EES NOTES

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

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EESN-2-70
February 27, 1970

In This Issue:

WATER POLLUTION CONTROL

Many improvements in man's way of living have resulted from the new molecules of the organic chemist's research. The new surfactants, for example, have eased the problems of the housewife in getting her clothes clean, even when living in hard-water areas.

Although synthetic surfactants have caused some problems in treating domestic waste water, many more problems have developed with industrial waste water. The textile industry, for instance, uses high concentrations of surfactants which are discharged to sewers after use in dye becks (reaction tanks of up to 4,000-liter capacity).

Domestic waste-water treatment destroys most of the new biodegradable surfactants which occur in the untreated flow at concentrations of two to five milligrams per liter. However, even the best biodegradable detergents are not readily destroyed when present at 200 mg per liter, especially when normal food also is available to the bacteria.

The textile industry generally uses a surfactant not commonly sold to the housewife. "Ekaline G. Flakes" (EGF) is partially degradable at low concentrations in a short time, but higher concentrations degrade very slowly, if at all. EGF is used at concentrations from 400 to 1,000 mg per liter in a dye beck as an aid to the adsorption of the dye. When the fabric has attained the right shade, the dye bath water is discharged and the beck is filled with an equal volume of rinse water. Since this water also is discharged directly to the sewer, waste-water treatment must degrade the surfactant from a final concentration of 200 to 500 mg per liter. Inorganic chemicals used to control the pH are included in the waste water along with the surfactant and dye.

The objective of our studies is to ascertain the environmental conditions necessary to degrade synthetic surfactants such as EGF. While some natural molecules are degraded almost exclusively under anaerobic conditions, those synthetic organic compounds which we have studied are degraded slowly, if at all, under these conditions. Furthermore, an observation of a quiescent pond with anaerobic conditions at one textile mill showed no evidence of bacterial activity.

Aerobic conditions were attained in the laboratory by bubbling air through the waste water. Antifoaming agents must be used in the laboratory. A sample of waste water containing a single dye was treated in the laboratory for 22 hours. Analysis showed that only a very small change in the organic matter concentration had taken place even though many bacteria from the mill's waste-water treatment facility were added initially. In the conventional technology of waste-water treatment, a substantial quantity of the bacteria is retained from day to day. We saved 20% of our

treatment mixture and added an aliquot (i.e., 80% of the reaction vessel volume) from dye-bath waste water. After 22 hours, 80% of this mixture was withdrawn and analyzed. The bacteria still were not able to degrade the surfactant appreciably. We continued filling, aerating, and withdrawing the treated waste water for four days before the effluent attained a good quality (before a high percentage of organic matter was destroyed). When the same seed bacteria were fed a smaller aliquot (50%) of the same waste water, a much higher percentage of the organic matter was destroyed during each 24 hours.

This example illustrates the procedure used for completing the chemical cycle. The synthetic organic chemicals (dyes and surfactant) are used in a desired process, and then the waste water is freed from the chemicals to restore its purity for preserving the esthetic value of the stream and/or for re-use.

Robert S. Ingols
Chemical Sciences and Materials Division

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SEA CLUTTER STUDIES

The term "sea clutter" is used in radar work to denote electromagnetic energy which is scattered from the surface of the sea. Sea clutter seriously limits radar detection of small targets (such as navigational buoys or small boats) on or near the surface of the water because the return signal from the desired target is immersed in the return from the surface of the sea. The inability to distinguish the presence or location of the desired targets presents a dangerous navigational condition.

The problems of predicting electromagnetic scattering from the sea and of reducing the radar effects of this scattering have not been solved, although extensive efforts have been made by research teams throughout the world since the early 1940's. The problems are very complex from a theoretical standpoint, and it is very difficult to conduct meaningful experiments in order to test hypotheses or to draw empirical conclusions.

The relative magnitude of the signal reflected from the surface depends upon factors such as the angle of incidence of the transmitted wave, the wavelength and polarization of the incident wave, and the state of the sea surface. One indication of the difficulty is the virtual impossibility of specifying adequately the state of the sea surface. Even a statistical description of the surface (including the spray and water droplets above the surface) depends upon several parameters: depth of water, contour and shape of the ocean bottom, presence of suspended or floating matter (e.g., sea weed, oil slick), incidence of swells from remote locations, currents, and proximity of land masses (including shape, location, type of shore, mountains).

