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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 calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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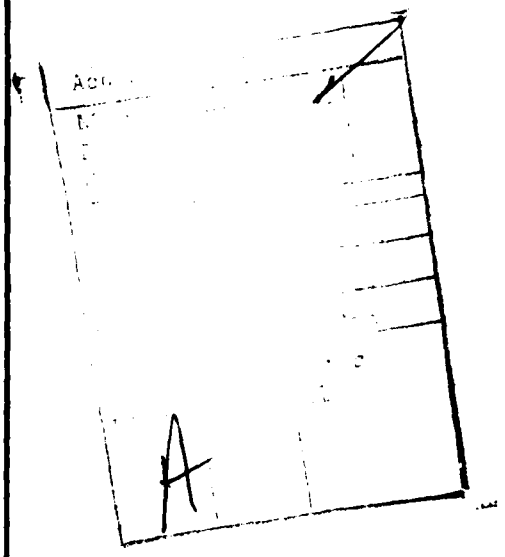

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CHEMISTRY

POLYMERS, SURFACES, AND LASERS AT ABERYSTWYTH

Tucked between the Irish Sea and the Cambria Mountains, the Welsh city of Aberystwyth has an air of isolation. Just to drive to Shrewsbury, a little more than 50 miles to the east, takes from 2-3 hours. Once a seaside resort, Aberystwyth is no longer frequented by the fickle vacationer who, in recent years is more likely to be found in southern France or sunny Spain. The once popular seafront hotels still have their Victorian charm, but many now serve as housing for university students.

We visited the Chemistry Department in the Edward Davies Chemical Laboratories, University College of Wales, and heard about their research in polymer science and surface chemistry and also their increasing involvement in laser spectroscopy. The present Head of the Department, Prof. W.J. Jones, recently came from the Univ. of Cambridge and succeeded Prof. J.M. Thomas (who went to Cambridge). Thomas had succeeded Prof. A. Trotman-Dickenson, now at the University of Wales (Cardiff). Jones' two predecessors strongly influenced the direction of the research in the Department; Trotman-Dickenson emphasized gas phase kinetics and when Thomas took over, he redirected the effort into solid-state chemistry. Now Jones is himself doing some redirecting into sophisticated laser spectroscopy. There is not much left of the gas-phase work, but a significant amount of the solid-state work continues including an MSc course in solid-state chemistry designed specifically to train people from industry.

When Thomas was department head, he brought in x-ray photoelectron spectroscopy (XPS) and Auger spectroscopy (AS) for the surface analysis of solids. Both techniques can identify chemical species in the surface; AS probes the first 10-20 Å, but usually cannot identify molecular groups. AS is complemented by XPS which can identify molecular groups, but is not as surface specific. Dr. S. Evans is using both XPS and AS to investigate the adsorption of O_2 on diamond and layered compounds such as GaSe, PbS, and MoS_2. He is working at pressures of 0.5 torr, which is relatively high for XPS and AS. He plans to study catalysis reactions when low molecular weight (MW) alkanes are used as adsorbates. Evans is also studying the structure of the surface of mica, using variable angle photoelectron diffraction (PED). X-ray diffraction cannot distinguish the Al sites from the Si sites as can PED. Using PED, he is also able to detect impurities.

Dr. P. Cadman is studying the interaction of various gases (e.g., O_2, F and C_2F_4) with the surface of graphite. In a microwave-glow discharge at 10^{-3} torr the fluorocarbon forms a low MW polymer layer on the graphite surface which is easily desorbed in vacuum. At higher pressures (0.5 torr), C_2F_4 forms a film with a stoichiometry of $-CF_2-$, and indeed the XPS spectra is very similar to that of polytetrafluorethylene (PTFE).

An accurate knowledge of the escape depth of the photoelectrons is required for the estimation of surface coverage using XPS. Cadman has found that the values for the escape depth given in the literature (~10-30 Å) are too low compared to his values of 30-70 Å. The problem seems to be that the escape depth ascribed to gold, which is the standard for comparison, was wrong. At first these findings were not accepted by others in the field, but Cadman said that even though he still runs into some heated opposition, he is gradually getting support.

Cadman has a special interest in the polymer/metal interface, specifically, interfacial reactions. He began with an investigation of the rubbing wear of PTFE on bulk graphite surfaces and on metal films evaporated onto glass substrates. He confirmed Prof. D. Tabor's (Univ. of Cambridge) prediction that a continuous film of PTFE will initially be deposited after which the polymer will deposit as lumps. Cadman also found that a "graphite fluoride" was forming on graphite, and that metal fluorides were forming on the evaporated metal films. He is pursuing this evidence of interfacial reaction by mixing PTFE and metal powders and compressing the mixture into pellets. The pellets are heated to 300-500°C and he observes the evolution

of fluorocarbon products. This suggests that in regions of local heating during the process of rubbing, low MW fluorocarbon products could form which would be able to react with graphite or metals.

In the Physics Department, we visited Dr. M.W. Jones who has a number of projects underway on fluid flow. In connection with enhanced oil recovery and with support from British Petroleum, he is studying flow through porous media. The work centers on aqueous polymer solutions and their oil displacement characteristics, and the objective is to eliminate interfacial instabilities which cause the aqueous phase to break through the oil phase. Also, the formation, stability, and displacement behavior of water-in-oil emulsions formed by the polymer solutions is being investigated.

In a joint program with the Royal Aircraft Establishment at Farnborough, Jones is studying mist formation by aviation fuels. Fuel misting in an airplane crash contributes significantly to fire, explosion and fatalities. Fuel additives are available that reduce misting, and Jones is trying to determine the mechanism by which these additives work. He initially looked at cavitation as part of the mechanism, but now thinks it unimportant. Currently, he thinks that perhaps the mist formation involves the breakup of thin columns of liquid into microdroplets.

In another aspect of his fuels work, Jones is trying to find a simple test that will indicate the presence of additives. He believes that the rheological behavior of the fuel may reflect their presence, and hence, he is measuring the shear and longational viscosities and viscoelastic behavior of the fuel.

Jones has a project in conjunction with Shell Oil Co., Ltd., on the molecular configuration of polysaccarides produced by enzymatic reactions. He is using light scattering to determine the translational and rotational diffusion coefficients of the polymers from which he can determine the molecular shape. He is also using scanning electron microscopy to determine molecular and/or molecular aggragate shape. In addition he is determining MW distribution (using gel permeation chromatography) and the gel formation characteristics of the polysaccarides.

In close cooperation with the Applied Mathematics Department, Jones is determining the flow pattern of liquids through rectangular ducts which have abrupt changes in the duct dimensions, e.g., a change in cross section or a tee junction. The work is ultimately aimed at injection molding of plastics and is supported by the Imperial Chemical Industries, Ltd. Jones hopes to obtain additional support for this work from the Science Research Council in the near future. At present the model fluid being used is glycerol in water which exhibits inelastic, non-newtonian behavior. Later, the fluid will also contain polyacrylonitrile and maltose which is expected to introduce elastic flow behavior as well. Flow velocities are being measured using laser Doppler anemometry and the Mathematics Department uses these data and numerical techniques to generate plots of the velocity network. Velocity networks are being generated for a variety of boundary conditions.

Returning to the Chemistry Department, we talked with Dr. Graham Williams. He spoke in a somewhat philosophical vein, first about the effect of the University's physical isolation, and then about his own work in polymers and liquid crystals. Both faculty and students experience some intellectual isolation resulting from being cut off from their contemporaries in the UK. One result is a difficulty in attracting students, especially good graduate students. In many cases, they leave for campuses in the East in less than a year.

Turning to his research, Williams remarked that not enough is known about the molecular dynamics of solid polymers. Bulk measurements, including sophisticated relaxation experiments, give only indirect information about molecular motions. There is, however, a change in the wind. Advanced NMR (*ESN* 33-4:154), small angle neutron scattering (*ESN* 34-2:75), and William's work using the Kerr effect, are all capable of providing direct information on molecular dynamics. The Kerr effect, or more precisely the electro-optical Kerr effect, occurs when a liquid or gas is placed in a stationary electric field and becomes optically anisotropic and double refracting. Since the magnitude and sign of the anisotropy are related to the permanent and induced dipoles of the molecule, information is obtained about molecular structure and organization.

