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EUROPEAN SCIENTIFIC NOTES VOLUME 37 NUMBERS 12(U)
OFFICE OF NAVAL RESEARCH LONDON (ENGLAND) L E SHAFFER
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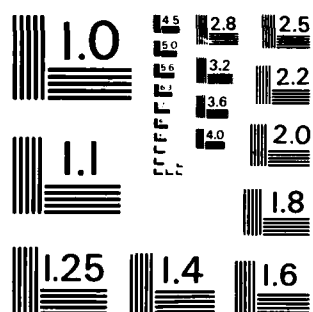
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EUROPEAN SCIENTIFIC NOTES

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 37-12	2. GOVT ACCESSION NO. 10-4135883	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EUROPEAN SCIENTIFIC NOTES		5. TYPE OF REPORT & PERIOD COVERED Monthly December
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Larry E. Shaffer, editor		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Office of Naval Research Branch Office London Box 39 FPO NY 09510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE December 1983
		13. NUMBER OF PAGES 60
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) European Scientific Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the USAF		

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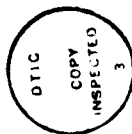
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**EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON**

Edited by Larry E. Shaffer

December 1983
Vol 37, No. 12

**BIOLOGICAL
SCIENCES**

International Symposium on Bioelectrochemistry Martin Blank 439

The meeting dealt with a broad range of topics reflecting the current emphasis on membrane function and structure.

Scottish Development Agency Boosts Biotechnology Thomas C. Rozzell 439

Scotland has started to increase its support of biotechnology research. A government agency is helping to develop the health-care industry in Scotland and is fostering the medical, industrial, and process uses of biotechnology.

CHEMISTRY

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The Dynamics of Polymer Solutions Vivian T. Stannett 442

A meeting of the Macromolecular Club in Uppsala, Sweden, focused on the dynamics of polymer solutions.

**COMPUTER
SCIENCES**

A General Operator Processor for Image Processing J.F. Blackburn 444

The University of Linköping, Sweden, has developed a special computer, the General Operator Processor, for processing structural information.

The Alvey Program: Update and Assessment J.F. Blackburn 447

The Alvey program on fifth generation computer systems is off to a fast start. A comprehensive plan exists, and the program is well under way. However, there are areas of concern.

EARTH SCIENCE

Engineering Geology of Tidal Rivers Robert Dolan 450

The Regional Conference of the UK Geological Society's Engineering Group dealt with topics ranging from site-specific case studies to the applications of geotechnical methods.

- The 18th IUGG: Oceanography, Geodesy,
and Geophysics D. Conlon and John G. Heacock 452

The 18th International Union of Geodesy and Geophysics met in Hamburg during August. This article highlights some of the papers dealing with oceanography, geology, and geophysics.

ENERGY

- Egypt's Energy Crisis Robert Dolan 453

Because of the present system of subsidies for petroleum and electricity, Egypt is making little progress in developing alternative sources of energy.

ENGINEERING

- Leeds-Lyon Tribology Conference Harold G. Elrod 454

Held from 5 through 9 September, in Villeurbanne, France, the symposium dealt with applications of numerical and experimental methods to tribology.

GENERAL

- Toward a European Research and Science Strategy Thomas C. Rozzell 455

The Commission of European Communities recently proposed a new scientific and technological strategy designed to build the foundation for a community research policy.

MATERIAL SCIENCES

- Fiber Composite Materials in the UK:
Royal Aircraft Establishment Tsu-Wei Chou 456

This is the final article in a series reporting research on fiber composite materials in the UK.

- First International Symposium on Structural
Crashworthiness R.W. Armstrong 458

The First International Symposium on Structural Crashworthiness was held at the University of Liverpool in September. A special issue of the *International Journal of Impact Engineering* includes some of the papers presented. The international conference and exposition "Structural Impact and Crashworthiness" is to be held 16 through 20 July 1984, at Imperial College, London.

- Research on Ultrahard Materials at Exeter R.W. Armstrong 459

Synthetic cubic boron nitride (amborite) and diamond (syndite) are among the ultrahard tool cutting and machining materials being studied--mostly by hardness testing methods--at the University of Exeter, Department of Engineering Science, with support from De Beers Industrial Diamond Division Ltd.

- The Sixth European Sea Horse Institute Meeting:
Materials in Marine Environments James F. Jenkins 461

The meeting dealt with materials in heat exchangers, design and operation of heat exchangers, materials in seawater handling systems, biofouling in seawater systems and heat exchangers, and materials in structural applications.

OCEAN SCIENCES

- A Perspective on the Oceanography of Straits D. Conlon 464

Although sea straits have been important to economic, social, and military history, they are among the least-understood aspects of the ocean. This article examines the status of research on sea straits.

- Marine Science of the Northwest Indian Ocean Robert Dolan 466

The main topics of a conference hosted by the University of Alexandria, Egypt, were physical, chemical, geological, and biological oceanography; living and nonliving resources; and marine pollution.

- Whitecap Workshop Held in Ireland Chester McKinney 470

The Whitecap Workshop's central theme was the relation of multiple environmental factors to the generation of whitecaps at the ocean-atmosphere interface.

PHYSICS

- A New Diagnostic Technique for Collective Ion
Acceleration David Mosher 472

The Weizmann Institute of Science in Rehovot, Israel, has developed a new diagnostic tool to probe the structure of the electric field in collective ion acceleration experiments.

- Energy-Transfer Processes in Condensed
Matter B. Di Bartolo and R.L. Carovillano 475

A NATO advanced study institute considered the basic mechanisms by which electronic excitation energy, initially localized in a particular constituent or region of a condensed material, is transferred to other parts of the system.

- The Physics of Electronic and Atomic Collisions B.R. Junker 478

The Thirteenth International Conference on the Physics of Electronics and Atomic Collisions included discussions of clusters, dielectric recombination, ionization processes, and three-body Coulomb breakups.

- Thermal Sputtering in Metals I.S.T. Tsong 481

Does thermal sputtering really exist? This question was addressed recently by a panel at the 10th International Conference on Atomic Collisions in Solids.

The 11th International Congress on Acoustics	Chester McKinney	483
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The 11th International Congress on Acoustics met in Paris from 19 through 27 July. The meeting covered all the technical areas of the broad field of acoustics--ranging, for example, from musical to psychological to underwater acoustics.

SPACE SCIENCE

ESA Holds Spacecraft-Charging Symposium	R.L. Carovillano	485
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The 17th ESLAB Symposium, "Spacecraft-Plasma Interactions and Their Influence on Field and Particle Measurements," was held in Noordwijk, the Netherlands, from 13 through 16 September.

European High-Energy Astronomy and Cosmology	Herbert Gursky	486
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A symposium hosted by the Bulgarian Academy of Science dealt with the observation of collapsed objects and with cosmological investigation involving high-energy particle physics.

Historical Records in Geophysics	R.L. Carovillano	489
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A session at the 1983 International Union of Geodesy and Geophysics dealt with the theme of historical records in the study of geomagnetism and history. The papers were on topics such as the earth's core, the rotation axis, eclipses, solar periodicities, noctilucent clouds, and the eruption of Krakatau in 1883.

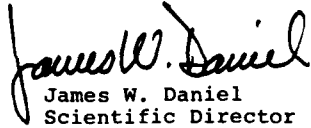
NEWS & NOTES


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European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research, London, in accordance with NAVEXOS-P-35.


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Scientific Director


M.A. Howard
Captain, USN
Commanding Officer

BIOLOGICAL SCIENCES

INTERNATIONAL SYMPOSIUM ON BIOELECTRO- CHEMISTRY

by Martin Blank. Dr. Blank is Associate Professor of Physiology at the College of Physicians and Surgeons of Columbia University.

The seventh International Symposium on Bioelectrochemistry took place in Stuttgart, Federal Republic of Germany, from 18 through 22 July; it brought together over 100 participants from 22 countries. Many biological phenomena involve changes in electrical properties; the meeting provided a concentrated exposure to a broad range of topics reflecting the current emphasis on membrane function and structure. The major areas covered were small biomolecules, electrophysiology, biopolymers, biomembranes, bilayers, field effects, membrane-bound reactions, cell fusion and gene transfer, oscillating reactions, electrode reactions, medical problems, and photoreactions. The presentations included papers on theory as well as experiments; several devices and techniques also were described.

The opening address by M. Losada (Seville) provided a clear introduction to energy transduction processes in biological systems. He summarized the subject in terms of three types of equilibria: redox, involving electrons; acid/base, involving protons; and phosphate bond, involving phosphate group transfers. Losada went on to show the relationships between them. These topics were touched on many times during the meeting, and the last day on photoreactions was devoted entirely to them.

One of the classic interests of bioelectrochemists has been the detection, analysis, and elucidation of the mechanisms of reaction of biologically interesting molecules. All of these aspects were well represented in Stuttgart. A more recent and growing interest has been understanding the mechanism, at the molecular level, of the demonstrated effects of electric fields on cell growth and development. Results were presented for many systems--e.g., bone cells in culture, whole bone under direct-current stimulation, increased longevity of paramecium, tumor cells in mice, and ion currents in early amphibian egg development. All the results

showed the important effects of electric fields. Other studies showed some evidence for the effects of pulsed electric fields on the Na K ATPase of cells, on plant root development, on mice tumors, and on changes in the dielectric properties of red blood cells after exposure to magnetic fields. All of these studies raise important questions about the responses of different biological systems to external stimulation.

The orientation and fusion of cells in electric fields has received much attention in the last few years. While "pearl chain formation" has been known for many years, reversible membrane breakdown and cell fusion under special conditions have attracted considerable interest. Despite the fair degree of know-how, there are still many questions about mechanism. Nobody seems to know what happens to the excess membrane material after fusion, especially when many cells are involved.

Bioelectrochemistry meetings differ significantly from most scientific meetings. Of course there are the interdisciplinary discussions that frequently lead to communication across scientific boundaries. But the special quality I refer to is a coverage of a broad range of subjects leading to an insight into a whole field and into the relationships between many different problems. At the Bioelectrochemistry Symposia one can still get a feeling for the particular insight electrochemistry offers when biological phenomena are considered.

9/8/83

SCOTTISH DEVELOPMENT AGENCY BOOSTS BIOTECHNOLOGY

by Thomas C. Rozzell. Dr. Rozzell is the Liaison Scientist for Biological Sciences in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until August 1985 from the Office of Naval Research, Arlington, where he is Group Leader for Cellular Biosystems.

The government of Scotland has started to increase its support of biotechnology research. For a number of

years the Scottish Development Agency (SDA) has played a major role in the stimulation and support of traditional sectors of Scotland's economy. The agency has now begun to focus on new high-technology industries. To carry out this mission, SDA formed the Health Care and Biotechnology Division (HCBd), which has a specific charge to support the development of the health-care industry in Scotland, and to foster the medical, industrial, and process uses of biotechnology.

This brief look at some of the activity in biotechnology in Scotland is meant only to give an overview of this emerging technology. In-depth assessments of important and relevant research will follow in future articles.

The work of the HCBd is guided by four interconnecting objectives. The first is to explore ways to help develop existing companies in Scotland. The second objective is to encourage diversification by Scottish companies into health care and biotechnology areas. The third objective is to stimulate relevant R&D activities in academic and research institutions. Finally, the HCBd is actively marketing Scotland as a base for foreign research and manufacturing corporations.

To help meet these objectives, the SDA is underwriting new companies. For example, in 1982 a new pharmaceutical company, Drug Development (Scotland) Ltd., was launched. SDA provided about \$325,000 of start-up capital, and \$160,000 came from the Bank of Scotland. The SDA apparently believes that such venture-capital activity is complementary to the broader grants-in-aid available from other Scottish governmental agencies.

Other small biotechnology companies have been formed specifically to exploit gaps in the market. One such company, Cruachan Chemicals Ltd. in Livingston, has developed and is marketing over 150 specialized chemicals used in biotechnology research. One-half of the company's products are exported to the US.

Bean Products Ltd. of Cumbernauld has developed an improved inoculum for fermenting soya meal into soy sauce. The company produces this product in large quantities in a fraction of the time required by traditional methods. A third example is a small company in Glasgow, Monotech Ltd., which is developing a range of monoclonal antibodies to use in kidney-disease therapy and to reduce tissue rejection following transplantation.

Along with the work of the SDA, several other programs are under way to boost biotechnology-based industries. For example, the Centre for Industrial Innovation at the University of Strathclyde, the Highlands and Islands Development Board, and the Applied Microbiology Department of the University of Strathclyde have programs.

The SDA recognized early that if it were to be effective in promoting and exploiting relevant academic research, it would need a good information base concerning the resources available to potential Scottish and foreign investors. A detailed survey was conducted, looking first at two important cornerstones of industrial biotechnology: generic engineering and sophisticated fermentation systems. It was found that all eight Scottish universities, and at least two colleges of further education, contained research groups engaged in some aspect of biotechnology. All eight of the universities reported some level of research on genetic manipulation. At both Glasgow and Edinburgh, work is under way on applying recombinant DNA techniques to microorganisms, viruses, and higher animal and plant cells. A small group at Napier College under the direction of Dr. Peter Hill is carrying out basic research on protoplast fusion; at Strathclyde, Glasgow, and Heriot-Watt, groups of microbiologists are studying the genetics and physiology of yeasts and fungi. At Dundee, there is research on the genetics of algae and of nitrogen-fixing organisms, while at Stirling a small group is studying the genetics of viruses that infect commercially important fish.

As for fermentation technology, the two main centers of expertise are at Strathclyde and Heriot-Watt Universities; traditionally, both have had cooperative ties with industry.

The survey requested the research groups to indicate the potential applications of their work. These applications fall mainly into seven areas: (1) production of chemicals, (2) food technology, (3) agriculture and aquaculture, (4) pollution control, (5) health care and medicine, (6) resource recovery, and (7) fuel and energy production.

From all indications, the health care and medicine area is now the strongest. The SDA has recognized that health-care products tend to be less sensitive to price changes than those that emerge from most of the other technologies. Several university projects are under way that focus on the treatment of infections. The University of

Glasgow, for example, is attempting to produce interferons from eukaryotic cells rather than from genetically engineered bacteria; work is also in progress on improved antiviral agents and vaccines for use against pertussis and cholera. At Heriot-Watt, a group of chemists under the direction of Professors Buchanan and Wightman is looking into the biosynthesis of novel antibiotics for cancer treatment. At Dundee University, Prof. Steward and a graduate student recently isolated an actinomycetes as a potential source of new antibiotics.

Several studies are under way at Glasgow University on fundamental aspects of nucleic acid biochemistry, while Dr. Bailey at Strathclyde is working on the use of liposomes to enhance the delivery of drugs. Other research on therapeutic agents, spread throughout the universities, includes projects focusing on an enzymatically modified casein diet; the biosynthesis of alkaloids; the production of narcotic analogs by algae; the production of serum complement proteins (both human and bovine); the production of novel collagen products; and blood protein production. One study at Glasgow deals with the possibility of deriving immunodiagnostic proteins from fungal sources; the possibility of using certain plant enzymes to screen potentially active therapeutic chemicals, as an alternative to using animals, is being examined at Heriot-Watt.

A major strength in the general health-related area is monoclonal antibody research. There are studies on the use of monoclonal antibodies as a possible treatment of rheumatoid arthritis and, as mentioned above, of certain forms of kidney disease and tissue rejection. Research on the diagnostic use of monoclonals is about to begin at Aberdeen, under the direction of Dr. W.T. Melvin; Dundee is now producing a range of immunological test kits to aid in the diagnosis of infections. Finally, the Scottish Blood Transfusion Service in Edinburgh and Glasgow is exploring the use of monoclonals as blood-grouping reagents.

(Note: Much of the information for this article was derived from the *Biotechnology Bulletin* [No. 24], published by Oyez Scientific and Technical Services Ltd., and from reports supplied by the Scottish Development Agency, Glasgow.)

9/30/83

CHEMISTRY

POLYMER RESEARCH AT THE UNIVERSITY OF SALFORD

by Vivian T. Stannett. Dr. Stannett is the Liaison Scientist for Polymer Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until January 1984 from North Carolina State University, where he is Camille Dreyfus Professor in the Chemical Engineering Department.

The University of Salford has suffered a 44-percent cut in funding--probably the most severe financial setback among British universities. However, there is still considerable activity in polymer science. In classical polymer chemistry, the largest effort is by Dr. M.B. Huglin and his coworkers. Salford probably has one of the most versatile cobalt-60 radiation sources in the UK, and a great deal of Huglin's work has involved the use of gamma radiation. His research has been primarily in the area of grafting, where there have been a number of important contributions dating back to 1968. In general, Huglin's findings were concerned with two systems: the grafting of styrene to cellulose and the grafting of acrylic acid to nylon 6. The emphasis was on the mechanism and kinetics, and on the development of methods to separate and characterize the reaction mixture of graft and the two homopolymers.

More recently, gamma radiation has been used to prepare copolymeric cross-linked hydrogels. These can be prepared as essentially perfect, monomer-free, transparent rods. They are of great potential interest for contact lenses. Similar rods that are hard and hydrophobic also have been prepared. Both have high permeability to oxygen and may have other, including biomedical, applications. Huglin has developed very effective techniques, after using direct gamma radiation, to remove the rods from the glass tubes in which they are prepared. In addition, techniques for cutting uniform disks from the rods have been worked out (Huglin and Zakaria, 1983a). The monomers used have included a very hydrophilic vinyl lactam, a hydrophobic alkyl acrylate, and a hexafunctional methacrylate. Examples of the monomers studied are n-vinyl pyrrolidone, n-butyl acrylate, methyl methacrylate, and 1,1,1-trimethylol propane trimethacrylate.

An intensive study of the effects of the monomer composition and the dose rate on a number of properties of the polymeric rods has also been conducted. Researchers examined optical clarity and textural inhomogeneity, such as spongy opacity. At medium to high dose rates (0.005 to 1.0 Mrads per hour), the optical homogeneity was dictated only by the monomer composition. In general, increasing the amount of crosslinking monomers led to greater optical clarity. The unhydrated polymers, called xero-gels, showed a general tendency toward lower transparency and optical homogeneity on hydrating--e.g., by immersing in pure water for up to 7 days. This effect can be essentially eliminated, however, by the correct choice of monomer compositions (Huglin and Zakaria, 1983b). Work on the oxygen permeability and the swelling and elongation of the hydrogels is also under way.

Other research in progress in Dr. Huglin's group is on polymer compatibility and the behavior of polymers in mixed solvents. In the field of polymer compatibility, low molecular weight models have been used, particularly the alkanes and the polysiloxanes. Essentially monodisperse polymers are used--either synthesized at Salford or purchased. These are characterized by light scattering and osmometry. The cloud point, upper and lower critical solution temperatures, and melting points are used to study the compatibility of particular pairs. The results are quantified using the Flory-Huggins interaction parameters.

The behavior of polymers in mixed solvents is studied with light scattering, differential refractometry, viscometry, and osmometry. The overall behavior is described in terms of three types of interaction: solvent-solvent, polymer-solvent (1), and polymer-solvent (2). Preferential adsorption effects are observed. An interesting outcome of the thermodynamics is the phenomenon of cosolvency, whereby a polymer can be dissolved in a mixture of two liquids, neither of which, alone, is a solvent for the polymer. This obviously extends the range of solvent systems.

Dr. F. Vernon is active in research on preparing and modifying crosslinked beads and fibers based on polyacrylonitrile. The main applications are as chelating agents for the extraction of trace metals, including uranium from seawater (Vernon and Shah, 1983). In biochemistry, Drs. J.S. Lawton, R.H. Risby, and C.G. Morgan are active in research on proteins and other polypeptides and enzymes.

References

- Huglin M.B., and M.B. Zakaria, *Journal of Applied Polymer Chemistry*, 28 (1983a), 2452.
 Huglin M.B., and M.B. Zakaria, *Polymer* (1983b), in press.
 Vernon, F., and T. Shah, *Reactive Polymers* (1983), in press.

9/9/83

THE DYNAMICS OF POLYMER SOLUTIONS

by Vivian T. Stannett

The Macromolecular Club is an informal organization based originally on the polymer research centers at Mainz, Federal Republic of Germany (FRG); Strasbourg, France; and Uppsala, Sweden. Inactive in recent years, the club was recently re-established with a meeting at Wik Castle, Uppsala, under the chairmanship of Dr. Wyn Brown of Uppsala University. It was a small meeting; 12 participants were from Uppsala University, and 24 were from other European institutions. Another, larger meeting is being planned for 1985 in Mainz.

The Uppsala meeting focused on the dynamics of polymer solutions; there were 23 brief presentations with discussion period. Many of the papers were by comparatively young researchers concerning work in progress.

Dr. J. Bastide (Centre de Recherches sur les Macromolécules [CRM], Strasbourg) discussed neutron and quasi-elastic light scattering of swollen gels. The swelling degree was reduced osmotically by the addition of high polymers which could not enter the gels themselves. The cooperative diffusion constants were measured and the results interpreted by use of the scaling theories developed for semidilute solutions of high-molecular-weight polymers.

Dr. B. Nyström (Kjemisk Institutt, Blindern, Oslo) discussed photon correlation spectroscopy on protein solutions under very high pressures, up to 4000 atmospheres. Pressure was a more innocuous method of denaturing proteins than the use of higher temperatures or chemicals. Bovine serum albumin was found to convert to a more open conformational form at pressures greater than 1000 atmospheres suffered to pH 4.7 (the isoelectric point) and 7.4. This was established by the increases in the hydrodynamic radii. The effect was not reversible, nor were the decreases in

the cooperative diffusion constants with increasing pressure. Lysozyme at pH 4.0 showed an initial increase, followed by a decrease and a further increase at higher pressures. Interestingly, a simple synthetic polyelectrolyte, such as sodium polystyrene sulfonate, showed no effects of pressure. Nyström hopes to study the mechanism of stabilization of proteins by methods such as hydrogen bonding and hydrophobic or electrostatic interactions.

Dr. T.J. Odijk (University of Leiden, the Netherlands) presented a theoretical paper concerned with the dynamics of entangled stiff polymer chains in solution and the paradoxical results between rigid rod theory and the flexible reptation approach. In particular, the rotational diffusion constants versus the concentration⁻² power did not extrapolate to zero. The shortcomings of the Doi-Edwards approach and attempts to develop a new theory were discussed (see also Odijk, 1983).

Dr. W. Brown (Uppsala University) discussed slow-mode diffusion in semidilute polymer solutions using dynamic light scattering. Monodisperse polyethylene oxide in aqueous solutions, polystyrene in chloroform, and toluene were studied; the slow mode contrasted with the self-diffusion constants determined from Fourier transform, pulsed field gradient, nuclear magnetic resonance (NMR). The slow mode expressed in terms of a diffusion constant is two orders of magnitude lower than the self-diffusion constants. The slow relaxations are attributed to geometrical entanglements (see Brown, Johnsen, and Stilbs, 1983; and Brown, 1983).

Prof. F. Rondolez (Collège de France, Paris) described work on the temperature dependence of the hydrodynamic radius of flexible polymers in solution. Results were presented on polystyrene with a wide range of molecular weights in cyclopentane. The transition from swollen to collapsed coils was studied and the radii of gyration and the hydrodynamic radii calculated. Light scattering and sedimentation measurements were used. The results were interpreted using the "thermal blob" model; they fitted the mode only at very high molecular weights.

Prof. G. Meyerhoff (University of Mainz) discussed the viscosity and friction behavior of dilute and semidilute polymer solutions. The behavior found was related to the radii of gyration. Good agreement with the classical theory was found, but only in theta solvents.

Prof. M. Mandel (University of Leiden, the Netherlands) described experiments concerning quasi-elastic light scattering by polyelectrolyte

solutions. Sodium polystyrene sulfonates were used with narrow molecular weight distributions both in salt-free solutions and with various concentrations of sodium chloride. The effective diffusion coefficients, D_{eff} , showed two separate concentration regimes with a transition region. In the dilute region there was a dependence on the molecular weight, whereas in the semidilute region (e.g., above 1 g/l) D_{eff} became independent of molecular weight. The results are in at least qualitative agreement with the scaling theories of Odijk (1979). It was indicated that more experimental and theoretical work is needed to reach a better understanding of the problem. The work has been described in detail in recent papers by Koene and Mandel (1983a and 1983b), and by Koene, Nicolai, and Mandel (1983).

J. Roots (Imperial College, London) discussed quasi-elastic neutron scattering from polymer melts. New results were presented with polydimethyl siloxanes. Increasing the pressure gave evidence of closer interactions between the polymer chains--interactions similar to those observed on reducing the temperature.

