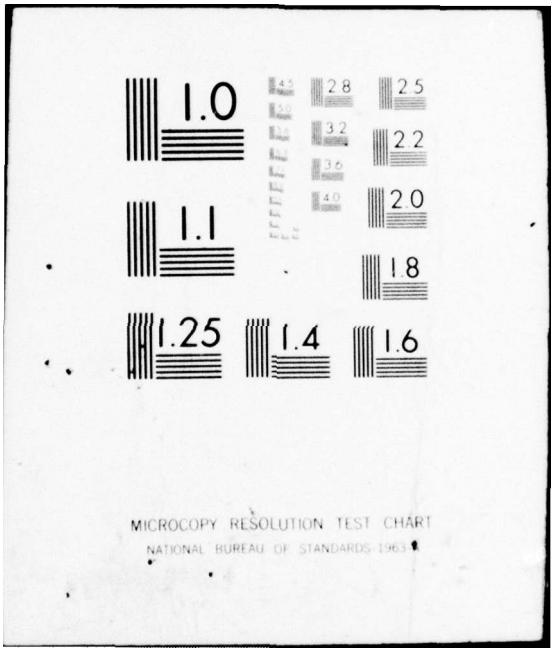
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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

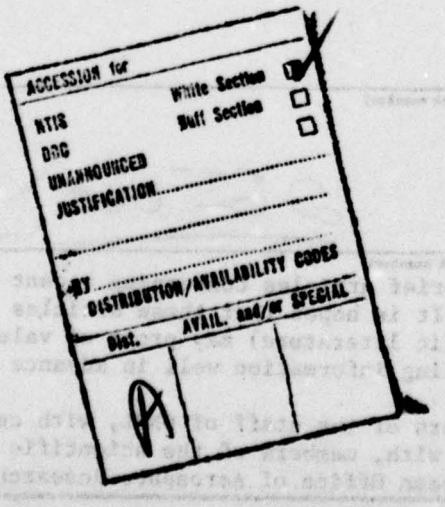
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AERONAUTICAL ENGINEERING

MAN-POWERED FLIGHT

Flight in a heavier-than-air machine that is powered and controlled by the crew over an entire flight remains a goal yet to be fully accomplished. Over the past 15 years, straight and level flights of limited durations have been achieved. In January 1977, the Japanese STORK B craft flew a record 2093 m in 4 min 27 sec. The "Everest" in man-powered flight, however, is the Kremer Prize which offers £50,000 for a successful flight around a figure-8 course about two points not less than a half-mile apart.

The Royal Aeronautical Society sponsored its second annual Symposium "Man-Powered Flight--The Way Ahead" on 7 February 1977 in London (for the First Symposium, see ESN 29-5:203). These Symposia set out to provide a forum for the exchange of knowledge in the development of man-powered flight projects. Interest in the one-day Symposium was worldwide as evidenced by several visitors and speakers from overseas among the audience of about 110 people.

Professor E.E. Covert (Massachusetts Institute of Technology) presented the first paper, "Some Considerations in the Choice of Man-Powered Airplane Configuration", based upon studies by his students. Before discussing details of configurations, he emphasized the value of the goal of man-powered flight and, in particular, the Kremer Prize in bringing an engineering flavor into a standard course of study. This project is clear and well defined, yet complex enough for surprises, and it has been ideal as a directed course of study for his students, for discernable progress has been made since they started in 1969 at MIT. His view that this type of project is excellent for a university class of study was reinforced by M.S. Pressnell (Hatfield Polytechnic) when he described his students' progress in their development of Toucan I and II. Toucan I is the only two-seat man-powered aeroplane to have flown to date (640 m in July 1973), and Toucan II, with a wingspan of 42.37 m, is the largest such craft yet constructed and is now being readied for flight.

Further reinforcement of Covert's viewpoint was provided by Japanese students' progress in the development of their Stork aircraft which was illustrated later in the day by a short film clip. Not only does the Stork B hold the current straight and level record, but the movie duly impressed the audience when it showed the craft making one successful turn of 180°--even if it did stall and drag its wingtip in its attempt to make a second turn. That movie was the first anyone in the audience had seen of successful turning flight by a man-powered aircraft. So students in at least three countries are making significant progress in their man-powered flight projects.

In his presentation, Covert discussed in detail the energy requirement (the power of the pilot multiplied by the time he must produce it), airframe loading requirements, and some considerations relative to turning flight. His well-received presentation led to many conclusions, and also included several observations that resulted from experience. For instance, the ventilation or cooling requirement for the pilot to preclude loss of visibility due to condensation in the cockpit required aerodynamic changes to the cockpit resulting in substantial drag losses. He made another interesting observation relative to the use of canards for lateral stability in slow flight. Use of canards would add 10% to the total aircraft lift and would be practicable in the control of skilled pilots who were mindful of the complete loss of lateral control should the canard stall: novice pilots had better stick to conventional tail assemblies! Because of the structural difficulties of maintaining wing cross section over long spans with ultra-lightweight construction, the MIT student team has been driven toward a biplane with tip plate design.

Professor F.X. Wortman (Univ. Stuttgart), world renowned for his lifting surface designs which most of the audience were using in their aircraft-wing cross sections, presented his paper on "Aerofoil Design for Man-Powered Aircraft". After pointing out the relative incompatibility of trying to design a wing with a very high lift coefficient while minimizing its consequent poorer stall

characteristics, he recommended the use of C_L of 1.4 to 1.6 for the very low Reynolds numbers involved in man-powered flight. Responding to the needs of designers in the audience having no access to wind tunnels, Wortman made a practical suggestion for testing for the position of the transition point along the surface of a wing. He suggested that the designer build a wing section about 6-ft long and mount it on an automobile or truck in such a manner that the airflow about the wing is not disturbed by flow over the vehicle. However, the wing should be close enough for the designer to move a stethoscope over the inside of its surface. The location of the transition point for any speed traveled and angle of attack can then be detected by the sound emitted. He emphasized that the resulting transition point should be greater than 70% beyond the leading edge but that this should occur significantly before to the aileron hinge. During the several lively discussion periods between the presentations, Wortman was frequently asked for opinions and advice. He feels that the preferred approach is a conventional airframe with conventional tail surfaces extended from the wing and cockpit in such a manner as to minimize total wetted surface for the aircraft. Incidently, his description aptly fits the current record holding Stork B aircraft.

Mr. M.S. Pressnell (Hatfield Polytechnic), in his paper on structural design, described construction techniques and materials used in the Toucan I and II aircraft. He pointed out the desire to start construction with the cockpit and drive-train area(s) because that is where the greatest stresses (500 lbs tension unevenly applied on the bicycle chain) accumulate. Landing-gear stresses also require significant design strength. His paper went into some detail on materials and their applicability in various areas of a man-powered aircraft and included many valuable tables of materials' characteristics of interest to the audience.

Propeller design received avid attention from the audience when F.G. Irving (Imperial College) presented his paper describing propeller design for the Newbury Manflier (a two-man aircraft currently being built). Reliable section data for propellers operating at low R_e ($\sim 10^5$) are rare, but section-profile drag coefficients are likely to be high (~ 0.03). He said that the Newbury Manflier (and probably any man-powered aircraft) will be required to operate over a wide range of conditions. Mean climb thrust is expected to be twice that required for cruise, and the requisite ratio of maximum torque during climb to minimum torque during cruise is on the order of 6. With a fixed-pitch propeller, accommodation over the range without stall during climb or negative lift during cruise is difficult and compromise is necessary unless a simple two-position variable-pitch propeller can be designed for man-powered flight.

"The Power Required By a Man-Powered Aircraft" was the theme presented by Rear Admiral H.C.N. Goodhart (Royal Navy, retired and a consultant). His studies show that for the range of reasonable wing spans, aircraft weights, aspect ratios, and drags envisioned for most man-powered aircraft designs, the required horsepower per 150-lb pilot would be no less than 0.3 hp exerted throughout the Kremer course with extra exertion required during climbs and turns.

Professor D.R. Wilkie (University College, London) followed the power-required presentation with his paper "Theoretical and Practical Considerations in Harnessing Man Power". He concluded that by using his legs, a man will develop his maximum power, and for a given man the rate of oxygen consumption is the limiting factor for continual "full power" generation over a period of time greater than a couple of minutes. He recommended that potential pilots undergo tests on an ergometer since power-producing capabilities of individuals vary greatly. Ideally, the pilot/engine should be one who produces his power at a relatively low torque and a high rate of pedalling. With low torque, high-speed power generation, the strength and weight of the transmission can be substantially reduced. Power/time curves for various bicycle riders were shown, and typically competitive cyclists can maintain between 0.4 and 0.5 hp over times in excess of 30 min.

In summarizing the Symposium, Professor G.H. Lilley (Univ. Southampton) suggested that the choice of the proper pilot/engine who typically comprises one-half the total weight may be every bit as important as the actual aircraft design to win

the Kremer Prize. In his view, progress has been impressive over the past few years, and creativity and perseverance will surely result in successful man-powered flight within the next few years.

Copies of the proceedings of this Symposium are available from The Royal Aeronautical Society, 4 Hamilton Place, London W1, England at £4.20 per copy. (CAPT L. Roy Patterson)

CHEMISTRY

INORGANIC AND ELECTROCHEMISTRY AT THE NTH

The Norwegian Institute of Technology [Norges Tekniske Høgskole (NTH)], Norway's only technical university, was established at Trondheim in 1910. Its objectives are to provide education for engineers and architects and to further the development of those branches of science and art which are pertinent to technological education and activity (see also ESN 31-3:119). NTH consists of eight Departments: Architecture, Earth Sciences and Metallurgy, Civil Engineering, Electrical Engineering, Chemistry, Mechanical Engineering, General Sciences, and Naval Architecture. Each Department in turn is divided into several Institutes. The Department of Chemistry has ten Institutes: Inorganic, Organic, Industrial, Physical, Chemical Engineering, Cellulose Technology, Industrial Electrochemistry, Applied Biochemistry, Silicate Science, and Marine Biochemistry.

There are a number of research institutes closely associated with NTH. The most important is SINTEF (Foundation for Science and Industrial Research). The aim of this independent, non-profit organization is to place the research facilities of NTH at the service of industry and to coordinate NTH-industry relations.

The Institute of Inorganic Chemistry was visited by the author in September 1976. It is directed by Professor Harald A. Øye and has a staff of about 9. Students starting on the 4½-year program toward the degree of "sivilinginiér", equivalent to an MS in Engineering, number from 3 to 10 per year. There are currently 12 graduates working on their PhDs. Support for the Institute comes from the government (about 50%) for teaching and from grants (about 50%) by science councils, industry, NATO, etc., for research projects. These grants are administered through SINTEF.

The Institute has 14 active research projects, mostly allied to the industries for production of aluminum and magnesium. These projects range from matrix isolation spectroscopy studies of the configuration of alkali aluminum and iron fluorides, to current efficiency and convection studies in commercial aluminum reduction cells.

Øye's group has constructed a one-of-its-kind viscosimeter. The instrument is capable of measuring the viscosity of liquids up to 1200°C under many atmospheres pressure. The viscosity is determined by observation of the damping effect exerted on an oscillating geometric body by the liquid under investigation. The machine suspends an accurately characterized sphere or other body from a thin wire. The body is rotated through an arc of a few degrees' magnitude with a frequency of 10-20 sec. The damping effect that is observed when the body is subsequently immersed in a liquid is related to the viscosity of the liquid. For systems where vapor pressures are a problem, the sample is merely placed in a sealed cylinder which is then rotated. The damping effect when the cylinder contains a liquid is much like that observed when one compares the spinning characteristics of a hard-boiled egg and a raw one. The viscosimeter suspension system holds a mirror onto which a laser beam is directed. The damping effect is measured by observation of the reflected beam. The entire system is on-line with a PDP 11/10 computer and viscosity is automatically computed. The machine is possibly the only one in the world capable of measuring, with high accuracy, the viscosity of melts at high temperatures and high pressures.

In addition to viscosity determinations, Øye's group has also measured vapor pressures, surface properties, and the solubility and diffusivity of chlorine and aluminum in $AlCl_3$ containing melts. All are topics of interest to anyone studying aluminum chloride electrolytes. Additional current projects at NTH which are possibly pertinent to battery development programs

are: (1) complex formation in molten solid halides, (2) gas complexes with transition metal halides, (3) theory of aluminum electrolysis, and (4) formation of Al_4C_3. The last four projects are all directly related to aluminum refining technology.

A current project at NTH not related to the battery work lies in the area of membrane chemistry. The understanding of transport processes in membranes is fundamental for the understanding of the thermodynamics of important processes occurring in living tissue and of many electrochemical processes in general. One part of NTH's membrane research has been diverted toward a study of the water-transport properties of anion and cation ion-exchange membranes. During the current year the group has investigated about 20 different membranes. The water transport numbers, obtained by streaming potential measurements with LiCl, NaCl, KCl, RbCl and CsCl as electrolytes in the concentration range 0.001-1 mol/l, are much more precise than those reported in the literature. The results have been interpreted on the basis of a proposed model, and theoretical studies based on irreversible thermodynamics have been performed in order to obtain a more exact and general description of the transport processes.

The Institute of Industrial Electrochemistry at NTH, headed by Professor H. Holtan, is primarily engaged in research on molten salt electrolysis and corrosion. As in the Institute of Inorganic Chemistry, research is directed at understanding electrochemical processes and improving efficiencies of a aluminum and magnesium production methods. Current projects include determining the activities of $AlCl_3$ in $NaAlCl_4$ melts, electrode reactions in $NaCl/AlCl_3$, and kinetics of halogen evolution reactions. Techniques employed in electrode studies include current density/potential, double layer capacitance, cyclic voltimetry and anodic stripping. Work on $NaCl/AlCl_3$ indicates that the primary discharge reaction is the rate controlling process in $AlCl_3$-rich compositions, but the mechanism changes in NaCl-rich compositions. Also the nature of complexes in the double layer changes with temperature. In the future Dr. R. Tunold plans to study aluminum densification reactions and to investigate additives for reducing the melting point of salt mixtures. This Institute is also investigating the corrosive effects of molten salts on such metals as aluminum and steel.

Dr. P. Renolen, Industrial Chemistry Division of SINTEF, is one of six people working in plastics technology. Their research is directed mainly toward developing better impact resistant polyvinyl chloride and long-term aging and weathering properties of plastics used in construction.

In conclusion, NTH has outstanding facilities and exceptional expertise in molten-salt electrochemistry and processes. Work within the Institute of Inorganic Chemistry and Industrial Electrochemistry, though strongly guided by Norway's industries for aluminum and magnesium production, is directly related to molten-salt thermal battery technology. NTH projects that could provide basic knowledge for operation and improvement of molten-salt batteries include: complex formation in molten salts, formation of aluminum carbide, electrode/electrolyte interactions, low melting salt compositions, and kinetics of electrode reactions. Investigations of petrochemical reactions in molten salt catalysts may lead to unique synthetic processes. [D.W. Seegmiller, Lt Col, USAF (EOARD)]

1976 EUCHEM CONFERENCE ON MOLTEN SALTS

The Leeuwenhorst Congress Center, Noordwijkerhout, The Netherlands, was the site of the 1976 EUCHEM Conference on Molten Salts. The EUCHEM meeting is patterned after the semi-annual "Gordon Conference on Molten Salts" and is held on alternating years, the next to be held in Sweden. No abstracts or proceedings of this Conference are published, the feeling being that recording the presentations and discussions would inhibit the desired free and informal debate that seems to accompany each paper. Further, many of the papers were merely progress reports of on-going programs and did not represent completed, ready-for-publication work. The Conference was attended by approximately 80 participants representing 15 countries, the United States having 6 in attendance, and almost all Western European and Scandinavian countries being represented. Also present were attendees

from Israel, Iraq, Yugoslavia and East Germany. The majority of internationally recognized European molten-salt researchers attended.

Interest in molten-salt chemistry relates to the use of fused systems as electrolytes for high-energy density batteries, and possibly as novel reaction media for preparation of special materials.

