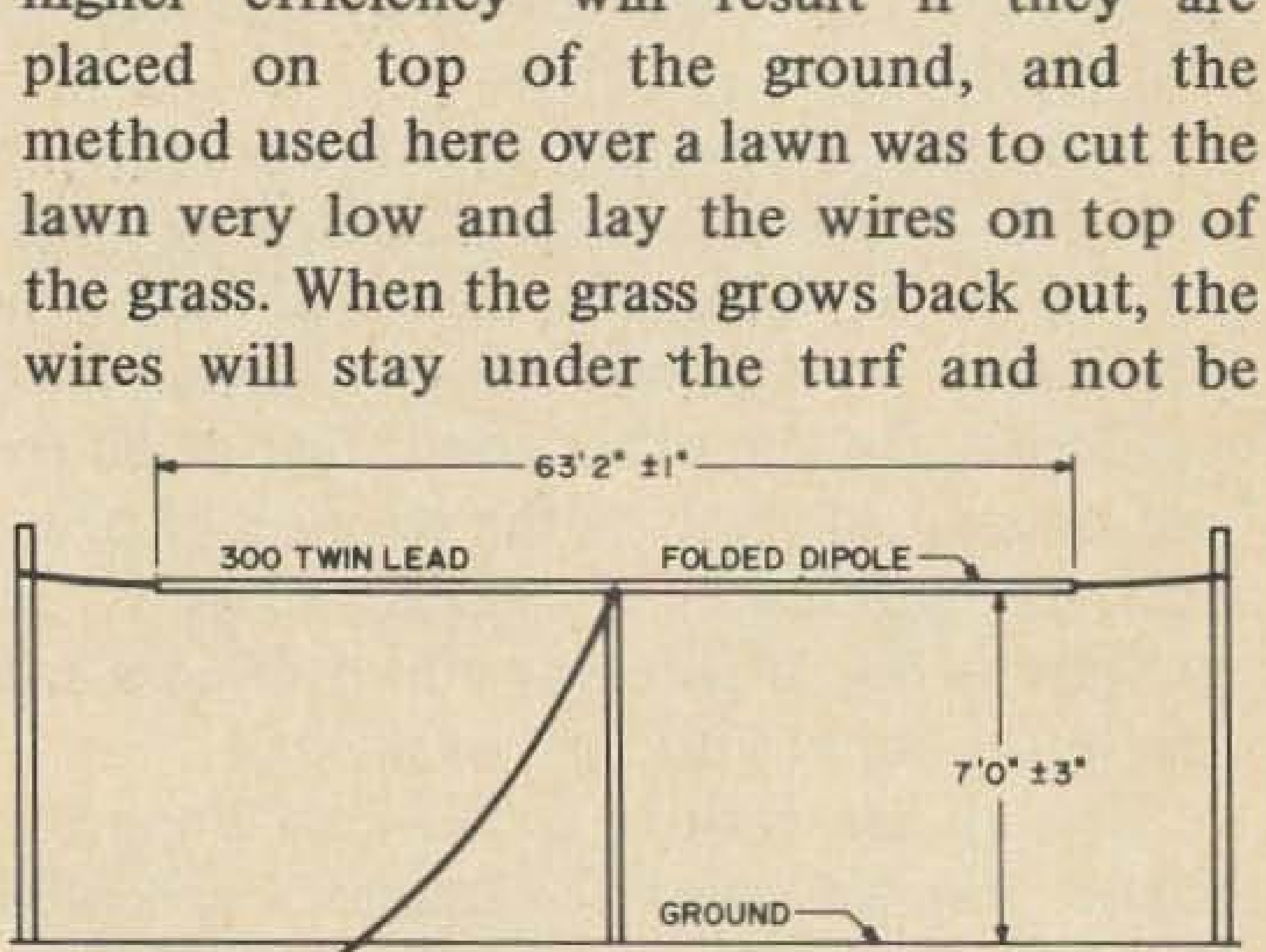

Fig. 1. Super-gain 40 meter skywire.

bothersome. The ends may be wrapped around large nails and the nails driven into the ground to assure that the reflectors do not curl up on the ends. Any reflector wire size larger than about No. 26 will be adequate, and larger than No. 14 is being wasteful.

As can be seem from the foregoing description, this antenna is sufficiently simple that every radio amateur can construct one. Although this antenna is intended to be used mostly for short-range communications up to about 200 miles, due to the nature of the 40 meter band, short skip conditions prevail much of the time at night and the antenna is then effective for distances of 1,000 miles and sometimes more with full gain.

An antenna constructed in accordance with the directions given above yields the following VSWR when fed with a 50 ohm coaxial cable. The antenna measured was fed by 100 feet RG-58 cable, used No. 26 wire reflectors and was tested at 2,000 W PEP:

FREQ	7.0	7.1	7.2	7.25	7.3	7.4
VSWR	3.6	2.6	1.3	1.05	1.5	3.0

Propagation Effects

Tests conducted in Florida on the effectiveness of this antenna in improving communications capabilities on the 40 meter band revealed significant improvement of an amount unexpected before the tests were made. These tests revealed the following characteristics:

Daytime Use

Typical daytime results comparing the super gain antenna to a two element collinear array with 2 DB[4] gain and elevated sixty feet above the ground (maximum radiation at 35° elevation) gave the following comparisons.