The state of the sea surface depends strongly on the wind conditions: velocity, fetch, "history," and gustiness.

In the process of trying to understand the physical world around us, it is quite common to construct a model which incorporates certain qualitative ideas and which obeys certain quantitative rules of behavior. The model then can be used to explain or predict results of real-world observations. An outstanding example of this process is in nuclear physics, where models of the nucleus have been evolving for many years. In a similar manner, radar scientists have been evolving models to explain electromagnetic scattering from the sea.

Even though the nuclear physicist and the radar scientist are working in radically different environments, they both are attempting to explain phenomena in our physical world. Each is dealing with a very complex problem, and both have experienced only limited successes. It also can be said with reasonable certainty that, in both cases, many more years of work lie ahead before completely satisfactory models are realized.

The Electronics Division has been active in sea clutter studies since the late 1940's as one of its major areas of sponsored research. Early experimental measurements were made at Panama City and Port St. Joe, Florida; more recent measurements have been made at Mount Cadillac, Maine, and at Boca Raton, Florida. The Boca Raton site has been used most extensively; it was selected primarily because of the deep water located close to the shore. Much has been learned during the last 20 years -- but much still remains to be discovered.

R. C. Johnson
Electronics Division

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A STUDY OF INSECTICIDES

For some time, personnel of the Nuclear and Biological Sciences Division have been working on two projects concerned with the chemistry and toxicology of insecticides, specifically DDT and other "persistent" chlorine-containing insecticides.

The first project involves the synthesis of compounds of chemical structure related to DDT, and the study of the toxicology and the physical and chemical behavior of these substances in the metabolic processes of both insects and higher animals. The results obtained in this study throw new light on the biochemical changes undergone by DDT in living systems. The purpose of one aspect of this work is the development of new substances with the insecticidal properties of DDT but without the long-lasting qualities that made DDT undesirable.

In another aspect of this work, DDT has been converted to a sulfonic acid derivative which is non-toxic and will not be concentrated in the fatty tissues

of animals exposed to trace quantities. Unfortunately, it is improbable that this conversion of DDT to a non-toxic derivative is a feasible means for the chemical detoxification of DDT residues already present in the environment because of the high concentration of the chemical reagent required for the reaction.

The second project is a study of the chemistry and the toxicology of the products produced by the gamma irradiation of DDT in fat. The purpose is to determine what chemical and radiative changes occur in DDT residues present in foods that are preserved by gamma or X irradiation. The results to date indicate that the toxicity of DDT is not changed on irradiation; that is, no substance or substances more toxic that DDT itself are produced.

The chemical syntheses, the irradiations, and the chemical analyses of the irradiated materials were carried out at EES. Some of the simpler toxicological work also was done here. The more sophisticated toxicological studies using insects were conducted at the Communicable Disease Center laboratories in Savannah, and the toxicology on higher animals was done in cooperation with the Food and Drug Administration laboratory in Atlanta.

Raymond D. Kimbrough, Jr.
Nuclear and Biological Sciences Division

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APPLICATION OF TECHNOLOGY TRANSFER TECHNIQUES TO TWO CONTRASTING INDUSTRIES

In June 1968, the Office of State Technical Services, U. S. Department of Commerce, awarded research grants, to be matched equally by state funds, to the Industrial Development Division of Georgia Tech and the Industrial Extension Service of North Carolina State University for a two-year joint Special Merit Project. The purpose of the program is to demonstrate the application of technology transfer techniques to two contrasting regional industries. In North Carolina, the upholstered furniture industry, a traditional industry with a reputation for being relatively slow to take advantage of technological change, was selected. In Georgia, the mobile home industry, an emerging industry considered to be technically advanced and receptive to innovation, was chosen. The overall objectives of the joint program are to identify the most effective methods of technology transfer and to determine whether they differ for traditional and emerging types of industry.

In conferences between the two state groups, it was decided that three techniques for transferring technology would be evaluated -- group presentation, written material, and direct personal contact and in-plant assistance. These were considered to be parallel, possibly equal methods for dissemination of technology. For the Georgia Tech part of the project, a carefully selected sample of mobile home manufacturers was divided into three groups. Each time new technology is transferred,

all groups receive the same basic information, but a different transfer technique is used for each group. Subsequently, field personnel canvass the manufacturers to determine the degree of acceptance of the transfers.

