# EES NOTES

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

**In This Issue:**



EESN-3-69
December 31, 1969
Edited by:
Arthur L. Bennett
Martha A. Deadmore

MICROWAVE RADIATION HAZARDS

For many years the scientific community and the general public have been informed of the hazards associated with ionizing radiation such as X-rays and gamma radiation. What has been left almost unpublicized is the biologically deleterious effects that can be caused by electromagnetic radiation. Since World War II microwave engineers and radar specialists have known that high-powered radar systems can cause severe burns. The recent availability to the public of the so-called electronic or microwave ovens has indicated to regulatory agencies the need for standards of protection and safety.

The reason microwaves are particularly hazardous stems from the wavelengths involved and high water content of living matter. The dissipation factor (energy loss) in the body is not great enough to yield much absorption of radiation if the body is less than 1/10 wavelength in size. Hence, humans are virtually transparent to radiation in the region below 20 MHz, i.e., a wavelength of 15 meters (49 feet) or greater. Short wavelengths, such as millimeter and submillimeter waves, interact only at the surface of the skin, causing burns if their power density is sufficiently high.

Thus the electromagnetic region of primary concern from a human hazard standpoint is, indeed, the portion of the spectrum between 100 and 10,000 MHz (wavelengths of 3 meters to 3 centimeters). Because of the high water content of biological tissue, this particular frequency region is also one of high absorptivity for living organisms. One of the reasons that 915 and 2450 MHz are the two primary frequencies for microwave cooking is the trade-off between penetration and energy absorption.

One of the organs most sensitive to microwave radiation is the eye. Prolonged or repeated exposure to microwave radiation of the order of a few hundred milliwatts per square centimeter will unquestionably produce cataract-like opacities on the lens of the eye. Power levels of this magnitude also are likely to produce physical damage internally. Hence, the U. S. has established a level of 10 $mw/cm^2$ as the maximum power density allowable for continuous exposure to microwave radiation. This level would seem reasonable except for a number of reports in the literature, particularly that of the Russians, that indicate many more subtle, nonthermal, biological effects occur as a result of exposure to microwaves at levels lower in power density than 10 $mw/cm^2$. In fact, the Eastern Bloc has a maximum permissible continuous exposure standard set at 0.01 $mw/cm^2$.

There is considerable statistical evidence that bradycardia (slow heart rate), fatigue, lenticular changes in the eye, genetic anomalies, tension, headaches, glandular changes, and other physically distressing effects can occur as a result of continued exposure to low-level microwave radiation. When one considers that used (and sometimes even new) microwave ovens often have leakage around their doors that may exceed the 10 $mw/cm^2$ level and almost always have a leakage above 1 $mw/cm^2$, it is evident that a genuine possibility of a health hazard around such ovens exists.

The Electronics Division, in cooperation with the School of Biology, is working to uncover additional information which will lead to the establishment of a standard of exposure that will indicate the level of microwave power density that actually represents a hazard. The effects of microwave radiation on blood, the effects of low-level microwave radiation on cells, and techniques for accurately measuring microwave fields near their source of origin are the areas where the Georgia Tech microwave radiation hazards research is being concentrated.

A. P. Sheppard
Electronics Division

\- - -

CHEMICAL ANALYTICAL SERVICES

The Chemical Sciences and Materials Division has available an experienced staff in chemical analytical research. Because of needs in geological studies, the analytical group has functioned as part of the Minerals Engineering Branch since 1965. Its purpose is to provide specialized and reliable chemical analyses, and related research, in support of various Georgia Tech projects.

The majority of samples analyzed have been minerals from the South Georgia Minerals Program sponsored by the Georgia State Department of Mines, Mining and Geology. Other work has included analysis in support of studies pertaining to fertilizers, clay and heavy minerals, trace analysis in natural waters, and control of metal finishing baths. Studies of dental amalgam solubilities in artificial saliva, identification of corrosion products on structural materials after long environmental exposure, and collaboration with investigators evaluating new methods of analysis also indicate the scope of the work.

