EES NOTES

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

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In This Issue:

MERCURY POLLUTION STUDIES AT TECH

If you have read beneath the recent headlines on mercury pollution, you are probably aware that Georgia Tech is playing an important role in dealing with the hazards of mercury in our environment. Reactor-neutron activation analysis techniques as used by the Nuclear and Biological Sciences Division (Fortune, January 1971, p. 110) have proven to be a most effective method for measuring the minute but significant levels of mercury which are typically found in environmental samples.

The special facilities and capabilities of EES have been applied to protecting both the health and the industrial interests of Georgians. In one study, techniques were devised to permit measurements of the mercury content of large numbers of fish and shellfish from Georgia fishing areas. In excess of 400 fish samples have been analyzed in cooperation with the State Water Quality Control Board (Atlanta Journal, October 25, 1970). The same technique for fish sample analysis was applied to studies for the Skidaway Institute of Oceanography and the Bureau of Commercial Fisheries of the U. S. Department of Interior.

NBSD staff members also have worked with Georgia industry to evaluate potential mercury problems in their foodstuff products and waste effluents. For apparent reasons, it is to the advantage of an industry to take corrective action on its own initiative rather than under an ultimatum from a regulatory agency.

On a national level, NBSD has assisted Dr. Fred Hochberg of the National Center for Disease Control to show that Eskimos in certain areas of Alaska have abnormally high body mercury levels (N. Y. Times, November 6, 1970). The source of mercury intake was identified as seal meat, which comprises a major portion of the diet of this group of people. In another study with NCDC, Tech analyzed follow-up samples from the family in New Mexico who were disabled after eating pork from hogs which had been fed on mercury-treated seed grain.

Although mercury contamination incidents invariably attract nationwide attention, a coordinated national approach to the overall mercury problem has not yet emerged. Many important questions remain to be answered concerning the behavior of mercury in biological systems and in defining the routes by which mercury enters and progresses along the food chain to man. In the meantime, the mercury study capabilities at Tech will continue to be applied on a rapid, informal basis to problem areas of particular importance to our region.

D. M. Walker and M. E. McLain, Jr.
Nuclear and Biological Sciences Division

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PHYSICS UNDERGRADUATES PARTICIPATE IN VACUUM EXPERIMENTS

Effective use of ultra-high vacuum has become a discipline in its own right -- a very sophisticated and uncompromising one. Increasingly, the research efforts of experimentalists require exacting control of the environments in which a specimen is immersed. High vacuum indicates a pressure less than 10^{-6} torr (10^{-9} atmosphere). Ultra-high vacuum designates a pressure less than 10^{-8} torr, which simulates outer space, and under these conditions gas molecules can travel kilometers between collisions.

High vacuum equipment is being used frequently to provide a suitable experimental environment. At these low pressures, a surface is only slowly contaminated. The absorption of short wavelength ultraviolet energy at low pressure is reduced to an acceptable level for spectroscopy. Electron and ion beams can be propagated in these rarified atmospheres without energy loss and consequently are of higher quality when used in both the focused and unfocused conditions.

During the past academic year, undergraduates from the School of Physics have participated in a set of vacuum-related surface science experiments developed at EES. The experiments were conducted in a bakeable stainless steel chamber/bell jar system pumped by sorption, sputter-ion, and titanium sublimation pumps. The pressure was monitored with thermocouple, hot cathode ionization, and partial-pressure mass-spectrometer gauges. All components necessary to the series of experiments were within or appended to the chamber.

In the first familiarization experiment, the students were introduced, through lecture, hardware manipulation, and selected reading, to the characteristics of the vacuum environment and how to produce and measure it. Having thus learned to manipulate the vacuum system and to interpret conditions within it, the students progressed to other experiments. In one experiment the mass spectrometer was used to measure the peak current of a number of ion fragments. The spectrometer separates the ions by the ratio of particle mass, m, to ionic charge, e, designated m/e. The spectrum produced from a gas such as methane (m/e = 16) was observed as the accelerating potential of the ionizing electron beam was changed. With the increase in electron energy, new ion peaks appeared on the spectrum, indicating a fragmentation of the methane. The threshold electron energy for creation and ionization by electron impact of these fragmentation products with peaks CH_3^+, m/e = 15, CH_2^+, m/e = 14, etc. was noted.

In another experiment, observations were made by low energy electron diffraction patterns (LEED) of a refractory metal crystal before and after cleaning by heating to incandescence and also after partial recontamination by a controlled

introduction of a gas such as oxygen. The students were also introduced to the "flash filament" technique: that is, observing pressure excursions while desorbing gas from a metal filament by heating it to incandescence and alternately adsorbing the test gas by cooling the filament surface. These measurements were used to determine both the sticking probability and the binding energy of the adsorbed gases as a function of surface coverage.