Five transfers have been completed: The first transfer recommended the use of the patented "Gang-Nail" bowstring truss machine and connectors for the fabrication of roof trusses for mobile homes. The second transfer presented the use of urethane, foamed in place, as an insulation material for mobile homes. The third transfer recommended the use of a Teflon-S coating (a non-wetting, non-stick, low-friction material) on saw blades and other wood cutting and shaping tools. The fourth transfer utilized a management technique, "Management by Objectives," developed by North Carolina State. This was the only transfer not production-oriented. The most recent transfer presented production aids, i.e., an air receiver with multiple duct outlets and a cool light (fluorescent lamp) for use in the finishing stations of the mobile home production line. The sixth, and final, transfer is planned for March 1970; it will be a seminar on factors involved in the design of floor systems for mobile homes.

The rapid expansion of mobile home production in Georgia makes this industry of particular interest. The Mobile Home Manufacturers Association indicates that Georgia ranked third in the nation in the number of units produced in the first 10 months of 1969. During this period, 19,627 mobile homes were produced, a 48% increase over the same period in 1968. This burgeoning growth has resulted in an industry that is thinly staffed with experienced engineers and managers, which has compounded the difficulty of transferring technology.

Analysis and evaluation of the work will continue for inclusion in the joint final report in June. Results of the IDD part of the project thus far appear to confirm the greater effectiveness of direct personal contact in technology transfer.

Charles I. Poole
Industrial Development Division

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ADVANCED TECHNOLOGY APPLICATIONS CENTER

The Advanced Technology Applications Center (ATAC) is a project of the Office of Technical Services of the Board of Regents. The Center has representatives at Georgia Tech and the University of Georgia, and a third representing Georgia State and the other four-year colleges in the University System. The primary purpose of the Center is to provide a means by which Georgia industry can, on a subscription basis, have access to advanced technical information systems. It also is able to provide access for industry to the resources and capabilities of the Georgia University System.

The major information services are the retrospective search and the current awareness service. The retrospective search provides abstracts from the various information sources in response to a specific technical problem. A current awareness service is a periodic compilation (usually monthly) of information pertinent to the activities and interests of a company which subscribes. These searches can be performed either manually or by computer, according to the depth of information desired from the various sources and the availability of the computer-based sources.

For several years the Center has been using the automated retrieval system of the Aerospace Research Applications Center at the University of Indiana, which has the tape versions of the Scientific and Technical Aerospace Reports (STAR), International Aerospace Abstracts (IAA), Nuclear Science Abstracts (NSA), and The Engineering Index. In 1968 the University of Georgia Computer Center acquired the tapes of Chemical Abstracts Condensates, Chemical-Biological Activities (CBAC), Chemical Titles, and Biological Abstracts, and is currently performing many of the automated searches for subscribing companies. Present search programs which are used with the Chemical Abstracts tapes are based on word or word fragment matching with provisions for term weighting and AND, OR, and NOT logic. Several special thesauri and search guides are used to aid in question framing.

The University of Georgia Computer Center is in the process of acquiring the tapes of Nuclear Science Abstracts, Physics Abstracts, and others. Future plans call for providing access to these tapes for all units of the University System through the installation of terminals throughout the state. Demonstrations of this retrieval system will be held on the Tech campus at a time and place to be announced later.

Most of the manual searching, including retrospective searches, is done in the Georgia Tech Library by the staff of the Technical Information Section, headed by James B. Dodd. Mr. Dodd's section also handles inquiries which come to the library from out-of-state companies.

Presently ATAC has 25 member firms participating in this program, which is open to all interested firms in Georgia on a fee basis. Many members of the EES staff have participated in the program by assisting ATAC personnel in problem definition and information acquisition. Much of the benefit of this program to both the participating firms and the institutions of the University System has been due to the interest and cooperation of the staff of the Engineering Experiment Station and teaching faculty of Georgia Tech.

Henry C. Sawyer
Industrial Development Division
Georgia Tech ATAC Representative

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RADIOTRACER STUDIES OF FILTRATION MECHANISMS

Water is a basic human need, and we prefer that it be free of harmful organisms or substances, free of suspended matter, and palatable. With the increasing pollution of our water sources, improved methods and greater care are necessary if the water treatment industry is to continue to supply a high-grade product.

