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ELECTRICALLY SMALL ANTENNAS

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Semiannual Report 711964-6

Contract DAAG29-79-C-0082

1 January - 30 June, 1982

Department of the Army
U.S. Army Research Office
Research Triangle Park, North Carolina 27709

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50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No

4. Title and Subtitle

ELECTRICALLY SMALL ANTENNAS

5. Report Date

1 JAN.-30 JUNE,1982

6.

7. Author(s)

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8. Performing Organization Rept. No.

ESL 711964-6

9. Performing Organization Name and Address

The Ohio State University ElectroScience Laboratory
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10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.

(C)

(G) DAAG29-79-C-0082

12. Sponsoring Organization Name and Address

Department of the Army
U.S. Army Research Office
Research Triangle Park, North Carolina 27709

13. Type of Report & Period Covered

Semiannual Report

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

   This summary describes the work on ARO Grant Number DAAG29-79-C-0082 from
1 January to 30 June, 1982. The purpose of this grant is to develop theory and
techniques for small antennas mounted on structures, for printed-circuit antennas,
and for k-pulse applications.

17. Document Analysis   a. Descriptors

Small antennas   Proximity effects
Moment methods   Wire Antennas

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No of Pages
	Unclassified	5
	20. Security Class Unclassified	22. Price

PROGRESS REPORT

1. ARO PROPOSAL NUMBER: 08542-55-00

2. PERIOD COVERED BY REPORT: 1 January to 30 June 1982

3. TITLE OF PROPOSAL: Electrically Small Antennas

4. CONTRACT OR GRANT NUMBER: DAAG29-79-C-0082

5. NAME OF INSTITUTION: The Ohio State University
                          ElectroScience Laboratory

6. AUTHOR(S) OF REPORT: J.H. Richmond and C.H. Walter

7. LIST OF MANUSCRIPTS SUBMITTED OR PUBLISHED UNDER ARO SPONSORSHIP
    DURING THIS PERIOD, INCLUDING JOURNAL REFERENCES:

    Leon Peters, Jr. and Jack H. Richmond, "Scattering from
    Cylindrical Inhomogeneities in a Lossy Medium," Radio Science,
    September - October, 1982.

8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES
    AWARDED DURING THIS REPORTING PERIOD:

    J.H. Richmond
    C.H. Walter

    No degrees awarded during this period.

AD-A124364

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BRIEF OUTLINE OF RESEARCH FINDINGS

This summary describes the work on ARO Grant Number DAAG29-79-C-0082 *described on* from 1 January to 30 June, 1982. The purpose of this grant is *to* *developing* theory and techniques for small antennas mounted on structures, for printed-circuit antennas, and for K-pulse applications. The specific objective for this reporting period was to develop the theory, techniques and computer codes for electrically small antennas mounted on quite general structures.

To achieve our objective for this period, we developed the electromagnetic theory *was developed* for a horizontal cylindrical structure in the presence of a horizontal dielectric interface. The cylindrical structure may be a conducting body or a concentric dielectric multilayer. It may represent a thick cylindrical antenna, a structure on which the antenna is mounted, or part of the environment in which the antenna operates.

The horizontal dielectric interface may represent the air-earth interface, or it could be a grounded dielectric substrate such as the microstrip antenna environment. The cylindrical structure may be located either in the dielectric region or in the air. The antenna or source may be located in the dielectric, in the air, or on the interface.

The field is expressed as a continuous or discrete spectrum of TE and TM cylindrical waves. Using the wave transformations and the boundary conditions at the planar dielectric interface, ~~we developed~~ *were developed* integral and asymptotic expressions for the cylindrical-wave couplings

introduced via reflection at the interface. Computer subroutines were developed for these fundamental quantities.

Applications for this development include microstrip antennas and buried or hardened antennas. *(P4)*

With partial support from this grant, one paper was accepted for publication during this period. Next we present the abstract of this paper.

SCATTERING FROM CYLINDRICAL INHOMOGENEITIES IN A LOSSY MEDIUM

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ABSTRACT

Many buried scattering objects of interest take the form of two dimensional (2-D) geometries. This includes scattering from utility lines, tunnels, and geological structures such as fault lines. Radar systems used to detect these objects commonly use antennas that are at least comparable in size to the depth of the target. Thus the target and the antenna do not satisfy far zone conditions and the radar range equation is not applicable. Consequently the usual separate analyses of range, antenna and target are not possible. In a previous paper a method was outlined that permitted the antenna properties and the scattering properties of a 2-D target to be treated separately for the case of a linear electric or magnetic dipole source parallel to the axis of the 2-D scatterer. This involved computing the received voltage for an antenna located at the image position; i.e., at twice the target range and computing the back scattered fields for an electric or magnetic line source at the position of the transmitting antenna. This model has also been applied approximately to a Video Pulse radar with an orthogonal dipole antenna system. It would also be applicable

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to large loop antennas quite commonly used in geophysical explorations as will be discussed. The primary goal of this paper is to discuss additional scattering analyses that could be used to extend the previous results. The major thrust then is to generate solutions for the scattering attenuation function (SAF) which has the form

$$\frac{E^S}{E^I} \text{ or } \frac{H^S}{H^I}$$

where E^I (or H^I) are the electric (or magnetic) fields of an electric (or magnetic) line source at the image position and E^S (or H^S) are the respective scattered fields. Eigenfunction solutions have been used to obtain the SAF for circular cylindrical geometries to represent pipes and tunnels. Moment method solutions have been applied to perfectly conducting wires with and without a dielectric sheath. Moment method solutions have been applied to non circular penetrable bodies using the polarization currents to represent the unknowns. Such solutions have been developed for a line source above dikes by Parry and Ward [1971] and Hohman [1975] in the early seventies. Such solutions can be made for frequencies that include several target resonances for potential target identification. These solutions can possibly be extended to include fault lines, joints, etc., provided their electrical properties can be estimated by using some of the concepts involved in the hybrid GTD-moment approach. The methods of the modified geometrical optics could also be applied to obtain scattered fields at higher frequencies. These and other potential approaches will be discussed.