Using the Kerr effect, Williams has been examining the "reptation" model of polymer chain motion. According to this model, the motion of a single chain is represented by the chain snaking through a tortuous tube, the walls of which are the surrounding polymer network. William's experiments seem to confirm this model. In his work on liquid crystals (based both on soaps and polymers) he is using the Kerr effect to observe molecular ordering phenomena. By cooling and heating through the crystallizing temperature he finds that the transition is sometimes abrupt and sometimes broad, but in all cases precritical phenomena can be detected, i.e., that the system anticipates the transition. Thus the crystallization cannot be considered a true phase transition.

Energy transfer mechanisms in dielectric crystals are being investigated by Williams, and the handle on these mechanisms is provided by the characteristics of the observed phosphorescence, and prompt and delayed fluorescence. Until recently, the crystals have been excited by exposing them to filtered light from either a chopped tungsten lamp or a stroboscope. (As will be pointed out below, lasers are being added as excitation sources.) The tungsten source (chopped at a low frequency) was used for steady-state studies, whereas δ-function excitation was provided by the 10-20 μsec pulses from the stroboscope. Investigations have concentrated on anthracene crystals grown by the Bridgman technique. [The lifetime of the triplet exciton was used as a measure of crystal purity and perfection, and crystals grown from the melt (Bridgman) exhibited longer triplet lifetimes than those grown from the vapor phase.]

Delayed fluorescence is the emission from singlet excitons, each of which is produced by the interaction of two triplet excitons. The delay in emission results from the long lifetime of the triplet excitons, and the objective of this study is to determine the crystal characteristics (purity, types of imperfections, etc.) affecting the triplet exciton lifetime. The time evolution of delayed fluorescence yields a curve that upon analysis gives the triplet exciton lifetime. The total intensity of delayed fluorescence, I_{DF}, is typically measured from 4 to 350 K, and maxima in the I_{DF} vs T curve provide information on chemical impurities and structural imperfections. Peaks in the prompt fluorescence spectrum from cleaved surfaces at 4 K also are indicative of the chemical purity and structural imperfection content.

The study of energy transfer of very fast processes (e.g., singlet-singlet, triplet-triplet, and host-guest) obviously require short-pulse excitation, << 5 nsec. A commercially available laser has been obtained by the Edward Davies Chemical Laboratory that not only meets the short-pulse requirement, but also can provide the wavelength tunability required for selective excitation. The source is a dye laser pumped by a mode-locked argon-ion laser. The dye-laser pulse width is <10 psec, and pulses can be generated at pulse repetition frequencies up to 4 MHz. An acousto-optical cavity dumper provides for the selection of a variable-width pulse train (from 1 pulse to cw), and tunability from 580 to 660 nm is achieved with the popular dye rhodamine 6G.

As this laser is new, no results are available. However, some upcoming experiments will be briefly described. In one experiment it is planned to irradiate a crystal simultaneously with two crossing psec pulses, and a phase grating will be produced as a result of the absorption of the two plane waves by the specie under investigation. As a result of the short pulse and resulting high peak power of this laser, the sample is readily bleached, and the phase grating is a result of higher singlet state absorption. The pump pulses will be followed by a probe pulse, and the intensity of that portion of the probe beam that is diffracted by the laser-induced grating will be measured. By varying the time delay between the pump and probe pulses, the time evolution of the excited species comprising the phase grating can be followed. This is one of several two-photon excitation projects to commence soon at Aberystwyth.

This laser is also going to be used to study the mechanisms of dimerization in single crystals. Again, the emission spectra and lifetimes provide the information required in the energy transfer study.

In another effort, an N_2 laser-pumped dye laser will be used in conjunction with a supersonic jet capability

to study the rotational and vibrational spectra of large molecules in the gas phase at low temperatures. The gases to be studied will be cooled (~2 K) as a result of undergoing rapid expansion, and the dye laser will provide for the excitation. A 9-W argon-ion laser will be used to pump a ring dye laser and the resulting tunable narrow bandwidth emission will be used in high resolution spectroscopic studies.

There is a sense of excitement in the Chemistry Department as they begin their adventure into laser spectroscopy. At the same time, the sudden redirection of the research away from solid state chemistry, especially surface studies, has produced a little disillusionment. One thing is certain. The research in the Chemistry and Physics Department at Aberystwyth is first rate, despite their geographical isolation. (W.D. Bascom and R.S. Hughes)

ENERGY

SULLOM VOE—THE SHETLAND ISLANDS OIL TERMINAL

The largest single oil terminal in Europe and the largest construction project ever attempted in the UK is under construction in the Shetland Islands about 140 miles NNE of Scotland. The terminal is located on a 1000-acre site on Calback Ness, a peninsula at the mouth of Sullom Voe (voe means a deep inlet or fjord) on the north end of the main Shetland Island. The terminal is designed to process crude oil and load it aboard tankers for shipment to UK and other ports. The crude comes from oil fields within the areas in the northern part of the North Sea that are allotted to the UK for oil exploration.

The 4 loading jetties on the protected side of Calback Ness can handle three 300,000 dwt tankers at a time; each tanker is over 3 football fields long. A fourth jetty will service smaller crude and liquefied petroleum gas (LPG) tankers. A fifth 300,000 dwt tanker jetty is on the drawing board which will increase the total length of tankers that can be berthed at one time to about one mile. The three stages of construction will provide processing capacities of 820,000 barrels per day (b/d) in 1980, up to 1,390,000 b/d in 1981, and provisions for up to 3,000,000 b/d sometime in the future if more new oil fields are discovered near the Shetland Islands. The 1,390,000 b/d will provide about 2/3 of Great Britain's daily oil needs. However, because of its high quality—especially low sulfur content—part of it will be traded on world markets for blending with less desirable fuels. Processed crude oil will be loaded on tankers at a rate of 30,000 tons/hr (220,000 b/hr). The maximum rate for a single tanker will be 20,000 tons/hr (147,000 b/hr).

Permanent houses and apartments for several hundred families are being built in small towns near the terminal to accomodate part of the permanent operating staff. The peak work force during construction will be about 6000 people, most of whom are being housed in temporary barracks and in two converted large sea-going ferries.

Two pipelines called Brent and Ninian, each 36 inches in diameter and 100 miles long, connect the oil fields to Sullom Voe. Their total cost was almost a billion dollars. By 1981, the Brent line will be bringing in about 1,000,000 b/d, and the Ninian line another 400,000 b/d. Each line services several different oil fields. The crudes arriving at the terminal from the two pipelines differ considerably; for example, Brent crude has much more gas and much less water than Ninian crude, and is at much lower pressure. The different characteristics of the crudes require two distinctly different parallel processing trains within the terminal. In critical places, extra parallel components are added to the trains to be used during breakdown and servicing periods. Thus the processing plant is designed for continuous 24-hour operation. There is one 200,000 gallon surge tank per pipeline. In the event of any breakdowns or other malfunctions, oil can be diverted into the surge tanks. This gives time for the orderly shutdown of production off shore if necessary.

Gas is removed by heating the crude and lowering the pressure in several stages. The process also aids emulsified water to settle to the bottom of the tanks where it can be drawn off. The gases then go to high-pressure refrigerated columns where the lighter fraction, methane and ethane, is separated and used to power the 125 mW electricity plant that is housed in the largest

building (160 m × 100 m) in the Shetland Islands. During construction the electrical plant is run on unprocessed crude oil. The heavier fraction of the gases goes to parallel sets of 2 columns each, where propane and butane are removed from the stream and liquified by cooling. The resulting LPG is stored in 4 different tanks (the propane and butane are kept separate and the gas from each field is handled separately) prior to loading into special refrigerated LPG tankers.

Between 12 and 18 floating-roof crude-oil storage tanks will be used to store crude prior to processing and after processing prior to loading into tankers. These tanks will give a total crude-oil storage capacity between 7.2 and 10.8 million barrels, or 5 to 8 days production.