One widely used purification process is filtration through sand, which removes most of the suspended matter present. The art of filtration has been developed empirically to a high degree, but only within the last 20 years has attention been drawn to the scientific principles involved when particles are removed by deposition from water flowing rapidly through a porous bed.

There is a widespread idea that all filtration takes place at the surface of the sand; i.e., the sand acts merely as a strainer to remove those particles too large to enter the interstices of the sand. This notion is indeed correct for the larger particles, but an important part of the filtration occurs within the depth of a sand bed.

Using sized particles labeled with radioactive cesium-137, G. G. Eichholz and T. F. Craft have made a study of the pattern of particulate deposition within sand and anthracite beds. Their results have confirmed the theory that particles are removed in successive layers of a filter in proportion to their concentration at that level. Deposits therefore decrease exponentially with depth in the filter bed.

It has been further confirmed that the action of a filter bed is not the result of a single mechanism, but of several. Three distinct actions, dependent primarily on the size of the suspended particle and its size relative to the interstices of the porous bed, have been deduced. Particles too large to enter the openings between the grains of the bed are trapped on the surface; smaller particles may be collected lower down in the crevices between the grains and held by double-layer forces; and the behavior of particles a few microns in diameter is governed by electrical and van der Waals forces.

Studies are under way at present to apply this information to the improvement of sand filter design. Experimental equipment has been set up at the Atlanta Water Works to investigate filtration effects on "real water" with various filter bed configurations.

T. F. Craft
Nuclear and Biological Sciences Division

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SCHEDULING THE TRAVELING SALESMAN

One of the most intriguing problems encountered in operations research is the traveling-salesman problem. Simply stated, the problem is to find an optimal "tour"

through n locations or cities that starts at one location, visits each of the n-1 remaining locations once and only once, and returns to the starting location. An optimal tour is defined to be a tour of minimum total distance or cost.

Finding an optimal solution is difficult because the problem is essentially combinational and there are $(n-1)!/2$ solutions to the symmetric form of the problem. Two exact solution techniques are known, dynamic programming and the branch-and-bound method. The primary disadvantages of dynamic programming are that it requires on the order of $(n-1)(n-2)2^{n-3}$ calculations and more than $(n-1)2^{n-2}$ storage locations for an n-node problem. Consequently, practical application of dynamic programming to the traveling-salesman problem is limited to tours with few cities. The branch-and-bound method can handle larger problems, but the amount of computing time is unpredictable and increases rapidly with the size of the problem. It is estimated that computer time increases approximately by a factor of 10 for each increment of 10 in the number of nodes.

Many applications, however, do not demand optional solutions. Several heuristic algorithms exist which yield optimal or near-optimal solutions. These algorithms trade optimality for reduced running time or storage.

A promising technique for handling the traveling-salesman problem is to organize all tours in groups or classes, and then to eliminate from consideration entire groups of tours by examining only a few of them. In this way an overwhelming number of tours can be reduced to a reasonable number. A lower bound for the optimal tour can be deduced so that near-optimal tours may be obtained should one wish to place a restriction on computer time.

Though the problem is stated in terms of a traveling salesman, many applications to other types of problems might be mentioned, such as achieving minimum tool travel in the numerical control of manufacturing machines or the routing of railway freight cars.

Research in this area is being carried out at the Rich Electronic Computer Center. A systems approach has been emphasized to insure wide applicability of the program.

Charles A. Sparrow
I. E. Perlin
Rich Electronic Computer Center

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FELTED CERAMICS

A basic process for forming a ceramic product into large, flat sheets has been developed at Georgia Tech over the past several years. The process essentially involves water felting techniques long used in the paper-making industry to form

lightweight structures with controlled densities. Instead of combining cellulose fibers with various sizes as is common practice in making wallboard and acoustical tiles, the ceramic process combines inorganic fibers such as mineral wool, fiber glass, and alumino-silicate refractory fiber with a clay or refractory particulate material. The refractory material prevents excess shrinkage when the felted ceramic is sintered (heat treated at 1800° to 2500°F).