Analytical methods have included classical gravimetric and volumetric procedures prescribed by the Association of Official Analytical Chemists for agricultural materials, the American Society for Testing Materials for silicates and refractory materials, and the Association of Florida Phosphate Chemists for phosphate matrices. Arc-emission spectroscopy was used for qualitative examination of most of the mineral specimens processed. Minor components of complex samples have been analyzed by atomic absorption, spectrophotometry, colorimetry, or ultraviolet and visible spectrophotometry. Concentrations have ranged from 99.7 $\pm$ 0.1% $SiO_2$ (gravimetric) in a glass sand to 10 parts of phosphorus per billion (spectrophotometry with 10 cm quartz cells) in a natural water. The rate of analysis has exceeded 400 volumetric phosphate determinations per week when sufficient samples were available.

Lewis W. Elston
Chemical Sciences
and Materials Division

\- - -

ISOSTATIC PRESSING FUSED SILICA POWDERS

During recent months, the Processes and Fabrication Branch has been investigating isostatic pressing as a means of forming fused-silica shapes ready for heat treatment. Fine silica powder in a closed rubber mold is placed in a pressure vessel containing water or hydraulic fluid. The pressure in the container is then increased to produce the desired level of compaction. With such equipment, pressures up to 100,000 psi can be realized, although most ceramic powders are pressed in the range from 10,000 to 30,000 psi.

The main advantages of isostatic pressing are uniform compaction throughout the formed shape and the ability to form more complex shapes than with conventional methods such as slip casting or die pressing. A further advantage is that high purity powders may be formed into dense shapes without contamination by binder materials.

Possible applications of the technique are the production of fused silica radomes for hypersonic reentry vehicles and fused silica dielectric windows for slot antennas mounted on the surface of high-speed aircraft.

E. A. Welsh
High Temperature Materials Division

\- - -

ECONOMIC DEVELOPMENT TRAINING PROGRAMS AT IDD

The successful planning and implementation of economic development programs require the services of personnel trained in the practical processes of community, district, and regional economic development. However, many programs are being retarded by an acute and continuing shortage of qualified and experienced economic development practitioners across the United States. This shortage has been brought about primarily by the constantly increasing number of local and state development and planning agencies, the advent of numerically large staffs in some agencies, and the proliferation of Federal programs in the development and planning fields. Additionally, staff personnel normally required to perform specialized duties must now do so in a manner that will insure that particular programs provide the maximum economic contribution in the community and district. Accordingly, such personnel also must be familiar with the concepts and methodology involved in economic development programs.

During April and May 1967, the Industrial Development Division (IDD) conducted a prototype, four-week training program in the fundamentals of economic development for staff personnel of the area planning and development commissions in Georgia under sponsorship of the Economic Development Administration (EDA). An evaluation following the program concluded that this type of training program could perform an extremely useful role in providing short-term training and orientation for professional personnel associated with economic development agencies.

EDA then asked IDD to develop and conduct a series of short training programs during 1968-1969. The basic objective of these economic development training programs is to provide instruction in the practical processes of economic development for economic development district staff members, personnel associated with EDA's University Centers for Technical Assistance Program, and other interested personnel in order to increase the effectiveness of EDA-related economic development programs.

Two types of programs were presented the first year. An Executive Training Program was developed to provide instruction for executive directors and senior staff personnel of recently organized economic development districts, personnel who have recently joined the staff of an economic development district, and for staff members of other organizations whose programs relate to the Economic Development Administration. A companion program, the Basic Economic Development Training Program, was designed to provide instruction for personnel with little formal or informal instruction or work experience in the field of economic development.

Two additional training programs are being presented during the period 1969-1970. The Advanced Executive Training Program was developed to furnish professional instruction for executive directors who have attended the Executive Training Program or who have served as executive directors for a period of at least one year. It is designed to introduce advanced scientific methods into present and future economic development district staff operations. The program provides a balanced methodological approach in which student participation is emphasized.

The purpose of the Industrial Development Training Program is to furnish executive directors and staff assistants involved in industrial development activities with formal instruction in the theory and fundamentals of industrial development and the practical application of theory in development district planning and operations. This program is designed to view the industrial development process through the eyes of the district staff, enabling the staff to work in a more rational manner with professional industrial developers, with other public development commissions, and with private agencies, chambers of commerce, public utilities, banks, and other organizations active in industrial development.

