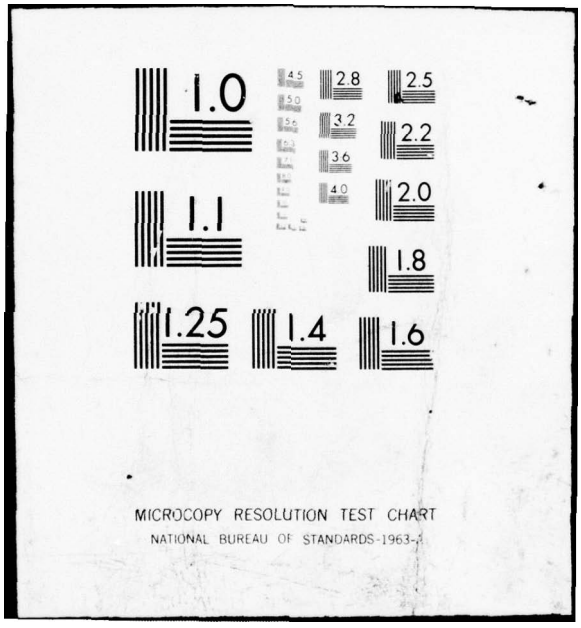
AD-A052 067 OFFICE OF NAVAL RESEARCH LONDON (ENGLAND) F/G 5/2
EUROPEAN SCIENTIFIC NOTES NUMBER 32-2,(U)
FEB 78 A W PRYCE, V S HEWITSON

UNCLASSIFIED ESN-32-2 NL

| OF |
AD
A052 067



END
DATE
FILMED
5-78
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A052067

(12)

OFFICE OF NAVAL RESEARCH
LONDON

EUROPEAN SCIENTIFIC NOTES

ESN 32-2

28 February 1978

AD No.
DDC FILE COPY



DDC
RECEIVED
APR 3 1978
F

Distributed by the
Office of Naval Research Branch Office,
London

This document is issued primarily for the information of U.S. Government scientific personnel and contractors. It is not considered part of the scientific literature and should not be cited as such.

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ESN-32-2	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): EUROPEAN SCIENTIFIC NOTES Number 32-2,	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): A.W. PRYCE & V.S. HEWITSON, editors	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Office of Naval Research Branch Office London, Box 39, FPO New York 09510	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE: 28 February 1978
	13. NUMBER OF PAGES: 40 (12) 46 p.
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)

AEROSPACE
ENERGY
ENGINEERING
MATERIAL SCI
MATHEMATICAL SCI
PHYSICAL SCI
PSYCHOLOGICAL SCI

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.
The articles are written primarily by members of the staff of ONRL, with certain articles prepared by, or in cooperation with, members of the scientific

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

965000 EB

ITEM #20 (cont'd)

staffs of the United States Air Force's European Office of Aerospace Research and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

Edited by Aubrey W. Pryce and Victoria S. Hewitson

28 February 1978 Volume 32, No. 2

AEROSPACE	Cranfield Sails On	C.J. Martin	42
ENERGY	The European Joint Research Center—ISPRA Establishment	R.W. Rostron	44
ENGINEERING	Mechanical Engineering at the Technion	M. Lessen	46
	Aeronautical Engineering at the Technion	M. Lessen	47
	Superconductivity in Switzerland	D.S. Gubser	49
GENERAL	IIASA: Multidisciplinary Research in Maria Theresa's Palace	N.M. Blachman	51
	Terotechnology—What Is It?	L.R. Patterson	54
MATERIAL SCIENCES	Laboratoire de Physique Cristalline—Point Defects and Phase Changes in Insulators	C.C. Klick	55
	A "Universal" Law of Dielectric Response	C.C. Klick & A.K. Nedoluha	57
	Review Symposium on Recent Studies of Electrolyte Solutions	A.L. Powell	59
	The Chemical Society's Faraday Division Ion-Ion and Ion-Solvent Interactions Discussion	A.L. Powell	61
MATHEMATICAL SCIENCES	Computer-Aided Ship Design at Bath	D.F. Rogers & W.J. Gordon	64
PHYSICAL SCIENCES	Advances in Electron Optics: A Summary of Two Recent Conferences	I.M. Bernstein	65
	Vth Conference on Uv and X-ray Spectroscopy of Astrophysical & Laboratory Plasmas	R.H. Dixon & G. Doscheck	70
	E-O Tells More About Big Molecules	V.N. Smiley	72
	Optical Computing	V.N. Smiley	74
PSYCHOLOGICAL SCIENCES	The Heat, the Head, and Human Factors Conference on the Psychological Consequences of Crowding	J.A. Adams J.R. Adams	76 77

ACCESSION for
NTIS White Section
DDC Buff Section
UNANNOUNCED
JUSTIFICATION
BY
DISTRIBUTION/AVAILABILITY CODES
Dist. SPECIAL
A

NEWS & NOTES 79

ONRL REPORTS 81

European Scientific Notes is a Group II Newsletter type Class B periodical prepared and distributed by the Office of Naval Research London in accordance with NAVEXOS-P-35. Prepared and submitted by the scientific and technical staff.

Herbert Solomon
HERBERT SOLOMON
Chief Scientist

L. Roy Patterson
L. ROY PATTERSON
Captain, USN
Commanding Officer

Dr. J.A. Adams	Psychology
Dr. I.M. Bernstein	Metallurgy & Materials Science
Dr. N.M. Blachman	Electronics Engineering
Dr. W.J. Gordon	Mathematics
CDR D.A. Hart	Airborne Systems
Dr. C.C. Klick	General Physics
Dr. M. Lessen	Mechanical Engineering
LCDR J.D. McKendrick	Ship Systems & Military Oceanography
Mr. A.W. Pryce	Acoustics
Dr. R.W. Rostron	Space Science & Technology
LCDR D.C. Rummler	Command, Control & Communications
Dr. V.N Smiley	Optical Physics
CDR S.E. Sokol	Weapons Systems
CDR C.D. Stevenson	Undersea Systems

AEROSPACE

CRANFIELD SAILS ON

A few years ago, I attended a Flight Mechanics Short Course at the University of Tennessee. The instructor was Harry Ratcliffe from the Cranfield Institute of Technology, in Bedfordshire, UK, and he spoke in glowing terms of the aeronautical research activities there. One of these was an airborne classroom capable of providing a real-time laboratory environment for ten students.

Intrigued with the prospect of seeing these flying classrooms and the other aerodynamic research, I made arrangements to visit the Institute. On a gray November day, I journeyed the 65 miles north of London and found this treasure trove of aeronautical activity.

The College of Aeronautics was founded in 1946 with an enrollment of 49 students. At that time it was the government's intention to make the College Europe's center of aeronautical education. In 1969 by Royal Charter, the College became the Cranfield Institute of Technology, but for historical reasons its name was retained as one of the five divisions of the new Institute (see R.D. Mathieu's *ESN* 24-11:321: A. Sosin has more recently discussed in *ESN* 31-4:144 the Institute with particular reference to the materials work).

The enrollment of postgraduate students alone at the College of Aeronautics now stands at 140. As a part of the Institute's Faculty of Technology, the College of Aeronautics is under the direction of Professor D. Keith-Lucas, and is organized into three areas of study: Aerodynamics Division (Prof. J.L. Stollery), Aircraft Design Division (Prof. D. Howe), and Flight Division (Wing Cdr. C.G.B. McClure). The College of Aeronautics educates engineers for technical positions in the aircraft industry, air transport industry, and the technical branches of the Civil Service.

A variety of interesting and timely research projects is being carried on in the College. In the Department of Aircraft Design, Mr. Roy Tetlow is concentrating on the design and testing of reinforced plastic components. He has published numerous reports on this subject, the latest of which outlines design procedures for selecting the correct layer orientation of multi-layer fiber-mat composite structures. By utilizing a simple computer program, it is possible to scan a range of layers of a particular composite material to determine the best orientations for given stress or shear criteria. The results of his work have been used to demonstrate a potential weight savings for aircraft structure compression panels, especially wings where stiffness criteria would normally eliminate both fiber glass and Kevlar because of their low specific stiffness.

Mr. D.I.A. Poll of the Aerodynamics Division is examining the behavior of the leading edge boundary-layer transition on swept wings. Having developed criteria to determine the attachment-line boundary layer for a given geometry and free-stream conditions, he has set about validating this experimentally. His calculations indicate that the present generation of civil aircraft have turbulent attachment lines in the cruise condition. His work indicates that a disturbance-free leading edge (very smooth) would not guarantee even small areas of laminar flow, therefore it would be necessary to resort to some form of boundary-layer suction system for lower cruise drag through laminar flow.

Messrs. J.J. Spillman and J.E. Allen have conducted both wind-tunnel experiments and flight tests on small multiple wing-tip sails that have demonstrated a trimmed lift-drag ratio improvement of 29% at cruise-lift coefficients. This represents a significant improvement over the 5-7% claimed for single Whitcomb winglets. Many investigators have studied wing-tip devices to improve aircraft performance, and most recently a trend toward their use has evolved with aircraft manufacturers who are just beginning to incorporate Whitcomb winglets on aircraft.

Spillman and Allen's work on wing-tip sails had its origin in a series of wind-tunnel studies of the flow behind the tip of an unswept wing of moderate aspect ratio. These studies showed a classical wing-tip vortex rolled up behind the wing as well as just behind the trailing edge and over the top region of the wing tip itself. A yaw meter was used to measure the local-flow

direction and velocity in the immediate vicinity of the wing tip. A clear definition of the local-flow velocity was then obtained. The investigators then searched for a method to utilize the vortex energy in a positive manner. They accomplished this by installing a series of small cambered surfaces in the wing-tip flow so that the resultant force on these surfaces is a positive vector in the aircraft's free-stream direction. The surfaces act like the sail of a ship by utilizing the cross-wind airflow of the tip vortex to obtain a thrust in the direction of flight. They significantly reduce the induced drag of the vehicle at a small penalty in form drag. This was demonstrated in the wind tunnel using an unswept wing of aspect ratio five.

Supported by funding from the National Research Development Corporation, a flight-test program was undertaken to validate the advantage of these devices when installed on an aircraft. An instrumented Morane-Soulnier PARIS turbojet aircraft with aspect-ratio five wings was chosen as the test-bed. Three small sails were fitted to each wing-tip fuel tank. The installation appears as staggered fingers at 0°, 45°, and 90° from the vertical. Wind-tunnel data were used to determine the optimum size, location, and shape of the sails. The aircraft was flown steady and level at 250 knots during the experiment. The flight-test results indicated that a single sail per side (à la winglet) reduces the lift-dependent drag by 9%, while three sails per side demonstrated a reduction of 29%. The flight-test results confirmed the tunnel results and indicated that a very significant reduction in lift-dependent drag can be obtained through the proper use of these devices. In addition, the pilots who flew the flight-test aircraft with three sails mounted per wing said there was a noticeable improvement in the handling qualities of the aircraft during take-off and approach, i.e., at high-lift coefficients.

Spillman is now planning on investigating the feasibility of varying the sails' incidence in flight. This should yield a higher performance gain over a wide range of lift coefficients and possibilities for utilization of the sails on high-performance aircraft.

The teaching and reseach activities at Cranfield are supported by the usual engineering facilities. The equipment includes a considerable range of experimental and test installations with their adjunct support instrumentation and recording equipment. The College has the expertise and is CAA approved to design, modify, manufacture, and flight test aircraft and associated equipment. The Institute has its own airfield that is fully operational to IFR standards. The airfield, located on a high plateau, is 360 ft above sea level. This provides excellent flight conditions to support the aeronautical research programs. Two long runways, each 5800 ft in length, are used for operations.

The Institute maintains its own fleet of aircraft, including two Handley Page Jetstreams, two Pups, and the Morane-Saulnier PARIS turbojet which was modified for the wing-tip sail work and used as a flight demonstration vehicle.

The Jetstreams are the backbone of the fleet. They have been modified to serve as airborne classrooms and are an innovation in teaching. As "flying laboratories," they are used for both teaching and R&D in aerospace engineering. One is outfitted with ten student consoles for the study of flight mechanics. The instructor can select a number of channels of information to be sent to each student's console. A closed-circuit TV monitor on the console either displays cockpit information or may be aimed at parts of the aircraft (e.g., wings and flaps). The students become involved in the experiment by reading and recording their own data. The other Jetstream has been outfitted with a newly developed autogyro and is flying under an industrial contract.

A further demonstration of the uniqueness of the Institute is the Cranfield A-1 aerobatic aircraft. From a student's design project in an aircraft design course, a fully aerobatic aircraft has been manufactured; design, development, and construction of the A-1 being carried out at Cranfield. The aircraft design is now considered to be a leading contender to represent the British in aerobatic competition, the world over. Today, Cranfield Institute's College of Aeronautics is continuing to educate students for the future in its unique environment.

(C. Joseph Martin, Liaison Technologist from David W. Taylor Naval Ship Research and Development Center, Bethesda, MD)

ENERGY

THE EUROPEAN JOINT RESEARCH CENTER—ISPRA ESTABLISHMENT

Tucked deep in the mountain region of Northern Italy and virtually a stone's throw from Lake Maggiore, at Ispra, lies one of the research facilities of the European Joint Research Center (JRC). The Joint Research Center is a component of the Commission of the European Communities and consists of four research establishments and a headquarters in Brussels. Its research establishments in addition to that at Ispra, are located at Geel, Belgium; Karlsruhe, Germany; and Petten, The Netherlands. The Commission of the European Communities is an administrative body consisting of representatives from France, Federal Republic of Germany, Italy, The Netherlands, Belgium, Luxembourg, the United Kingdom, Denmark and Ireland. It operates on the provisions of three treaties: the European Coal and Steel Treaty, the European Economic Commission Treaty, and the European Atomic Energy Commission Treaty (EURATOM).

The Joint Research Center Headquarters has a personnel component of about 25, and in addition to performing the normal administrative functions expected, also directly funds projects at various institutions within the member nations. The Geel Establishment is primarily involved in measurements, standards and reference techniques and consists of a total staff of about 200 persons. The Karlsruhe Establishment, consisting of approximately 200 persons, is primarily involved in plutonium and actinide research and to a lesser degree in nuclear reactor safety and waste disposal. The Petten Establishment is primarily involved in high temperature materials research and has a contingent of about 165 people. The Establishment at Ispra, which is by far the largest facility, consisting of over 1700 persons, is engaged in many areas of research involving energy production and utilization, and environmental research. This stems from the fact that the facility was originally the EURATOM research and development facility. The writer recently visited JRC Headquarters and the Ispra Establishment and will describe in more detail several of their ongoing programs in subsequent paragraphs.

The mission of the Joint Research Center is to carry out research of a central nature specializing in projects of a common interest to the European community rather than development work which is left to the member states. In addition, the JRC acts to provide scientific and technical support to the Commission as required. The JRC research potential is concentrated on a small number of pertinent projects having clearly defined content and milestones with priority set on energy research, environmental research and public service. Because of its adhesion to these aims, the JRC and the Commission itself have been very successful in their operation and have just recently adopted a four-year program with a roll-over option that promises to permit current and planned programs to be quite fruitful in the total European interest. These research programs consist of nuclear reactor safety, nuclear reactor plutonium fuels, radio-active waste materials management, solar energy conversion, production of hydrogen by thermochemical processes and related subjects, thermonuclear fusion technology studies, high-temperature materials, preservation of the environment and the earth natural resources, and nuclear and nonnuclear measurements, standards and reference studies. The JRC also provides to the Commission and the Community various technical services including informatics, training and education programs, and technical evaluations.

Many of these programs are underway at Ispra. One of the very interesting programs in progress there is "Project Habitat," designed to investigate all aspects of domestic heating and cooling by solar energy. A standard pilot-test facility has been constructed for the determination of solar collector performance and energy storage. The pilot facility itself consists of a solar "house" with inclined roofs containing various types of solar collectors. The interior contains various energy storage devices, several types of energy distribution systems, different thermal insulators and data analysis equipment. The facility operates in collaboration with 18 European laboratories to establish standard test procedures for various types of solar collectors and will

support industry in their characterization. Research will be performed to define: high efficiency solar energy collectors, measurement techniques and analysis for solar data with regard to global, diffuse and direct solar radiation, and reference solar months. Complete solar energy systems for the production of domestic hot water, space heating and space cooling will be analyzed. Various methods of chemical and ground energy storage will be investigated. In this regard optimization of thermal performance, validation of system models, and testing of subsystems and systems for corrosion, maintenance and lifetime will be undertaken.

Other planned uses for "Project Habitat" include investigation of the application of solar collectors for distillation of ethanol and sea water, technico-economic studies contributing to a central documentation and information center, and the teaching of specialist courses.

Other aspects of the overall solar energy program include the construction of a European Solar Irradiation Facility at Ispra which will be centered around a 500-kW Xenon solar simulator lamp which will provide a 4-m diameter uniformily irradiated spot of 1.0 sun intensity. The facility will be the largest in Europe and will contain provisions for air mass control as well as incidence control of the Xenon spot. The facility will permit accelerated aging tests of solar energy conversion components, measurement of system performance, studies of the influence of extreme ambient conditions, and development of standardized test procedures. Research on electrochemical solar cells based on semi-conductor/electrolyte electrodes and bio-conversion of solar energy is also underway.

The solar energy program falls under a more general program of future energy investigation both nuclear and nonnuclear. Another nonnuclear program of considerable interest to the JRC and being carried out primarily at the Ispra facility involves the production of hydrogen through thermochemical processes. The future importance of hydrogen as a significant energy source and means of energy transport depends largely on its cost. The studies underway at Ispra involve basic research on hydrogen production through the thermochemical decomposition of water, with theoretical studies including identification of new cycles, cost analysis of selected cycles, technical design of a full size decomposition plant, collection of industrial data, and analysis of the problems arising from interfacing hydrogen with a nuclear reactor heat source. Experimental studies underway include fundamental research on the chemistry and reaction kinetics of hydrogen and associated materials research. A Laboratory test installation for the thermochemical production of hydrogen is to be realized in the near future.