H.H. Grapengeter (University of Duisburg, FRG) presented NMR and neutron scattering experiments on polydimethyl siloxanes in solution. He expected to obtain the distribution function for the degree of hindering of the rotational barriers.

M. Rawiso (CRM, Strasbourg) also discussed neutron scattering of polymers in solution and compared the results with x-ray scattering. The following polystyrenes were studied: (1) fully deuterated, (2) aromatic rings only deuterated, and (3) aliphatic only deuterated. The Debye form factors were determined; this work is still in progress.

Prof. M. Almgren summarized his extensive work on micelles, in particular the use of fluorescence quenching (Almgren and Swarup, 1982, 1983).

F. Boué (Centre des Études Nucleaire, Saclay) spoke on the dynamics of polymer melts in a transient relaxation investigated by elastic neutron scattering. Polystyrene at 117°C and polydimethyl siloxane at 200°C were studied. The former showed elastic responses and the latter inelastic. Initial results indicated that the reptation approach agreed well with the data.

G. Weil (CRM, Strasbourg) discussed the structure of polyelectrolyte solutions using neutron scattering and magnetic birefringence. Sodium polystyrene sulfonate was studied in aqueous solution (Weil, 1982).

Prof. R. Kirste (University of Mainz) spoke on the use of neutron scattering to study exothermic blends. The radii of gyration of labeled polystyrene in polystyrene-polymethyl vinyl ether and other polymers were measured. The values were found to be slightly higher than with polystyrene alone.

Prof. H. Wennerström (Stockholm University) presented a theoretical paper on the counterion dynamics in polyelectrolyte solutions using nuclear spin relaxation data from NMR measurements. The motions were tentatively interpreted using a solvation cell model, site bondings, diffusion along the polymer backbones, and exchanges between ions and the different macroions.

P. Stilbs (Uppsala University) discussed the dynamics and organization of micellar systems from spin relaxation measurements using pulsed field gradient NMR (Stilbs, 1983).

Prof. H. Sillescu (University of Mainz) described the use of fluorescein-labeled polystyrene to follow the motions in melts. The diffusion constants were determined as a function of molecular weights and were found to follow the reptation model. Holography was used to present the data.

J. Raczek (University of Mainz) reviewed the various problems connected with the use of dynamic light scattering for the characterization of polydispersity of polymers in solution. The various sources of errors were discussed.

Prof. V. Stannett (US Office of Naval Research, London) spoke on the diffusion of small molecules in glassy polymers. Considerable data were presented. The results fitted well the partial immobilization model (Petrooulos, 1970; Paul and Koros, 1976; and Paul, 1979). This model is based on the dual mode sorption approach; alternative ideas were also briefly presented, together with their weaknesses and inadequacies.

H. Vink (Uppsala University) discussed experiments using electrical conductivity measurements to determine the transport properties of polyelectrolyte solutions (Vink, 1982).

G. Guillot (Collège de France) presented some results concerning the diffusion of large macromolecules through porous membranes. The work might be applicable to oil recovery. The porous membranes were prepared by heavy ion bombardment of polycarbonate films (Guillot and Rondelez, 1981). The hydrodynamic radii of the polymer penetrants in solution were related to the pore size. Because of their elongation, larger molecules diffused more slowly before passing through the pores.

R. Perzynski (Centre des Études Atomique, Saclay) discussed the hydrodynamic dimensions of polymer chains in solution below the theta temperature using light scattering. Very low concentrations were studied: 10^{-5} to 10^{-3} g/cm³. The results were extrapolated to zero concentration (see also Perzynski, 1982).

Finally, J. Wells (Uppsala University) described a model for the overlap concentration for the transition from dilute to semidilute solutions using measurements of the hydrodynamic radii. Nonoverlapping molecules were assumed to fill the entire space. A random overlap model similar to that of Simha was proposed. Nondispersity was assumed.

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10/5/83

COMPUTER SCIENCES

A GENERAL OPERATOR PROCESSOR FOR IMAGE PROCESSING

by J.F. Blackburn. Dr. Blackburn is the Liaison Scientist for Computer Science

in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the National Academy of Sciences, where he is Executive Director, Computer Science Board.

The University of Linköping, Sweden, has developed a special computer for processing structural information. The General Operator Processor (GOP), designed by Prof. G.H. Granlund and his research group, is a multiple-instruction, multiple-data (MIMD) system using parallelism and pipelining extensively. For the special applications for which it is designed, the system is reported to be 100,000 times faster than nonparallel systems using more conventional techniques.

Image processing can be used in the following ways:

1. For analysis of biomedical images of complex tissue structures, chromosome classification, and computer tomography images.
2. For remote sensing in analysis of multispectral images, generation of maps, analysis of meteorological images, forestry surveys, agricultural inventories, land use planning, and environmental quality monitoring.
3. For advanced computer graphics for the use of hierarchical models for image synthesis, texture synthesis, and computer art.
4. For robot vision, stereoscopic vision, nondestructive testing, particle analysis, fingerprint identification, and artificial intelligence.

Its designers believe that the Linköping system can provide a unifying philosophy of image processing, embracing techniques such as edge and line detection, line description, texture analysis, and description of regions.

The GOP system has shown that it can outperform existing systems in most conventional image-processing tasks. For example, when analyzing a remote-sensing image in relation to the corresponding section of a map, one may want to classify points with respect to a number of contextual conditions. To do this with sufficient accuracy would take 50 to 100 hours with a conventional computer with a 100-ns machine cycle time. This process is executed on the GOP image processor in 10 seconds.

Information Representation

The information representation implemented in the GOP image processor provides a high degree of data compres-



Figure 1. Left: original image at 8 bits per pixel. Right: image compressed to 0.27 bits per pixel with the GOP image processor.

sion without an irrecoverable loss of information (Figure 1).

A set of operations is applied on each image neighborhood, each operation measuring a particular feature of the event within that neighborhood. For example, the operation can measure the edge content in each of four different directions. Because edges of all orientations cannot be expected within a particular, small neighborhood, we can infer the mutual exclusion of edges of perpendicular orientation. This leads to a two-component vector representation, where perpendicular edges are represented by vectors of opposing directions (see Granlund and Knutsson, 1982).

This interpretation at low levels has been extended to a general principle for information representation at all levels. Features derived from a particular neighborhood are mapped into a two-dimensional space and arranged in a circular fashion where conflicting or incompatible features are located at opposing positions.

The feature measurements are weighted together to form a vector describing the event within the neighborhood. The direction of the vector indicates the dominant class membership of the event, and the magnitude gives the confidence in this choice. (Details of the information representation and

processing are given by Granlund and Knutsson, 1982.) This information representation is used consistently throughout all levels of the hierarchy. However, the meaning of the information varies with the level of the hierarchy (Figure 2).

Image Operations

To complement the information representation, a set of operations has been developed. These operations are used to implement various functions, depending on the level at which they operate. The use of symmetry in operations permits a condensed description of event relations. A hierarchy is provided in which features of increasing order are represented as antisymmetric and bisymmetric relationships.

One class of operators--using a rotationally anisotropic symmetry--is applied at the lowest hierarchical level for implementation of edge and line operations, which can be used for texture description. (For edge detection techniques, see Davis, 1975.)

Another class of operators using an isotropic symmetry indicates curvature and divergence, which can be used to describe convexity and concavity. Relations between properties of convexity and concavity are used for segmentation.

Application at the next level gives structural relations between different segments. At high levels, the symmetry operations assume the function of symbolic operations upon locally one-dimensional strings, where the top-down control invokes contextual and syntactical rules.

An important consequence of the symmetric information representation used is that a large class of relaxation operations can be implemented as partly linear operations, enabling high speed computation. Furthermore, the symmetric relationship between information at different levels enables top-down control of restriction rules in a way that emphasizes dominant trends or, through context-sensitive modifiers, defines specific operations.

The Parallel Pipelined Processor

The GOP image processor operates on gray-scale, color, or multispectral images of any size. Conventional arithmetic and logical image operations are efficiently implemented. The architecture of the processor is multiple-instruction, multiple-data stream parallel, which is easily reconfigured and reprogrammed for new tasks.

The processor is designed to simplify the use of relaxation methods of feedback processing. In hierarchical

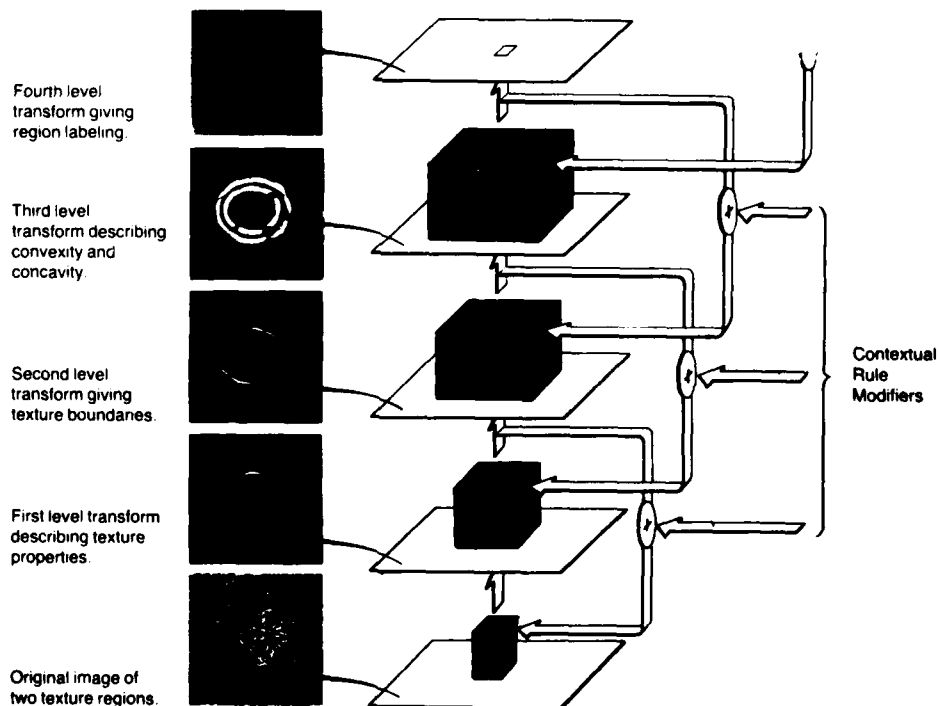


Figure 2. The hierarchy.

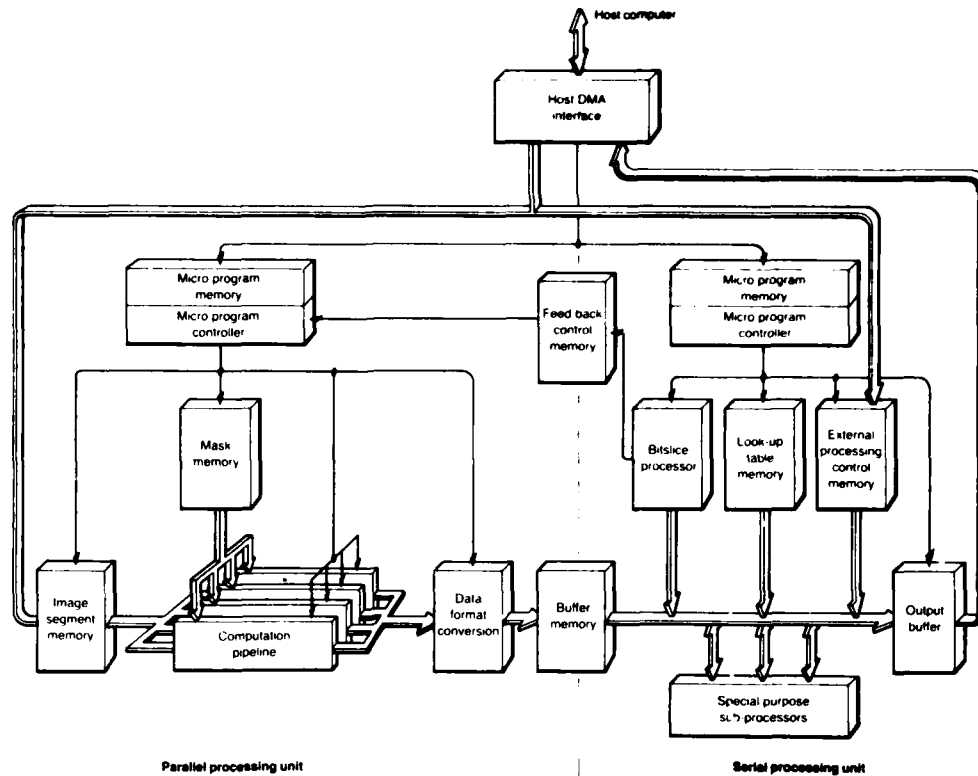


Figure 3. Parallel and serial processing units.

image processing, this permits representations of the image to determine its subsequent processing. In general image processing, tasks involve two computation phases. First, there are operations in which a set of masks operates on the image. Second, certain relaxation or decision functions operate on the data from the first phase. The GOP image processor uses four parallel pipelines in the first phase to combine the data from the image memory with weights from the mask memory (Figure 3). The second phase computations use a serial processor with a high degree of flexibility.

This dual architecture effectively deals with conventional image processing tasks. It also supports the implementation of context-sensitive operations. The serial processor controls the operational configuration of the parallel processor, which can be changed from one neighborhood to another.

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9/6/83

THE ALVEY PROGRAM: UPDATE AND ASSESSMENT

by J.F. Blackburn

The British response to the Japanese fifth-generation computer project

was one of the topics at the Fifth Generation World Conference held in London from 27 through 29 September. A progress report on the British initiative was given by Brian Oakley, Director of the Alvey Advanced Information Research Program sponsored by the Department of Trade and Industry (DTI), Ministry of Defense, and Science and Engineering Research Council (SERC).

The program is named for John Alvey, Engineer-in-Chief and Managing Director of Development and Procurement at British Telecom. In October 1982, the government-sponsored committee that he headed issued a report calling for a 5-year research program in computer science. The report estimated that the program would cost about £350 million over 5 years--£50 million in academic institutions and £300 million in industry. Work in industry will be 50-percent government funded, while all the work in academic establishments will be government funded. The expenditure in any year will depend on the progress of the program and on the contribution made by industry.

In addition to the progress report given by Oakley, a critique of the program and an assessment of its chances for success were given by Edward Feigenbaum, Professor of Computer Science and Director of the Heuristic Programming Project at Stanford University.

Management and Organization

A small committee under the chairmanship of Sir Robert Telford will steer the Alvey Program. Day-to-day operations will be the responsibility of Brian Oakley and a small directorate. Most of the key members of the directorate will come from industry. The program will integrate defense and industry activities, and will be considered complementary to the European Strategic Program of Research and Development in Information Technology (ESPRIT). Four main technologies will make up the Alvey Program:

- Very large scale integration (VLSI)
- Software engineering
- Expert systems and intelligent knowledge-based systems (IKBS)
- Man-machine interfaces (MMI)

Experts from industry and the academic community will prepare plans in each of these areas. Then invitations to bid for participation in designated parts of each program will be issued. The four main technologies are interdependent and will require coordination by the directorate.

The directorate will be looking for proposals that are consistent with the major thrusts of the program and will be particularly interested in collaborative proposals.

Major Demonstrator Projects

There will be a few demonstrator projects to motivate and focus the research in the relevant technologies and to prepare for their use. The purpose is to show that advances made in the various technologies can be combined to achieve greater efficiency in managing and using information at lower cost, and to provide services not previously available in government and industry. These demonstrators will cover applications in industry, defense, medicine, and the social services. Even though the demonstrators may not be operational until the end of the 5-year period, setting goals now provides motivation for development in the enabling technologies. Basic project teams are being formed to plan and execute each demonstrator project, which will be managed for the directorate by a company able to use the final system. However, the projects will be executed through subcontracts to several companies working in relevant technologies.

The Technology Program

Plans are being drawn up by firms in the VLSI industry, and it is expected that this part of the program can proceed quickly. Ferranti, for example, has a very high growth rate in this field and has established a reputation for analog and digital circuits. Ferranti, GEC, and Plessey have made impressive investments in this area, and GEC's work in gallium arsenide as well as silicon chips is most promising. Computer aided design (CAD) for VLSI is important for the Alvey Program, and a separate strategy for this part of the program will be developed.

The British have a good record of success in software engineering. Some parts of the software engineering program can be initiated without much delay. But for other parts an action plan will have to be drawn up before much progress can be made. The results of software engineering need to be moved from laboratories into industry more quickly, and an engineering approach to reliability needs to be taken, according to Oakley.

Britain has some world leaders in IKBS. Many teams are now being formed to proceed with this work. An SERC/DTI committee under the leadership of Dr. J.M. Taylor of the Ministry of Defense

has generated a draft proposal: "Intelligent Knowledge Based Systems--A Programme for Action in the U.K." This report was circulated for comment at the end of August; it is the draft basis on which the Alvey Directorate will proceed. Universities have begun establishing linked computers dedicated to IKBS research, and it is planned that machines in industrial operations soon will be added. The demonstrator projects also can be started shortly. The SERC will be asked to administer the IKBS program. Staffing is a concern; but some British expatriots are returning, and there is an increased program for training people.

The strategy-action plan for man-machine interface probably needs the most work. A SERC committee under Prof. Brian Shackel has made some progress, and members from industry and the Ministry of Defense are to be added to the committee. There will be work on pattern recognition, including speech and solid state displays. Like the Japanese, the British have chosen PROLOG as a basic language.

Cooperation and Participation

The Alvey Program requires collaborative research, and it is expected that proposals normally will involve at least two industrial parties. One company generally will take the lead in coordinating the project; in some cases, a user firm will be a member of the team. All members of each sector of the Alvey Program will cooperate through discussions and presentations at meetings and symposia.

Academic and government research establishments will be included in many of the collaborative projects. Consolidated applications covering both industrial and academic components will be submitted to the Alvey Directorate; the components must be clearly delineated. In very long-term projects carried on by academicians, a special representative from industry will monitor the work.

All research work connected with the project must be done in the UK. The participation of European firms working in the European Economic Community will be reviewed in light of the progress made by the ESPRIT program. In exceptional cases, participation of firms already taking part in the ESPRIT program will be allowed; the main consideration will be the benefit to the UK.

Infrastructure and Communications

Soon, a network linking the main Alvey research centers will be established. Industrial participants will be

asked to pay for their terminals and line charges; the central infrastructure costs will be paid by the directorate. Connection with the ESPRIT network is under discussion. In the meantime, an SERC mailbox facility already connected to universities via SERCNET, a communications network used by SERC, will be augmented to allow the inclusion of industrial organizations.

To improve communications further, a regular general newsletter service and specialized bulletins for particular subgroups will be provided. This information will cover program development and opportunities, specific research developments, and intelligence service reviewing overseas developments.

Information Dissemination

To ensure effective collaboration and to safeguard rights of participation, information will be disseminated at three levels:

1. Between parties in a specific contract
2. Between parties in associated contracts
3. Throughout the industry.

Parties in a specific contract will be expected to communicate daily. Partners in a single Alvey category will constitute an Alvey category club, and will use a newsletter and seminars to communicate occasionally. When significant milestones have been reached in a project, seminars will be held to present results to the whole community.

ESPRIT

The Alvey Program is seen as complementary to ESPRIT. The Alvey Directorate will monitor the development of the ESPRIT program and ensure that the two programs are providing the maximum benefit for the UK. To ensure proper coordination, the Alvey Program may have to be modified when the ESPRIT program gets under way.

Assessment of the Alvey Program

Prof. Edward Feigenbaum gave his personal assessment of the Alvey program's potential for success. What follows is a paraphrasing of his remarks.

On the optimistic side, the program has gotten off to a fast start; there appears to be a national will to succeed, and the British have a good track record in artificial intelligence.

However, the following factors may make it difficult for the program to succeed.

1. There are insufficient resources for a multifaceted approach to the problem; on the other hand, the British

tend to work in a multifaceted way. There is no national center, and the talent pool is dispersed into groups all below the level of critical mass.

2. The Alvey report is a compromise of focus. It mandates a dispersion of forces, and IKBS has an insufficient share of the resources. Furthermore, there is a missing generation of talent, which has largely gone to the US. They are unlikely to return because of salary and other advantages in the US.

3. Leadership is a problem. Fred Brooks, who managed the IBM 360 development program, has said, "Big projects require a chief surgeon and a hospital administrator." Feigenbaum said the UK has an able administrator in Brian Oakley, but he asked where is the chief surgeon comparable to Gene Amdahl on the IBM 360 and Larry Roberts on ARPANET.

4. There appears to be tension between long-term and short-term goals. Industry, by and large, takes the short-term view. A long-term view must extend to the highest levels among government officials.

5. Although there is a good logic program in the UK, total commitment to PROLOG is risky. It is an untested system. LISP is a more completely proven language. Feigenbaum does not think there is enough time and talent to prove PROLOG to the extent that LISP has been proven over the last 25 years. A modern version of LISP would provide a good anchor in a high-risk program.

6. The ties between universities and industry are weak. These two sectors have different expertise. They need to have mutual respect for effective cooperation; Feigenbaum believes this is missing in the UK.

7. The will to succeed must be mobilized. In the US, artificial intelligence is respected by universities, government, industry, and the public. This is lacking in the UK--in part because of the negative impact of a document known as the Lighthill report, published a decade ago.

Brian Oakley countered some of Feigenbaum's arguments, but admitted that some of them had merit and that corrective action needs to be taken. In any event, there is a strong commitment by the British government to the Alvey Program. It will be several years before a clear indication of the degree of its success will be fully apparent. ESN will follow the work in 1984.

EARTH SCIENCE

ENGINEERING GEOLOGY OF TIDAL RIVERS

by Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

The Regional Conference of the UK Geological Society's Engineering Group was held at the University of Hull from 11 through 16 September. The meeting's theme was "The Engineering Geology of Tidal Rivers." About 75 geologists and engineers attended; most were British. About 30 papers were presented on topics

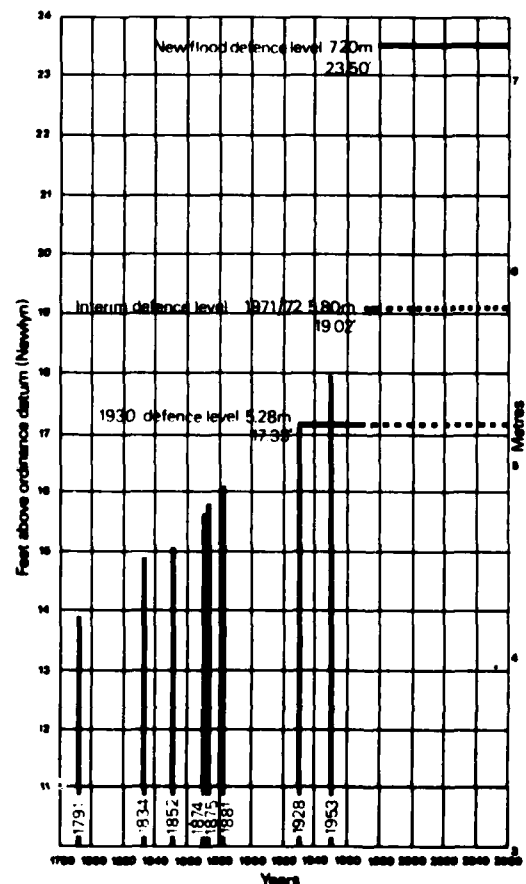


Figure 1. Increasing high tide levels and defense levels at London Bridge.

10/4/83

ranging from site-specific case studies to the application of geotechnical methods. The conference proceedings will be published by the Geological Society; copies can be obtained through the publication office, Burlington House, Piccadilly, London W1V 0JU.

Several of the papers summarized the construction of large flood-control structures. The most prominent is unquestionably the Thames River Barrier that was completed recently to prevent flooding in central London (see ESN 37-1:27-30 [1983]). Central London was last flooded in 1928, when 14 people drowned. There was a major flood of the lower Thames Estuary in 1953, with a loss of 300 lives. If this storm surge had reached far enough up the river to flood central London, the losses would have been substantially greater.

There are two reasons for the flooding problem in the London area. First, the city is sinking on its bed of clay, and southeastern England in general is gradually tilting downward at a rate of about 30 cm per century. Second, high tide levels are rising.

As Figure 1 shows, high tides have risen by 60 cm at London Bridge over the last 100 years. An additional threat is produced by storm surge, which occurs when low pressure systems move eastward across the British Isles into the North

Sea. Of particular concern is the potential damage that a flood could cause to the London Underground (subway) system. Some 40 stations, 76 miles of track, and 20,000 signals and switches are in flood-prone areas along the Thames. A flood crest only a few feet higher than that of two floods in the 1970s would inundate the lower parts of the city and the underground. It is estimated that at least \$6 billion in damages would result.

