EES NOTES

ENGINEERING EXPERIMENT STATION • GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

Edited by:
Arthur L. Bennett
Martha A. Deadmore

EESN-7-70
November 2, 1970

In This Issue:

WELCOME TO DEAN VALK

Henry S. Valk became Dean of the General College at the beginning of the Fall Quarter, 1970. Before coming to Georgia Tech, Dr. Valk was Head of the Physics Department of the University of Nebraska. He has served the National Science Foundation in several capacities, and is a Fellow of the American Physical Society.

MEASUREMENT OF DIELECTRIC CONSTANT AND LOSS TANGENT AT HIGH TEMPERATURES

A new technique has been developed for measurement of the dielectric constant and loss tangent of radar window materials at temperatures up to 4500°F. Since this temperature is at least 1500° higher than that of previous measurements, the new technique represents a "quantum jump" in the state of the art. The program was a cooperative effort between the Electronics and High Temperature Materials divisions.

Radar window materials are transparent to radar, and as the name implies, they provide a means of preserving the streamlined profile of the craft over the radar antenna. Present window materials are made of rubber or reinforced plastics, but ceramic windows are needed to withstand the high temperatures expected in future craft such as the space shuttle. Knowledge of the dielectric constant and loss characteristics of window materials up to their maximum operating temperatures also is necessary for design of the radar systems.

These measurements are ordinarily made by placing a carefully machined window material sample in a waveguide and measuring the effect of the sample on the transmitted microwave signal. For high temperature measurements, the sample and waveguide are heated in a furnace. The maximum temperature that can be achieved is limited by the temperature at which the waveguide or sample melts or begins to react chemically with the other during the time required for thermal equilibration (typically 30 to 60 minutes). For platinum waveguides and the usual window materials, maximum measurement temperatures are 2500° to 2800°F.

The basic problems in developing the new measurement techniques were (1) to contain the sample in a known goemetry while it was heated to about 4500°F, (2) to include the sample in a microwave bridge in such a manner that the required phase shift, transmission, and power loss could be measured, (3) to heat the sample and know its temperature distribution, and (4) to avoid interference between the microwave and heating systems.

The approach was to use a sample in the form of a rotating disk about 18 inches in diameter, with the microwave beam passing through a 6-inch circle on one side; the beam axis and sample axis of rotation were parallel. The sample, exclusive of the microwave beam area, was heated on one side by oxyacetylene torches. The system operated in a transient mode; that is, thermal equilibrim was not reached. During a typical experimental run of about 3 minutes, the temperature of the heated surface of the sample rose to 4500°F and the unheated surface to 2000°F. The amplitude and phase of the microwave beam and the temperature were recorded continuously during this period, and later these data were analyzed to determine dielectric constant and loss tangent as functions of temperature.

Measurements were made successfully on slip-cast fused silica, and a follow-on program has begun to obtain the same data for other potential window materials.

Steve H. Bomar, Jr.
High Temperature Materials Division

\- - -

CERTIFICATION OF INDUSTRIAL DISTRICTS

Although the industrial district is a type of industrial land development dating back at least to 1885, usage of the terms "industrial district" or "industrial park" has long been the source of much confusion in the field of industrial development. This is due, in part, to the present tendency to use "district" or "park" synonymously, despite original distinctions in their meanings. But confusion over the terms today continues to be compounded by their indiscriminate application, especially by local promotion groups. Many chambers of commerce and similar organizations engaged in community industrial development boast of their industrial district or park, yet comparatively few such plant site areas deserve either designation. All too often, the so-called district or park is nothing more than a corn field or a tract of vacant land on the outskirts of town, distinguished only by a sign that may read "Any Town Industrial Park."

Awareness of the increasing need in Georgia for giving proper recognition to land developments that, in actuality, are industrial districts or parks led, in 1968, to the initiation of the Georgia Industrial District Certification Program, under the sponsorship of the Georgia Industrial Developers Association. This new statewide program, originated and administered by the Industrial Development Division, rates the state's industrial districts against a set of exacting standards, based on the developmental and operational policies and practices that prevail in well-known industrial districts or parks throughout the country. The rating evaluations, covering eight basic areas -- ownership, development plan, management, restrictions, location, services, maintenance, and protection -- involve completion by each applicant district of a detailed 14-page questionnaire, supplemented by an on-the-ground inspection of the property by a team of professional industrial developers. Among the many points included in these investigations are management policies, street widths and paving, building setbacks and heights, site coverage, parking, outdoor storage, and similar details of the physical aspects of the property. From the resultant findings, an evaluation report is prepared and furnished to the management of each applicant district, regardless of whether or not a rating is achieved.