These and other appropriate experiments are being made available to interested students as an extension of their classroom and laboratory course work. The opportunity to manipulate up-to-date research equipment is being made through collaboration of interested faculty members.

K. B. Wear
Physical Sciences Division

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DEVELOPMENT OF RESIN-REINFORCED MOLD MATERIALS

Slip casting is an old and established ceramic process which makes use of a plaster of paris mold to form a ceramic into a desired shape. The slip, which is an aqueous suspension of particulate material, is poured into the plaster mold; the capillary action of the plaster removes water from the suspension, leaving a dense wall of particulate material on the surface of the mold. When the cast wall reaches the desired thickness, the excess slip is poured from the mold. After a short period of drying, the cast piece can then be removed from the mold and fired.

Generally slip casting is used for the fabrication of two types of ceramic products: (1) technical ceramics (electrical insulators, chemical ware) and (2) mass-produced clay-type ceramics such as art ware and sanitary ware. Slip-cast technical ceramics are made from slips of alumina, silica, zirconia, and other refractory materials which are generally acidic and highly abrasive. Such slips rapidly deteriorate the surface of the plaster mold, limiting its use to one or two castings with a good surface finish. On the other hand, slip-cast clay products are not abrasive or acidic and many castings, often more than 100, can be made from one mold. The casting process is slow, however, requiring the use of many molds and a large floor area for mold storage and drying in order to achieve high production rates.

The slip-casting process can be substantially shortened by the application of pressure to the slip during casting; the higher the pressure the higher the casting rate. Unfortunately, the strength of conventional plaster allows only relatively low pressures to be used, and even at these low pressures mold life is significantly reduced. It is obvious, therefore, that an alternate or new high-strength mold

material is needed to increase mold life in the production of items slip-cast from abrasive materials such as alumina, zirconia, zircon, and fused silica, as well as to provide molds which can be used for pressure casting of conventional ceramics.

Such a mold material should have pore size distribution and permeability similar to plaster of paris, and must have greater hardness and mechanical strength to promote durability. Satisfactory mold materials must be easily fabricated, and should be dimensionally stable to eliminate warpage and to reduce shrinkage during the mold forming process. In addition, the mold material should be chemically inert to eliminate contamination of the casting slip.

Studies have been made on two grain/resin systems for possible mold material use. The basic component of both is fused silica grain, with one system using epoxy as a bonding material and the other utilizing polyester resin. Permeability, pore size, and flexural strength have been determined as a function of resin content. The more promising material is an epoxy-silica grain material. Although for a given pore size, permeability is lower than that of plaster, the flexural strength is far greater. Cylindrical molds are being made to test the durability of the material.

Earle A. Welsh
High Temperature Materials Division

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ON THE DETECTION MECHANISM OF ELECTRIC FISH AND EELS

An article in the Scientific American (H. W. Lissman, March 1963, pp. 50-59) raised the question of whether electric fish and eels use electromagnetism or some other phenomenon in their detection processes in a manner unknown to designers of "inanimate" detectors.

The more familiar "treasure" finders or land-mine detectors consist of a transmitting coil through which passes an alternating current of audio or low radio frequency, creating an alternating magnetic field in the vicinity. The alternating field induces a voltage in a receiving coil; the output signal is then amplified and indicated on a meter or by a speaker or headphones. As an area is searched, a change in the induced signal indicates the presence of a "foreign" body (one with conductivity or permeability different from that of the surrounding medium).

Several practical variations of the basic detection scheme may be employed. There are many possible shapes and relative positions for the two coils -- one type uses the same coil for both functions, while in other types the two coils may be separated. Often the received magnetic signal will be nulled out for the condition of no foreign body in the vicinity in order that a change may be more readily

recognized. It is always necessary to maintain a rigid spatial relation between coils where two are used, since relative motion or distortion of either coil will result in signals similar to those produced by the sought-for foreign bodies.

An alternating electric field rather than magnetic field may be used, in which case changes in the field indicate the presence of foreign bodies with either conductivity or dielectric constant different from the surroundings. Although magnetic systems designed for use on land are not very different from those designed for use in water, an electric-field system used in a nonconducting medium like air or through dry earth will be markedly different from that used in a relatively good conductor like sea water.

The ability possessed by electric fish and eels to detect foreign bodies appears to involve the sensing of changes in an electric field produced by pulsed direct current rather than by alternating current.