Stations from Alabama received at Melbourne, Florida, were typically 10 DB stronger on the 60 foot antenna than they were on the super gain array. This communication was at a distance of about 500 miles, which is long skip (about 35° arrival angle) for daytime 40 meter conditions. At approximately the same time, stations in North Carolina, a distance of about 700 miles, were 6 DB stronger on the high antenna than on the super gain array, while stations in Tennessee, approximately 700 miles distance,

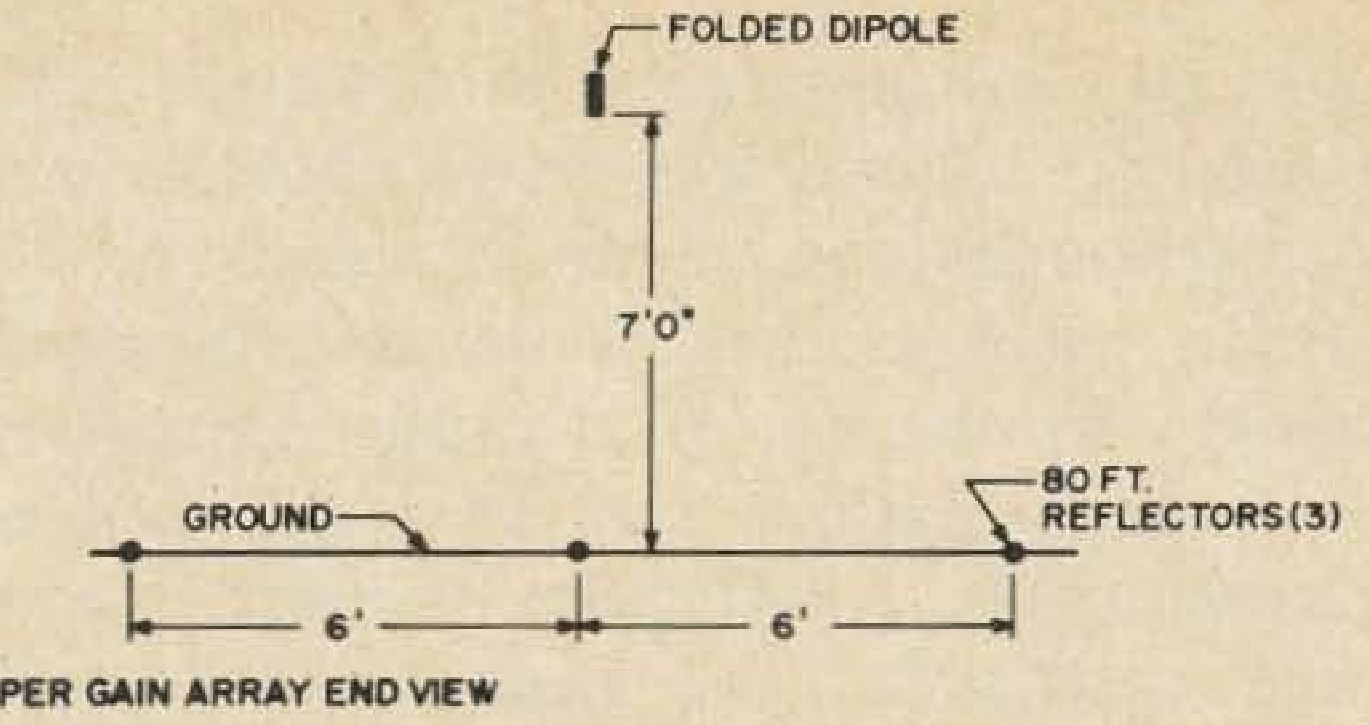

Fig. 2. Super gain array end view.

were 6 DB stronger on the high antenna than on the super gain array. The rejection drop to 6 DB from 700 mile distant stations was due to the loss of gain in the collinear at the 25° arrival angle and not due to improved pickup on the super gain array at the lower angles. These data show that the super gain array does in fact discriminate against signals arriving at the lower elevation angles. Comparison checks, made at the same time, on stations transmitting from sites in Florida revealed that signals originating within 80 miles of the super gain array were approximately 15 DB stronger and stations within 200 miles were 10 to 12 DB stronger on the super gain array than on the collinear array at 60 feet altitude. In general, in the daytime a very marked increase in received signal level is apparent on any station within approximately 200 miles of the super gain array, and the most noticeable aspect is that signals that are received on the super gain array are much more free from QRM, whereas on the other antenna noticeable QRM, or even difficult copy, may be present. This is a result of the combination effect of the super gain antenna 9 DB gain plus its 10 to 15 DB rejection capability for low angle QRM. The 15 to 25 DB improvement in signal to QRM is very obvious.