The Conference was arranged into eight half-day sessions, each covering a different topic. Each presentation was followed by a discussion period normally lasting about 15 minutes. The free-ranging discussions often included rather critical comments on the work, but were helpful in assessing how the real experts in the field judged the value of any given investigation. The 51 papers presented were grouped into one of the following eight categories: (1) The Theory of Molten Salts, (2) Thermodynamics of Molten Salts, (3) Electrochemistry, (4) Spectroscopy, (5) Reactions in Molten Salts, (6) Transport Properties of Molten Salts, (7) Low-Melting Salt Systems, and (8) Applications of Molten Salts. A brief description of each session follows:

Theory of Molten Salts--This session was highly theoretical; most of the investigations employed molecular dynamic-statistical mechanical methods for the development of models involving both short- and long-range forces present in molten salts. The associated computer models employed time-step computations requiring huge amounts of computer time. Good models allow the reliable prediction, for various melts, of physical properties such as viscosity, surface tension, particle mobility, and internal pressure. A number of the investigations were also concerned with the theoretical prediction of thermodynamic properties such as heat capacity, excess enthalpy, excess free energy and excess entropy. The majority of the systems considered in the theoretical approaches were nitrates, which are undoubtedly the most extensively studied and best understood of all molten salt systems. Authors of papers read in the first session were: Dr. F. Lantelme (Lab d'Electrochemie, Univ. P. et M. Curie, Paris, France), Dr. U.L. Schäfer (Max-Planck Inst. f. Chemie, Mainz, FRG), Dr. P. Cerisier (Lab de Thermodynamique, Univ. de Provence, Marseille, France), Dr. H.M.H. van Wechem (Koninklijke/Shell Lab., Amsterdam, The Netherlands), Drs. G. Knape and L. Torell (Dept. of Physics, Chalmers Univ. of Technology, Göteborg, Sweden).

Thermodynamics of Molten Salts--The second session was devoted to the prediction and measurement of thermodynamic properties of fused salt systems. Prof. Dr. J. Richter (Rhein-Westf. Technische Hochschule, Aachen, FRG) discussed a non-isothermal cell of the Soret type in which application of a thermal gradient across a concentration cell produces a significant emf. [A somewhat similar cell has been investigated by the US Air Force's Frank J. Seiler Research Laboratory (FJSRL) at the Air Force Academy and possibly has some rather unique practical potential.] A paper by Dr. J.B. Lesourd (Univ. de Provence, Marseille, France), which discussed a cell employing a $ZnCl_2$-NaCl electrolyte, was particularly interesting because of its surprising similarity with the $AlCl_3$-NaCl electrolyte which is the basis of the FJSRL battery program. A paper by Prof. O.J. Kleppa (Univ. of Chicago, US) on the thermochemistry of some liquid solutions of AlF_3 was also closely related to Seiler work. In addition to the above, papers were read by J. Keuning (Lab. of Electrochemistry, Univ. of Amsterdam, The Netherlands), Dr. M. Gaune-Essard (Lab. de Thermodynamique, Univ. de Provence, Marseille, France), and Dr. B. Holmberg (Div. of Physical Chemistry I, Chemical Center, Lund, Sweden).

Electrochemistry--In this session a number of papers were relevant to thermal batteries, all of which employ molten-salt electrolytes. Prof. B. Tremillon (Lab. d'Electrochemie Analytique et Appliquée E.N.S.C.P., Paris, France) discussed a method of measuring and expressing the oxygen content of chloride melts. Dr. J.R. Selman (Illinois Institute of Technology, Chicago, US) read a paper dealing with the high energy density cell Al-Li/Li-KCl/S-FeS_2. Concern was expressed relative to the purity of commercial LiCl and KCl. Some $CO_3^=$ is usually present and apparently, in this cell, is decomposed and plates out as graphite on the AlLi cathode. Since this is the electrolyte employed in almost all present thermal batteries, the same phenomenon probably occurs in them. The effect is probably unimportant in short-life batteries but may be important in those that are

designed to remain active for rather long periods of time. Also discussed was a possible electrochemical means of recycling CO_2 for space applications. Dr. B. Gilbert (Université de Liège, Belgium) reported an investigation of lanthanide chemistry in NaCl-$AlCl_3$ melts. This is the electrolyte employed in the FJSRL batteries, and his results contribute to the basic understanding of the system. In private discussions with Gilbert it was revealed that he will very shortly depart for a postdoctoral position at Colorado State University where he will work with Dr. Robert Osteryoung who is investigating the same system under an AFOSR grant. Dr. D.G. Lovering (Royal Military College of Science, Shrivenham, UK) presented a very good paper dealing with the effect of H_2O on nitrate melts. Dr. J. Lumsden (Imperial Melting Processes, Ltd., Avonmouth, Bristol, UK) presented a paper dealing with anionic electrons in melts. Apparently, as in liquid ammonia, in some molten-salt electrolytes it is convenient to consider electrons to behave much like common anions. Such an assumption leads to some very interesting theoretical considerations. Lt. Colonel Lowell A. King (FJSRL) presented a paper concerned with the kinetic behavior of aluminum in NaCl-$AlCl_3$ melts. Additional authors were: F. Paniccia (Instituto di Chimica, Via Amendola 173, Bari, Italy) and C. Nicollin (Lab. d'Electrochemie, Faculté des Sciences, Reims, France).

Spectroscopy--This session was devoted to the spectroscopic analysis of molten salt systems. Because of inherent high temperatures, and in some cases high pressures, fused salts are much more difficult to study than most aqueous systems, and highly specialized techniques must be employed. Dr. P. Chieux (Inst. Laue-Langevin, Grenoble, France) described an investigation employing small-angle neutron scattering for the characterization of metal-salt solutions. The neutrons employed have wavelengths of approximately 7 Å, and thus the technique is capable of very high resolution. Very precise (better than the literature) thermodynamic data for the K-KBr system have been obtained. The method is capable of resolving concentration fluctuations in the dimensional range of 5 to 5000 Å. Such fluctuations, of course affect various physical properties and by means of the method it is possible to determine the size of the zone which is causing the change. Raman spectroscopy investigations of several systems were reported by Dr. G. N. Papatheodorou (Argonne National Lab, Ill., US), Dr. W. Brockner (Lehrstuhl B, Anorganisch-Chemisches Inst., Technische Universität Clausthal, FRG), and G. Okon (Lehrstuhl B, Anorganisch-Chemisches Inst., Technische Universität Clausthal, FRG). Raman spectroscopy is probably the most widely employed means of investigating these high temperature systems, and it yields structural information about both the liquid and vapor phases. A paper by Dr. S.S. Al-omer (Basra Univ., Iraq) involved electronic spectral studies of some transition metal ions in nitrite melts.

Reactions in Molten Salts--Although this session was quite academic, some of the techniques may provide means for the preparation of compounds not obtainable by usual methods. As an example, Dr. W. Wichelhaus (Max-Planck Inst. f. Festkörperforschung, Stuttgart, FRG) has synthesized a series of lanthanide sulfides and phosphides, probably not obtainable by other means. His method employs a CsCl-KI melt which dissolves the metal in question. Sulfur or phosphorus is then added from the vapor phase to produce the series of compounds LaP, LaP_2, LaP_5 and LaP_7 or the corresponding sulfur compounds. The particular compound produced is determined by the pressure and temperature employed. Papers were also presented by P.G. Zambonin (Univ. of Bari, Italy), M. Sørlie (Technical Univ. of Trondheim, Norway), J.C. Rey (Dpto. de Quirnica Inorganica, Facultad de Ciencias, Santiago de Compostela, Spain), and Dr. D.H. Kerridge (Dept. of Chemistry, Univ. of Southampton, UK).

Transport Properties of Molten Salts--The most important papers in this session were probably those presented by H. Linga and T. Østvold of the Technical University of Norway. Both dealt with the NaCl-$AlCl_3$ system. Linga presented results of vapor pressure measurements and Østvold discussed chlorine solubility in the melts. Other papers dealt with the measurement of ionic conductivity, viscosity, and diffusion coefficients associated with various fused systems. Conductance measurements were discussed in separate papers by P. Claes (Lab. de Chimie Inorganique et Analytique, Batiment Lavoisier, Louvain la Neuve,

Belgium), K. Tödheide (Inst. f. Physikalische Chemie und Elecktrochemie der Univ. Karlsruhe, FRG), W.E. Haupin (Aluminum Co. of America, Process Metallurgy Div., Alcoa Labs., New Kingston, PA), H. Keller (FRG), and L. Segers (Service Metallurgie Electrochimie, Univ. Libre de Bruxelles, Belgium). L. Martinot (Université de Liège, Belgium) discussed the determination of the activation energy for diffusion of U(III) and U(IV) in chloride melts. A paper by J.C. Poignet (Domaine Universitaire, Saint Martin d'Heres, France) dealt with transport properties of molten copper chloride.

Low-Melting Salt Systems--Certain low-melting salt systems may be of potential interest since they offer the possibility of developing low-temperature thermal batteries, or high-energy non-aqueous secondary batteries. Prof. A.R. Ubbelohde (Imperial College, London, UK) showed that the ratio of boiling point to melting point for alkali halides is approximately 1.6. He further showed that if this ratio is considerably different from 1.6, some profound irregularity is occurring in general with the melting process, which is normally much lower than expected. This low melting point is usually associated with a lack of symmetry in the crystal phase. He discussed in detail organic acid salts which are in many cases abnormally low-melting. He pointed out that many organic salts which are believed to decompose at their melting points are really quite stable and that impurities which are immobile in the solid phase really are responsible for the decomposition. Many carboxylates which commonly decompose on heating may be heated to bond cracking temperatures of approximately 550°C without decomposition if highly purified. His current work involves carboxylates of the form CH_3-$(CH_2)_n$-COOH with $n \leq 7$. Evidence indicates that for many alkali metal carboxylates the liquid possesses a great deal of structure just above the melting point. Such liquids are spoken of as being non-isotropic and have very interesting transport properties. Conductivity in this region is especially unusual, exhibiting remarkably high values. Melts may also exhibit the Hall effect while in this state. G. Picard (Lab. d'Electrochemie Analytique et Apliquée, E.N.S.C.P., Paris, France) read a paper dealing with acidities of molten hydrogen sulphates and disulphates. Dr. G. Sacchetto (Universita di Padova, Italy) discussed ion-ion and ion-molecule association equilibrium in concentrated DSMO-alkali nitrate melts. Papers were also presented by Dr. E. Rhodes (Dept. of Chemical Engineering, Univ. College, Swansea, UK), Prof. M. Zangen (Instituto di Electrochimica dell Universita, Pavia, Italy), and Prof. I.J. Gal (Dept. of Chemistry, Faculty of Science, Univ. of Belgrade, Yugoslavia).

Applications of Molten Salts--This session was primarily concerned with the electrochemical winning of metals from various fused salt systems. Prof. H.A. Øye (Norway) discussed the current industrially oriented research on aluminum production at the Norwegian Technical University at Trondheim (NTH) where some of the most fundamental research in the world on aluminum winning and metallurgy is being conducted. Prof. R. Winand (Dept. Metallurgy and Electrochemistry, Université Libre de Bruxelles, Belgium) presented a paper dealing with pilot plant-scale electrolysis of molten oxides for the production of manganese. This work is probably the most advanced in the world on this topic and bears watching as more experience is gained on the economics of the processes and the ability to handle various manganese ores. Dr. V. Plichon (Lab. de Chimie Analytique, Paris, France) presented a paper on chemical and electrochemical aspects of molten cryolites and their application to alumina electrolysis. Dr. E.R. Buckle (Univ. of Sheffield, UK) described an iron-sensitive concentration cell which is being used to monitor the iron concentration in a Fe-Cu melt, and Dr. A. Bonomi (Battelle, Geneva, Switzerland) described a process in which a molten salt bath is used as the pyrolysis medium for recovery of useful materials from plastics and used tires. The bath employed consists of the LiCl-KCl eutectic and is operated at 500-600°C. The shredded materials are added directly to the bath and are pyrolyzed in 1/5 to 1/10 the time required for similar processes in air. Polyethylene yields a wax, polystyrene yields styrene, and tires yield oils and carbon black. The advantage over conventional systems appears to lie primarily in the greatly reduced time required for the

pyrolysis to be accomplished. The equipment is obviously more complicated than that employed in more conventional schemes. [D.W. Seegmiller, Lt. Col., USAF (EOARD)]

METALLURGY AT THE UNIVERSITY OF SAARLANDES--THE NEW LOOK

The University of Saarlandes is of recent vintage, constructed on a former military installation some twenty years ago. The architecture is a mix of new buildings plus some remaining (rather sterile) military buildings. Materials research at Saarlandes is carried out in several departments drawn together in a loose confederacy. In addition, there is a federal field-of-expertise umbrella grant in ferroelectrics which spans several professorial institutes. This grant, at the $1\text{-}2 \times 10^6$ DM per year level, was recently extended for three years at the University. The facilities for research are excellent.

The research area of a particular institute generally covers one or more disciplinary themes. In the case of U. Gonser's institute, the activities revolve about an experimental tool--Mössbauer resonance spectroscopy (MRS). MRS is, of course, subject to the limitation that only particular nuclei can be used, but the richness of detail that can be obtained concerning the local environments of these nuclei makes it a powerful, versatile, and truly microscopic technique. The versatility is demonstrated by the wide range and varieties of subjects that have been addressed by Gonser *et al*--from the characteristics of recording tapes to the elucidation of biological molecules.

In MRS, ^{57}Fe serves as the dominant probe, so it is logical that Gonser has directed attention to Fe-containing materials. One such material is Fe itself, and a question that Gonser *et al* have examined is the magnetic state of γ-Fe, the high-temperature form of Fe which is unstable with respect to α-Fe at lower temperatures. However, γ-Fe particles can be stabilized with less than 1% Cu (which is diamagnetic). Gonser *et al* used Cu-Fe alloys containing precipitated γ-Fe with particle sizes between 25 Å and 350 Å and measured the magnetic transition (Neel) temperature, T_N. For particle sizes ∿300 Å, T_N = 57 K; below 300 Å, T_N decreases to zero as the size tends toward zero (as it must since the transition disappears with decreasing particle size). The use of MRS allows a measurement of the average internal magnetic field, H_o, in γ-Fe, 23 kOe; for comparison, H_o = 330 kOe in α-Fe. This large difference in values of H_o reflects the consequence of presence of ferromagnetism in α-Fe.

Other studies of MRS in metallic systems include: (A) MRS in Al-0.5-5%Fe, splat-quenched (i.e., rapidly cooled from the melt). The spectra show the association of Fe atoms (e.g., Fe dimers) through the analysis of the line splitting (quadrupole splitting). (B) MRS in invar (Fe-28%Ni-3%C) indicates the coexistence of some anti-ferromagnetism along with the dominant ferromagnetism. (C) The use of MRS in the determination of the texture of grains in metals, a standard problem of major technological significance in metal processing. Unfortunately, the anisotropy of lattice vibrations (the Goldanskii-Karyagin effect) tends to confuse the texture determinations (through a similar hyperfine variation). (D) MRS in myoglobin, deoxymyoglobin, and bacterial cotalase. These studies, similar to previous studies by Gonser on hemoglobin, indicate that internal chemical structure and physical characteristics (e.g., electric fields) of biological molecules can be elucidated by MRS. (E) MRS study of magnetic recording tapes (i.e., thin Fe_2O_3 films on polymer substrates). Here Gonser *et al* were able to determine the amount (16%) of superparamagnetic component present, a component which is useless for practical purposes, and the particle alignment available. They found an alignment parameter of 1.1 compared with an ideal of 1.33, demonstrating considerable alignment but far from ideal. (F) Valence state. The Fe^{2+}/Fe^{3+} ratio in Fe-doped $LiNbO_3$, as altered by oxidation or reduction treatments, has been determined.

Imaginative metallurgy is the research area of H. Gleiter and colleagues. They have considered an old problem--grain boundary energy determinations, as a function of mismatch angle between grains in metals--using

a novel method to avoid the many samples and multitude of measurements. Gleiter does, in fact, use many samples and a multitude of measurements, but in an ingenious way which drastically reduces the drudgery. He starts with a crystallographically oriented (001) single crystal sheet of copper, for example, then places on this sheet $\sim 10^4$ single crystal spheres, each of about 100 μm diameter. Their orientations are determined, *en masse*, by x-ray diffraction. Obviously the spheres are positioned at random initially, which generally means high-energy contacts. The spheres rotate toward lower-energy orientation when the ensemble is heated, typically for about 100 hours up to temperatures within 1 degree of melting; they also rotate upon the application of pressures (up to 30 kbar). Among the observations that Gleiter *et al* have made is that the grain boundary energy, in Cu-Ni, depends on the electron-to-atom concentration.