The Thames Barrier is a series of 10 separate and movable gates built side-by-side across the river (Figure 2). Each gate is pivoted and supported between concrete piers, which house the operating machinery and control equipment. Closing the barrier seals off the upper Thames Estuary from the sea. When not in use, the six rising sector gates in the navigation channel rest out of sight in curved recesses in concrete sills in the riverbed. Thus river traffic can pass through the openings between the piers. The width of the barrier is 520 m, with four main openings each having a clear span of 61 m. The four main gates are massive. Each is designed as a hollow-steel-box structure 19-m high and weighing, with counterweights, about 3300 MT. Each is capable of withstanding the 9000-MT thrust from the high surge tide.

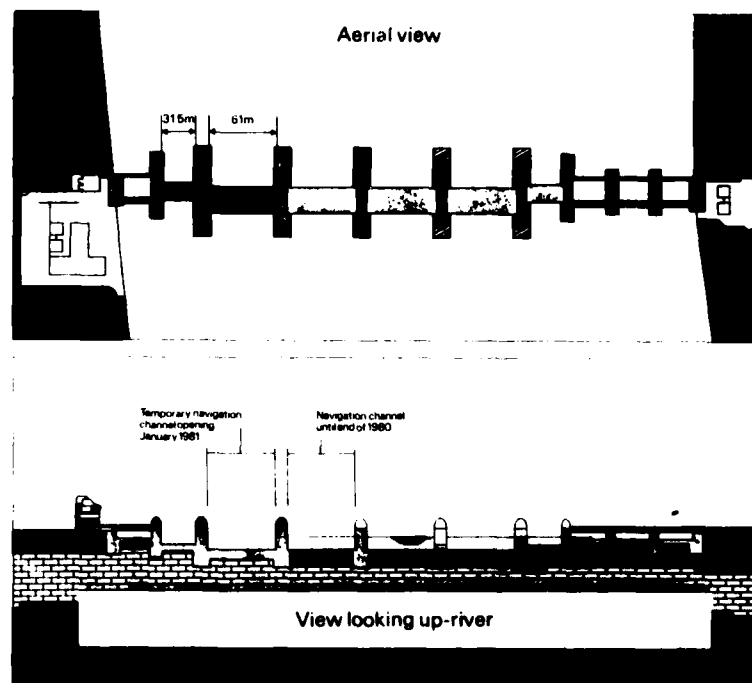


Figure 2. The Thames Barrier.

When a tidal surge threatens and an order to close is given, the engineer in charge raises the gates 90 degrees from their riverbed position into a vertical defensive position. The gates form a continuous steel wall facing downriver ready to stem the tide. The operation takes only 30 minutes. Construction of the Thames Barrier cost \$1 billion.

One final observation about the discussions at the engineering geology meeting. The UK consulting engineers have a long and distinguished history for construction projects throughout the world. However, competition today is extremely keen from Germany, France, the Netherlands, and the US; so there is a "recession" in the civil engineering profession and a fair amount of pessimism among the young participants at this meeting. More than 10 percent of recently graduated engineers are unemployed, as are 25 percent of the geologists and geophysicists. (See "Hard Times for Higher Education in the UK" elsewhere in this issue.)

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THE 18TH IUGG: OCEANOGRAPHY, GEODESY, AND GEOPHYSICS

by D. Conlon and John G. Heacock. Dr. Conlon is Group Leader for Coastal Sciences and Mr. Heacock is Scientific Officer (Geology and Geophysics) at the Office of Naval Research, Arlington, VA.

The General Assembly of the International Union of Geodesy and Geophysics (IUGG) met in Hamburg, Federal Republic of Germany, in August. This article highlights some of the papers dealing with oceanography, geodesy, and geophysics.

Coastal Oceanography

The coastal domain is the region of the ocean in which the presence of a coastal boundary has a significant effect on dynamic processes. (If numbers are required, this places the seaward limit of the coastal domain some 10 to 100 km beyond the shelf break.) Even if one limits attention to physical processes, coastal work is intimidating in its scope, comprising small-scale and intermediate-scale work, air-sea interaction and boundary-layer meteorology, bottom boundary-layer dynamics, and associated subjects. For a meeting such

as the IUGG, it is not possible to provide a complete report on papers dealing with coastal oceanography; relevant papers were presented in as many as four simultaneous sessions. What follows, then, are general comments relating to several fields of inquiry represented at the IUGG.

In the small-scale domain, little work has been done in studying turbulent processes in the coastal regime. With the recent advances in fine-structure and microstructure instrumentation, it is hoped that more attention will be given to the extremely interesting (and energetic) processes of the coastal domain. On the other hand, research is being done on turbulent structures and internal waves generated by strong tides over shallow ridges. John Apel (Johns Hopkins Applied Physics Laboratory, US) presented an interesting summary of investigations of large-amplitude, solitary-like internal waves in the Sulu Sea, and David Farmer (Institute of Ocean Sciences, Canada) presented a study of various aspects of hydraulic control over fjord sills; the work combined theoretical, laboratory, and field results. Substantially more work was reported in the intermediate-scale domain (e.g., coastal boundary currents, eddies, and upwelling).

Research on storm surge has reached an advanced degree of sophistication, with impressive results now seen almost routinely. Although storm-surge models do not usually pretend to be accurate representations of the relevant physics, their predictive capability is quite remarkable (e.g., work in the UK's North Sea waters).

Several papers were presented on the Donde Va Experiment, which focused on the dynamics of the anticyclonic gyre in the Alboran Sea. Although this work is still in an early stage of analysis, the hypothesis is that the gyre is formed by the Strait of Gibraltar's topographic steering of water from the Atlantic Ocean. An interesting counterpoint was provided by Sugimoto and Kawasaki's (ORI, Tokyo) study of the Tsugaru Strait anticyclonic gyre, which they agree is governed by a combination of lateral adjustment processes and vertical mixing, parametrized by thermal Rossby and vertical Ekman numbers.

Additional straits-related work was presented by F. Schott (University of Miami, FL) and S. Murray (Louisiana State University). Schott and coworkers are in the middle of a 2-year program to observe the flow in the Florida Straits. An interesting early result of this analysis is that while Florida Straits transport is not coherent with southward

transport over the Atlantic at the same latitude (i.e., Sverdrup balance) on seasonal scales, it does appear to be coherent at time scales of 2 years and longer. Murray's work in the much smaller Strait of Tiran (1-km wide) indicates that critical flow conditions are usually observed in the strait only when the tides are in less energetic parts of the fortnightly cycle.

Geodesy and Geophysics

Prof. Paul Melchior (President of the Commission on Solid Earth Tides and Secretary-General of the IUGG) reported that the difference between observed and computed gravity (considering the ocean-loading effect, which is created by the elastic response of the earth to the weight of the ocean tide) leaves a 17 microgal residual at all world stations studied. Sometimes this residual effect is abnormally high and not understood, but in general it tends to support the general validity of the Schwidershki deep-ocean tidal model. Thus, one can conclude only that the model is adequate for computing the ocean-loading effect. But until more work is done, one should not conclude that the model also is adequate for all other applications.

Dr. Seiya Uyeda (Tokyo University) in an Inter-union lecture, proposed two categories for subduction zones: (1) the Peru-Chile type--associated with a continent and characterized by strong earthquakes and shallow subduction angles; and (2) the Marianas, ocean-island type--associated with back-arc spreading, smaller earthquakes, and steeper subduction zones.

Prof. Raymond Hide (Meteorological Office, UK) presented an Inter-union lecture entitled "Rotating Fluids in Geophysics on Planetary Physics." He demonstrated with thermally convecting rotating bodies the flow patterns from a combination of thermal inertial forces. Applications of these studies include atmospheric motions affecting the world's weather and magnetic fields generated by motions in the earth's core.

9/19/83

ENERGY

EGYPT'S ENERGY CRISIS

by Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and

Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

The number of motor vehicles in Egypt tripled between 1975 and 1982. Today there are over a million cars, trucks, and buses, and most are in the great urban centers along the Nile. My guess is that anyone who's taken a taxi from the Cairo airport to the city center would conclude that 90 percent of the cars and trucks are in that one corridor. The confused traffic flow and density is unimaginable if you haven't actually seen it.

But the rapid increase in the number of vehicles is only one aspect of Egypt's continued growth problem, as measured by Western standards. A better measure is overall energy consumption. Between 1973 and 1982 the Egyptian production of oil and gas almost quadrupled; during the same period, consumption of petroleum products and electricity increased twofold, or about 13 percent annually.

The rapid rise in oil production over the past decade has resulted in current exports of about 300,000 barrels a day. Based on estimates of proven and potential reserves, it is unlikely that this will increase, and the prediction is that the fields will be depleted within 25 years. With forecasts of a 7 percent rise in energy consumption per year, or another tripling by the year 2000, the Egyptian government is looking for alternative energy sources. Their current estimate is that the use of fossil fuels will double by then, but that the portion of total energy supplied by oil, gas, and coal will drop from the present 90 percent to about 50 percent. Where will the 50 percent come from? The only possibilities are conservation, nuclear power, and renewable energy resources.

Because of the present system of energy subsidies, little progress is being made in the development of alternatives. In Egypt, petroleum products and electricity sell for far less than their value on the international market. Consumers and industry are thus unwilling to invest in alternative energy sources, and there is little incentive to use energy efficiently. Nevertheless, the government is committed to the subsidies as a way of improving the quality of life in Egypt. This has shielded the poor from the burden of high energy costs following the rapid

rise in oil and gas prices after 1973 and 1974.

The average subsidy is 75 percent on all energy sources. That is, energy in Egypt, including gasoline, sells on the open market for about one-quarter of its true value. This places a tremendous burden on the national economy and promotes waste and inefficient use of energy resources. In 1982, for example, oil products alone worth \$10 billion were sold for \$3.5 billion. The Deputy Prime Minister for Oil and Gas stated that it cost more to transport a ton of oil in Egypt than the subsidized price; he said that it would be cheaper to simply give oil away, but require the consumers to transport it.

In a recent analysis of how energy is used, it was found that 65 percent is consumed in the urban centers that include 40 percent of the population. In Cairo, the richest segment of the population consumed three times as much energy as the poor; that is, the richest one-third of the population received three-quarters of the energy subsidies.

Alternative energy sources now being considered in Egypt include nine nuclear reactors that would provide 40 percent of the country's electrical needs by the year 2000, solar energy, and a unique hydroelectric project in the district west of the Nile Valley.

Solar power certainly represents the major renewable energy resource in Egypt; skies are clear about 330 days per year; the amount of solar energy reaching Egypt is twice that in the US. However, there has been little development of solar power simply because the government subsidies on traditional energy sources are so high that there is little encouragement for even the most rudimentary solar devices--water heaters, for example.

A unique plan for adding to the energy base of the country dates back about 70 years, when a German scientist suggested that it was feasible to channel water from the Mediterranean to the Qattara Depression, a 20,000 km² low area (-145 m) in the Western Desert. The idea is that a canal or tunnel could carry enough seawater into the depression to drive turbines with a 320 MW capacity. It would take 12 years to fill the depression and transform it into a great salt lake with a surface level of about 60 m below sea level. The lake level then would be maintained at -60 m by control of the water flow, so that flow into the lake would match the evaporation rate (650 m³/s). After the initial 12-year filling process, the generating capacity would be reduced to about 160 MW annually.

The biggest problem with the scheme, other than myriad environmental questions, is moving some 6 billion cubic meters of rock, or the equivalent 3000 great pyramids. The canal would be 70-km long and up to 200-m deep, or twice as wide and four times deeper than the Suez Canal. About the only possibility for moving so much rock economically would be a series of "clean" nuclear explosions.

Officials of the Qattara Depression Authority admit that the project is no more than speculation. Work cannot start, they say, until the technological and economic feasibility of the scheme has been considered, and the potential side effects produced by the creation of the large saltwater lake are better understood. People living in the region worry about the possibility of earthquakes (Lake Nasser has been blamed for tremors in the south of the country), and Nile Delta farmers are concerned about the danger of saltwater intrusions. Finally, there remains the question of finance; detailed costs have yet to be worked out. However, until the actual cost of existing energy is spread among the consumers of Egypt, there is little hope for development of alternative sources.

9/16/83

ENGINEERING

LEEDS-LYON TRIBOLOGY CONFERENCE

by Harold G. Elrod. Dr. Elrod is Professor of Engineering Science at Columbia University.

The 10th Leeds-Lyon Symposium on Tribology took place at the Institut National des Sciences Appliquées (INSA), Villeurbanne, France, during the first week of September. This annual event is jointly sponsored by INSA and the University of Leeds (UK) and is held alternately in Leeds and Lyon. It treats topics in the fields of friction, lubrication, and wear, which compose the area of science and engineering known as tribology. The proceedings of the symposium are to be published by Butterworth Co., Ltd., at a price of \$68, and will be available during the summer of 1984.

The host laboratory at INSA was started by Prof. Maurice Godet, who now shares administrative duties with Prof. Daniel Berthe and other senior staff

members. The laboratory's present complement is 36, making it the largest organization in France devoted to tribology. Technological emphasis has been given to the rheology and performance of heavily loaded contacts, and to wear; but most aspects of tribology are researched to some extent.

The theme of the symposium was "Numerical and Experimental Methods Applied to Tribology." Individual sessions were designated for rheology, bearing performance, film thickness and separation, hydrodynamics, numerical methods (finite elements and thin-film theory), experimental methods (material aspects and thin-film analyses), bearing dynamics, contact phenomena, and plasticity. During an introductory session, Prof. Frederick Barwell (University of Wales, Swansea) described the role of particle analysis in the monitoring and assessment of bearing operation, and Dr. Bernard Hamrock (NASA Lewis) described the use of super-computers in modern elastohydrodynamic contact theory.

Of the more than 36 conference papers, only a few can be mentioned here. D. Dowson, A. Miranda, and C. Taylor (Leeds University) demonstrated improved agreement between bearing performance and theory by using the Jakobsson-Floberg boundary conditions for film rupture and reformation. But G. Hamilton (Reading University, UK) pointed out that the challenge still left for theorists is to predict adequately the subambient nonequilibrium pressures or tensions that are sometimes realized in bearing films. A. Bush and G. Hughes (Teesside Polytechnic, UK) outlined what they believe to be a general, finite-amplitude Reynolds roughness theory. Good agreement with the Patir-Cheng model was demonstrated.

The results of three-dimensional computations of variable-property lubricating films were described by Braun, Mullen, and Hendricks (NASA Lewis). Their analysis was needed in cryogenic applications. Increasingly, finite-element methods are being used to analyze both fluid films and the adjacent solid media. In this category were the general analysis for transient elastohydrodynamic lubrication, by J. Booker (Cornell University), and the sophisticated packaged program for multidimensional, transient contact-impact problems, by A. Curnier (Swiss Federal Institute of Technology, Lausanne). In very heavily loaded elastohydrodynamic contacts, it appears necessary to solve for the fluid pressure, given the surface displacement. This "inverse problem" was discussed by Hamrock, and was the subject of a paper

by M. Meurisse (INSA). Gardner and coworkers (Leeds) provided nonlinear stability analysis of journal bearings, including limit-cycle trajectories.

Experimental papers disclosed improved methods for measuring: (1) lubricating film characteristics; (2) thickness, with infrared reflectance (H. Spikes and P. Cann, Imperial College, UK); (3) velocities, with laser-illuminated tracers (S. Mutuli, D. Bonneau, and J. Frene, Université de Poitiers); and (4) pressure, with a wafer-integrated piezoelectric sensor (G. Rightmire, Columbia University). E. Kingsbury (Draper Laboratory, Massachusetts Institute of Technology) showed how to use a ball bearing as a rheological test device, in a manner both ingenious and practical. Four papers dealt with on-line measurements of bearing performance, and six with partial lubrication and dry contact. One of the most interesting was presented by F. Kennedy in collaboration with the INSA staff; it dealt with temperatures generated in sliding contacts.

The papers of the symposium displayed recent substantial improvements in the numerical and experimental techniques used by tribologists. Researchers are studying the lubricating film in detail and giving much more attention to solid-fluid interaction. Professionals from the allied disciplines of mathematics and of fluid and solid mechanics are participating in greater numbers.

The next Leeds-Lyon symposium will be held from 4 through 7 September 1984 at Leeds; the subject will be "Mixed Lubrication and Lubricated Wear."

9/30/83

GENERAL

TOWARD A EUROPEAN RESEARCH AND SCIENCE STRATEGY

by Thomas C. Rozzell. Dr. Rozzell is the Liaison Scientist for Biological Sciences in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until August 1985 from the Office of Naval Research, Arlington, where he is Group Leader for Cellular Biosystems.

The Commission of European Communities recently proposed a new scientific and technological strategy designed to

build the foundation for a Community research policy. As a first step, the Commission sought the assistance of a number of experts, who helped define what the objectives of such a research policy should be. These objectives are to be approved and periodically re-examined by the member governments. The Commission recommended that 3.75 billion European currency units should be devoted to this strategy between 1984 and 1987 (1 ECU equaled approximately US\$0.95 as of 11 March 1983). If the Commission plan is adopted, 4 percent of the Community budget would be devoted to research by 1987, compared with 2.6 percent at present.

The member states of the European Community possess considerable research potential. With about 350,000 scientists, engineers, and technicians, the Community accounts for about one-fifth of the world expenditure on research, development, and technology. The Community's research capacity, not including defense projects, is double that of Japan and about three-fourths that of the US.

The Commission is attempting to develop its new strategy because over the past few years there has been a measurable decline in the productivity of European research. There are recognized gaps in multidisciplinary research, insufficient coordination between applied and basic research, inadequate industrial utilization, and international discrepancies in patent law. The consequence has been a reduction in the range of Europe's contribution to scientific and technological knowledge. There is, thus, a strong argument for improving Community research activity proper and developing a unified policy. Increased research effort at the European level would exploit the advantages of activity on a continental scale. By sharing research work and findings, member states can tackle larger problems and meet fierce international competition head-on. There is little question that Europe is at the forefront of research and technology in areas such as nuclear energy and aerospace, where cooperation between member states has been intense. However, it has fallen behind in areas where there has been limited research cooperation, such as computers, biotechnology, automobiles, and chemicals.

The Commission document sets forth specific and detailed objectives and priorities based on an analysis of social and economic needs, the range of existing research resources in the Community, and a variety of sectoral and forecasting studies. The program, if

adopted, should place European research in a stronger position to meet the challenges of the 1980s.

9/27/83

MATERIAL SCIENCES

FIBER COMPOSITE MATERIALS IN THE UK: ROYAL AIRCRAFT ESTABLISHMENT

by Tsu-Wei Chou. Dr. Chou is Professor of Mechanical Engineering at the University of Delaware.

This is the final article in a series reporting research on fiber composite materials in the UK. ONR London report R-16-83 provides a general assessment of the UK's work on fiber composites.

Fiber composite material research at the Royal Aircraft Establishment (RAE, Farnborough) is now being conducted in the Materials and Structures Department. The department consists of six divisions: Air Worthiness, Helicopters, Dynamics and Loads, Structural Materials, Non-structural Materials, and Analysis and Assessment (see J. Perkins, "Materials Research at Royal Aircraft Establishment," ESN 32-11:381-383 [1978].)

The Structural Materials Division has research activities in Al alloys, Ti alloys, unconventional alloys, metal properties, and composite materials. Current research on composites in the division is directed by Dr. Graham Dorey. The work includes the assessment of carbon fiber properties, effects of fiber surface treatment on composite performance, static and fatigue behavior of composites, notch sensitivity, impact and damage tolerance, and fractography. The Analysis and Assessment Division is also doing research in composite structures.

The RAE probably has the highest concentration of research on composites in the UK. There has been major emphasis on assessing the relationship between defects and the failure of fiber composites. The RAE is studying defects produced during manufacture, cracking produced during loading, and in-service damage. Scientists are considering the effect of these flaws on mechanical properties, and the implications for structural design. The RAE is also modeling the behavior of notched composites and is examining the design of

composites to achieve improved toughness and increased tolerance to damage. The following summary of research is based on excerpts from an RAE report by S.M. Bishop (1982).

Bishop found that the damage zone formed at a sharp notch is larger than that formed at a circular hole; the blunting effect is such that the failure stress of a composite containing such a sharp notch may not be very different from that for a circular hole. Thus the formation of a damage zone at a notch has a beneficial effect on notched behavior under tension; the larger the damage zone, the greater the failure stress. The size of the damage zone depends on the shear strength parallel to the fibers--i.e., the fiber-matrix bond strength--and this has been varied by changing the fiber, the fiber surface treatment, and the matrix. The size of the damage zone also depends on the lay-up and stacking sequence. Studies of the interactions between layers have indicated that shear cracking parallel to load-bearing, 0-degree fibers always reduces the stress concentration in the 0-degree layer. But cracks parallel to fibers at other orientations, while having the beneficial effect of releasing stored strain energy in a noncatastrophic way, increase the stress concentration in a neighboring 0-degree layer.

Delamination reduces these interactions and removes constraints on 0-degree shear cracking, and this is beneficial. It was found that delamination increased when the thickness of the layers was increased. In addition, the failure stress was increased when thin layers of the same orientation were stacked together to produce thicker layers. Increasing the laminate thickness by repeating the basic stacking sequence with thin layers had no effect. Thus the notch sensitivity of a multidirectional carbon-fiber composite under tension can be reduced substantially by careful material design. However, it should be noted that shear cracking and delamination can reduce the material's compressive strength and fatigue performance.

Woven carbon-fiber cloth offers many production advantages, and it is being used more often in reinforced plastics. Therefore, Bishop has carried out research on how woven cloth affects the notch sensitivity in tension. For a particular type of lay-up--e.g., (0 degree, 90 degree), (± 45 degrees), or (0 degree, 90 degree, ± 45 degree)--there was no effect due to layer stacking sequence or the way the cloth faced in laminates made from five-shaft satin woven cloth. (The dominant fiber direc-

tion in this weave is different on each side of the cloth.) Results for laminates made with the woven material were compared with those for the equivalent nonwoven lay-up made with unidirectional material. The effects were the same as those for sharp notches and circular holes. The value of stress intensity, $K = \sigma_f \sqrt{a}$, for sharp notches (σ_f is the notched failure stress, and a is the seminotch length) is a measure of the toughness of the composite--i.e., its capability to absorb stored strain energy noncatastrophically, mainly by shear cracking and delamination.

For 0 degree, 90 degree lay-ups, the K values were 30 percent lower for woven material--partly because of the reduced volume fraction of fibers, but mainly due to the kinking of fibers in the load direction. However, for ± 45 -degree lay-ups the values of K were the same for nonwoven and woven material; indeed, K for the same volume of fiber was greater in the woven case. Woven laminates with 0-, 90-, ± 45 -degree lay-ups had K values 20 percent lower than for the nonwoven case--mainly because of the reduced toughness of the 0-degree, 90-degree layers of woven cloth. As might be expected from the results for ± 45 -degree lay-ups, the toughness of 0-degree, ± 45 -degree laminates with 50 percent 0-degree layers was not significantly changed when woven cloth, instead of unidirectional material, was used for the ± 45 -degree layers. Damage zones were the same size in both cases. The implications of these results are that woven cloth may be substituted for unidirectional material in ± 45 -degree plies, when under tension in the 0-degree direction; notch sensitivity will not be increased nor toughness reduced. Indeed, woven cloth may offer improvements in other properties, particularly where an area of damage must be internally contained. However, delamination between a layer of woven cloth and a neighboring layer of woven or unidirectional material could still occur.

R.T. Potter of RAE also has tried to incorporate into a failure theory the effect of microstructural behavior at the notch tip. The stress gradient at the notch tip is the critical parameter that determines whether adequate load can be transferred from fiber to fiber to break them in sequence and cause failure. He has compared his model with the "average stress" criterion of Whitney and Nuismer, and has obtained good agreement in both cases with the experimental data for a laminate with thin layers. As with all the models, difficulties arise for tougher laminates.

G. Dorey has been studying how damage produced by impact affects mechanical properties. The type of damage produced by impact depends on incident energy, material properties, and geometry. No damage occurs if the energy of the projectile is accommodated by the elastic strain energy in the material. Calculations have been made of energies necessary to cause delamination, flexural fracture, and penetration. Whether delamination or flexural fracture occurs depends on the relative values of interlaminar shear strength, flexural strength, and span-to-depth ratio. Lower fiber-matrix bond strengths result in delamination at lower incident energies. Materials with lower moduli, such as glass-fiber-reinforced plastic, can accommodate more elastic strain energy; delamination or flexural fracture only occur at higher incident energies. Flexural fracture is less likely when there are low-modulus layers on the outside, e.g., ± 45 -degree layers. Whether penetration occurs depends not only on the incident energy, but also on the size of the projectile; penetration is more likely for small masses traveling at high velocities. Dorey and coworkers also have examined the residual tensile, compressive, shear, and flexural strengths of laminates after impact loading. Both plain and hybrid laminates were used in the studies.

