THE HALF WAVELENGTH DDRR ANTENNA

BY G. W. HORN,* I1MK

The author presents a half wave version of the DDRR antenna that results in a more manageable size for construction at very high frequencies along with an increase in gain so that the performance, at all frequencies, is almost equal to a conventional quarter wave vertical.

While important for v.l.f. and m.f., the reduced height antenna is also valuable in mobile and portable operation in the h.f. and v.h.f. bands, where the vertical height of a resonant $\lambda/4$ radiator is mechanically impracticable.

A naturally resonant $\lambda/4$ vertical radiator, as the ground-plane, is an ideal device for general communications, providing an omnidirectional radiation pattern with most of the signal's power delivered at low angles. Theoretically speaking, a radiator of this kind can be considered as a sollinear aperture: at full height its radiation resistance is far larger than any other loss-resistance, permitting excellent radiation-efficiency.

To reduce the physical height of the classical $\lambda/4$ vertical dipole, series inductances and/or terminal capacitances can be used in order to restore electrical resonance. Unfortunately, the reduction of antenna height removes a portion of its colinear aperture, the loss of which means loss of radiation resistance: antenna performance deteriorates severely because of the reduced energy coupled to space.

In 1963 Mr. J. M. Boyer [1] presented the DDRR-antenna (directional-discontinuity ring-radiator), a sketch of which is shown in fig. 1. In 1964 an amateur version of the DDRR was published in CQ.[2]

A review of the original version of the DDRR would be in order before discussing the new unit. In the DDRR-antenna, the circumferential aperture is substituted for the collinear portion lost in height reduction. A ring-conductor whose diameter D is 28.6 electrical degrees (0.078 wavelength), in which case its circumferential length will be a quarter wave, is naturally resonant. The DDRR-antenna is set up by such a ring-conductor erected over a ground-plane at a distance of approximately 2.5 electrical degrees (0.007 wavelength) from it; the ring is left open for a short distance (Y) and one end of the gap is connected to the ground plane. The mathematical analysis shows that the radiation efficiency of an antenna of this kind must be within 2 to 3 db of a full-height $\lambda/4$ vertical radiator erected on the same ground plane.

If an r.f. generator is connected across the slot set up by the ring-conductor and ground plane, an electromagnetic wave will be launched in this curved boundary region, and from that into the space. By the way, the DDRR-antenna ring forms a transmission-line (or a guide) with its ground plane:

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[1] Boyer, J. M., "Hula-Hoop Antennas: A coming trend?," *Electronics*, Jan. 11, 1963.

[2] Hicks, C. E., "The DDRR Antenna," *CQ*, June 1964, p. 28.

