View of the loop antenna mounted on a wooden pole driven by a TV type rotator. The two fittings on the sides of the loop were used for vertical rotation experiments and are not needed for the application described in the text.

A Top Band Loop Antenna

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THE recent revision of amateur frequency assignments and power maximum in the 1.8 to 2.0 mc band, the availability of the new Heathkit HW-18 series s.s.b. transceiver, and the approach of winter with improved band conditions is certain to rekindle the interest of many hams and produce an increase in the amount of activity on the 160 meter band. It suffices to say that increased activity also means increased QRM.

The author regained interest in the top band several years ago by designing and constructing a transmitter described in *CQ*.[1] Operation of this transmitter on the 160 meter band during the past few years has convinced the author that a need exists for a simple, rotatable, receiving type directional antenna to help lick the intereference problem. There isn't too much one can do about constructing a full size, rotatable antenna for transmitting and receiving on the 160 meter band. The mechanical problems would be tremendous, to say the least.

Since, generally speaking, most stations use omnidirectional antennas for receiving and transmitting on the top band the most reasonable approach is to attempt to provide some means of directional discrimination for receiving. The purpose of this article is to describe a simple approach to the construction of a directional loop antenna for receiving on the top band.

Loop Theory

The usefulness of loop antennas in rejecting unwanted signals is well known and accounts for the wide use of loops, for direction finding, aboard aircraft and vessels. Amateurs have used loops on all bands although loops of small physical size in comparison to the wave length at which they are being operated are primarily used on frequencies below 4 mc for direction finding in transmitter hunts. The physical arrangement of a loop antenna need not be restricted to a circle and shapes such as squares, triangles, octagons, and diamonds are often used. The mechanical simplicity of the circle makes this shape most desirable, however. Whatever physical arrangement the loop assumes, maximum directivity will be along the plane of the loop with a pronounced null at right angles to the plane. This null or minimum can be extremely sharp in a well designed loop providing accuracy of one degree or better in low frequency direction finding application. The antenna pattern is

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[1] Genaille, R. A., "A Top Band SSB Transmitter," *CQ*, September 1967, p. 33.

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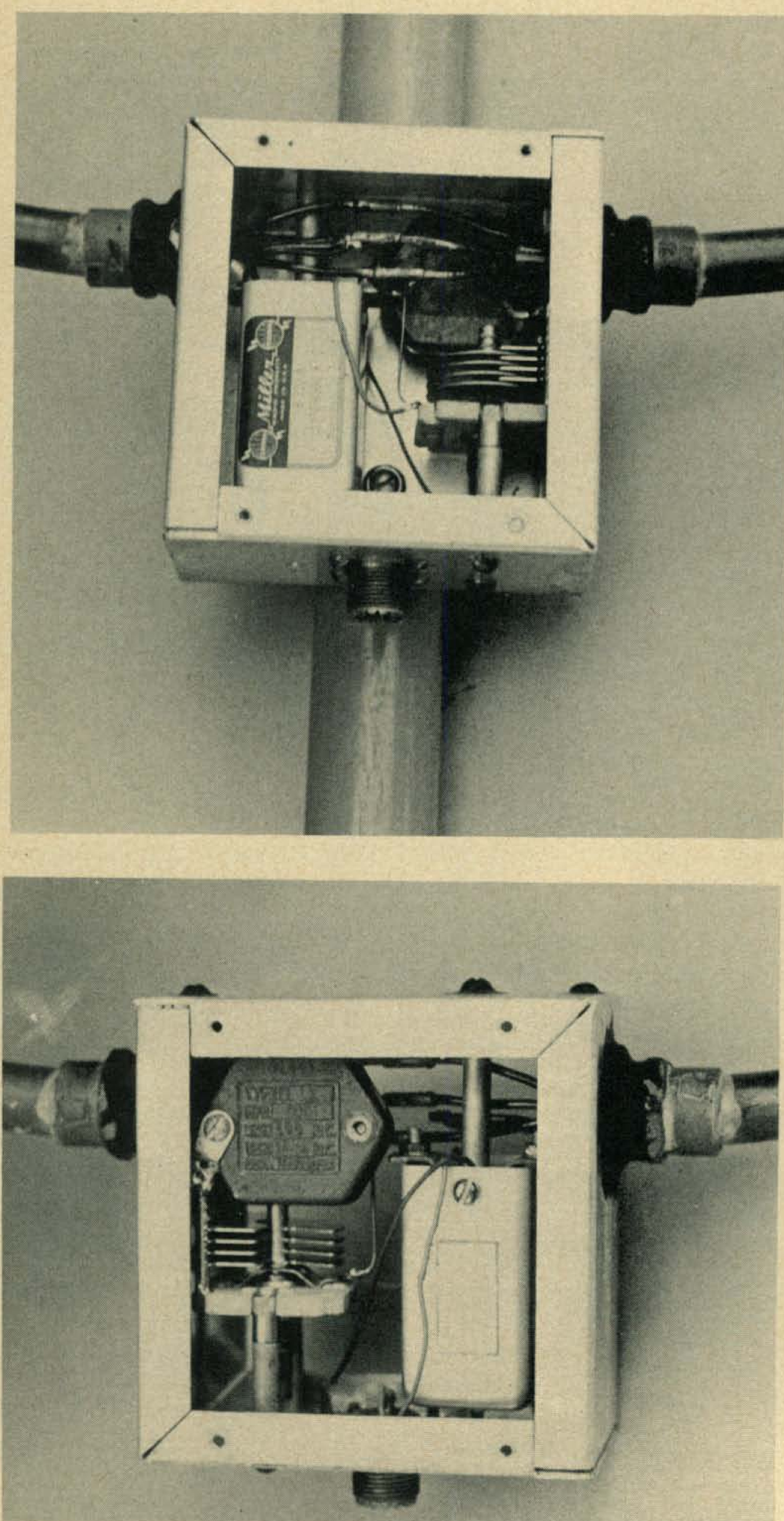