Most of the JRC's reactor-safety and waste-management research is also being carried out at Ispra. In the reactor-safety program a test reactor known as ESSOR is available in which nuclear-fuel elements of other reactors may be substituted for safety and materials testing. This facility is utilized by national reactor activities of the various member nations. Various other facilities are available for simulation of reactor situations such as mechanical, reactor core, and coolant loss accidents. Early warning techniques for accident detection and prevention, and structural failure prevention studies are also under investigation.

The radioactive waste management program consists of three basic projects: evaluation of the long term hazards of waste disposal; chemical separation and nuclear transmutation of actinides; and studies on decontamination of reactor components. Two methods of disposing of high radioactivity nuclear waste materials are under investigation. The first consists of encapsulating the material in some form of glass and placing the encapsulated material in a secondary container which is then placed in a geological formation such as a depleted salt mine, or a clay or granite bed. The second method under investigation is to extract from the radioactive waste material the actinides with long lifetimes ($>10^5$ years), to burn these in a reactor, and to bury the shorter lifetime materials in the manner described above.

The JRC appropriation for the ensuing four-year program is about $500 million and the program involves a total staff build up to 2340 persons with a research staff of about 1000. The Ispra facility is under the direction of Mr. Jean-Albert Dinkespiler who is also a Deputy Director of the JRC as

a whole. Mr. Dinkespiler was formerly with the European Space Agency and has brought his knowledge of successful international organization management to the JRC, and in particular to the Ispra Establishment. (Robert W. Rostron)

ENGINEERING

MECHANICAL ENGINEERING AT THE TECHNION

The Technion in Haifa, also known as the Israel Institute of Technology, is the principal center for the training of engineers in the country. A general overview has been given by Nunn in a recent article "Further Observations on Engineering Research and Education at the Technion" (*ESN* 31-2:40-43). The 4-year undergraduate program is comprised of 160 semester credits of course work taken at the rate of 20 credits per semester after which the BSc degree is awarded. At entry, the student has already had one year each of calculus and physics. Although the undergraduate curriculum in Mechanical Engineering is basically oriented, the student is exposed to application in design courses. After the BSc, students that are admitted to graduate studies are required to complete an additional 40 credits for the MSc degree, and those going on further for the PhD must complete at least 6 credits more and a dissertation. The scale of the program can be gauged from the fact that there are 40 full-time and 60 adjunct faculty (the latter teaching one course), 700 undergraduate students, 45 full-time and 200 external (part-time) master's degree students, and 20 PhD students in the Mechanical Engineering Department. Overall at the Technion 1100 BSc, 300 MSc, 70 PhD and 20 MD degrees are awarded each year. Most of the full-time graduate students are teaching assistants or instructors; the practice in connection with research grants is to hire research engineers.

The Dean of Mechanical Engineering, Prof. Chaim Gutfinger, outlined the research activities conducted in the various departmental laboratories, namely: Energy, Materials Processing, Stone Technology, Turbine and Jet Engines, Mechanics of Materials, Control and Automation, and Instrumentation. It is interesting to note that the activities of the Stone Cutting Laboratory concern the automation of cutting and faceting diamonds and other gems. The Control and Automation Laboratory is concerned with the control of processes, mechanical systems, pneumatic and hydraulic systems, industrial automation, and fluidics. The Energy Laboratory is conducting basic research in the thermal sciences as well as applied research in solar energy and the cleaning of flue gases using fluidized-bed technology.

Prof. Avraham Shitzer detailed some of the solar energy activities. Since sunshine is a plentiful resource, it is natural that it be utilized as much as economically feasible. The sight of solar collectors providing a means of heating water is very common in Israel, and such collectors on rooftops are more the rule than the exception. Shitzer told me that an installation designed for an average family costs approximately $200 and lasts upwards of 7 years.

The Solar Energy Group in Mechanical Engineering is engaged in a number of investigations involving flat plate and concentrating collectors, energy storage, and applications in heating, air conditioning, and distillation. The design and control problems associated with a moderate-size space heating system are being studied in the operation of an experimental flat-plate collector system that is currently heating the departmental library. The system consists of 48 flat-plate collectors with a total area of 70 m^2 and insulated water-storage tankage totaling 10 m^3 in volume which is connected to fan-coil heating units in the library. A thermostatic control system operates the circulation pumps. Shitzer told me that a large solar water-heating system on the roof of a hotel in Elat had never needed help from its fossil-fueled standby system. In a similar set-up, an experimental hot-water supply system serves the 5-story Energy Laboratory Building.

Research on two different types of solar collectors is in progress; one collector, a parabolic cylinder, focuses the radiation on a linear absorber with

both collector and absorber oriented in an east-west direction. The other collector is a fixed spherical mirror and a moving absorber that tracks the sun; this one is capable of sufficiently heating a working fluid so that the storage system can be compact and economical. Calculations for a Rankine-cycle energy converter with a concentrating collector system that could supply a household with 12-kWH energy per day yield a collector area requirement of 120 m^2 in a temporate climate; the necessary investment for such a system seems much too large at this time.

An interesting system for air conditioning, using solar energy to dehydrate desiccants, is being pursued. The dehydrated desiccants are used to dry air which is in turn cooled by evaporating water in it. It is hoped that this system will work out to be simpler and cheaper than one using mechanical or absorption-type refrigeration. A solar still intended to convert salt water to fresh using wicking material to increase the evaporative surface while recovering some of the heat of condensation of the freshwater is also being studied. The use of plastic-bag collector shallow-water ponds for heating greenhouses is under investigation in connection with an agricultural settlement. An experimental 10-cm deep water-bag collector and storage tank that is 3-m wide and 50-m long is being used to heat a 250-m^2 greenhouse during the night. The stability of solar ponds with slow, imposed flow is being investigated by Prof. David Pnueli and Senior Lecturer Yoram Zvirin, who are noting how hot water may be withdrawn while mixing is minimized.

In the area of materials processing, Profs. Pnueli, Ehud Lenz and Dr. L. Rozeanu have studied the performance of cutting tools. In metal cutting, the high temperature at the cutting edge causes the material being cut to fail locally, therefore the higher the temperature, the easier the cut. A high temperature is achieved by a low thermal conductivity cutting tool, but such a tool is not very "tough" and therefore shatters easily. The beneficial effect of a low-thermal conductivity cutting tool can be combined with the toughness of a metallic cutter, however, and this has been accomplished by Pnueli, Lenz and Rozeanu by applying a very thin coating of a hard refractory material to a metal base. The thickness of the coating exceeds slightly the small penetration depth of the high temperature region at the tool surface.

My brief visit to the Mechanical Engineering Department and the Energy Laboratory left me impressed with the determination of the staff not only to learn more in general but also to utilize real, pressing problems as research examples. (Martin Lessen)

AERONAUTICAL ENGINEERING AT THE TECHNION

The Department of Aeronautical Engineering, one of the most heavily endowed and funded divisions of the Technion (Israel Institute of Technology, Haifa) is probably one of the most active departments of its kind in the world. The reason for this is that, while most of the world is wondering about the future of large scale air transport because of a bleak energy outlook, Israel is designing and producing its own fighter (the Kfir) along with executive and transport type aircraft and is providing its own high technology back-up in computer-aided design, aerodynamics, structures, combustion, propulsion, aeroelasticity, stability and control, avionics etc. This is the only Aeronautical Engineering department in the country, and its laboratories constitute the national Aeronautical Research Center (ARC) that functions as the NASA of Israel. The Department has a faculty of 36 while the Center has a professional staff of 120. The Department has 300 undergraduate and 110 graduate students. Mathieu previously reported on the Institute in ONRL R-15-17 and Nunn wrote about some of the Departmental activities in *ESN* 31-2: 40.

The ARC consists of six laboratories in the areas of aerodynamics and wind tunnels (the principal wind tunnel center in Israel); structures; aeroelasticity and structural dynamics; flight control; propulsion and combustion; and jet engines (jointly with the Mechanical Engineering Department).

The Dean of the Department Prof. Eliahu Wasserstrom, who appropriately chose fluid mechanics as his field of

specialization, graciously arranged for Dr. D. Weihs to show me the facilities and introduce me to the various faculty. Wasserstrom and Y. Crispin (a graduate student) are studying the stability of electrical discharges in a low pressure gas. Because of temperature inhomogeneities, the glow discharge becomes unstable when driven sufficiently and collapses into an arc. However, turbulence in the low pressure gas reduces the temperature inhomogeneities and stabilizes the discharge. It is felt that in this way more energy could be pumped into a non-equilibrium state of the gas and thus the output of a gas laser might be increased.

Prof. M. Wolfshtein is active in the area of numerical fluid mechanics and experiments on turbulence. His work includes study of the efficiency of various solvers (numerical, finite difference schemes) for the Navier-Stokes equations, a study of closure schemes for numerically approximating turbulent flows and application of the foregoing to problems like numerical solution of flows with fast reactions; two-phase flow effects in hybrid combustion (solid fuel-liquid oxidizer rocket); a model of unmixedness for turbulent reacting flows; and numerical calculations of two-phase turbulent round jets. His work on the model of unmixedness for turbulent reacting flows considers the reaction to cease where one or another of the reactants is used up locally but does not seem to include the effect of reactants diffusing through each other and the reaction products, to replenish local deficiencies in concentration. With respect to the two-phase turbulent round jet, the change in the turbulent state owing to the presence of suspended particles is observed not to be totally explained by the additional dissipation caused by the relative motion between particles and fluid. Since in a closure scheme the available parameters are fitted to experimental data, physical intuition plays very little part in a solution. Might I suggest that the hydrodynamic stability of the flow is affected by the presence of suspended particles and hence that turbulence "production" is also influenced.

Prof. Y.M. Timnat of the Propulsion and Combustion Laboratory is active in various aspects of combustion and propulsion. His work is both theoretical and experimental and runs the gamut from the vaporization of droplets in burning jets, the influence of pressure on combustion intensity, and liquid-fuel combustion in tunnel burners to the effects of catalysts on the performance of a monopropellant (hydrazine) engine, jet misalignment in rocket nozzles and the effects of swirl on flames. The tunnel burner work purports to optimize the geometry of the burner so that the recirculation in the standing toroidal vortex permits a fuel-air mixture as close to stoichiometric as possible; with heavier fuels and consequently slow droplet-vaporization rates, the burner geometry is important. Timnat's work on the effects of swirl was done before the stability of swirling flows was studied, therefore the beneficial effects of possibly improved mixing could not be sought in other than a trial and error manner.

Dr. D. Weihs (Sr. Lecturer) has been active in the biomechanics of fish propulsion; his work has led to an optimization of swimming fins for humans. The swim fin in use today is slender (low aspect ratio), and he has found through his computer program, which describes the large amplitude oscillation of flexible surfaces, that a high aspect ratio fin is optimal for propulsion. Of course, the geometry of the fins must be such that they do not interfere with each other in use. He is also working on the stability of two dimensional jets and of thin films in air including capillarity to study the break up into aerosols. In the case of a hollow cylindrical film geometry, he is studying the relationship of the sausage to the kink mode of instability. Another area is Karman vortex shedding (periodic trail) in confined flow.

The Structures Laboratory in which Profs. J. Singer, M. Baruch, A. Libai, and A. Berkovitz, among others are active is devoted to studies of buckling, fatigue, creep and high temperature effects. Some of the general areas are thin-wall structures, dynamic stability, stability of composite structures, and correlation of buckling and vibration characteristics. Areas of applications include offshore structures, containers, and naval vehicles. Prof. E. Nissim and Dr. T. Weller of the Aeroelasticity and Structural Dynamics Laboratory cooperate in the program.

There was unfortunately no opportunity to visit with Prof. S. Merhav in order to discuss the activities in the Flight Control Laboratory or see the late developments in Prof. W. Kogan's Desalinization Laboratory. However, I did see abundant evidence of a virile program of quality. (Martin Lessen)

SUPERCONDUCTIVITY IN SWITZERLAND

Swiss interest and activities in low temperatures in general and in superconductivity in particular date from the late 1940s and early 1950s when hydrogen and helium were first liquefied in Switzerland. In commemoration of these earlier beginnings and to demonstrate continued interest in low-temperature physics, Switzerland will host the "100th Anniversary of Liquefaction of Air/Advances in Refrigeration at Lowest Temperatures Conference" next year in Zurich.

A noteworthy change in the overall low-temperature R&D effort since the start of the 1970s (ONRL R-8-71) is the Swiss effort in applied superconductivity. Switzerland has long been noted for precision machines and instruments, both of large and small scales, and her interest in superconductivity stems from a desire to maintain a level of competence that would allow quick entry into the potentially lucrative export market for large-scale, superconducting machinery such as electrical generators or magnets for magnetohydrodynamics (MHD) and fusion reactors. Such applications are dependent on, among other things, the commercial availability of superconducting wire of suitable operational parameters. Although multifilamentary NbTi superconducting wire is commercially available today, any sophisticated and complex machinery based on the use of superconducting wire will require a strong interaction between the design engineers and the wire manufacturers in order to determine the optimum material and conductor configuration for a given application. For these reasons, the majority of Swiss efforts in the field of superconductivity are currently directed toward basic materials research and to the fabrication of these materials into useful wire forms.

Swiss R&D efforts concerned with superconductivity are found at universities, federal laboratories, and in the private-industry sector. At the Universities of Lausanne and Geneva, and at the Swiss Federal Institute of Technology (ETH), Zurich, active groups are working on the basic and applied properties of superconducting materials. Interests in superconducting-magnet development are centered at the Swiss Institute of Nuclear Research (SIN) and the European Organization for Nuclear Research (CERN). The industrial firm of Brown Boveri et Cie (BBC) is engaged in multifilamentary-wire development, in magnet design, and in feasibility studies on superconducting ac electrical generators.

At the University of Geneva, Professors O. Fischer and J. Muller head groups concerned with the basic aspects of high-transition temperature T_c, high-critical magnetic field Hc_2, superconductors. Compounds possessing the A15 crystal structure have been extensively studied in Muller's group. This group relies on a strong interaction between materials scientists who carefully prepare samples and low-temperature physicists who measure their properties. One noteworthy materials-preparation facility is a high-pressure argon-induction furnace (40-atm pressure operational and 5000-atm future design) which significantly reduces evaporation loss of the lower melting component in A15 compounds. A common measurement of the group has been specific heat from which values of the transition temperature, Debye temperature, and electronic density of states at the Fermi level have been deduced for a wide variety of compounds. Past studies included the effects of heat treatment, crystallographic order, and magnetic impurities on the superconducting properties of A15 compounds. Some current studies include the accurate determination of A15 phase diagrams and a mapping of the electron charge density in compounds using x-ray diffraction techniques.

Fischer's group at Geneva is intensively studying the Chevrel phase compounds such as $PbMo_6S_8$. These materials are important because of their extremely high critical magnetic fields [i.e., $Hc_2(T = 4.2\ K) \sim 70$ Telsa for some compounds] as well as the fact that they represent a new class of

superconducting ternary compounds whose properties are quite unusual. For instance, as one lowers the temperature, the compound $Ho_{1.2}Mo_6S_8$ becomes superconducting at 1.2 K but then returns to the normal state at 0.64 K. This later transition is attributed to the magnetic ordering of Ho^{3+} ions in the compound. The group at Geneva is studying not only basic properties of these various compounds, but also technologically important parameters such as the critical current density of wires fabricated from them. The program has only recently begun, and high J_c values have not been produced as yet.

Professor L. Rinderer is director of the low-temperature research group at the University of Lausanne. Static and dynamic behavior of flux flow in pin-free granular Al superconductors is one area of active research. Particularly interesting is the behavior of J_c when the applied magnetic field is parallel to the film surface. J_c is modulated by the applied magnetic field such that J_c vs H curves form a diffraction pattern with J_c becoming nearly equal to zero when one vortex chain is formed in the film. Alternating current effects were also investigated, and it was found that radio frequencies alter the current-voltage relation with formation of regions of negative resistance at specific frequencies. All these effects have intriguing analogies to Josephson-junction characteristics and as such, merit continued study.

At the ETH in Zurich, the low-temperature group is headed by Professor J.L. Olsen. Historically this group has been interested in pressure effects (hydrostatic and uniaxial) on the superconducting elements. More recently research has been expanded to include alloys and compounds of a more general interest as well as dynamic studies of flux flow in the mixed state.

The basic-materials research group at ETH, which has one operating dilution refrigerator and has purchased a second, emphasizes material studies below 1 K and has recently found superconductivity in La-pnictide compounds possessing the anti-Th_3P_4 crystal structure. These compounds, La_4X_3 where X = As, Sb, and Bi, become superconducting below 1 K and are the first known superconductors in this crystal structure. Studies of ternary A15 superconductors V_3- TM Ga, where Tm is the transition metal Ti, Cr, Mn, Fe, Co, or Ni, were undertaken to establish the relationship between T_c and TM concentration and to look for a systematic trend in the pressure derivative of T_c. It was found that T_c is a universal function of the electron per atom ratio while the relative pressure derivative $(1/T_c)\ (\partial T_c/\partial p)$ is dependent only on the number of TM atoms on the vanadium lattice sites. These results suggest that while T_c is controlled mainly by electron interactions, pressure changes in T_c are influenced strongly by lattice vibrations.