Polyethylene is a "metal" that this group has examined in some detail. In a study of thin molten polyethylene films, J. Petermann and Gleiter have used defocus-contrast transmission electron microscopy. They observe a pattern of quasi-parallel crystals, each about 400-500 Å thick, separated by thin amorphous regions before melting, the crystals being aligned approximately parallel to the direction of the drawing that was used in producing the films. On melting (about 150°C), the initially sharp contrast between the amorphous and the crystal regions is reduced, but considerable structure remains. If the film is electron-irradiated (in the microscope), the resulting pattern is very similar to the original one. Petermann and Gleiter argue that this lends weight to the identification of the molten film as a smectic liquid crystal, where each layer is formed by folded molecules whose chain axes lie approximately parallel to the direction of drawing. Upon raising the temperature from room temperature to 130°C, the extent of the amorphous region increased over two-fold. Petermann and Gleiter have also looked at recrystallization in polyethylene at free surfaces and find the process to be basically the same as occurs in metals, suggesting that metallurgical concepts can be profitably carried over to polymers--at least to semi-crystalline ones. (A. Sosin)

COMPUTER SCIENCE

VISUALIZATION TECHNIQUES AND AESTHETICS AT THE COMPUTER-AIDED DESIGN CENTRE, CAMBRIDGE

The term "computational geometry" refers to those applications of computer technology which are concerned with problems of computerized shape description and visualization. Automated drafting systems, computer-aided geometric surface design, numerical control technology, finite-element modeling of structures, printed circuit board design and computer animation are only some of the important facets of computational geometry. Since all of these applications are concerned with lines, curves, surfaces and 3-D shapes, the natural mode for the presentation of "solutions" to such geometric problems is visual, or graphic. For that reason, computational geometry is often incorrectly thought of as a sub-branch of computer graphics. Whereas "computer graphics" is concerned with computer languages and techniques for displaying computer-generated pictures on graphical output devices (cathode-ray tubes, for example), the term "computational geometry" refers to the mathematical techniques and associated computer software used for the digital computation of shape representations.

The Computer-Aided Design (CAD) Centre, located just outside the town of Cambridge, was established nearly a decade ago by the Department of Industry to develop CAD techniques for use by British engineering firms. Over the years, an increasing proportion of the Centre's funding has come from consulting and service contracts with private industry. The present staff consists of about 150 professional and support personnel from various engineering disciplines (mechanical, industrial, electrical, chemical and civil) and from various branches of computer science and technology. In addition to research and development of computer methods and engineering applications software, the more senior staff members act as consultants within their own specialization.

Over the years, the CAD Centre has developed a host of computer

software packages for commonly occurring problems of engineering design and analysis. Examples include TORVAP (torsional vibration analysis), DYLOAD (analysis of dynamic loading of bearings), PCB1 (computer-generated artwork for printed circuits), LENS (design of electromagnetic and electrostatic lenses), MULTICOL (distillation column simulation) and PRESBEAM (design of pre-stressing cable profiles in continuous concrete beams).

However, the most notable achievements of the Centre are its unique computational geometry packages for graphical display and visualization of 2-D and 3-D shapes. The most important of these are the following:

GINO-F: A comprehensive library of machine and display-device independent routines for the production of graphical output representing objects of all degrees of complexity.

THINGS: A library of FORTRAN routines for the mathematical definition of solids.

HIDDEN LINES: A program for the generation of perspective views of mathematically defined solids with all hidden lines removed.

GREYSCALES: A program for the generation of perspective half-tone views of a mathematically defined model with continuously shaded grey-levels for display on a cathode ray tube (CRT) display device.

MEDALS: A computer-aided drafting system for the production of engineering or architectural drawings.

My hosts at the CAD Centre were R. Newell and T. Sancha who have contributed greatly to the development of the visualization packages just described. At present, they are working on a very exciting new system for full color display of mathematically defined 2-D or 3-D objects.

This new system, called Advanced Graphics Display Terminal (AGDT)--BUGSTORE, was designed by Newell and Sancha. The BUGSTORE hardware consists of a color raster-scan display designed to operate as a peripheral connected to any 16-bit computer. The so-called frame buffer is a random access store which, with a 400-nsec cycle time, can store 1.5 million bits of picture information. It uses metal oxide semiconductor (MOS) technology and is picture-element ("pixel") addressable so that each of the 1024 pixels can be individually altered. The complete picture can be changed in 70 msec.

What all this fancy hardware does is perhaps best explained by the applications which I was shown. The first of these was done by Newell and Sancha for a local wallpaper manufacturer. The problem is that of color selection in the design of a new floral patterned wallpaper. To begin, the desired pattern of flowers, leaves, stems, etc., is digitized from a drawing and stored in the computer. (This involves simply storing the key lines of the drawing and is rather straightforward.) The drawing is then displayed on the CRT, and the designer begins to "paint" the pattern by selecting desired colors through a teletype hooked into the computer and display system. In this particular application there are only several distinct colors required (e.g., the background, flower petals, stems, leaves, etc.), but each of these colors can be selected from anywhere in the visible spectrum. The intensity of the color is also under user control. The up-shot of all this is a full color CRT picture of the wallpaper pattern, the several colors of which can all be changed dynamically until the most aesthetically pleasing color composition is achieved. This is a beautiful and impressive demonstration to see. Whereas conventional color-studio techniques for color composition selection are arduous and practically limited in the number of alternatives which can be considered, the computerized color-selection technique provided by BUGSTORE is fast, simple (for the user) and unlimited in the range of alternatives which can be examined.

The second application which was demonstrated was a consulting job done for a local building-brick manufacturer. The problem is that of visualizing the final appearance of a brick wall (of a house, for instance) which is constructed from a mix of bricks of different color shades. It's typical for a building contractor to mix bricks of two or three shades in order to create a certain aesthetic effect. He may also, on occasion, want to use colored mortar in laying the bricks. With a very simple computer program on the BUGSTORE system, Newell and Sancha are able to provide virtually instant answers to questions such as: What if we use a 20-30-50% mixture

of three shades of red brick layed with white mortar? (The shade of any given brick in the wall is determined by a random number generator based on the 20-30-50% stock pile.) The colors of bricks, the percentage of each in the stock pile and the color of the mortar are all parameters which the user may vary to achieve the best aesthetic effect. It is absolutely fascinating to watch the dynamically changing colors in the CRT-displayed brick wall as one or more of these parameters are swept continuously through their ranges.

As one of the Centre's glossy advertising brochures immodestly admits: "At the Computer-Aided Design Centre, Cambridge we have the most advanced visualization techniques in Western Europe, and offer the most economical system of its type at present available to the technical and scientific user." On the basis of my several years familiarity with the work of the CAD Centre and my recent visit to the facility, I have absolutely no reason to doubt the veracity of these claims. (William J. Gordon)

COMPUTERIZED COMMAND AND CONTROL OF UK POLICE RESOURCES

On 19 January at IEE headquarters in London, Arthur T. Burrows, Acting Director of the Police Scientific Development Branch of the UK's Home Office, presented a lecture on the computer-based system that has been installed in Birmingham and Glasgow for keeping track of police resources and optimally allocating them. This system has reduced to 2.5 minutes the time from an emergency phone call until the arrival of appropriate personnel and equipment.

In an earlier era, electrical communications with the policeman on the beat went over a special telephone network, terminating in call boxes surmounted by blue lights. The light would flash to summon the policeman to the telephone inside the box. The first radio communication with police cars used the Morse code, which was later supplanted by radiotelephony. But the volume of such communications has grown so great that measures are required for shortening the transmissions and relieving the congestion of the radio spectrum. In Britain, the police use the upper half of the FM broadcast band and the 147-MHz band to communicate with vehicles, while shorter-range personal transceivers operate in the uhf band.

The new system provides for the transmission to or from the police vehicle of both 1-sec bursts of frequency-shift-keyed digital information and simultaneous voice transmission of any necessary messages not provided for in the standard digital repertoire. The latter includes information about the status and location of the vehicle within 1.5-km squares. (More exact information is considered undesirable, as it would give the policemen the impression of being watched too closely.) Location information is sent from the vehicle whenever it moves from one square to another, the designation of the new square being set by the driver before he presses the button to transmit it. There are also buttons to be pressed upon arrival at the scene of an incident and in case of panic, the vehicle's call sign being automatically included in the message. In addition, an acknowledgment is sent automatically upon receipt of every message.

The Glasgow system uses two Ferranti Argus 500 computers with 2-megabyte fixed-head disks plus magnetic-tape storage and is entirely of British manufacture. The operating-room consoles were designed by the Royal College of Art in South Kensington. The two women who operate the system are provided with both alphanumeric displays and maps of the vicinity of any incident, first showing the available vehicles and their call signs and then, if desired, all vehicles, so that the optimum assignment of resources can be made. At a lower level, there is only an alphanumeric display for each division controller, while at a higher level the entire country is tied together via a telex network.

The computer builds up a chronological file on each incident, which is found to be very useful in the law courts. The system is designed to avoid any need for pencil or paper, and it helps the operators by presenting lists of available choices of

action in response to various situations. In addition, it monitors all actions and issues reminders when responses are late.

Burrows was assisted in his presentation by Dr. Gordon Turnbull of the Home Office, who mentioned that the Argus 500 computers are to be replaced by Argus 700S's in 1978. Also participating were Chief Superintendent Peter Coates of the Birmingham police, whose computerized command and control system was put into operation on an experimental basis in 1972, and Alec McNair of the Glasgow police, whose system has been in operation and working well since May 1975. Three more counties in Britain are soon to commence using similar systems, and several other countries have expressed interest in this approach to command, control, and communication (C^3) for police and emergency services. The operating experience that will be gained should be very useful to the designers of military C^3 systems. (Nelson M. Blachman)

EDUCATION

ON THE CARE AND FEEDING OF TECHNOLOGY IN ACADEME: CRANFIELD INSTITUTE OF TECHNOLOGY

Approximately $6,000,000 are invested in research within academic institutions each year by British industry. Of this amount, approximately one-half is given to the Cranfield Institute of Technology. That statistic in itself makes it worthwhile to ask: What goes on at Cranfield?

The answer is applied research. Fundamental research is an activity at Cranfield but, with few exceptions, always with reasonably clear aims as to its applications.

There is little doubt that the Cranfield Institute is unique in the UK. It would be reasonable to expect to find such an institute located in the industrial heartland--in Birmingham or Manchester, say. Not at all. Cranfield is located in the rural and peaceful countryside, some 55 miles north of London. Students live on campus as do some of the faculty. The external appearance of Cranfield bears no resemblance to industry; it bears little resemblance to most universities. In fact, the Institute is mainly a cluster of former residences occupied previously by the Royal Air Force and located about 10 miles from the nearest railway stations.

The description of the origins and much of the composition of the Institute given in the *European Scientific Notes* in 1970 (ESN 24:321) remains largely intact. The reader is referred to this excellent account by R.D. Mathieu.

Most academic institutions in the United Kingdom receive about 90% of their funding from the Department of Education; Cranfield receives about 50% in this way. Research activities account for an additional 30%, a little over a third of which is received from industry. Accordingly, the Institute prospectus starts with the statement "Cranfield is a national centre of postgraduate and post-experience studies and research in technology and management."

Cranfield is divided into a Faculty of Technology and a Faculty of Management. The former (and larger) consists of a College of Aeronautics, School of Automotive Studies, Department of Electronic and Control Engineering, Department of Materials, Department of Mathematics, School of Mechanical Engineering, School of Production Studies, Unit for Precision Engineering, Ecological Physics Research Group, and National College of Agricultural Engineering. As one might surmise, the size determines the title; colleges are largest, schools and departments follow, then units and groups. The Unit for Precision Engineering is fully self-financing; it offers no academic program of its own but does serve as a doctoral studies resource. The Unit manufactures and sells complex machines, including spinning equipment and gyroscopic systems.

An impression that Cranfield is as much a research center as an academic institution is strengthened by the nature of the faculties in the Institute. About one-half are academic; the remainder, largely employed on three-year contracts, are research faculty with much the same privileges as the academic members. Their livelihood is tied directly to the supply of

in-house research funds, and this explains an emphasis on securing funds for research, even by the academic faculty. Furthermore, each of the divisional units (i.e., colleges, departments, etc.) operates from a budget which provides the privileges and perils of a subsidiary in a holding company. For example, the Materials Department has about 12 academic members of staff and a roughly equal number of research members. It operates on a budget of about $1,000,000 per year, with just over half of this obtained from outside research sources. Yet it operates with only 10 full-time research students. To do so, the Department engages the aid of technicians and machinists for which it must pay from its budget, precisely as a business venture would.

The industrial commitment is apparent in the courses of study that may be pursued: aviation electronics, railway engineering, gas turbine technology, design of production machines, international business, etc. The Department of Materials, under the direction of D.W. Saunders, where I spent the bulk of my time, reflects this situation in itself. The studies in polymeric materials engineering encompass the more fundamental ones in the department. C.B. Bucknall *et al* have carried out a series of experiments on creep and strain damage in rubber-toughened plastics, including an acrylonitrile-butadiene-styrene (ABS) emulsion polymer and high-impact polystyrene. One of the results of this study has been an evaluation of the relative importance of crazing and microcracking *vs* shear deformation. Once the stress level is sufficient, the importance of microcracking increases exponentially with applied stress. In most books, this effort is a rather fundamental study; however, it fits into the applied program that is continuous with this work. In metallurgical engineering, under the leadership of P. Hancock, the more fundamemtal studies concern yield and fracture mechanisms, but the bulk of the work is applied: the attack of marine gas-turbine materials to corrosion by V_2O_5, Cl, SO_4, the selection of sheet metal steels for automobiles and their deformation on impact, salt water corrosion in steels, etc. The last example is one of several to be found in the Department emphasizing the importance of off-shore technology, obviously related to North Sea oil recovery. Other courses of study in the Department of Materials are off-shore structures and welding technology, with emphasis on off-shore welding.

A frequent point of discussion in the UK is the reputed lack of liaison between industry and universities. Cranfield Institute of TTTTechnology stands out as a vivid counter-example. (A. Sosin)

ELECTRICAL ENGINEERING

COMMUNICATION ENGINEERING IN FINLAND

Communications research and development in Finland is carried out principally at the Helsinki University of Technology (Helsingin Teknillinen Korkeakoulu, HTK) in its Telecommunication Switching, Communication, and Radio Laboratories; at the Technical Research Center of Finland (Valtion Teknillinen Tutkimuskeskus, VTT) in its Telecommunication Laboratory; in the Telegraph and Radio Departments of the Post and Telegraph Administration (Post- ja Lennätinhallitus, PTT); at Nokia Electronics Company; in the Electrical Engineering Department of the University of Oulu; and in the Helsinki Telephone Company's Research Institute. The HTK and VTT are doing a considerable amount of research in this area--supported in many instances by the PTT.

In assessing the importance of the Finnish activities reported below, it should be kept in mind that the population is 4.7 million--about 1/50 that of the US. Its area is 130,000 square miles--72% of it forested--and wood products are thus a major industry. In 1975 the GNP was $5100 per capita as compared with $7060 for the US and $3840 for the UK.

The town of Espoo with a population of 120,000 is the fourth-largest city in Finland and lies 6 miles west of Helsinki. In 1969 the HTK moved from Helsinki to a part of Espoo that has been designated "Otaniemi", and most of the facilities of the VTT are located there, too--some of them in HTK buildings. The newest facilities of Nokia Electronics are located in Kilo, which is another part of Espoo. These

facilities, like other new buildings in Finland, are beautiful and spacious, as there is a great emphasis on the care of the environment, and something like 194 ft^2 of floor space per industrial employee and 269 ft^2 per engineering student are required by law.

The VTT was established in 1942 under the Ministry of Commerce and Industry to carry out research, development, and testing, as well as the dissemination of technical information. It has 1500 employees (35% of whom are university graduates) and 32 laboratories in the fields of Building Technology and Community Development, Materials and Processing Technology, and Electrical and Nuclear Technology, with a total of 620,000 ft^2--five-sixths of this space in Espoo and the rest divided among Helsinki, Tampere, and Oulu. Its budget is about $18 million per year, roughly half of which comes directly from the national government and half from government and industrial research contracts. The work done under the latter is sometimes confidential.

The VTT focuses on engineering research to support industrial product development and to protect the interests of consumers, society, and the environment. In addition, it carries out fundamental research in order to maintain technical preparedness, develops methods and equipment for the testing and control of materials, and maintains measurement standards. Among its larger goals have been the alleviation of Finland's trade deficit by accelerating the development of new products, the introduction of greater automation to relieve the shortage of labor, and the search for new energy sources. It also serves as a headquarters for Finland's scientific attachés, distributing their reports to industry and to research institutes, and organizing conferences for them and lending the materials they collect. In addition, it acquires documents directly from abroad, e.g., from the US and Canada through the Scandinavian Documentation Center in Washington.