Districts that successfully meet the program standards qualify for one of two ratings. The basic rating of Certified Industrial District is awarded for meeting the minimum prescribed standards. The top rating, Certified Superior, is based on substantially higher requirements. The managements of all rated districts are awarded, by the Georgia Industrial Developers Association, an appropriately engraved plaque and the privilege of using the rating for promotional purposes.

The Atlanta Fulton Industrial Center, a 164-acre development in southwest Atlanta under the present management of Kunian Brothers, holds the distinction of having received, in July 1968, the initial award of a rating, that of Certified Industrial District. To date, only 15% of all districts investigated under the program have been accorded a rating, a fact that indicates the high standards established for the program. However, ratings for a considerably higher percentage of the applicant districts have been deferred, pending correction of deficiencies revealed during the investigation.

The program has received an enthusiastic response from the developers and operators of industrial districts as well as professional industrial developers, because of the quick recognition of the benefits of certification. To the land developers, the evaluations proved valuable for the suggestions on improvement of their operations, while to representatives of state development organizations, the program offered needed guidance to the ongoing districts. Publicizing of the rated districts in IDD's monthly Georgia Development News affords both these rated districts and their home communities a competitive sales advantage over towns with non-rated districts. Furthermore, the ratings can help the prospective new industry itself to save time and money on plant location surveys, since certification of a district gives assurance to the industry that it will find physical conditions satisfactory for a successful operation.

Generally, the Georgia Industrial District Certification Program is proving to be an effective means of identifying and upgrading the state's industrial districts and parks.

George I. Whitlatch
Industrial Development Division

\- - -

MILLIMETER RADOME DESIGN TECHNIQUES

Operation of electronics equipment in the millimeter-wave region offers the opportunity for high-gain antennas and other small, lightweight components which would be especially useful in spacecraft systems. Recent progress in the frequency region below 140 GHz (wavelength about 2 mm) has resulted in sources, mixers, and waveguide components which have performance characteristics comparable to those achieved at lower frequencies (e.g., 30 GHz and below). However, radomes and their associated antennas have not been developed as extensively as many of the other elements needed for millimeter systems.

A recently completed study of design techniques for millimeter-region radomes has included measurement of the electrical properties of some candidate radome materials. Relative dielectric constant and loss tangent were measured from room temperature up to 1500°F at 50, 70, and 94 GHz using a novel, specially developed free-space waveguide bridge. Measured materials included fused silica, Pyroceram, Rayceram III, and alumina. Measurements on epoxy-glass laminate and Rexolite were made at temperatures up to 400°F.

Use of a dielectric lens to serve both as an aerodynamic radome and as a collimating antenna offers a potential solution to the millimeter radome problem. A design procedure was developed for single lenses; it showed that a specified aerodynamic outside contour cannot be obtained simultaneously with a beam which is free of degradation during scanning. Experimental data indicate, however, that use of a two-lens configuration may provide the additional degree of freedom needed for achieving good scanning quality along with a desired outside contour.

A combined radome-antenna (radant) to meet the requirements of highly directive antenna systems was investigated. Streamlined radomes which are employed are structurally rigid and rugged enough to withstand environmental stresses. The radant concept was studied in the 50-94 GHz frequency band using a holey-waveguide, leaky-wave antenna. The antenna was flush-mounted on a conical ground plane and covered with various thicknesses of dielectric. It was found that the performance of the antenna was strongly influenced by the dielectric thickness and, hence, by the frequency. Presence of other complex surface waves in addition to the desired leaky wave suggests that mutual coupling would be troublesome among elements of an array sharing a common ground plane.

Since several phenomena observed during tests with the conical ground plane are not well understood, more research is required before the radant concept can be implemented successfully at millimeter wavelengths.