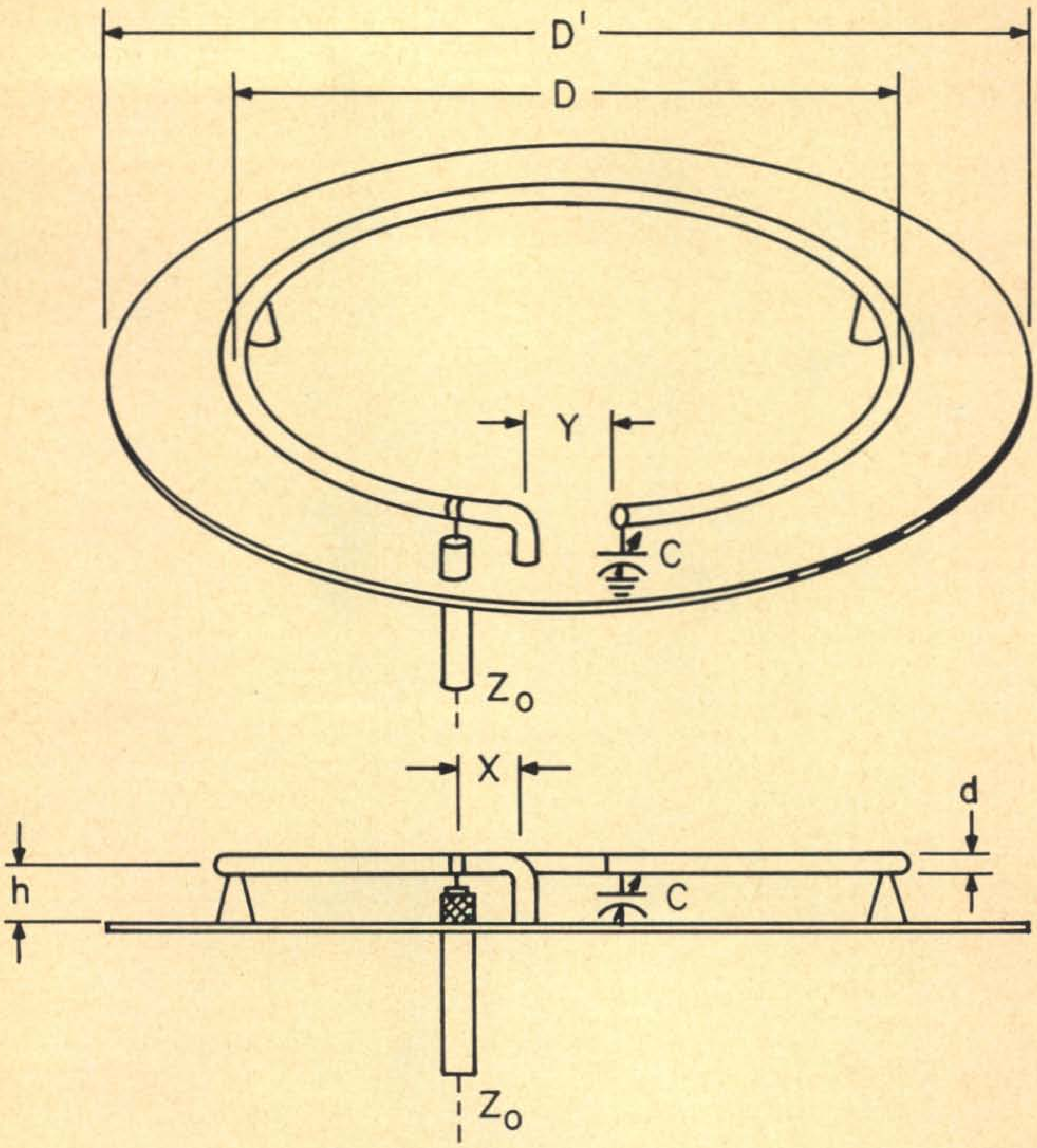

Fig. 1—Standard λ/4 DDRR antenna.

$D' = 2D$ $h = 0.007\lambda\ (2.5^0)$
$D = 0.078\lambda\ (28^0)$ $X = f\ (Z^0)$

the question which arises is why such a line (or guide) radiates.

The radiation comes from the curvature of the ring-conductor; in fact the slot between ring and ground plane is a constant series of physical discontinuities. Thus the wave, in its path along the slot, radiates continuously in a direction transverse to the ring axis throughout its full length. The electromagnetic wave, launched by the generator into the guide, radiates until it meets the far end of the slot; the energy remaining at this point reflects back to the generator and, interfering with the outgoing wave, produces standing-waves in the slot gap. On both the outgoing and return trip, the wave radiates a part of itself into the space.

The electromagnetic field radiated by the DDRR antenna is set up by a horizontally polarized component, due to the current flowing in the ring-conductor, and a vertically polarized wave which takes place from the higher modes determined by the geometrical discontinuities. The first electromagnetic component is cancelled out by its antisymmetrical in the image plane. Far from the antenna, the radiated field consists therefore of a vertically polarized wave only.