The demand for oil is so great that the loading facilities of the terminal have already been in use for a year. Oil is degassed in the oilfields, where the gas is flared (burned). The oil is then pumped to the terminal, where it bypasses the processing section and is pumped directly into the waiting tankers.

Empty tankers, such as those arriving at Sullom Voe, carry 25 to 40% of their cargo capacity as sea water for ballast, in the tanks normally used for oil. Before this ballast water can be discharged into the ocean, most of the oil must be removed at a special ballast-water treatment plant at the terminal. Until this plant is completed, the tankers are required to carry their ballast water back and forth with them, reducing their effective capacity (and hence their revenue) by 25 to 40%. The temptation to pump oily ballast water into the ocean prior to entering Sullom Voe is discouraged by (1) spotter planes that may pick them up 200 miles off shore and follow them in, (2) periodic examination of ships' logs to determine when and where ballast water has been discharged, and (3) stiff penalties for dumping ballast water near the Shetland Islands.

The ballast water treatment system is designed to handle up to about half a million barrels a day. First it is allowed to settle for 24 hours in large tanks. The oil is skimmed off and the water run through large filters to remove as much of the remaining oil and particulate matter as possible. The final treatment is in a large artificial lagoon where some settling and biodegradation take place. The effluent is discharged through a diffuser on the bottom about 1/4 mile north of Calback Ness, whence it will be carried by 2 to 3 knot tidal currents into Yell Sound to the north, where tidal currents up to 10 knots will rapidly mix and diffuse the effluent into the large volumes of sea water passing through the sound. The organic content of the seawater several miles from the outfall should then be less from this petroleum than from recent natural sources such as plankton and algae.

Having seen individual terminals being built by individual oil companies in a piecemeal fashion elsewhere, the canny (in the Scotch sense, meaning careful or steady) Shetland Islanders have kept tight control over the development of the Sullom Voe terminal.

The local ruling body of the Shetland Islands, the Shetland Islands Council (SIC), formerly the Zetland County Council (ZCC), formed a partnership with the 34 oil companies that have financial interest in the oilfields to be serviced by the terminal. The partnership is a nonprofit organization called the Sullom Voe Association (SVA), which governs all developments connected with the terminal.

A single company, British Petroleum, was designated by SVA to design, construct, and manage the terminal. With the stimulus of the worldwide oil crisis, the ZCC persuaded the UK Parliament to pass a private bill, the Zetland County Council Act of 1974, that gave the Council extraordinary powers regarding the terminal: to control the sea approaches, to act as harbor authority in charge of pilotage and berthing of tankers and LPG ships, to purchase land, if necessary through condemnation proceedings, to create a reserve fund from oil revenues, and to receive a levy from all oil shipped from the terminal which will be used to lessen some of the long-term adverse effects of the terminal operations on other local industries. The Sullom Voe Port and Harbour Agreement was signed by the oil companies and SIC in 1978. It gave control of the construction and operation of the oil loading jetties to the SIC, to whom payment is given by the oil companies for the use of the jetties.

Early in the planning, SIC insisted on a thorough assessment of the potential environmental effects of the terminal. To accomplish this goal, the Sullom Voe Environmental Advisory Group (SVEAG) was established. The Group is essentially independent, although it is made up of members from oil companies, the SIC, government agencies responsible for protection of the environment, and university professors known for their environmental concern. A very thorough environmental impact assessment was completed and the results published by SVEAG in 1976. A broad spectrum of 30 different organizations submitted reports or provided assistance to SVEAG and its working groups in the preparation of the report.

Teams from various organizations are monitoring salt marshes, rocky shores, soft shores, air pollution (lichens are used as indicators of SO_2 pollution), benthic water and sediment chemistry, benthic biota (horse clam tissue is used to test for the presence of heavy metals in ballast water discharge that was loaded in the Rhine River), birds (by a full time ornithologist), and hydrography. Only ongoing programs are mentioned.

A large selection of equipment and techniques are available for cleaning up oil spills. British Petroleum and the SIC are extremely anxious not to leave any traces of inevitable oil spills to foul beaches and damage sea birds. Twenty trained men are prepared to operate the oil recovery systems. These groups are augmented by unskilled labor whenever a spill occurs. A small spill (estimated at 1 ton) occurred about midnight the day I arrived, when a gust of wind blew a tanker against a jetty. Fifty men were called out and cleaned up all evidence of the spill by the time I saw the area, about noon the next day.

There is no question that the British Petroleum Company and the Shetland Islands Council are making every effort to minimize the adverse impact of the terminal on the natural environment and the people of the Shetland Islands. (Wayne V. Burt)

ENGINEERING

COLLOQUIUM ON MULTIPATH PROPAGATION

Once is enough, spare me the extras—was the theme for a one day colloquium entitled "Modern Techniques for Combating Multipath Interference in Radio, Radar, and Sonar Systems." It was held at the Institution of Electrical Engineers (IEE) in London and focused on problems due to "extra" propagation paths which give interference causing fading and distortion. It was organized by the IEE Professional Groups E8 (radio communications systems) and E15 (radar, sonar, and navigation systems). The chairman, D.C. Smith (Plessey Co., Ltd) started the proceedings for this well-attended meeting with an apology for the brevity and inadequacy of the title (!) and pointed out that the purpose of the meeting was to identify and describe the problems as well as suggest solutions. The hope was, he said, to have this meeting as a first of a self-adapting series where the attendees would determine the nature of future meetings. At the end of the colloquium a discussion brought out a majority desire for a frequency of about once a year, a duration of one day per meeting, and for a wide coverage of subjects.

The keynote was set with a review paper, "Multipath Propagation" by Prof. P.A. Matthews (Univ. of Leeds). He described the deleterious effects of multipath propagation leading to amplitude and phase distortions. He discussed the causes of multipath transmissions for guided wave and "free-space" systems: distinct propagation modes, reflection points, the presence of layered structures in the medium, scattering from the medium and reflections from its boundaries. He found that a tapped delay line could be the basis of a useful model, indicating, perhaps not surprisingly, that the product of bandwidth and multipath delay should be much smaller than unity for distortionless transmission. The best general protection against multipath effects is obtained by reducing the reception of undesired paths with a directive antenna, preferably together with a null steering system, and by using frequency or space diversity. If the time-delay or frequency charac-

teristics of a given transmission path are known, then, Matthews concluded, it is possible to choose a method of modulation that allows maximum information to be transmitted.

There were six papers concerned with multipath effects on radio communication channels. A paper, "Characterization of the Mobile Radio Channel in a City Area at UHF," by A.S. Bajwa and J.D. Parsons (Univ. of Birmingham) and presented by the latter, discussed the severe fading problems encountered with a mobile system in built up areas. Rapid variations in signal strength were obtained with a narrow-band signal and distortions were found with wide-band systems caused by selective fading. A shift in frequency due to the Doppler effect will be obtained, proportional to the vehicle velocity measured along the direction of arrival of the signal. With multipaths, there will be several such directions and corresponding Doppler shifts. A characterization of the mobile radio channel was suggested in the form of a time-delay/Doppler-shift scattering function which explicitly illustrates its dispersive characteristics. Three dimensional plots were presented from experiments in the city of Birmingham, with power density being plotted vertically against a base of time-delay and Doppler-shift, the latter being an indication of the angle of arrival of the particular path. The characteristics change with location and it was found necessary to limit the characterization of dispersion and scattering phenomena to specific city areas.

A paper by A.N. Kent (R&D Section, Directorate of Telecommunications, Home Office), "Living with Man-made Multipath in Mobile Radio Multibase Station Systems," covered personal, hand-held UHF/FM radio telephones, particularly as used by the UK police force. Increased coverage was obtained by adding additional "base" stations. Quasi synchronous base transmitters were found most suitable, giving an interference field pattern that moves through the area.