G. K. Huddleston
Electronics Division

\- - -

DIRECTORY OF SCIENTIFIC RESOURCES IN GEORGIA

With the release of the Industrial Development Division's Directory of Scientific Resources in Georgia, 1969-1970, current information relating to research activities in the state is now available. Like the first two editions, the third edition describes the research capabilities and facilities of industrial firms, consulting engineers, government laboratories, and colleges and universities. Within each section the directory reports, in addition to names and addresses, specific information on personnel, fields of interest, kinds of activity, equipment, and availability of services. All areas of scientific investigation in the state are covered except the fields of medicine, social science, business, and economics. A subject index directs the user to the various fields of specialization in each section.

The 137 industrial firms listed have research staffs ranging in size from one person to that of the huge Lockheed-Georgia Company. Exclusive of the Lockheed-Georgia facility, these firms employ 921 scientists and engineers. Although fewer companies are identified in the current edition, 131 more professional persons are employed than were listed in the 1966-1967 edition. The most frequently mentioned areas of research are chemistry, ceramics, electronics, electrical equipment, food products, pulp and paper technology, and textile technology.

The services of 161 consulting firms and individuals are described, as compared to 133 such firms and individuals in the previous edition. The majority of the consultants lists capabilities in the fields of architectural engineering, civil engineering, electrical engineering, and mechanical engineering.

Government laboratories described in the directory number 23. Eleven of these units are administered by the U. S. Government; eight are cooperative concerns which involve federal agencies, the State of Georgia, and associations. The remaining facilities are state-owned. Government research in Georgia is still predominantly agricultural.

A wide variety of research activities in the various fields of the natural and physical sciences is found in the programs of the 12 colleges and universities covered in the directory. Over 1,000 professionals are engaged in these programs, which include the activities of Georgia Tech's Engineering Experiment Station, the three agricultural experiment stations of the University of Georgia, and the University System's oceanographic research institute at Skidaway Island.

The directory will be distributed nationally to appropriate agencies. For general distribution there is a charge of $3.00 a copy. The directory is intended to assist the firm or individual seeking research capabilities to solve a specific problem. Companies considering locating a plant in Georgia will be able to ascertain if there are research competencies available to support their programs. The directory also can suggest possible sources of employment for persons with a scientific background.

Kay C. Rogers
Industrial Development Division

\- - -

ELEMENT ANALYSIS WITH THE SCANNING ELECTRON MICROSCOPE

The scanning electron microscope (SEM) in the Analytical Instrumentation Laboratories (AIL) has been used extensively during the past two years to obtain micrographs of many types of materials. With the recent addition to this instrument of an energy-dispersive x-ray detection system, it is now possible to identify and determine the distribution of most of the chemical elements in a sample.

The SEM forms an image by scanning the surface of a sample with a finely focused electron beam about 100 angstroms (10^{-6} cm) in diameter. The high-energy beam stimulates the emission of secondary electrons, backscattered electrons, x-rays, and sometimes light photons from the sample surface. The emission of radiation varies with surface topography and the atomic number of the elements present. In the normal mode of scanning microscopy, the electrical signal derived from the collected secondary or backscattered electrons is used to form a television-type image of the surface being examined. Since the x-rays emitted are characteristic of the elements present in the sample, if these can also be collected and analyzed, both the chemical nature and spatial distribution of the elements comprising the area under the electron beam can be determined.

The established method of detecting and analyzing x-radiation in x-ray spectroscopy requires collimation of the beam and diffraction from an analyzing crystal into a detector. The x-ray energy or wavelength can be determined from the geometry of the diffraction process. This equipment is referred to as a wavelength-dispersive analyzer.

The small amount of x-rays producted in SEM operation makes this analysis method impractical because long periods of x-ray measurement would be required to analyze a sample. Fortunately device physics has come to the rescue with the recent development of a solid-state x-ray detector.

The solid-state detectors used in our SEM sort out the x-ray spectrum directly, on the basis of individual photon energy rather than wavelength, and hence are called energy-dispersive analyzers. This detector utilizes a single crystal semiconductor material (lithium-drifted silicon) which is placed near the sample to intercept x-radiation from the sample. X-rays impinging on the detector produce electron-hole pairs in a sensitive layer of the detector. An applied bias voltage across the crystal collects the liberated charges. Since ionization takes a fixed amount of energy from the x-ray, the total charge collected is in linear proportion to the energy of the incoming x-ray. This charge is integrated to a current pulse by a field-effect transistor preamplifier and subsequently amplified and converted to a voltage pulse.

