EES NOTES

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

In This Issue:

EESN-1-69
October 31, 1969
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Arthur L. Bennett
Martha A. Deadmore

EES NOTES

This issue of EES Notes initiates a monthly publication of brief articles concerning recent scientific and technical developments. Articles and announcements written by members of the research staff of EES will provide the major content, with occasional contributions by others. It is designed to improve internal communications, and will be circulated to the professional personnel of the Station. Copies also will be sent to other interested persons (see back page about distribution).

The Notes will include articles on programs in progress and the results of completed projects. Abstracts of EES technical reports that stress relevance to solutions of national or local problems, as well as potential applications to Georgia industry, will be encouraged. Highlights of technical meetings or seminars also may be of interest. Summaries of papers prepared for presentation at meetings or for journal publication will sometimes be appropriate. Brief descriptions of potentials of new or unique instruments and techniques also will be pertinent. From time to time, short write-ups on the technical background and duties of new senior staff members will be included.

Technical editorship of the Notes will be rotated among senior staff members of EES. Continuity will be provided by a permanent editor. A coordinator from each division (appointed by the division chief) will assist in selecting material for publication. These coordinators are listed on the back page.

Because of the brevity and relatively nontechnical style desired, EES Notes is not to be considered a part of the engineering or scientific literature. Nevertheless, this publication will provide the author with a limited but important group of readers.

Some readers will recognize similarities between EES Notes and the highly successful European Scientific Notes, published by the London Branch of the U. S. Office of Naval Research. Differences in format and coverage reflect our special purpose of providing timely information on activities concerning EES -- a small but important step toward improving our technical communications.

M. W. Long

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ONE ATTEMPT TO FILL A VOID

One of the most tiresome of the cliches of the modern educational world is that gem, "Our major problem is communications." For years, the entire blame for this state of affairs was put directly upon the communicator. But recent studies indicated that quite the reverse is true -- people just are not reading what comes across their desks.

And no wonder. Besieged by mass media of all types, beleaguered by technical reports, books, pamphlets, and correspondence, the poor reader must spend too much of his time just ferreting out those things that might help keep him abreast of his own field and of the general condition of the world around him.

Out of this quandary has emerged a new popularity for the digest concept of publications. Tech has several of these currently in its publications program, with the most successful of them being Tech Topics, the bimonthly newsletter. But until the appearance of EES Notes, no attempt has been made to use this concept to keep members of a segment of the Tech community up-to-date on technical happenings in a nontechnical style. In an organization as large as the Engineering Experiment Station, this type of communication is most necessary.

EES Notes obviously is not in conflict with any publication now being produced or distributed on this campus. It will be watched with interest by this office for the selfish reason that it should prove a source of leads on feature material worthy of expansion in publications such as Science and Technology/Today, Technology and Mankind, and The Georgia Tech Alumnus. But more importantly, it will be observed for its ability to communicate important information to its audience. If it works, expansion of the concept is inevitable.

Robert B. Wallace, Jr.
Director of Information Services
and Publications

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NASA AWARDS FOR F. L. GRISMORE, JR. AND J. E. RHODES

The Chairman of NASA's Inventions and Contributions Board, E. W. Brackett, recently informed M. W. Long, Director of EES, that F. L. Grismore, Jr. and J. E.

Rhodes each have been awarded $25 in appreciation for their contribution to the NASA Tech Briefs. The Briefs are issued to summarize specific innovations derived from the U. S. space program in order to encourage their commercial application. Brief 69-10060, dated March 1969 and reprinted below, describes work done by Grismore and Rhodes in the Physical Sciences Division under contract to the Marshall Space Flight Center.

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OPTICALLY EXCITING A MAGNETIC MEMORY: A FEASIBILITY STUDY

A study has been made to determine the feasibility of modifying the magnetic moment of a magnetically ordered material by optical pumping for application to digital memories.

The potential of optically addressed (often referred to as beam addressable) digital memories has been considered by a number of workers and is presently an area of much research. The goal to which these efforts are directed is the achievement of high-density bulk memory with storage capacity of approximately 10^8 bits. This density can be achieved in reasonable size, for example a planar area of 10 x 10 cm, with bit resolution of 10 microns. Such a bit size is about an order of magnitude larger than diffraction-limited resolution of visible light. Thus, optical approaches appear attractive. In addition, the interaction of polarized light with magnetic materials exhibiting the magneto-Kerr effect and Faraday effect provides a means for detecting the magnetization state of a local region via reflection or transmission providing communication with the "store" without interconnecting wires.