R.C. French (Philips Research Laboratories) discussed a model for calculating bit error rates in communication systems caused by multipath fading. A pocket-size paging system was described (POCSAG) with a quoted false paging rate of 10^{-8}. J.T. Ong (Cable and Wireless Ltd, London) reported on fading with a microwave line-of-sight path in the Persian Gulf where considerable improvements were obtained by changing the frequency from 7.5 to 2 GHz. J.E. Doble (Post Office Research Center, Martlesham Heath, Ipswich) talked about the prediction of multipath characteristics of microwave links. He obtained good predictions by extrapolating from results of an existing link and derived a model for the UK with area dependent constants. J.P. McGeehan and D.T. Burrows (Univ. of Bath) presented the last paper on radio communications. The paper was read by Burrows, and described how very fast acting feedforward gain control can be used to suppress fading.

The remaining two papers concerned shallow water propagation.

N.P. Chotiros (Univ. of Birmingham) discussed the calibration of sources, such as motor boats, in shallow waters with a vertical string of receiving hydrophones. He showed that under perfect reverberating conditions, the best estimate is simply the average of the sound intensities measured. With absorbing boundaries a better estimate can be made using the cepstrum at each receiver; the cepstrum being the inverse Fourier transform of the logarithmic power spectrum.

J.F. Dix [Admiralty Underwater Weapons Establishment (AUWE), Portland, Dorset] presented a paper written jointly with R.F. Palmer (Royal Military College of Science, Shrivenham, Wilts.), concerning echo fading of torpedo mounted active sonar systems deployed in shallow waters. Experimental results were shown under conditions where many propagation modes existed. Coherent processing was found to give significant improvement to the sonar, typically extending the range by some 20%.

The meeting was heavily biased towards radio communications and, with one exception, did not include typical radar and sonar problems, which can be very different. These may well be addressed at a future meeting, perhaps one year from now.

A digest of the presentations, Paper No. 1979/62, is available from the IEE (Institution of Electrical Engineers, Savoy Place, London WC2R OB6, England). (T.C. Cheston)

ELECTRONICS AT THE IMPERIAL COLLEGE, LONDON

London's Imperial College of Science and Technology is as prestigious an institution as can be found anywhere in the world. It was established in 1907 by Royal charter to provide "... the most advanced training and research in the various branches of science, especially in its application to industry." To this end three old colleges were combined: The Royal College of Science (founded in 1845 as the Royal College of Chemistry), The Royal School of Mines (founded in 1851), and The City and Guilds College (founded in 1884). These three colleges still maintain their identity within the framework of the Imperial College. More recently, two new colleges have been added, one "Interdepartmental," to study environmental technology, and the other, "Associate Studies," covering the humanities. In 1908 the Imperial College became a "School" of the vast complex that forms the University of London.

There are about 4,600 full time students at the Imperial College, about one third of which, 1,500, are post-graduates. A large percentage of the undergraduates and almost one half of the post-graduates come from overseas or from Europe. At the present time the government, as part of its cost reduction program, has declared its intention to withdraw its subsidies for foreign students. This, if carried out, would require an increase in fees for foreign students, so large that the majority may well have to withdraw. This reduction in student body, it is argued, will in turn lead to higher cost per domestic student who is subsidized by the government. The issue is being debated at this time and undoubtedly a compromise will be found.

My visit was to the Electronics Section of the Electrical Engineering Department, City and Guilds College, and my hosts were Prof. John Brown, Head of the Section, and Dr. Richard H. Clarke. The position of Head of the Electrical Engineering Department is rotated between the section heads; Brown has just vacated it and it has been taken over by Prof. B. McA. Sayers. The Electrical Engineering Department accounts for about 10% of the student body; there are about 450 students including about 150 post-graduates. The Department is divided into 5 sections: Communications (Prof. E.C. Cherry), Electrical Machines (Prof. E.R. Laithwaite), Electrical Materials (Prof. J.C. Anderson), Electronics (Prof. J. Brown), and Engineering Applied to Medicine (Prof. B. McA. Sayers).

Brown is this year's President of the Institution of Electrical Engineers (IEE). His busy schedule includes additional activities: He is Chairman of the Engineering Board of the Science Research Council and Chairman of the Academic Council of the University of London.

There is yet another major issue being avidly debated at this time, promoted by the deliberations of the Finniston Committee which is investigating engineering education in connection with the needs of industry. Brown has considerable interest in this problem and discussed it on 4 October 1979 on the occasion of his inaugural address as President of the IEE ("Academic Strategy," IEE paper 8403). He differentiated between two types of engineers that are needed; one to create and introduce new technology, and the other to effectively use existing technology. The first would be a diploma engineer, the second a qualified engineer, and there would be two separate and distinct educational courses provided, with the selection of the students based on their past, pre-university performances (A-levels).

Brown's special interest has always been in microwave antennas and he still lectures on that subject. Many years ago he wrote a book, "Microwave Lenses." Currently he and Clarke are collaborating on a book, "Analysis of Aperture Antennas" in which the method of analysis is based on the use of an angular spectrum of plane waves to represent the electromagnetic field. The single plane wave then becomes the building block in the same way as the sinusoidal wave form is the building block of circuit analysis. The book deals with most forms of microwave antennas: horns, lenses, reflectors, dielectric rods, and includes non-planar apertures.

Research projects are grouped under 1) antennas and microwaves, 2) propagation and systems, and 3) optics, and are briefly discussed below. Sponsorship for some of these projects comes from the Andrew Corporation in the US which specializes in antennas.

G. Mitsioulis (with Brown) is investigating feed systems for collimating devices such as mirrors and lenses. Few restrictions are placed on the nature of the feed itself, which can be complex, consisting of multi-element/multi-mode structures forming a primary aperture which, in turn, provides the excitation of the secondary aperture at the mirror or lens. A general solution is sought so that optimal performance can be derived giving, for example, maximum gain or efficiency or low side-lobes, or a combination of these and other parameters. The feed system can further contain restraints so as to reduce spill-over and perhaps compensate for errors elsewhere in the system.

Jacob Ronen (with Clarke) is investigating a monitoring/fault-finding system for a phased array antenna. A traveling probe is used, somewhere in front of the antenna, examining the field. It is hoped that a suitable algorithm can be found that will lead to the detection of errors or failures in the antenna.

An attempt at measuring clear air turbulances was made by M.R. Inggs (with Clarke). An 8.6 mm wave propagation path was set up near London over a distance of 12 kms. On the receiving side two receivers were used, laterally displaced by about 1 m, and the phase difference between the two received signals was measured. Very small variations in phase (few degrees) were measured and attributed to air turbulence. In another effort, J. Kanellopoulos (with Clarke) made a theoretical study of cross-polarization and attenuation statistics of rain with millimetric wave transmissions.

There are several research projects going on involving optical fibers. An investigation was started by V. Handerek (with Mr. R.B. Dyott and Dr. J.R. Cozens) into the possibility of measuring currents in, for example, overhead power cables. The scheme was to spiral-wrap an optical fiber around an overhead cable and observe Faraday rotation with optical transmission. The need became apparent to first study polarization degradation and led to an investigation of circular and single-mode elliptical fibers. Hollow fibers were also investigated when filled with liquids for possible use as low-loss, long-distance, undersea communication cable, it being argued that liquids are likely to be more homogeneous than solids. Another possible application for homogeneous elliptical fibers is for laser gyroscopes. S. Al-Shukri (with Dyott and Cozens) is investigating growth of crystals in hollow optical fibers by filling the fibers with organic materials which are then allowed to crystallize. The aim is to use such devices with integrated optical chips. In an extension of this program, B. Nayar (with Dyott and Cozens) is investigating the possibility of second harmonic generation from lasers by using crystal cored fibers. In a separate effort, N. Nourshargh (with Dyott and Cozens) is looking at switchable directional couplers. Two parallel fibers, about 2-4 μm in diameter and with a center-to-center spacing of about 2 diameters, are immersed in an electro-optical material which can be influenced by an external field.