The spatial rigidity between transmitter and receiver noted above is required for both electric and magnetic systems. It is noteworthy that electric creatures swim with their bodies essentially rigid when operating in their "search mode." However, "data processing" in the fish's nervous system could compensate for some changes in geometry.

The detection range of both the magnetic and the electric devices is not limited by either transmitter power or receiver sensitivity, but rather by the effective dynamic range of the receiver, which must respond to a small change due to the sought-for object in the presence of the relatively large field of the source. Practical dynamic ranges (up to 80 db, say) limit the range of detection to distances comparable to the size of the transmitter-receiver array. Indeed, it is asserted that electric fish detect objects at distances of only a few fish lengths. For fish as well as inanimate systems, detection range is not very sensitive to size or properties of the foreign body.

Analysis indicates that power consumed will be a minimum if the transmitting array is as large as possible. This result is consistent with the fact that "electrodes" are located on the fish near the tail and head with insulating skin on their bodies in between.

It has been observed that an electric fish in an aquarium will be excited by a magnet or electrified comb in motion nearby. Such motions would set up transient potentials and currents comparable to those produced by a foreign object in the pulsed electric field of the fish, and thereby evoke responses.

There are unanswered questions about how the fish's sensitive sensors work, and the interpretation of the data by the fish's nervous system is not understood.

However, bringing off detection by presently unremarkable means is clearly possible. There seems to be nothing to suggest that the pulsed direct-current detection system of these fish is anything more than an electric analog of a magnetic land-mine or buried-pipe detector. The fish may use several sensors and may process his data to a high degree, but there is no need to postulate any unfamiliar phenomena to explain the basic detection process. A more complete understanding of the fish's sensory system could lead to improvements in design and operation of man-made detectors.

J. Elmer Rhodes, Jr.
Electronics Division

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COMMUNITY DEVELOPMENT BRANCH

The Community Development Branch of the Industrial Development Division primarily assists community and development organizations in their efforts to make their communities attractive to industry. Various programs and approaches are used to accomplish this purpose.

Economic Profiles, which are audits of community resources, have been published since 1962 by the Branch. Information is compiled on population, existing industry and industrial services, the labor situation, raw materials, transportation, utilities, city services, living conditions, industrial financing, and sites. The Profiles have a standard format which permits comparison of the resources of various communities by industrial developers and industry location analysts. Economic Profiles have been published on 174 communities, and they are updated periodically. The Georgia Chamber of Commerce is a cooperating agency in this effort.

Community development workshops and seminars are offered throughout the state to present new techniques to community development leaders. At the current series of seven regional seminars, information gleaned from the 1970 Census will be analyzed and interpreted. Highlighted will be various population and growth trends, as well as the social and economic impact of these trends.

The Branch conducts an annual one-week basic industrial development course in mid-April in cooperation with the College of Industrial Management, using facilities of the Department of Continuing Education. This course is aimed at upgrading the knowledge and quality of performance of industrial development professionals from the Southeast who are affiliated with chambers of commerce, railroads, utilities, banks, and development agencies. Lecturers include outstanding development specialists from many areas of the United States.

The Community Development Branch also publishes the Georgia Development News, an eight-page monthly newsletter. Its distribution list of 4,000 includes mayors and county commissioners, state and federal legislators and public officials, local and area industrial developers, libraries, newspapers, radio and television stations, and many individuals employed by utilities, banks, businesses, and industry. The News reports on new plants and recent expansions, acquisitions and mergers, new products, and development activities in Georgia's communities. It also contains editorial matter concerning the philosophy and practice of industrial development.

Special studies and services are undertaken by the Branch from time to time. Industrial Plant Financing: A Guide for Georgia Communities and A Study of Industrial Needs and River Sites in Autauga County, Alabama are two recent reports in this category. The Community Development Branch also acts as the Secretariat for the Southern Industrial Development Council, of which Robert B. Cassell, Branch Head, is executive director and past president.

Annelly B. Deets
Industrial Development Division

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ELECTROMAGNETIC COMPATIBILITY STANDARDS

The electronic units and systems used in our space exploration programs are required to comply with numerous and often stringent constraints. These requirements are typically defined in terms of size, weight, and cost. Despite the constraints, mission requirements demand improvement in equipment sensitivities, more density in electronic packaging, increased attention to crew safety, and higher reliability. All of these factors increase the possibility of electromagnetic incompatibilities which are the result of electromagnetic emissions from one or more sources being coupled into susceptible equipment in such a way that normal operation is impaired.