Dynamics of flux motion in type II superconducting granular aluminum films is another interesting research endeavor at ETH. Scientists have found dramatic changes in the J_c vs H characteristics when these films are thickness-modulated to provide linear pinning arrays. When the spacing between the individual fluxoids is equal to the thickness-modulation distance, enhanced fluxoid pinning occurs. This effect manifests itself as an increase in the critical current (resistance minimum) at specific magnetic-field values. The equation of motion describing the effect is similar to the Josephson equations describing current flow between two weakly coupled superconductors. Experimentation on these films has indeed revealed effects similar to that seen in superconducting junctions, i.e., rf-induced steps in the current vs voltage curves and emitted rf radiation with current-induced fluxoid motion at the matching condition. These observations suggest that the fluxoids are coherently coupled in the film. Further experiments on modulated films are in progress.

ETH and Brown Bovari are collaborating on a project to study ac losses in multifilamentary superconducting wire. The main concern of the program is to measure ac-loss characteristics in commercial as well as experimental wire. They are attempting to separate matrix losses from the inherent hysteretic losses of the superconductor itself and to study these losses as functions of frequency, amplitude, and twist pitch of the filaments. Work has been concentrated so far on NbTi wire, but current studies are being directed toward A15 wires as well.

BBC in collaboration with a number of local wire-drawing and cable-producing companies is producing NbTi superconducting wire of various geometries. The

superconductivity group, headed by Dr. G. Meyer, is directing this effort, characterizing the properties of the resulting wires, and is engaged in design studies for large-scale magnets to be used in ac generators or in fusion reactors. In addition to their work on NbTi wires, the group is developing a computer-simulation program for the growth kinetics of A15 multifilamentary wire in order to facilitate the transition to the next generation of higher T_c/higher J_c wire.

No story of superconductivity can be complete without discussion of refrigeration systems. Here again, the Swiss have an industry developing hydrogen- and helium-liquefication systems. Sulzer has concentrated on large-size liquefication plants in which turboexpansion engines are economical. For instance, they have recently built a liquefier capable of producing 4000 liters of liquid helium per hour.

In conclusion, Switzerland today has considerable activity and interest in the field of superconductivity. This interest is spurred by the potential marketability of superconducting systems. Surprisingly, the Swiss are not developing small-scale device technology, i.e., Josephson-junction devices, to the extent one might expect although the intriguing character of the flux-film experiments at Lausanne and ETH may eventually lead to some unique applications. Only one industry, IBM Zurich, has work in device technology. Apparently there is concern about competing with the large electronic and computer firms of other countries.

The Swiss, on the other hand, have considerable know-how in large-scale machinery, consequently the transferral to superconducting technology appears practical. They are currently developing a firm basis in superconducting materials and superconducting-wire fabrication while at the same time developing designs for large-scale application of these materials—particularly as related to electrical generators. It should be very worthwhile to follow the development of superconductivity in Switzerland as it may prove a representative model for the field of large-scale applied superconductivity. (Donald U. Gubser, Naval Research Laboratory, Washington, DC)

GENERAL

IIASA: MULTIDISCIPLINARY RESEARCH IN MARIA THERESA'S PALACE

At the time of *ESN*'s last report [R.T. Schneider, "Schloss Laxenburg—A Palace for Scientists," *ESN* 29-7:314 (July 1975)] on the International Institute for Applied Systems Analysis (IIASA), the renovation of the Hapsburg summer palace in Laxenburg, a hamlet 12 miles south of Vienna, had only recently been completed, and IIASA's international interdisciplinary research was just getting started. An earlier article by B.J. McDonald and R.J. Collins [*ESN* 27-12:339 (December 1973)] reported on the formation of the Institute in 1972, with $1 million annual support to come from the Academies of Science of the US and USSR and $150,000 from each of the other 12 national member organizations (NMOs). It also reported the arrival of the first scientists in 1973. Since that time IIASA has grown to about 300 people, the dues have been raised twice by 20% to $1.44 million and $216,000, and three additional NMOs have joined the supporters of IIASA; they represent Sweden, Finland, and the Netherlands. The indirect support via NMOs has made it possible for both Germanys to participate. In addition, about $1 million came from foundations in various countries during 1977, and 15 of the 100 IIASA scientists were supported by outside institutions.

Well over a dozen conferences are held annually in the Institute's palace, Schloss Laxenburg. An article by R.C. Harriss [*ESN* 29-9:389 (September 1975)] reported on one, an IIASA Workshop on Energy Resources—their assessment and forecasting—Energy being one of the present two IIASA research "Programs" and Food and Agriculture the other. IIASA's research is described as being organized in matrix form, with the Programs intersecting the five research "Areas": Resources and Environment, Human Settlements and Services, Management and Technology, Systems and Decision Sciences, and General Research.

Each Program or Area comprises between three and seven tasks, to each of which a number of staff members are assigned along with research assistants in some cases. Only a few of the hundred scientists are assigned to more than one Area or Program, but most are working on several tasks. These are very highly qualified people, usually on leave from universities or research institutes, who go to IIASA for periods between one and two years, generally continuing the sort of work they had been doing but now much better able to get inputs and feedback from experts representing other disciplines and other countries. Area and Program leaders, however, are expected to stay at IIASA at least three years. Less than 30% of the staff comes from nonmember countries.

The Chairman of the IIASA Council, the Institute's governing body, is Prof. Jermen Gvishiani, Deputy Chairman of the State Committee for Science and Technology of the Council of Ministers of the Soviet Union. IIASA's Director since November 1975 has been Dr. Roger Levien, a systems scientist, who was previously Director of Domestic Programs in the Rand Corporation's Washington office. The Deputy Director is Prof. Wolf Häfele of the German Federal Republic, who also heads IIASA's Energy Program. This Program focuses on the problem of furnishing sufficient energy for the future and, in particular, the transition to inexhaustible resources. The prediction and management of demand during the transition, the utilization of waste heat, and the design of large solar heating systems are also included within its scope.

The Food and Agriculture Program, led by Prof. Ferenc Rabar of Hungary, is concerned with assessing and meeting the nutritional needs of the growing global population through improved national and international efforts. A third Program—Regional Development—is being considered for formal inclusion in IIASA's organizational structure.

The Energy Program's tasks cover Resources, Demand, Options, Constraints, Strategies, and Deployment, while the Food and Agriculture tasks are Resources and Technology, Nutritional Requirements, Constraints, and Strategies. In the perpendicular direction on the organizational matrix, the Resources and Environment Area's tasks are related to water, climate, and other ecological problems. The Human Settlements and Services Area includes health care, migration, and population growth; and the Management and Technology Area deals with the handling of technological change and of complex development projects.

The Systems and Decision Sciences Area, under Prof. Michel Balinski of the City University of New York, includes tasks dealing with Economic Planning, System Optimization, Decision Analysis and Conflict Resolution, and the IIASA Computer Network. Along with Prof. H. Peyton Young (also from CUNY), Balinski is continuing studies of the fair apportionment of representatives [*American Mathematical Monthly* 82, 701-730 (1975)], discussing it this time in terms of the EEC's European Parliament. There are several different desirable properties, and fairness would seem to require all of them. A tendancy to encourage coalitions should also be desirable, but only a few such properties can be simultaneously achieved. Balinski and Young have characterized the methods of apportionment that offer any of these desiderata. In addition, Young is continuing his work on the evaluation of voting power in a representative assembly in terms of the potentialities for bribery, measuring the effectiveness of each member's vote in terms of the price that it may command.

The IIASA Computer Network is intended to supplement the Institute's PDP 11/45 "minicomputer" and to provide a link to databases in the countries from which IIASA scientists have come as well as permitting the transmission of messages. Since Eastern Europe has very little in the way of computer networking to tie into, there is the possibility of IIASA's connecting up with the Cyclades network (*ESN* 31-8:296) in France. Because of the shortage of telephone lines (there are only three telephone voice channels between Vienna and Moscow), the use of a satellite in a packet-switched configuration is being considered. A radio link between Laxenburg and Vienna gives IIASA access to the Cyber 74 computer at the Technical University, and the NORD 20 minicomputer in Bratislava, Czechoslavakia (30 miles east of Vienna) has occasionally been linked to IIASA via telephone connections. There are leased lines to Warsaw and Pisa, the latter giving access via IIASA's small Wang 2200 computer to the CNUCE Computer Institute and its

IBM 370/168 machine running the VM virtual system. In Warsaw there are five institutes being tied in in this way.

The Computer and Automation Institute in Budapest and the Center for Computing Technology of the Academy of Sciences of the German Democratic Republic in Berlin are to be connected with the network as well as facilities in Kraków, Moscow, Kiev, and Riga. Such communications would be particularly useful for those coming to IIASA from Eastern Europe, as copying facilities are hardly available in their home countries (such machines might serve as printing presses), and so they are unable to bring complete files of the data they may need in their research. Approximately three full-time IIASA people are working on setting up the network, transferring technology, coaxing countries into providing the necessary interfaces, devising standard protocols for use on the network, and arranging for the protection of sensitive data. The group is also cooperating with the International Atomic Energy Agency in Vienna, which does not yet have its own network.

Although IIASA's PDP 11/45 is a "minicomputer," it is equipped with 131,072 16-bit words of memory and 90 megabytes of file storage and is connected to 20 time-sharing terminals distributed around the Schloss. The roughly 30 scientists who use this computer are encouraged to do their own programming, but there are four high-level programmers to provide instruction and assistance. The Computer Services Department, headed by James Curry, also has a small unused TPA-70, which is a "copy" of the PDP-11 that was built in Hungary but is unable to use PDP-11 software. In addition IBM in Vienna has provided a lot of free time on its 370/158, which was used for large (5000 × 5000) linear-programming problems.

Another task, simulation games, to which IIASA computing facilities have been applied falls under the General Research Area, where Prof. Olaf Helmer (retired from Univ. of Southern Calif.) has been working on global modeling. During the week 19-23 September 1977 he arranged a Seminar on Interactive Simulation at the Institute for the benefit of IIASA management and scientists who might find use for the technique. Experts in this field—Dr. Jan Klabbers (Univ. of Nijmegen, the Netherlands) and Prof. Richard D. Duke (Univ. of Michigan) as well as Dr. Igor Zimin (USSR), who is now at IIASA—discussed their work and exhibited numerous simulation games.

Helmer got the audience to participate in an interactive Global Economic Model simulation exercise in which different teams represented the interests of countries having particular needs in various areas, i.e., sources or markets for food, fuel, raw materials, manufactured goods, labor, etc. In this way the game, which involves capital investment, trading, investment in training, and a conversion matrix from investments and inputs to outputs over a series of stages of play, spans the specialties of most of the IIASA groups. The goals of the game are not programmed into the computer but must be introduced by the players, who in this case represented these IIASA groups. Such games are intended not only to give the participants new insights for their own work and a feeling for the larger picture but also to aid in the development of improved models of the global economy while at the same time retaining human participation in the simulation because of the impossibility of modeling this aspect adequately by means of a computer program. Ultimately the gaming should become useful for training those who, as national or international decision makers, actually serve in the simulated roles, thereby communicating the results of scientific analyses to nonscientific policymakers.

Under IIASA's General Research category also falls the publication of a series of monographs and handbooks on systems analysis under the editorship of Prof. Edward S. Quade (previously at the Rand Corp., Santa Monica, CA). In 1977 John Wiley and Sons, London, published the first two of these books, *Conflicting Objectives in Decisions*, by Bell, Keeney, and Raiffa (US), and *Material Accountability: Theory, Verification, Applications*, by R. Av Avenhaus (FRG). The manuscripts of *Adaptive Impact Assessment of Ecological Problems*, by C.S. Holling *et al.* (Canada), and *Organization for Forecasting and Planning*, with W. Dill (US) as editor, are ready and will be published shortly, while nine other manuscripts are nearing completion, and the prospectuses for many others are being prepared or reviewed.

In addition to these books and the IIASA reports, which often represent manuscripts to be submitted to professional conferences and journals, there are also more tangible results of IIASA research, such as the work of the Ecology Project on the management of the spruce budworm in New Brunswick, which is already being applied in Canada, and the work of the Water Project in conjunction with the Hungarian National Water Authority on the development of the Tisza River basin. Such specific tasks will be broadened so as to find application to other countries and regions, and methodologies for decision making in the global context are to be developed. Those who have been at IIASA are, furthermore, expected to carry back to their home countries enhanced capabilities not measured simply by the output during their stays, which will enable those countries to pose their problems more clearly and to solve them in a broader context.

Restoration of the Schloss Laxenburg is continuing, with the result that the number of conference rooms and offices is growing, but the size of the staff has reached its limit, and inflation prevents further growth in that direction. However, Switzerland, Mexico, and Iran may soon join the other 17 IIASA supporters. The Institute's domain has been described as "the world of the ill-defined," which it appears to be able to handle very capably. It is initiating international cooperation despite differing economic, social, and political systems and is making its findings available to national and international decision makers, the scientific community, and the public. (Nelson M. Blachman)

ONRL REPORTS

See the back of this issue for the abstracts of current reports.

TEROTECHNOLOGY—WHAT IS IT?

Don't waste time looking in your dictionary; *terotechnology* is not listed. About seven years ago, the same people in England that coined the word tribology (*ESN* 30-9:408 and ONRL Report R-7-76) evidently used the same Greek lexicon and coined the word terotechnology after the Greek word *tero* which means to look after, or care for. The word is defined by the National Terotechnology Centre (NTC), Leatherhead, Surrey, UK as "a combination of management, financial, engineering and other practices applied to physical assets in pursuit of economic life-cycle costs." Looking at the definition, the reader is more likely to question the technology part of the word than the tero. Seemingly little technology is involved in the concept of terotechnology—although the technologies involved in tribology among others are relevant. Mr. Dennis Parkes, the Director of NTC, admits that teroeconomics or teromanagement could have just as readily described the concept, but the word itself has been useful as he explained during my recent visit to NTC.

In 1975 the UK Department of Industry (DoI) founded NTC as a subsidiary of the Electrical Research Association, Ltd. (ERA) to tell British industry about the benefits of terotechnology and to provide assistance in its application. While totally under contract to DoI, the Centre acted as a focal point for the promotion of terotechnology and provided basic information and advisory services free of charge. Impressed with the success of the NTC promotion of terotechnology, DoI has started to curtail funding of NTC as the Centre begins charging its customers for its services. Currently heavily booked with work, NTC has a permanent staff of just five people but draws support from the collocated staff of ERA. They also contract out for those services not available at ERA, while the permanent NTC staff act primarily as project managers.

Basically a multidisciplinary approach to optimizing life-cycle costs, terotechnology requires the skills and experience of a number of specialists. It is unlikely that any one individual would have the range of knowledge and experience necessary for its full implementation. Readers need not fear the creation of a new specialist, the

terotechnologist. In practice, terotechnology concerns the specification and design for reliability and maintainability of physical assets (machinery, equipment, buildings, etc.) as well as their installation, maintenance, modification, and replacement, with emphasis on feedback of information on design, performance, and costs. Note that life-cost is something that can be assessed and used without employing terotechnology. It is the application of terotechnology to life-cycle costing that distinguishes the two. Effectiveness of terotechnology should be measured by the contribution it makes to the reduction of the cost of ownership.

Line managers, engineers, accountants, maintenance men, and others all work on facets of terotechnology in their daily working lives, but the full benefits of the multidisciplinary approach of terotechnology are not realized without the active participation and understanding of senior management. The advantage of the word terotechnology is that it seems to be awakening senior management to the benefits of this multidisciplinary pursuit of economic life-cycle costs. The overall approach can be classed as common sense, but it does require senior management backing to encourage breadth of planning and enhance communication between different functions and thus realize the full benefits of an integrated approach.

Readers familiar with the defense industry are probably acquainted with the US military emphasis on the concept of Integrated Logistics Support and the design economics approaches of Design to Cost as well as Life Cycle Cost. The staff at NTC believe that terotechnology encompasses all of these concepts. They also believe that the US defense industry, because of strong direction from the Pentagon, leads the world in actual practice of terotechnology although there has been little or no use of the word in the US. Where NTC is leading is in the promotion of the concept within non-defense industries.

After talking with the NTC staff, I believe they are making good progress in promoting the application of terotechnology. With terotechnology conferences taking place during the past year in Norway and Japan as well as in Britain, I expect the word terotechnology to be in the Oxford and Webster dictionaries by 1979. No doubt by then the use of the word will have grown such that few people will need to resort to a dictionary to learn its meaning. (CAPT L. Roy Patterson)

MATERIAL SCIENCES

LABORATOIRE DE PHYSIQUE CRISTALLINE—POINT DEFECTS AND PHASE CHANGES IN INSULATORS

The Laboratoire de Physique Cristalline is part of the Université de Paris-Sud-XI which is located in semi-rural beauty at Orsay near Paris. Professor Jean Pierre Chapelle is head of the Laboratory and works on problems associated with phase changes in ferroelectric and ferroelastic materials. He also looks after an extensive crystal-growth facility. The other senior scientist is Professor Lucienne Taurel, who is primarily involved with point-defect studies. A staff of 20 assistants, students, and technicians constitute the remainder of the group. It was pointed out that within the Laboratory there is a noticeable increase in foreign students and visiting staff, many of whom are from the Middle East. Chapelle feels that this is not simply a local fluctuation of population in his group, but is in part a result of the dwindling supply of French students who choose science for a career.

I gained the impression that the Laboratory is broad and flexible. This applies both to the program, which will be discussed in more detail later, and to the equipment. There is a great deal of high-resolution optical apparatus for measuring spectra and electro-optical and photoelastic properties of materials. There is a variety of lasers, including a dye laser, for studying Raman and Brillouin scattering at all temperatures. Electron spin resonance (ESR) equipment is also part of the experimental arsenal. In addition to experimental work, there is a small amount of closely coupled theoretical research. One must also note

the happy coexistence of studies on large-scale cooperative phenomena involved in phase changes along with the isolated and singular phenomena of point defects. Finally, the existence of a productive crystal-growth facility has allowed the study of a broad range of materials including many that are far off the beaten track.