To date, 111 individuals have attended the training sessions. They represented 31 states, 56 economic development districts, and five county planning groups. Thirty-three executive directors and 26 deputy/assistant directors have attended the programs. At least 12 Industrial Development Division staff members regularly participate in each training program.

Robert E. Collier
Industrial Development Division

\- - -

NEUTRON ACTIVATION ANALYSIS AT THE NUCLEAR RESEARCH CENTER

One of the more frequent uses of the high neutron flux available at the Georgia Tech Research Reactor is neutron activation analysis (NAA). Most materials when exposed to the flux of the reactor become radioactive, hence the name. After exposure, the sample is removed and placed in a radiation counting chamber. Analysis of the characteristic energy of the emission and the amount of radiation gives the identification of the elements activated and the total mass of each.

Not all elements can be measured, but the technique is so sensitive that $10^{-10}$ grams can in many cases be identified. Since this method measures the mass of the element and not the concentration, the required sample size is dependent on the sensitivity for that element and the concentration in the specimen. Like emission spectroscopy, NAA does not distinguish chemical states but measures only the total amount of the element present.

As with any other general analytical method, NAA has been used in a wide variety of determinations. The high sensitivity of the technique is one of its chief attractions, as, for example, in the recent measurement of mercury to an accuracy of parts per million in tissue sections weighing only 100 micrograms. Another advantage is that the test often can be performed nondestructively, leaving the sample available for subsequent tests. Other examples of use of NAA at Georgia Tech are given below.

| Application | Use | User |
|---|---|---|
| Trace gold in barbiturates | - | University of Florida, Chemistry Dept. |
| Platinum on asbestos fibers | Catalytic combustion apparatus | Chemical Sciences & Materials Div. |
| Aluminum on boron nitride | Measurement of $Al_2O_3$ deposit | Chemical Engineering School |
| Uranium on molecular sieves | Graduate student thesis research | Nuclear & Biological Sciences Div. |
| Trace elements in rice hulls | - | Chemical Sciences & Materials Div. |
| Mineral analyses | Unknown rock for Hg and rare earths | Oak Ridge Associated Univ. |
| Chloride in apatite | - | Physical Sciences Div. |
| Trace elements in hair | Measured quantities of Hg, I, Cu, As, Sb in hair samples of patients suspected of poisoning | Emory Clinic |
| Manganese in water | Trace Mn in surface water supplies | Chemical Sciences & Materials Div. |
| Mercury in fish | Determination of pesticide residues | Nuclear & Biological Sciences Div. |
| Iridium in wood pulp | Development of stable Ir tagging of wood pulp for paperboard manufacturer | Nuclear & Biological Sciences Div. |
| Aluminum in minerals | Comparison of NAA with atomic absorption spectrophotometry | Nuclear & Biological Sciences Div. |
| Gold and aluminum in quartz | Measurement of Au and Al concentration as function of depth in quartz for determination of diffusion of these metals into quartz | Physical Sciences Div. |
| Vanadium in refinery ash | Evaluation of recovery economics | Industry |
| Potassium in peanut hulls | By-product recovery | Chemical Sciences & Materials Div. |

Milton E. McLain, Jr.
Nuclear and Biological
Sciences Division

TEXTILE FIBER ATLAS

Even the best reference books on textile fibers now available leave much to be desired. These usually contain either physical and chemical data or identification test data (burn test, stain test, etc.), along with micrographs or drawings of fiber surfaces and cross sections. Optical cross sections have been very satisfactory in most cases, of course, but surface data have been limited, mostly by the optical microscope itself. Even the limited resolution of the optical microscope cannot be wholly utilized because of the microscope's small depth of field. Since fibers are round and not flat, at higher optical magnifications where more detailed surface studies can be made, only a very small portion of the surface can be brought into focus at one time. Some electron microscopy has been done, but replication of fiber surfaces is at best a tedious process and the chances of artifacts in replicas leaves some doubt as to the true fiber topography.

The invention of the scanning electron microscope (SEM) in 1938 stimulated interest in its applications in a number of fields of science. However, it was not until the early 1960's that the instrument was developed to the stage where reliable commercial production was feasible. The first SEM in this category was produced by the Cambridge Instrument Company in 1965.