The VTT's Division of Electrical and Nuclear Technology comprises seven laboratories, including the Telecommunication Laboratory, which in 1974 had 53 employees and a budget of about $6.5 million. The Radio Section of this Laboratory is working on electromagnetic propagation (including EMPulse generation and coupling into telephone lines), radio communication and direction-finding (DF) equipment, radar, special measuring instruments, and antennas. Antennas have replaced radar as the principal activity of the Radio Section; they now include a phased array for ships, an electronically steerable traveling-wave antenna, and a log-periodic monopulse DF antenna.

The encryption of speech is among the research topics of the Telephone Section of the VTT's Telecommunication Laboratory. It involves a modification of delta-modulation in which the speech waveform is sampled at truly random times. Each sample shows either an increase (represented by 1) or a decrease (represented by 0) from the total represented by the previously transmitted bits (0's and 1's), and every bit is conveyed by a pulse of the same shape--the information (0 or 1) being carried in its time of occurrence, which is slightly delayed from the sampling time. The amount of the delay is such that a secret binary sequence (0's and 1's), re-initiated at the time of the preceding pulse, has the desired value at the time of the new pulse. Thus, the receiver has no need to generate the sequence of random sampling times, and there is no need for long-term synchronization between receiver and transmitter.

Although this approach increases the bandwidth requirements and hence the susceptibility to noise and interference, it is considered to provide a high degree of secrecy. The scheme is not highly sophisticated, but it represents a basis upon which to build up a capability in this field.

The Telephone Section is also working on the emulation of various manufacturers' call-routing minicomputers and the simulation of telephone exchanges and networks in order to be able to select the most suitable one by tests in simulated traffic. The choice between IBM's and ITT's programming languages for telephone systems is being studied, and plans are being developed for the transmission of data along with speech on the telephone network. In addition, an error-rate analyzer is being constructed, optical-fiber transmission is being investigated, and small telephone exchanges are being built for the military. It can thus be seen that the VTT is engaged in a wide range of R&D in the field of communication.

Nearby, at the Helsinki University of Technology, the Electrical Engineering Department is divided into five groups of laboratories which carry out its teaching and research: Power Engineering, Electromagnetism, Electronics, Control Engineering, and Communication Engineering. The last of these includes the Acoustics, Communication Switching, and the Communication Laboratories. The Communication Laboratory, headed by Professor Seppo J. Halme, who earned his first two degrees at the HTK and his PhD at MIT, offers courses on traffic theory and switching, as well as the usual work on the theory and practice of communication engineering.

Aside from the diploma projects, which take at least six months after the completion of the four undergraduate years of study, and the thesis research, whose publication is required for the advanced degrees (licentiate and doctorate), the Communication Laboratory is involved in four research projects--three of which are supported by the PTT: the study of selective fading at 6.7 GHz over a 49-km path through its effect on pulse envelopes and the optimization of a receiver subject to this fading; the construction of laboratory equipment for the comparison of various methods of synchronizing data communications; and experiments with optical glass-fiber transmission at 50 kbit/sec and 2 Mbit/sec, with work in progress toward higher speeds. These optical-fiber experiments are intended to provide experience with this medium and to prepare for participation in Nordforsk work in this field, under which low-attenuation fibers are to be drawn in Trondheim, Norway; in Stockholm, Sweden; and perhaps in a year or two, in Espoo as well. Because of its very high proportion of telephones per capita (0.35), Finland may well decide to install optical-fiber transmission systems in the southern, more densely populated part of the country.

The data-communication synchronization work, the second project mentioned above, is related to the Finnish part of the Nordic Data Network, for which Ericsson, Nokia, and ITT equipment is to be delivered between 1978 and 1980. It is to be fully digital, with many advanced features such as packet switching.

The fourth research project is a satellite-ranging laser system which is a joint effort of the Communication Laboratory and the Geodetic Institute, partially financed by the Academy of Finland and the nongovernmental Finnish Academy of Sciences. The system is located in Matsähovi, 150 m east of the HTK Radio Laboratory's 13.7-m radiotelescope (see "Radio Research at Helsinki University of Technology", by D.K. Cheng, ESN 31-2;43-45). The assembly and testing of the system have been completed, showing an accuracy of 0.8 nsec on the 200-m test line, and satellite ranging is now commencing. With the cooperation of the Geographical Survey Office of Sweden, the system is intended to establish geodetic ties between Finland, Sweden, and other countries and to study crustal movements, especially of the lithospheric blocks. Since this project involves numerous techniques from a wide variety of fields, it is providing a great deal of training as well as the foundations for international scientific cooperation.

The work at the University of Oulu is concerned mainly with pulse-code modulation (PCM) and with telephone transmission techniques suitable for the special conditions of northern Finland, while the PTT and Helsinki Telephone Company work is largely of a developmental nature, dealing with time-division multiplexing and switching, traffic theory, and radio propagation. In addition, a small amount of work, supported by industry and by telephone companies (of which Finland has 63 plus the PTT), is being done at the Tampere University of Technology on the operating characteristics of specific telephone systems. Nokia Electronics, with 2400 employees, has developed a wide range of electronic systems for telecommunications, industrial automation, data processing, etc., including combinations of these systems for such applications as railway reservations and the remote control of the power-distribution network, as well as navigation and military communication systems.

Finland has a 1948 agreement of friendship, cooperation, and mutual assistance with the USSR, which is regularly renewed and which the latter uses to intervene in her domestic affairs. Moreover, the 1947 Treaty of Paris severely restricts the size of the Finnish armed forces (which inflicted over half a million Soviet

casualties in the 1939-44 war), making it necessary for Finland to be careful not to annoy her eastern neighbor. Thus, Soviet-Finnish friendship societies flourish although the war killed 2% of the Finns and made refugees of another 10%, not to mention the reparation payment exacted by the USSR. The 425,000 refugees from the ceded eastern part of Finland were resettled by sharing the remaining nine-tenths of Finland with them.

Finland, though small and a bit isolated by her geography, is evidently active in the field of communications and is keeping abreast of developments throughout the world. Further details of the work mentioned above will be found in a forthcoming ONRL report. (Nelson M. Blachman)

ENVIRONMENTAL SCIENCES

ACID RAIN PRECIPITATION IN NORWAY--THE SNSF PROJECT

Since the 1920s acidic water has been recognized as being responsible for the disappearance of freshwater fish such as trout and has become a growing concern in the Scandinavian countries. In the early 60s it was suggested that this was a consequence of the acidification of lakes and rivers by acid precipitation. Measurements of precipitation in Europe, and particularly in the Scandinanvian countries, showed increasingly more acid, and it was suspected that greater emissions of sulphur dioxide from fossil fuel combustion were responsible for acidification of rain and snow. The consumption of coal and oil in Europe has increased by more than a factor of 2 during the last 20 years. The yearly dispersion patterns for acidity in precipitation indicated that pollutants might be carried by air currents over long distances from the heavily industrialized areas of Central and Western Europe to the Scandinavian Countries (see ESN 30-4:171). In 1969, Sweden brought this problem to the attention of the Organization for Economic Cooperation and Development (OECD), and in 1972 OECD launched the "Cooperative Technical Program to Measure the Long-Range Transport of Air Pollutants" (The LRTAP Project).

The long-term social and economic problems associated with acid precipitation and its control are particularly complex and vexing since rain and snow take no account of existing political barriers. In Norway, early in 1972, concern for the disappearance of trout and salmon from many rivers and lakes, combined with fear for forests and forest-related industries, led to an interdisciplinary research project: "Acid Precipitation Effects on Forest and Fish" (The SNSF project). This project, part of the OECD's LRTAP project, was supported by Norway's Agricultural Research Council, the Council for Scientific and Industrial Research and the Ministry of Environment who came in, in 1973, as a third sponsor when the magnitude of the financial effort became clear. In addition, institutes involved in this multidisciplinary research have also contributed some of their own resources. There are about 11 institutes in this project headed by Dr. L. Overrein, the research director, whom I visited in Aas, near Oslo. The research carried out by these institutes is on a contractual basis and supports about 30-40 scientists on a part-time basis.

In order of priority, the objectives of this project are to "...establish as precisely as possible the effects of acid precipitation on forest and freshwater fish; and investigate the effects of air pollutants on soil, vegetation, and water, to the extent required to support the primary objective." The original plans called for completion of the work by the end of 1975; however, the Norwegian Parliament has extended this work until December 1979. The first phase had a total budget of some $2 million. Furthermore, European cooperation in this area will be continued in the form of a multinational monitoring system for air pollution. Therefore, much of the acquired expertise is expected to be used in future projects after 1980.

The minimum pH value expected in pure water in equilibrium with ambient concentrations of atmospheric carbon dioxide is 5.6. Thus, "acid precipitation" is defined as rain or snow with pH values less than 5.6. In Norway, the geographical distribution of wet

deposition; i.e., deposition of SO_2 by rain or snow (rather than by dry deposition found when SO_2 is present in aerosols that settle on the ground), reaches a zone of maximum acid precipitation along the southern coast where the annual mean pH is about 4.3 and the annual mean deposition of excess sulphate is about 4 g of SO_4/m^2. To put matters in their proper perspective, we are talking about annual deposition of SO_4 on the order of one teaspoon per m^2 per year.

The presence of these high concentrations on the southern coast of Norway is partly due to rain induced by orographic lifting; i.e., precipitation occurs when air masses loaded with moisture and pollutants are forced over mountainous regions. About 2/3 of the acidity is associated with sulphate and 1/3 with nitrate. Additional amounts of sulphur are deposited though dry deposition of SO_2, although such contributions are much smaller than those incurred by wet deposition.

Most of this deposition happens over rather short periods of time. For example, it is not uncommon that 25% occurs in a 15-day interval. Periods of high acidity are common during the spring melt, when pollutants accumulated in the snow are released, and are also found in the autumn during heavy rain. These two periods of increased acidity behave somewhat differently although they are both lethal as far as fish life is concerned. In the spring, because water at 4°C is denser than at 0°C, the snow run-offs are confined to very shallow surface layers. In the fall, however, the acid inputs are easily mixed through the water column.

Research pertaining to the problems discussed above can be roughly subdivided into acid precipitation effects on fish, forest, freshwaters, and other ecosystems; the network required to sample acid rain; its chemical analysis; data interpretation; the numerical modeling of long-range transport of pollutants in the atmosphere; aerosol physics and related studies on pollution. In the following I shall discuss some of the research on fish and briefly summarize some of the findings on forest research.

Norway has in excess of 200,000 lakes. Those affected first are small, high altitude lakes with low buffer capacity in the catchment area where bedrock is mostly granite. Originally many of these lakes were densely populated with slow-growing fish. The first symptom of acid stress is usually a decrease in population density with the remaining fish growing faster due to increased food abundance. The fry are mostly affected by a fall in pH, but if the pH falls below certain levels, the older fish also die.

All of the Scandinavian countries and particularly Norway have very poor (granite) soil which is highly resistant to chemical weathering and is only partially covered by a thin humus layer. Such soil does not constitute an efficient buffer against acid precipitation. Salts, such as Ca, Mg, Al which are found in healthy streams, are chemical compounds dissolved from the soil by rain and melting snow. The soil conditions play an important part in determining the acidity of the streams and lakes. At the spring melt the soil is frozen and therefore the melting snow is a surface run-off that does not penetrate into the soil; in the autumn, on the other hand, the soil is saturated with water due to heavy precipitations and the acid rain also tends to run-off as a surface run-off without percolating into the soil. Thus in both these cases the acid water does not come into contact with rocks and cannot dissolve a substantial amount of salts.

Many tank experiments have been performed to determine acid-tolerance and sensitivity of various species. Causes of death were attributed to destruction of body salts. All freshwater animals have higher salt concentrations in their tissues than the water that surrounds them, with a resulting osmotic uptake of water. Excretory organs excrete surplus water and salts. This loss must be replaced, and in most freshwater animals salts are taken-up actively from the very dilute salt solutions surrounding them. In experiments it was found that this active uptake mechanism is inhibited in the presence of acidity in the water. It therefore seems that fish have a restricted ability to regulate their salt budget. It was found that sodium and chloride concentrations in blood plasma are always reduced in acid-stressed trout with the lowest value found in fish that have died from this stress. Also, loss of potassium from muscle tissue was reported. It was found that, with abundant food, the

fish in neutral water (pH = 6) weighed more than twice as much as comparable fish in acid water. Survival of fish then depends on both pH and salt levels. Experiments have shown that an increased salt content in water reduces mortality: distilled water with pH of 5.6 is nearly as lethal as melt-water (acid rain or snow) with pH of 4.4. Based on the above experiments one expects fish population to be eliminated first from lakes with the lowest concentration of dissolved salts.

As far as research in forestry is concerned, the studies have been divided into two main topics: germination and growth of forest trees and changes in forest production potential. Irrigation of field plots with acidified water shows an increase in the leaching of metal cations and reduction of basal soil characteristic. Soil biological processes are little influenced by acid water (pH between 6 and 2). Spruce-seed germination and seedling establishment are negatively influenced by acidification, and surveys of diameter growth in spruce and pine are yet inconclusive, for the time scale of 3-4 years is too short compared to the maturing age of such trees.

What are the solutions to these problems? Obviously from an ethical point of view something must be done to prevent the further degradation of the natural resources of Scandinavian countries by the industrialized countries of Europe. The introduction of lime in streams and water in an attempt to neutralize the acidity is a temporary solution, but there are far too many lakes to monitor effectively. Probably the only solution lies in establishing tighter European-wide restrictions for clean air. Such a measure might be aided by the soaring price of fuel which should encourage industries to seek the most efficient means of using it and disposing of its side effects.
(A. Barcilon)

ONAL REPORTS

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

GENERAL

APPEAL TO A HIGHER AUTHORITY: BRITISH COUNCIL OF CHURCHES PUBLIC HEARING ON FAST-BREEDER REACTORS

One of the lessons to be learned in the development of contemporary technology in democratic societies concerns the wisdom of including the public sector in the decision-making process. Failure to do so--whether real, imagined, or pretended--has been a charge frequently made in the nuclear discussion in the US. So it was that Mr. Anthony Wedgewood Benn, UK Secretary of State for Energy, called, in mid-1976, for a public debate on the policy that the UK should adopt toward nuclear power, in general, and fast-breeder reactors (FBR), in particular.

The latest voice to weigh in, in response to Benn's call, is the Church. On 13-14 December 1976, the British Council of Churches conducted 10 hours of Hearing on the proposed Commercial Fast Reactor (CFR-1). Interest in the Hearing was heightened by Benn's disclosure, made some two weeks before the Hearing, that a radioactive leak had occurred at the Windscale nuclear power plant, and had not been reported to him for several weeks. This disclosure was well publicized on radio, TV, and in the press; the fact that the emission was barely above the established acceptable level was usually treated as a minor detail, if at all.

The hearings were chaired by the Rt. Rev. Hugh W. Montefiore, Bishop of Kingston-upon-Thames; his listing in *Who's Who 1976* includes publications on "Can Man Survive?" and "Doom or Deliverance?". The Hearing's secretary and the person who provided the nuclear "know-how" for the Church was Mr. D.L. Gosling, currently a lecturer in the Department of Theology at the University of Hull. Gosling served as a lecturer in nuclear physics at Delhi University and a research assistant in nuclear physics at Manchester University.

The panel which heard the testimony consisted of Bishop Montefiore; Peter Adams (Vice-Chairman, UK Atomic Energy Authority); Sir Alan Cottrell (Master of Jesus College, Cambridge

and formerly Chief Scientific Adviser to the Government and a highly regarded metallurgist); Prof. David Henderson (U. College, political economy); Alan McKnight (former Inspector General, International Atomic Energy Authority); Lord Kearton (Chairman, British National Oil Corp.); Keith Richardson (industrial correspondent, the *Sunday Times*); Graham Searle (Director, Earth Resources Research, Ltd.); and Rev. Prof. J. Whyte (St. Andrew's U., practical theology and Christian ethics).

In its first session, the panel considered the quantity and quality of end-use energy required by the year 2000. R. Bulgrave (policy advisor to the Board of British Petroleum) and P. Chapman (Director, Energy Research Group, the Open U.) presented differing projections. Belgrave predicted a doubling of energy requirements in the UK by 2000; Chapman estimated half this increase. Possible minimization of energy usage by governmental influence was pursued next. A lively discussion followed when J. Davoll (Director, Conservation Society) attacked profligate energy-consuming life-styles and advocated return to a simpler life, but he provided little direction on ways to achieve this in a democratic manner.