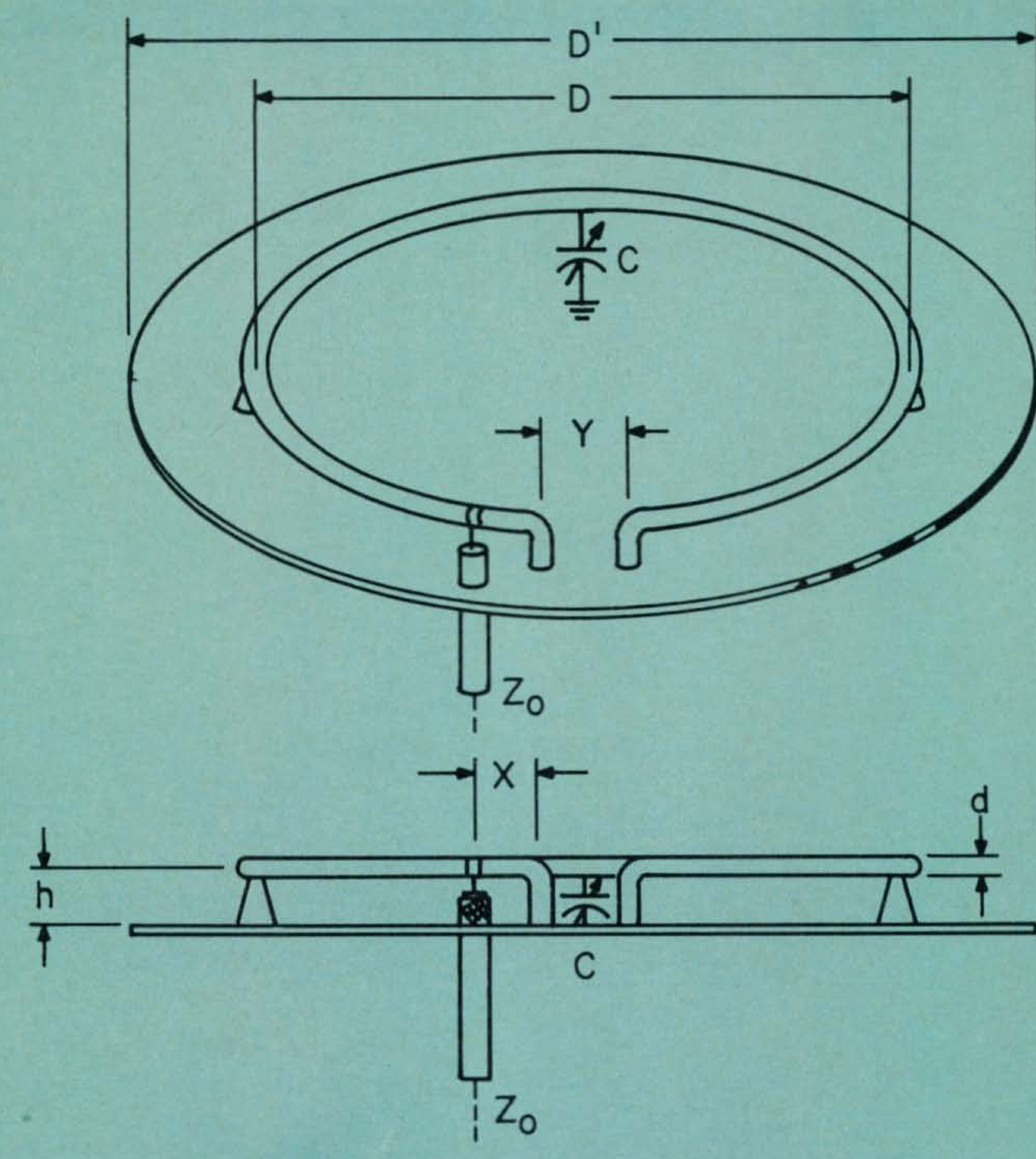

Fig. 2—Dimensions of the λ/2 DDRR antenna.

$D' = 2D$
$D = 0.158\lambda$ (56°)
$h = 0.007\lambda$ (2.5°)
$X = f(Z^0)$

The DDRR antenna is naturally resonant when the diameter of the ring is approximately 28 electrical degrees since the circumference will then equal 90°. Resonance is practically independent from ring's height above the ground plane. In practice, to remove small mechanical differences, it is advisable to adjust the ring's diameter slightly to restore resonance by means of a low-loss air capacitor connected from the open end of the ring-conductor to ground.