It should be mentioned that extensive research programs in notch sensitivity and damage tolerance are also being conducted at British Aerospace (Manchester, Warton, and Weybridge), and the Universities of Salford and Reading.

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01/20/83

FIRST INTERNATIONAL SYMPOSIUM ON STRUCTURAL CRASHWORTHINESS

by F.W. Armstrong. Dr. Armstrong is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until January 1984 from the University of Maryland, where he is Professor of Materials.

The First International Symposium on Structural Crashworthiness was held in the Department of Mechanical Engineering, University of Liverpool, 14 through 16 September 1983. A special issue of the *International Journal of Impact Engineering*, entitled "Impact Crashworthiness," includes some of the papers presented (Vol 1, No. 3 [1983], 197-317). The total conference proceedings also will be covered by the *International Journal of Mechanical Sciences*, Vol 25, No. 9/10 (1983), 613-774, and by the book *Structural Crashworthiness*, edited by Norman Jones (Department of Mechanical Engineering, University of Liverpool) and Tomasz Wierzbicki (Department of Ocean Engineering, Massachusetts Institute of Technology), published by Butterworth Press, London and Boston, September 1983. The book contains 15 chapters which range from the crashworthiness of basic structural members (Chapters 1 through 5) to structural damage in airship crashes (Chapter 15). Other chapters cover experiments on scaling of plated steel structures under impact (Chapter 6), aircraft crashworthiness (Chapters 7 through 10), collision of ship and marine structures (Chapters 11 and 12), crashworthiness of road vehicles (Chapters 7 and 13), and rail structural vehicle crashworthiness (Chapter 14).

The subject of crashworthiness is generating considerable interest on a worldwide scale. The international conference and exposition "Structural Impact and Crashworthiness" is to be held 16 through 20 July 1984 at Imperial College, London, with the US Air Force as the main sponsor. The proceedings are to be published by Applied Science Publishers Ltd. Topics are crashworthiness of automobiles, aircraft, and helicopters; impact of ships and marine structures; protection of ground installations and isolation of sensitive plant (structures); impact failures of metals and composite materials; hydraulic shock in fluid-filled structures; and protective design of structures for high velocity impacts (see R.W. Booker and R.W. Armstrong, "Scaled Impact Experiments on Concrete Structures," *FSN* 37-4:164 [1983]). The conference co-chairmen are Dr. G.A.O. Davies, Aeronautics Department, Imperial College, London SW7 2BY, UK, and Prof. J.S. Przemieniecki, USAF Institute of Technology, Wright Patterson AFB, Dayton, OH 45433.

Norman Jones will deliver one of the keynote addresses at the Imperial College Symposium. He is editor of the *International Journal of Impact Engineering* (published by Pergamon Press),

which includes in its first issue an article of his with B. Song, "Dynamic Buckling of Elastic-Plastic Complete Spherical Shells Under Step Loading" (Vol 1, No. 1 [1983], 51-71). Song is now in the Department of Civil Engineering, Zhejiang University, Hangzhou, People's Republic of China. Articles of potential interest in the issue (Vol 7, No. 3 [1983]) on impact crashworthiness are "The Crush Analysis of Vehicle Structures," H.C. Wang and D. Meredith (Ford Motor Company, Dearborn, MI 48121), pp 199-225; "A Proposed Method of Predicting Ship Collision Damage," K. Hagiwara, H. Takanabe, and H. Kawano (Ship Strength Research Laboratory, Nagasaki Technical Institute, Japan), pp 257-279; and "Mechanics of Minor Ship Collisions," K.A. Reckling (Technical University of Berlin, Federal Republic of Germany), pp 281-299.

2/82/88

RESEARCH ON ULTRAHARD MATERIALS AT EXETER

by E.W. Armstrong

The hardness properties of ultra-hard materials are being researched by Dr. C.A. Brookes, Reader in Engineering Materials, Department of Engineering Science, University of Exeter, Exeter EX4 4QF, UK. Synthetic diamond and cubic boron nitride are materials of interest recently (Brookes and Lambert, 1982). De Beers Industrial Diamond Division Ltd. has provided the specimens and supported the research. Sintered aggregates of syndite or amorphite based on synthetic diamond or cubic boron nitride, respectively, are being developed for cutting tools for steel or rocks. Wire drawing dies and machining are other uses. Hardness, wear, temperature effects, and microstructural characteristics are topics of concern.

Brookes, Hooper, and Lambert (1983) have identified the crystallographic shear planes for plastic deformation of cubic boron nitride. Slip on $\{111\} \langle 1\bar{1}0 \rangle$ systems was revealed on indented (001) surfaces by thermal etching at 900°C in air. The hardness impressions were made with a Knoop indenter under 500-g load at room temperature. Figures 1 and 2 show scanning electron micrographs, taken at a strongly tilted angle, of thermally etched ridge structures at low

and high magnification, respectively, surrounding a Knoop impression. Micro-hardnesses ranging between 30 GN/m² for the long axis of the indenter along $\{110\}$ and 43 GN/m² along $\{100\}$, were measured. The hardness values compare with 80 to 90 GN/m² along $\{110\}$ and 90 to 100 GN/m² along $\{100\}$ for Type I and Type II industrial diamonds. Cubic boron nitride has the zincblende structure of two interpenetrating face-centered-cubic lattices. Thermally etched pitting of slip traces was produced at indentations on (111) surfaces when heated in air at 900°C. The (100) and (111) etch structures and an analysis of the anisotropy of the Knoop hardness measurements led to the conclusion that $\{111\} \langle 1\bar{1}0 \rangle$ slip systems are operative.

Brookes, Hooper, Lambert, and Ross (1983) have reported the observation of etched plastic zone spreading from hardness indentations in germanium, silicon, and boron nitride crystals when annealed above threshold temperatures of 300, 400, and 900°C, respectively. A threshold temperature less than 1150°C was estimated for diamond from direct observations of slip lines at indentations. The spread of dislocations from the indentations relieves the localized residual stresses. Brookes and his coworkers propose that analogous accelerated chemical attack of locally deformed regions occurring during amorphite tool operation--say, in cutting steel in an air atmosphere--may be the mechanism responsible for wear of the tool. Sato, Endo, Kashima, Fukunaga, and Iwata (1983) have commented on the superior mechanical properties of cubic boron nitride, even compared to diamond, for grinding and cutting materials containing nickel, cobalt, or iron. The observation of plastic zone spreading may be interpreted to give evidence, also, for the presence of dislocation pile-up stresses at hardness impressions. Such stresses have been proposed by Elban, Coffey, Armstrong, Yoo, and Rosemeier (1983) to account fundamentally for localized adiabatic heating effects in inert and energetic (explosive) materials.

The primary cubic boron nitride particles are bonded within amorphite by direct contact sintering and secondary growth of joined particles (Brookes and Hooper, 1982). The continuous skeletal framework of the primary material is proposed to give a stronger basic microstructure than occurs in conventional tool materials--for example, cemented tungsten carbide material, in which the cobalt binder material, though in small proportion, can undergo plastic

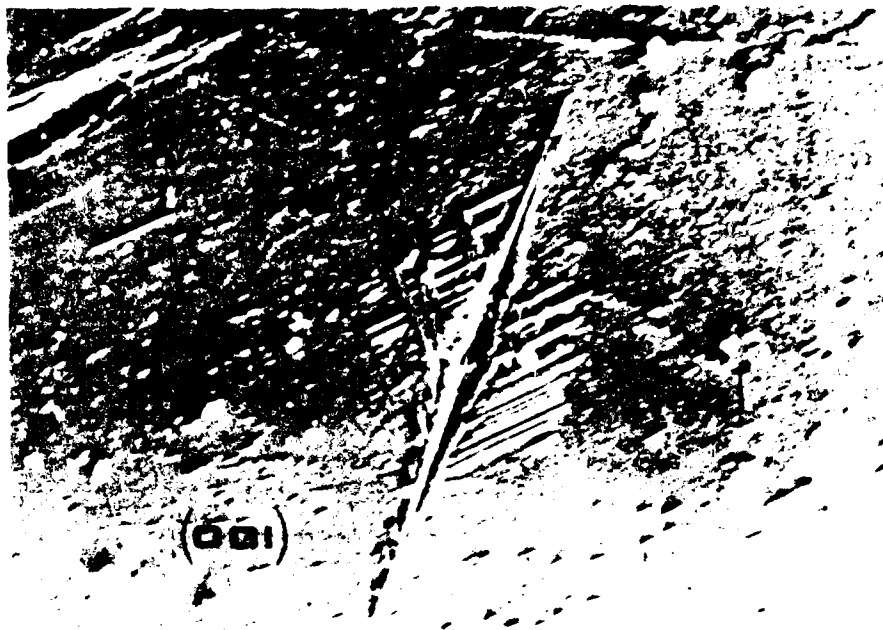


Figure 1. Knoop hardness impression at 500-g load with major axis along $[100]$ on (001) cubic boron nitride surface, after thermal etching at 900°C in air.



Figure 2. Enlargement of interpenetrating $\{111\} \langle 1\bar{1}0 \rangle$ slip trace ridges revealed at an annealed indentation with scanning electron microscopy.

deformation without deformation of the tungsten carbide particles. Aluminum, aluminum nitride, and traces of calcium and potassium have been identified in the filler phases within the sintered cubic boron nitride of amborite. The average size of boron nitride particles is about 10 μm , and hardness values of 26.5 and 49 GN/m^2 are reported for amborite indented at 2.0 and 0.1 kg, respectively.

The temperature dependence of hardness properties of cubic boron nitride and diamond materials is being investigated. The machining operation is being studied. An explosive rig has been designed to separate a machining tool from the work piece so as to examine the interaction between the tool and work piece as it existed very near to the operating condition. Indentation creep, wear of hard materials by softer surfaces, deformation of hard surface layers on metallic substrates, scratch hardness testing, and fracture toughness measurements by indentation testing are additional topics of interest. A value of stress intensity for plane strain, $K_{IC} = 3.3 \text{ MPa}\cdot\text{m}^{1/2}$, was determined for single-crystal SiC (6H structure-type) with Vickers and the (Russian) Berkovich indenters (Henshall and Brookes, unpublished). The result has been correlated with results from single-edge, notched-beam bend tests.

At the first conference on the Science of Hard Materials in 1981, Brookes (1983) gave an excellent review of hardness measurements for the evaluation of hard materials, including results on titanium carbide and vanadium carbide. He is on the organizing committee for the Second International Conference-Science of Hard Materials, scheduled for 23 through 28 September 1984, at Rhodes, Greece. For further information, contact him at Exeter or contact Dr. Eric A. Almond, National Physical Laboratory, Teddington, Middlesex, TW11 0LW, UK; telephone: (01) 979-3222. Readers of ESN also may be interested in the upcoming Microindentation Hardness Testing Symposium and Workshop, cosponsored by the International Metallographic Society and the American Society for Testing and Materials, 15 and 16 July 1984, in Philadelphia, PA. Contact Dr. P.J. Blau, National Bureau of Standards, Washington, DC, 20234; telephone: (301) 921-2974.

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9/29/83

THE SIXTH EUROPEAN SEA HORSE INSTITUTE MEETING: MATERIALS IN MARINE ENVIRONMENTS

by James F. Jenkins. Mr. Jenkins is a metallurgist with the Naval Civil Engineering Laboratory, Port Hueneme, CA.

The sixth annual European Sea Horse Institute meeting was held in Solihull, Birmingham, England, from 6 through 8

September 1983, under the sponsorship of the LaQue Center for Corrosion Technology, an affiliate of the International Nickel Company. Five technical sessions highlighted materials in heat exchanger applications, design and operation of heat exchanger systems, materials in seawater handling systems, biofouling in seawater systems and heat exchangers, and materials in structural applications.

The purpose of the meeting was to exchange information on the latest technology in the applications of materials in marine environments. The 125 attendees from 16 countries principally represented users of materials--for example, the electric power generating companies and ship operators; the producers of both equipment and materials for marine applications--such as pump manufacturers, casting producers, and suppliers of alloy products; and personnel involved in marine materials research from government agencies, independent research organizations, and corporate research groups.

Materials in Heat Exchanger Applications

The session dealing with materials in heat exchangers focused on applications of copper alloys, stainless steels, nickel alloys, and titanium and aluminum alloys in heat exchangers. There was also discussion of the effects of environmental variables and chemical additions on the performance of the materials. With regard to the use of copper-nickel alloys, there appears to be a preference for the CN1089 (66 Cu, 30 Ni, 2 Fe, 2 Mn) alloys in Europe, whereas the alloy 722 (8 Cu, 15 Ni, 0.5 Cr) is preferred in the US. While this may be due to differences in relative levels of pollutants and silt, it can also be attributed to differences in manufacturing techniques. The use of ferrous sulphate additions continues to be widely accepted for corrosion control of copper alloys in recirculating and once-through systems. Adding chlorine for fouling control generally harms the performance of copper alloys. However, under certain conditions it was reported that chlorine can improve film formation on copper alloys up to relatively high fluid velocities; but when the velocity limit is exceeded, the local film breakdown results in deeper attack than encountered without chlorine additions. Many participants discussed the differences in the performance of materials in sodium chloride solutions, artificial seawater, solutions with additions of organic ligands such as albumin or hemoglobin, fresh natural seawater, polluted natural seawater, sterilized

natural seawater, and various other test and operational media. It was agreed that these differences were significant and that the natural environments were generally the more aggressive. The effect of pretreatment films on copper alloys was considered an important factor for inhibiting corrosion. Precommissioning of heat exchangers with potable water to avoid sulphide film formation is effective.

Experience with stainless steels, both as a tube and tube-sheet material, continues to be successful--except for several reported problems with crevice corrosion. Both service experience and experimentation with crevice corrosion on stainless steels continue to be difficult to reproduce and quantify. A new technique has been developed by the LaQue Center for Corrosion Technology (Wrightsville Beach, NC): the anodic and cathodic areas are maintained in separate vessels. This approach promises to improve knowledge of the processes involved in both the initiation and propagation of crevice attack.

Design and Operation of Heat Exchanger Systems

In the session on designing and operating heat exchangers, the topics included factors influencing the selection of materials for heat exchanger system components such as tubes, tube-sheets, and water boxes; the effect of combinations of materials on system performance; the use of coatings and cathodic protection in heat exchanger systems; the use of corrosion monitoring devices to control system operation; the use of chemical additives for corrosion control; materials for plate-type heat exchangers; and experience with desalination and reverse osmosis systems.

It was emphasized that the performance of the materials in the system is influenced by many factors, including the cooling water composition at the site; variations in the cooling water composition with time due to seasonal factors or pollution; the operating parameters of the system; and operating procedures during thermal excursions, such as may occur during shutdowns or reduced capacity operation.

Galvanic interactions, particularly where titanium or stainless steel tubes or tube-sheets are used, continue to be difficult to predict quantitatively. Whereas the interior of tubes of materials such as copper alloys cannot be effectively polarized, apparently the stainless steel or titanium tubes perform differently. Polarization at distances of up to 200 tube diameters from the inlets were reported. Coatings

and cathodic protection have been successfully applied in new systems, and have been used to correct problems in existing systems.

Corrosion-monitoring devices have had only very limited application in cooling water systems. It was suggested that the experience with monitoring and control by the chemical industry should be evaluated for possible application to cooling water systems, particularly when additives for corrosion or biofouling control are being used.

Titanium is the material of choice for plate-type heat exchangers. The high material costs are offset by the efficiency of plate-type units. Biofouling is the primary problem with such units. Chlorine additions, either continuous or intermittent, are required.

The materials for heat exchangers in desalination systems are no longer a problem; however, auxiliary components such as pumps, piping systems, and shells are unreliable. Reverse osmosis units appear to limit severely the selection of materials. Very low levels of corrosion products can seriously affect the reverse osmosis membranes. High-alloy stainless steels appear to be the best materials when full strength seawater is used.

Materials in Seawater Handling Systems

The session on materials in seawater handling systems dealt with the selection and performance of materials for pumps, valves, and pipes; galvanic interaction; the performance of cast versus wrought materials; and the use of cathodic protection, coatings, and weld overlays. The performance of materials in pumps and valves is highly dependent on velocity effects; however, velocity alone cannot define material performance. Corrosion researchers and hydrodynamicists may need to cooperate so that they can define better the flow condition both in actual service and in experiments to examine material performance.

Highly alloyed stainless steels appear to be gaining acceptance for critical components such as impellers and wear rings. However, traditional materials such as copper alloys are still widely used. Economic considerations evidently outweigh actual performance. Galvanic interactions do not appear to be significant problems in pumps and valves used now, but may be significant between pumps, valves, and pipes of different composition. There have been no surprises, but one must carefully apply well-known interactions. The effects of operating a system (shutdown and precommissioning environments, for example) are as troublesome

for seawater handling systems as for heat exchangers. Cast and wrought materials seem to give similar performance, but the wrought materials appear superior for stainless steels that are sensitive to crevice corrosion. Cathodic protection and coatings are widely used in piping systems, as are weld overlays in pumps and valves.

Biofouling in Seawater Systems and Heat Exchangers

The session on biofouling in seawater systems and heat exchangers dealt with the mechanisms of the settlement of organisms on metallic surfaces, the effect of organisms on system performance, the impact of heat exchanger design on fouling, and the use of chemical or mechanical biofouling control techniques.

An important finding related the thickness of the laminar flow sublayer to the size of the fouling organism larvae. If the larvae are larger than the sublayer thickness, then the exposure to turbulence appears to prevent settlement. Thus settlement can be directly related to flow conditions.

In most systems, macrofouling appears to be more troublesome than microfouling: the blocking of flow channels and the localized turbulence caused by shells are more important than the small loss of heat transfer caused by slime accumulation. When velocity is used to inhibit the accumulation of fouling, the system's design is extremely important. Even if fouling is prevented in high velocity areas, the accumulation of organisms in low velocity areas can lead to damaging turbulence.

Chemical treatment using chlorine appears to be well understood from an operational standpoint. Both continuous treatment of very low levels (0.1 ppm) and intermittent treatment at low levels (0.5 ppm) appear to be effective, depending on location. Tube cleaning with either brushes or sponge balls is widely used in addition to chlorination; however, their combined effect sometimes corrodes aluminum or copper alloys.

Materials in Structural Applications

In the session on materials in structures, the topics included the performance of cathodic protection systems; the nature of the calcareous films formed on surfaces; the effects of cathodic protection on fracture and fatigue; protective coatings for underwater applications; splash zone protection; and marine atmospheric material applications.

The state of the art in cathodic protection systems appears to be well

developed. Both sacrificial anode and impressed current systems perform well. Mechanical problems such as loss of anodes and cables are more troublesome than design problems such as anode consumption and current distribution. The formation of calcareous deposits can now be effectively predicted and can be counted on to reduce the requirements for cathodic protection. It is important to control conditions so that a tightly adherent deposit is formed.

The effects of cathodic protection on fatigue and fracture are not well understood. Empirical guidelines for material selection and fracture control have been developed and are probably conservative. While hardness is the most commonly used material parameter, fracture toughness, microstructure, and hydrogen levels appear to be more directly related to actual performance. Vast differences in the fracture and fatigue behavior of materials exposed to artificial versus natural environments were reported. Accelerated tests are often misapplied to the prediction of service life in natural seawater.

Coatings for underwater applications continue to improve. Self-polishing coatings are performing very well in service; a 5-year life on ship hulls appears to be possible with these coatings. A major problem is that previously exposed surfaces must be decontaminated before or after sand-blasting. The Steel Structures Painting Council in the US has issued a new manual for protective coatings.

Splash-zone protection using 90-10 Cupro-Nickel and monel is now common. One problem is the settlement of old platforms; when this happens, the existing cladding is below the splash zone. Extending the cladding on new structures was recommended. Atmospheric corrosion is now being considered a greater problem as the underwater corrosion problems are being solved. Increased use of stainless steels in the marine atmosphere has been successful; they need much less maintenance than painted steel, and their corrosion usually is not structurally significant.

9/14/83

OCEAN SCIENCES

A PERSPECTIVE ON THE OCEANOGRAPHY OF STRAITS

by D. Conlon. Dr. Conlon is Group Leader for Coastal Sciences with the Office of Naval Research, Arlington, VA.

Background

Although sea straits have been important throughout economic, social, and military history, they are among the least-understood aspects of the ocean. The fundamental exchange that occurs in most straits (lighter water flowing in one direction near the surface, heavier water flowing in the opposite direction at depth) was documented in the late 17th century.

The observations of Merz, Schott, and Vercelli provided the basis for the first formulation of straits dynamics by Albert Defant in 1929. Defant postulated a two-layer system with a steady-state balance of momentum between pressure gradients and friction (using constant eddy-viscosity coefficients for turbulence closure). To this day, Defant's solution is the only formulation that depicts a time-averaged vertical profile of horizontal currents. In 1952 and 1953, Henry Stommel and Harlow Farmer formulated a principle of hydraulic control for estuaries and straits. Simply stated, the principle is that a two-layer exchange has a maximum rate of transport that is limited by the adjustment capacity of the internal density field; beyond a critical value (parameterized by internal Froude numbers of various kinds), a hydraulic jump will be generated and will choke the flow. This principle is important in understanding water-mass formation in adjacent seas; it is easily demonstrated, for example, that the capacity of the Strait of Gibraltar to exchange water between the Atlantic and the Mediterranean largely determines the salinity of deep Mediterranean water.

Until recently, the works of Defant and of Stommel and Farmer have been the cornerstones of our understanding of the physical oceanography of straits. The defects in these formulations are well recognized; they do not treat time-dependent flows or three-dimensional variability, and mixing within straits is treated crudely, if at all. Other important features, such as the formulation of flow instabilities (e.g., lee waves), are neglected as well.

A lack of observations is the primary reason that there has not been more progress in the last 30 to 50 years. Sea straits are unfriendly places to work; strong currents and heavy shipping traffic hinder field experiments. In addition, for an adequate treatment of dynamics a great deal of data is needed—for example, two- or three-dimensional current and density fields, continuous sea-level measurements at several coastal sites, winds, and atmospheric pressure fields. Still, it comes as a surprise to many

that only within the past few years have researchers acquired data sets of even rudimentary adequacy (e.g., Garrett and coworkers in the Strait of Belle Isle, Murray and coworkers in the Strait of Tiran).

Straits research also has been stimulated by laboratory investigators during the past 10 years (e.g., Whitehead and coworkers, Nof, and others). Laboratory observations are of particular value in investigations of the nature of flow instabilities in the regions of straits. In addition, they provide insights into the basic scales of processes important to dynamics formulations.

Most recently, technological advances in observational hardware are providing the first real opportunities to study dynamic processes in straits at appropriate time and space scales. Notable among these advances are new mooring designs for high-speed regions (Schott, Florida Straits), new fine- and micro-structure profilers, expendable velocity shear profilers, expendable conductivity-temperature-depth probes, and high-resolution, low-cost meteorological sondes. Perhaps the most exciting advances are in acoustic techniques. For example, a group at the University of New Hampshire has developed a bottom-mounted, upward-looking Doppler acoustic profiling current meter (DAPCM). The DAPCM emits four narrow acoustic beams into the water column and measures the Doppler shift of gated backscatter from several levels. Thus, one can obtain vertical profiles of three-dimensional velocity over a 300-m range with vertical resolution of 5 m. The enormous power of this technique is only beginning to be explored.

International Workshop on Sea Straits

A resurgence of research on sea straits has provided valuable new findings. In addition, breakthroughs are imminent in several areas. In recognition of this, the International Workshop on Sea Straits was held from 17 through 21 January 1983 at the Institute for Physical Oceanography in Copenhagen. Forty participants from 10 countries met to discuss the current state of knowledge in straits oceanography; as part of the discussion, there were about 25 formal presentations on various aspects of this area of research.

A general framework for the workshop was provided by specific case studies which illustrated the breadth of the research to be considered. Presentations were given on the Strait of Tiran (Hecht and Anati, Israel; Murray and Babcock, US); Belle Isle Strait

(Garrett, Petrie, and Toulany, Canada); Denmark Strait (Malmberg, Iceland); Faroe Channels (Meinecke, Federal Republic of Germany [FRG]; Kinder, US); Unimak Pass (Schumacher, US); Kattegat/Skagerrak (Stigebrandt, Sweden); the Bosphorus (Tolmazin, US); and the Tsugaru Strait (Conlon, US).