CFR-1 then came under scrutiny. W. Patterson (Friends of the Earth, UK) predicted that fast-breeder reactors would lead to increased centralization of decision-making processes; more coal burning was recommended. Not surprisingly, Sir John Hill (Director, UK Atomic Energy Authority) then pointed out the large pollution problems of coal over nuclear energy sources.

The familiar list of potential risks of CFR-1 was debated next: bomb-like explosions, carcinogenic implications, radioactive waste disposal problems, etc. Predictable arguments were made by predictable proponents, with predictable counter-replies. Novel and, for this Hearing, of possible special impact, was the discussion of J. Ravetz (Secretary, Council for Science and Society, London). He said, "A nuclear reactor is a completely different sort of system from an organism, human or social. Its design has been conceived abstractly, and has not had a chance to evolve through long experience. It is brittle in response to disturbance, not homeostatic like an organism. Accidents not anticipated in the original design are liable not to be buffered, but to rip through the system to culminate in disaster....Abstention from the nuclear option involves a challenge, in which all our common technological and social skills will be engaged. In this way, the choice is ethical rather than technical: where should we place our confidence?"

The Hearing continued in a more established vein with considerations of financial, economic and technological feasibility followed by an overview of alternative sources--coal, solar, wind power, wave power, geothermal, nuclear fusion--and conservation. Benn closed the Hearing with these comments. "The public debate now taking place, of which this Hearing is a part, is a genuine debate in that the Government have not yet taken a decision, and therefore the recommendations made by the Commission today will be in time to influence our thinking....In the decision about the FBR, it seems to me that the most important thing is that we should take adequate time before we decide what to do....An issue of this magnitude must have time and must have information available." The Hearing resulted in no recommendations, despite Benn's apparent request for them. The proceedings are to be published at the end of March as *Nuclear Crisis, A Question of Breeding*, edited by Montefiore and Gosling and published by Prism Press.

A subsequent criticism of this Hearing has been its emphasis on scientific and technological data with insufficient attention to the moral aspect. Ravetz's comments are the noteworthy exception. Bishop Montefiore anticipated this criticism with the defense that "Christianity is, by its nature, a world-orientated religion. The BCC's interest in future energy supplies is not an aberration from its main concerns, but issues directly from its deepest convictions about the nature and activity of God."

Questions remain. Accepting the thesis that public debate is desirable, how should it be conducted? Should special groups, such as the Church, be invited and, if so, why not teachers, scientific bodies, trade unions, etc? Would it be preferable to conduct local hearings instead (or in addition), such as town meetings? Would local hearings suffer from heterogeneities

that special group meetings avoid? What products should be expected from these meetings--summaries, recommendations, etc.? Is the real purpose of such hearings educational, in fact, rather than advisory? What of the expense? How many meetings can the "experts" attend and still survive? How will "grass-root" response be evaluated and integrated? Is there any alternative to public hearings (e.g., the Science Courts proposed by Kantrowitz) that would be more valuable, would reflect public interest, and would acquire public acceptance? In fact, isn't this the function of our established democratically elected constituent assemblies? (A. Sosin)

TELEPHONES IN ISRAEL

In Israel, every bus and every taxi always has its radio receiver on for the hourly news broadcasts. In case of a military alert the drivers and their passengers might hear word of where they and the vehicles are wanted. Getting a message through by telephone, however, is another matter, as there is a shortage of both telephone equipment for homes and the slotted tokens ("asimonim") used in pay phones.

The tokens have nearly disappeared because they represent an excellent financial investment. The Israeli pound (lira, abbreviated IL) is devalued by 2% on the first day of every month, and the price of tokens is raised from time to time. Hence, a post office will sell no more than 4 tokens to a customer--if there are any to sell--and private suppliers sometimes offer them at a premium above the IL 0.50 ($.05) present official price. A few telephones that take IL 0.50 coins can be found at the Tel-Aviv airport and railroad stations, but even there the vast majority require tokens.

Along with inflation, of course, come unionization and strikes, which are usually successful--even in the case of such, at least temporarily dispensable, services as university teaching. Faculty members often find their strikes a mixed blessing as they provide time needed for research.

The rapid absorption of immigrants from Eastern Europe, South America, and Arab countries leaves Israel with a shortage of telephone lines for both businesses and residences, necessitating an extensive hierarchy of priorities for the installation of telephones. The list of priorities fills an entire page in the Hebrew editions of the telephone directories, and it covers a page and a half of fine print in the English versions, which are available in hotels. There are, in addition, Arabic editions for some parts of the country.

The telephone priorities (in English) run from A (for cabinet ministers, members of parliament, hospitals, fire brigades, the police, and large businesses needing many lines together with facilities for routing incoming calls to those that are free) down to H. Applicants are upgraded one level per year until they reach C. Thus, hoi polloi can never outrank government offices, embassies, clinics, utilities, daily newspapers, and the homes of local officials and union leaders, who have priority B. Even though engineers, architects, and many others are entitled to priority E, it generally takes people four to six years to get a telephone, and they must then be ready to pay the installation fee, which at present is IL 3000 (about $330). In this respect Israel resembles other developing countries.

In the US, where telephones abound, the choice of where to install the next available telephone equipment is not a political problem. But Israel has had to study this question and has come up with an answer which, if not optimum, at least provides a reasonable framework within which to function. This framework even includes priority B for those wishing telex or data-transmission services and priority G for the homes of military and police officers, NCO's, ambulance drivers, pharmacists, clinical psychologists, the infirm (but particular infirmities rate priority C or D), new immigrants, and several additional groups.

Like most of the world's telephone systems, Israel's is not as well maintained as that of the US--perhaps because there are no courses or research in telephone engineering at the university level in Israel. Under Prof. Benjamin Epstein, Head of the Statistics Department in the Technion's Faculty of Industrial and Management

Engineering, a great deal of work has been done on reliability and maintenance. There is also a strong program of operations research elsewhere in the same Faculty, as well as in Tel-Aviv University's Statistics Department headed by Prof. Harold Greenberg. But these disciplines are not yet being applied as widely as they ought except, perhaps, in the defense program, which absorbs much of Israel's best talent.

Israel's telephone system, however, does offer at least one advantage over the American system: from a pay phone one can dial a call directly to any part of Israel or to other countries after having inserted one or more tokens, and they will be automatically used up, one at a time, as one talks, the remainder being returned at the end of the call. (Nelson M. Blachman)

BRITISH SALARIES TAKE A POUNDING

When scientific colleagues meet, salary levels are generally avoided as a topic or, if discussed, treated with a deference reserved for few other topics. Kilovolts, not kilobucks, unless its the size of that research grant. Yet pay does matter, and some figures quoted in the London *Times* (13 Feb. 1977) which are typical of a management class, but probably relate reasonably to scientific professionals, demonstrate the relative financial situations in six countries.

Country	Gross Annual Salary	After-Tax Salary
Belgium	26	15.5
Brazil	28.5	18.5
France	25.5	20.5
Germany	26.5	16.5
Switzerland	28	19
U.K.	10	6.5

The figures are given in thousands of pounds sterling; at this writing, the pound was valued at approximately $1.70. Numbers have been rounded off to 0.5.

The financial straits of the British need no special comment. (A. Sosin)

MATERIALS SCIENCE

MATERIALS ON THE BEAM: SUCCESS AT SUSSEX

The University of Sussex has its origins in the educational splurge of the '60s. Set in an eminently pleasant rural campus near the vacation sea-side city of Brighton on the southern coast of England, Sussex gave promise of becoming a star in the Materials Science skies, particularly since it was designated as a "Science Campus", i.e., emphasis on science beyond the normal degree. That promise has been largely realized; Sussex is one of a handful of major university materials centers in Britain.

Materials Science is organized at Sussex as one of four "Subject Groups". The others are Electrical, Electronics and Control Engineering; Mechanical and Structural Engineering; and Operational Research. R.W. Cahn is Professor of Materials Science (in addition to Dean of the School of Applied Sciences), the only person with this designation currently. There are two Readers: B. Harris (also chairman of the Materials Science Department) and A.W. Simpson (also course convener for the School of Applied Sciences). Four Lecturers and several Research Fellows round out the primary staff. In addition there are several associate members, including M.W. Thompson (who is currently also Pro-Vice Chancellor of the University), J.A. Venables, one chemist, one biomedical specialist, and three polymer science faculty. This organization represents more a voluntary association of a set of individuals located in several academic departments, rather than a formal organization, but it gives every evidence of working well in its environment.

Materials Science research in the Physics Department has been largely directed toward atomic processes, with accelerators serving as favored experimental tools. Thompson's studies are directed toward the physics of charged particle interactions with atoms in solids. He has recently studied the bombardment of amorphous WO_3 with protons, single-crystal W with protons,

and gold polycrystals with A ions, to demonstrate the different types of situations under investigation. The theme of these studies is channeling; i.e., the guidance of bombarding ions by atoms of the solid, so that the atoms behave almost like continuous deflecting strings or planes. Since the charged particle must initially enter the solid, the surface plays a special role. When Thompson and co-workers irradiated the W crystal, with its oxide surface, they found that the channeling yield reflected an oxide stoichiometry in the surface very similar to that of WO_3, extending about 10 Å into the material. Other topics include the energy distribution of atoms sputtered from the surface of gold on bombardment, and the range of heavy ions in solids, particularly in aluminum.

While Thompson's investigations have been centered on metals, P.D. Townsend has concentrated on ionic crystals and glasses. A major distinction between metals and ionic crystals is in the efficiency, in terms of energy transfer, by which atoms are displaced by irradiation. In both cases, the amount of energy required for displacement is a few electron volts. To deliver this small amount in metals, one is required to bombard with MeV electrons or keV light ions. By comparison, displacements can be effected by x-ray photons in ionic crystals. The mechanism for this easier displacement in alkali halides, a subject of much fascination in the past, was postulated by D. Pooley and H.N. Hersh in 1966 as a two-step process involving the absorption of the photon or particle energy to create an exciton. This was followed by a relaxation of the exciton which resulted, very efficiently, in the creation of a vacancy on the negative-ion lattice (an incipient F-center) and a concomitant interstitial halogen (an H-center). The details of this vacancy-interstitial creation are more difficult to establish, and it has been suggested that the atom ejection process proceeds by an atomic replacement sequence along preferred crystallographic directions. In NaCl, the preferred direction is <110> along halogen-ion strings.

Townsend and co-workers have verified this replacement sequence in a direct manner. They have electron-bombarded alkali halides and observed patterns of the atoms on a silica collector plate placed in back of the sample with respect to the incident beam. These patterns result from replacement sequences penetrating the back surface. The patterns each consist of a central member plus an array of spots. These spots are due to halogen deposition only, and can be identified as corresponding to <110>, <112>, and <133> directions. The central pattern is due to the evaporation of alkali metal atoms which accumulate in excess on the surface because of the departure of halogen atoms. In fact, the number of spots observed is more than anticipated from the model. Replacement collisions are expected along <110> directions, conceivable along <112> directions (where the distance between halogen-ions is larger) but unlikely along <133> directions. Presumably there are events which transpire near the surface that account for the latter. The sputtering yields are anti-correlated with luminescent yields, as a function of temperature, which is expected since the exciton energy can either be dissipated as described above or the system can return to the ground state by a luminescence process. Thus the replacement model seems well verified and, furthermore, is even more versatile than realized.

Townsend has also investigated the compaction of silica (i.e., the increase in density) achieved by ion implantation. The refractive index is correspondingly altered, reaching a maximum increase of $\sim$2% for an energy deposition of $\sim 2 \times 10^{20}$ keV cm^{-3}, independent of ion species. This density increase results from radiation damage by atomic collision mechanisms. Townsend has now shown that very low electron irradiation (11-16 keV) also results in compaction. An index change of 0.9% for energy doses of $\sim 10^{24}$ keV cm^{-3} is observed. Since the compaction is limited to the near-surface region, graded-index devices (such as waveguides) are feasible.

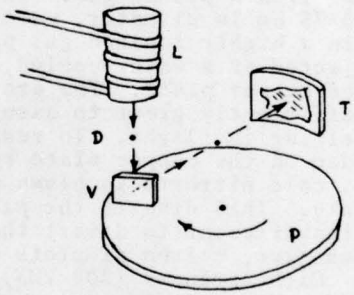
Another approach for surface modification which is competitive with ion-implantation is low-pressure plasma-deposition, a technique pursued by L. Holland at Sussex. In fact, a variety of processes is employed--deposition (sputtering,

ion-plating, activated evaporation, plasma polymerization), etching (sputtering, plasma etching), and surface treatment (nitriding). The technological potential of plasma-processing is excellent. Glow-discharge apparatus is simpler, more available and less costly than ion-beam accelerators, and the ion fluxes are larger. While ion-beam irradiation affects surfaces by physical methods primarily, plasma-processing offers the possibility of chemical reactions, too. For example, material can be removed by physical sputtering, both by ion-beam and plasma processing, or by chemical etching in which a volatile compound is formed at a surface by gas activated in a plasma.

Plasma-processing is the descendant of the older techniques of chemical and physical deposition. The more recent advances owe much to vastly improved vacuum technology and deposition apparatus. Holland's work is aimed toward exploiting these advances to understand plasma-processing in more detail than now available. I was particularly impressed with a fine, clear fluorocarbon sample produced by plasma-polymerization.

Venables is currently pursuing still another aspect of surface studies, using incident electrons and ions. His activities center on a newly designed ultra-high-vacuum scanning electron microscope (UHVSEM), constructed for Venables by V.G. Microscopes, Ltd. This instrument, incorporating several novel features, will have a 50-Å resolution. Molecular beam deposition can be achieved *in situ* without degrading the SEM vacuum elsewhere. Desorbed species are identified by quadrupole mass spectrometry. Auger electron spectroscopy and reflection and transmission high-energy electron diffraction are standard sensing techniques incorporated into the SEM. The Auger spectroscope can be operated in a scanning mode, made possible by the brightness of the field-emission gun which has been incorporated. The gun can deliver 1-2 x 10^{-9} A into a 300-Å spot at 30 kV.

The bombarding of surfaces is an activity in the Materials Science laboratory, as well. Here Cahn and a young colleague, B. Cantor, are using plasma-spraying and vapor-quenching as extensions of splat-quenching, a technique which Cahn has used for about seven years and is still developing further. In splat-quenching, liquid alloy is projected onto a cold surface to obtain rapid solidification and rapid subsequent cool-down of the solid to avoid atomic migration which might otherwise stabilize equilibrium solid-state phases. Perhaps the ultimate in splat-quenching is the stabilization of amorphous materials. In attempts to achieve faster cooling rates than with the gun introduced by P. Duwez, who pioneered splat-cooling, Cahn and co-workers built a rebound device in which a liquid drop, D (see Figure), is levitated at L, then dropped toward a horizontal plate, P, on which vertical vanes, V, are located. The plate spins at 13,000 rpm. The drop is struck by a vane and batted onto a liquid-nitrogen cooled vertical target plate, T. *Splat!*



Cahn's assessment is that the quench-rate is slower than the Duwez gun but offers an advantage in the levitation melting for refractory and reactive alloys. In a second method, Cahn *et al* constructed high-speed, magnetically-driven plates to smash--and cool--the liquid drop. The goal of higher quenching speed was not obtained, but improved sample homogeneity was effected.

A logical extension of splat-cooling, in which multitudes of atoms (in the liquid) are simultaneously collected on a substrate, is to deliver the atoms in the smaller numbers characteristic of vapors or plasmas. As one example of vapor-quenching, Cantor and Cahn have co-sputtered Ag and Cu onto NaCl in an rf getter-sputtering unit. The crystal structures obtained were similar to those

in splat-quenching, but the grain size was reduced from several microns to ~50 Å. The structure does differ from thermally evaporated Ag-Cu alloys, where amorphous phases have been observed. The implied slower quenching speed in co-sputtering might be related to the higher kinetic energy of the incident atoms in this method, albeit the energy differential is small.

Plasma-spraying is a particularly promising development with strong potential for industrial application--a fact that Cahn and a former student, K.D. Krishnanand, are pursuing. Splat-quench alloy applications generally involve extrusion of quenched flakes, must not involve the application of heat that would vitiate the initial quench, and are costly because of multi-stage handling. Plasma-spraying combines melting, quenching, and formation into a single process. Thus, for example, pre-alloyed Al-6 at.% Cu powders were first prepared by melting and spraying from a plasma gun. These powders, 45-75 μm in diameter, were entrained in a highly ionized gas plasma and projected at a water-cooled, grit-blasted copper plate. The arc power is sufficiently great to assure particle melting in flight. To reduce the heat load on the copper plate by the plasma, cold nitrogen is blown over the substrate. This diverts the plasma but is insufficient to divert the fine, but massive, molten droplets appreciably. High hardness (300 VHN) was obtained. Using another powder system, the investigators have achieved 1-mm thick deposits on inexpensive steel substrates and hardnesses that rival carbide coatings!