The DDRR antenna is fed by a transmission line connected between ring and ground plane: any line having a characteristic impedance from 50 to 300 ohms may be used. Impedance-matching is accomplished by varying distance *X* (see fig. 1). This operation should be carried out while monitoring the s.w.r. on the feedline.

The DDRR antenna may be tuned over a 2:1 frequency range by adjusting capacitor *C*, without the s.w.r. exceeding a value of 2. Antenna bandwidth depends somewhat on the diameter of the conductor which forms the ring. A tubular conductor of at least ¼" is recommended. Ground plane diameter is

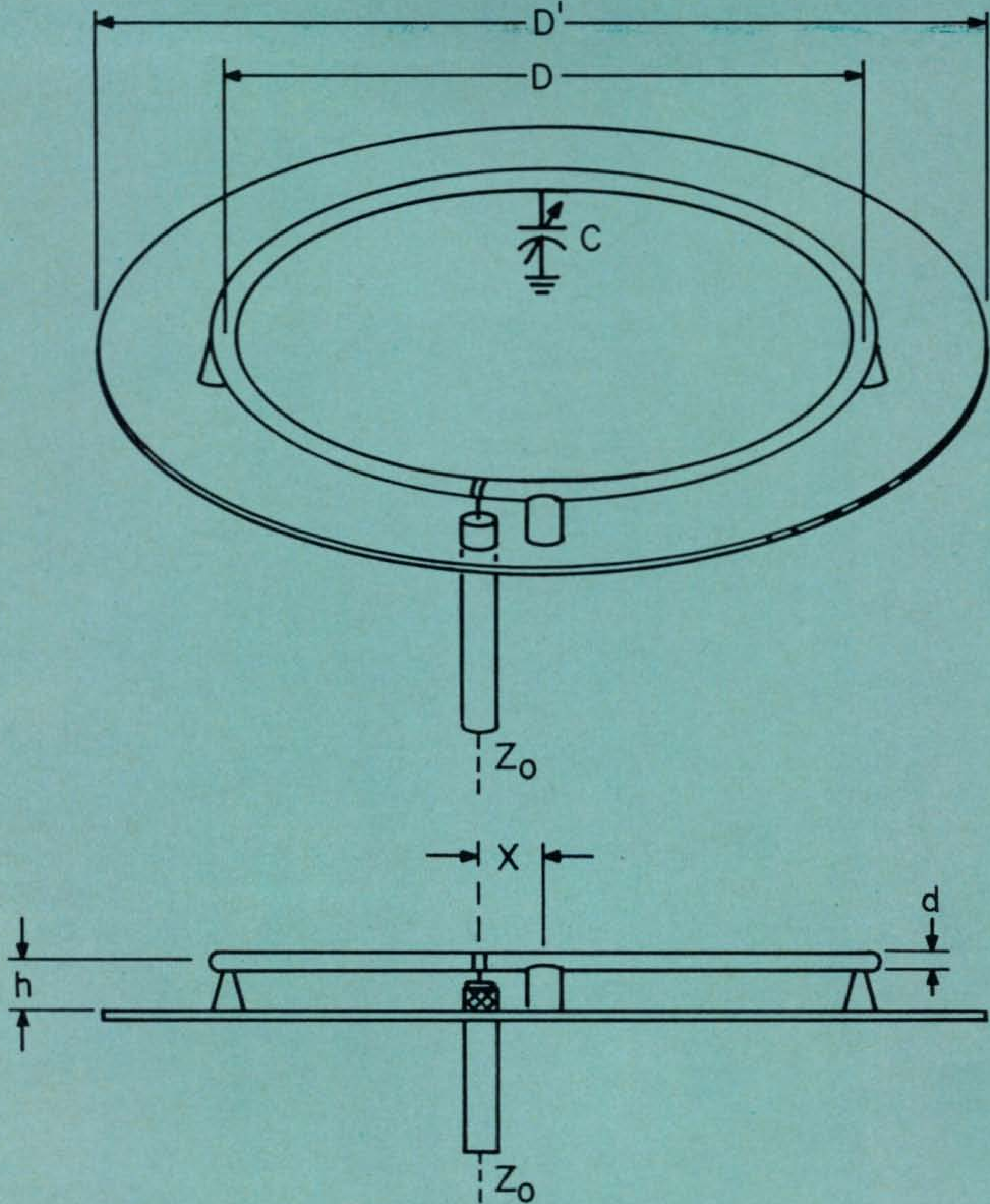

Fig. 3—Final design of the λ/2 DDRR antenna. Perfect symmetry is provided by joining the ring's ends at the ground point.