Within government agencies directing the space programs, there is an increasing awareness of the necessity of solving electromagnetic compatibility (EMC) problems before they occur rather than trying to fix them on an after-the-fact basis. To this end, there is considerable interest in both improving existing standards and generating new ones which delineate realistic EMC efforts with major emphasis on before-the-fact design techniques. Such standards must establish (1) the primary sources of undesired signal emission, (2) the most susceptible receptors of the emitted signals, (3) design techniques to realistically reduce the undesired signal levels and raise the susceptibility thresholds, and (4) test and measurement techniques adequate to assure compliance with requirements. The standards, therefore,

must be quite broad in coverage and applicable, to some extent, in essentially every phase of space system development.

The major technical considerations in establishing the above requirements involve the nature of the undesired signals and the mechanisms by which they are coupled between units within a space system. Such signals may occur at any discrete frequency or over any band of frequencies within the usable frequency spectrum. They may be steady state or transient in nature and may vary in magnitude from high-intensity transmitter outputs to very-low-level transducer outputs. Coupling between equipment units may occur either by air coupling or by conduction along interconnecting signal and power leads. An additional consideration involves the fact that standards must include adequate provisions to account for the changing electromagnetic status of the space system as it is influenced by the ambient electromagnetic environment, often unknown and always variable over the flight trajectory.

A research effort to develop improved EMC standards for space equipments and systems was completed recently by investigators in the Electronics Division. Three resulting documents are under review by NASA personnel as potential replacements for the present EMC standards. One of the documents provides a summary of the major design factors, at both the system and equipment levels, that must be considered in providing an electromagnetically compatible final space system. A second document establishes the test techniques and limits necessary to assure that the system level design requirements are realized. The third document has the same goal as the second document, but is oriented toward the equipment level instead of the system level.

When imposed as contractual requirements, these three standards should substantially improve the ability of NASA to procure highly reliable space systems at minimum cost and on a timely schedule. Also of importance is the fact that imposing these standards on space systems is a step in the direction of reducing the number and magnitude of unnecessary electromagnetic emissions. Further application of these principles in the terrestrial environment will result in less "pollution" of our severely congested electromagnetic spectrum so that television sets, radios, telephones, etc., will be better able to function.

James C. Toler
Electronics Division

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PROFESSIONAL ACTIVITIES

Robert M. Boyd, NBSD, has been named president-elect of the Atlanta Chapter of the Health Physics Society.

J. L. Edwards, ED, is coauthor of two recently published papers. "Total Cross Sections for Formation of Excited Atoms by Charge Transfer at High Energies," with E. W. Thomas and J. C. Ford of the School of Physics, was published in Bulletin of the American Physical Society, Series II, Vol. 15, No. 11, p. 1502, November 1, 1970. "Formation and Destruction of Excited Hydrogen Atoms at High Impact Velocities," with E. W. Thomas, appeared in Physical Review, Vol. 2, No. 6, pp. 2346-56, December 1970.

L. H. Glassman, PSD, coauthored with S. E. Wiegand and P. L. Strobel of CDC a paper, "Microscopic Anatomy of Pathogenic Treponema Pallidum," which was presented at the Winter Meeting of the Southeast Electron Microscopy Society in Atlanta on December 4-5, 1970.

"Effects of the Sea on Echo from Rain," by M. W. Long, EES, and S. P. Zehner, ED, was published in the November 1970 issue of IEEE Transactions on AES.

Three more short articles by Charles I. Poole, IDD, appeared in Mobile Home/Recreational Vehicle Dealer: "Heating Systems," October 20, 1970; "Plant Layout," November 20, 1970; "Operation Breakthrough's Impact on Mobile Homes," December 20, 1970.

"Parametric Self-Excitation of a Belt into Transverse Vibration," by J. E. Rhodes, Jr., ED, was published in the Journal of Applied Mechanics, Series E, Vol. 37, No. 4, December 1970.

M. E. Sikorski, PSD, gave a paper, "Catheter-Tip Transistor Transducer," co-authored with F. Dixon, PSD, F. R. Williamson, PSD, R. A. Newsom, PSD, R. C. Schlant, M.D., and D. O. Nutter, M.D., an extended abstract of which was published in Proceedings, 23rd Annual Conference on Engineering in Medicine and Biology, November 15-19, 1970. An abstract, "Catheter-Tip Transistor Transducer for Intracardiac Pressure and Sound," by the same authors, was published in Circulation, October 1970, prior to the 43rd American Heart Association Conference in Atlantic City, New Jersey, November 12-15, 1970.

J. D. Walton, HTMD, edited Radome Engineering Handbook: Design and Principles, New York: Marcel Dekker, Inc., 1970. He also wrote Chapter 5, "Inorganic Radomes," and N. E. Poulos, HTMD, wrote Chapter 1, "Historical Development of Radomes."

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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