One of the directions taken by the point-defect studies is to work with alkaline earth halides. Starting with CaF_2, they have moved into relatively unstudied materials such as $BaCl_2$, $SrCl_2$, BaClF, and SrClF where the site symmetry for defects is much lower than in the well-studied alkali halides. Their studies include electron centers—especially the F-center which is an electron at a negative ion vacancy, trapped-hole centers, and the effects of incorporation of hydrogen into the lattice. In some materials it is necessary to add monovalent positive ions such as Na^+, K^+, Rb^+, or Ag^+ to bring up the concentration of negative-ion vacancies so that exposure to x-rays can produce F-centers.

Another area of interest has been the careful analysis of the Raman scattered spectrum of alkali halides with F-centers. Although CsBr and NaI have been studied, the most elegant work has been done on KI. It is known from neutron-scattering data that there is a gap in the vibrational phonon spectrum between 70 cm^{-1}, where the acoustic phonon distribution ends, and 96 cm^{-1}, where the optical phonon distribution begins. Taurel and her associates found a very narrow "gap mode" at 78.4 cm^{-1} and a strong "resonant mode" at 96.5 cm^{-1} just above the well-resolved gap region in Raman scattering studies. The value at 78.4 cm^{-1} is in excellent agreement with a line in the far infrared spectrum of KI with F-centers. It also agrees with the vibrational frequency influencing the F-center in KI as deduced from the variation of the width of the absorption band as a function of temperature.

The Orsay group attempted to reproduce by calculation the results obtained experimentally. For this purpose they used a shell model for the vibrational spectrum of KI from the literature. The eleven parameters of the model had been chosen to fit the neutron scattering data for KI. However, two parameters were changed in their calculation to account for the presence of the vacancy at the F-center. The major change was a reduction to 1/3 of the longitudinal force constant involving the nearest ring of positive ions surrounding the F-center and a 5% reduction in a similar constant for the second ring of positive ions. This choice is made to obtain the experimental value of 78.4 cm^{-1} for the gap mode. By using this modified shell model along with the appropriate theory for Raman scattering, it was possible to duplicate fairly well the broad Raman scattering below and above the gap. By geometrical variation of incident-light direction, electric polarization of the incident light, and viewing directions in the crystal, the influence of lattice vibrations of simple symmetry on the F-center scattering can be obtained. These can be compared with the selection rules when the crystal and the defect center symmetries are known. The results for the sharp gap mode and the resonant mode were unexpected in that they appeared to violate the selection rules.

Taurel and her associates suggested that the symmetry of the ground state of the F-center might be altered by spin-orbit interaction with the excited state. Calculations using the known value for this interaction seemed to indicate that this was the probable source of symmetry lowering. Experiments with a magnetic field applied to the F-centers increased the troublesome effects and substantiated the interpretation.

A material that is being carefully studied by Chapelle and his associates is $(PO_4)_2 Pb_3$ which is ferroelastic, that is it has a transition at 180° C that involves only a very small displacement of a few ions. An analysis of the structural data suggests that the transition involves the translation in opposite directions of the two Pb ions in the unit cell. It was possible to use this information to propose that the phase transition involved a specific soft mode of the lattice. Parenthetically, Chapelle maintains that all of the phase transitions he has studied appear to involve the occurrence of some soft mode. Building on these assumptions, the temperature dependence of a particular sensitive elastic constant could be derived from free-energy calculations. Brillouin scattering

measurements of this constant show a strong discontinuity at the transition temperature as predicted. An additional experiment is being performed that appears to nail down the mechanism even more tightly. Mn^{++} is substituted for Pb^{++} and the ESR of the Mn is observed above and below the transition temperature. If the opposite displacements of the Pb^{++} ions occur as postulated, a substantial dipole field is set up and the effects of the large fluctuations of the electric field near a substituted Mn^{++} ion should be seen in the magnetic resonance spectrum. A broadening of the ESR spectrum by about a factor of two is seen as predicted. This work is still in progress.

A very strong element in the work of Chapelle's group arises from the extensive crystal-growth facilities that have been built up. There are between five and ten working rigs each for Kyropoulous growth, Bridgeman growth, and solution growth of crystals. Each design is simple and reliable. The philosophy seems to be to turn out a lot of useful crystals rather than attempt to extend the crystal-growing art itself. The result is a collection of insulator crystals that is impressive both for its size and its variety. In this laboratory, at least, availability of materials is seldom a limiting factor in the progess of research. (Clifford C. Klick)

A "UNIVERSAL" LAW OF DIELECTRIC RESPONSE

To many scientists the phrase "dielectric research" evokes a slightly musty aura of days gone by. It may bring back memories of an early chapter in the Electricity and Magnetism course; perhaps we see mental pictures of an electric dipole oscillating as an ac-electric field is applied to it. However, in recent years the scope and importance of dielectric studies has grown far beyond that primitive image.

A visit to the Chelsea Dielectrics Group at Chelsea College of the University of London illustrated the activity in this field for us. Within the Physics Department there is a group of approximately 15 people devoted to studying dielectrics in the broadest sense. Professor A.J. Jonscher is the principal architect of the program; another senior staff member, Dr. R.M. Hill is also heavily involved. Younger staff members, visiting scientists, students, and technicians round out the staff.

The group has made strong efforts to advance in three directions. One has been to enlarge the experimental techniques available and to improve the handling of data; a second has been to encompass the largest variety of conducting and nonconducting materials; and the last has been to look for new unifying factors or guiding principles that arise from this broad-scale study. We shall attempt to describe briefly these various aspects of the Chelsea program.

The heart of the experimental program has been a Solartron Frequency Response Analyser coupled to a PDP minicomputer. This combination covers a frequency range from 10^{-5} to 10^{5} Hz with a dielectric loss sensitivity better than 10^{-2}. The computer not only runs the experiment but also treats and plots the data as complex impedance, admittance, or permittivity—all as a function of frequency on linear or logarithmic scales. At very low frequencies the data taking is slow; an experimental run down to 10^{-4} Hz takes 40 hours. For this reason automatic operation is essential. Automatic data handling and plotting is also a great time saver and allows an on-line examination of the results as the data are being taken. A newer system is being installed which is similar to the one already described but with the sensitivity to dielectric loss improved by two orders of magnitude. A collection of bridges and microwave-slotted lines completes the frequency response gear.

A complementary experiment is to place a step voltage across a dielectric and measure the current flow as a function of time. Jonscher feels that this type of experiment gives unusually direct information about the physical phenomena under investigation. The apparatus at Chelsea currently extends from 0.1 sec to 10^{4} sec after the voltage pulse is applied. It is being extended to work down to 10^{-4} sec, and the data will again be computer treated and plotted during the measurement.

Other equipment is available for studying the frequency dependence of the complex mechanical modulus of solids, for looking at thermally stimulated polarization, and for investigating the photo-injected charge in solids as a function of the wavelength of the exciting light. All of the dielectric experiments can be done as a function of temperature.

The materials being studied include both organic dielectrics and conductors (usually semiconductors). We will discuss the dielectrics work first. If an electric field E is applied to a dielectric—normally by placing the latter between the plates of a capacitor—a charge Q will flow as a result of the polarization of the dielectric. The relationship is

$$Q = \varepsilon_o(1 + \chi)E$$

where ε_o is the dielectric permittivity of free space and χ is called the susceptibility of the dielectric. Furthermore, χ is usually written as a complex quantity

$$\chi = \chi' - i\,\chi''$$

where χ' is in phase with the applied electric field while χ'' is 90° out of phase and is a source of energy loss. Experiments on a wide range of organic dielectrics at different temperatures and degrees of crystallinity show results like those in Fig. 1.

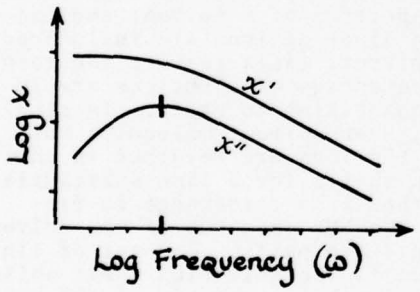


FIG. 1.

The peak in χ'' is more pronounced in some materials than others, but it is never as sharp as the classical Debye peak. A Debye peak would correspond either to an electric dipole moving in a viscous medium or jumping between two preferred orientations separated by a potential barrier. Those models do not seem adequate to describe what is happening in ordinary dielectrics. In all cases that have been measured, the fall off of χ'' as a function of frequency (ω) at high frequencies is given by

$$\chi'' \sim \omega^{n-1} \text{ with } n<1.$$

As is well known, χ' and χ'' are related by the Kramers-Krönig relationship so that if one quantity is known as a function of frequency, the other quantity can be computed. It turns out that a high frequency dependence of (ω^{n-1}) in either χ' or χ'' will imply the exact same frequency dependence in the other. Thus the two curves of Fig. 1 are parallel in the high-frequency region. We shall return to this point later.

Another class of materials has polarization produced by the discontinuous hopping of electrons or ions between localized sites. Materials studied include amorphous semiconductors such as amorphous Si and As_2S_3, single-crystal anthracene; inorganic glasses, single-crystal β alumina with fast-ion Na^+ conduction, and thin films of amorphous SiO and stearic acid.

Normally, conduction in these materials is given in terms of a complex conductivity composed of dc and ac components. These can be easily transformed to values of susceptibility, however, so that the same quantities can be used again to describe this class of materials. Typical curves are given in Fig. 2.

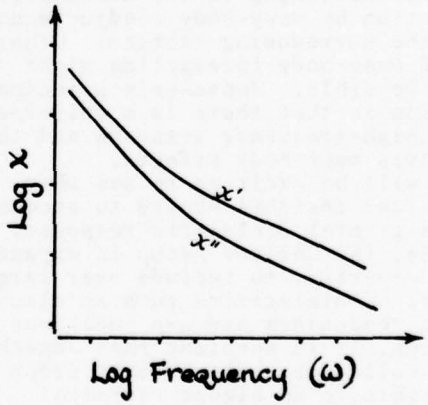


FIG. 2

There is no peak in χ'' for these materials as there had been in Fig. 1. However, the high-frequency dependence of χ' and χ'' still follows the same ω^{n-1} dependence. A similar functional relationship holds at very low frequencies but with a different value of (n).

In a paper entitled "The 'Universal' dielectric response" [*Nature* 267, 673, (1977)] Jonscher reviews much of the data his group has collected and emphasizes two points. First, as we have seen, the high-frequency response for χ' and χ'' in all kinds of materials varies as (ω^{n-1}). If a ratio of χ'' to χ' is taken in this frequency range, it is independent of frequency. Physically, this means that the energy lost per cycle divided by the energy stored per cycle is a constant over this frequency range. Further this is true for crystals, polycrystals, and glassy structures; for ionic, covalent, and molecular bonded materials; for polarization due to dipoles, hopping electrons, and ions; and for bulk samples and thin films. Jonscher suggests that this must be the result of a very general property of all non-metallic solids. In limited experiments the same form of response is found in the case of dynamic mechanical response of glassy solids and in magnetic response. His conclusion is that it is the result of some kind of many-body interaction. In particular he suggests that the discontinuous jump of electrons or ions or dipoles on sudden application of an electric field is followed by the slower screening of the new charge distribution by many-body readjustments within the surrounding lattice. Other forms of many-body interaction might also be possible. Jonscher's principal conclusion is that there is a universal form of high-frequency response and that it involves many-body effects.

It will be exciting to see what new physical insights evolve to account for this general dielectric response. Meanwhile, the Chelsea group is expanding its expertise to include ever larger varieties of dielectrics such as electrolytic condensors and n-p junctions in silicon. It is apparent that Jonscher and his colleagues have brought fresh new insights to an almost classical field. (Clifford C. Klick and A.K. Nedoluha, USARSG)

REVIEW SYMPOSIUM ON RECENT STUDIES OF ELECTROLYTE SOLUTIONS

An informal meeting, attended by 116 participants, was organized on 12 September to serve as an introduction to the Faraday Discussion on "Ion-Ion and Ion-Solvent Interactions" which was to be held in Oxford on 13-15 September and an account of which follows. The locale for the one-day meeting was the University of Reading.

Professor A.D. Pethybridge of the University of Reading, Chairman of the Organizing Committee, set the tone for the symposium in his opening remarks, emphasizing that it must be conducted in such a way that it would not violate the spirit of the ensuing Faraday Discussion in Oxford. Hence, all lectures would be of a review nature. There would be no questions or discussion following each paper and only a short, general discussion at the end of the day. After a few routine announcements, he introduced Dr. A.K. Covington (Univ. of Newcastle upon Tyne) who served as Chairman of the morning session at which three of the five scheduled lectures were presented.

The first talk was given by H. Schneider (Max-Planck-Institüt für Biophysikalische Chemie, Göttingen, FRG) on "Recent Applications of NMR Spectroscopy to Electrolyte Solutions." This paper dealt with the use of nuclear magnetic resonance spectroscopy for investigating solvent and electrolyte solution phenomena. The presence of ions affects the NMR spectrum of a solvent and the resonance lines of ions are influenced by the solvent. As a result, the resonance frequencies of a nucleus are important quantities to study. In single solvents, when solvent molecules surrounding the ions are retained in their solvation shells for a time substantially greater than $1/\Delta\gamma$ ($\Delta\gamma$=change in frequency), the NMR spectrum of the solvent splits into two parts. One set of lines is related to the solvation shell while the other is characteristic of the bulk liquid. In mixed solvents the spectrum of the ions comprises several resonance lines because of the different compositions of the solvent shells. In the research reported, Schneider and his group investigated solutions of Al^{+++} in N,N-dimethylformamide (DMF) and in dimethylsulfoxide (DMSO), separately, and in mixtures of the two. They found

that in both pure solvents the lines of the solvating molecules could be observed separately from the lines of the solvent. In mixtures of DMF and DMSO many more lines were seen, and evidence was found for a complex species $[Al(DMF)_z(DMSO)_{6-z}]^{3+}$ with z=1,2....6. The ^{205}Tl NMR chemical shift of $TlBF_4$ and $TlClO_4$ in hexamethylphosphortriamide (HMPT) offered an example of an exchange-averaged chemical shift. A graph of the chemical shift of Tl^+ plotted as a function of the mole ratio of HMPT to $TlBF_4$ exhibited a maximum at a ratio of 4:1, indicating the existence of a four-coordinated species.

A second speaker from West Germany, W.A.P. Luck (Philipps Universität, Marburg), followed with a discussion of "Recent Applications of IR spectroscopy to the Determination of the Structure of Water and of Electrolyte Solutions." Luck stated that the anomalous properties of water can be explained by a simple mixture model of free and bonded OH groups, a somewhat controversial position to take. He has employed infrared spectroscopy to measure both of these quantities. According to Luck, the influence of H-bonds on the water spectra can be ascertained in mixtures of water with organic bases of different strength. In 1:1 complexes, the symmetrical stretching frequency ν_1 (of free molecules) can be used as a basis to determine the concentration of free OH groups. Overtone spectra of H_2O and HOD were used to obtain information in this area. The results indicate that the acceptor strengths of neighboring water molecules for H-bonds are influenced by H-bond angles which alter the charge density for proton interaction. Luck also found through overtone spectroscopy that the spectra of water and electrolyte solutions change in a similar manner with change in water structure temperature T_{str}. He concluded that the limit between structure-making and structure-breaking by ions depends on T_{str} and the concentration. With increasing T_{str}, the structure-breaking effect becomes smaller and there is a reversal to structure-making properties. Thus, the spectra of electrolyte solutions can be interpreted by the known model of three water types: (1) primary hydrate, (2) secondary hydrate, and (3) normal water.

The third paper of the morning session was delivered by Dr. Roberto Triolo (Univ. of Palermo, Italy, and the Oak Ridge National Laboratory, Oak Ridge, Tennessee). His talk dealt with "Recent Applications of X-ray and Neutron Diffraction to Electrolyte Solutions." According to Triolo, x-ray and neutron diffraction data can provide a useful insight into the structure of electrolyte solutions. The interactions between ions and solvent in solution lead to positional and orientational parameters which can be inferred from information obtained by diffraction methods. The total structure function of a system is the quantity that can be determined for different types of radiation and is a combination of a number of partial structure functions. These latter functions can be obtained through properly selected experiments with systems of different isotopic and/or chemical composition, using different kinds of radiation.

With these considerations in mind, Triolo discussed work currently in progress on the heavy ion accelerator at Oak Ridge. As a starter, an aqueous NaCl solution, the simplest example, is under investigation. Ten different pairs of ions or molecules are being studied such as Na-Na, Cl-Cl, H_2O-H_2O, Cl-H_2O, Cl-Na, etc. in order to obtain the necessary interactions. Because of the complexity of the systems required, involving different isotopes and chemical compositions, as well as long-range particle correlations, it will take a long time to collect the necessary data.

Professor M. Spiro (Imperial College, Univ. of London) served as Chairman of the afternoon session. He introduced Professor Raymond M. Fuoss (Emeritus, Yale University), who reviewed his long-time work on the theory of electrolytic conductance in solution and discussed the development of his latest model for relating the equivalent conductance of an electrolyte to concentration. In so doing, he traced the evolution of several intermediate models that followed his classic early work with Charles A. Kraus and Lars Onsager. The 1977 model conductance equation may be stated as follows:

$\Lambda = \Lambda_o\ (C, \Lambda_o, R, E_S)$

in which

Λ = equivalent conductance
Λ_o = equivalent conductance at infinite dilution
R = the Gurney diameter (the distance beyond which a central ion no longer affects the properties of the solvent)
E_S = a contact energy term for ion pairs

Fuoss emphasized that he considers the main improvement for this equation to be that the contact distance (which is difficult to determine) does not appear at all. He humorously likened his new model to the 1977 automobiles from Detroit with E_S analogous to a catalytic converter.