The scanning electron microscope utilizes an electron beam which is made to scan the surface of a sample in the same manner as the electron beam scans the phosphorescent surface in a TV picture tube. As the beam strikes each point on the sample, each point in turn emits a number of different types of radiation (secondary electrons, light, X-rays, etc.). A picture of the sample is obtained by using the signal from one type of radiation, usually secondary electron emission, to control the intensity of a cathode ray tube synchronized with the scanning electron beam. The diameter of the electron beam can be controlled by the use of a series of electromagnetic lenses and the magnification changed by controlling the size of the area scanned by the electron beam. The result is a microscope having a resolving power 10 times greater and a depth of field 300 times greater than the optical microscope. The usable magnification range of the instrument is from 20 times to 30,000 times.

The availability on the campus of a scanning electron microscope has prompted the creation of a fiber atlas which is expected to be published in early 1970 at Georgia Tech. This first edition will survey some 43 natural and 35 man-made fibers, arranged by their natural or generic classifications. Each section will be preceded by notes on the history, general characteristics, and usage of the class of fiber. Each individual fiber type will be given two pages in the atlas. The first page will contain physical, chemical, and test data (e.g., specific gravity, density, chemical resistance, color of stains). The facing page will show the cross section of the fiber in an optical micrograph and surface features at low and high magnifications in scanning electron micrographs.

This atlas is planned to be the first of a number of editions. The second edition should complete the survey, at least pictorially, of all of the natural fibers and enlarge the man-made fiber section. A later edition should contain a fairly complete survey of at least the most used man-made fibers from all of the manufacturers and enough chemical, physical, and test data to allow one to identify an unknown fiber. Other scanning electron microscopic techniques may be added, such as the examination of fractured fiber ends. It is expected that this atlas will find broad use in industry, education, crime laboratories, and among others concerned with fiber identification.

James L. Hubbard
Physical Sciences Division

\- - -

COMPUTING SERVICES

A visiting committee from the National Science Foundation made a site visit to Georgia Tech on October 27 and 28. The purpose of the site visit was to review the following two proposals.

Improvement of Computing Services for Education and Scientific Research at the Georgia Institute of Technology

This proposal involves upgrading of the present Georgia Institute of Technology computing facilities to the higher level of service needed to support education and academic research. With currently available equipment, the Rich Electronic Computer Center is unable to provide sufficient on-campus remote terminals and adequate turnaround for batch processing to support known requirements. The proposal is related directly to the Five-Year Plan for the Rich Electronic Computer Center for the period 1969-1973. The additional equipment and services are intended primarily for improvement in the amount and extent of computing services provided for education and research. However, since the overall capacity would increase, the percentage of total computing resources devoted to these two categories would remain about the same.

An Experiment in the Development of a Regional Computer Center Serving All Units of the University System of Georgia

The hypothesis to be tested by this experiment is as follows: The University System of Georgia can provide, by means of a data communication network and an associated educational undertaking, the same level of computing power at other schools in the System not possessing computers on campus as that which exists at Georgia Tech and the University of Georgia, and this data communication system will be completely adequate to fulfill all of the requirements at each institution for high-quality computing educational programs. It is further hypothesized that the alternative system of providing separate computers at each institution would cost considerably more than the data communications network.

Discussions concerning the second proposal are being held with the 24 other schools in the System on budgeting, designation of campus coordinators, and similar matters. NSF currently is considering revised budgets for both proposals. It appears that favorable action on both proposals will be forthcoming from NSF.

John P. McGovern
Rich Electronic Computer Center

\- - -

SYMPOSIUM ON INTERFACE PHENOMENA

Since September 1, 1967, a team of faculty members, technical staff, and students from several departments of the Georgia Institute of Technology has been conducting research on various aspects of surface or interface phenomena. Prior to that date individual efforts had received recognition but there were few coordinated studies. With the onset in 1967 of Project THEMIS, sponsored by the Air Force Office of Scientific Research, it became possible to strengthen existing programs and to develop new groups in accordance with certain objectives. These objectives are to strengthen the graduate programs of the Institute which include the area of interface phenomena and to achieve a significant capability for responding to the needs of the Department of Defense in the same area.