Nighttime performance

In general, the super gain array gives approximately 10 DB rejection against the foreign broadcast stations much of the time but some of the time, due to the nature of the 40 meter band, these long distance signals arrive over many, many hops and come down within the vertical acceptance angle of the super gain array. At these times, there is little significant difference between broadcast interference received on the high collinear or the super gain array, but the super gain still boosts the transmitted signal greatly. At other times, when short skip is not predominating, there is a marked reduction in QRM as well as increase in signal strength by the use of the super gain array for communications out to a distance of approximately 1,000 miles at night. Under these conditions, the strength for signals originating within 1,000 miles is boosted similar to that experienced over 200 mile daytime paths.

Most persons who have worked with array antennas on the high frequencies are aware of the fact that it is difficult to get a sizeable change in S-meter level between a reference antenna and even moderate sized array. However, the results obtained with the super gain array are striking in that the S-meter moves appreciably, usually at least one and sometimes two S-units in actual signal level, and if the QRM level will be noticed in the quiet periods of the transmitting station, it will be found to drop from 3 to 5 S-units when using the super gain array. If the QRM is of low angle origin, our experience has been that this antenna frequently changes a QSO from barely readable to armchair quality.

Due to the extreme simplicity of this antenna and to its significant improvement in communications on this particular band, plus its small size, I believe that if amateurs erect such an antenna and test it for themselves, they will be quick to see the value of it and by this means more use can be obtained from the 40 meter band. Particularly, this antenna would be an ideal antenna for local nets or statewide nets operating in the 40 meter band in the daytime, since it not only greatly increases the signal strength of the stations communicating, but significantly reduces the QRM leaving the state and rejects any QRM coming in from outside the state.

For those amateurs wishing to study further on the subject of super gain antennas and the types of gain that may be obtained, perhaps the most understandable and clearly-written dissertation is to be found in "Electronic and Radio Engineering" by Terman, fourth edition. Discussions on pages 903 through 908 cover the subject briefly and references are given there no more theoretical work should one desire to dig deeper.

Many amateurs have from time to time used very low dipole antennas on the 40 and 80 meter bands and some have remarked that these antennas do not perform as poorly as they would expect based on the low height. These results, however, have been erratic because the effect achieved is greatly dependent upon the conductivity of the ground under the antenna, and no compensation was made for the drastic change in radiation resistance or the change in effective length for such low antennas. The directivity gain of the very low antenna, which can be up to eight times in signal power, is frequently attained, in part, in these low installations over moderately conducting ground. However, the counteracting loss in antenna efficiency suffered, unless a reflecting screen is placed under the antenna to control the enormous losses in the ground, the variable reflection distance and low radiation resistance make the overall results highly variable from one installation to another.

The use of the reflecting screen is very important for three reasons. First, the antenna impedance will be 50 ohms only when the elements are cut as described above with reflecting elements installed. Without the reflecting elements this impedance can vary significantly. Secondly, the efficiency of drop well below 50 percent in most installations without this reflecting screen. This means that the overall gain of the antenna may be anywhere from zero gain, or perhaps even a loss, to a full 9 DB gain, depending upon the peculiarities of the soil under the antenna. Thirdly, without the screen the spacing between antenna and image is unknown and unstable, varying with ground conditions. Due to the utter simplicity of the reflecting screen, it is not worth the risk to omit it. Also, the effective length of the antenna varies with ground conductivity without the screen, so design becomes a cut and try affair.

It is hoped that other amateurs will erect similar antennas and run comparative tests on 40 meters as well as 80 meters and 160 meters. The 80 meter band performance of the super gain array has not been explored yet so that the relative percentage of the time during which short skip conditions prevail, and therefore the magnitude of improvement possible, is unknown to me at this time, but will be published as soon as my tests are completed. However, those wishing to try such an antenna on 80 meters or 160 meters may scale the dimensions given, which is centered on 7250 khz, to obtain the design numbers. For those with lots of room, a group of these units operating broadside could generate a formidable signal indeed, but more than about four units would begin to restrict coverage noticeably. . . . W4NVK

[1] Patent disclosure filed.

[2] a. "Maximum Directivity of an Antenna," H. J. Riblet, Proc. IRE, 36 p 620, May, 1948.
b. T. T. Taylor, Proc. IRE, 26 p 1135, September, 1948.
c. "Physical Limitations of Directive Systems," L. J. Chu, J. Apl. Phys., 19 p 1163, December, 1948
d. "Directional Antennas," G. H. Brown, Proc. IRE, 25 p 122, January, 1937.

[3] This figure is referenced to a dipole, all others in this article are referenced to isotropic.

[4] Reference to dipole.

Printed Circuit Soldering Aid

Fixing printed circuits is really quite simple. Just clip out the defective component, leaving as much lead on the board as possible, and solder the new component to the old leads. This method works, and is recommended by many authorities. It does look like a butcher job though, doesn't it? A much better way which doesn't take much more time, considering the time spent locating the defective component, is to take it out completely. Usually the holes, whether printed through or eyelets, are plugged up with the old solder. Let it cool off; then quickly reheat and clean the holes with a piece of piano wire or stainless steel wire about .050 inch diameter. Solder will not stick to it, yet it can be formed and filed to a sharp edge at one end to aid in cleaning out the fringes of solder. A bit of masking tape makes a convenient handle if wrapped around the center portion of the tool.

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