The final lecture of the Reading Symposium was given by Professor B.E. Conway (Univ. of Ottawa, Canada) on "Recent Developments in the Thermodynamic Properties of Single Ions." Conway presented a broad review of the field, pointing out that progress in understanding the properties of electrolyte solutions, including ion-ion interactions, depends on improved information with regard to the properties of individual cations or anions in solution, especially with respect to thermodynamic and spectroscopic aspects of individual ion-solvent interactions. He outlined the present state of knowledge regarding individual ion properties in solution, especially in aqueous solution, discussing evaluation of thermodynamic functions such as partial molecular entropy S^0, heat capacity $\bar{C}^0_p$, volume V^0, expansibility α, adiabatic compressibility $K_S{}^0$, isothermal compressibility K^0, enthalpy H^0, chemical potential μ^0 and corresponding functions for the solvation process: $Ion_{(gas)}$ + Solvent → Solvated Ion ($\Delta X_{solvation}$). The validity and quantitative reliability of various non-thermodynamic methods and assumptions that are also involved were analyzed critically. Measurements of NMR ^1H chemical shifts in water provide valuable information on salt-dependent values. In the description of ionic interactions at moderate to high concentrations, Gurney co-sphere interaction parameters are required for interpretation of activity coefficients and their derivatives for other functions. Conway emphasized the importance of knowing individual ionic properties in interpretation of kinetics of electrode processes and the properties of the electrical double layer, where one kind of ion (+ or -) predominately is reacting or is accumulated. Therefore, such problems as calculation of electrostriction charges in the activation process in redox reactions and the evaluation of entropy and volume changes in elementary single-electrode processes necessitate information on the appropriate thermodynamic properties of individual ions in solution. (A.L. Powell, Office of Naval Research, Boston, MA)

THE CHEMICAL SOCIETY'S FARADAY DIVISION ION-ION AND ION-SOLVENT INTERACTIONS DISCUSSION

On the morning of 13 September, the Reading Symposium participants were transported by bus to St. Catherine's College, Oxford. A number of additional people registered during the morning, swelling the total for the Faraday Discussion to 191. The international flavor of the gathering is attested to by the distribution of attendees: United Kingdom 73, France 27, United States 26, West Germany 15, Italy 10, The Netherlands 9, Canada 8, Poland 4, Belgium 4, Australia, Ireland, and Israel two apiece, and one representative each from Sweden, East Germany, Nigeria, Hungary, Finland, India, Japan, Iraq, and Pakistan. Included in this group were many of the leading experts in solution chemistry.

Dr. D.H. Everett (Univ. of Bristol), President of the Faraday Division, presided at the first session held at 2:30 p.m. in the Bernard Sunley Lecture Theatre of St. Catherine's College. After a few initial announcements, he presented the Division's Marlow Medal and Prize to Dr. J.N.L. Connor of Manchester University in recognition of his outstanding research accomplishments in solution chemistry. Everett then explained the modus operandi of the discussion. Each speaker would be permitted five minutes to outline the most important aspects of his paper and then the floor would be opened for discussion. Each discussant would also be given a maximum of five minutes to ask questions or make his points. At the end

of the period allotted to each paper, the speaker would have five minutes to respond to the points made and questions raised during the discussion. The secretary would operate a timer which resembled a highway traffic light. A green signal would be given for the first four minutes, followed by orange for one minute as a warning, and when the red light appeared, the speaker would be expected to stop almost immediately. Before the scheduled papers began, Dr. H.L. Friedman (State Univ. of New York, Stony Brook) presented introductory material which set the stage for the conference.

Friedman pointed out in his remarks that the Debye-Hückel theory had formed the basis for all papers presented at a Faraday Discussion on Electrolyte Solutions held twenty years ago, chaired by R.P. Bell. This is not true today. Instead, the modern approach is to start with a Hamiltonian to express molecular interactions in ionic solutions. The newer models are based on measurable properties with the exception that the value of the dielectric constant still presents a problem. Conductivity cannot be calculated for the Hamiltonian model and an experimental approach must be taken. This procedure could involve a neutron scattering study in aqueous solution and measurement of viscosities, entropies, and the dielectric constant as a function of concentration. As far as the theory is concerned, the Hamiltonian will require that libration frequency, hydration enthalpy, and one-cluster thermodynamics be tied together—a process that may require 20-30 years. Friedman also described various fundamental concepts involving the development of other types of Hamiltonian models. These included such considerations as utilizing more functions of the nucleus and electrons of molecules in solution, application of Born-Oppenheimer theory, classical field theory, the spin Hamiltonian, and the use of the so-called "brass balls in a bath tub" hydrodynamics model.

After Friedman's introductory remarks, the scheduled presentations and discussions began. Since the complete texts of the papers to be given at this meeting had been mailed to all participants about two months in advance, the assumption was that the audience was sufficiently familiar with the material that a five-minute talk on the most important points would suffice to refresh their memories for the discussion. The chairman of each session generally grouped the papers in pairs having related subject matter, and two five-minute presentations were made in succession before the floor was opened for question and comment. This procedure was followed, with a few exceptions, at this and the succeeding three sessions on the ensuing two days.

A rather attractive innovation in the form of a poster session was tried in the latter part of the afternoon on Wednesday, 14 September. Twenty-six worthwhile papers which could not be included in the regular discussion were accommodated by this procedure. This event turned out to be a most informal and pleasant method for exchanging scientific information, and many of us in attendance would like to see poster sessions tried in more scientific gatherings in the future.

There seemed to be general agreement among the attendees at this meeting that the paper by P. Kebarle, W.R. Davidson, M. French, J.B. Cumming, and T.B. McMahon (Univ. of Alberta, Canada) provided the most significant new information. Kebarle's work utilized data obtained from gas-phase ion equilibria measurements to provide insights into ion solvation by protic and aprotic solvents. He measured gas-phase ion equilibria between ions M and solvent molecules Sl which provided binding energies of the complexes $M^+(Sl)_n$ for n=1 to ~6). The experimental technique involved using mass spectrometic detection of ions that have attained equilibrium in a reaction chamber containing known pressures of Sl. Comparison of these results with single ion energies of solvation showed that the differences observed were related to the binding energies of ion-molecule complexes in the gas phase. Weaker solvation of negative ions in aprotic solvents is related to a weaker binding observed in negative-ion aprotic complexes for the first and several of the next few aprotic molecules. An investigation of the solvation of substituted phenoxide ions by protic and aprotic solvents was undertaken. It was found that solvation by protic solvents is adversely affected to a high degree by charge dispersal in the ion. Aprotic solvents, on the other hand, are much less sensitive to charge dispersal. These observations

are related to the hydrogen bonding ability of the phenoxide. The hydrogen bonding interactions in the first few molecules of aprotic solvent (such as water) thus provide an extremely sensitive probe for reduction in charge density. Aprotic solvents, on the contrary, with their bulky positive groups at the extremities should be notably insensitive to charge withdrawal from the small functional group.

A paper by J.C. Justice and M.C. Justice (Université Pierre et Marie Curie, Paris, France), entitled "Generalization of the Bjerrum Association Concept to the Friedman Hamiltonian Models," provided new information on the interpretation of thermodynamic properties and transport coefficients of electrolyte solutions in terms of specific short-range interactions. Such a goal has been difficult to achieve since even the long-range Coulombic interactions cannot be handled precisely enough by existing theory. The model the Justices' proposed involves a reformulation of the conductance system of equations as follows:

$$\Lambda(P_{+-}, C) = \gamma\Lambda(R,C) \qquad (1)$$

$$(1-\gamma)/\gamma = (K_A + K_h)C \quad K_A C \qquad (2)$$

where K_A is related to Bierrum's constant and K_h is a short-range hydrodynamic contribution that is negligible compared with the purely ionic short-range contribution K_A. The parameter P_{+-} defines the short-range anion-cation direct potential. If R is large (near the Bjerrum critical distance q), any classical function such as that of Pitts, Fuoss-Hsia, or Falkenhagen *et al.*, provides a good approximation of $\Lambda(R, C)$. The system defined in equations (1) and (2) is a step nearer to theoretical legitimization of grafting the Bjerrum model onto the Debye approximations. In his presentation, J.C. Justice openly challenged Fuoss on some of his views on short-range processes in electrolyte solutions, thus provoking some lively interchanges in the ensuing discussion. Justices' model may be controversial, but its existence provides a great deal of stimulation for further theoretical work in the field of electrolyte solutions.

The Faraday General Discussion provided a splendid example of a novel approach to conducting scientific meetings. The emphasis on discussion following a very short presentation of highlights worked very well in attracting audience participation. To be sure, the format required that all participants read and understand the papers in advance or be experts in the field, or both. Thus, the conference must be a working session to be most effective in interchange of new ideas and innovative approaches to the various problems presented. This situation does make life more difficult for the generalist like myself who attends one of these meetings, but the opportunity to acquire valuable knowledge compensates for any inability to participate meaningfully in the discussions. I found the interchanges on the floor to be informative, stimulating, and exciting at times. A few serious disagreements that occurred should lead to advances in knowledge in the future after the antagonists return to their home institutions to renew their work.

After listening to the presentations and discussions at this meeting, one came away with the unavoidable impression that, despite a great deal of hard work, progress is relatively slow in advancing knowledge of electrolyte solutions. Our inadequate understanding of the nature of liquids and liquid structure seems to be at the root of the problem, and the situation is obviously exacerbated when ions are put into solution. Nevertheless, the display of knowledge by the experts working in this field is overwhelming, and this in itself is encouraging. The fundamental obstacles to be overcome in providing explicit electrolyte theory and conducting the sophisticated experimentation required for elucidation of ion-ion and ion-solvent interactions in solution will provide great challenges to scientists in this field, now and in the future. It was heartening to see so many good people from various countries around the world gainfully occupied in significant research endeavors. It is hoped that support will be continued in the future in whatever magnitude required to advance the state of knowledge in this important scientific field. (A.L. Powell, Office of Naval Research, Boston, MA)

MATHEMATICAL SCIENCES

COMPUTER-AIDED SHIP DESIGN AT BATH

The city of Bath, located approximately 100 miles west of London and once the site of renowned Roman spas or baths, is today the center for all ship design carried out by the UK's Ministry of Defense (MOD). With a total employment of approximately 5500, the MOD is the largest single employer in Bath, which still relies heavily on summer tourism for its revenue.

The activities of the MOD's Ship Design Department (SDD) are divided into three areas: Forward Design (which we would call preliminary design), Design Services, and Contract Definition. Roughly speaking, the SDD is the British counterpart of the Naval Ship Engineering Center (NAVSEC), Alexandria, VA, in connection with the maintenance and refurbishing of ships.

The main purpose of our visit was to learn of SDD's research and development efforts in the area of computer-aided ship design (CASD). This activity is being carried out by a small group within the Forward Design section. The head of Forward Design is Dr. Kenneth J. Rawson who is well known for his book, *Basic Ship Design*, coauthored with E.C. Tupper. Rawson assumed the responsibility for all new MOD ship design concepts only recently when he returned to Bath after a five-year term as Naval Architecture Professor at University College, London. Within Rawson's Forward Design section, Mr. David Brown, a chief constructor, is responsible for the actual preliminary design activities.

Our hosts for the visit were Mr. Lorrie Tucker, a chief constructor in the Royal Corps of Naval Constructors (RCNC) and Mr. Stuart J. Holmes, a constructor in the RCNC. Tucker is responsible for all technical computing within the Design Services Dept., and Holmes directs the CASD project.

Historically, computer-aided ship design started within the Ministry of Defense approximately 12 years ago when Dr. Ian Yuille began his research in CASD at the Admiralty Research Laboratory in Teddington. [Only three months ago, the Admiralty Research Laboratory was renamed the Admiralty Marine Technology Establishment (AMTE) (Teddington)]. During the first 8 or 9 years of effort, little real development was done within the MOD, although Yuille made significant advances in the mathematical and computer foundations for such a system. Upon assuming office, the present Director General, R.J. Daniel, decided that a significant computer-aided ship design effort should begin, and the requirements were laid down for a detailed and complete system to be operational by April '78.

Yuille at AMTE is responsible for producing the actual design system to specifications developed by the Ship Design Department at Bath. The project is well on its way to completion, and it is anticipated that it will be completed and the first generation system operational by or shortly after the April '78 target date. The SDD feels that the main advantages to be gained from a computer-aided ship design system are increased designer productivity and the ability to examine a much greater number of design alternatives within a given time.

Yuille and his colleagues are interested in incorporating a wide range of options and flexibility within the system. The CASD system should be capable of both *ab initio* design (i.e., starting from scratch) and in perturbation design, where the starting point is an already existing ship. Another area of interest is feasibility studies for modernization and design alteration of existing ships. It is anticipated that the CASD system will have the required capability for this type of investigation.

A unique characteristic of the CASD system at Bath is that it is designed to operate on a mini-computer, namely a Digital Equipment Corporation (DEC) PDP-11/50 or 11/55. The system configuration presently has 32K words of core, three RK-05 disc drives, a DEC tape, a CALCOMP 563 plotter, and a line printer. Interactive graphics output is provided by a Vector General scope (i.e., CRT display) equipped with light pen and alpha-numeric keyboard. An additional DEC computer system, a PDP-11/55, complete with a Vector General scope, is due for installation next month.

The CASD system is modular in design so that individual computer programs or subroutines can be extracted and replaced by superior software as it becomes available. The data-base management system is of some interest because of the way it has been implemented on a mini-computer. The three DEC RK-05 disc drives are divided in utility in the following way. The first drive is for the operating system and the main program as well as current data, the second drive is used for the principal ship characterization data, and the third drive is used to hold basic design data.

The development of the CASD system at Bath is being carried out by a group of 10 naval architects and computer technologists. The naval architect principally involved with the project as a representative of the prospective users is Mr. Peter Chamberlain, chief constructor (RCNC), who has recently returned to Bath from a term as Lecturer at University College, London. At this stage, the work consists principally of testing and implementing programs, providing appropriate linkages between the various programs and building the user interface to the system.

The system is set up so that it is highly man-machine interactive. That is, very little automatic optimization is undertaken by the computer software; the selection of design parameters and the evaluation of results are left entirely to the designer, as is the judgment of what is an acceptable or "optimal" design. The designer's experience and expertise are crucial to the successful use of the system. Although the programs do not guide the user in the selection of design parameters, they do provide warnings if the designer should choose values outside the normal usage limits for particular programs or techniques. Some of the programs incorporated within the suite are: resistance and propulsion, seakeeping, strength of ships, arrangements, hull design including surfaces, stability, electrical layout and housekeeping.

A demonstration of the surface design program which uses a standard bicubic Coons patch technique was given. An entire ship (of a destroyer or cruiser type) was shown in which four patches were used to describe the entire hull. As expected with the use of a bicubic patch, difficulties have been experienced in manipulating and modeling the surface patches used to represent a ship hull. Hopefully this will be corrected by the introduction of more modern techniques (for example, Bézier and B-spline methods) once the system is operational. We also saw demonstrations of the resistance/propulsion program, the endurance program and others.

Although still embryonic, the initial system is well on its way toward completion and user acceptance. The continued development of the mini-computer based CASD system at Bath should be of interest to naval architects and those doing similar work in graphically interactive computer-aided design systems. [David F. Rogers (US Naval Academy) and William J. Gordon)

PHYSICAL SCIENCES

ADVANCES IN ELECTRON OPTICS: A SUMMARY OF TWO RECENT CONFERENCES

Two major meetings were recently held in the United Kingdom covering theoretical and experimental advances in design and manufacture of electron optic instrumentation and in the analysis and understanding of the information obtainable. On all fronts there were strong signs that not only is the field flourishing but that while Britain is maintaining its preeminant position, there is considerable other effort in the rest of the world, particularly Japan.

The first of these meetings was held at the University of Glasgow, Scotland, from 12-14 September 1977, under the auspices of the Electron Microscopy and Analysis Group of the Institute of Physics in association with the Royal Microscopy Society, and had the obvious acronym EMAG 77. More than 200 people registered of which 32 were from outside the UK. In conjunction with the technical meeting, a small instrument exhibition highlighted the new generation of electron microscopes, scanning, transmission, and scanning-transmission,

as well as a wide variety of analytical accessories. Since the show was in the same building as the technical meetings, it was convenient to visit during either actual or self-imposed breaks, and a large number of brochures were gradually accumulated. The show was quite useful since many of the talks discussed new applications and new devices; it was satisfying to ascertain for oneself whether such-and-such a stage or component is really "child's play" to use.

A well-organized series of receptions and excursions were available, although the latter, of course, were intended only for the spouses of participants (ahem). Of particular note was an evening reception and buffet as guests of the Lord Provost and the City of Glasgow in the City chambers. The chambers themselves were the highlight of a pleasant evening, aided without doubt by a few drams of Scottish dew. They were resplendent with their marble walls and floors, and gilded mouldings, with a puzzling, although eye-catching mixture of architectural periods. Such an edifice is in marked contrast to the general grayness of the city; I wonder if the miners and dockworkers had a voice in the best way the city was to spend its resources.