A symposium on "Interface Phenomena in Engineering Materials" held at Georgia Tech on December 10, 1969 was organized to serve several purposes: It provided a means for reporting on all the THEMIS research and other efforts related to the scope of the THEMIS program; it gave graduate students an opportunity to participate so that they would gain experience for other similar meetings; through the presentations all participants could hear what others were doing; and through the published proceedings further exchange is expected.

The symposium comprised four sessions whose general themes were as follows: Session I - Fundamental Science, i.e., physics and chemistry of surfaces; Session II - Oriented Basic Research, i.e., research directed towards the solution of broadly defined problems; Session III - Conceptual Studies, i.e., models or techniques; and Session IV - Application Investigations. Copies of the proceedings of the symposium are available to interested faculty members.

Edwin J. Scheibner
Physical Sciences Division

ROSS HAMMOND CHAIRS HOUSING COMMITTEE

Gov. Lester G. Maddox recently named Ross W. Hammond, Industrial Development Division chief, to a 27-member Governor's Committee on Housing in Georgia. At the organizational meeting of the committee in December, Mr. Hammond was elected chairman. The committee is charged with the responsibilities of determining the status of housing needs in the state and recommending to the Governor proposed courses of action and legislation to improve Georgia's housing picture, to remove current obstacles to solving Georgia's housing problem, and to enhance the construction industries in Georgia. A continuing body, the committee is composed of persons from the fields of education, public health, local and state government, religion, banking, architecture, home building, real estate, and business.

\- - -

PROFESSIONAL ACTIVITIES

Speeches and Papers

Six papers coauthored by members of the Nuclear and Biological Sciences Division were presented at the 1969 Winter Meeting of the American Nuclear Society in San Francisco November 30-December 4, and are included in the Transactions of that meeting:

John M. Jamieson and W. Waverly Graham III, "Cyclic Activation in a Reactor Neutron Beam."

R. J. Johnson, J. D. Clement, and others, "Nuclear Design Education at Georgia Tech."

R. Joe Johnson and others, "Spatial Xenon Stability Measurements on the Connecticut Yankee Reactor."

J. M. Kallfelz and others, "Fast Reactor Integral Studies of Modifications to ENDF/B $^{238}U$ Inelastic Scattering."

J. M. Kallfelz and others, "Neutron Energy Spectra for Fast Reactor Irradiation Effects."

J. R. Williams, "Thermal Radiation Transport in Particle-Seeded Gases."

Other papers presented during December include the following:

At the NASA Electronics Research Center Quarterly Technical Program Review held at Cambridge, Mass., on December 10-11, L. J. Gallaher, RECC, gave a paper entitled "An Evaluation of Some High-Accuracy Numerical Integration Methods for Systems of Ordinary Differential Equations."

Ross W. Hammond, IDD, spoke on "Our Industrial Future" at the Annual Meeting of the Georgia Electric Membership Corporation in Atlanta December 15.

Raymond W. Tooke, Jr., CSMD, delivered papers on "Research in Traffic Marking Systems" and "Specifying Paint Systems for Bridges" at the Annual Meeting of the Southeastern Association of State Highway Officials held in Atlanta December 7-10.

Honors and Awards

G. G. Eichholz, NBSD, is on the executive committee of the Isotopes and Radiation Division of the American Nuclear Society and also a member of the Student Conference Committee and the Educational Development Committee.

James L. Hubbard, PSD, has been reelected secretary-treasurer of the Southeast Electron Microscopy Society, a post which he has held since 1968.

David C. Morgan, IDD, has been elected to the Board of Directors of the Georgia Industrial Developers Association.

At the Georgia Industrial Developers Association Annual Meeting in December, George I. Whitlatch, IDD, was given an honorary life membership.

Robert L. Zimmerman, NBSD, is treasurer of the Health Physics Society.

Abou Award

For 22 years "Abou," the two-foot-high plaster bust of an Arabian chieftain, has stood guard over EES staff members who have suffered in the cause of research. First presented at the 1947 EES Christmas Party in an exchange of ten-cent gifts, Abou was found to exercise protective powers over his owners. This year's joint recipients are S. P. Lenoir, Jr., Senior Research Engineer at RECC, and T. F. Jones, Assistant to the Director.

\- - -

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 |
| Rich Electronic Computer Center | John P. McGovern |