The limiting operation, however, in all presently proposed memory schemes is the write process. This has generally been accomplished by applying heat to the lattice in order to effect a change in coercivity of a local spot. The heat source may be a laser or electron beam; both have been proposed and experimentally studied. The use of temperature changes to modify the magnetic state of a memory medium introduces speed performance limitations. In addition to the relatively long thermal time constants, another problem associated with thermal excitation is that of thermal creep. In order to prevent adjacent bit disturbing effects it appears necessary to provide thermal barriers between storage element locations. This results in a reduction of achievable storage density and increases the fabrication process complexity. To overcome these limitations associated with thermal excitation, the study sought to determine the feasibility of optically pumping a magnetic material to effect the switching process. This approach provides the potential of achieving excitation and decay times in the sub microsecond range without the problem associated with thermal creep. The experimental work to date has been directed toward the rare earth iron garnets. These materials show a rapid change in coercive force versus temperature at the antiferromagnetic compensation temperature. This effect is attributed to the fact that slight variations in temperature cause a net magnetic moment to exist. A technique is therefore being sought for holding the lattice temperature constant while the magnetic moment is changed by optical excitation.

It is apparent from the study to date that the gadolinium iron garnet crystals grown by the present molten flux technique will not exhibit the desired characteristics. The conduction band causing the large competing absorption is probably a characteristic of the iron-oxygen combination rather than impurity-induced interband gap levels. As such, the rare earth garnets are all limited by this absorption edge. Only terbium and dysprosium offer a possibility of pumping at energies below the conduction band edge. Antiferromagnets overcome the problem of lattice phonons creating uncompensation, but little is known of the optical properties of the potentially useful materials.

The concept of uncompensating an antiferromagnetically ordered system is of significant interest both theoretically and practically. The significance of achieving 10^8 bit high-speed random access computer memories with passive element reliability should not be understated. Optical pumping is considered a powerful approach towards achieving that goal.

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ADVANCED NUCLEAR ROCKET RESEARCH AT GEORGIA TECH

The world watched while man recently first set foot upon the moon. Many are now wondering whether man will go on to inhabit Mars and the planets beyond, or be satisfied just to send a few instrumented probes. Pressure is on the governments of the nations involved to divert funds from space programs toward solving problems of people on the ground.

Space travel is expensive. A single Saturn 5 launch costs $120 million. The cost of putting material into earth orbit is about $1,000 a pound. The costs of manned trips to the planets would be astronomical. It is no wonder that today the commercial exploitation of space may appear to be hopeless.

Two approaches may be taken to reduce the high cost of space flight. The first is to get away from the ammunition concept of rockets and develop reusable space ferries. If a jet airliner could be used for only one flight, the cost of an airline ticket would be over $10,000. NASA is pushing the development of reusable rockets which would bring the cost of putting things in orbit down to about $100 a pound. Although this would lower the cost by a factor of ten, space travel still would be expensive.

The other approach is to develop higher performance propulsion systems for space vehicles so that much smaller, and correspondingly cheaper, rockets could be used. These smaller rockets would use less propellant, so refueling costs could be less. Reusable rockets using very high performance propulsion systems could make space travel relatively cheap.

High performance generally means high exhaust velocity and high thrust per pound of engine weight. The exhaust velocity is important because the higher the velocity of the rocket exhaust the less propellant required to produce a given thrust. A rocket with a high exhaust velocity would be smaller than a rocket with a lower exhaust velocity designed to execute the same mission.

NASA, the Atomic Energy Commission, and the Air Force are investigating several different types of advanced propulsion systems, but only three appear to offer the potential for high exhaust velocity and high thrust-to-weight ratio. These are the nuclear-pulse rocket, the gaseous-core nuclear rocket, and the fusion-propulsion rocket. The nuclear-pulse rocket would use nuclear explosives to provide thrust, but work on this concept has now been abandoned because of the necessarily very large size and corresponding high cost of each rocket. Fusion propulsion is currently being investigated, but the feasibility of such a system probably will not be established until fusion power becomes a reality. The gaseous-core nuclear rocket, which would employ a fissioning gas as the energy source, appears to be the most promising approach to a high performance rocket that will make space travel inexpensive.