Front and rear views of the aluminum housing that contains the impedance matching network.

very much like the familiar figure 8 field pattern of a doublet antenna.

Electrically, the loop senses the direction of signal sources by virtue of the voltages induced in the loop wire by electromagnetic waves generated at the source. The induced voltages in turn produce a current flow depending upon the positioning of the loop with respect to the electromagnetic wavefront. When the loop is exactly broadside to the incoming wavefront a current cancellation is effected which results in little or no signal voltage appearing at the loop feedpoint. Repositioning the loop with respect to the incoming wavefront causes an unbalance with incomplete cancellation of current and consequently a signal voltage at the feedpoint.

The null property of the loop antenna, which makes this type of antenna so useful for direction finding by nulling out signals, can also be used for discriminating against interfering signals providing that these signals are not coming in from the direction in which we wish to receive. It can easily be understood from previous discussion, that a loop will have two nulls one at zero and one at 180 degrees. This presents certain complications when using the loop for direction finding but not when discriminating against interfering signals such as we wish to do. Good loop electrical balance is required for accuracy in direction finding work and, although the loop circuit design shown is not perfectly symmetrical, excellent results may still be obtained even though the bearing accuracy may be impaired. Since signal discrimination is the prime function of the subject loop, and not direction finding, bearing accuracy is not of major importance.

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Static electricity in the air is a source of much noise in 160 meter band reception, in fact, static noise level is what accounts for the rather limited activity on this band during the summer months. Static noise pickup is greatly reduced by enclosing the loop wires in a non-magnetic shield. To enhance the over-all receiving signal-to-noise ratio the loop wires are completely enclosed by a copper tubing shield except for a narrow transverse gap or break at the apex of the electrostatic shield. The noise reduction capability of the shielded loop should increase operational activity during those periods when the static noise level is high or when high levels of man-made noise are encountered.

Circuit Arrangement

The loop antenna shown in the photograph can be tuned over the major portion of the 160 meter band with the components specified in the schematic diagram. The feedpoint impedance will be very close to 52 ohms. The construction of the loop is quite simple and straightforward and the cost of the materials used represents a very small investment for the results obtained. All of the components of the loop antenna circuit are readily available.

The schematic of the loop is shown in fig. 1. Winding L_1 is a continuous loop made of 4 turns of #12 enameled or formvar insulated wire. Transformer T_1 is a matching transformer with slug tuning which, with capacitor C_1, tunes the loop to the desired frequency. The capacitors and transformer are housed in an aluminum box with suitable dimensions to permit freedom in making the necessary internal connections.

The electostatic shield for the loop wires is made from a length of soft drawn copper tubing with a 1/2 inch inside diameter. This tubing is available from Sears Roebuck or any plumbing supply house. A length of inexpensive plastic hose with a 3/8 inch outside diameter is used inside the copper tubing to protect the loop wires when pulling them into the tubing loop. The hose is not absolutely necessary but it may help prevent abrasion of the wire insulation and subsequent operational troubles. The plastic hose also provides additional loop rigidity lost by the necessity for a gap in the copper tubing at the apex of the loop.