The ubiquitous multiple sessions (2) and large number of papers (108) created the usual problems; nevertheless, the principal thrust areas were identified and at least partially covered. These included electron optics and instrumentation; microscope stages and analytical detectors; image analysis and reconstruction; scanning transmission electron microscopy (STEM); high resolution microscopy; image contrast; specimen-beam interactions; dynamic experiments; crystallography; Auger, x-ray and electron-energy analysis; and solid-state and materials science.

In the area of instrumentation, interest focused on the attainment of maximum resolving power in the conventional transmission electron microscope (CTEM), the increasing utilization of STEM and scanning electron microscopy (SEM), and the development of analytical packages for these instruments to permit elemental analysis, either by the use of x-rays or electron energy-loss spectroscopy, compound identification by micro-diffraction, and other specialized applications.

A group of papers were devoted to describing the construction of a new, maximum resolution 600-kV TEM, a joint project of the Department of Engineering and Department of Physics at Cambridge University under the sponsorship of the Science Research Council (SRC). They have taken a standard engineering development approach: Work largely with existing technology, identify the problem areas, maximize the quality of the individual components, and construct the total system as carefully as possible. The progress of the program was described by W.C. Nixon, J.R.A. Cleaver, and C.J.D. Catto of Cambridge's Engineering Department. The complete instrument, weighing 7 tons, is suspended from the walls of its room by a three-point, self-leveling isolation system with a resonant frequency of $\frac{1}{2}$ Hz. A commercial microscope column was extensively modified and carefully matched to a high-voltage generator and accelerator. The electron optics of the illumination system are being optimized by the use of a high-intensity thermionic lanthanum hexaboride rod cathode gun and a computer-designed electron lens system. The aim of the latter is to minimize both spherical and chromatic aberration and current lens drift. Image intensification will be used to enhance the final image. These efforts have been ongoing for several years with several more years yet to come. If successful, the instrument will provide point-to-point resolution of 1 - 1.5 Å, a doubling of the currently available resolution of about 3 Å. While cost figures for this development project are difficult to come by, corridor gossip suggests a figure of at least £250,000. The wisdom of such a large expenditure for a modest resolution increase was privately questioned by some of the attendees.

Several papers considered the value of the availability of such high-resolution capability. V.E. Cosslett (Cavendish Laboratory, Univ. of Cambridge) considers that the main advantage is that the imaging of individual atoms or assemblages of atoms becomes possible at such resolutions (what is really seen is the average electron potential distribution). C.J. Humphreys (Univ. of Oxford) discussed high-resolution imaging of such crystal defects as dislocations, stacking faults, and point defects.

While the first two can be effectively, but not optimally, studied with available resolution and new electron diffraction techniques, the last cannot, nor can features such as the core structure of dislocations.

Warnings were voiced on the problems of image interpretations at ultrahigh resolutions. A. Howie (Cavendish Laboratory, Cambridge) showed that such images are highly focus (or defocus) dependent and can be difficult to interpret directly because of image-contrast reversal or even disappearance of detail at certain focus levels. Proper interpretation requires a series of through-focus micrographs and computer analysis of the resulting images. At such levels of detail, TEM is no longer a simple, routine analytical tool.

The STEM is rapidly developing as another powerful device for studying microstructures and and defects in crystalline and noncrystalline materials. The image is produced by a scan or raster of a focused electron beam and a storage and display system. L.M. Brown (Cavendish Laboratory) presented evidence that the diffraction and phase contrast with a STEM is comparable to that of a CTEM with the same operating voltage and objective lens. However, since the electron beam of the STEM can be focused to a diameter of about 100 Å, microelectron diffraction and analysis of small structural features is now possible and has been proven an increasingly powerful tool for material characterization. Coupling this capability with the ability of STEM to image more effectively thicker low-contrast specimens than a CTEM of the same accelerating voltage, Brown predicted a bright future for the technique.

P. Doig and P.E.J. Flewitt (Central Electricity Generating Board, South Eastern Region) used the STEM technique to study and identify the segregation of impurity elements to grain boundaries of iron-3.9% nickel alloys and the subsequent role of such elements in grain-boundary embrittlement. Using the microanalytical capability of the STEM, they showed that only a small proportion of the impurity elements, phosphorous and tin, are segregated after heat treatment. This suggests that these elements are either highly potent embrittlers or that they do not play a major role in promoting premature fracture.

An interesting application of STEM to semiconductor devices was presented by D. Fathy (Cavendish Laboratory), who, by combining transmission and conduction imaging techniques with microanalysis, was able to characterize the crystal defects present and to relate them to the electrical performance of these devices. The ability to image both in STEM and SEM enabled the correlation of surface and internal structural features.

SEM continues to be an important tool for surface studies. In addition it, too, has fallen under the spell of sophisticated analytical instrumentation experts with a resultant increase in its capabilities. W.C. Nixon (Cambridge Univ.) described how video-tape recording can monitor dynamic SEM experiments. This has provided valuable information both on *in-situ* studies of the effect of water vapor on botanical and biological materials and on the electron charging behavior of uncoated insulators under compression and shear. In this latter study, strain-related contrast allowed moving crystalline defects to be seen.

An ultrahigh vacuum SEM combined with facilities for *in-situ* molecular-beam deposition and Auger analysis has been used by A.P. Janssen and J.A. Venables (Univ. of Sussex, Falmer, Brighton) to study such surface-physics problems as the deposition of Zn on GaAs, grain-boundary and surface diffusion of Ag on Au, and crystal growth of Ag on Mo. By using a field emission gun and careful image analysis, they were able to reduce experimental uncertainties caused by variations in surface topography and beam current, thus allowing for a more confident quantitative analysis of small volumes of material.

D.J. Dingley (Univ. of Bristol) described how to obtain Kossel x-ray diffraction patterns in an SEM. The usefulness of this technique for surface studies was illustrated by a general review of several ongoing programs. For example, lattice parameters of such materials as GaAs and NiTi can be measured to an accuracy of 1 part in 10^5; elastic and plastic strains can be detected and in some cases measured from changes in lattice parameter or x-ray line broadening; relative orientations of adjoining grains can be obtained to ascertain the presence of any preferred orientation (texture) in crystalline

materials; and the nature of the fracture process can be studied by post-examination of fracture processes, revealing the role of elastic and plastic processes. Dislocation densities have been measured in SEM specimens by N.P. Gregory, K.W. Richards and G.R. Booker (Univ. of Oxford) by correlating the density to changes in and disappearance of certain orientation lines in the diffraction pattern.

In summary, this meeting provided ample evidence that electron optics is not a stagnant field. New techniques and capabilities requiring unfortunately new and increasingly more expensive equipment are continually being developed. This is not a case of conspicuous consumption, however, as newness in this case can be justified by the considerable improvement in our ability to "see" and understand materials.

The second of the meetings was held at Imperial College, London, from 19-21 September, sponsored by the Institute of Physics in collaboration with the Royal Microscopy Society and the Faraday Division of the Chemical Society to celebrate the 50th anniversary of the discovery and initial applications of electron diffraction. While EMAG 77 was concerned primarily with the design and application of new and existing electron optics instruments, this conference was more an examination of the physics of electron diffraction, both in predicting diffraction behavior and in examining how such information can be used. While many of the topics covered were similar to those of EMAG 77, the presentations were more theoretical in nature and in the main required more than a passing knowledge of many-beam dynamical theory of electron diffraction. Many were the times I wondered whether I belonged at such a high-level meeting—I persevered though.

There were 128 registrants of whom almost half (62) were from outside the UK. A similar ratio was followed for both the 9 invited papers and the 64 submitted ones. This healthy competition among different countries mirrored some significant advances in the study of crystal structure and symmetry of crystalline solids.

The lead paper was by Prof. M. Blachman, FRS (Imperial College, London), who provided the historical background both to the early days of the development of electron-diffraction techniques and analyses, primarily at Imperial, as well as to the conference itself. In 1967, the organizers had held a 40-year conference to ensure that many of the pioneers could be present; few were present 10 years later. The rapid progression of the field justified holding the present conference even without the enticement of a golden anniversary.

Topic areas covered included; dynamical theory of electron diffraction, diffuse scattering of electrons, low-energy electron diffraction (LEED), medium-energy electron diffraction (MEED), structure factor and symmetry determinations in crystals, instrumentation, and crystal defects.

A. Howie (Cavendish Laboratory) reviewed the detailed and complex theory of electron diffraction, particularly the concepts and applications of Bloch waves, the splitting of incident electrons in the crystal into wave packets. The intensity distribution of these can be used to study the structure of dispersion surfaces in various crystallographic directions. From these basic concepts a detailed methodology has developed with a host of predicted and verified diffraction defects. B.F. Buxton and P.T. Tremewan (Univ. of Bristol) discussed one of these, the critical voltage effect, which is the enhanced electron penetration through a crystal for specific diffraction directions and high (usually > 500 MeV) accelerating potentials. Knowledge of these potentials can yield basic information on the crystal potential seen by the electrons of the various Bloch waves as they are diffracted.

P. Goodman (CSIRO, Melbourne, Australia) discussed available techniques for determining the crystal symmetry from electron diffraction patterns. Two methods appear most prominent; the critical voltage technique, discussed previously, and convergent-beam diffraction at medium voltages, a technique where the diffraction spots from a particular reflecting plane or set of planes are imaged so that their fine structure or intensity variation can be studied. Both of these techniques consider and analyze the balance of intensities obtained at points of high symmetry near a zone axis. Goodman discussed recent advances that have provided interpretation of 3-dimensional symmetries and

crystallographic space groups. He provided illustrations that used graphite and boron nitride as model systems.

Crystal structure determination by use of electron diffraction was also discussed by J.M. Cowley (Arizona State Univ., Tempe), who examined the problem in terms of the experimental difficulties usually encountered. As Goodman did, he pointed out that, in principle, electron diffraction can be much more powerful than x-ray diffraction for determining crystal structure, since the stronger electron scattering allows smaller, more perfect crystalline regions to be analyzed, and the coherent interactions of diffracted electron beams (convergent-beam technique) can be made to produce direct images of crystal structure.

Full exploitation of these procedures has been prevented by the loss of necessary information on electron intensities owing to the lack of crystal perfection, variations in crystal morphology, and unstable structures. These problems are gradually being solved by the application of new or improved electron microscopy techniques. In particular, he mentioned microdiffraction for studying smaller areas and the synergistic combining of intensity data information from both electron microscope images and that of electron diffraction patterns from the same specimen area.

Since the above techniques are critically dependent on crystal perfection, they are not well suited to the study of crystal defects by, for example, electron-diffraction contrast. However, improved resolution capabilities and novel imaging techniques have led to new advances in this area also. This subject was introduced by Sir Peter Hirsch (Univ. of Oxford). Lattice defects cause changes in local scattering as well as atom displacements, and the resultant changes in the amplitude and phases of the diffracted beams produce defect contrast in the electron microscope image. The dynamical theory of diffraction, mentioned previously, is used to predict defect-image contrast and can be compared with experimental images to identify the specific defects. These techniques have been successfully used in such diverse fields as solid-state physics and chemistry, metallurgy and materials science, and geology and mineralogy. Hirsch discussed some of the more exciting techniques that under certain conditions have permitted direct imaging of the crystal lattice (but not individual atoms), as well as more efficient ways of imaging line defects (dislocations) and surface structure. He pointed out that as yet successful techniques for imaging of point defects have not been developed.

Several papers dealt with the study of irradiation-induced defects; for example, those presented by M.J. Whelan, M.L. Jenkins and S.M. Holmes, all from the Department of Metallurgy and Science of Materials, Univ. of Oxford. The interest in this problem stems, of course, from wanting to understand how materials behave under irradiation in a reactor. Of particular concern is that the defects produced, usually dislocation loops, can lead to preferential expansion and therefore dimensional swelling of a component such as a fuel can. The described studies concerned themselves with the measurement of the displacement cascades that produce the damage, the identification of the number and type of dislocation loops produced by cascade collapse, and whether there is alignment of vacancy or interstitial loops to produce preferential expansions or contractions.

Another paper, by H. Sake (Nagoya Univ., Japan), presented some *in-situ* observations of dislocation behavior in the high-voltage electron microscope (HVEM). Cine films of these are always interesting visual experiences, even if they do not provide significant advances in our understanding of the observed phenomena. He did show, however, some dramatic examples of dislocation multiplication as well as dislocation-interactions which can either produce new slip dislocations or act as a means of damage accumulation.

I hope that this brief overview of some of the papers presented at these two conferences successfully conveys the current vigorous state of electron optics. Critics say that the field is too introspective and that few "useful" technological breakthroughs can be advanced to justify the very large sums of money that have been spent. I would suggest that this criticism is not pertinent except perhaps for those who work at the interface between the study of structure and its manipulation to improve properties. Here there is a

responsibility to look for ways to improve real materials and to do so through the microstructural manipulations made possible by a greater understanding of structure. The much used and abused term, technology transfer, can probably be applied to this area. For the more physics-oriented activities, however, relevancy should not be of overriding concern. The only problem I perceive is the vice of duplication of expensive and specialized equipment. I share the concern of, I believe, many who feel that the exigencies of rapid technological successes are providing an atmosphere that discourages the fundamental studies that will provide the bases of understanding and solving as yet unidentified problems. We seem destined to repeat the expensive and annoying cycle of assuming that we have all the scientific understanding we need and that a significant commitment to basic research activities is no longer necessary.
(I.M. Bernstein)

VTH CONFERENCE ON UV AND X-RAY SPECTROSCOPY OF ASTROPHYSICAL & LABORATORY PLASMAS

The Vth Conference on UV and X-ray Spectroscopy of Astrophysical & Laboratory Plasmas was held 4-7 July 1977 at the Blackett Laboratory, Imperial College of Science and Technology, London. The talks presented were grouped into sessions concerning solar, astrophysical, and laboratory topics.

In the three laboratory plasma sessions of the Conference, the general trend in uv and x-ray spectroscopy seemed to be toward dense, high atomic number plasmas, with an emphasis on laser-vaporized, solid-target plasmas. This is exemplified in the work presented by Drs. G. Tondello, A.M. Malvezzi, and colleagues [Padova University and Centro Informazioni Studi Esperienze (CISE), Milano, Italy] where initial line broadening measurements in Be IV have now been extended to include lines of hydrogen-like C VI through O VIII. This work is of particular value for dense plasmas where the short wavelength lines suffer less absorption and hence give information on the interior conditions of the plasma. Several groups reported on spectra from laser-irradiated solid targets of Al, Ti, Cs, Ba, the Lanthanides, Sr, and Mo. Satellite line identifications were emphasized in the majority of these talks. Theoretical and experimental studies on high density corrections to spectral line shapes were outlined in two presentations by a group at Imperial College headed by Dr. D. Burgess. It was pointed out that correct calculation of line shapes in dense plasmas must include terms involving ion dynamics, multicomponent plasmas, non-thermal conditions, and relative motions of ions and electrons. The appearance of quasi-molecular features in the spectra of a dense (0.5 to 3×10^{18} cm^{-3}) linear pinch and poor fit of the Ly-α wing shape with theory in this plasma emphasize the necessity for more experimental and theoretical work in the area of dense plasma spectral-line profiles.

In contrast to the dense laser-produced plasma experiments, excitation rates for Be-like Ne VII were measured in a theta-pinch plasma at Culham Laboratory by Dr. J. Lang. Absolute intensity measurements of the intercombination line allowed the determination of the metastable level population density. The experimental rates obtained gave temperature and density measurements accurate to within ±50% for the triplet state and a factor of three for the singlets.

The uv spectra of Tokamak plasmas were covered in one session of three talks and an invited talk overview by Dr. N.J. Peacock (Culham Laboratory, Abington, Oxon). Identification of highly stripped Mo lines from the retainer-plasma interaction was discussed. With the diverter system operating at 40 kA, metallic impurity lines were found to disappear effectively from the xuv spectrum, and gaseous impurity lines were reduced by about 70%. Similarities between uv lines occurring in Tokamak plasmas and those observed in the solar spectrum were also noted. The appearance and relative intensities of several species of iron-ion lines, especially Fe VII, were found to be quite comparable in the solar and Tokamak plasmas.

Of interest to uv spectroscopists is the continuing study of soft x-ray grating characteristics on a unique testing apparatus at Imperial College. Many gratings—both plane and spherical, ruled and holographic—have been checked

by this instrument. Of the 76 Bausch and Lomb vacuum-uv grating categories offered for sale, 35 have been analyzed here. Dr. R.J. Speer (Imperial College) has invited those spectroscopists who think the Bausch and Lomb grating they use might be identified with one of the 35 grating categories tested to write for a copy of the report on their grating class. Also, information for testing individual gratings can be obtained from the Blackett Laboratory of Imperial College. A review article on the tests appeared in *Space Science Instrumentation* 2, 463-488 (1976). Another development in this department is the holographic grating formed on a toroidal blank. This design reduces the astigmatism of the grazing angle and increases the grating's spatial resolution. Using a 5-m grazing incidence spectrograph, they claim 5-μm resolution in the x-y plane of the focus. The advantage of this grating is the short exposure spatial resolution capability; a disadvantage is the loss of wavelength resolution necessary in the trade-off to obtain spatial resolution.

The solar sessions at this Conference were primarily concerned with the interpretation of new observations from the Skylab manned space station, the Eighth Orbiting Solar Observatory (OSO-8), and high spectral and spatial resolution rocket spectra in the extreme ultraviolet (euv). From spectra recorded on Skylab between 1100 and 2000 Å, Dr. U. Feldman and co-workers [Naval Research Laboratory, (NRL), Washington, DC] determined that electron densities in a transition-zone flare plasma ($\sim 10^5$ K) can reach values above $10^{13} cm^{-3}$, which is about as high as that in some Tokamak laboratory plasmas. The volumes of the solar plasmas are quite small; characteristic lengths are on the order of ∿50 km. These results were determined using density-sensitive line ratios of euv spectral lines. The high resolution of the Skylab spectrograph also allowed the NRL investigators to study the profiles of euv lines. The variations of the widths and shapes of transition-zone lines have been determined in many different solar regions, including flares, active regions, the quiet sun, and coronal holes.