It is to be hoped that the tradition of the College will be maintained in spite of economies, so that it will retain its present position as one of this world's educational centers. (T.C. Cheston)

POWER, ANTENNAS, AND FUZZY SETS AT QUEEN MARY COLLEGE

Among the 44 colleges, schools and institutes of the University of London, Queen Mary College, located on Mile End Road in London's East End, is now the fourth largest. This is a report on a visit to the Department of Electrical and Electronic Engineering (EEE) at QMC.

Although the word "College" is in its name, this institution functions virtually as an independent university. It has somewhat over 3,000 students, of whom over 80% are undergraduates. There is a Faculty of Arts, a Faculty of Science, a Faculty of Engineering, a Faculty of Laws, and a Faculty of Social Studies. All departments are housed on the main college site, although certain engineering laboratories, including the Antenna Laboratory of EEE, are a short distance away from the main site.

EEE has 17 staff members, about 150 undergraduate students, and about 30 graduate students. The entrance selection process makes it possible to choose only good students, for the

annual intake of undergraduate students is 45 students per year, out of a total number of 600 applicants. As in other universities in England, the program of study for the undergraduate degree requires three years. The level of work that a student has had by that time is comparable to somewhere between that of BS and an MS of a university in the US. This can be accomplished in only three years of training because prior to entering students have had to spend on the order of two years studying mathematics and physics in a high school program.

Until a few months ago, the Head of EEE was Prof. M.W. Humphrey Davies, who has now retired. The new Head is Prof. Peter J.B. Clarricoats, well known to many microwave and antenna people in the United States. Clarricoats is not only Chairman of EEE but is also currently Dean of the Faculty of Engineering. The position of Chairman of EEE implies control of funds and therefore a considerable degree of power, while that of Dean of Engineering implies very little power and carries no extra remuneration. The Dean is the individual responsible for proper coordination of courses and other activities among the various departments of the College and represents the College to the central university administration. His office, therefore, is chiefly one of prestige.

While the undergraduate program in EEE has the usual courses, recitations and laboratories that one would also find in the United States, the master's, or MSc program, has no general graduate course requirement at this time. (The only course actually offered in the MSc program is a course in Power and Machines.) To work toward an MSc, the student normally works on a project for about a calendar year and writes a report on it. A person who has completed undergraduate work, has not already been awarded an MSc and wishes to obtain a PhD, is normally required to register for the degree called the MPhil. If, after one year, the student's supervisor is satisfied that the quality and progress of the work of the student warrant it, he or she will be allowed to transfer registration to that for the PhD degree without loss of time. Otherwise the work continues toward the MPhil, which is awarded after the second year.

The minimum time requirement for a PhD degree is two years. (This can include any time spent on the MPhil.) In many cases, however, the time required to complete a project satisfactorily for a PhD thesis is longer than this.

Among the 17 staff members of the Department there are now three professors: Clarricoats (Electromagnetic Theory and Antennas), M.A. Laughton (Power Systems), and M. Redwood (Physical Electronics) E.H. Mamdani, one of my hosts, is a Reader, while A.D. Olver, another one of my hosts, and R.F. Thumwood are Senior Lecturers. These two ranks carry the same salary. The name designations date from the days when research involved chiefly library research, for a Reader is normally looked upon as more in the research category. Actually there is little difference, except that a Reader at Queen Mary College has a small amount of extra prestige, since his appointment is from the University of London while that of a Senior Lecturer is only from Queen Mary College.

Research topics at EEE cover the areas of Power, Electromagnetics, Electronic and Dynamic Systems, and Physical Electronics. The three principal areas in Power covered are Power Systems, Electric Machines, and High Voltage. The aspects of Power Systems under study concern modeling theory and computer applications, with particular emphasis on optimization and network analysis. Much of the work centers around the computer facilities of the College and the University. This includes a number of in-house computers, as well as the University of London computer center with its CDC 7600/6600/6400 computer array. Recent work in the planning of power systems has dealt with generation-system expansion studies, including refinements of linear programming and mixed integer LP formulations. Sensitivity theory and parametric programming have been used to determine stability of solutions. Work has also been carried out on transmission and distribution network synthesis. Very recent work in the power system optimal operation area has focused on some new developments in nonlinear programming. Other subjects treated are power system state estimation, phase coordinate analysis and modeling theory, network theory and network analysis.

The major areas of research in Electric Machines have involved theoretical and practical studies of the general theory of electric machines, with the aim of improving the prediction of

performance of the various types of machines under arbitrary conditions. This has included computer-aided design of electrical machines, some aspects of linear A.C. machines, improved analysis of various performance characteristics of conventional machines and the development of improved measurement techniques, use of semiconductor devices for machine control of synchronous machines (in particular for brushless excitation systems), direct on-line computer control of machines, and acoustic noise produced by electrical machines.

The High Voltage work, which is principally under the direction of J.K. Nelson, has been dealing with conduction and electrical breakdown of industrial dielectric media. High-speed optical techniques and statistical methods are being used to investigate the physics and chemistry of breakdown situations.

The successes of some of the work in Electromagnetics, due principally to the efforts of Clarricoats and Olver, have caused EEE to become internationally known, and several overseas visitors, such as Professors L.M. Andrushko (USSR) and L. Lewin (Univ. of Colorado), have enhanced EEE's reputation by spending time there. Clarricoats has also been very active in professional activities outside of the University. For the past year he has been Chairman of the Electronics Division of the Institution of Electrical engineers. Recently he was Chairman of the Technical Program Committee of the 9th European Microwave Conference, while Olver was Secretary of this Committee.

A principal area of interest in Electromagnetics has been that of antennas and antenna feeds. One project recently completed dealt with limited beam scanning, i.e., how to steer a radiated or received beam without excessive aberrations and loss of gains. This involved theoretical and experimental studies of a spherical reflector, a spherical reflector with dual sub-reflector, a stepped reflector, a spheraboloid, and a two-point corrector.

The latter, which was found superior to the others, is a dual-reflector antenna whose shape is specially chosen so that the gain of the antenna reaches a shallow maximum when the beam points off axis. Beam movement is achieved with minimum gain loss by tilting the subreflector. This type of antenna can also be used in multiple-beam applications, where a number of feeds are used.

In the mid-1960s, groups working independently in Australia and the US recognized that conventional waveguides and horns used as feeds for reflector antennas do not yield the highest efficiencies possible. Analysis, using diffraction methods, led to the development of feeds with corrugated metal walls, which are now used widely in high efficiency designs. According to Clarricoats and Olver, a complete understanding of the operation of these feeds evolved during the 1970s as a result of the effort of many groups, including the group at Queen Mary College. Designs produced by this group have aided the development of feeds used in radio-telescopes and in ground station and spacecraft antennas. There the advantage of low cross-polarization offered by corrugated feeds opens the way for dual polarization communication systems and a subsequent doubling of channel capacity.

Another area pointed out to me by Olver was the development of measurement systems. Specifically, I saw an antenna range which had been compacted by the use of a plastic foam lens to obtain a collimated beam within which the radiation pattern of a test antenna can be measured. Here a novel feature is the introduction of a controlled amount of loss into the lens, so that a nearly uniform electric field is measured over a higher proportion of the lens aperture. Because of such a compact antenna range it is now possible for the group at Queen Mary College to perform measurements with an antenna range that is only 3-m long. The same thing outdoors without a lens would require a range 25-m long.

Other projects in Electromagnetics include work on the propagation of microwaves over forest terrain and some work on optical waveguides. (Fiber optical waveguides are said to have been invented by Kao, a former honorary research fellow in the Electromagnetics Group.)

Finally, I witnessed an interesting demonstration of a portable radar, designed to detect buried objects—both metallic and nonmetallic. It is an FMCW radar that operates in a linearly swept frequency band of 2-4 GHz, uses a focused forward-looking antenna (not in contact

with the ground), and can detect polystyrene foam targets buried at shallow depths in sand with vertical and horizontal resolution of about 4 cm and 20 cm, respectively.