The investigations described here are only a portion of those underway. Cahn is looking at the plasticity of amorphous alloys ("alloy glasses"). M. Grenness, Thompson and Cahn have introduced minute amounts of Pt into W and found a dramatic increase in the rate of cathodic hydrogen evolution from electrolyzed 1 M sulphuric acid. Venables has investigated the very small free-energy difference between hcp and fcc Ar and has shown the phase sensitivity (i.e., free-energy sensitivity) to oxygen. E. Lilley has measured the frequency-dependence of the electrical conductivity of β-β" Al_2O_3, thereby separating bulk conductivity from grain boundary conductivity. R.D. Doherty is examining microsegregation and dendritic growth by, for example, dropping a seed nucleus into a supercooled melt, observing the seed growth rate, the temperature as a function of time, and the resulting morphology.

The University of Sussex is a materials center which is "sussexfully" on the beam! (A. Sosin)

HOW LONG DO POLYMERS LAST IN SERVICE?

This was the title of a one-day conference sponsored by the Plastics and Rubber Institute in London on 22 February 1977, and is clearly a legitimate question for researchers and industrialists. Last summer, I attended a three-day conference in Stockholm related closely to this, entitled "Long-Term Properties of Polymers and Polymeric Materials" (ESN 30-11:511). That conference, sponsored by the International Union of Pure and Applied Chemistry, was directed toward basic considerations but, unfortunately, provided few new insights into degradation fundamentals. The London meeting offered the opportunity to observe the situation from the applied point of view. My conclusion, drawn from both meetings, is that length of life in service of polymers is poorly known, the reasons for failure are familiar in outline but obscure in detail when applied to particular systems, and progress in these matters will be difficult.

The accent of the London Conference, according to R. Loneragan (Royal Armament Research and Development Establishment), one of the two conference chairmen, was on "hard-use functions" of polymers. Of the nine papers, three satisfied this billing. F. Torzo (Chimosa, Italy) described the stabilization of low-density polyethylene films, intended for greenhouse use, against ultraviolet irradiation by the inclusion of various additives, and the synergistic effects when these were added in pairs. C.J. Derham *et al* (Malaysian Rubber Producers' Research Association) demonstrated that the familiar degradations of rubbers, due to oxidation, ozone

attack, oil impregnation, etc., may actually be inconsequential in some applications; natural rubber bridge bearings have been in operation for 20 years without evidence of even superficial deterioration. E.R. Gardner and J. Morris (Avon Processed Polymers, Ltd.) discussed skirt-seal components for hovercrafts. Tests of materials on craft service show much greater deterioration of tear strength and adhesion than water absorption alone can explain; fatigue is an important factor.

J.C. Harrison (Post Office Telecommunications) pointed to the virtual impossibility of obtaining an answer to the Conference's theme question. With the additions of fillers, antioxidants, ultraviolet stabilizers, pigments, flame retardants, plasticizers, and others, what polymer should be considered? Nevertheless, the need for prediction remains, and Harrison categorized five approaches. Full-term field testing remains the final arbiter but generally is too time-consuming and expensive. Accelerated testing, approach number two, is always a conceptual favorite and occasionally can be applied with confidence; the lifetime characteristics of telephone mechanical components can be confidently simulated in five days of continual dialing. More generally, accelerated testing involves elevated temperature, higher force, greater pressure, higher electrical potential, etc. In these cases, the burden is on the tester to demonstrate the legitimacy of the accelerated test results. A third method for prediction is extrapolation from early life results. This approach may well be the most dangerous, unless reinforced by a large measure of confidence that a sharp failure mechanism will not set in to terminate life. But this usually implies an understanding of failure mechanisms that is absent when short-time extrapolations are used. A fourth alternative is the prediction of lifetime based on an understanding of the mechanisms of failure. This requires the correct identification of the failure mode and sufficient knowledge of the failure mechanism. Finally, there are the most difficult cases in which practically nothing substitutes for full armament against all possible failure modes. Harrison gave as an example transatlantic cables where the cost and small number of cables prohibit the use of statistical analysis to predict failure rates. The amount of material in such a cable is equivalent to the amounts in serving 20 million phones in common terrestrial use; some failures here are expected, but one transatlantic failure is essentially unacceptable.

A possible newer approach was discussed by T.R. Manley (Newcastle upon Tyne Polytechnic). He uses differential thermal analysis and thermogravimetric analysis to observe the degradation of a particular plastic under a constant heat-up mode. He is attempting to correlate the observation of particular exotherms with service life. If development is successful, the technique offers the advantage of ease, but it is obviously restricted in application.

Cracking is a familiar lifetime-limiting failure for plastics. G.P. Marshall (Manchester Polytechnic) discussed his concerted attack on crack growth in plastics, using a combination of standard crack theory and attention to service conditions. The studies proceed from the questions: what article is actually in use; what is the use of the article; and what are the abuses that the article will suffer? Knowing the answers to these questions, Marshall stated that his research indicates that fracture mechanics analysis and test techniques can be developed to a sufficient degree to allow predictions of the lifetimes which may be expected of products that are subjected to long-term loading in service. Marshall's optimism was a welcome addition to the Conference, an optimism not necessarily supported by the other papers. (A. Sosin)

DEFECTS IN PARIS--THE UNIVERSITY OF PARIS

Solid-state physics and metallurgy are important research areas at the several campuses of the University of Paris, with the work at the Paris and Orsay campuses most well known. In a recent visit, I had the opportunity to see a select portion of the work at each of these.

P. Baruch was my host in Paris. He presented his recent results on

solute atom redistribution at a conference on radiation effects in Dubrovnik last September (ONRL Report C-39-76). To induce a redistribution of B in Si, Baruch irradiates with 250-450 keV protons, then monitors the concentration of B-atoms as a function of depth. The results are unusual in that B diffusion toward higher concentrations can be observed; this "up-hill" diffusion appears to almost violate a law of nature! A key to the interpretation is found in a "double-dip" profile. Baruch explains the observations with a model that involves two types of diffusion. Si-interstitials, created by collisions with incident protons, diffuse until meeting B-atoms which reside on regular lattice positions (substitutionally); on reaction, the Si becomes substitutional and the B, interstitial. B-interstitials are fast diffusers and allow B to diffuse extensively until they meet vacancies, also created by bombardment. The reaction of a B-interstitial and an Si-vacancy yields a B substitutional atom, terminating the process.

Still other mechanisms of defect diffusion in Si and other semiconductors have been explored by J. Bourgoin, a very active Centre National de la Recherche Scientifique (CNRS) Fellow in Baruch's group, in collaboration with J.W. Corbett (SUNY, Albany). One migration mechanism proposed by Bourgoin starts with the initial presence of a defect in a state of pseudo-equilibrium and, therefore, in a potential energy trough. Suppose that the charge state of the defect is altered by interaction with a bombarding particle or by a photoelectric process. The stability of the defect would be effected so that the potential energy diagram may be inverted, in which case the defect will find itself at an energy peak. This is a temporary configuration. If the charge state is sufficiently persistent, the defect will move toward a trough in the inverted energy diagram. This model was inspired by an observation made by J. Zizine, also in Baruch's group, in n-type Ge irradiated near 4 K. An annealing stage is observed at 65 K on heating following irradiation when operating in the dark. Under illumination, the stage is shifted to 27 K. This shift in temperature--over half the absolute temperature--is extraordinary.

Bourgoin has looked in some detail at defects in synthetic, B-doped diamond also. Earlier measurements by E.W.J. Mitchell and coworkers (Univ. of Reading, UK) indicated a threshold energy for the displacement of atoms in diamond of 80 eV--which is two to eight times higher than observed in other monatomic materials; these (electrical) measurements were made at room temperature. Bourgoin has irradiated near 15 K and finds an annealing stage at 260 K that is apparently due to the recombination of vacancies and interstitials. This lower temperature recombination could account for the high displacement energy found by Mitchell *et al*; Bourgoin finds an energy of 35 ± 5 eV, still high but more consistent with other elements. Bourgoin has also examined the kinetics of crystallization of amorphous regions in Ge and Si, obtained during ion implantation or by evaporation on a substrate. In Si, amorphitized by bombardment of 10^{15} P ions cm^{-2} at 80 keV, a Raman (broad) peak near 480 cm^{-1} diminished during post-irradiation isothermal annealing at 500°C, while the (sharp) lattice peak at 522.5 cm^{-1} increased. The time-dependences of the variation of these peak amplitudes provide a history of crystallization which Bourgoin has found to fit a homogeneous first-order rate process, consistent with the passage of a crystalline front through the amorphous region at a rate of 1.6×10^{-2} Å/sec at 550°C. Bourgoin has used electrical conductivity measurement to confirm these Raman observations.

The radiation effects group of P. Lucasson located in Orsay, continues to concentrate on the anisotropy of defect creation in electron-irradiated metals, with an extension to the consideration of recovery of particular defects in Fe single crystals after irradiation. Examples of the scope of this work in Fe are the following. Minimum energy for displacement of an atom in the <100> direction--17 eV; in the <111> direction--20 eV; in the <100> direction--more than 30 eV. Recovery near 66 K is due to defects created in the <100> direction; recovery near 87 K is probably due to recombination of interstitial-vacancy pairs in the <111> direction.

A second phenomenon under study is the trapping of interstitial atoms near impurity atoms during interstitial

migration. Lucasson *et al* have examined Al with the addition of small concentrations of Mg or Ag, and Ag with small additions of Cd and In. By analyzing the amount of suppression of annihilation of interstitial atoms at vacancies during interstitial diffusion, due to the trapping of the alloying additives, they deduce the radius for interstitial capture of each solute-atom type. The analysis is based on computer fits to the solution of coupled chemical rate-theory equations. Lucasson is extending into a new area: hydrogen in metals. He has found a shallow minimum in the electrical resistivity vs temperature curves in the case of 23% H in W. The source of the minimum is unknown, and to complicate matters, the depth of the minimum depends on the rate at which the sample is heated in making the measurements through the critical temperature range near 180 K.
(A. Sosin)

MECHANICS

THE FLUIDS GROUP OF THE INSTITUTE OF MECHANICS, DARMSTADT

The Institute of Mechanics (IfM) of the Technische Hochschule Darmstadt (THD) is a subdivision of the Department of Mechanics, the other subdivision being the Institute of Meteorology. The IfM is further subdivided into four groups, the largest of which is concerned with fluid dynamics and continuum mechanics and is directed by Prof. Dr. Ernst Becker; the other groups are in elasticity, rigid body dynamics and systems, and thermoelasticity-viscoelasticity and fracture mechanics. Each group of the IfM is directed by a full professor. The IfM has, moreover, four associate professorships of which two are designated for Becker's group.

Although the IfM is more fundamentally oriented than the Institute for Applied Fluid Mechanics (IfTS) at the THD, it is significant that its research is also application-oriented. One example of this is the problem of water run-off from road surfaces exposed to rain which was posed to Becker by the Civil Engineering Department of the THD and resulted in the development of studies of the hydrodynamics of film flows. The rain incident on the road surface adds mass to the flow along with momentum tangential to the surface. For the case of uniform rain and constant curvature of the road surface, a closed-form similarity solution of the modified Navier-Stokes equation exists which checks with experimental data generated at the Civil Engineering Department. For an arbitrary surface of small slope, including mass addition at the surface due to ground water seepage, the film thickness can be obtained by solution of an integro-differential equation. If viscous effects are neglected, the analysis can be generalized to a large surface slope for a thick-film flow for which an exact, closed solution is obtained for a specific, though complicated, family of surfaces of convex shape.

In the field of rheology, some flows involving fluids with memory are being studied. A simple example of a fluid with memory is the continuum generalization of a spring and dashpot in series (end to end). If the fluid is deformed rapidly, the dashpot will deform very little, the majority of the deformation being taken by the spring. For the case of slow deformation, the reverse will be the case. A viscometric flow is one with a constant rate of shear; hence, in such a flow the dashpot accommodates the rate of deformation of the flow and the spring remains stationary. Since the flow of a fluid in a boundary layer is nearly viscometric, the memory of the fluid produces only a weak effect on the flow. Solution of such boundary layer flow problems has shown non-linear viscosity and normal stress effects, but because the flow is nearly viscometric, only small differences from the solution of the Navier-Stokes equations involving a Newtonian fluid (linearly viscous) were noted.

The application of the concept of nearly viscometric flow to the study of hydrodynamic journal bearings is of particular interest. Since a lubricant generally is a fluid with memory, the resulting force generated at a journal bearing is different than that predicted by the Reynolds-Sommerfeld theory involving a Newtonian fluid. It was found that unlike the classical theory, the bearing force in the case of nearly viscometric flow is not perpendicular to the eccentricity

direction of the journal and bearing. For a given eccentricity, the magnitude of the force is also different; but again because the flow is nearly viscometric, the difference from Newtonian flow is small.

A problem in classical viscous flow analyzed at the Institute involves the flow caused by a long cylindrical rod moving axially and concentrically out of a cylindrical hole. The annulus between the rod and hole is filled with a viscous liquid. The solution was obtained for a small annular gap and involved the shape of the free surface of the fluid over the rod emerging from the hole. The motivation for the problem was to study a process for coating wires.

Another current interest is the axial pressure-driven flow of a viscous fluid in the annulus between a cylindrical rod and tube. The effect of oscillation of the rod in a direction transverse to its axis on the axial flow and the resulting heat transfer between rod and tube is being studied. The results are applicable to the problem of vibrating fuel-rod bundles in nuclear reactors.

The activity in gas dynamics centers upon the dynamics of real gases. For a shock wave in a chemically-reacting gas with thermal conductivity but negligible viscosity, it is found theoretically that, in the case of weak shock waves, the state variables are continuous through the shock wave. For a strong shock, thermal conductivity causes a relaxation zone behind the shock and chemical reaction a relaxation zone ahead of the shock; in between the relaxation zones, there exists a sub-shock.

A flow with weak relaxation is defined as one where the energy of relaxation is small compared to the internal energy. Such a flow about a body causes a drag specifically associated with the relaxation. At the IfM, airfoil shapes have been optimized to minimize relaxation drag for a given lift and cross-sectional area. Non-linear weakly-relaxing flows have been studied for standing, continuous and shock waves in a piston-driven oscillating tube. Also, closed-form solutions for flow in a convergent-divergent (DeLaval) nozzle have been obtained.

The propagation of shock waves through a gas-filled porous medium has been investigated, it being found that the medium's heat capacity acts like an internal energy mode of a gas in that it lowers the translational energy of the gas. The resulting flow is similar to that in a relaxing gas.

Some work in the recasting of the theory of idealized gas dynamics using modern mathematical techniques has been underway. The theory of distributions applied to compressible flow problems allows the handling of discontinuities such as shock and Mach waves in the flow field. While there do not appear to be very new results, there have been some improvements in accuracy. For instance, in the case of linearized gas dynamics, boundary conditions at the actual surface of the airfoil may be applied, whereas in the usual theory, they are usually applied to the airfoil mid-surface.

An Associate Professor at the Institute, Julius Siekmann, is interested in fluid mechanical problems associated with space. Included are sloshing due to large amplitude vibrations in missiles and rockets and large amplitude oscillations of liquid spheres with surface tension in a zero gravity environment. Both problems are being investigated numerically. The processing of materials in space requires a knowledge of bubble motion under reduced gravity. With this potential application in view, the effects of centrifugal force and temperature gradient in driving bubbles out of a medium are being studied. (Martin Lessen)

THE INSTITUT FUR HYDROMECHANIK, KARLSRUHE

The Institut für Hydromechanik (IfH) is one of two major institutes involved in some aspects of fluid mechanics research at the Universität Fredericiana, Karlsruhe; the other, the Institut für Strömungslehre und Strömungsmaschine will be reported separately in these Notes. A related note on the IfH entitled "Center of Excellence, German Style" by R.H. Nunn appeared in ESN 29-12:527. During my visit, the Director, Prof. E. Naudascher, graciously showed me around the Institut.

The IfH is comprised of some 75 people and extensive flow research equipment; there are 20 scientific workers, 5 guest or visiting professors, 25 technical and secretarial support personnel, and 20 graduate students. The annual budget of the Institut is approximately DM 2.5 million or $1 million.

The activities of the IfH concern fundamental flow processes of interest to civil engineers. The areas studied are therefore basically low speed, incompressible flows, the transport phenomena associated with such flows, and the interaction of these flows with structures.