A continuing point of discussion was the relevant lateral scale of straits (McClimans, Norway). For example, when is a strait so wide that it behaves like two independent coasts? Conversely, when is a strait so narrow that the effects of the earth's rotation are negligible? There was broad argument that the Rossby internal deformation radius (R) must be the critical parameter, and that the ratio of R to the width, W , of the strait is the quantity of interest to determine whether a strait is wide (ratio much greater than 1) or narrow (ratio much less than 1). Not surprisingly, relatively few straits are clearly wide or narrow, and this ratio has rather limited utility.

Another major discussion focused on the nature of fluid flow in straits. Again, there was agreement that control is intimately linked to some sort of internal Froude criterion, but Stern (US) pointed out that Froude criteria were formulated for very simple cases. Nearly all showed pronounced temporal and topographic variability. Froude-type formulations probably are not sensitive measures of conditions in such straits; more research is needed to broaden the validity of the criteria.

Another set of papers dealt with the formation of internal waves in straits regions (Salusti, Italy; Cushman-Roisin, US, and Svendsen, Norway; Farmer, Canada). It has been known since the mid-1970s that very large (up to 80-m) low-mode internal waves are generated in many shallow regions that are subject to strong tidal action, and much progress has been made in understanding the formation and propagation of such waves. The effect of the waves on the internal dynamics of the straits (e.g., mixing) remains an area of active research.

Numerical modeling of straits regions was the subject of three papers. Cushman-Roisin and O'Brien (US) proposed a new, reduced set of governing equations which allows separation of baroclinic and barotropic motions. This simplified set of equations can help reach a wide range of efficient solutions to a variety of coastal problems. Stigebrandt (Sweden) presented a model of the Kattegat/Skagerrak Straits which incorporates horizontally two-layer

submodels. The model gives very reasonable representation of major features of the Kattegat and Belt Sea. Preller (US) described work on numerical modeling of the gyre in the Alboran Sea. Using both reduced-gravity and two-layer models, she presented results which suggest that the presence of the gyre may be primarily due to topographic steering at Gibraltar of the inflowing Atlantic Ocean water. Conlon (US) contrasted the Alboran Sea gyre with a seasonal gyre found east of the Tsugaru Strait, and suggested that both gyres may be generated by buoyant-inertial processes instead of topographic steering.

Finally, a set of papers showed that valuable insights into straits processes may be gained by examining biological and chemical parameters. Kullenberg (Denmark) examined distributions of suspended matter and fluorescence in straits areas, while Schlosser et al. (FRG) investigated Gibraltar overflow using geochemical tracers. Yentsch (US) showed vivid examples of how straits can act as local amplifiers of primary production.

The Copenhagen workshop was sponsored by the International Association for the Physical Sciences of the Ocean (IAPSO), the Nordic Council for Physical Oceanography, and the US Office of Naval Research (as part of the Special Focus Program on Strategic Straits Research). Co-convenors of the meeting were Prof. Gunnar Kullenberg (Copenhagen) and Prof. Stephen P. Murray (Coastal Studies Institute, Baton Rouge).

Future Work

The recent resurgence of interest in straits research is continuing to open exciting avenues of new investigation. Fundamental deficiencies in our understanding are well appreciated; at the same time, new programs of research promise to make substantial headway in remedying these deficiencies. The Strait of Gibraltar, for example, is the focus of discussions on instrumenting a "classic" strait to obtain a complete picture of the operative dynamics. Such an effort would require massive numbers of moored and expendable instruments deployed over the better part of a year. The necessary instruments are now available, and they are survivable.

It is also apparent that straits must be studied in the context of their regional oceanography; i.e., it is important not only to understand dynamics within a strait itself, but also to understand how the strait influences regional oceanographic processes and vice versa. For example, coastal boundary currents and eddies near straits

are intimately connected to what is going on within the strait itself, even though these boundary features may be far from the strait. Therefore, it is necessary to deal with much larger regions (numerically or analytically) than have been treated before.

Numerical modeling has enormous potential. Although physical processes in and near straits are very complicated, the presence of coastal boundaries contributes to "well-boundedness" of problems. With the anticipated breakthroughs in straits physics through experimentation, there is real confidence that time-dependent, three-dimensional numerical models soon will yield quantitative results in describing the temporal and spatial evolution of current-, density-, and sound-velocity fields in straits regions.

Other areas of straits research are intriguing but essentially unexplored. As Dr. Yentsch pointed out in Copenhagen, straits amplify biological signals, and this includes bioluminescence events; for example, the areas which show the most frequent bioluminescence events are near the Straits of Hormuz and Malacca, two of the most heavily trafficked straits in the world. The study of internal waves is also of interest. The existence of 50- to 100-m amplitude low-mode internal waves near straits is well documented; energy levels over much of the internal wave spectrum are probably quite high, but there are almost no usable observations.

Quite clearly, straits are as exciting scientifically as they are important strategically, and over the next several years we can anticipate major findings. Much of the impetus for on-going work is in fact being provided by the US Office of Naval Research through its Special Focus Program on Strategic Straits; the author would appreciate receiving any inputs from interested parties.

10/3/83

MARINE SCIENCE OF THE NORTHWEST INDIAN OCEAN

by Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

On Sunday, 3 September 1933, the oceanographic vessel *Mabahiss* left Alexandria, Egypt. It was beginning the John Murray Expedition, a joint Anglo-Egyptian venture through the Red Sea, the Gulf of Aden, the northwestern Indian Ocean, and the Gulf of Oman. By the time the ship returned 9 months later, it had worked 209 scientific stations and had brought back data which formed the basis for scientific reports published by the British Museum over the next 30 years.

The John Murray Expedition laid the foundations for marine science in the region and was especially important in Egypt. Soon after the cruise, the Department of Oceanography in the University of Alexandria was established, as well as the Egyptian Institute of Oceanography and Fisheries.

To commemorate the 50th anniversary of the John Murray Expedition, the University of Alexandria convened the International Symposium on Marine Science of the North West Indian Ocean and Adjacent Waters from 3 to 7 September 1983 in Alexandria. The symposium was organized to "determine the importance of this expedition and to describe its significance to the development of our understanding of the oceanography of the region." The meeting offered reviews of the general status of knowledge of the area and provided a forum for initiating future international and regional cooperation. The symposium was supported by UNESCO, the Royal Society (UK), and the US Office of Naval Research, London. The main topics covered were physical and chemical oceanography, geological oceanography, biological oceanography (shallow and deep-water), living and nonliving resources, and marine pollution.

Ninety-two people attended the symposium; 33 from Egypt, 14 from the UK, 11 from France, and six from the US. The remaining 38 participants were from Germany, India, Pakistan, Italy, Kuwait, Iraq, Qatar, Canada, Monaco, Turkey, Norway, and Greece. The proceedings will be published in a special issue of *Deep Sea Research*.

Physical, Chemical, and Biological Oceanography

Among the papers presented within this session, those concerned with upwelling were the most interesting to me and seemingly to the other participants. The physical setting for upwelling along the Somali Coast was presented by Michele Fieaux, Pascale Delecluse, and Mark Luther.

During much of the southwest monsoons, the Somali Current has a southern branch which veers offshore

near 4°N and a northern branch which forms a clockwise gyre between 4°N and 10°N. Theoretical studies indicate that the feature near 4°N is determined by the dynamics of the ocean, the feature near 10°N by wind stress. The gyre is of special interest because it is very stable and persists well into the northeast monsoons.

The results of a wind-forced numerical model of the seasonal response of the northwestern Indian Ocean (designed by Luther and O'Brien, Florida State University) predicts that with the onset of the summer monsoon's southerly winds in the northern hemisphere, northward flow develops across the equator along the western boundary and turns offshore a few degrees north. At this time, an anticyclonic gyre--the remnant of the previous summer's circulation--has developed in the northwestern corner of the basin. This gives rise to a two-gyre circulation in the Somali Current, which is consistent with field observations. As the summer monsoon intensifies, the southern gyre moves northward until it begins to interact with the northern gyre. The flow in the southern gyre meanders intensely as it separates from the western boundary. The model shows that both gyres maintain their integrity until the summer monsoon winds relax and then begin to coalesce. The modeled southward flow across the equator starts about 1 month before the onset of northerly winds, indicating a remote forcing mechanism. By the time the winds reverse with the onset of the winter monsoon, the northern gyre has almost completely dissipated, but remnants of the southern gyre persist throughout the winter. As the winter monsoon intensifies, the southern flowing boundary current extends farther south, forming numerous meanders and eddies as it separates from the boundary. The winter Somali Current dissipates rapidly as the winter monsoon winds relax. Northward flow across the equator begins at the same time that the winds reverse, and forms a new southern gyre. The remnants of the previous summer's southern gyre are now the northern gyre, and the cycle repeats.

In my opinion, Sharon Smith (Brookhaven Laboratory) gave the symposium's best paper. She compared the surface properties of the northwestern Indian Ocean during the southwest monsoon of 1964 (R.R.S. *Discovery*) with those of 1979 (R.V. *Iselin*). The area of upwelling around Ras Hafun (10°N) is the clearest similarity. The highest surface concentration of chlorophyll *a* between Mombasa (4°S) and Cabo Guardafui (12°) occurred near Ras Hafun in both

years and was between 4 and 5 mg.m⁻³. Similarly, sea-surface temperatures around Ras Hafun were lower than elsewhere along the coast, and surface nitrate was higher. The abundance of the copepod *Calanoides carinatus* was in excess of 100 m⁻³ there and near 5°N in both years. Smith said the age structure of this dominant copepod suggests active reproduction in both years. Biologically, the northwestern Indian Ocean during the southwest monsoon of 1964 was quite similar to 1979, suggesting that considerable biological production in a short period of time is a regular, annual feature of this area.

Smith reported that for 9 months of the year the copepods move down to depths of 500 to 900 m, where they remain stable in terms of size and maturity. Then, when upswelling begins, they move to the near-surface waters. Over the 3 months of upwelling, they multiply rapidly and gain in size up to 15 percent of their body weight daily. Just how they "know" when to move upward in the water column was discussed. Smith said, "It's simple, after 9 months they're hungry."

Marine Pollution

The papers presented in this session generated the hottest discussions. One group, mostly scientists from the Middle East, is convinced that irreversible damage is being done to the ecosystems of the area, while another group, mostly from Western Europe, remains skeptical.

Those who are convinced say that oil production, refining, and transport have caused chronic oil pollution in the Red Sea, especially in the Gulf of Suez, and that there is enormous potential for future offshore oil production in the area. In fact, the relatively enclosed Gulf is likely to become one of the world's largest offshore oil production areas in the next two decades, and a different approach to new developments is essential.

S.Z. Qasin and R.S. Gupta (India) expressed similar concern for the Indian Ocean, which is bordered by 19 countries inhabited by some 950 million people. The average population density in the region is 99 persons per square kilometer. Agriculture, industry, and mining form the economic base of the countries. Some effects of pollution from these activities are now appearing in the marine environment, but the problems are largely confined to coastal areas.

Because of increasing urbanization and industrialization in the region, the

volumes of sewage and industrial waste along the coasts are also increasing. Many countries have heavily polluted rivers flowing through them. Large quantities of untreated or partially treated sewage are discharged into the rivers; high counts of coliform have been reported on the beaches and coastal areas of several countries.

Oil pollution is a chronic and acute problem in and around the harbors of all the countries in this region. In 1980, 51 percent of the world's oil was shipped from the Middle East across the Arabian Sea. One of the main shipping routes passes through the Mozambique Channel, around South Africa, to the western hemisphere; the other is around Sri Lanka, across the southern Bay of Bengal and Malacca strait, to the Far East and Japan. The effect of oil pollution--a tar-like residue--can easily be seen on the beaches of almost every country. The amount of floating tar present in the Arabian Sea at any time has been estimated at 3700 tons. The floating tar has a residence time of 30 to 40 days.

Living Resources

The role of the Suez Canal as a habitat and pathway for marine organisms was the subject of an excellent presentation by A.A. Aleem of Egypt. The canal is 163-km long, 125-m wide, and 30-m deep. For 10 months of the year there is a net flow of water through the canal from the Red Sea into the Mediterranean, and for 2 months the reverse occurs. Over the 115 years since construction, Red Sea and Mediterranean organisms have adjusted to the special environmental conditions in the canal. For example, in 1908 a biological survey identified only eight species of algae; 50 years later there were 68 species of algae and five new sea grasses. Many seemingly delicate species, including fish, have adjusted even to the harsh conditions of the highly saline Bitter Lakes (50 percent above seawater). Since 1869, over 2000 species have used the Suez Canal as a pathway and new habitat, with the overwhelming majority moving from the Red Sea to the Mediterranean. The canal recently has been made deeper and wider; this probably will accelerate movement throughout the canal environments.

A similar presentation discussing changes in eastern Mediterranean fisheries emphasized the danger of large-scale environmental impact in response to man's engineering works. In this case study, the role of the Asswan Dam was analyzed. The dam and the associated irrigation network has

reduced the Nile discharge into the Mediterranean by 90 percent. In addition, the attributes of the water now reaching the delta are significantly different. The previous sediment load is no longer transported, and the amount of chemicals in solution is vastly higher. Consequently, plankton production near the delta is down a hundred-fold; so species higher in the food chain, such as sardines, are much reduced. For example, the catch of sardines is down from 18 million metric tons in 1962 (before the dam) to less than 2 metric tons in the 1970s. In addition, land losses along the seaward edge of the Nile delta have been extreme.

Marine Geology and Geophysics

Excellent papers on the geology of the Indian Ocean and vicinity were presented by three British geologists, Prof. F.U. Vine (FRS), R.W. Girdler, and R.S. White. Vine provided an overview of the geological evolution of the Northwest Indian Ocean; he described the passive or trailing continental margins and spreading ocean ridges of the Indian Ocean. In principle, he said, it should be possible to deduce the history of formation from fracture-zone trends and linear magnetic anomalies. This history is geometrically complicated, as evidenced by the presence of "microcontinents" such as Madagascar and the Seychelles Bank. However, because Mesozoic magnetic anomalies in the Mascarene, Mozambique, and Western Somali Basins have been recognized in recent years, an evolutionary history now can be described.

Five distinct phases of sea-floor spreading during the formation of the Indian Ocean can be recognized; four of these are represented in the northwest Indian Ocean. The earliest, in the late Jurassic and early Cretaceous, was a period of north-south spreading about east-west trending ridges in the Western Somali and Mozambique Basins. This spreading produced the initial separation between west Gondwana (Africa and South America) and east Gondwana (Madagascar, India, Antarctica, and Australia). Spreading ceased in these areas in the early Cretaceous; then spreading is thought to have started between India and Antarctica. Throughout the mid-Cretaceous, spreading occurred to the south of India, separating India and Madagascar from Antarctica and Australia. Hence this phase is absent from the northwest Indian Ocean. In the Santonian period (i.e., magnetic anomaly 34+), spreading began between Madagascar and India; and between the Santonian and

Danian (anomaly 28), the Mascarene Basin was formed. As a result of a major ridge jump in the Danian, spreading ceased in the Mascarene Basin and started to the northeast of the Seychelles. Thus the Seychelles Bank was separated from India; spreading about the Carlsberg Ridge began and continues today. There was a major change in the rate and direction of spreading in the mid-Eocene and an extension of this spreading regime into the Gulf of Aden and Red Sea, through the Sheba Ridge, in the late Tertiary.

R.W. Girdler (University of Newcastle, UK) presented evidence that the Red Sea has formed by the anticlockwise rotation of Arabia with respect to Nubia. The exact way in which the oceanic lithosphere has evolved in between Egypt and Arabia, he said, is difficult to resolve. However, the regional geology indicates that the northern Red Sea evolved in three stages: (1) the Gulf of Suez stage, which was mainly in the Oligocene; (2) the Aqaba-Dead Sea stage one, in the lower Miocene; and (3) the Aqaba-Dead Sea stage two, in the Plio-Pleistocene and still continuing. The best estimates for the last two stages of movement along the Dead Sea transform are 62 km and 45 km, respectively. If Arabia were moved back by 107 km along the Dead Sea transform, the western scarps of Sinai and Arabia would be almost collinear. The reconstruction obtained in this way gives the Gulf of Suez stage, in which the fit of the coastline suggests a simple tensional origin with a direction of motion perpendicular to the strike of the present Gulf of Suez. There was a change in the direction of movement of Arabia with respect to Nubia between the first and second stages.

Finally, Robert S. White (Bullard Laboratories, Cambridge, UK) gave an excellent paper on the tectonics of the gulf of Oman. The gulf is a triangular remnant of oceanic crust created in the Cretaceous and subsequently buried by up to 8 km of sediment. Along the northern margin, this oceanic portion of the Arabian plate is being subducted beneath the continental Eurasian plate. As the thick pile of sediments is scraped off the subducting plate, it accumulates in the Makran accretionary prism of Pakistan and Iran. This is a good example of an accretionary prism formed where there is a large sediment input. White discussed the tectonics and evolution of the accreted sediment wedge and showed how new slices of sediment are incorporated into the seaward edge of the material that has been scraped off. Sediment dewatering and the generation

of weak zones of overpressured material appear to play a crucial role in governing the tectonics of the accretionary prism. White showed examples of seismic refraction lines across the continental margin that defined the shallow (1 to 2 degree) dip of the subducting plate.

The western end of the subduction zone is marked by the fault system known as the Oman line, near the Strait of Hormuz. Beyond this point the Arabian-Eurasian collision changes to a continent-continent type, and the type of deformation changes markedly. At the eastern end of the subduction zone there is a triple junction near Karachi between the Arabian, Eurasian, and Indian plates. The Murray Ridge forms the southeastern boundary of the Gulf of Oman, separating the oceanic part of the Indian plate from the oceanic crust of the Arabian plate, and terminating at the northernmost end in the Karachi triple junction and at the southernmost end in the Oman fracture zone. Seismic reflection profiles across the Murray Ridge show that it is an extensional feature with normal listric faulting in the sediments. The continental margin is unusually steep, and an offshore buried ridge may represent part of a back-arc volcanic chain which became trapped against the margin when the Semail sequence was emplaced.

White presented geophysical data to illustrate the tectonics and structure of the three margins which form the edges of the Gulf of Oman: in the north, the compressional margin of the offshore Makran; in the southwest, the passive continental margin of Oman; and in the southeast, the intra-oceanic extensional Murray Ridge.

9/20/83

WHITECAP WORKSHOP HELD IN IRELAND

by Chester McKinney. Dr. McKinney is the Liaison Scientist for Underwater Acoustics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from The University of Texas at Austin, where he is Senior Research Scientist at Applied Research Laboratories.

The Whitecap Workshop was held at University College, Galway (UCG), Ireland, from 4 through 7 September 1983. The workshop, international in

scope, had as its central theme the relation of multiple environmental factors to the generation of whitecaps at the ocean-atmosphere interface. Prof. Edward C. Monahan (Department of Oceanography, UCG) organized and conducted the workshop, which comprised 22 invited papers plus about 20 contributed poster papers. The meeting was largely funded by the US Office of Naval Research (ONR), Arlington, VA. Table 1 lists the countries represented in terms of participants and papers presented. This was the first Whitecap Workshop, although there have been other air-sea interaction conferences under ONR sponsorship.

The relation of whitecaps to causal factors such as wind speed and wave spectra is an interesting scientific problem. It is of special interest to naval forces because whitecaps can be remotely sensed from satellites and aircraft, and can indirectly provide information about the sea's surface and sub-surface conditions and about the lower atmosphere.

However, it is evident that these relationships are not simple. The number of experimental data sets is not large; but based on those available, the percent of coverage of the ocean surface by whitecaps as a function of the exponent of wind speed can vary from perhaps 1.5 to 4.0. Also, the standard deviation for each data set precludes using whitecap coverage to estimate wind speed with high precision. Clearly there are more significant factors than just surface wind speed. The processes are nonlinear, which further complicates matters. The rewards for a better solution of the problem justify further and much-needed research. Five of the papers dealt primarily with the relationships between wind speed and whitecapping.

Five of the invited papers related primarily to bubble generations and bubble characteristics. M.S. Longuet-Higgins (Cambridge University, UK) gave an interesting basic paper on whitecaps and wave motion. S.A. Thorpe (Institute of Ocean Sciences, UK) presented considerable data on bubble depths as a function of wind speed and included some theoretical work. His data, obtained with upward-looking and sidescan sonar at 248 kHz, showed some bubble layer depths up to 20 m and depths to 3 m after a squall and wind speeds of 9 m/s. These data, of interest to sonar developers and to those interested in whitecap generation, point to the importance of operating sonar transducers below the bubble layers for best performance. Thorpe's data also showed a significant

Table 1

Whitecap Workshop Participation

<u>Country</u>	<u>Participants</u>	<u>Invited Papers</u>	<u>Poster Papers</u>
US	20	7	7
UK	12	5	3
Ireland	10	3	4
France	3	2	1
Canada	2	1	1
Japan	2	2	
West Germany	2	2	
Italy	1		1
Netherlands	1		
Norway	1		
Total	54	22	17

difference between seawater and fresh-water in regard to bubble generation and behavior. B.D. Johnson (Dalhousie University, Canada) gave an interesting paper on the life history of bubbles. It may take 500 seconds for a bubble to dissolve in seawater; afterward, a residue remains. This may be significant because in this environment a sonar might well cavitate at a lower sound intensity than otherwise would be the case. Johnson used a bubble camera for his experimental work.

Another five papers dealt primarily with the generation of aerosols in the lower atmosphere. These ranged from tests in wind and water tunnels to global surveys covering several years of work. M. Griggs (Science Applications Inc., US) summarized his work in analyzing satellite data on aerosol distribution, using data from Landsat II and NOAA V, VI, and VII. Using ground-truth data for comparison, he showed good correlation between radiance data and aerosol data. He then used radiance data to estimate whitecap coverage. P. Koepke (University of Munich, Federal Republic of Germany) discussed remote sensing signatures of whitecaps in the solar spectral and microwave range. It is interesting to note that these were the only two papers which dealt with satellite data.

There were two papers on surface tension, an important factor in whitecapping. John Scott (University of Essex, UK) gave a paper on the theory of surface tension in nonlinear waves, which dealt with capillary-gravity waves.

Electrostatic phenomena at the sea surface are factors in whitecapping. B.

Vonnegut (State University of New York, Albany) presented an interesting review/tutorial paper on this topic. S. Gathman (US Naval Research Laboratory [NRL], Washington, DC) summarized the extensive NRL program on measuring the electric field near the sea surface. Although a number of measurements of the electrostatic field have been made over many years, the phenomenon is not understood in detail. This is an aspect of oceanography that probably is not generally appreciated.

The study of whitecaps has been a major project at UCG for several years; M. Spillane summarized the work, which includes global prediction of whitecapping and aerosol generations.

All the invited papers and posters were well presented and were interesting and relevant to the workshop theme. Most of the papers emphasized experimental work. Perhaps a third of the papers were reviews or tutorial in nature; this may seem unusual for a workshop agenda. But to an "outsider," as I was, they were very welcome; and I perceived that the other participants appreciated them also. Whitecapping is a complex topic, and not all the workers are familiar in detail with the work of others doing relevant work. D.C. Blanchard (State University of New York, Albany) gave an interesting talk on the scientific contributions of Dr. Alfred H. Woodcock of Woods Hole Oceanographic Institution. Woodcock has been a pioneer in many areas of oceanography, including air-sea interaction.

Monahan is committed to publishing the workshop proceedings within a year, and this seems feasible since he had copies of most of the papers at the time

of the meeting. (Questions relating to the availability and cost of the proceedings should be directed to Dr. E.C. Monahan, Department of Oceanography, University College, Galway, Ireland.) The published proceedings, if given appropriate distribution, might well alert the broader US Navy community to the work of the very small whitecap community. This in turn might trigger a better dialogue between those doing basic research and those who will ultimately make use of the science. It is my view, based on a few informal discussions, that this dialogue at present is not vigorous.

University College, Galway, founded in 1849, is the smallest of the Ireland universities with some 4000 students, 10 percent of whom are at the graduate level. The Oceanography Department is quite small but very active and enjoys considerable participation by faculty members from other departments. The weather in Galway was appropriate for the subject of the meeting--a strong gale provided nearly complete whitecapping of Galway Bay.

9/28/83

PHYSICS

A NEW DIAGNOSTIC TECHNIQUE FOR COLLECTIVE ION ACCELERATION

by David Mosher. Dr. Mosher is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until July 1984 from the Naval Research Laboratory, Washington, DC, where he is Supervising Research Physicist.