The work of the Electronic and Dynamic Systems Group falls broadly into the categories of (1) dynamic systems analysis, (2) on-line and hybrid computation, (3) digital systems and adaptive logic, and (4) biomedical engineering. While most of this work is being carried out by lecturers and graduate students, it is said to have been aided considerably by T.H. Hammond, Head of the Control Division, Department of Trade and Industry, Warren Spring Laboratory, who is designated by the Department as a Visiting Professor. His presence has enabled a considerable amount of technical collaboration between the College and his organization. Similar collaboration, I was told, is being actively developed with a number of other organizations and institutions in the field of biomedical engineering.

Falling roughly in the area of adaptive logic is the research of E.H. Mamdani, who won a $100 prize for the best paper in the 6th International Symposium on Multiple Valued Logic in Logan, Utah, in 1976. Mamdani, although he teaches digital circuits, performs research on artificial intelligence, and in particular in the area of fuzzy logic and fuzzy subsets. Mamdani told me that this is an area of research initiated by Prof. L. Zadeh (Univ. of California) in 1965, and that since then important theoretical advances have been made in this field. Its framework was established mainly so that it could be used as a tool for dealing with vague statements expressed linguistically. Such statements would then be useful in the modeling and control of humanistic, societal or the so-called "soft" system. Mamdani and his group have shown that fuzzy set theory or fuzzy logic is equally applicable for the control of hard systems. Many industrial processes, because of their complexity, cannot be modeled precisely. However, skilled operators can often give vague linguistic statements about how such processes may be controlled. Previous work here has shown that controllers using fuzzy algorithms are able to work reliably. The group has also investigated the application of fuzzy logic for the control and heuristic decision making in discrete type systems, such as management systems, control of traffic road junction, pattern recognition, and so on.

Recently the group has been developing comprehensive computer algorithms that are able to achieve self-organizing control. Starting with little more information than the desired response from the system, the algorithms "learn" the control policy for any dynamic process. Exhaustive experimentation has shown the remarkable robustness of these algorithms. Algorithms are also being developed that can deal with multi-variable processes. Work has also aimed at making these algorithms efficient, so that they may be run on a microprocessor.

At the time of my visit, I was unable to meet with anyone from the Physical Electronics area, where recent work has dealt with piezoelectric devices for signal processing and filtering. A departmental brochure indicated that there were fewer individuals involved in this work than in the other three disciplines.

The impression gained on my visit to EEE is that, despite its relatively small size, the Department of Electrical and Electronic Engineering at Queen Mary College has been making some very useful contributions to technology. Moreover, under the leadership of Prof. Clarricoats, who is known to be a most vigorous individual, we can look to even more numerous and outstanding contributions in the future. (Irving Kaufman)

ENVIRONMENT

ENVIRONMENTAL PROTECTION IN BULGARIA

We tend to think of pollution as being an American problem, but it is world-wide. There are days in Katmandu when one cannot see the Himalayas for the smog, and the "beautiful blue Danube," one of the world's most polluted rivers, is now an ugly gray-brown. Thus it is not surprising that the Committee for Environmental Protection in Bulgaria has been set up as a super-departmental body reporting directly to the Council of Ministers. The Committee itself is small but its main activity is performed by the "Information and Computer Center" of the Committee,

which has about a hundred people in Sofia, almost all highly technically trained. I talked with I. Etropolski, Director of the Center, E. Boydanov, Chief Engineer of the Center, and D. Boichev, Chief of the National Program for Management and Utilization of Water Resources.

The Committee has a wide variety of responsibilities, which in America would be handled by many different bureaucracies. Its personnel are responsible for planning all new plants in Bulgaria for treating water, and is specifically charged with control of the budgets for constructing such plants. They are supposed to control and protect the purity not only of water but also of air, land, soil, landscape, flora, fauna, and "natural reserves"; these reserves are like our National Parks. They are responsible not only for controlling the environment but also for monitoring it. Under the heading of monitoring they expend a great deal of effort in measuring the degree and kind of pollution of both air and water throughout Bulgaria; it is this collection of statistical data on pollution and purity which leads to the word "Information" in their title. Finally, as far as water resources are concerned, they are charged not only with protecting them, but also with allocating them when the demand exceeds the supply.

In the performance of many of these functions, the Committee is heavily involved in systems analysis. For example, they have major responsibility for allocating water from the major dams to such competing consumers as power, irrigation, and urban water supplies. When there is ample water there is, of course, no problem; but from time to time there are shortages, and it is then necessary to balance off these competing needs and demands. They have built some interesting models; for example, there are subsystem models to forecast flow of water within the basin, as well as to forecast the national economy. The criterion they have chosen for the overall model is to minimize the total loss function for the nation as a whole. The basic model was obtained from the International Institute for Applied Systems Analysis (IIASA) in Vienna, Austria (*ESN* 32-2:51) and has been translated for use on a Bulgarian computer (the EC 1020, a Bulgarian version of the IBM 360/20).

Another optimization problem concerns the location of stations for controlling and monitoring pollution. This implies locating the stations in such a way as to maximize the amount of information obtained at a fixed cost.

Still another interesting problem is the distribution of purification plants in a river. The objective function is the total capital investment for a given level of pollution reduction, and this function is to be minimized. This involves determining which effluent sources should be treated, and to what extent they should be treated; it is a problem of national importance—hence the decisions are appropriately made by this Committee. These effluents and sources of pollution arise not only from industry, but also from sewers and farms. Synthetic fertilizers placed on a farm are eventually, to a considerable extent, leached out and deposited in the waterways, where they lead to eutrophication (this has led to a political problem since, while the increasing use of synthetic fertilizers has adverse effect on the water, it has a very favorable effect on the agriculture, which is under a separate jurisdiction). This study requires not only an optimization model, but also a detailed model of the spread of pollution within the rivers, and the tendency of rivers to self-purify.

A wide variety of operations research techniques have been used in the above studies. They have, for example, used Monte Carlo simulations of hydrological processes for long-term forecasting; the location and allocation of the purification plants involved discrete optimization; and dynamic programming has been used in connection with the optimal distribution and allocation of water. Dynamic programming was appropriate to the last-named problem because several forecasting models had to be involved, including forecasting the needs of the national economy and the flow of water within the basin.

Of particular interest to me was the international nature of much of this research. I mentioned above the model obtained from IIASA, and they have also used a Polish model which, in turn, was derived from a US model, for the way in which pollution is transported through a river.

Not only is the technology international, but so is the problem. The Danube, which constitutes the border between Bulgaria and Rumania for some hundreds of kilometers, picks up an incredibly large load of pollution from Austria, Czechoslovakia, Hungary, Yugoslavia, and Rumania before it ever reaches Bulgaria. The Black Sea, which is Bulgaria's maritime outlet, is rapidly being polluted by Rumania, Turkey, and the USSR, as well as Bulgaria. I am pleased to see the Bulgarians making such a rational assault on this problem. (Robert E. Machol)

FLUID MECHANICS

FLUID MECHANICS AT THE DEPARTMENT OF MECHANICS OF THE KUNGLIGA TEKNISKA HOGSKOLAN (KTH) IN STOCKHOLM

The Fluid Mechanics program headed by Prof. Marten Landahl at the Royal Technical University is part of the Department of Mechanics. This Department, headed by Prof. Olof Brulin, offers courses and conducts research in various aspects of mechanics such as classical mechanics, continuum mechanics, statistical mechanics, kinetic theory, quantum mechanics, and continuum rheology. The teaching faculty of the Department numbers 35. In fluid mechanics, the staff consists of 7, of whom 2 have professorial rank. Landahl spends one semester of each academic year at M.I.T. where he holds a professorial appointment in aeronautical engineering, and in his absence, I was conducted about the facilities by Prof. Fritz Bark. I also had the opportunity of meeting Prof. Rune Lindgren, who was visiting from the Univ. of Florida in Gainesville. Lindgren has maintained contact with the KTH over some years and has spent considerable time in Stockholm. Since undergraduate courses are taught in the Departments of Hydrodynamics and Gas Dynamics at the Technical University, the activity in fluid mechanics in the Dept. of Mechanics is limited to research and the teaching of graduate students, of whom 5 are enrolled at present.