Several different designs of gas-core nuclear rockets are currently being investigated. Each of these concepts would use hydrogen containing small particles as the propellant. The small particles are necessary to enable the hydrogen to absorb heat from the hot, gaseous uranium. The hydrogen must be heated to a very high temperature in the engine so that it will have a high velocity when it is exhausted from the rocket. Hydrogen is used because it has a higher molecular velocity than any other gas at the same temperature.

The selection of the material to produce these particles is very important, and in order to predict the performance of a particular gas-core rocket engine the heat transfer parameters of hydrogen seeded with particles of the material must be known. These parameters are currently being measured at EES under continuing support from NASA by J. R. Williams and J. D. Clement.

The heat transfer parameters have been measured for hydrogen containing very small particles of carbon, tungsten, and silicon at temperatures to 3500^{o}F at one atmosphere pressure. The current effort is aimed at making these measurements at

100 atmospheres at temperatures to 4500^{o}F. NASA is assisting in obtaining radio-frequency heating equipment to permit measurements at much higher temperatures.

These data will be used to design the first gas-core nuclear rocket engines. Plans are currently being made in NASA for construction of a nuclear rocket engine of this type and the required test facilities, starting about 1975. If the gas-core nuclear rocket development program remains on schedule, NASA planners are seriously considering using this rocket for the first manned trip to Mars if this trip is delayed until the late 1980's or 1990's.

Another application of the gas-core nuclear rocket engine is receiving serious consideration. Large electric power plants using the newly developed hydrodynamic (MHD) topping cycle can be efficient because of the increase in operating temperature feasible with MHD. The exhaust from the MHD generator can be used to produce steam for conventional turbines before being returned to the reactor. The advantages of the higher efficiency are reduced fuel costs and greatly reduced thermal pollution. Preliminary calculations indicate that thermal efficiencies of 50% to 60% are reasonable for such plants. Thus, gas-core reactors may serve not only to provide power for space propulsion but also to greatly alleviate the problem of thermal pollution on the earth.

J. R. Williams
Nuclear and Biological Sciences Division

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ACTIVITIES OF THE OFFICE OF RADIOLOGICAL SAFETY

The Office of Radiological Safety has the campus-wide mission of advising principal investigators in the safe use of ionizing radiation for research and teaching purposes. In all matters affecting radiation health and safety the Radiological Safety Officer reports directly to the President. Administratively, the Office of Radiological Safety (ORS) functions as a part of the Nuclear and Biological Sciences Division of the Engineering Experiment Station.

Each principal investigator is responsible for the safe conduct of any work at Georgia Tech involving the use of hazardous materials or equipment. If his work involves the use of ionizing radiation, he must obtain the approval of the Radioisotopes Committee (or the Nuclear Safeguards Committee if one of Tech's two nuclear reactors is the research tool). The investigator's administrative problems are eased considerably through the cooperation of the Office of Radiological Safety. Assistance provided by the ORS includes the following items:

Consultation in the planning of experiments with the aim of providing necessary conditions for the safe conduct of the experiment with the minimum in additional cost and delay. This assistance is especially valuable for those who are inexperienced in using ionizing radiation.

Handling licensing contacts with appropriate offices of the U. S. Atomic Energy Commission and the Georgia Health Department.

Providing liaison between license compliance inspectors and radiation users. Frequently the ORS maintains information sufficient for the inspector so that he is able to bypass certain laboratories.

Provision of film badges and other personnel-monitoring devices and maintenance of records.

Arranging for medical examinations which are required by the Radioisotopes Committee and paid for by the ORS.

Review and approval of proper orders for radioactive materials. Frequently, the ORS can suggest alternative sources of supply or supply a suitable isotope without charge from its inventory of radioactive material which is no longer in use on the campus.

Receiving all shipments of radioactive material, checking for leakage, storing, distribution of the material upon request, and maintenance of a central inventory record to supplement the investigator's record.

Pickup, storage, packaging and shipment to the burial ground in Kentucky of all radioactive waste material.

Calibration of radiation dose-rate survey meters which are the property of research projects.

Provision, wherever possible, of radiation survey meters for temporary use of short-term projects.