A large program in turbulent transport phenomena in flows is underway at the Institut. Both theoretical and experimental studies in turbulent jets, wakes, and plumes seek to model and observe momentum, heat, and mass transport in flow systems. The "theoretical" approach is to use a turbulence closure model similar to that used by B.E. Launder and D.B. Spaulding of Imperial College in London. Unfortunately, no universal closure model exists because "turbulence" is only a generic term for flow situations which contain large-scale structures whose character depends on the hydrodynamic instability giving rise to the turbulence. The flows are also modeled experimentally, and probes and flow visualization are used to obtain data for reduction and comparison. Examples of particular turbulent mixing flows studied are jets discharging co-linearly and transversely to flowing streams buoyant plumes in various velocity and density stratified flow fields, swirling jets discharging into flowing streams, etc. The flux of heated water into a river and the subsequent mixing is the subject of a thermal pollution study for the Ministry of the Interior.

Along with the general turbulent transport research are studies in particulate transport and erosion. An example of the latter is a study of the erosion of a sand bed by steady and pulsating turbulent jets. Other related areas investigated are the influence of a seepage flow through the bed and the effect of secondary flow on the erosion process. Secondary flow occurs in river and channel flow around a bend; the boundary layers along the bottom and sides provide a return for the centrifugally driven transverse circulation. (Albert Einstein once studied the related problem of the Coriolis-induced meandering of rivers due to the earth's rotation.) The erosion due to secondary flows about bridge piers and other hydraulic structures is another example being modeled.

Besides the fluid-solid particulate two-phase system, the liquid-gas two-phase flow system is under investigation. The mixing and entrainment of air in water during the impingement of a water jet onto a wall is of interest along with the entrainment of air from a fine jet blowing into water; an application is the oxygen enrichment of water by forced air or oxygen injection into a flowing stream. Other useful information obtained is the jet- and bubble-induced secondary circulatory flows.

Ground-water and other flows through porous media are being investigated at the IfH. Examples are the influence of polymer additives on diffusive flows through porous media and transport processes in flows through beds. Diffusive ground water flows near wells and rivers are being modeled. The use of polymer additives for optimizing industrial processes is under experimental and computer study.

Many problems in the area of pipe and channel hydraulics are being pursued. The area of unsteady flows and water hammer in pipes is of great importance in oil pipelines, water supply systems, and in some hydraulic power installations. The general problem of non-stationary pipe flow is being modeled on a digital computer. The problem of cavitating flow in piping systems is also of importance and, along with various facets of the hydraulics of water supply systems and their optimization through polymer additives, is under investigation.

Besides purely flow problems, the coupling of structures and flow phenomena forms yet another area of study. The coupling may consist simply of steady fluid mechanical loads such as wind and water flow loadings or may fall into the class of aero- or hydroelastic dynamic interactions resulting in self-induced vibrations. An example of the latter is the Kármán vortex street shed from a cylinder in a transverse flow field. If the cylinder and support system has the proper elastic parameters, a self-excited vibration will ensue.

Naudascher and Visiting Professor Rockwell (on leave from Lehigh Univ., Bethlehem, PA) have classified various flow-induced structural vibrations and are embarking on a program of studying their characteristics and control.

Various flow measurement techniques are under development with particularly noteworthy work taking place in laser-Doppler anemometry under the direction of Dr. F. Durst. Durst has developed particle generators for seeding flows to be studied such that the seeding provides proper light scattering.

Durst is conducting a theoretical and experimental study of vortex rings using numerical simulation and laser-Doppler anemometry. An example of a vortex ring is a smoke ring; the ring is caused by pulsing the outflow from a nozzle. Durst finds the usual disintegration and reformation of the rings in a repeated succession of instabilities as the ring proceeds from the nozzle. The purpose of the study is to assess the feasibility of causing a waste product-bearing vortex ring to penetrate an atmospheric inversion layer and deposit the waste above the layer. Of course, when an inversion does not exist, the vortex ring-producing chimney can revert to an ordinary mode of operation. If the system works, it could be of great value to places like Los Angeles. However, I feel that the minimization of waste scattering is nevertheless of primary importance.

A study of the flow ahead of ship propellers using laser-Doppler anemometry had been proposed in cooperation with the Institut für Schiffbau (IfS) in Hamburg and the IfS has proceeded with it. However, after some delay, the IfH is now back in the act and, hopefully, exciting results are in prospect.

There has been a development program on laser-Doppler systems that has resulted in packaged optics and electronics for 2-dimensional laser-Doppler anemometry with the option of fitted scanning. A three-dimensional system can also be supplied. The systems are available through a splinter group from the Institut which is Opto-Electronische Instrumente GmbH, 7517 Waldbronn, Siemenstrasse, West Germany.
(Martin Lessen)

MEDICAL SCIENCES

AN UP-DATE ON BURN TOXIN

Slightly over two years ago, a three-day conference was held to discuss "burn toxin", a proteolipid found in the serum of severely burned patients and thought to be in part responsible for the high mortality rates. The meeting was sponsored by the US Army's European Research Office (ERO) and Chelsea College, University of London. Proceedings of this conference were edited by ERO, and published in a 240-page report entitled "Toxic Factors in Burns" (Technical Report ERO-4-75). It was my privilege to revisit some of the key contributors to this report and learn what progress has been made in the field.

The problems of severely burned patients are complex. Large fluid losses through the burn wound and increased susceptibility to burn-wound infection lead to a very high mortality rate when burns involve more than 50% of the body surface. Adequate fluid replacement and treatment of infection has reduced the early mortality; but late mortality, two to three weeks after the burn, has not changed significantly over the past decade. The cause of this late mortality is not known. However, two Swiss researchers, Dr. G.A. Schoenberger and Dr. M. Allgöwer of Basel, have been studying the problem in depth over the past fifteen years. Their major contribution to the field comes from studies of "burn toxin", a toxic lipoprotein that is produced when skin is exposed to dry heat. The toxin is found in the serum of burned animals and humans, and is thought to be the polymerized product of certain normal lipoproteins found in the skin. The target for these burn-toxin molecules is the cell membranes of nearly all parenchymal cells of all organs. The toxin causes severe plasma membrane damage, manifested by increased cell permeability to products not normally able to enter the cells. The toxin itself is lethal to animals if given in high enough doses, survival being dependent on the ratio of intact to damaged cells. The Basel workers have

also shown that sublethal doses of toxin may prepare a background upon which bacterial infection, a major problem in burn patients, turns into lethal sepsis, the actions being synergistic.

Schoenberger, Allgöwer, and colleagues described in detail the biochemical characterization of the molecule in the ERO report. The isolated lipoprotein is basically similar between species, has a molecular weight of about 3×10^6 and is a trimer of molecules found normally in the skin. The toxin has a lipid coat surrounding a protein inner core, the ratio of lipid to protein being about 40:60. The natural step after isolation was to attempt to produce an antibody against the toxin molecule: an antitoxin. The Swiss group has been able to do this, but only with difficulty because the molecule is poorly antigenic. The antitoxin, prepared in rabbits, was shown to have protective effects when given to burned animals.

Similar experiments have now begun using toxin extracted from burned human skin. The antitoxin prepared with this material was also partially protective of burned animals, and cautious initial trials of the antitoxin in a few severely burned patients showed limited protective effects. However, the situation is much more complex than in the animal model. The Basel group has continued its research on a broad front. Investigation of the specific mechanism of action of the toxin has been carried on by Dr. B. Kremer, who has shown, using electron microscopy, that mitochondrial vacuolization in liver cells may be induced by the toxin.

A great deal of work has been done in trying to prepare adequate amounts of human toxin so as to begin antitoxin production on a scale that will allow controlled clinical trials to be carried out on severely burned patients. As most researchers know, the step from biochemical isolation to large-scale antiserum production is a very big one. The Swiss are somewhat better off than other groups, however, since government agencies will take over antitoxin production once the toxin is purified and can be produced in sufficient quantities. Progress in this field, as in most difficult areas, is slow, but the Basel researchers are approaching the problem with a background of innovative research and will no doubt continue to make major contributions to the burn-injury field. (LCDR J.N. Woody, MC, US Naval Activities London)

PHYSICS

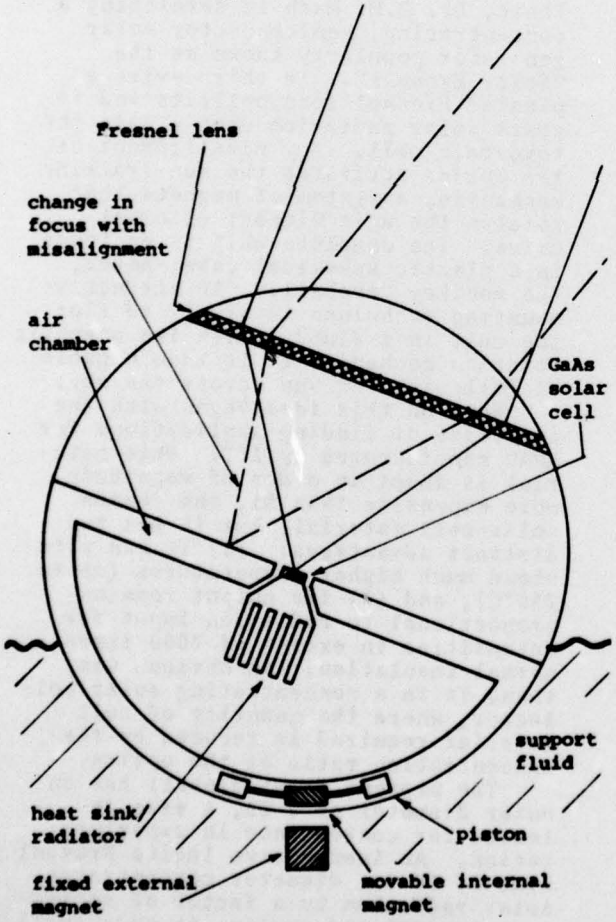
SEARCHING FOR ENERGY WITH THE "SOLAR EYEBALL"

On a dark, drizzly February day the writer visited the Standard Telecommunications Laboratory of ITT at Harlow, Essex to discuss, somewhat inappropriately, a novel device for converting solar energy to electricity. There, Dr. D.H. Mash is developing a concentrating, semiconductor solar generator popularly known as the "Solar Eyeball". In this device a plastic Fresnel lens collects and focuses solar radiation upon a GaAs photovoltaic cell. Any misalignment of the optics activates the sun-tracking mechanism, a system of magnets that rotates the unit without external drive. The complete unit is enclosed in a plastic spherical case; hence, the moniker "eyeball." An attractive mounting technique is simply to float the unit in a fluid. With its magnetic rotation mechanism it is then capable of following the sun across the sky.

Work on this idea began with the objective of finding applications for GaAs manufactured by ITT. This material is about an order of magnitude more expensive than Si, the common solar-cell material, but it has two distinct advantages: (1) it can withstand much higher temperatures (up to 250°C), and (2) its output remains proportional to radiation input for intensities in excess of 2000 times normal insolation. An obvious use, then, is in a concentrating solar collector, where the quantity of cell material required is reduced by the concentration ratio of the optics.

The present Solar Eyeball has an outer diameter of 1 ft, a size selected for convenience in experimentation. An inexpensive lucite Fresnel lens of 10-in. diameter concentrates solar radiation by a factor of approximately 2000 and applies it to a small cluster of GaAs cells. The cells are

connected in series to raise the voltage to a convenient level (output per cell is about 1 V). These cells are mounted on a substantial heat sink/radiator that withdraws waste heat and transfers it to the air inside the case. This heat then passes through the case into the ambient air and supporting fluid; the latter can in fact serve as a source of hot water. Although the cells can withstand much higher temperatures, operation will be set at about 100°C because GaAs exhibits a loss in output with increasing temperature (at 140°C there is a 20% loss relative to 20°C). Power is withdrawn from the unit through two small electrical leads, the only physical connection between the sphere and its surroundings.



Components of the Solar Eyeball

Much effort has been devoted to perfecting the self-aligning mechanism in the Eyeball. Motive power is derived from the solar radiation itself. Misalignment of the optics causes radiation to fall to one side of the GaAs cells and heat the air in neighboring chambers that are connected to a movable magnet via tubes and pistons. Heating of the air produces pressure changes that shift the piston-magnet assembly and, through interaction with a fixed external magnet, effect rotation of the sphere and realignment of the optics. While the system is a clever application of pneumatics, only the technique for achieving essentially zero friction and zero air leakage between the pistons and tubes will be described in more detail here.

The over-pressures generated in the air chambers by misaligned radiation are very small. Thus, if the system is to function properly, both the static friction and the air leakage about the pistons must be virtually zero. This has been achieved by magnetizing the pistons and introducing into the tubes a ferromagnetic substance trade named "Ferrofluid", a suspension of Fe_2O_4 in oil. This fluid "bunches" about the ends of the pistons (magnetic poles) and effectively seals the piston-tube clearance space. The static friction in this arrangement is essentially zero. There is, of course, viscous friction, but it has a beneficial effect in providing damping within the system. There are surely many other applications for this sealing technique.

The quantity of solar radiation intercepted by the Eyeball lens is approximately 35 W. Present GaAs cell efficiency is 16%, so output of the unit is about 5.6 W. Mash expects cell efficiency to be improved to 20%, which would yield an output of 7 W. An interesting point made by Mash is that there is no gain in conversion efficiency from increasing the size of the Eyeball (in contrast to conversion systems that employ heat engines). Thus to obtain more output one simply uses more Eyeballs, and the picture comes to mind of a large pool or lake with its surface covered by these spherical units, each gazing steadfastly at the sun.

As Mash summarized his results--to the accompaniment of rain pattering

against the windows--it became clear that the Eyeball project is facing a serious problem: the shortage of sunny weather for realistic testing of hardware. The development work has thus far relied largely upon laboratory light sources, but simultaneous simulation of intensity and size (so important to the function of the tracking mechanism) requires a source at 6000 K, the temperature of the sun! Consequently, if the program is to proceed much further, a change of location is required.

The writer came away with the impression that Mash is pursuing a new and important course toward inexpensive solar energy conversion. The use of optical concentration effectively eliminates the primary shortcoming of photovoltaic devices, the high cost of the cells. Tracking of the sun becomes necessary, though, and this feature in turn becomes cost-controlling. Mash is consequently working to produce a simple, self-contained tracking mechanism of minimum cost. The combination of fluid support and his pneumatic-magnetic torquing system constitutes significant progress toward that goal. (William G. Soper)

ACOUSTIC EMISSION AND MICROSTRUCTURAL DAMAGE

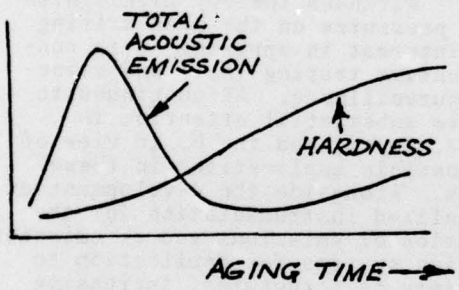
On 19 January the Metallurgical Engineering Committee of the Metals Society organized a round table discussion on Acoustic Emission and Microstructural Damage to explore progress in understanding of the correlation between the nature of the emission and microstructural events as a crack propagates. This Committee aims to bring physical metallurgists and design engineers together with the object of applying metal science in engineering design. It is concerned with development of science in needed areas; dissemination of advances that have been and will be made, through appropriate publications and meetings of an educational nature; and the securing of the best design practice by a critique of current design practices and recommendations. Formed in 1975, the Committee's attention is currently focused on fatigue, creep failure and fast fracture. Hence, the interest in Acoustic Emission (AE) and concern as to an appropriate role.

Some general overview of the status of the UK's research in AE was provided by T.A. Kitchens in an ESN article, "An Overview of Acoustic Emission from Great Britain" (29-12:509), reporting an Institute of Physics, Materials and Testing Group one-day meeting held in October 1975. He concluded by commenting "We do need to understand AE better. It would be unfortunate if the potential of AE in materials research and also its technical applications were lost because of disenchantment due to its being oversold by instrument manufacturers and the users' desires for an easy answer to their structural failure problems." Kitchens thereby highlighted major pressures on the area arising from interest in applying AE to nondestructive testing (NDT) and structure surveillance. AE continues to receive substantial attention in Europe, Japan, and the US in view of its possible applications in these fields. Alongside the development of specialized instrumentation for the detection of emissions and of emission-location systems for application to a variety of structures, increasing attention is now being given, however, to the study of the nature of the sources of acoustic emission and of the emission itself and of their interrelation. In practice an emission as normally observed probably has little resemblance to the signal waveform close to its source. It is a matter of conjecture and debate as to how important this is. One would assume it becomes more important with any attempt to use more detailed information concerning an emission as a basis for assessing the nature of its source.