Bark has recently been interested in the problem of swirling water bells. A bell of water is formed when a jet is projected axially onto a cone; upon leaving the conical surface, the flowing water forms a thin conical film which expands for a while and then is pulled back together by surface tension forces. Such bells were studied previously by G.I. Taylor. Bark became interested in what would happen if the jet or cone were spun as the bell was formed. As the sheet is contracted by surface tension, conservation of angular momentum causes the spinning bell to rotate more rapidly, so that it fails to close down. Bark developed a theory for the swirling water bell, and in experiments he showed that he could obtain two cycles of divergence and convergence of the spinning sheet. It would seem that some idealization of this problem could be formulated very elegantly using the concept of adiabatic invariance.

Lindgren showed me apparatus with which he studied Poiseuille-type flow. By injecting polymer (polyox and/or polyacrilimide) at concentrations of 1-100 ppm, he obtained complete suppression of turbulence up to Reynolds numbers of 9000.

In a rectangular water channel with a test section 6 m long, a height of 80 mm, a width of 400 mm, and a maximum velocity of 10 m/sec, instrumentation was being installed to study turbulence-induced noise. The apparatus, which was supplied by the Swedish Navy, contained mesh-filled settling chambers before and after the test section, vaned turns, rubber coupling vibration isolation before and after the test section, and porous rubber channel lining and baffling to suppress pumping noises. The channel has variable convergence and divergence up to 1°. The channel is mounted on bed rock, and hydrophonic instrumentation, hot wires, etc., are being installed.

Landahl is continuing his studies of local instabilities in connection with locally disturbed velocity profiles in a turbulent boundary layer. The approach is to see if a fundamental Tollmien-Schlicting wave will cause local velocity profiles that are in turn subject to Kelvin-Helmholtz type instabilities of a much smaller scale. Landahl feels that such local disturbances will have a smoothing effect on the velocity profile via their Reynolds stresses.

Besides drag reduction in bounded turbulent flows, Bark has studied the effect of polymer additives on mixing

in jet-type flows and has taken very interesting pictures of the dominant helical mode of disturbance present in a turbulent far-field jet flow. He has also recently started the theoretical study of the stability of plane Poiseuille flow of a dilute suspension of slender fibers. He is currently looking at the effect of such suspensions on the properties of the shearing layer. Finally, some work by Bark and associates on boundary layers in a rapidly rotating gas and spin-up complete the picture of research at the KTH, Stockholm. (Martin Lessen)

GENERAL

AUSTRIA, INC.

A recent visit to Graz, the capital of the province Steiermark (Styria) and Austria's second largest city, left no doubt in my mind that Austria is one of the more prosperous countries of Europe. The city was clean, neat, and orderly, the buildings were all painted, the stores were well-stocked and busy, and everything seemed to be in apple-pie order. A possible clue to one of the reasons for this affluence was revealed to me through a coincidence: a large complex of new buildings, in which feverish activity was in progress well into the late evenings, was located just a stone's throw from my hotel. Whenever I passed these buildings, I was also struck by the posters that pictured a man in working clothes closely associated with a man in a business suit, with each of the posters captioned with the letters WIFI. Since both the late activity and the puzzling posters had aroused my curiosity, I decided to investigate.

As I walked into one of the buildings, I soon found out that the large complex of buildings was the Seat of the Handelskammer of Steiermark, the Economic Chamber of Styria; that WIFI stands for Wirtschaftsförderungsinstitut der Handelskammer Steiermark (Institute for Economic Advancement of the Chamber of Commerce of Styria); and that the feverish activity was due to persons engaged in vocational training.

On surprisingly short notice, I was able to meet and talk to Dr. Herwig Brandstetter, manager of the presidential and administrative section of the Chamber, and find out about the structure and operation of his organization. Brandstetter, who had spent one of his college years in the US, told me that unlike organizations such as the Chamber of Commerce or medical associations in the United States, in Austria such organizations, or chambers, are not associations joined voluntarily but organizations set up by public law. They were created by acts of Parliament with the mission of serving the country, and membership of all businesses or professional establishments is compulsory. This includes enterprises under public ownership and control. There are separate chambers for businesses, physicians, attorneys, agricultural establishments, labor unions, etc. While this may seem to smack of a "big brother" system, it is not actually so. In spite of their governmental origin, the chambers are independent bodies. The government only sees to it that the chambers keep within the law; it has no right to give them directives. This means that as autonomous bodies with specific and legally defined rights and obligations they conduct their activities through decisions of their own elected representatives.

The chambers have two main fields of activity: (1) The so-called autonomous functions that comprise all activities concerning common economic interest of the members. This, for example, includes giving expert opinions on bills of law and offering advice to governmental authorities. (2) The delegated functions: In a number of cases the chambers have the legal authorization to assist in fulfilling or even to fulfill completely tasks normally carried out by public authorities.

Among the various professional chambers the Handelskammern, or economic chambers, are the oldest, dating back to 1848, though not in their present form. They are organized along provincial lines, in the pattern of the Austrian Federal Republic. Austria, with a population somewhat more than 7 million, has 9 provinces. Each province has its own economic chamber, with a total membership of 284,000. In addition to the provincial chambers there is also a federal chamber, located in Vienna, whose function is to coordinate regional and professional interests and cultivate international contracts. Each of the chambers, the federal as

well as the provincial ones, consists of six sections: (1) small-scale production, (2) industry, (3) commerce, (4) financial, credit, and insurance enterprises, (5) transport, and (6) tourism. These sections are subdivided into approximately 130 specialty, or "professional" organizations, whose membership is determined by the product or type of endeavor engaged in. Another of the functions of the chambers, then, is to coordinate aims and activities of the professional groups, both internally and with external agencies such as the government.

The economic chambers and their professional organizations are democratic institutions, and there are specified procedures for electing the governing members (president, assembly of the chamber, etc.) In their operation there is a division into the following departments: presidential department, departments for economic policy, social policy, commercial policy and foreign trade, legal and trade policy, financial policy, transport policy, and an institute for economic development.

The main financial resources that are used to support the professional groups are levies on the members. These may differ. A levy may be a fixed sum per firm, a percentage of the total sum of wages and salaries, or a percentage of the turnover, etc., as determined by the competent organs of the professional groups.

The expenses of the federal and regional chambers, on the other hand, are met by the "chamber levy," which is a surcharge of the trade tax. There is, of course, a committee controlling the management of the finances, elected by the assembly of the chamber.

In an organization composed of so many individual groups it must be rather difficult to equalize the interests of the various groups. The aim in making decisions is to arrive at conclusions that are considered the best for the whole economy, which at the same time meet the special wishes of the branches concerned. According to the information given me, this is usually accomplished by a great deal of give and take, resulting ultimately in unanimous decisions. Only rarely are the managers obliged to follow the wishes of just a majority of the members.

Since the chambers and the professional organizations view as their main task the representation of interests of their members towards parliament, the government, the ministries, and other authorities, they are often requested to give advice on economic questions and governmental bills. These activities are said to make it possible for public authorities to base their decisions on realistic and experienced views, which they assert is of great importance in a modern economy with its numerous and difficult problems. According to Brandstetter, this system has worked very well for Austrian industry and for that matter, for labor relations, for he told me that the number of industrial disputes has been virtually nil.

While the function of the chambers in giving advice to governmental agencies is an important one, equally important are the services rendered to the various professional groups. For example: advice on taxes and credits, cooperative advertising and market research, arrangement of professional meetings and excursions, vocational training of young people, additional training of the employers, establishment of teaching and examination facilities, measures to promote the traditions of the trade, representation of members at labor courts, and, perhaps of greatest interest to the readers of these Notes, subsidies for research institutes.

It was the vocational training that had caught my attention, and that kept people in the building close to my hotel working until late at night. Brandstetter told me that about 1,000 persons participate each night in the vocational training in the WIFI of Graz, out of a population of around 250,000. A multitude of courses are offered. Some examples are Group Dynamics and Communications, Decision and Problem Solving Techniques, Personnel Management, Marketing, Finance, Electrotechnology, Welding, Metal Working, Quality Control, and Insurance. There is even a course that teaches students how to make milk shakes and alcoholic cocktails. Moreover, while the principal place for taking these courses is the WIFI Institute in Graz, there are a number of other provincial locations offering some of the courses. Brandstetter's catalog of courses had 365 pages.