$D' = 2D$
$D = 0.158\lambda\ (56^{\circ})$
$h = 0.007\lambda\ (2.5^{\circ})$
$X = f\ (Z^{\circ})$

not critical at all, if it is extended beyond the boundaries of the ring. If feasible, a ground plane having a diameter of 1.5 to 2 times that of the ring should be installed; copper, brass, aluminum or even tin-plate can be used. At lower frequencies, the solid ground plane can be replaced by a star of radials.

A λ/2 Version of the DDRR Antenna

The standard DDRR offers many advantages: small horizontal-plane dimensions, extremely low height, ease of construction, mechanical strength, *etc*. Besides, it acts as a high-Q bandpass filter centered at the operating frequency, providing better selectivity which, in receiving, results in

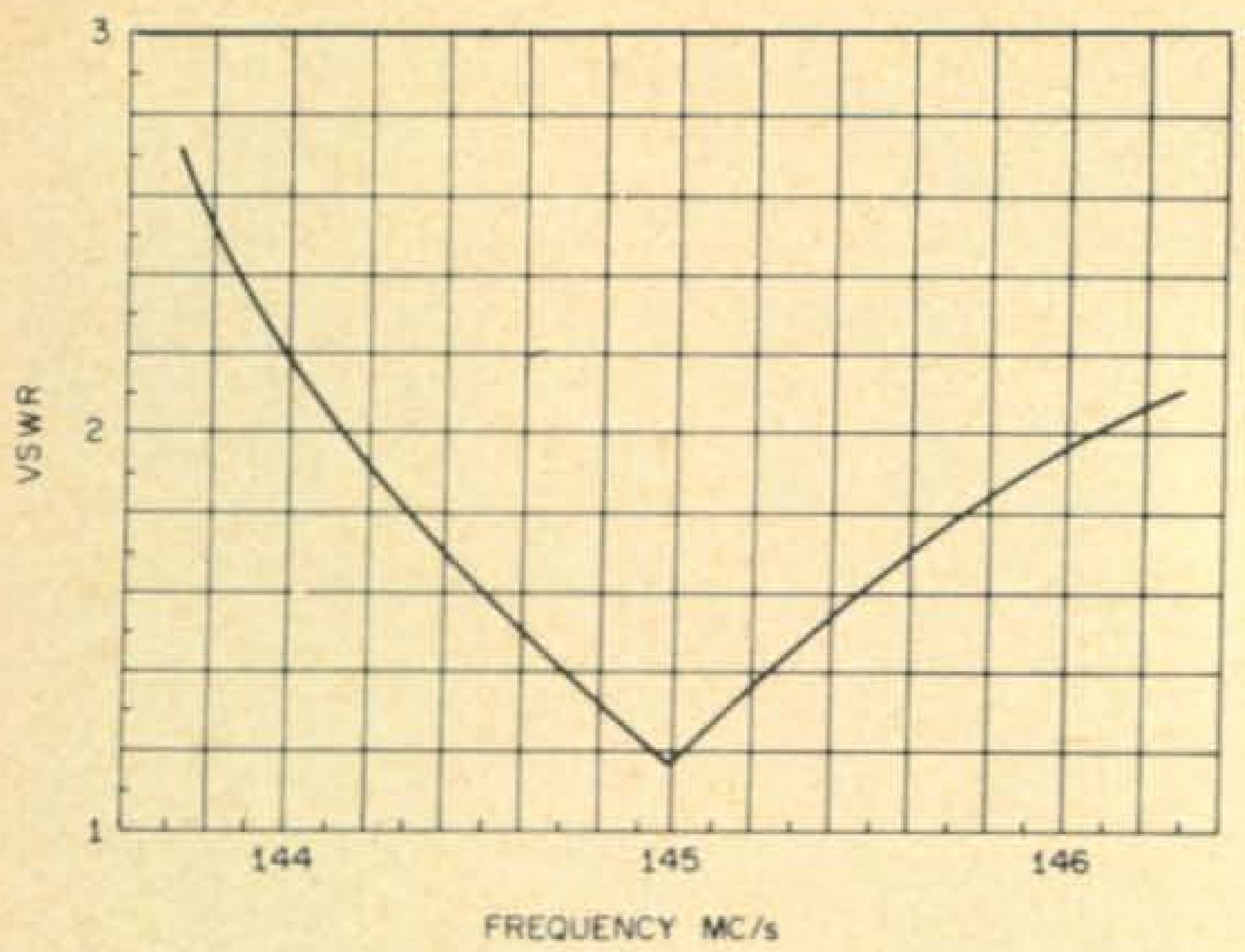

Fig. 4—A plot of the s.w.r. *versus* frequency of the 2 meter DDRR constructed by the author. The antenna dimensions are listed in Table I.

minimizing adjacent-channel interferences, improved image response and reduced cross modulation from strong signals. Being grounded, an automatic static-drain is also provided which reduces the worst effects of charges induced by fog, dust and rain.

It was thought desirable, therefore, to experiment with the DDRR-antenna at v.h.f., having in mind the installation on the car-roof, for mobile operation as the DDRR-antenna is very inconspicuous.

Unfortunately, at v.h.f., the physical dimensions of the ring-radiator become so small (half a foot in diameter, at 144 mc) that the slot cannot be coupled efficiently to space. Besides, the close proximity of ring's open end to its feedpoint causes a stray r.f. coupling on the transmission-line: impedance matching becomes very difficult, if not impossible.[3]