The new transition-zone observations of flares in the euv have prompted much new theoretical work on the interpretation of spectral line ratios in the quiet sun and during solar flares. A search for density-sensitive spectral diagnostics below 1300 Å was made in a joint effort by Drs. J.E. Vernazza and H.E. Mason of Harvard University and Cambridge University, respectively. Studies of the effects of mass motions, i.e., transient ionization and recombination on euv spectral-line intensities have been carried out at Harvard by Drs. J. Raymond and A. Dupree. In some situations transient conditions can significantly alter the interpretation of line intensities. A continuing problem in the interpretation of the C III euv lines was discussed by investigators from several groups.

Extremely small structures in the corona were resolved in high spectral- and spatial-resolution NRL rocket spectra. Dr. G. Brueckner (NRL) reported that the images in the forbidden line of Fe XII at 1349 Å are on the order of 2000-3000 km in size (∿4 arcseconds).

Dr. P. Lemaire and colleagues (Service d'Aéronomie du CNRS, Verrieres-le-Buisson) reported on their observations from OSO-8 of the O VI euv lines shortward of 1100 Å. The profiles of this line were observed at varying heights above the solar limb and allowed the nonthermal motion at the temperature of formation of the O VI lines to be determined. The nonthermal motions versus temperature are now known at temperatures ranging from chromospheric to coronal values.

Drs. R. Athay and O. White (Colorado University, Boulder) reported on high-time resolution studies of the Si II lines near 1817 Å. These data were obtained from their spectrograph on OSO-8. The correlation of line intensity, central wavelength, and Doppler shift of the Si II lines was studies in spectra obtained from different solar regions, including supergranule cells, network, plages, and sunspots. The results were compared with theoretical expectations based on wave propagation in the chromosphere.

In the astrophysical sessions, a number of interesting new observations and theoretical calculations were presented. Dr. S. Truemper and coworkers at the Max-Planck-Institute reported on observations of the x-ray source HERC X-1. The data were obtained from a four-hour balloon flight. A narrow line found near 58 keV was interpreted as being caused by electron cyclotron emission

from the polar-cap plasma of a rotating neutron star. The deduced magnetic field is 5×10^{12} Gauss.

Wolf-Rayet stars (a class of hot, broad-lined, emission-line stars) were studied in the ultraviolet using spectra recorded by the S2/68 experiment on the ESRO satellite TD-1. These results were reported by Drs. R. Wilson and A. Willis (University College, London). The temperatures deduced for these stars using the flux at ultraviolet and visible wavelengths are ~30,000 K, close to the temperatures derived using the Zanstra method with the He II 1640-Å line. In a WC (strong carbon and oxygen lines) star studied, the C/He and N/HE abundance ratios were close to cosmic values. However, in the WN (strong nitrogen lines) stars the C/He ratio is much reduced. The H/He ratio is very low in both WC and WN stars.

The ultraviolet interstellar extinction curve from 2740 Å to 1350 Å was determined by Dr. D. Carnochan and colleagues (University College, London) again from data obtained from the S2/68 satellite experiment. The extinction curve shows a pronounced peak (i.e., absorption) at 2200 Å, with a halfwidth of 360 Å. The origin of this absorption is unclear. The general shape of the extinction curve is independent of variation with distance to the sun, direction around the galaxy, and height above the galactic plane.

On the theoretical side, calculations were made of the intensities of certain satellite lines observed in high resolution x-ray spectra $1s^2nl$ - $1s^2pnl$, $n \geq 3$). This work was done by Dr. F. Bely-Dubau at the Nice Observatory, Dr. A. Gabriel of Culham Laboratory, and Dr. S. Volonté of the University of Mons. These lines have diagnostic value as temperature indicators for solar flare plasmas.

Calculations were also made at Stanford University on the x-ray opacity of the interstellar medium. Dr. A. Walker discussed calculations based on a model of the interstellar medium which includes chemical evolution of the galaxy, the formation of molecules and grains, and the ionization structure of the gas.

The Conference ended with a panel discussion on spectroscopic instrumentation. It was apparent from the ensuing interchange between panel members and audience that solar and astrophysical uv-spectroscopy is alive, well, and flourishing. Skylab and OSO satellites have given investigators unprecedented data which are still being analyzed. The influx of new and improved instrumentation techniques from the fusion community and elsewhere has been a measurable asset and promises to keep the uv-spectroscopic program moving at its present brisk pace. (R.H. Dixon and G. Doscheck, Naval Research Laboratory)

E-O TELLS MORE ABOUT BIG MOLECULES

I visited the Electro-optics (E-O) Research Group at Brunel University recently and found some excellent work in progress. Brunel is a fairly small university with about 3700 students situated on 170 acres of open land south of Uxbridge, Middlesex and about 17 miles northwest of London. The E-O Group is part of the Physics Department and is headed by Professor B.R. Jennings who has recently been awarded a personal chair within the Department. Jennings has nine people in the Group, all of whom are working in the general area of electro-optical properties of suspensions of giant molecules and of colloidal particles.

Jennings, together with H.J. Coles, published a significant new experimental result in 1974 [*Nature* 252, 33 (1974)]. They reported the first realization of laser-induced orientation and accompanying birefringence of macromolecules and particles in a liquid medium. A. Buckingham [*Proc. Phys. Soc.* B69, 344 (1956)] had previously predicted that simple liquids could be made birefringent from the electric field present in a high power laser pulse while M.A. Paillette [*C.R. Hebd. Seanc. Acad. Sci., Paris* 267b, 882 (1968)] verified this experimentally; but Jennings and Coles were the first to produce the effect in macromolecules suspended in liquids. Their successful results were carried out with aqueous suspensions of clay particles and also with tobacco rattle virus. The suspensions were excited with an 8-kW Nd:YAG laser (1.06μm) pulse, 200-μsecs long, and an Ar laser (0.488μm) was used as a probe to measure the birefringence.

Jennings' Group has been concentrating mostly on methods of characterizing macromolecules and other particles in the size range 0.05μm to 3μm by electro-optical methods in which external electric fields (dc and/or ac) are applied and one or more optical effects are measured. The underlying principle in these experiments is that viruses, polymers, biopolymers, and colloidal particles are anisotropic in their optical properties, hence a polarized laser or other light beam will interact differently with a particle depending on the direction of polarization with respect to the particle's major axis. The application of an electric field to a suspension of particles causes partial alignment with accompanying anisotropic characteristics. In many cases molecular information can be obtained by this technique in dilute solutions which would normally have to be obtained by growing large crystals of the material and measuring their optical properties.

A list of anisotropic optical effects used in these studies includes: birefringence, dichroism, electro-optical rotation, and scattering. Measurements of changes in these properties induced by the application of electric fields permit the determination of axial components of optical properties as well as the permanent electric dipole moment and the polarisability of the particles. The rotational relaxation time (τ) can also be determined by measuring the rate at which some optical property changes when an electric field is applied or removed while the size and shape of the macromolecules can be related directly to τ.

Jennings and his co-workers have developed a quick way of determining whether a molecule is flexible or not. The change in scattered intensity (ΔI) when an electric field is applied is easily calculable for a rigid rod-shaped molecule for the 0° and 90° scattering angles. Jennings found the ratio $\Delta I(0°)/\Delta I(90°)$ was a sensitive indicator for flexibility with a value of -2 for rigid rod molecules but far from this value for flexible molecules. This method was used on an aqueous solution of a lefthanded helical form of polyproline II. The results showed that at high molecular weights the helix acts as a flexible chain rather than a rigid cylinder.

Jennings' Group is a cooperative unit interested in applying its talents toward solving problems in other fields such as biochemistry, medicine, chemistry, and colloid, and polymer science. One example of work applied to other fields is a study carried out by V. Morris and Jennings on the effects of antibiotics on the electric polarisability of aqueous suspensions of bacteria [*Biochim. et Biophys. Acta* 497, 253 (1977)]. They observed the change in scattered light intensity during application of an electric field pulse to a suspension of *Escherichia coli* bacteria. Changes in ΔI occurred when various antibiotics such as polymixin B, bacitraxin, penicillin, streptomycin and neomycin were added. In all cases ΔI decreased, indicating a decrease in the polarisability factor, $\Delta\alpha$, which is the difference between the polarizability along the major and minor axes of the bacteria. This decrease was interpreted as being due to a decrease in the local dielectric constant as a result of an accumulation of antibiotic at the bacterial surface which is thought to be an important step in facilitating entry of the antibiotic into the bacterium.

The current research program of the Electro-Optics Group includes the above as well as the use of light scattering, electrically induced birefringence and dichroism to study several other problems. Some of these investigations are: aggregation of clays, the nature and structure of polymers and globular proteins, and interactions of antibodies and viruses with bacteria and mammallian cells.

The excellently led Electro-optics Group is composed of good research assistants and research students. It is well equipped with various cw and pulsed laser sources of various wavelengths, power supplies to produce fields up to 40 kV/cm at frequencies from dc to 150. kHz and pulse lengths from μsecs to seconds, and various detectors and data-recording electronics. Significant results have been produced in the past and can be expected to continue in the future. (Vern N. Smiley)

OPTICAL COMPUTING

An International Conference on Optical Computing in Research and Development was held in Visegrad, Hungary, 4-9 October 1977. The meeting took place at a secluded resort hotel on a mountain-top overlooking the Danube Bend. The choice of locations was a fortunate one as interaction between scientists from Western and Eastern Bloc countries occurred more frequently than would have happened if the meeting had been held in Budapest.

The conference chairman, Professor P. Greguss [Biofizikai Intezet (Biophysics Institute), Budapest, Hungary] and its secretary S. Tökés [Magyar Tudomanyos Akademia (Hungarian Academy of Sciences, HAS), Symitastechnikai es Automatizalasi Kutato Intezet (Computer and Automation Institute, CAI) Budapest] are to be congratulated on their skillful handling of the Conference in circumstances in which the titles and authors of many papers were changed at the last minute, requiring very considerable reorganizing and rescheduling. Their efforts contributed substantially to the conference being a worthwhile effort, and were especially important as optical computing is not a well defined topic as, for example, digital computing. At this stage indeed optical computing is perhaps best described by a listing of the techniques being worked on by people associated with it. Beyond this most of the conference papers were concerned with research and development of optical computing components, devices and techniques rather than application of optical computing in R&D as might be implied from the Conference title, although there were some papers on applications in the biomedical sciences and other technologies. Subjects discussed included: electro- and acousto-optics, holography hybrid (optical and electronic) image processing, pattern recognition, and holographic methods applied to biomedical sciences.

It will be clear from this preamble, and it was from the Conference, that the field of optical computing is in an early stage of evolution. While a few applications are envisaged and some systems and devices have been developed, a unified approach to the development of efficient information processing techniques has yet to appear. Probably hybrid systems (combining optical and digital or analog electronic schemes) will be very important. A factor slowing their development is that people from different disciplines are required to integrate their ideas in order to produce efficient systems utilizing a combination of techniques. Nevertheless, for the rapid processing, recording, storing, transmitting or displaying of information in pictorial form optical image processing has tremendous advantages over digital image processing as parallel processing can be used and it will undoubtedly be employed.

In a session on electro- and acousto-optics there were several papers on components for laser graphic devices. The use of laser graphics which includes printing and other output devices can speedup computer output and may eventually replace mechanical devices in many systems. There are at least three methods for printing with lasers. All of them use intensity modulation of the beam with acousto- or electro-optical modulators and x-y deflection with mirrors, acousto-optical scanners or transport motion. One method called the dot-matrix system, appears to offer the most advantages, since the y-axis motion takes place continuously while several beams are writing simultaneously. In this method the characters are recorded as arrays of dots.

A new character generator for printing was described by A. Podmanicszky (HAS, CAI). The modulator for this is based on Bragg diffraction of light by acoustic waves generated in a crystal by an electrically driven transducer. Podmanicszky uses seven acoustic frequencies which result in seven useable diffracted beams each of which is individually addressable. Other beams associated with two-phonon scattered radiation, zero-order diffraction and mixed frequencies are eliminated by use of aperture stops in the optical system. Podmanicszky's modulator is different from similar multi-channel Bragg modulators developed by others as it uses abnormal Bragg diffraction of light in a TeO_2 crystal. A partial list of the technical data pertinent to a printer using this modulator follows: writing speed, 1800 lines per minute; length of lines, 285 mm; character dimensions (nominal) 2.1 × 1.5 mm; characters in a line, 200 (max.); power in a single beam, 0.08 mW; and power of incident laser beam, 10 mW.

M. Lehmann [Stanford Research Institute, Menlo Park, CA] in a speculative paper on holographic methods for associative memory systems, stressed the need for a practical 10^{15}-bit memory with reasonable accessibility. He suggested that optical systems may help solve the problem of how to cope with an overabundance of data. Lehman feels that the human brain may function in a manner similar to that of some optical systems and that this similarity should be studied and exploited. It had been suggested earlier by Pribram [*Languages of the Brain*, Chapter 8, Prentice-Hall, Inc. (1971)] that the process by which the mind makes decisions is related to holographic recording and retrieval. The high data rate and complex correlation capability of the brain could be explained on the basis of a resonant response to spatial frequencies in the input. Matched filter recognition similar to that which takes place with the optical Vander Lugt filter is observed to take place in image-learning experiments with humans. That is, human observers learn to recognize images of any size after the shape of an object has been learned.

An interesting discussion of work on dynamic holograms was given by E.V. Ivakin (Physical Institute Belorussian Academy of Sciences, Minsk, USSR). A dynamic hologram is one which is formed and reconstructed in a short span of time and then disappears. They may be formed by two beams interacting in a nonlinear medium. Generally, there are two types: one makes use of a thermal grating formed by the variation of the index of refraction caused by local heating during absorption of two interfering beams, and the other utilizes saturable absorption. Ivakin has demonstrated the latter principle using saturable absorption in a Rhodamine 6G dye solution with a laser repetition rate of 50 pps and has made an optical correlator of which the dynamic hologram was an integral component. Cross-correlations of two parts of a water surface disturbed by wave action were successfully obtained.

A few papers were presented in the important area of hybrid image processing amongst which Z. Wrzeszcz (Instytut Maszyn Matematycznyca Mera, Warsaw, Poland) showed a processor that puts holograms into digital signals and stores them. He feels that practical realization of his techniques usirg well-known software should come soon. A round-table discussion on hybrid image processing was chaired by A. Lohmann of the Physikalisches Institut der Universität Erlangen-Nürnberg, FRG. He gave the lead-off presentation in which he summarized the state-of-the-art in the field. The reason for pursuing hybrid systems is that they can make use of the special advantages available from both optical and electronic techniques. Digital methods offer flexible software and high accuracy. Electronic analog systems offer convenient optical-electronic (O/E) and electronic-optical (E/O) transfer of signals, as for example, TV cameras and monitors. Optical analog techniques offer large storage capacity and are fast due to spatial parallel processing. Additionally, holograms have been generated by computer rather than optically and these may be used in optical transformations. However, in general, there are problems in trying to implement the marriage between electronic and optical techniques. Various skills in software and hardware are necessary; therefore, people with mixed skills are required to make something of it.

In another session, the technique of matched spatial filtering as applied to biological specimens was discussed. J. Kinder and colleagues (Gesellschaft für Strahlen-und Umweltforschung mbH, Abteilung für Kohärente Optik, Neuherberg, FRG) have investigated a scheme to find cancerous cells in a cytological smear among a large number of healthy cells. They propose using a combination of optical and digital information processing in which the optical processor acts as a preselector which quickly finds "suspicious" cells. These cells are then analyzed in more detail with an image digitizer and computer. Kinder has made some measurements with such an optical processor and found 28 out of 37 cells previously identified as cancerous in a particular sample containing a large number of normal cells.

Biological applications of holographic and speckle interferometry were discussed in several papers in other sessions. K. Høgmoen (Physics Dept, Univ. of Trondheim, Trondheim, Norway) uses speckle pattern interferometry to detect motions in the bones of the human middle ear (post mortem) driven by an external sound field. This

technique is so sensitive that motions as small as 20 Å are observed on a biological specimen and as small as 0.1 Å for a test object. In an another paper C. Sieger (Institut für Medizinische Optik, München, FRG) demonstrated on a model the feasibility of studying vibrations of the human ear drum using holographic interferometry.

Holographic techniques in biomedicine were also discussed in a roundtable. During the discussion it was pointed out by several of the people working on optical applications to biomedicine that there are difficulties in communicating with doctors and medical researchers in regard to these new techniques. It was feared by more than one participant that this might turn off some good work and result in the medical people missing some good applications. Commenting on acoustical holography Greguss stated that in his opinion this is a nice scientific toy but not of much real value. He feels that acoustic imaging techniques give far better images and can provide 3D. The use of optical holography for storing information on biological specimens also was suggested as a way to store large amounts of data without keeping all of the specimens.

Despite the organizational difficulties, this was a worthwhile meeting. Some progress has been made in optical computing. However, many of the results presented at this conference were preliminary or speculative. A great deal remains to be done yet before computers utilizing optical or hybrid systems become practical.

A longer version of this report will be published soon as an ONRL Conference Report. (Vern N. Smiley)

ONRL REPORTS

See the back of this issue for the abstracts of current reports.