Performance of radiation safety surveys in laboratories to supplement those surveys which the principal investigator and his staff are required to perform.

Maintenance of a stock of radiation safety supplies, such as signs, rope, tape, plastic bags, which may be needed infrequently but urgently by the investigator.

Assistance in training an investigator's staff for work under Georgia Tech rules by holding quarterly a six-hour class on applied health physics.

From the beginning of an organized radiation-safety program at Georgia Tech, we have been required to comply with AEC regulations regarding the safe use of reactor-produced radioisotopes. Naturally occuring isotopes such as radium and machine-produced radiations such as those associated with X-ray machines, electron microscopes, and neutron generators have not been regulated by governmental agencies. The Office of Radiological Safety, with the authorization of the President of Georgia Tech, has required that good radiation safety practices be maintained on these unlicensed sources. On December 15, 1969, the State of Georgia will assume certain regulatory authority from the U. S. Atomic Energy Commission. At about the same date, the State will begin enforcement of new regulations concerning the safe use of all sources of ionizing radiation. The State law regarding machine-produced radiation is considerably more comprehensive than any previously in effect in other states. The burden will fall on the investigators to be certain that their radiation-producing equipment complies with the law. In many cases, modifications must be performed. As an example, none of the approximately 60 X-ray diffraction machines presently used on the campus comply with the new standards without modification. The ORS has studied the new regulations in detail and can offer considerable assistance to investigators in deciding upon the most efficient methods of modifying their machines.

The Office of Radiological Safety has traditionally received the support of the administration of Georgia Tech to aid the Institute in becoming a recognized leader among colleges and universities in establishing an effective applied health physics program. Several universities have used portions of the Georgia Tech program as a model. The first conference of university radiation safety officers was held at Georgia Tech in 1967. The State Board of Regents has appointed Tech's Radiological Safety Officer to be "Consultant in Radiation Safety" to other units of the University System. Any state-affiliated college in Georgia may call on the ORS for advice on specific problems in developing a radiation safety program suited to its needs.

All persons at Georgia Tech who are considering the use of ionizing radiation at Georgia Tech for the first time in their research and teaching programs are urged to contact the Radiological Safety Officer early in their planning to facilitate the most efficient and safe use of radioactivity.

Robert L. Zimmerman
Radiological Safety Officer
Nuclear and Biological Sciences Division

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IDD STUDIES STEEL INDUSTRY POTENTIALS IN GEORGIA AND THE SOUTHEAST

More than one-half the steel mill products used in the Southeast have to be brought in from northern mills or from abroad. And Georgia is a strategic location for additional steelmaking facilities to serve this rapidly growing steel-deficit area.

These are among the major findings of a recently completed research project of the Industrial Development Division. Impetus for undertaking the study, which was conducted without outside sponsorship, was provided by a recognition of several significant changes in the steel industry as well as the dynamic economic growth of the Southeast. These developments have made the region, traditionally a deficit area, increasingly attractive as a location for additional steelmaking and steel fabricating capacity.

The objectives of the study were to determine the extent of the imbalance between steel supply and demand, to identify specific steel fabricating opportunities, and to point out the potentials in Georgia.

Several factors have caused the U. S. steel industry, historically raw material-oriented, to place more emphasis on location in relation to markets in recent years. The advent of the electric furnace has made feasible the production of small volumes of steel with much lower capital outlay. Because it uses scrap as raw material, it frees steelmakers from dependence upon coal and iron ore, permitting much greater flexibility in choice of plant location. In addition, a combination of such technological advances as vacuum degassing and continuous casting offers exciting possibilities for the future -- the highest quality of steel produced at the lowest cost.

Iron ore production in the U. S. has declined substantially, while imports of foreign ores have increased steadily since the end of World War II. The main reason is that imported ores yield a more favorable price-quality ratio in the blast furnace than domestic ores, thus bolstering the competitive potential for U. S. steel mill products in world trade as well as in the domestic market. The recent development of jumbo tankers for volume transportation makes foreign ore even more attractive and enhances the potentials of deepwater ports as sites for steelmaking facilities.

With the abandonment of the "Pittsburgh-plus" and multiple basing-point pricing systems and the adoption of the freight equalization practice generally followed today, the traditional steel-producing areas have lost much of their artificial economic advantage in selling to the national market. By serving the southeastern market from a location within the natural market area rather than from northern mills, millions of dollars can be saved in shipping costs alone on a volume which is approximately the output of a small to medium-sized steel plant.