The pulse generated by the detector is fed to a multichannel analyzer. The analyzer sorts the incoming voltage pulses by height (energy) and counts the number of pulses in each energy band (or memory location) to produce a complete energy spectrum of the x-rays. The readout can be seen on an oscilloscope, and it represents a complete x-ray spectrum from low to high energy.

Using this technique, it is possible to obtain a nondestructive analysis of particles 0.2 to 0.3 microns in size. The data can be presented in chart form or as a teletype printout of the x-ray counts in each channel of the analyzer.

It is also possible to electronically gate the x-ray spectrum while scanning a sample and select x-rays from any particular element. This output can be used to modulate the viewing screen and produce a two-dimensional picture of the distribution of the selected element within the scanned area.

The energy-dispersive solid-state detector is limited to the detection of elements heavier than fluorine and has an energy resolution of only 200 electron volts. The wavelength-dispersive system used in the electron microprobe analyzer (another scanning-beam instrument in the AIL) can detect elements down to boron and has an energy resolution near 5 electron volts. This is an older instrument designed strictly for x-ray analysis and has limited optical resolution. However, the SEM and microprobe function in a complementary manner, and both have made important contributions in the microanalysis of clays, papers, textiles, composites, metals, and many other materials. Increasing use in these fields as well as even more diverse fields, including the life sciences, is expected in the near future.

John L. Brown
Physical Sciences Division

\- - -

ORGANIZATION OF REFERENCE MATERIALS FOR A RESEARCH GROUP

The offices of research workers, particularly project directors, are often littered in a seemingly random fashion with technical journals, reports, and computer programs, as well as administrative paperwork. Some who have adopted this procedure have an uncanny knack for finding, on a moment's notice, an item last seen six months ago. Many of us, however, are finding that the increased flow of information is swamping such a simple approach. Because of this need a way has been developed to organize reference materials so that items of interest may be retrieved readily.

The scheme which has been developed is a classification system similar to the usual library card catalog. Items for retention are classified and, in place of a library card, a computer entry is prepared. After classification, each item for filing is identified by a diary number. The specialist handling a technical article assigns appropriate key-word subjects for use in retrieval. Computer entries can then be completed by a nontechnical person. Current acquisitions are cataloged as they arrive; full value is attained, however, only when all retained items have been made accessible by computer. This cataloging method is flexible; neither the location nor the order of existing document storage need be disturbed.

The effort of locating filed items is substantially reduced by the use of the computer for retrieval. Appropriate references can be isolated by author, source, or key word. A computer print-out of the file data, classified according to the desired topics, provides a catalog which replaces the conventional card file. The catalog then permits prompt location and retrieval of the needed reference materials.

As each new item is prepared for file, a corresponding computer entry is written. When it is desired to bring the catalog up to date, the new entries are added to the computer tape (data base) and these appear in the revised print-out of the catalog.

The tape may be used for inventory of the reference materials. A special print-out of the tape, sequenced to correspond to item location, provides the means for checking the completeness and order of the files.

The computer program is written in COBOL and run on the B-5500. While it is presently a card batch program, it is designed for easy conversion to remote-terminal operation.

The application of this system has brought order to our office filing and information retrieval tasks. On request the undersigned will demonstrate the system as applied in the Industrial Products Branch.

Raymond Tooke, Jr.
Chemical Sciences and Materials Division

Charles A. Sparrow
Rich Electronic Computer Center

\- - -

GALLAGHER JOINS ELECTRONICS DIVISION

James J. Gallagher recently joined the Electronics Division as a Principal Research Physicist in the Special Techniques Branch. He will develop and expand programs in millimeter waves, laser techniques, and spectroscopy.

Mr. Gallagher completed his undergraduate studies in physics at Sienna College and did graduate work at Columbia University, New York University, and the Johns Hopkins University.