Construction Details

The first step in the construction of the loop proper is to stretch out about 6½ feet of copper tubing on a level floor and straighten the tubing so as to remove all bends. After the tubing has been straightened, solder a 1/2 inch copper tubing-to-outside thread adapter to each end of the copper tubing. Next, measure to the exact center of the length of tubing and make a suitable reference mark for future cutting. A piece of masking tape will do quite well. The loop can now be formed into a 2 ft diameter circle by using a suitable form. The author used a hot water tank having a diameter of 2 feet as a form. Using a tubing cutter or hacksaw cut the tubing at the center of the loop. A 2 inch long piece of plastic pipe having an inside diameter of 5/8 inch can be slipped over the center cut to hold the apex of the loop together during the plastic hose and wire threading operations that are to follow. The plastic pipe is of the variety used for cold water lines in many areas. If the plastic pipe is used care must be taken to insure that the copper tubing ends at the apex do not make contact. A small air gap must be maintained between the two

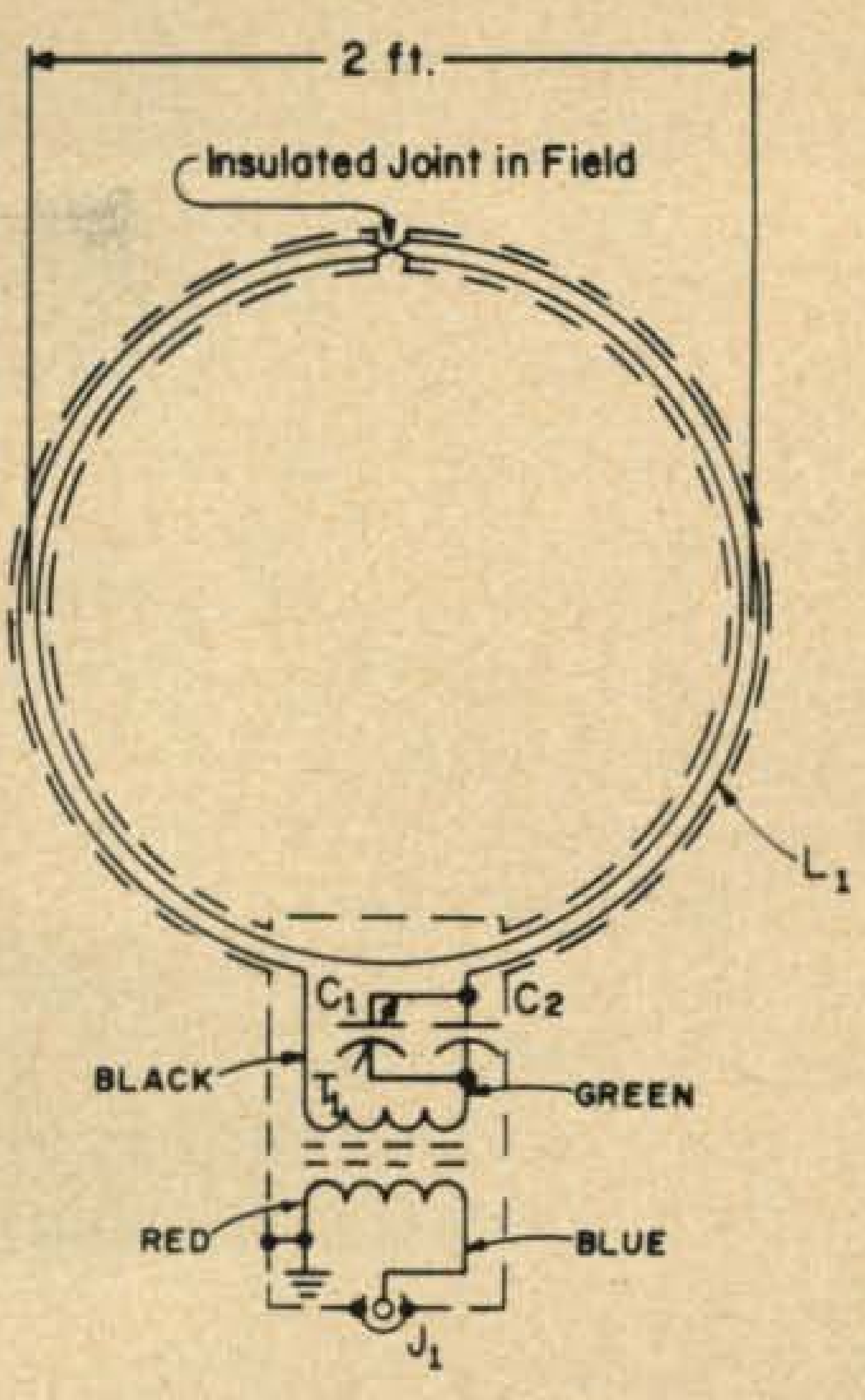

Fig. 1—Schematic of a 160 meter loop antenna and impedance matching network. The network is contained in a 4" × 4" × 2" aluminum box and is fed to a 52 ohm line. The loop is formed from a 6½' length of 1/2" i.d. soft drawn copper tubing.