The standard DDRR-antenna original design has been changed according to fig. 2. The ring radiator has been made λ/2 long, 56 electrical degrees in diameter. The ring is mounted on steatite pillars at a distance of approximately 2.5 electrical degrees (0.007 wavelength) above the ground-plane. By constructing the ring as shown in fig. 2 perfect symmetry is achieved; at the same time, the cross-section of the slot is doubled. As the original, the λ/2 DDRR may be capacitively tuned by means of *C*, while feedline matching is provided by adjusting feedpoint distance *X*. The capacitor *C*, which must be a low-loss well insulated air variable, is connected between loop's highest impedance point and ground. Because of the reactive loading due to *C*, the diameter of the ring should be reduced to about 52 electrical degrees (0.158 wavelength).

Rod diameter *d* and height *h* above the ground plane determines the bandwidth of the radiating system. About its gain, a remarkable improvement over the standard λ/4 DDRR has been experienced. Distance *Y* is not critical; the geometrical discontinuity at *Y*, which causes a 3 db jump in the directivity pattern, can be eliminated, of course, by closing the loop joining its end, as in fig. 3.

Several λ/2 DDRR-antennas have been experimented and installed for operation either in the 2 meter band as in the 156-174 mobile-service band. For operation in the 144-146 mc band, the λ/2 DDRR-antenna may be built according to the following dimensions:

Table I—DDRR antenna dimensions for 145 mc.

Ground plane diameter	*D'*	(copper)	500 mm (19.7")
Ring diameter	*D*		288 mm (11.34")
Rod diameter	*d*	(copper)	6 mm (0.24")
Ring height	*h*		25 mm (0.98")
Feedpoint distance	*X*	(50 Ohms)	15 mm (0.6")
Capacitor	*C*	(at 145 mc)	7.5 mmf

In fig. 4 a graph shows s.w.r. behavior as a function of frequency. The DDRR-antenna was resonant at 145 mc and, at this frequency, the standing-wave ratio has been found to be 1.15 to 1.