Mr. Gallagher served as Staff Scientist and Chief of the Electromagnetic Research Laboratory at the Martin Marietta Corporation. He also was an adjunct professor in the Physics Department at Rollins College. Prior to joining the staff at

Georgia Tech, Mr. Gallagher had authored more than sixty papers and reports in his areas of interest and specialization. He has served as invited speaker, session chairman, technical program chairman, and in many other capacities at a number of international symposia on millimeter waves, lasers, and frequency control.

- - -

PROFESSIONAL ACTIVITIES

Papers and Presentations

"Sinusoidal Coupling to the Two Wire Line," a paper coauthored by G. W. Bechtold, ED, was presented at the 1970 IEEE EMC Regional Symposium, Southwest Research Institute, San Antonio, Texas, in October.

J. L. Brown, PSD, was coauthor of two papers presented at the annual meeting of the American Society of Agronomy in Phoenix, Arizona, in August: "Scanning Electron Microscopy of Sesquioxide Crusts Intercolated in Naturally Weathered Microceous Vermiculite" and "Cristobolite and Quartz Isolation from Soils, Sediments, and Rocks by Hydrofluosilicic Acid and Heavy Liquids."

A paper entitled "Enhanced Effectiveness of Chemotherapy and Regression of Tumors after Their Electromagnetic Heating in Deeply Hypothermic Animals," by H. A. Ecker, ED, R. P. Zimmer, ED, and V. P. Popovic, Emory University, was presented at the 1970 International Microwave Power Symposium, The Hague, Holland, October 7-9.

At a Community Industrial Development Seminar held in Tifton, Georgia, August 11 for leaders in the Coastal Plain Area Planning and Development Commission, Ross W. Hammond, IDD, gave the keynote address on "The Importance of Industrial Development in Georgia"; David C. Morgan, IDD, spoke on "Basic Data for Industrial Development."

J. R. Williams, NBSD, presented a paper entitled "A Parametric Survey of Gas Core Reactor-MHD Power Plant Concepts" at the Intersociety Energy Conversion Engineering Conference in Las Vegas, September 18-22.

- - -

Publications

Raymond D. Kimbrough, Jr., NBSD, "The Production of Solvated Electrons in Solid Alkali Metal Halides," The Bulletin of the Georgia Academy of Science, Vol. 28, No. 3, pp. 107-111 (June 1970).

J. A. Knight, NBSD, "Gas Chromatographic Analysis of γ-Irradiated Nitrobenzene for Biphenyl and Nitroaromatic Products," Journal of Chromatography, Vol. 48, pp. 526-529 (1970).

J. A. Knight, "Arylation of Nitrobenzene Induced by γ-Radiation," Radiation Research, Vol. 44, pp. 50-58 (October 1970).

Charles I. Poole, IDD, "Modulars: Myth or Magic," Mobile Home/Recreational Vehicle Dealer, September 20, 1970, pp. 10, 14, 16.

\- - -

Appointments and Elections

Harry L. Baker, Jr., ORA/GTRI, is the 1970-1971 Chairman of the Subcommittee on Patents and Copyrights of the National Association of College and University Business Officers Committee on Governmental Relations.

Howard Dean, EES, has been named technical representative for Georgia to a U. S. Department of Housing and Urban Development advisory committee which reviews designs for prototype housing systems under Project Breakthrough in the eight states in which these projects are located.

Maurice W. Long, EES, is a member of the Student Awards Committee for the 1971 IEEE, G-MTT International Microwave Symposium; the committee will judge student papers submitted to the symposium.

David C. Morgan, IDD, has been elected 1971 President of the Georgia Industrial Developers Association. A former president of the four-year-old organization is Ross W. Hammond, IDD.

\- - -

SUBMISSION OF ARTICLES

Contributors in the divisions should submit their articles to the appropriate division coordinator listed below. Others may send their contributions via campus mail to Martha Ann Deadmore at the Industrial Development Division.

Division Coordinators

Chemical Sciences and Materials Division	Walter H. Burrows
Electronics Division	H. A. Corriher, Jr.
High Temperature Materials Division	Nick E. Poulos
Industrial Development Division	Martha Ann Deadmore
Nuclear and Biological Sciences Division	Geoffrey G. Eichholz
Physical Sciences Division	Robert L. Bullock