C_1—4.6—51 mmf variable capacitor. E. F. Johnson 167-3 or equiv.
C_2—100 mmf mica capacitor.
J_1—U.H.F. type coax connector, SO-239.
L_1—4 t. #12 e. wire wound as directed in text.
T_1—Antenna coil, J. W. Miller #B-320-A or equiv.

sections of copper tubing in order for the antenna to function properly.

Insert a 7 foot length of plastic hose into one end of the copper tubing loop and, by working it slowly, pass the hose through the tubing so that equal lengths of hose remain outside at each end of the tubing. At this point, four 7½ foot lengths of #12 insulated wire should be pulled through the hose and tubing with equal lengths of wire remaining outside at each end of the tubing.

Before fitting the loop to the aluminum box cut back the excess plastic hose. The wire insulation should be removed by scraping or by using paint and varnish remover, making sure that the insulation is not removed where the wires begin to "bundle" upon entering the tubing, and the wire ends tinned. The tinned wire ends should not be permitted to short together.

Assuming that suitable size holes have been cut in the aluminum box at the appropriate locations, screw a conduit nut up on each tubing adapter as far as possible. Fit the adapters into the aluminum box and secure the adapters with conduit nuts inside of the box.

The wire ends should be soldered so that one continuous loop is made. Identifying the individual wire ends may be accomplished by using an ohmmeter or a dry cell and buzzer or pilot light combination. After the loop wires are all connected the remaining components may be mounted approximately as shown in the photographs and the wiring inside of the aluminum box completed.

The loop proper is now electrically complete and should be mounted in a manner convenient to the builder. The author mounted the loop and associated box on a 5′ length of 2¼ inch o.d. wooden closet pole. Don't use a metallic support for the loop proper otherwise the electrical operation of the loop may be impaired. As shown in the photograph, a simple TV antenna-type rotator was used for antenna rotation. The fitting on the sides of the loop, that show up in the photograph, are not necessary. These were originally installed by the author to permit rotation in a vertical plane; however, the improvement in electrical results did not justify the additional mechanical complications of being able to rotate the loop in two planes. To help keep water out of the tuning box the author "gunked" around the tubing adapters, on the outside of the box, with plastic rubber cement.

Tuning and Impedance Matching

Tuning the loop to resonate in the 160 meter band is not much of a problem. It is accomplished in the same manner as tuning and impedance matching of other types of antennas for this band or other bands. A standing wave ratio bridge or reflected power meter can be used. Connect the bridge or reflected power meter to the loop antenna coax connector through a short length of 52 ohm coax cable, feed the bridge or reflected power meter with signal of the appropriate frequency and adjust capacitor C_1 and the slug in transformer T_1 for minimum reflected power. A standing wave ratio very close to 1:1 should be obtained at the adjustment frequency.

While the design of the top band loop is not perfectly symmetrical excellent nulls may still be obtained provided that the loop is not installed in close proximity to power lines, other antennas, gutters, downspouts, or other large metallic objects. Reradiation from nearby metallic objects acting as antennas may be as strong or stronger than the direct signal received by the loop resulting in poor null response and, consequently, unsatisfactory loop operation.

Operation of the loop needs little comment. After connecting the loop antenna feedline to the receiver and listening for signals one will find that the signal levels are lower than those obtained on the regular station antenna but that the signal-to-noise ratio will be somewhat improved over the conventional station antenna. Rotation of the loop, when listening to a signal, should produce two very sharp nulls broadside to the plane of the antenna loop where the signal is completely eliminated or considerably attenuated. You will also notice that once the null position has been passed the received signal will stay almost at the same level while the loop is being rotated through 180 degrees to the opposite side null. Weaker signals which previously were drowned out by QRM and QRN can now be copied by nulling out the QRM providing the QRM is not arriving from the same direction as the desired signal.

The 160 meter band promises to become more active than ever. Constructing the top band loop antenna described in this article will give you a distinct advantage over interference and static noise conditions and will increase your operating pleasure considerably. ■

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