Ongoing experimental research at the Weizmann Institute of Science in Rehovot, Israel, is investigating collective ion acceleration (CIA) by relativistic electron beams and the related electron dynamics. A key aspect of the work is development of a new diagnostic tool to probe the structure of the accelerating electric field. The research is of interest because a number of charged-particle acceleration techniques have been proposed for directed energy applications based on devices that are orders of magnitude more compact than conventional accelerators (Mosher, 1983). The new probe may

provide a means of experimentally evaluating such techniques.

The Weizmann Institute is a major Israeli center for research and graduate training in the natural sciences and is dedicated to the development of new science-based industries. The Weizmann Institute houses the Feinberg Graduate School, so 50 to 60 percent of the institute's operating budget comes from Israel's University Grants Commission. Research grants, contracts from abroad, and private donations account for most of the remaining funds. About 60 percent of the institute's efforts are in areas of biological science, although it is also well known for research in theoretical high energy physics, experimental nuclear physics, computer science, and applied mathematics.

The intense charged particle beam (CPB) research is carried out within the nuclear physics faculty under the direction of Prof. A.E. Blaugrund. I discussed the group's research with him and his associates, Z. Zinamon, E. Nardi, and M. Markovitz. The experimental program centers around a high-intensity relativistic electron beam (REB) accelerator. In addition to investigations of collective ion acceleration by pinched electron beams, diagnostic techniques for measuring properties of intense CPBs are being tested (Nardi and Zinamon, 1981). Recent theoretical work has stressed the interactions of intense beams with matter (Nardi and Zinamon, 1983) and the use of characteristic x-rays (K-alpha line radiation) to diagnose the interactions.

Background

Since 1968, when collective acceleration of ions by REBs was first observed (Graybill and Uglum, 1969), there have been many reports of CIA in a variety of experimental configurations. The phenomenon was observed in low-pressure, neutral-gas drift tubes into which the electron beam was injected, and in evacuated drift tubes with either dielectric or metal foil anodes (a review of CIA is given by Olson, 1979). The collectively accelerated ions were usually characterized by energies per nucleon several times higher than the voltage applied across the REB diode, and by ion beam propagation in the direction of the drifting electron beam.

A number of mechanisms for CIA have been proposed, although it is generally accepted that no one of them can account for all of the experimental results. Most models include the formation of electron space charge in the drift tube behind the anode of the REB diode. Ions produced by electron collisions with the

drift-tube gas or anode material are trapped in the electric-potential well formed by the electron cloud and are then accelerated by it. Ions might then be accelerated to the velocity of the electron cloud.

Because of the large mass difference between electrons and ions, controlled motion of an electrostatic well composed of several megaelectronvolt electrons could theoretically lead to acceleration of ions to gigaelectronvolt energies. It is therefore important to understand CIA mechanisms and the structure of the ion-accelerating electric field as completely as possible. Previous studies have concentrated on measuring the characteristics of the accelerated ions. The Weizmann experiment uses a new diagnostic technique to directly probe the structure of the accelerating space-charge potential well. Preliminary results have just been reported by Markovits and Blaugrund at the Fifth International Conference on High-Power Particle Beams, held in San Francisco from 12 through 14 September.

The CIA Experiment

Blaugrund's group is well known for its ability to add to and refine existing diagnostic techniques to perform novel measurements in harsh intense-beam environments (for example, see Blaugrund and Cooperstein, 1975; and Blaugrund et al., 1981). The CIA experiment provides another example of the group's skill.

The idea behind the experiment is simple. A probing proton beam is injected transverse to the drift-tube axis behind the anode and passes through the cloud potential well (Figure 1). The electric field in the well produces a deflection of the proton beam in the axial direction. The deflection is recorded on a scintillator opposite the probe-beam source. The motion of the beam-excited light spot on the scintillator describes the real-time variation of the electric field at the axial position where the probe beam crosses the well. The drift tube is designed so that the beam can be injected at various axial positions within the well to map out its spatial structure. The most difficult part of the experiment is designing it for an adequate signal-to-noise ratio--the scintillation signal from the milliamper probe beam must exceed the extraneous signals due to the 100-kA electron beam, a 10-kA CIA beam, the bremsstrahlung x-radiation and softer plasma radiation emitted by the anode.

The electron-beam accelerator is an Ion Physics Corp. Neptune C generator operated at about 400-kV peak voltage,

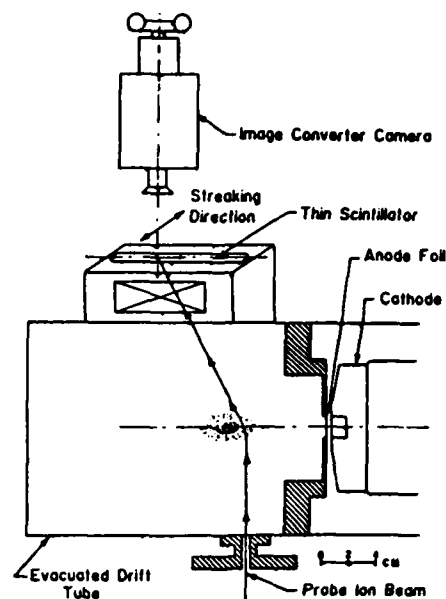


Figure 1. The CIA probe experiment.

100- to 150-kA peak current, and 80-ns pulse duration. The conically tapered cathode is 80 mm in diameter and faces a 1-mm-thick aluminum anode with a 15-mm-diameter central hole covered with either a 15- μ m-thick aluminum foil or 2- μ m-thick Kimfol. The 3-mm-diameter pinched electron beam which forms during the pulse is transmitted into the drift chamber by either of the thin foils.

When the pinched electron beam passes into the drift chamber, it gives rise to a 50-ns duration, 5-kA/cm², 10-kA collectively accelerated ion beam. The characteristics of the CIA beam were determined in previous experiments using deuterated polyethylene targets (Gilad and Zinamon, 1976).

The ion probe beam system consists of a surface breakdown ion source, an accelerating electrode structure and a high-voltage Marx generator. The ions are extracted from the plasma created by breakdown across a grooved polyethylene sheet placed between two carbon electrodes. Discharge of a 20-nF capacitor charged to 5 kV creates the proton and carbon plasma. The lighter protons reach the acceleration region before the heavier carbon ions, so that the extracted beam consists mainly of protons for the first few hundred nanoseconds. The lighter protons are preferred for diagnosis because of their well-defined

charge state, higher current density, lower divergence, and stronger light yield in the scintillator. A probe beam accelerating voltage of 180 kV is produced by an eight-stage, oil-immersed Marx generator. The probe current density is 50 to 100 mA/cm², and the beam diverges from about 1.5-mm diameter at the injector to about 6 mm at the scintillator.

After crossing the potential well, the probe beam impinges on a 3- μ m-thick strip of NE 102A plastic scintillator placed parallel to the drift tube axis and 1.7 cm from it. Discrimination against x-rays and fast electrons is achieved by limiting the scintillator thickness to the probe ion range. Since the thinnest commercial thickness is 10 μ m, that material is etched in toluene at Weizmann to the desired 3 μ m. A strong permanent magnet field (1.5 kG) in front of the scintillator prevents electrons from reaching it. Baffles and collimation reduce scattered ions from the CIA beam to acceptable levels--the probe beam current is seven orders of magnitude lower than that of the CIA beam. Shielding reduces the anode x-radiation that can reach the scintillator. Finally, the NE 102A strip is front coated with 2000 angstroms of vapor-deposited aluminum to prevent light from reaching the detector optics.

The light produced by the probe ions on the scintillator is gathered by f1.4 optics and transmitted to the photocathode of a fast image converter streak camera. The optical signal is amplified by a microchannel plate image intensifier coupled through fiber optics to the image converter tube. The light distribution is recorded as a function of time by the streak camera using a 200-ns sweep duration.

The spatial resolution of the measurements is determined by the probe-beam cross section and its divergence. Currently, the potential well can be probed with 2- to 3-mm resolution. Temporal resolution is determined by the slit aperture above the scintillator. Matching the slit width to the probe beam spot size results in about 8-ns resolution. A higher quality probe beam can reduce this figure to about 2 ns, the scintillator decay time.

In experiments carried out to date, the probe beam was injected at various distances from the anode plane on the axis of symmetry, and deflection by the potential well was observed. In addition to the signal-to-noise problem, a second major difficulty was synchronization between the REB pulse, the probe accelerating voltage pulse, the probe ion source, and the camera sweep.

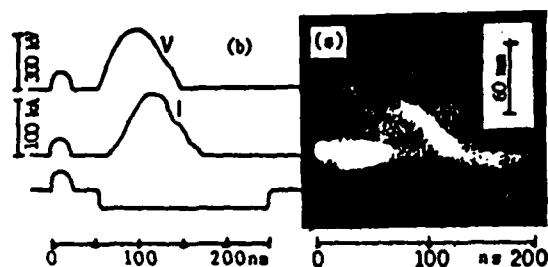


Figure 2. (a) Streak photograph of probe beam motion. (b) Diode voltage and current, and streak gate traces.

Figure 2 shows data for a successful synchronization with the probe beam injected 40 mm from the anode. The upward direction on the streak corresponds to a probe deflection along the drift axis and away from the anode. At early and late time, no deflection is observed. During the second half of the diode current pulse, the probe is suddenly deflected off the scintillator and reappears about 10 ns later with a 45-mm downstream deflection. Injection 24 mm from the anode produced a 90-mm deflection, and injection 55 mm from the anode produced a 25-mm deflection. No deflection was found when the probe was injected immediately (about 3 mm) behind the anode. As a check, no deflection was observed when a thick aluminum anode prevented the pinched electron beam from entering the drift tube.

These preliminary results indicate a 20-mm lateral by 40-mm longitudinal well with a depth about equal to the diode voltage. The potential well exists for about 50 ns at probe points as far as 55 mm from the anode, and the deflection decreases with anode distance.

More and better data will be needed to obtain a complete physical picture of the potential well and acceleration process. Future plans include efforts to improve the spatial and temporal resolution. It is hoped to develop a better probe beam with higher current density, lower divergence, and longer pulse duration. A higher probe ion energy can fulfill these objectives as well as provide enhanced scintillator light output and an improved signal-to-noise ratio. A systematic mapping of the well, with the addition of off-axis transverse injection and axial injection is planned. These data, combined with an accurate time correlation between different deflection measurements, are expected to give a fairly complete

picture of the three-dimensional well structure and its time evolution. It is hoped that this picture will provide a better understanding of CIA mechanisms.

Concluding Remarks

The particular CIA technique researched at the Weizmann Institute is not currently under consideration as a viable advanced accelerator concept. The potential well is produced in a "virtual cathode" cloud within which electrons move in all directions. Although individual electrons are relativistic, the rate at which the cloud can move axially is a small fraction of light speed. The technique cannot then be expected to accelerate ions to very high energy in a well-collimated axial beam.

A number of other REB-drive ion-accelerator schemes with more desirable properties have been proposed (Mosher, 1983). These schemes employ higher quality REBs in which electrostatic wells are created on the propagating beam by the interaction of the electrons with a plasma or vacuum drift tube structure. In some cases, the drift tube geometry or an externally applied magnetic guide field is varied to provide acceleration of ions over long (many meter) distances by controlling the velocity of a wave on the beam. Others employ an electromagnetic field structure or guided laser radiation to control the motion of a plasma-ionization front in which ions can be trapped and accelerated. One technique employs a doughnut-shaped electron ring to form the electrostatic well.

The importance of the Weizmann research lies not with the determination of the particular structure of their potential well, but with the development of a new tool to evaluate more promising compact accelerator concepts. New experimental difficulties will be encountered with probe-beam measurements in these other experiments. In particular, improved temporal resolution will be required to probe wells moving past the probe at near-light speeds. Electromagnetic effects may perturb the probe beam orbit. However, the signal-to-noise problem may be easier to deal with than in the Weizmann experiment--researchers may want to determine the electric field structure some meters from the REB diode so that the x-radiation background is reduced. Also, since the REB must be better collimated than the virtual-cathode cloud, the high energy electron background may be reduced. In any case, incorporation of a probe-beam diagnostic in US compact-accelerator projects can provide valu-

able information for evaluating the technique and new insights into acceleration mechanisms.

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10/5/83

ENERGY-TRANSFER PROCESSES IN CONDENSED MATTER

by P. Di Bartolo and R.L. Carovillano. Dr. Di Bartolo is Professor of Physics at Boston College. Dr. Carovillano is the Liaison Scientist for Space Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1984 from Boston College, where he is Professor of Physics.

The NATO Advanced Study Institute on "Energy Transfer Processes in Condensed Matter" was held in Erice, Italy, from 16 to 30 June 1983. The program was organized by the International School of Atomic and Molecular Spectroscopy of the "Ettore Majorana" Center for Scientific Culture under the direction of Prof. B. Di Bartolo of Boston College. A total of 65 participants attended the Institute from 47 laboratories or institutions and 16 nations.

The objective of the institute was to present a comprehensive treatment of

the basic mechanisms by which electronic excitation energy, initially localized in a particular constituent or region of a condensed material, is transferred to other parts of the system. Energy transfer processes are important to many fields, such as spectroscopy, lasers, phosphor technology, solar energy conversion, and photobiology. This was the first meeting dedicated entirely to this important topic.

The program included comprehensive sets of lectures, long and short seminars, and research reports. Perhaps two-thirds of the 65 participants made a formal presentation to the group at least once. Sessions were often lengthy and took place on weekends and several evenings. Highlights of the invited lectures and long seminars are described in this article.

Prof. F. Williams (University of Delaware) gave the introductory lectures and reviewed basic principles and methods in energy-transfer processes and solid state physics. Topics included the many-body problem, phonon-phonon and phonon-electron interactions, band structure, the role of nuclear motion, radiative transfer, Auger processes, conduction, and other processes affecting energy transfer. Williams was an important participant, not only for his own lectures but also for his enlightening questions and comments throughout the program.

The physical processes that deposit and transfer energy in condensed matter were described by Di Bartolo and U.M. Kenkre (University of Rochester, NY). Di Bartolo emphasized static and dynamical interactions among atoms (specifically treating two-atom interactions), statistical transfer effects and the role of migration, and collective excitations. Kenkre emphasized mathematical methods with applications to molecular crystals, experimental situations relating to exciton capture, mutual annihilation, and gratings.

G. Blasse (Rijksuniversiteit, Utrecht) dealt with energy transfer processes in nonconduction materials; G.F. Imbusch (University College, Galway) dealt with ruby; N. Schwenter (Freie Universität, Berlin) with solid rare gases; C. Klingshirn (Physikalisches Institut der Johann Wolfgang Goethe-Universität, Federal Republic of Germany) with semiconductors; F. Auzel (Centre National d'Études des Télécommunications [CNET], France) with ionic solid state lasers; and R. Reisfeld (Hebrew University of Jerusalem, Israel) with inorganic ions in glasses.

Blasse discussed the importance of energy transfer in luminescent materials

such as lamp phosphors and certain laser materials. Energy transfer between ion pairs was used to discuss cross relaxation and materials in which energy migration occurs. The latter were divided into two groups in which the energy migration had either a strong temperature dependence (YVO_4 , CaWO_4 , Ce^{3+} compounds) or a weak dependence (MnF_2 , uranium compounds, rare earth compounds). The migration processes depend strongly on the nature of the rare earth ions and the type of impurities.

The efficiency of energy transfer between donor and acceptor ions in a solid depends on whether the excitation can spread rapidly among the donors--i.e., whether the excited donor state is delocalized or localized. If the interaction between donors is sufficiently short-ranged, the donor excitation will be localized below a critical concentration of donors and delocalized above this concentration. Imbusch reviewed the experiments that have attempted to determine whether localization occurs in ruby, but the issue remains controversial.

Three types of energy transport are essential in condensed rare gases: migration of free excitons, transfer by localized centers, and mass diffusion of electronically excited centers. The first two processes are observed in solid rare gases, and a combination of the last two processes in liquid rare gases. Schwentner discussed free and localized exciton states and analyzed the balance between localization and migration of free excitons that determines the transfer range of free excitons. Photoelectron and luminescence experiments are used to monitor the migration of free excitons. Förster-Dexter type of energy transfer for localized centers was illustrated by host-to-guest and guest-to-guest electronic and vibrational transfer. The competition between transfer and nonradiative relaxation is crucial, and examples for transfer prior to electronic or vibrational relaxation were developed. The long lifetime of triplet states, especially in liquid helium, causes transfer ranges on the order of centimeters. The application of emission from self-trapped excitons in rare gas crystals for vacuum ultraviolet solid state lasers was shown. The efficiency is determined by losses due to transport. At high excitation densities an electron plasma is created in the crystal and induces additional transport and scattering processes.

Klingshirn divided his discussion of semiconductors into three parts: (1)

energy transfer from an external photon field to a semiconductor, (2) energy transfer from the polariton to the phonon field, and (3) energy transfer between various polariton modes by nonlinear interaction. (The term polariton is used for the coupled photon-electric dipole excitation mode that occurs in dipole crystals.) In the first case, polarization, dispersion, and surface effects in semiconductors are important. In the second, thermalization, luminescence, Raman and Brillouin scattering, and radiationless transitions occur. In the final case, Klingshirn explained two-photon Raman scattering, degenerate four-wave mixing, and the use of laser-induced gratings.

Only a few years after the demonstration of the first Nd-glass laser, energy transfer processes were considered for improving the coupling of broad optical pumping sources with the narrow absorption lines of active ions. A number of schemes were proposed, but it was soon recognized that multiple energy transfer and cooperative effects could play either a useful or a detrimental role, depending on the positions of the energy levels. Auzel pointed out that in materials research for new lasers, a compromise has to be found between useful fast decay and self-quenching.

Peisfeld discussed possible mechanisms of energy transfer between inorganic ions in the condensed phase, and described the influence of inhomogeneous spectral broadening on probabilities and efficiencies. Results were presented on energy transfer between Uranyl or first transition metal ions to the rare earths Nd^{3+} , Ho^{3+} , Er^{3+} , and Yb^{3+} in inorganic glasses. Finally, Reisfeld gave suggestions for using energy transfer in luminescent solar concentrators and in neodymium and erbium glass lasers.

Magneto-optical research on energy transfer in ruby is conducted by G. Viliani and coworkers at the University of Trento (Italy). Viliani reported that both resonant and nonresonant contributions were found from the magnetic field dependence of the transferred intensities. The transfer to third neighbors was predominantly nonresonant and magnetic-field independent, while the opposite was observed for transfer to fourth neighbors. The effects of magnetic fields have been studied at several temperatures and at different emission wavelengths.

G. Boulon (Université de Lyon, France) reported on the Lyon group's experimental results on the energy transfer processes between active ions in doped stoichiometric fluorescent materials. Various examples were used

to illustrate different types of energy transfer from which useful theoretical parameters were determined. The examples included divalent (Eu^{2+}) and trivalent (Eu^{3+} , Gd^{3+} , Tb^{3+}) rare-earth ions, and the Mn^{2+} ion and Bi^{3+} heavy ion incorporated in some oxide, chloride, or certain glasses.

J. Klafter (Exxon Research and Engineering Co., NJ) described his research on electronic energy transfer among impurity molecules in mixed organic crystals. In the low temperature regime, the role of disorder in impurity bands was examined in terms of the Anderson model. A concentration was found above which the excitations are delocalized; this predicted concentration was qualitatively in agreement with experiments. In the high temperature regime where the excitations migrate incoherently, the dynamics were described in terms of the continuous time random walk (CTRW). Klafter first derived the diffusion coefficient for random systems, and then introduced trapping centers and established the decay laws due to trapping.

C. Landraitis (Boston College) discussed the use of large computers in experimental and theoretical studies on energy transfer problems. A major problem is to obtain timely and reliable results from automatic computation procedures.

A.J. Nozik (Solar Energy Research Institute [SERI], CO) discussed energy and electron transfer in photobiological, photochemical, and photoelectrochemical processes. The conversion of radiant energy into stored chemical energy is an important process that occurs in biological photosynthesis and in the nonbiological conversion of solar energy into fuels and chemicals. The photobiological process depends on natural photosynthesis, while the photochemical and photoelectrochemical processes depend on inorganic or organic photoactive materials, such as semiconductors or molecular chromophores. All the processes rely on the efficient transfer of excitation energy from the light-absorbing site to another region of the system that consequently exhibits enhanced electrochemical potentials for oxidation and reduction reactions. Nozik compared energy transfer and charge transfer processes as approaches to solar energy use; he discussed both their importance and their different roles.

R. Carovillano's (US Office of Naval Research [ONR], London) talk on the liaison science program of ONR was received enthusiastically by the European audience. In addition to direct

support of research and development at the naval research laboratories, ONR has a major multidisciplinary program of external support for research conducted at universities and other institutions and laboratories. To help keep abreast of worldwide trends and developments, ONR has a London branch office to maintain scientific and technical liaison with Europe and the Middle East.

In a summary presentation, Williams expressed his views of important topics discussed at the conference and speculated on trends in the field. Solid state physics basically reduces to a many-body problem in the description of condensed matter, and useful mathematical models and approximations are needed. Energy transfer involves collective excitations of one type to another, and factors such as quantum states, energy spectra, and material structure must be adequately described. Important concepts include the Förster-Dexter mechanism and development of a generalized master equation; coherent transport, stationary and time-dependent diffusion; cross relaxation, quenching, and up-conversion; the continuous random walk; homogeneous and inhomogeneous broadening; energy transfer from a sea of donors; and Auger transitions and collisional ionization effects.

Energy-transfer studies relate to many different amorphous materials and glasses. Transition metals, rare earth compounds and solids, molecular crystals, and biological material were described at the conference; ionic materials were not treated. Experimental techniques included time-resolved spectroscopy, photoemission spectroscopy, Fourier-wave mixing, and diamond pressure cells, where 100 kilobars is no longer uncommon.

Williams said that research on energy transfer has a promising future. The trend is toward more sophisticated experiments and exotic materials; amorphous materials, glasses, and structured materials were singled out. More detailed descriptions of quantum states, including effects of the crystal field environment, are needed. Computer simulation methods will be especially useful when analytical solutions are not possible. Applications in the field will be in fluorescent lamps and three-level lasers.

The lectures of the NATO program will be published in a book by the Plenum Publishing Corporation of New York. The work will be part of the NATO Advanced Study Institute lecture series and will appear in 1984.

9/27/83

THE PHYSICS OF ELECTRONIC AND ATOMIC COLLISIONS

by B.R. Junker. Dr. Junker is Scientific Officer (Physics) at the Office of Naval Research, Arlington, VA.

The Thirteenth International Conference on the Physics of Electronics and Atomic Collisions took place from 29 July through 2 August 1983 at the Freie Universität Berlin, Federal Republic of Germany. The chairmen were Professors Jorg Eichler and Nikolaus Stolter-Foht of Hahn-Meitner-Institut für Kernforschung Berlin, and Ingolf F. Hertel (Freie Universität Berlin). The 750 participants came from more than 35 countries.

The areas treated at the meeting are listed in Table 1. This conference had a relatively large number of papers on photon processes; there were several papers concerning polyatomic (greater than two atoms) molecules and clusters. In addition, several quantum chemists gave invited talks. This article cannot hope to summarize the conference and workshops, but instead will concentrate on new areas or fields in which substantial progress has been made.

Clusters

A minisymposium and about five to 10 contributed papers addressed the subject of clusters--their structure, their properties, and their dynamics. Prof. E. Shumacher (University of Bern) discussed a number of techniques that could be used to produce clusters, depending on the species--i.e., rare gas, alkali, or heavy metal. He also dealt with the dependence of some properties on cluster size. For example, the ionization potential of sodium clusters showed peaks and dips as a function of the number of sodium atoms in the cluster. He also discussed the results of various model calculations (extended Hückel, complete neglect of differential overlap [CNDO], pseudopotential) for the structure of clusters.

Prof. Haberland (University of Freiburg) discussed the photo-destruction of rare gas clusters and suggested that adding energy could lead to evaporation of constituents. In the case of photoionization of clusters, he suggested that within a picosecond, the electron left the cluster, charge localization occurred, and the dominant dimer ion formed. Subsequently, dissipation of the additional energy took place with fractionalization of the cluster. He also noted the occurrence of magic numbers--i.e., cluster sizes which were evidently more stable than others due to

Table 1
Conference Topics

1. Photoionization of atoms and molecules
2. Photodissociation of molecules
3. Multiphoton ionization of atoms
4. Multiphoton processes in molecules and clusters
5. Electron-atom/molecule collisions (low energy inelastic, differential and total scattering alignment and orientation, theoretical methods, bremsstrahlung, ionization, dissociative attachment, and theoretical methods)
6. Atom-atom collisions (ionization, fine-structure transitions and polarization, excitation and excimer formation, and theory)
7. Ion-atom/molecule collisions (spectroscopy of continuum electrons, direct ionization of inner shells, electron exchange, rotational-vibrational excitation, reactions, fine structure transitions, dissociation and recombination in reactions, Penning ionization, and x-ray spectroscopy)
8. Laser-assisted collisions and collision-assisted radiative transitions
9. Collisions involving Rydberg atoms
10. Clusters
11. Dielectric recombination
12. Theoretical techniques
13. Experimental techniques

their high frequency of observation. His magic numbers included 13, 19, and 55. In the future he plans to study collisions of electrons, photons, He, metastable He, and metastable Ne with various rare gas clusters.