Tune Up Procedure

Tune up procedure involves first the adjustment of capacitor *C* for antenna resonance at the chosen frequency with the feedline disconnected from the ring. Resonance will be indicated by a grid-dip-meter held inside the slot in close proximity to the pillar which connects the ring to ground. Then the transmission-line may be connected and its tap adjusted for a minimum s.w.r. at the operating frequency. Capacitor setting and feedline tap adjustment are somewhat interdependent: both operations should be carried out many times till a minimum has been obtained. It should be possible to get

[*Continued on page 118*]

[3] Horn, G. W., "Una nuova Antenna Omnidirezionale per VHF," *SSB and RTTY Press*, Nr 1/1967.

Transmitter

The carrier output of the transmitter, rated at 10 watts, was 13 watts (with 120 v.a.c. line potential) and it could be modulated a full 100 percent. Raising the speech-input level clips the envelope peaks, resulting in an increase in average power, yet not introducing deteriorating splatter. The a.f. quality sounds excellent and the signal carries a good punch, particularly in comparison to many of the inadequately modulated rigs we've heard on the air. The transmitter tunes up quickly and easily, even when crystals for operation at the extremes of the range are interchanged. With the 66'er operating in the same room with a TV set, t.v.i. was not experienced on Channels 2-13.

The transceiver also may be used for MARS, CAP and CD service near 50 mc, for which adapter kits are available to provide on-channel crystal-controlled operation on both receive and transmit. Further information in this regard may be obtained from the manufacturer.

The Clegg 66'er is priced at $249.50, less microphone and crystals. An adjustable mobile cradle for floor mounting is available at $15.00. The size of the set is 12″ W. × 12″ D. × 6½″ H. and it weighs 19 lbs. The manufacturer is Squires-Sanders, Inc., Martinsville / Liberty Corners, Millington, N.J. 07946.—*W2AEF*

DDRR Antenna [*from page 16*]

an s.w.r. near 1.15 to 1 at resonance and a ratio not larger than 2.2 in the whole 144-146 mc band.

After the DDRR has been tuned to a given frequency, a change of frequency requires a resetting of *C*. This operation may be facilitated by leaving a standing-wave indicator in the feedline at all times for tuning to minimum s.w.r. as needed.

Another tune-up procedure consists in adjusting capacitor *C* for maximum field-strength at some distance from the antenna (as picked up by a field strength meter) and adjusting tap *X* for minimum s.w.r. on the feedline. The adjustment of capacitor *C* may be made by means of a remote control using, for instance, a flexible shaft, in order to avoid mistuning due to the operator's proximity.

Results

The performance of the $\lambda/2$ DDRR antenna was found to be excellent. By recording the fieldstrength far from the radiator, the proposed antenna showed a +1 db gain over the standard full height λ/4 radiator. Radiation directivity was in very good accordance with the theoretical omnidirectional pattern reported by Mr. J. M. Boyer.[1] The proposed modification of the DDRR-antenna is also highly valuable in lower frequency operation. In fact, doubling ring's diameter does not enlarge the overall DDRR dimensions beyond practical limits, while it avoids the loss of 2 to 3 db which characterizes the λ/4 DDRR as compared with the full-height λ/4 vertical radiator. ■

M.A.R.C. Award *[from page 62]*

Network was founded by Dr. Braley, an amateur radio operator, WØGET, in December, 1962 to provide rapid, inexpensive and effective communication once a day to make known to participating eye banks throughout the country any emergency requirements for eye tissue and where such eye tissue is available. The fact that eye tissue deteriorates in 48 hours unless used makes such a rapid method of communication essential, and prior to the network's foundation many persons became blind because the eye tissue could not be obtained fast enough. The sight of scores of patients has been saved since the network was founded.

The Medical Amateur Radio Council —(MARCO) was established in 1966 and the major purpose of the Council is to establish broad personal communications among members of the medical, dental and related professions through amateur radio for the dissemination of factual medical, electronic and communication information, both theoretical and practical.

The corporation proposes to establish emergency public assistance networks among members.

Scratchi *[from page 11]*

rig so that Scratchi can talking to it from main headquarters control point which are on Hon. Brother Itchi's ranch in Feenix. Beginning to getting the picture, Hon. Ed?

Also, of course, are needing Hon. Compooter to keeping track of which saddlelites are where. Are even having threedimenshunal map so so can visually seeing where each saddlelite are at eachmoment.

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