PSYCHOLOGICAL SCIENCES

THE HEAT, THE HEAD, AND HUMAN FACTORS

The hot Israeli sun can raise the cockpit temperature to 45°C in a helicopter, enough to make a pilot dizzy from the heat on a long mission and marginal in his performance. J. Brandshtater, Aeromedical Center, Israeli Air Force, Tel Hoshomen, has head-cooling equipment under development that can be a solution to the problem of debilitating cockpit temperatures. He has furrowed the foam rubber padding of a pilot's helmet with channels so that small plastic tubing can be woven back and forth over the inside of the helmet. The tubing connects to a small refrigeration unit and a pump, and cold water is continuously moved through the helmet. His head-cooling device is inexpensive, he says.

That a head-cooling device will be effective in reducing the effects of heat is based on US research. Under the sponsorship of NASA and the Bureau of Mines, Acurex Corporation, Mountain View, CA, developed a head-cooling "cap," with the configuration of an old-fashioned aviator's helmet, and a cooling "vest" that can be used along with the cap if needed. Both the cap and the vest are run from a cooling unit that hangs on the belt and is battery operated. (This Acurex equipment is marketed by Lifecom Safety Service & Supply, Inc., Buena Park, CA.) The Aerospace Medical Research Laboratory (Wright-Patterson Air Force Base, OH) had an experimental interest in the physiological and behavioral effects of head cooling [A.T. Kissen, *et al*, *Aviation, Space & Environmental Medicine* 47, 265-271 (1976)]. In this work, no cooling (control condition) was compared with three experimental conditions: water cooling by the Acurex cap worn under a standard Air Force helmet, a method for air cooling a helmet, and both water and air cooling of a helmet. The temperature for the human subjects was 46.1°C over an 80-minute session. The principal physiological measures were rectal temperature, skin temperature, body temperature, heart rate,

body heat storage, and sweat loss. The behavioral measures were performance on two kinds of tracking tasks. The gist of the findings was that the physiological measures showed a steady deterioration over the 80 minutes, with all experimental conditions having less deterioration than the control condition. Air and water combined cooled the best in this USAF research, with both air and water separately showing intermediate benefits and about the same in their effects. Behavioral measures were unaffected by the treatments. Brandshtater reports that the perceptual consequences of these physiological effects is one of whole-body cooling, not just head cooling.

It is these findings that Brandshtater relies on, and he has chosen a water-based system. A potential hazard with water is that a spill from everyday mishaps or combat causes could result in wet clothing, electrical short circuits, or steam that could burn. For these reasons the Air Force investigators, working from the same data, recommend an air-based system. Whatever the merits of water vs air cooling, Brandshtater is moving ahead with his water-based system. There should be early production and operational use if the evaluations go well. Brandshtater moved decisively on a good idea when he got wind of it, and one has the impression that the Israeli military supports a good idea without that collective of encumbrances known as red tape. (Jack A. Adams)

CONFERENCE ON THE PSYCHOLOGICAL CONSEQUENCES OF CROWDING

The conference on the consequences of crowding, sponsored by NATO and Middle East Technical University, Ankara, was held in Antalya, Turkey, 6-11 November 1977. It was organized by R.B. Bechtel (Environmental Research and Development Foundation, Tucson, Arizona) and W.A. LeCompte and M.R. Gürkaynak (Middle East Technical University, Ankara). The meeting was an interface conference in which disparate groups were brought together on a problem of common interest, the groups being architects, urban planners, and psychologists.

For centuries, architects have been designing buildings on the basis of aesthetics, a knowledge of structure and materials, and cost considerations, and they have expertise in these matters, but their understanding of the efficiency of people who live and work in their buildings is intuitive. Similarly, urban planners have an intuitive knowledge of behavior. Psychologists, on the other hand, know little about architecture and urban planning, but they are concerned with the scientific study of human behavior and they know how to get the behavioral information that architects and urban planners need.

The purpose of the conference was to examine the relationships between population density and human behavior, with the aim of helping architects and urban planners who must design living areas for the increasing population densities of the world. Behavioral questions on this topic are about groups of people, and so they are questions for social psychologists. The social psychologists in attendance mostly presented experimental papers, while the papers by architects and urban planners were mostly survey studies of the distribution of people and how they use the space in which they live.

What are investigators of crowding looking for? A high density of people can raise the room temperature, but to show that performance decreases in the presence of heightened temperature is trivial in the context of crowding research; it is the effect of crowding with temperature controlled that is of interest. Even the account of suicidal lemmings throwing themselves into the sea can be less than satisfactory evidence of crowding effects. As the lemming population density increases the food supply decreases, and some of the animals may fall into the sea as they press their search for food in an ever widening area. Crowding may aggravate the situation, but it is food supply, not crowding, that is the primary determinant of the suicide-like behavior. The wide searching behavior could occur with a food shortage in the absence of crowding. It would seem, then, that the investigators of crowding are looking for the social psychological effects that are a function of populatior density *per se*, not secondary effects.

Conventional wisdom has it that high population density produces negative effects for human behavior, but what has been revealed to investigators in recent years is that this truism is not always so. Indeed, performance decrements as a function of density are rather hard to show, and this was one of the emphatic points that J.L. Freedman (Columbia University) made in his keynote address. Schmitt [*American Institute of Planners Journal* 29, 210-217 (1963)], in his study of Hong Kong as one of the most densely populated territories of the world, reported crime and juvenile delinquency rates to be below that of the US and disease to be at tolerable levels. Freedman has demonstrated in various ways that crowding can leave behavior uninfluenced. In a study of New York City [*Journal of Experimental Social Psychology* 11, 539-552 (1975)], Freedman found that population density and social pathology (e.g., admissions to mental institutions, indices of juvenile delinquency, number of children born out of wedlock) were unrelated. In other studies, Freedman has shown that density and human competitiveness and agressiveness are unrelated, as is density and performance on various laboratory tasks [*Journal of Experimental Social Psychology* 8, 528-548 (1972); *Journal of Applied Social Psychology* 1, 7-25 (1971). In fact, density can be beneficial under some circumstances. In one of the more interesting presentations at the conference, D.E. Weldon (Washington Univ., St. Louis) reported that over a 24-year period in St. Louis greater density in classrooms was associated with higher achievement on SAT scores (a finding not likely to hearten teachers). A positive effect for crowding is not a new theme. J. Jacobs, in her book *Death and Life of Great American Cities* (Random House, 1961), contended that a crowded city can be a healthy city. People know each other, interact a great deal and are stimulated by the interaction, watch each other and each other's property, with the result that the crowdedness and watchfulness scares off criminals.

In the absence of strong effects of density on objective indices of performance, social psychologists increasingly have been turning to the perception of crowding as the focus of study [e.g., D. Stokols, *American Institute of Planners Journal* 38, 72-84 (1972)]. The perception of crowding is how one subjectively sees a situation and feels about it, and the subjective states are externalized by having the subjects answer questionnaires about their perceptions or respond with rating scales. Some of the investigators at the conference reported only the questionnaire and rating scale data, but others subjected their data to multidimensional analysis to obtain the dimensions of perception (papers by J. Schopler, Univ. of North Carolina; J.E. Stockdale, London School of Economics).

There are seeming advantages to this emphasis on perception. The measure is easy to collect. It can vary with population density and so it appears to be a useful measure of crowding. The measure can be used to assess the perception of crowding in the absence of a crowd, as in the feeling of being crowded when alone in a small room. And, the measure can be used in real crowding situations, pictured situations, or even imagined ones. These advantages, however, are outweighed by methodological difficulties. The outstanding difficulty is that we do not have complete access to our mental processes through verbal reports or the questionnaires that are used as a printed manifestation of them [R.E. Nisbett and T.D. Wilson, *Psychological Review* 84, 231-259 (1977)]. Various lines of research have shown that we can be unaware of events that influence our responses or of responses themselves. Secondly, there is no separating the perception of crowding from other perceptual states like fear, resentment, anger, etc. A questionnaire about resentment might yield the same results as one about perception of crowding. What is being measured? Thirdly, perception, in its classical conception, is considered to be a determinant of observable performance, and yet perceptual measures and measures of observable performance are often dissociated in crowding studies. How do we reconcile this lack of relationship with the classical view? With all these problems, the perceptual approach is suspect, and we are left with findings like Freedman's which, being without methodological problems, show us that population density is not the determinant of behavior that it is popularly thought to be. (Jack A. Adams)

NEWS & NOTES

ONRL NEWS

We welcome aboard our new Chief Scientist, Dr. Herbert Solomon, who comes from Stanford University where he is Professor of Statistics. Dr. Solomon received his BS degree from City College of New York, his MA from Columbia University, and his PhD from Stanford, and his professorial career has been with these three universities, his last appointment with Stanford having begun in 1959. He is not a stranger to the ONR community as he served as a mathematician with our headquarters office from 1949-52. Dr. Solomon is a member and former president (1965) of the Institute of Mathematical Statistics. His honors include the Samuel S. Wilks Medal awarded by the American Statistical Association and the Townsend Harris Medal from the City College of New York City. His research interests are in geometrical probability, multivariate analysis, psychometrics, engineering statistics, and operations research.

Dr. James A. Schulman, Chief Scientist of ONRL since August 1974, has returned to Washington, DC, where he has been assigned to a staff position in the Office of the Chief of Naval Research. He will be responsible for overall policy formulation, coordination and planning relating to the mission and functions of ONR London, ONR Tokyo and related matters. Dr. Schulman has also been appointed to the newly established Chair of Material Sciences at the Naval Research Laboratory.

BRITAIN SELECTS A REACTOR AT LAST

After many prolonged discussions on the merits of various nuclear reactors, the British Government announced on 26 January that they will authorize immediate orders for two British-built advanced gas-cooled reactors (AGRs) for power stations in the late 1980s. They have also tentatively retained the option of ordering the American-initiated pressurized-water reactor (PWR) at a later date. A more detailed article on this subject will appear in a forthcoming issue of *ESN*.

PERSONAL

QUEEN'S NEW YEAR HONOURS - In the New Year Honours list, the following were awarded the Knight Bachelor (KB): David Robert Bates, FRS, Research Professor of Theoretical Physics, Queen's University, Belfast; William John Butterfield, Regius Professor of Physics, University of Cambridge; Charles Frederick Carter, Vice-Chancellor, Lancaster University; and Professor Thomas Symington, lately Director Institute of Cancer Research. Receiving the award of Commander of the British Empire (CBE) were Professor W.E.J. Farvis, lately Professor of Electrical Engineering, University of Edinburgh; A.W. Kenney, Chief Scientific Officer, Dept. of Environment; L.E.J. Roberts, Director of the Atomic Energy Research Establishment, Harwell; C.N. Thompson, President, Royal Institute of Chemistry; and R. Wilson, FRS, Perren Professor of Astronomy, London University.

Dr. W.J. Albery, Lecturer at the Physical Chemistry Laboratory, Oxford, has been appointed to the Chair of Physical Chemistry at Imperial College, University of London, from 1 September 1978.

The University of Manchester has conferred the title of Professor Emeritus on the following: Dr. J. Diamond, formerly Beyer Professor of Mechanical Engineering; and Dr. H.S. Lipson, FRS, formerly Professor of Physics in the Faculty of Technology.

The Royal Society has awarded the Royal Medal 1977 to Sir Peter Hirsch, Issac Wolfson Professor of Metallurgy at the University of Oxford, for his studies of the structures and properties of imperfect crystals, and his determination of the atomic and crystallographic processes which enable strong alloys to be hardened by plastic working.

Dr. Edward Parkes, Vice-Chancellor of the City University, London, has been appointed full-time Chairman of the University Grants Committee for five years beginning 1 October in succession to Sir Frederick Dainton.

Dr. Patrick Sandars, Reader in Physics, has been appointed to the Chair of Experimental Physics at the University of Oxford, with effect from the date to be arranged.

Dr. John E. Smith, Reader in the Department of Applied Microbiology at the University of Strathclyde, has been appointed to a personal professorship within the Department.

OBITUARIES

Professor Leslie Fleetwood Bates, CBE, FRS, Emeritus Professor of Physics at the University of Nottingham, died on 20 January at the age of 80. In 1936 he was appointed Lancashire-Spencer Professor of Physics at Nottingham and established an active and thriving research group in the field of magnetism. In particular, he became renowned for his work on permanent magnetic materials, the magneto-thermal effect accompanying magnetization, and for his book, *Modern Magnetism*. He was also a pioneer in the application of Bitter pattern techniques to the study of magnetization processes in single crystal specimens of ferromagnetic materials. During WWII he acted as consultant-adviser to the Inner-Service Research Bureau where he was particularly concerned with the problems of degaussing of ships. He held many elected posts, and after his retirement in 1964, he remained active in his field. Perhaps his last post was as chairman of the Symbols Committee of the Royal Society, and he was responsible for producing *Quantities, Units and Symbols* in 1975.

Professor Arthus Erdélyi, FRS, Professor of Mathematics at the University of Edinburgh, died on 12 December at the age of 69. Leaving Czechoslavakia in early 1939, he came to Edinburgh where he became a Lecturer in Mathematics. In 1947 he spent a year at the California Institute of Technology and returned in 1949 for a 15-year stay as Professor of Mathematics. He returned to Edinburgh University as Professor of Mathematics in which capacity he served until his death. He was a Fellow of the Royal Society and the Royal Society of Edinburgh in addition to being joint or associate editor of a number of periodicals.

Professor Maxwell Bruce Donald, Emeritus Professor of Chemical Engineering at the University College, London, died on 6 January at the age of 80. In 1952 he was appointed to the Ramsay Memorial Chair of Chemical Engineering at UC, a position from which he retired in 1965. His early papers on percolation leaching, sedimentation of suspensions, and the Reynolds analogy all broke new ground. During WWII he was involved in the development of the limpet mines and fuses. One of his hobbies, the historical research into the metallurgical industries, resulted in the publication of two books on the development of the copper industries during the sixteenth century: *Elizabethan Copper* (1955) and *Elizabethan Monopolies* (1961).

Dr. John Watson Maccoll, retired from the Royal Armament Research and Development Establishment, died 17 December at the age of 74. His fruitful collaboration with the late Sir Geoffrey Taylor in the 1930s led to the solution for supersonic compressible flow over cones, and "Taylor-Maccoll flow" became a household phrase among dynamicists. Subsequently his main interest was in the development of new mathematical techniques for the study of problems in high-speed flow. From 1945 until his retirement in 1963, he directed the School of Theoretical Mechanics at RARDE.

Professor Peter A. Sheppard, CBE, FRS, one of Britian's leading academic meteorologists, died 22 December at the age of 70. During his early career he was one of a group working for the War Office on boundary-layer turbulence and diffusion in connection with chemical warfare. In 1952, he succeeded to the Chair of Meteorology at Imperial College of Science and Technology, University of London, where he remained until his retirement in 1974. Sheppard's research interest continued in boundary-layer turbulence, leading to some unique determinations of the drag of the wing on the earth's surface, both land and water.

ONRL REPORTS

R-12-77 A SAMPLING OF MILLIMETER WAVE TECHNOLOGY IN EUROPE—FALL 1977 by F.C. Essig

A summary of observations made on millimeter wave technology in the United Kingdom, the Federal Republic of Germany and the Netherlands during the Fall, 1977 is given. The report outlines available data on millimeter wave propagation and scattering phenomena in European weather models, the radar and radiometric properties of targets and terrain, and examples of component development relevant to the millimeter wavelengths. Some opinions on millimeter waves as an option for allweather target classification and terminal guidance are offered.

R-13-77 (LIMITED) A VIEW OF SURFACE ACOUSTIC WAVE TECHNOLOGY IN THE UK, FALL 1977 by F.C. Essig (Distribution limited to US Government agencies)

The findings of the author's survey of a representative group of United Kingdom research and development organizations working in the field of SAW technology are presented. Current areas of interest in the United Kingdom, such as Surface Skimming Bulk Waves (SSBW), Magnetostatic Surface Waves (MSW), SAW-CCD Fourier Transform Signal Processors and Pulse Compression Filter Techniques are outlined.

C-16-77 NATO INTERNATIONAL CONFERENCE ON EXPERIMENTAL & BEHAVIORAL APPROACHES TO ALCOHOLISM by J.A. Adams*

The international conference, "Experimental and Behavioral Approaches to Alcoholism" was held in Os, Bergen, Norway, 28 August to 1 September 1977 under the auspices of NATO. The viewpoint of the conference was that of behavior therapy. This report discusses the seven themes of the conference: Research methodology, alternative skills training, self-management procedures, the tension-reduction hypothesis, learning to discriminate blood-alcohol level, conditioned taste aversion, and individual differences. Methodological problems associated with some of the topics are examined.

C-18-77 RADAR '77 by CDR D.A. Hart

The Institution of Electrical Engineers and the IEEE Aerospace and Electronics Systems Society organized a major four-day international conference, Radar '77, held in London 25-28 October 1977. A brief description of some of the papers presented at this conference is presented. A complete list of the papers at Radar '77 is included as an appendix.

*This report was previously listed incorrectly as "Booze and Behaviorism".

C-19-77 NORTH AMERICAN/EUROPEAN HEALTH SYSTEMS RESEARCH CONFERENCE
by D. Whipple

The increases in the costs of operating the Military Health Services System (MHSS) of the United States have exhibited striking parallels to that of the private health care sector. The past three years have thus been characterized by research efforts which are motivated by the desire to contain these MHSS cost increases while maintaining the quality of the health care delivered. These efforts have identified various areas in which improved management, organizational change, incentive manipulation, and new modes of practice/delivery may enhance achievement of the goals. The subject conference and contacts with health systems management and research personnel in Britain and France during the trip to and from the meetings offered the opportunity to gather comparative impressions of the potential efficacy of research efforts underway and contemplated within the MHSS. This paper summarizes these results and policy recommendations.