About 40 invitees attended the meeting, which was chaired initially by Dr. B.L. Eyre (Atomic Energy Research Establishment, Harwell) and later by Prof. John G. Knott (Cambridge Univ.). As a basis for discussion a number of speakers had been asked to talk about their work with emphasis on its interpretative aspects. They included H. Wadley and C.B. Scruby (AERE Harwell); C. Green (British Steel Corp. Sheffield Labs., Rotherham); J.G. Knott (Cambridge Univ.); J. Holt

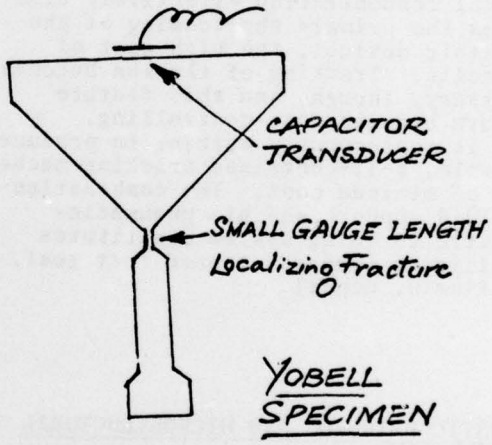
(Central Electricity Research Lab., Leatherhead); and P. Bartle (The Welding Institute, Abingdon, Cambridge).

Wadley reported on his work with aluminum alloys which is aimed at identifying the sources of AE and at determining whether they can be distinguished by their AE. Tests he had made on commercial purity aluminum indicated that in the yield region almost all the emission was from individual discrete events, suggesting that the emissions originated from the fracturing of inclusions. Tests made on 4% Cu alloy of high purity subjected to different agings show a high peak in total AE output when plotted as a function of the aging time, as shown below.



The peak occurs for aging times when the zones of metastable phase material identified as GP1 are disappearing and GP2 appearing. During plastic deformation, when serrations of the stress-strain curve are observed (dynamic strain aging) he has found AE increases as the load falls; other observers are said to have found the opposite. With Al 4% Cu when fracture occurs before plastic deformation (brittle fracture), the largest signals are observed, initial cracking of inclusions then being followed by tearing of the grain boundaries. Of the four mechanisms--(1) inclusion fracture, (2) metastable phase fracture, (3) dynamic strain aging and (4) intergranular fracture--(4) gives the largest signals, (3) the lowest, and (1) and (2) intermediate levels. Wadley did not believe that, without knowing the grain structure, it would be possible to make any general statement as to the source of AE on the basis of AE observations alone.

Scruby's work responds to two questions: (1) can different deformation and fracture mechanisms be distinguished by AE signal shapes, and (2) what can be inferred from detailed AE transient analysis about the microstructural changes during a given process? Conventional narrow-band AE systems observe an emission which has been very heavily modified by the specimen, by the limited capabilities of the transducer and by the subsequent processing. Scruby uses a so-called YOBELL-shaped tensile specimen designed to permit the initial pulse (both longitudinal and shear-wave information) reaching the transducer without reflection from the specimen's boundaries. Travel time from the source to the receiving transducer is of the order of 5 μsec.

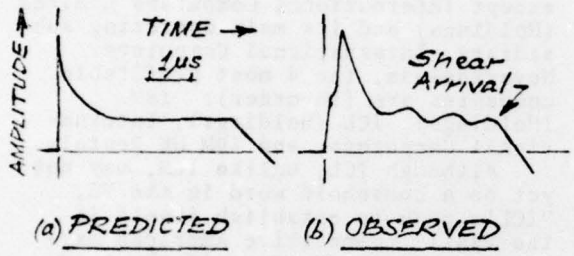


Use of an air-gap capacitor transducer allows wide bandwidth. His total system response permits observation of rise times down to 40 nsec. Typically he observes rise times of less than 100 nsec, and believes they range from 10 to 100. With this system, tests have been made on EN30A steel subjected to a variety of conditions--

(I) quenched (Q) 950°C
(II) Q, tempered (T) 650°C
(III) Q, T, Temper Embrittlement (TEm)
(IV) Q, T, TEm and H_2 Embrittlement.

The predominant type of fracture observed for specimens conditioned as (I) and (II) has been ductile fracture and for (III) and (IV) intergranular.

Observed emission waveforms, (b) below, approximate the form anticipated from theoretical work currently underway at AERE based on seismological approaches (a).



Results have shown differences in the distribution of rise times for the intergranular and ductile fractures, the first peaking at 80 nsec and the latter at 40 nsec. Moreover, intergranular fractures tend to produce a shoulder in the initial rise as shown in (b) which has not been observed for ductile fracture cases.

Green has studied stress corrosion crack growth of three high-strength steels. He has found a linear relationship between the total emission energy and the crack-area as the crack grows, but that the emission depends on grain size even in a single steel. He concludes that AE energy measurements in themselves are not sufficient to characterize the cracking process.

Knott has initiated studies of AE associated with crack growth in structural steels using specimens subjected to 3-point bending. Attention is being paid to the amplitude of the emission as bending proceeds. He believes that many emission signals observed may be carried by surface waves, and he stressed the importance of surface finish in this regard. He noted that if this is the case, surrounding liquids could have a very important effect on the nature of the emission actually observed.

J. Holt reported on work on A533B steel which has concentrated on emission associated with deformation ahead of a crack before the crack extends. Measurement and interpretation have been based on earlier work on carbon-manganese steel [Palmer I.G. *Mat. Sci & Eng.* 11, 227 (1973)]. While there are similarities to the earlier work, the results with A533B do not show the high sensitivity to heat-treatment observed in carbon-manganese steels.

Bartle stressed the difficulties to be expected in practical application of AE techniques--the great variation in signal strength, the complications imposed by the specimen or structural geometry, and the limitations imposed by the receiving systems. The Institute of Welding's work aims at an appreciation of these problems and, where possible, their circumvention.

The general discussion strongly supported the need for fundamental work such as that being undertaken at AERE, but questioned how such techniques could be applied in practical structural situations. It was also fairly generally agreed that work employing more conventional detection and processing systems appears to be yielding useful information on the interrelationship of source and emission, with potential practical application. Comment on the appropriate role for the Committee and the Society was limited.

It was felt there might be some benefit in the Society's sponsoring a meeting in about a year's time designed to bring the potential of AE techniques to the attention of industry and the design engineer. This timescale is not surprising; one might even argue that it is too early, for AE as a field has been subject to frequent review and discussion in Europe and the UK in recent months. The 8th World Conference on Non-Destructive Testing held in Cannes in September '76 carried some 20 papers on AE. There is in Europe, as in the US, a working group on AE normally attended by about 80 workers in the field which meets at about 9-month intervals. It last met in Copenhagen in September '76, having previously met in Paris in September '75. It should next meet in Rome in the summer of '77. In addition there is a UK working group on AE. Only one month prior to the round table, the (UK) Institute of Acoustics had organized a two-day meeting on "Fundamental Aspects and Applications of Acoustic Emission". The 25 papers given at this meeting covered a wide range of fundamental topics and numerous potential applications.

Clearly AE is a highly topical subject. The pressure is on. Any Metal Society meeting will require very careful tailoring and timing if it is to be effective in carrying knowledge to the metallurgist/design engineer interface. (A.W. Pryce)

NEWS & NOTES

RELATION BETWEEN LEAD AND MENTAL HANDICAP

Professor Abraham Goldberg's research group at the University of Glasgow has recently completed a study of the effect of environmental lead pollution on children. Unlike the recognized adult symptoms of chronic lead poisoning--anemia, nerve damage and cholic--it has not been known what, if any, effect exposure to lead at levels which cause no obvious physical symptoms actually does have upon young children.

In a two-year-old study, Goldberg and his colleagues had found that there was more lead in the domestic water supply of mentally handicapped children than in the homes of normal children. The more recent study was based upon an analysis of blood samples, taken at birth, of 80 children now aged between 4 and 7 years who are now recognized as handicapped. Tests on the lead content of these samples revealed that the blood of these children contained "slightly, but significantly" more lead than normal at the time of birth, implying a link between mental handicap and the lead content of the water drunk by mothers during pregnancy. Goldberg points out that the plumbing in 1,700,000 British households is of the type that water left standing in the pipes overnight--which will be the first sample drawn in the morning--contains more lead than the World Health Organization limit.

INTERNATIONAL COMPUTERS, LTD. ENTERS US MARKET

Of the 20 largest computer companies doing business in the UK, 18 are foreign-controlled--all, in fact, except International Computers Limited (Holdings) and its main operating subsidiary, International Computers. Nevertheless, the 4 most profitable companies are (in order): IBM (Holdings), ICL (Holdings), International Computers, and IBM UK Rentals.

Although ICL, unlike IBM, may not yet be a household word in the US, "ICL's push to establish itself in the vastly competitive American market is underway." So said the lead sentence in a recent issue of the British Computer Society's publication *Computing*. ICL has actually been operating in the US for 3 years now, but has managed to sell only 21 small business computers in the New York area. However, ICL has recently formed a full-fledged American subsidiary (ICL, Inc.) following the acquisition of Singer Business Machines and its US subsidiary Cogar Corporation. In the words of the president of its marketing division, Geoffrey Rowett, ICL plans to get into the US in a big way rather than "messing about in New York".

THE FLUID STATE AT FREIBURG

In a recent visit to Freiburg, it was found that Prof. H. Goertler who had been ill for some time, retired from his chair and directorship of the Institute for Applied Mathematics at the University. He is, however, retaining his directorship of an Institute of the Deutsche Forschungs- und Versuchsanstalt für Luft und Raumfahrt (DFVLR) which is being moved to Göttingen and integrated into the Aerodynamische Versuchsanstalt (AVA). Goertler's former chair has now been filled by Prof. Karl Nickel who came from Karlsruhe.

Of Goertler's team in Fluid Mechanics at the Institute for Applied Mathematics, Dr. Thorwalt Herbert is joining Prof. F.X. Wortmann in Stuttgart; Dr. Karl Roessner has already gone to join Prof. Jürgen Zierep

at Karlsruhe; Dr. Jörg Wellmann has joined Prof. Ernst Becker at Darmstadt; and Dr. Horst Lange has gone to Paderborn.

One must hope for Goertler's recovery of health and return to the lists!

There's only one way to get children away from television and interest them in science--compete on the Tube's own terms. Accordingly, one of the lectures for school children to be given by the Chemical Society in London this month is entitled "Sex and Violence In the Insect World".

PERSONAL

Dr. M.G. Audley-Charles, Reader in Geology, Imperial College, has been appointed to the Chair of Geology, Queen Mary College, Univ. of London.

At the Univ. of Sheffield, Dr. J.A. Barnard, Reader in Chemical Technology, Dept. of Chemical Engineering, University College London, has been appointed Newton Drew Professor of Chemical Engineering and Fuel Technology.
Dr. K.J. Miller, Lecturer, Cambridge Univ., has been appointed to the second Chair of Mechanical Engineering.
Dr. J.S. Pym, Reader, Dept. of Pure Mathematics, has been appointed Professor of Pure Mathematics.

Dr. B.J. Brinkworth has been appointed to the newly created Chair of Energy Studies at University College Cardiff, Wales. Dr. M. Brooks, Senior Lecturer in the Dept. of Geology, University College Swansea, has been appointed to the Chair and headship of the Dept. of Geology, University College Cardiff, Wales.

Prof. T.J. Chandler, Head of the Dept. of Geography, Univ. of Manchester, has been appointed Master of Birkbeck College, Univ. of London, in succession to Dr. R.C. Tress. The appointment begins 1 October.

Dr. E.G.S. Paige, Deputy Chief Scientific Officer, Royal Signals and Radar Establishment, Malvern, has been elected to the Professorship of Engineering, Oxford University, in succession to Professor H. Motz, who is retiring. Paige will take up the appointment 1 October.

The title of Professor of Electrical and Electronics Engineering has been conferred upon Dr. M. Redwood, Queen Mary College, Univ. of London.

At the Univ. of Warwick, Dr. R.G. Rhodes, Reader in the Dept. of Engineering, has been appointed to a personal professorship.

Two new members have been appointed to Britain's Advisory Board for the Research Council (ABRC): Professor R.R.E. Southwood, FRS, Professor of Zoology and Applied Entomology, Univ. of London, and Dr. Alfred Spinks, FRS, Director of Research at Imperial Chemical Industries. Prof. Sir Frederick Stewart has been reappointed Chairman of the ABRC until October 1978.

ONRL REPORTS

R-1-77 THE MARINE GAS TURBINE--THE UK PROVIDES A CASE STUDY IN TECHNOLOGICAL DEVELOPMENT by R.H. Nunn

This report provides a review of the history of marine gas turbines (MGTs) as propulsors for the Royal Navy, and some of the technological extensions that now appear to be especially promising. Beginning with the Gatric engine in 1943, successive engines are described which, in 1967, provided the confidence necessary for the UK to opt for total MGT propulsion in future naval surface craft. The developments from 1967 onward are briefly summarized, and the current state-of-the-technology is described. Special attention is given to gas generators and their associated ducting systems for use aboard ship.

R-2-77 MATERIALS RESEARCH AT UNIVERSITIES--EN FRANCE ET/UND IN DEUTSCHLAND by A. Sosin

Research activities in materials science and in solid-state physics at two German and two French universities have been reviewed. These universities are the University of Saarlandes, the University of Karlsruhe, the University Louis Pasteur (Strasbourg), and the University of Paris. An account of some of these research activities is given. In addition, we present a discussion of the status of research activities and the stresses imposed on these activities.

R-3-77 CLOSED CYCLE GAS TURBINE SYSTEMS IN EUROPE by S.C. Kuo and R.T. Schneider

A review on the status of closed cycle turbine research and development in Europe is given. Closed cycle turbines utilizing air as a working fluid, either coal, gas or oil fired have been used in the past for electricity generation and as additional sources for district heating. The newer developments employ helium as a working fluid. The gas is heated by a large sophisticated gas heater at present. However, the final intention is to use turbines in connection with the high temperature gas-cooled nuclear reactors. Marine applications for gas turbines exist and are discussed in the report.

R-4-77 COMMUNICATION ENGINEERING IN FINLAND by N.M. Blachman

The principal institution for electrical engineering education in Finland is the Helsinki University of Technology. The Technical Research Center of Finland is the leading organization in engineering research, and Nokia Electronics is the leading manufacturer of electronic equipment. This report discusses their activities--particularly in the field of communication engineering--and includes some remarks on the work going on elsewhere as well as on the general historical background.

C-41-76

VIIth INTERNATIONAL SYMPOSIUM ON MARINE MEDICINE, 23 THROUGH 30 SEPTEMBER 1976, ABOARD THE M/V BELLORUSSIYA by J. Vorosmarti

The VIIth International Symposium on Marine Medicine, sponsored by the USSR Ministry of Health, Research Institute of Water Transport, was held on the Black Sea on 23-30 September 1976. Presentations covered hygiene and epidemiology, chemical and physical factors on ships, clinical aspects of marine medicine, environmental hygiene and underwater medicine. This report reviews the diving medicine sessions specifically and the plenary sessions generally. Selected abstracts are included in the Appendix.

C-1-77

SYMPOSIUM ON THE STRUCTURE OF NON-CRYSTALLINE MATERIALS by P. Craig Taylor

In this symposium, which attracted contributions from both the amorphous semiconductors and the glass sciences communities, recent results were presented concerning the structure of non-crystalline solids as deduced from several different experimental techniques. These techniques include x-ray diffraction, extended x-ray absorption fine structure (EXAFS), infrared and Raman spectroscopy, low temperature specific heat, and electron spin resonance (ESR). The symposium featured discussions of recent EXAFS measurements and methods of data reduction, of defects in semiconducting and oxide glasses, and of structural modeling techniques including continuous random network models.

C-2-77

XIIIth INTERNATIONAL SEMICONDUCTORS CONFERENCE (1976) by P. Craig Taylor, T.L. Reinecke and B.D. McCombe

The major topics of this conference were generally the same as those emphasized at the two previous conferences (Stuttgart, 1974, and Warsaw, 1972). We review the following subjects which were of particular interest at this meeting: surfaces and interfaces, excitons and exciton condensation, disordered semiconductors, and future semiconductor devices. In addition, selected presentations concerned with impurities, lattice dynamics, band structure, and one- and two-dimensional systems are also summarized.