Less than one-half of the current demand in the six-state Southeast (Georgia, Alabama, Florida, North Carolina, South Carolina, and Tennessee) is supplied by producers in the area. Of the 7.4 million net tons of steel mill products used by area fabricators in 1967, more than 4 million tons had to be shipped in from outside the region, including 1.1 million tons from foreign countries. Area consumption is expected to grow by more than 360,000 tons a year until 1975 and by even larger increments thereafter.

Consumption of domestic steel mill products (excluding imports) increased three times as rapidly in the Southeast as in the nation as a whole between 1960 and 1967. Projections made during the course of the IDD study indicate that demand in the six-state area will reach 10.5 million tons by 1980, nearly double the 1967 "reported" demand (approximately 85% of estimated total demand for domestic products). This would represent 9% of the U. S. total, compared with 6.4% in 1967.

The burgeoning demand comes from the area's large and growing steel fabricating complex. Employment in southeastern fabricating plants more than doubled in the

1957-1967 decade, reaching a total of nearly 500,000 workers in about 2,000 plants -- nearly three times the percentage growth record for the U. S. During this time, the area's total primary metals industry increased employment by only 4.5%. The result has been a steadily widening gap between supply and demand.

Georgia has three major locational advantages for serving the southeastern market -- lower freight costs, faster delivery, and lower labor costs than are found at major steel-producing centers. This market can be exploited by large, established companies, by smaller, local firms, or by foreign steel producers. Three types of steel mills might be established in Georgia: a mill with electric furnaces and continuous casting facilities, utilizing scrap iron and steel; a facility in a port area using imported ores; and possibly a plant based on local ores (although the extent of the tonnage available in Georgia is currently unknown).

The study also preliminarily identified 29 steel fabricating industries which might be manufacturing opportunities for the state. They include items as diverse as commercial forgings, household appliances, transportation equipment, and metal toys and games.

Tze I. Chiang
Martha Ann Deadmore
Industrial Development Division

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NEW EES BUILDING

During October, the move by the administrative offices of the Station and the Physical Sciences Division to the new EES building in the northwest expansion area of the campus began.

For the first time, the personnel and laboratories of the Physical Sciences Division are under one roof, having been brought together from the Chemical Engineering/ Ceramics Engineering Building, the old Physics building, the Administration Annex, and the Hinman Research Building. Laboratories and research groups located in the new building are the Analytical Instrumentation Laboratories, Crystal Physics Branch, Special Problems Branch, and the Solid State Branch.

The new physical sciences research laboratories bring to our scientific and technical staff long-awaited opportunities to fulfill commitments to advancing technologies. For the first time, the Institute can boast of a clean room facility for microelectronic assembly and testing that will equal any in the Southeast; student preparation rooms and an instrument to be set aside for student use in electron microscopy; screen rooms for the isolation of patients from stray environmental electrical interference to monitor very weak body signals, such as heart (EKG), other muscle (EMG), and brain activity.

Administrative offices relocating from the Hinman Building include those of the Director, Assistant Director, Accounting, Supply Services, and Reports and Procedures.

The new building is a large step forward in providing needed work area. It is permitting the High Temperature Materials Division to return to the campus after 10 years in substandard, temporary quarters at Chamblee; they will be housed in the Hinman Building. However, the Chemical Sciences and Materials Division remains in scattered temporary housing, and the Industrial Development Division still is located in off-campus rented space.

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A NOTE TO POTENTIAL CONTRIBUTORS

Contributions to EES Notes should be concise and readable, ranging in length from one or two-paragraph announcements to articles not exceeding two pages. Technical jargon and specialized terminology should be kept to a minimum, since readers will come from many disciplines. While the content should be on a professional level, the style should be relatively informal and nontechnical.

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	Henry 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

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DISTRIBUTION OF EES NOTES

Distribution of EES Notes to division personnel will be handled by the office of each division chief. Copies will be sent directly to other persons on a selected mailing list. Requests to be placed on the mailing list should be made in writing to Martha Ann Deadmore by campus mail or at the following address:

Industrial Development Division
Georgia Institute of Technology
1132 West Peachtree Street, N. W.
Atlanta, Georgia 30309

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