Prof. Sattler (University of Konstanz) discussed studies of structures of metal atoms: antimony; covalent molecules--for example, N_2O ; ionic molecules--for example, sodium chloride; and some larger molecules. He also observed magic numbers. In addition, he noted that there was apparently a critical cluster size for multicharged clusters. For doubly charged clusters with more than 32 or 33 constituents, the charge evidently can separate sufficiently to avoid a "Coulomb explosion," while smaller size clusters broke up.

Additional contributed papers on clusters included magic numbers in mixed Ar/CO clusters, dissociation mechanisms for metastable cluster ions, reactions after ionization of methane clusters, electron attachment to CO_2 clusters,

time-of-flight analysis of Ar cluster scattering, one- and two-color multiphoton ionization experiments on molecular clusters, and spectroscopy of fluorobenzene Van der Waals clusters. The vast majority of the research reported on clusters was performed in the Federal Republic of Germany and Austria.

Dielectric Recombination

While it was suggested 20 years ago that dielectric recombination played a major role in neutralization in plasmas, serious theoretical treatments have only occurred in the last 5 or 6 years. The first experiments have only been realized in the last year. However, almost a half-dozen experiments reported varying degrees of success in observing dielectric recombination.

In dielectric recombination, the free electron colliding with the ion has energy to "excite" a low-lying electronic state of the ion when in the presence of the ion Coulomb field. A resonance of the neutral system is formed as an intermediate state. If a radiative transition is made to one of the lower states before the resonance decays, the initially unbound electron is trapped. For the most likely case--when the incoming electron is trapped in a high Rydberg state and the core is excited to a low-excited state--the probabilities of only a few transitions greatly outweigh all others, so simplifications occur.

Prof. Hahn discussed the status of the theory and recent calculations that included large numbers of intermediate states. Dr. Hickman (SRI) discussed a relatively simple complex-potential theory he is developing to treat this process. The radiative channels are represented as the imaginary part

(absorptive part) of a complex potential. Then a straightforward electron scattering problem is solved in this complex potential; the "absorption" due to the imaginary part accounts for the dielectric recombination.

Dr. Dunn (Joint Institute of Laboratory Astrophysics, University of Colorado, Boulder) discussed photon and neutral species detection coincidence experiments performed on Mg^+ ions. The cross sections he obtained were on the order of 10^{-17} cm² and were a factor of three to six larger than theoretical predictions. Similar experiments by Prof. McGowan (Western Ontario University) using C^+ showed a similar discrepancy with experiment. Since magnetic fields were used to keep the electron beam aligned, their impact was incorporated into the theory. These fields were found to have a large enhancing effect since they mix atomic states so as to permit previously forbidden states to undergo dielectric recombination. However, an experiment by Prof. Williams (University of Western Australia) showed similar discrepancies with a simple theory, even though no fields were present. Clearly, future experiments will have to control and characterize the fields more precisely, and theory will have to incorporate the appropriate fields. Finally, contributed papers reported on several experiments on dielectronic recombination.

Threshold Laws and Three-Body Coulomb Breakup

While analytic asymptotic forms for wavefunctions for two-body breakup including Coulomb systems are well known, the asymptotic three-body Coulomb function has defied solution. For electron impact ionization of hydrogen, Dr. Bottcher (Oak Ridge National Laboratory) numerically integrated the time-dependent, three-coordinate Hamiltonian to obtain numerical asymptotic solution (six of the nine coordinates play no role and can be removed trivially). Certain portions of the function can be associated with ionization, others with excitation, and others with elastic scattering. In the case of ionization, he found that the cross section was orders of magnitude larger when the electrons leave in opposite directions rather than in the same direction. In addition, he found that the probability of a given distribution of the energy between the two electrons occurring is independent of the particular distribution, except when one of the electrons carries away most of the energy. In the latter case, the probability increases

rapidly with increasing asymmetry in the distribution of the energy. This asymmetric partitioning of the energy in part overcomes even the problem of both particles being emitted in the same direction.

A closely related topic is three-body threshold laws for charged particle impact ionization and two-electron photoionization. The Wannier threshold law assumes both electrons leave with about the same energy and in opposite directions. This yields a threshold law which scales as $E^{1.127}$. Recently, Dr. Temkin (Goddard Space Flight Center) has suggested that for one particle leaving rapidly and one more slowly, the asymptotic potential seen by the more distant electron should look like a dipole potential, while the closer electron should see a Coulomb potential. Consequently, he approximated the asymptotic form of the wave function by the product of a dipole wavefunction and a Coulomb wavefunction. This yields a different threshold law that, among other things, approaches zero energy with a zero slope--as opposed to the non-zero slope of Wannier theory.

Prof. Klar (University of Freiberg) discussed several particular threshold laws, mainly in conjunction with Wannier theory. One special case was for the ionization of a highly charged ion. Here the final state should look like the product of two Coulomb functions; the result is a linear scaling law, because the electron-nuclear interaction far outweighs the electron-electron interaction.

While several experiments were reported (Dr. Peterson, SRI, and Prof. Kleinpopp, University of Stirling), none was capable of providing a definite answer on the two threshold models. However, a proposed experiment involving a measurement of polarization in a projectile-polarized target experiment could provide significant information; Temkin's model predicts a highly oscillatory structure under many conditions, while the Wannier model always predicts a straight line for the polarization.

Prof. Herrick (University of Oregon) reported on his research concerning the structure of atomic and molecular systems in which there are strong correlation effects. This work began several years ago, when he observed that the structure of energy levels in doubly excited atomic states was well correlated by the group structure $0(4)_1 \times 0(4)_2 \supset (4) \supset 0(3)$, as opposed to the usual classification by $0(4)^2 \supset 0(3)_1 \times 0(3)_2 \supset 0(3)$. He has now

extended his work to include the symmetry properties of the electronic structure of "single electron" atoms in magnetic or electric fields, the electronic structure of polyenes, and the prediction of the magic and "slightly magic" numbers observed in clusters of sodium and rare gas atoms. Based on the nearest neighbor interactions, it is known that the cluster's icosahedron structure yields the lowest energy. Using this as a building block, experimentalists find--and Herrick predicts--that the magic numbers 1, 13, 55, 147, and 309 are the most probable cluster sizes. In addition, he predicts the secondary magic numbers 19, 25, 71, 87, 89, and 91, which are also generally observed, though less likely, than the others.

Prof. Meyerhof (Stanford University) presented several interesting techniques for using atomic processes as clocks for nuclear processes. The nuclear time scales desired range from 10^{-15} to 10^{-21} second. The atomic "measures of time" included the frequency associated with the binding energy of the K-shell electron, the lifetime of an inner shell vacancy, and the collision time. The various techniques were based on relating the "atomic time measure" and the lifetime of certain nuclear phenomena--such as a compound nucleus formation or a deep inelastic reaction--to some observable, such as united atom x-ray emission. From a measurement of the observable and a knowledge of the atomic phenomenon, the nuclear lifetime could be inferred.

Finally, there were two other general areas in which the number of experiments proposed or being performed is increasing rapidly. The first of these is "complete scattering experiments," which determine complex scattering amplitudes rather than simply cross sections in, for example, electron atom scattering experiments. Measurement of electron-photon correlations are well established and provide valuable tests for theoretical models. In addition, several polarized projective-polarized target experiments that determine the final polarization were reported or proposed. Such experiments can probe the details of the collision, including spin dependent effects. The second class of experiments involves very detailed particle/photon-molecule collisions. These include very detailed rotational transition cross-section experiments which attempt to probe the dynamics and orientation of the collision.

Atomic and molecular physics have an impact on military systems such as

atomic clocks and lasers, and on military scenarios (e.g., cloud formation and other nucleation phenomena, ionospheric disturbances, and aircraft signatures). These applications require appropriate cross sections, spectra, structural data, and interaction potentials.

9/8/83

THERMAL SPUTTERING IN METALS

by I.S.T. Tsong. Dr. Tsong is Professor of Physics at Arizona State University.

Does thermal sputtering really exist in metals? A panel discussion addressing this question was one of the highlights of the 10th International Conference on Atomic Collisions in Solids, held from 18 through 22 July 1983 in Bad Iburg, Federal Republic of Germany.

About 20 years ago, R.S. Nelson of the UK's Atomic Energy Research Establishment (AERE, Harwell) observed that when metals were bombarded with 45-keV heavy ions, their sputtering yields showed dramatic increases at elevated temperatures. The threshold temperature for this rapid rise in sputtering yield is in the range of 500 to 1000°K, well below the melting points of these metals. Later, work by Thompson and other workers appeared to confirm this observation; the effect was attributed to the existence of thermal spikes in the collision-cascade volume in the solid. It was suggested that a high temperature (5000°K) existed in the spike, and that the thermal motion of atoms in the spike caused the evaporation of surface atoms. This thermal component of sputtering was superimposed on the normal sputtering component due to collision cascades. The thermal component's role became more important as the target temperature was raised, resulting in more thermal vibrations of the surface atoms and hence ease of evaporation. The thermal sputtering effect, apart from being observed as an increase in sputtering yield with increasing target temperature, also manifested itself as a low-energy (~ 0.1 eV) peak in the energy distribution of the sputtered metal atoms. Favorite targets in this type of study were generally noble metals such as Ag and Au.

Despite the experimental observations, skepticism has often been expressed about the interpretation of the

thermal spike. How could such a spike exist in a metal? A simple estimate assuming a phonon propagation velocity of 5×10^5 cm/s shows that heat will be dissipated from a spike radius of 50 angstroms in 10^{-12} second. This is comparable to thermal vibration times, and no equilibrium could exist in the spike volume to cause evaporation. Nevertheless, there have been theoretical arguments concerning the possibility that spikes overlap to extend spike lifetime to a more respectable 10^{-8} second, thereby achieving the desired sputtering effect. The validity of Nelson's experiment also has been questioned. Could the observation be due to an artifact in the experiment, such as poor vacuum and dirty surfaces? The panel discussion at the conference was designed to address these problems.

Wolfgang Hofer of Jülich opened the discussion with new experimental results of 5 keV Ar^+ bombardment of single crystalline Ag as a function of temperature up to 800°K. In contrast to previous work of this nature, he observed no increase in sputtering yield with temperature. Hofer's experiment was performed in ultrahigh vacuum conditions with the target surface carefully prepared and cleaned; the quartz crystal used to measure the sputtering yields was kept at a constant temperature. This negative result is certainly a blow to the concept of thermal sputtering. Mike Thompson of East Anglia countered by pointing out that Hofer has performed his experiment with sputtering parameters that might preclude the observation of thermal spikes. He proposed that the experiment should be done with higher ion energies and current densities--e.g., about 45 keV and 5 mA/cm^2 , similar to Nelson's experiment. He also suggested that a target and primary ion combination should be chosen so that a normal sputtering yield exceeds a critical value of about 20 atoms per ion, a figure that he claimed was essential for thermal sputtering to operate.

Peter Sigmund then gave a theoretical argument in which the thermal spikes were considered to be analogous to hot cylindrical regions. High current densities then resulted in spike overlap, the spike volume became spherical, and atoms evaporated from the surface. He fitted his theoretical predictions to experimental data given by Mark Szymon-ski of Krakow. Jurgen Andrä of Münster then asked the obvious question: why wasn't the heat in the thermal spike

conducted by phonons in the metal? No satisfactory answer was given. Frans Saris (FOM--Institute for Plasma Physics "Rijnhuizen") offered a way out by suggesting that the thermal conductivity of the metal at elevated temperatures could be considerably lowered, which is equivalent to lowering phonon velocities. Thus the spike might live long enough to produce sputtering. However, typical experimental observations indicate that thermal conductivity is only lowered by about five times at the target temperatures considered here, whereas a decrease of 100 times or more is required for the thermal spike to be feasible.

It became clear during the discussion that a "thermal spike" might exist in an insulator solid but is highly unlikely in a metal. More experiments of the same nature as Hofer's should eliminate this unphysical concept. A private conversation with Klaus Wittmaack revealed that his group at Neherberg had performed a similar but more detailed experiment involving the effects of a wide range of primary ion energies and current densities on the sputtering of Au. Preliminary results indicate the absence of a thermal effect.

In an insulator, it is not even necessary to postulate a thermal spike. In the theoretical model proposed by our group in Arizona, an isolated (microcanonical) region caused by the disturbance of the incident particle exists in which vibrational equilibrium is established faster than any other relaxation processes. Depending on the nature of the ejected particle under consideration, a quantum or nonquantum effect leads to a final population of levels higher than the dissociative limit of a dissociative electronic state. Our theoretical prediction of the energy distribution of a sputtered particle from insulating solids shows very good agreement with existing experimental data. Our model thus encompasses the thermal spike concept without invoking any temperature within the sputtered volume.

I believe that the experiments by Nelson and others produced accurate observations about thermal spikes. The effect exists in poor vacuum conditions in which metal surfaces are easily oxidized; the result is an insulator-like surface where the "thermal spike" or "microcanonical system" mechanism can operate. In the experiments by Hofer and Wittmaack, the metal surfaces were clean, sputtering was performed in good vacuum conditions, and phonon propagation is faster than other rate processes; therefore, the thermal effect was not observed. In fact, our Arizona

group has done work on the formation of excited molecules. At the conference we discussed the transformation of a semiconducting surface, Si, into an insulating surface, Si_3N_4 , due to N_2^+ bombardment, which produced the observed vibrational spectra.

2/8/83

THE 11TH INTERNATIONAL CONGRESS ON ACOUSTICS

by Chester McKinney. Dr. McKinney is the Liaison Scientist for Underwater Acoustics in Europe and the Middle East for the Office of Naval Research's London French Office. He is on leave until September 1984 from The University of Texas at Austin, where he is Senior Research Scientist at Applied Research Laboratories.

The 11th International Congress on Acoustics (ICA) met in Paris, France, from 19 through 27 July 1983. The ICA convenes every 3 years and is the only international meeting that covers all of the technical areas of the broad field of acoustics--ranging, for example, from musical to psychological to underwater acoustics. Each meeting is jointly sponsored by the International Commission on Acoustics and the leading acoustics organizations of the host country. For this meeting, the host was Groupement des Acousticiens de Langue Francaise (GALF, organized in 1948).

This article provides an overview of trends at the congress; for a detailed discussion, see US Office of Naval Research, London, conference report C-15-83. Table 1 lists the registrants and contributed papers for each of the 44 countries represented. The totals of approximately 1100 participants and 755 papers are not much different from those of the past four congresses. The figures of Table 1 provide some insight into the level of acoustics research in various countries, but the numbers should be interpreted with caution. Attendance at meetings (and the presentation of technical papers) is a function of national population, distance from the meeting site, political policy, and perhaps other factors, as well as activity in the field of acoustics. For example, the small number of USSR participants (and papers) is not representative of the size of the acoustics

program in Russia. (For international meetings, one never knows whether Russia will be represented at all until the opening of the meeting.) As one might expect, France heads the list in both attendants and papers. Japan's third place in attendants and second place in contributed papers are impressive. China's delegation of 17, with 33 papers, probably is a valid indication of the growth of acoustics work in that country. In general it appears that research and development is increasing in several countries, including China, Japan, and South Africa. It is interesting to note that a large number of countries were not represented, including several European ones. Representation from South America was slight and for Central America was nil.

The technical program comprised sessions of contributed papers, invited survey papers (two each day), special topic sessions, round-table discussions, poster papers, equipment exhibits, and technical tours. I found the general survey papers to be one of the best features of the meeting, as they provided a convenient way to get an overview of some of the most active current topics in acoustics. Table 2 gives a breakdown of contributed papers according to subject matter and country. The 16 subject areas of the table are somewhat arbitrary and are not fully aligned with the nine "themes" of the ICA, but this division may help in understanding the distribution of the type of acoustics work being done in each country, but again caution is suggested. Underwater acoustics is a major field in several countries (e.g., the US, USSR, UK, and France), but this is not reflected in the figures. China, which presented a comparatively large number of papers, seemed to aim at showing something in almost each subject area. Furthermore, most of the Chinese papers included a combination of theoretical and experimental work, and were well presented (in English). There is good evidence that China is building a strong, broadly based program in acoustics, and is familiar with the literature. The broad coverage of the Japanese program is evident.

When subject matter is considered, it is clear that the ICA was a major meeting for workers in physiological and psychological acoustics, speech, architectural acoustics, and noise and noise control. Musical acoustics and several branches of physical acoustics (e.g., nonlinear acoustics) were well represented. Airborne sound (including transducers and measurements) represented a major segment of the program. In

Table 1
Registration and Contributed Papers, by Country

<u>Country</u>	<u>Registrants</u>	<u>Papers</u>
1. France	349	189
2. US	115	82
3. Japan	100	90
4. Germany (West)	99	68
5. UK	77	58
6. Denmark	36	12
7. Belgium	32	22
8. Canada	30	23
9. Netherlands	24	17
10. Italy	21	9
11. Spain	19	13
12. USSR	19	19
13. Australia	18	13
14. Poland	18	24
15. China	17	34
16. Sweden	14	7
17. India	10	6
18. Switzerland	10	1
19. Norway	9	3
20. Hungary	8	9
21. Czechoslovakia	6	6
22. Finland	5	6
23. Israel	4	1
24. Yugoslavia	4	6
25. Argentina	3	5
26. Bulgaria	3	13
27. Greece	3	1
28. Portugal	3	---
29. South Africa	3	3
30. Syria	3	---
31. Hong Kong	2	1
32. Iran	2	1
33. New Zealand	2	---
34. South Korea	2	---
35. Algeria	1	---
36. Brazil	1	1
37. Chile	1	---
38. Cuba	1	1
39. Egypt	1	2
40. Ghana	1	---
41. Roumania	1	6
42. Singapore	1	1
43. Iraq	---	1
44. Nigeria	1	---
Unidentified	28	---
Total	1078	755

contrast, underwater acoustics, a field of major interest to the US Navy, did not have a major role. Military security restrictions may be a factor but must not be the only one. The ICA is just not a major forum for underwater acoustics.

The ICA official languages are English, French, and German. There were simultaneous translation facilities only

for the opening sessions. Two-thirds of the papers were presented in English, 29 percent in French, and 5 percent in German. Four-page versions of each contributed paper and most of the invited papers appear in eight volumes of the proceedings (3346 pages), which were distributed to participants at registration. Having these proceedings available at the time of the meeting (a

Table 2
Distribution of Papers by Country and Topic

Country	Psychological Physiological	Speech	Musical	Architectural	Shock & Vibration	Noise and Noise Reduction	Airborne Sound Propagation, etc.	Underwater Sound	Scattering	Physical Acoustics, General	Acousto-Optics	Nonlinear & Finite Amplitude	Transducers (air)	Transducers (underwater)	Measurements, Acoustic, etc.	Biomechanics	TOTAL
France	24	21	15	21	8	32	6	1	8	15	1	2	2	3	22	4	184
Japan	11	14	6	2	4	10	5	1	1	3	1	6	0	3	10	1	90
US	13	7	5	2	5	8	2	6	13	6	3	6	2	1	3	1	81
West Germany	9	1	3	5	3	15	11	1	2	2	1	5	1	2	2	2	68
UK	5	6	5	10	5	13	5	1	1	1	1	1	1	1	6	1	58
China	3	2	1	6	2	2	2	4	2	6	1	1	1	1	1	1	34
Poland	1	2	2	1	2	3	1	1	4	1	2	1	2	2	2	1	24
Belgium	2	2	6	1	4	2	2	2	1	3	1	1	1	1	3	1	22
Canada	4	1	6	1	3	2	2	2	6	3	2	1	1	1	1	1	23
USSR	2	1	1	1	1	1	2	2	6	3	2	1	1	1	1	1	19
Netherlands	6	2	5	2	1	1	1	1	1	1	1	1	1	1	1	1	17
Australia	2	2	1	4	1	1	1	1	1	1	1	1	1	1	1	1	13
Spain	1	2	3	2	1	2	1	2	1	1	1	1	1	1	1	1	13
Denmark	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	12
Bulgaria	2	2	4	1	3	1	1	1	1	1	1	1	1	1	1	1	13
Italy	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	9
Hungary	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	9
Czechoslovakia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	6
Finland	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	6
Sweden	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	7
India	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	6
Romania	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	6
Yugoslavia	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	6
Argentina	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5
Norway	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
South Africa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
Egypt	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Switzerland	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Israel	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Greece	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Singapore	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Brazil	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Iraq	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nigeria	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Iran	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hong Kong	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cuba	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TOTAL	97	72	45	97	41	108	17	20	26	47	16	26	23	16	65	15	755

standard procedure for the ICA) was a highly valuable feature, especially for people not fluent in the language of presentation. The proceedings provide good documentation of the congress and are available for FrF600 from Groupement des Acousticiens de Langue France, CNET, Lannion a., Route de Tregastel BP40, 22301 Lannion Cedex, France.

9/16/83

SPACE SCIENCE

ESA HOLDS SPACECRAFT-CHARGING SYMPOSIUM

by R.L. Carovillano. Dr. Carovillano is the Liaison Scientist for Space Physics

by Japan, and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1984 from Boston College, where he is Professor of Physics.

The 17th ESLAR Symposium, entitled Spacecraft-Plasma Interactions and Their Influence on Field and Particle Measurements, was held in Noordwijk, the Netherlands, from 13 through 16 September. The symposium was sponsored by the European Space Agency (ESA) and held at the European Space Technology Center (ESTEC) in Noordwijk. A. Pedersen, head of the space plasma division of the Space Science Department (ESTEC), convened the meeting.

Spacecraft-charging effects were emphasized from the Geostationary Earth-Orbiting Satellites (GEOS) of ESA

and the SCATHA (spacecraft charging at high altitudes) satellite of the US Air Force. Talks on planned missions included a presentation by M. Dobrowolny (Istituto Fisico Spazio Interplanetaria, Frascati, Italy) on the electromagnetic interactions of the Tethered Satellite System (TSS) with the ionosphere. TSS is a recently approved mission jointly sponsored by Italy and the US, with a 1986 planned launch from the space shuttle.

About 35 scientists attended the symposium; about two-thirds came from eight European nations, one from Canada, and the others from the US. The proceedings of the conference will be published by ESA within a few months. Inquiries about ESA publications may be directed to:

Distribution Office
ESA Scientific & Technical Publications Branch
ESTEC, Postbus 299, 2200 AG Noordwijk
The Netherlands

3/29/83

EUROPEAN HIGH-ENERGY ASTRONOMY AND COSMOLOGY

by Herbert Gursky. Dr. Gursky is Superintendent of the Space Physics Division of the Naval Research Laboratory, Washington, DC.

A conference on high-energy astrophysics and cosmology was held in Pomporova, Bulgaria, from 18 through 23 July. The meeting presented two major themes of astronomical research, reflecting totally different temporal and spatial scales. One is the observation of collapsed objects--neutron stars and black holes, several of which are known to have been created within the past 1000 years. On the other end of the size and energy scale are cosmological investigations involving: (1) high-energy particle physics as it is emerging from the world's great accelerator laboratories in the US and Europe, and (2) the study by astronomers of the distribution of matter on size scales ranging up to 100 million parsecs or more (roughly 3 percent of the size of the visible universe, now believed to be about 10 billion years old). The

meeting also provided a discussion of future space astronomy programs in the US, Europe, and Japan, including those of the Soviet Union.

The meeting was sponsored by the Committee on Space Research and the International Astronomical Union, the principal worldwide federations dealing with space research and astronomy, respectively. The meeting was hosted locally by the Bulgarian Academy of Science. (A similarly sponsored meeting was held 2 years ago.) Such meetings provide a measure of Europeans' increased effort in this area of science, and holding the meeting in Eastern Europe allowed wider participation by scientists from the Soviet Union and Soviet bloc nations. In this article, I will not try to sort out the contributions of individual scientists, but will present the picture that is emerging of astronomy and cosmology in Europe.