Felted ceramic boards can be processed rapidly on modified fourdrinier or cylinder machines, which commonly are used to make wallboard and ceiling tiles. The dry felted ceramic boards (prior to firing) have the unusual property of being nearly as strong and tough as sintered boards. A dry board can be handled much more roughly than a common dry ceramic body; it can be cut, drilled, and machined with conventional tools. Thus, it is possible for the ceramic boards to be felted and dried in one location and shipped to another location for firing.

The felted boards can be fabricated with final fired densities ranging from 30 to 80 pounds per cubic foot. They can be used as fired or glazed to make them impervious to moisture and to enhance their esthetic appeal.

Felted ceramics have almost unlimited potentials for use, such as in ceramic wallboard, acoustical tile, table, stove and counter tops; refractory boards, pipes, crucibles; leading edges and nose cones for missiles and space vehicles; chemical filters and catalyst supports. The realization of these future applications depends upon the imagination of ceramic industry researchers.

J. N. Harris
High Temperature Materials Division

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HUMAN HAIR IN MEDICAL DIAGNOSIS

The human hair root is one of the most active tissues in the body, both metabolically and mitotically. Since the root is estimated to reproduce its own mass in protein every 24 hours, it is sensitive to both local and systemic events. Despite this, only sporadic attempts have been made to utilize this tissue as means of assessing diseases or traumas.

On the other hand, because of their long-standing commercial importance, wool and other animal hairs have been the subject of extensive measurements made with various physical and analytical procedures. Human hair until relatively recently has been neglected as a subject of study except for studies related to the cosmetic industry. With the advancement of molecular biology, hair keratin has received increasing attention. These studies have been based on the extensive knowledge accumulated in wool research.

Of recent medical interest is the association of various hair defects and alopecia (hair loss) with abnormalities of amino acid metabolism. The clinical syndrome of arginosuccinaciduria, characterized by severe mental retardation, convulsions, atypical electroencephalogram, liver dysfunction, and a hair defect, Trichorrhexis Nodosa, has stimulated renewed interest in human hair research. It is quite probable that early recognition of this hair defect and the institution of a corrective diet early in life may minimize otherwise irreversible brain damage. With this in mind, Dr. A. C. Brown, Emory University Hospital, and Dr. R. G. Crounse, Medical College of Georgia, initiated comprehensive studies in cooperation with the late R. B. Belser and several other Georgia Tech scientists.

In the past several years, new techniques and methods of instrumentation have been developed which permit new insight into hair composition and structure. These include the scanning electron microscope, the electron microprobe, neutron activation analysis, and the double beam infrared spectrometer. Advanced micromechanical instrumentation which permits the plotting of analog data on the minute forces occurring in fiber bending and between the frictional surfaces of single cross-fiber pairs is a recent addition. X-ray scattering continues to be a very important tool for the investigation of keratin structure both at the molecular level and at higher levels of organization.

In a particular case of a congenital hair defect, neutron activation and microprobe analyses showed a deficiency of sulphur, and amino acid analysis showed a deficiency of crystine. Scanning electron micrographs showed loss of normal overlapping-plate exterior structure in the low-crystine regions and abnormal twisting of the hair filaments. Micro-mechanical measurements showed abnormal surface friction for the defective hair.

The disulphide bond (-S-S-) supplied by cystine in keratin is thought to be a principal source of structural stability of a hair filament. The lack of sufficient sulphur might be expected to permit other forms of cross-linking to develop. In the case cited, the hair is abnormally brittle. Small-angle X-ray scattering studies should be able to confirm whether the brittleness is associated with an unusual degree of cross-linking, such as occurs in β-keratin or, even more, in supercontracted keratin. Quantitative studies of optical rotary power can establish whether the brittleness may, on the other hand, be due to an abnormally large proportion of coiled vs. globular domains.

Several persons from the Physical Sciences Division and the Nuclear and Biological Sciences Division have participated in this work.

R. A. Young
Physical Sciences Division

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HOWARD DEAN TO PROVIDE ADDED EMPHASIS FOR HOUSING AND ENVIRONMENTAL ACTIVITIES

Howard G. Dean, Jr. recently joined the EES staff as a Special Assistant to the Director to work on development of sponsored research programs. First emphasis will be on housing resources, but other areas of attention will be solid waste disposal and related environmental problems. He will be working with Georgia Tech organizations that have interests in these areas.