High-Energy Astronomy

Scientists now realize that neutron stars are a ubiquitous feature of the galaxy, composing perhaps 1 percent of all the stars. They occasionally shine brightly in the radio, x-ray, or gamma-ray regime, but are exceedingly faint at ordinary optical wavelengths. It is now apparent that almost all the bright x-ray sources are neutron stars and that they appear in several distinctive categories, each with its unique evolutionary history.

The most important new results that have emerged regard the bulge sources, so named because they occur predominantly in the nuclear region of the galaxy. Scorpius X-1, the first discovered x-ray source, and still the brightest, is apparently a bulge source. Bulge sources probably are x-ray bursters as well. Although every bulge source has not been observed to burst, the steady emission from the x-ray bursters does have most of the properties of bulge sources, including power, spectral, and optical characteristics; distribution of x-rays; and location in the galaxy.

Observations with the Einstein X-ray Observatory have localized a large number of individual x-ray sources near the centers of globular clusters; in a few cases, two have been seen in a single cluster. These data provide the essential clue to the origin of the bulge sources. It is known that bulge sources outside globular clusters comprise binary systems, a neutron star, and a low-mass companion. But neutron stars are only known to be accompanied by a supernova explosion during their

formation, which would invariably disrupt the observed binary systems. However, in a globular cluster, which is a very dense concentration of old stars, single neutron stars and ordinary stars can form bound pairs during three-body collisions. The appearance of bulge sources outside globular clusters reflects the fact that many more globular clusters existed early in the history of the galaxy, but that most have been gradually disrupted by their repeated passage through the plane of the galaxy. The estimate that 1 percent of the stars in the galaxy are neutron stars emerges directly from the observed numbers of the bulge sources in globular clusters and the probability of the formation of a binary system by a collision process. Most neutron stars would still be single objects and not observed.

The x-ray bursts themselves may be runaway thermonuclear explosions. The steady x-ray emission in the bulge source results from the infall of material, presumably hydrogen and helium, that forms a thin layer on the surface of the neutron star. At some point the temperature and density exceed a critical value; the nuclear fuel ignites and burns vigorously for a few seconds.

The other kind of strong x-ray source is distinguished by periodic pulsing in a range from less than 1 second to 10 minutes, and is accompanied by a massive companion. The sources can form through the processes of normal stellar evolution; a subset includes the black hole candidates, such as Cyg X-1.

The Einstein data, with their high angular resolution and great sensitivity for faint objects, have yielded important new information on supernova remnants (SNRs). The remnant itself is a large region of x-ray, optical, and radio emission that can be caused by an expanding shock wave or by leakage of energetic particles from a central pulsar. There are by now a dozen known associations between SNRs and point x-ray sources. The nature of most of these point sources is not yet known, but it might indicate complex properties associated with single neutron stars. Furthermore, since the remnants themselves have a relatively short life (less than 100,000 years), a number of field sources might originate with SNRs.

Important new results were presented in the gamma-ray range (>50 MeV)--as revealed by COS-B, the European satellite containing a spark chamber that functioned for 6 years. The sky in gamma rays reveals a number of point

sources strung along the Milky Way, a band of diffuse radiation also coinciding with the Milky Way, and a more general background of radiation. Only two, and possible three, discrete sources in the Milky Way have been identified with known high energy sources of radiation. The Crab Pulsar and the Vela Pulsar have been positively identified based on the known pulse period. A third known object, Cyg X-3, was seen to be an x-ray source during an earlier x-ray experiment on SAS-B (NASA's Small Astronomy Satellite), but was not seen by COS-B. The brightest gamma-ray source, GBMINGA (for "gamma ray source in the constellation Gemini"), has not yet been identified.

Scientists have identified the rest of the radiation by assuming that the gamma rays result from the interaction of galactic cosmic rays (electrons and protons) with the interstellar medium. With some modification, this approach can be applied to diffuse radiation. For example, some of the diffuse emission must be attributed to inverse Compton scattering by high energy electrons from the 3K microwave background radiation. Point sources seem to be associated with prominent HII regions (dust clouds) in the Milky Way--if the local cosmic rays are enhanced compared with what is seen in the solar neighborhood. Such an enhancement could only imply a supernova (or remnant) origin for the cosmic rays.

New results in the area of gamma-ray bursts have emerged from a French-Soviet collaboration. Gamma-ray bursts are perhaps the least understood of all high-energy phenomena. Ten to 20 times per year bursts of gamma rays (energy greater than 100 keV extending to MeV) are observed on time scales of seconds from almost random directions around the sky. The net energy emission is $\sim 10^{-5}$ to 10^{-6} ergs/cm² per burst.

For many bursts, time-delay techniques have been used to obtain positions to within arc minutes. While no optical or radio counterparts have been discovered, searches through historical sky-monitor photographs have revealed optical outbursts (novae?) from their vicinity. Also, the indications are that the same object (or location in the sky) has been observed to burst more than once.

The evidence is that the gamma-ray bursters are fairly local to us on a galactic scale, which means that they are a common constituent in the galaxy ($\sim 10^6$ total). There is evidence that at

least two are rapid rotators (seconds), which makes a neutron star origin the obvious candidate. Most theories try to link the x-ray bursters with gamma-ray bursters.

Reports were also presented in the area of very high energy x-ray and neutrino astronomy (teravolt astronomy). The results in these areas are naturally very limited. The observation of Cerenkov light from large air showers has revealed x-ray emission from a few objects (Cygnus X-3, the Crab Pulsar and possibly one or two others). It was reported that partial funding had been provided for DUMAND, a large underwater array that will be established about 5-km deep off the coast of Hawaii. It will detect the Cerenkov emission from high energy muons. At such depths, muons can only result from local neutrino interactions; since the array has good directional sensitivity (~ 1 degree), discrete cosmic sources of neutrinos can be detected. In principle, sources can exist that are highly opaque to gamma-ray and x-ray emission, but still allow neutrinos to be emitted.

Cosmology

In keeping with symposia of this kind, sessions were dedicated to extragalactic astronomy and to cosmology. On the observational side of cosmology, the reality of the "missing mass" is becoming more and more accepted, as is the kind of matter it comprises. There are several essential measurements and predictions coming together. First, measurements of the cosmic abundance of helium, deuterium, and now lithium indicate that the baryon density was low when these elements were formed during the early stages of the universe. Deuterium and lithium are particularly important density indicators because of their high rate of destruction. On the other hand, dynamical studies of the motions of galaxies indicate that the matter density contributing to the local gravitational potential is much higher (at least a factor of 10) than can be accounted for by stars. The conclusion, after years of struggling with this apparent inconsistency, is that most of the local matter is not in the form of ordinary baryonic mass (e.g., neutrons and protons) but must exist in the form of lepton decay products, such as massive neutrinos left over from the early universe. Experimental data from the Soviet Union confirming this view was announced at the meeting: improved laboratory measurements of beta decay neutrinos yielded a mass of 33 ± 3 electron masses. Of course, a whole family of neutrinos is allowed by current particle theory.

The other aspect of cosmology that is gaining acceptance is based on the ground unification theory of fundamental particles, and has some startling predictions for the origin of the early universe. Of particular importance is the concept of "inflation," a period of time corresponding to a phase transition from one kind of physical mix of particles and field to another when the universe expands exponentially with time. When the transition is complete, the expansion takes place linearly, as is now observed. In this model, our universe is just one of many "bubbles" in a much larger and more complex medium. The model provides specific predictions that can be tested, and represents the first important departure from the standard "big-bang" model that was introduced by George Gamov 50 years ago.

Observational cosmology was represented by discussions of the large scale structure of the universe. Using correlation analysis of the three-dimensional distribution clusters of galaxies (i.e., simply studying the distribution of all separations), it has been found that significant structure exists on size scales corresponding to about 100 times the proton mass, the largest on which measurements can be made with current data samples. It appears that there may be vast regions empty of any large masses such as galaxies, surrounded by shells of high galaxy density.

More than a full day of the session was dedicated to a discussion of new space experiments. Four payloads currently flying include a Japanese, a European Space Agency, and two Russian missions containing a total of nine distinct experiments in high-energy astronomy. Five additional payloads are scheduled to fly before the end of the decade, including a German, an Italian and three small Russian missions containing a total of 14 distinct experiments. Some of the experiments are impressive by any standard. The German mission, ROSAT, scheduled to fly in 1987 comprises a telescope like Einstein but with several times the sensitivity. Also, a high-quality spark chamber is being flown on GAMMA-1, a Russian mission planned for 1984-85 as a French-Russian collaboration. The only US high-energy astronomy mission that will be flown during this time is GRO (Gamma Ray Observatory); it will contain four experiments, one of which will be German.

There was general surprise at the breadth and quality of the Russian program, which includes many experiments provided by Western European nations. It would appear that the Soviet Union is trying to make high-energy astronomy a

major element of their space science program.

In medium and low energy x-ray astronomy (less than 10 keV), the information presented at the meeting was principally from US missions. In the areas of hard x-ray astronomy, gamma-ray astronomy, and gamma-ray bursts, the focus is shifting to European and Japanese experiments. In a few years, with the impact of the new missions, Europeans will dominate all aspects of this exciting branch of astronomy. Furthermore, the US program is stretched over many years. Thus, foreign efforts that fly earlier probably will upstage many planned US experiments--for example, microwave background experiments, parts of the GRO mission, and observations in the extreme ultraviolet portion of the spectrum. In the area of elementary particle physics, new accelerator facilities in Europe are beginning to become the dominant machines from which new results will likely emerge. Thus, the US will lose its leadership role in some of the most vigorous areas of scientific research--areas in which the US pioneered and that provided the impetus for much of the scientific and technical revolution of the past 50 years.

9/9/83

HISTORICAL RECORDS IN GEOPHYSICS

by R.L. Carovillano.

Data management is a major problem in space science and many areas of geophysics. Modern experimental methods generate data in unprecedented amounts and often exceed the capabilities of even the largest and fastest computers for data recording, reduction, and analysis requirements. In many cases, very little of the recorded data from one mission or project is reduced or analyzed before the next mission is undertaken. Nevertheless, proper data storage and archiving is essential and requires enlightened planning and the allocation of funds. However, the cost of retaining "old" data is less and the potential value high. Indeed, certain studies are only possible when a suitable data base is available over the proper time scale. Examples are the 11-year sunspot cycle and the related 22-year solar magnetic field polarity cycle.

A valuable and interesting session entitled "The Use of Historical Records in the Study of Geomagnetism and History" took place in Hamburg, Federal Republic of Germany (FRG), at the August 1983 meeting of the International Union of Geodesy and Geophysics (IUGG). The session was chaired by Dr. Joan Feynman (Boston College) and included papers on topics such as the earth's core, the rotation axis, eclipses, solar periodicities, noctilucent clouds, and the eruption of Krakatau in 1883.

F.R. Stephenson (University of Durham, UK) discussed pre-telescopic observations of solar and lunar eclipses as a means to study the earth's rotational history. Particular emphasis was placed on evaluating the reliability and accuracy of ancient records from Babylon, the Far East, Europe, and Arab lands.

D.J. Schove (St. David's College, Kent, UK) discussed sunspots and auroras prior to 1700. Appeals for records or evidence of auroras have produced a large collection of auroral data from China, Korea, Japan, the UK, and elsewhere. An example of information collected is that the "religious visions" seen in England in 1661 occurred the same night as the "Nordlicht" in Hamburg. Relationships between auroral occurrence frequency and amplitudes of sunspot cycles have been used to reconstruct the sunspot cycle back to 300 AD and earlier. The results are similar to curves based on radiocarbon variations in tree rings.

D.R. Barraclough (Institute of Geological Sciences, Edinburgh) gave an interesting paper on the work of Edmond Halley, the scientist most famous for his work on the comet that reaches perihelion on 9 February 1986. Halley was a versatile scientist with accomplishments in geology, geophysics, astronomy, and mathematics. His first recorded scientific effort was the measurement of the geomagnetic declination in London when he was 16 years old. He carried out two voyages in 1698 and 1699 to extend this work and measure the magnetic declination in the Atlantic Ocean, and one in the English Channel in 1701 to measure tides. His ship, the *Paramore*, a Royal Navy vessel with three masts and a narrow stern, was provided by the British government. The main result of the two Atlantic voyages was Halley's famous magnetic charts of the Atlantic and of the world. Halley's original data was re-examined, and the accuracy of the declination was found to be one-quarter of a degree at best.

Feynman reported on her work with P. Fougere (Air Force Geophysics Laboratory, Hanscom Field, MA) searching for

periodic variations in solar or solar-terrestrial phenomena. Data sets selected for study were those for which the relationship between the data and solar or solar-terrestrial phenomena was understood at least in principle. Thus, auroral data were included, but climatic data were not--because the mechanism of possible solar-climate relationships has not been identified. The researchers used a data base consisting of sunspot numbers, or the number of auroras reported per decade in Europe and China, covering the period from 45 to 1450 AD; a periodicity of (88.4 ± 0.07) years was determined. The result closely approximates eight times the average sunspot cycle of 11.1 years. The significance of this curiosity is doubtful, however, since the sunspot periodicity is not very stable.

On the basis of historical records of auroras in Europe and China, N. Fukushima suggested that the orientation of the geomagnetic field in the 12th century was inclined toward China; the current inclination is toward Greenland. A Chinese scientist commented that the interpretation suggested by Fukushima could be directly tested by analysis of Chinese archeomagnetic results that have been published.

The IUGG meeting at Hamburg ended on 27 August 1983, exactly 100 years after the volcanic island of Krakatau exploded in the Sunda Strait between Java and Sumatra. Appropriately, the final papers of the history session dealt with geophysical aspects of the historic eruption. M. Gasden (Aberdeen University, Scotland) and W. Schröder (Geophysical Station, Bremen-Roenebeck, FRG) discussed noctilucent clouds and twilight phenomena associated with Krakatau, and showed magnificent color slides of these uncommon geophysical phenomena.

Reports of strange shining clouds seen in the middle of the night were made in June 1885 by European observers. These were noctilucent clouds that occur at mesospheric (15-km) heights and are visible when the sun is 5 to 16 degrees below the horizon. Gasden emphasized the importance of noctilucent clouds for determining visible traces of atmospheric constituents and possibly even for providing a visible manifestation of gravity waves through observable striations in the clouds. Schröder reviewed reports of the twilight phenomena seen in October and November of 1883 and 1884. He emphasized the importance of Krakatau in promoting widespread interest in observing and studying the upper atmosphere. For example, regular observations of noctilucent clouds began only

in 1885, despite the fact that they are regularly occurring phenomena that do not require a volcanic eruption to contaminate the mesosphere.

9/22/83

NEWS & NOTES

HARD TIMES FOR HIGHER EDUCATION IN THE UK

When one visits a UK university today, the conversation soon turns to budget cuts. Over the past 3 years, all the universities and polytechnics have been obliged to reduce operating costs. Oxford and Cambridge had to trim expenses by about 8 percent; the other institutions had to make reductions of as much as 25 percent. Recently the government announced that further cuts can be expected over the next several years.

The result has been a significant reduction in faculty, staff, and overall support. As people leave or retire, they usually are not replaced. Some administrators suggest that this has improved the system because many of those who take advantage of early retirement options have been "older and less productive people," so the universities are actually stronger than before. This point is contested at the departmental level at the universities that I've visited so far. The central government is calling for radical changes by universities to maintain and improve standards, while using resources more efficiently. This may mean not only changing the lengths of degree programs and the amount of work done each year, but also considering new methods of teaching and learning. There will be further shifts toward technology, science, and engineering and away from the arts and humanities. There will also be "much more efficient use" of that part of student grants used for research. Such support will be directed to selected departments, particularly those that show that they can also attract private money. Finally, the government is demanding "rationalisation" of courses between universities and with other institutions, such as neighboring polytechnics, to eliminate costly duplication.

I've noted some resentment about the unbalanced nature of the cuts. For Cambridge and Oxford, an 8 percent reduction can be absorbed with minor

impact; but the 20 or 25 percent cuts elsewhere are felt across the board. In addition, some educators have pointed out that the UK must remain highly competitive in the technical fields, such as electronics engineering, computer sciences, and applied mathematics. Many of these degree programs are offered at the UK polytechnics, the institutions hardest hit by the government cuts.

News on employment is equally depressing. Of last year's graduates, 12 percent remain unemployed, and as many as 40 percent are working at jobs unrelated to their degree programs. Even students with science degrees, especially in the biological sciences, are having great difficulty finding professional positions. I was told at a recent geology meeting in Hull that 25 percent of last year's geology and geophysics graduates remain unemployed today.

Robert Dolan
9/16/83

THE DELTAFLUME

The Delft Hydraulics Laboratory recently built a new large-wave flume called the Deltaflume. Constructed at a cost of \$5 million, the system is probably the largest in the world. At one time the US Army Coastal Engineering Research Center had the world's largest flume. But the entire organization was recently transferred to the US Army Waterways Experiment Station (Vicksburg, MS), and the flume has been, as I understand, mothballed.

The Deltaflume is 230-m long, 5-m wide, and 7-m deep; a 50-m-long section is 9.5-m deep. The deepened section is double-walled, with removable slots in the inner walls for installation of instruments. The flume has a powerful piston-type wave board that can generate regular waves with heights up to 2.5 m and random waves with significant heights up to 1.75 m. For many locations in the world, including most estuaries and inland lakes, such waves are the highest ever expected; so this flume allows engineers to test full-scale coastal structures, such as those for beach and bank protection.

Foreign investors may use the Deltaflume if they reimburse the laboratory for expenses. The person to contact for further information is Mr. J. Lindenberg, Geotechnical Engineer, Research Division, Stieltjesweg 2, P.O. Box 69, 2600AB Delft, Holland.

Robert Dolan
9/19/83

UK TO SLASH RESEARCH JOBS

Sir Keith Joseph, Secretary of State for Education and Science, intends to cut more than 200 jobs from four of Britain's research councils. This move, along with more efficient administration, is expected to save over £3.3 million (\$5 million) a year.

According to *The Times* (London), 19 September 1983, the Science and Engineering Research Council, Agricultural Research Council, Medical Research Council, and Natural Environment Research Council were evaluated in the areas of stores, purchasing, estate management, workshops, and library services.

The conclusion was that 18 percent, or 211, of the jobs in those operations could be eliminated; the government expects to save £2.1 million a year, or 13 percent of the total spent administering the services.

An additional £1.2 million could be saved by changes in purchasing patterns through closer cooperation between units.

L.E. Shaffer
9/29/83

CAPITALISM AND THE GOVERNMENT LAB

British scientists and engineers soon will be free to exploit commercially their government-funded research. Previously the British Technology Group (BTG), a government agency, had first claim to the inventions growing out of such projects.

According to the *New Scientist* (15 and 22 September 1983), Prime Minister Margaret Thatcher has decided to break the BTG's monopoly in order to encourage innovation. "This monopoly was very restrictive and widely criticized, not least by scientists who want to exploit the work," she said.

The government hopes that the move will help promote research and development in the UK. The idea is to make it easier for inventors to collaborate with small companies, which tend to be more willing than larger firms to take risks. According to Clive Sinclair, chairman of Sinclair Research, "Young companies have a particular advantage. Because they have no large capital investment in a particular technology, they have little to fear and much to gain from trying a new course. Older firms with large capital investments are wise to let young companies explore the frontiers,

following them swiftly once a successful path has been found."

L.E. Shaffer
10/3/83

SYMPOSIUM PLANNED ON SATELLITE-AIDED
SEARCH AND RESCUE

CNES, the French space agency, has announced that the international symposium "Satellite Aided Search and Rescue, Experimental Results and Operational Prospects" will be held in Toulouse, France, 9 to 13 April 1984.

The symposium will cover the development, implementation, and use of satellite systems in maritime and aeronautical search and rescue (SAR). Session themes will include the international organization of maritime and aeronautical SAR, national and regional requirements for SAR, polar and geostationary satellite systems for SAR, demonstration results of satellite systems, and implementation of future operational SAR systems.

Exhibits will be held in the main hall of the symposium building, and exhibition booths are available. CNES will organize visits to the French Mission Control Center and other facilities during the symposium.

The symposium is being organized by CNES in cooperation with NASA, the Canadian Department of Communication, and the Russian Ministry of Merchant Marine. Cosponsors include the International Maritime Organization; the International Maritime Satellite Organization (INMARSAT); the Canadian Department of Defense, Department of Fisheries and Oceans, and Ministry of Transport; the French Ministry of Transport and Department of the Sea; and the US Air Force and Coast Guard. The official languages of the symposium will be French and English, with simultaneous translation provided. CNES will publish proceedings of the symposium. Persons wishing additional information on the program may write either of the following addresses:

Mr. T. Mac Gunigal
NASA Headquarters Code EC4
Washington, DC 20546

Centre National D'Études Spatiales
Département des Affaires Universitaires
18, Avenue Edouard-Belin
31055 Toulouse Cedex, FRANCE

R.L. Carovillano
9/30/83

A NEW JOURNAL ON GEODYNAMICS

Dramatic discoveries in plate tectonics and the exploration of celestial bodies other than Earth have taken place recently. Broad areas of geology and geophysics have expanded into planetary studies, with greater emphasis on quantitative approaches. Such developments have led to the delineation of the field known as geodynamics, a term that now applies to studies in plate tectonics and generally to most large-scale convective motions in the earth.

Geophysical Press has recently announced plans to publish the *Journal of Geodynamics*, with A.L. Hales (Canberra, Australia) serving as chief editor. The journal will cover research on dynamics and dynamic history of the earth. Fundamental geological studies and interdisciplinary investigations will be emphasized, including research on historic and current earth movements and deformations. Studies relating to the lithosphere and to convective properties of the earth's interior will be included.

The international scope of the journal is reflected in its distinguished editorial board of 60 members from 18 nations. Countries with the most representatives on the board are the US (16), Germany (6), USSR (5), UK (5), Australia (5), and Switzerland (4). Policy objectives of the journal include a short publication time and high scientific quality. Nevertheless, controversial papers will be considered. Refereed research papers, review articles, and symposia proceedings will be published. The first issue of the journal is scheduled for December 1983, and two volumes of about 400 pages each will appear in 1984. The institutional subscription cost will be \$50 per volume (or \$100 per year), and personal subscriptions will cost \$15 per volume. A call for papers has been issued. Submissions (in triplicate) may be sent for consideration to:

Journal of Geodynamics
Editorial Office
Brouwersgracht 236
1013 HE Amsterdam
THE NETHERLANDS

There is no page charge now, and 100 free reprints will be provided for each accepted publication. Subscription and other information may also be obtained at the address given above.

R.L. Carovillano
9/20/83

ONRL COSPONSORED CONFERENCES

ONR London can nominate two registration-free participants in the conferences it supports. Readers who are interested in such participation should contact the Chief Scientist, ONR London, as soon as possible.

Second International Meeting on Lithium Batteries, Paris, France, 25-27 April 1984.

International Conference on Laser Processing and Diagnostics--Applications in Electronic Materials, Linz, Austria, 15-19 July 1984.

SEPTEMBER MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the US Office of Naval Research (ONR), London, Military Applications Division during September. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR London.

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104-83	ADA in Europe: A British National Effort
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106-83	Arctic Weather Hampers MIZEX 83
107-83	Notes on Maritime Remote Sensing in France
108-83	UK National Remote Sensing Center at RAE Farnborough
109-83	Skyhook--A British Aircraft Recovery System Which Would Enable Sea Harriers to Operate From Small Surface Ships
110-83	European Remote Sensing Satellite--ERS-1
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113-83	UK Royal Navy South Atlantic Operations Environmental Information
115-83	The Royal Navy Equipment Exhibition (RNEE) 1983; Aerospace Highlights Part 1
116-83	The Royal Navy Equipment Exhibition (RNEE) 1983; Aerospace Highlights Part 2

CNPL REPORTS

To request reports, check the boxes on the self-addressed mailer and return it to ONRL.

- C-13-83: *The 19th International Symposium on Applied Military Psychology*, by N.A. Bond, Jr. The symposium dealt with issues such as women in the armed forces, leadership and management, training, combat reactions and stress, decision aiding, and the role of psychologists in the military.
- C-15-83: *The 11th International Congress on Acoustics*, by Chester McKinney. This report provides an overview of trends in acoustic research, based on the subject matter of the 11th International Congress on Acoustics. The report includes an appendix, written by David Blackstock (Applied Research Laboratories, The University of Texas). The appendix deals with nonlinear acoustics at the congress.
- C-16-83: *Second International Symposium on Acoustic Remote Sensing of the Atmosphere and Oceans*, by Chester McKinney. This report discusses papers dealing with sodar (for sound detection and ranging), which is used for atmospheric echo ranging. In addition, work on underwater acoustic remote sensing is examined.

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