Howard Dean is an honor graduate of Georgia Tech, receiving a degree in electrical engineering in 1943 under the co-op program. He did advanced work in electronics and radar at Harvard and M.I.T. A former member of the EES staff for six years, he left the Station in 1959 to become manager of the systems engineering department at Scientific-Atlanta, Inc. He was made a vice president of the firm in 1962 and later became president of a subsidiary company as well. He rejoins us while on a two-year leave of absence from Scientific-Atlanta.

His previous work at EES involved participation in and direction of various operations research and radar systems projects. Other prior experience includes missile guidance and control work at Redstone Arsenal, navigation and communications systems with the FAA, and assignments as an electronics officer in World War II.

He has been active for a number of years as a member of the Industrial Development Council of the Georgia Chamber of Commerce and has participated in various technical advisory committees and special study groups for the DeKalb Area Technical School.

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PROFESSIONAL ACTIVITIES

AIChE National Meeting

Georgia Tech faculty members had major responsibilities in the organization and conduct of the second largest National Meeting of the American Institute of Chemical Engineers, which was held in Atlanta February 15-18, 1970. Present at the 67th National Meeting were 1,349 registrants. Sixty-four half-day Technical Sessions were held, involving 111 chairmen and co-chairmen, 47 panelists, and the presentation of 278 papers. Twenty-six committee meetings also were held.

Participating in arrangements for the meeting were 17 people from Georgia Tech. Henry A. McGee, Jr. was Technical Program Chairman; serving with him were President Arthur G. Hansen and G. L. Bridger. W. R. Tooke, Jr. was General Chairman of the Arrangements Committees. Serving under him were: G. L. Bridger, Auditor; Paul Weber (Chairman) and J. W. Mason, Finance Committee; Fred Bellinger (Chairman), H. C. Lewis, and Clyde Orr, Jr., Hotel and Meeting Rooms Committee; W. H. Burrows (Chairman) and Frank Clarke, Publicity; H. C. Ward (Chairman), C. W. Gorton, H. V. Grubb, W. M. Newton, M. J. Matteson, and J. D. Muzzy, Registration.

G. L. Bridger was vice-chairman of a two-part symposium on "The Role of Chemical Engineers in Solving World Food and Fiber Problems." Niels Engel chaired a symposium on "The Chemical Viewpoint Applied to Metallurgy" and read a paper on "The Properties of Metals." Other papers by Georgia Tech faculty members were "Theory of Metal Dusting in Iron-based Metal Alloys," by R. F. Hochman, and "The Behavior of Fluorosilicones as Lubricants," coauthored by W. O. Winer with R. E. Smith and E. D. Groenhof of Dow Corning Corporation.

Frederick Bellinger
Chemical Sciences and Materials Division

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Other Activities

Jerry B. F. Champlin, NBSD (now at Westinghouse Electric Corporation), had a paper on "Void-Space Analysis by Use of Thermal-Neutron Irradiated Air (^{41}Ar)" published in the March 1970 issue of Nuclear Applications and Technology.

John E. Husted, CSMD, presented a paper on "University Research in Industrial Minerals" at the AIME National Meeting in Denver, Colo., February 15-19. He also participated as a member of the Education and Mining Handbook committees.

An article on "Technology Transfer to Mobile Home Industry in Georgia" by Charles I. Poole, IDD, appeared in the January 1970 issue of State Technical Services Newsletter, a U. S. Department of Commerce publication.

George I. Whitlatch, IDD, presented a paper on "Industrial Sites -- Selection and Development" at the Second Annual Georgia Community and Resource Development Conference, Industry Section, held at the University of Georgia Continuing Education Center February 17-18.

NBSD staffers participated in a technically oriented lecture and panel discussion on "Nuclear Energy and the Georgia Tech Nuclear Research Center" held on February 10 at the Nuclear Research Center for the Atlanta Chapter of the Armed Forces Communications and Electronics Association. Panelists were R. L. Zimmerman, R. M. Boyd, and J. R. Wright. Present were about 30 members of the Association, which is made up of management personnel from the U. S. Army, Bell Telephone, Western Electric, IBM, GE, Georgia Power, and other companies.

Robert B. Cassell, IDD, is second vice president of the American Industrial Development Council and executive director of the Southern Industrial Development Council.

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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
Rich Electronic Computer Center	John P. McGovern