In addition to WIFI, there is also a community-supported scientific Research Center that serves the industrial community of Graz and Styria. For Graz is a rail and industrial center with iron and steel works, breweries, railway shops, and firms engaged in the manufacturing of precision and optical instruments, machinery, leather, paper, textiles, chemicals, and even theater stages that are shipped to as far away as Australia. The Research Center has as its expressed mission to strive for a close cooperation between science, industry, and management and is viewed as being a "window to the world." Its stated function is not only to service local industry, but also to import new ideas from the outside and to show the world the scientific activities of Graz. Chairman of the management of the Research Center is Dr. Werner Blanc.

The Center itself contains an extensive computer installation, facilities for electron microscopy, cryogenic installations, an institute of environmental research, an institute for scientific x-ray analysis, a nuclear reactor institute, a center for space research (which communicates with satellites), a mathematical and statistical section, an institute for construction physics, a group performing research on hydrogeology, a group looking for geothermal energy sources, and a laboratory for colloid research. Although not a gigantic establishment, the Center clearly has facilities for tackling a large number of problems.

In summary, the legally established chambers, such as the Handelskammern of Austria, are a great influence on the progress and prosperity of the country. A visitor's look at Austria quickly tells of their success. (Irving Kaufman)

MATERIALS SCIENCE

A DEFECTIVE CANTERBURY TALE

This tale, dealing with the Third Europhysical Conference on Lattice Defects in Ionic Crystals, is defective not only in terms of the subject, but also in that only half of the Conference is discussed. The meeting took place at the University of Kent, on a high hill overlooking the city of Canterbury and its magnificent cathedral, during 17-21 September 1979. As was the case for its predecessors (see e.g., ONR-London report C-37-76), the material neatly divided itself into two streams: (a) color centers and electronic properties, and (b) such ionic properties as mass transport, defect configurations and reactions, and dislocation phenomena. This article considers only the second of these two areas.

The University of Kent proved to be a felicitous site for a conference. We were all housed and fed (and "amenitied") at Rutherford College, a beautiful and well planned complex named after the famous physicist (amusingly, the biologists who were simultaneously meeting at Canterbury were accommodated in Darwin College). The lecture facilities were first rate (there was even a closed-circuit TV network that made possible the monitoring of progress of both concurrent streams of papers), and the organization of the Conference was very well done.

The Conference organizers employed as a logo the familiar old woodcut of the mounted Canterbury pilgrim, to which they had added, in the direction of his gesture, a drawing of the NaCl crystal model. A challenge to submit suitable captions elicited such suggestions as: "Aw, skip the Miller's Tale, and tell me about the Miller indices"; "That reminds me—I must get some Bath salts for my wife"; "Oh God, its Lot's wife!"; and "Begone you Devil Vision—Defects mar your Image of Perfection."

A detailed summary of the papers presented in the noncolor center stream is to be available as an ONR-London Conference Report. Also, the complete papers will be published by the *Journal de Physique*, as one of its "Colloque" series, and should appear sometime during the winter of 1979-80. Only a few general remarks, therefore, are offered in this article.

First, it is evident that physicists and chemists have discovered that the world is not made up solely of the alkali halides. For years, these substances have served as a workhorse for defect studies, but now, under the influences of better conceptual and experimental tools and the interests generated by technological applications, other ionic materials have become popular. Thus, many papers at Canterbury were concerned with defect properties

of the fluorites (MX_2), the oxides, and the silver halides. The greater complexities of these materials, which in earlier years induced investigators to remain self-trapped in the alkali halide potential well, have now become attractions and foci of interest.

A second observation is that atomistic calculations using HADES-type programs (of the sort developed by M. Norgett and exploited by R. Catlow et al., Univ. College, London) have made a truly enormous impact, especially in suggesting models for interpretation of experimental data on systems that are not yet well understood. In those cases in which there exist both theoretical and accurate experimental values for defect energies, the agreement is often—but not always—good. And it is these "but not always" cases that give rise to some concern, because occasionally the disagreement has proven unacceptably large. The main source of trouble in a HADES-type calculation is the choice of how to extrapolate the interionic potential down to small interionic separations, and one looks to this difficulty in rationalizing disagreements between theory and experiment. Unfortunately, it is not apparent in advance, at least to the uninitiated reader, which of the calculated energies are more to be believed than others. This, of course, depreciates somewhat the main value of such calculations: the predictions of defect phenomena in cases not yet settled experimentally.

Another problem which was mentioned several times at Canterbury is that these calculations minimize the potential energy for a hypothetical vibration-free crystal, whereas experiment deals with minimizing Gibbs free energy in a crystal with extensive vibrational energy. Thus, as has been argued for several years by Varotsos and Alexopoulos, these are two different types of parameters, and should not be expected to agree quantitatively. It was also apparent at Canterbury that such ideas as temperature-dependent thermodynamic parameters, excess expansivities and compressivities for defects (perhaps first argued by Gilder and Lazarus), and the correlation of these effects with anharmonicity are all receiving considerable experimental and theoretical verification.

To give the reader a bit of the flavor of what was presented at the conference, I summarize a few of the results and interpretations that emerged from individual papers. Thus far, all work on the superionic conducting beta-aluminas has of necessity been on highly nonstoichiometric material; W. Hayes (Oxford Univ., UK) discussed a method for preparing essentially stoichiometric material, with which one can test theories and interpretations of a variety of electrical and optical properties. In the fluorites, MX_2, it is becoming understood why the lead salts have so much such greater densities of Frenkel defects than do the alkaline earth salts (a matter of dielectric screening); nevertheless, for the well-studied $SrCl_2$ several apparently well determined values for the defect formation energy were offered at Canterbury, and the disagreement among them ranged over almost a full electron-volt. Several papers involving fluorites doped with a monovalent cation gave evidence that the charge compensation may be accomplished by the dopant itself—either by occupying both substitutional and interstitial sites, or by the residence of two ions on a single site. P. Jacobs (Univ. of Western Ontario, Canada) gave evidence, both theoretical and experimental, that even in the familiar KCl there is a non-negligible contribution to the high-temperature intrinsic ionic conductivity from both anion and cation interstitials. Two papers (by W. Fredericks and S. Dryden) attacked the problem of the approach to equilibrium defect concentration, studying time-dependent ionic conductivity after rapid cooling; it is interesting that equilibrium is attained very slowly.

The use of NMR to observe atomic motions is well-established, but the quantitative extraction of diffusion coefficients often involves difficult theoretical analysis. Several papers at Canterbury showed that these techniques have now been substantially refined, and that accurate diffusivities are often available from NMR. Another technique that was put on a firmer footing is the study of the often very slow diffusion of oxygen by means of implantation of ^{18}O and analysis by secondary ion mass spectroscopy. A new type of diffusion mechanism was suggested by A. Lundén (Chalmers Univ., Gothenburg, Sweden), for cation migration in crystals of sulfates in which the anion undergoes rapid rotation: this rotation causes fluctuations in

potential wells and barriers, and thus causes fast diffusion for virtually all cations (Lundén proposed the term "paddlewheel mechanism" for this process).

Impurity-vacancy complexes and their aggregation received a good bit of attention. E. Laredo, using thermally stimulated depolarization, showed that the defect rotation energy in rare earth-doped BaF_2, when plotted against the radius of the trivalent solute, goes through a maximum at Sm, which has the same radius as does the host cation. A number of investigators, and especially H. den Hartog, (Univ. of Gronigen, The Netherlands), showed that at solute concentrations exceeding about 100 ppm, one must take into account the interactions between the solute-vacancy complexes, in determinations of reorientation energy and also in studies of relative stability of different configurations. A very interesting identification and characterization of the different defect configurations and aggregates was demonstrated by means of laser-induced selective excitation of luminescence (J. Wright, Univ. of Wisconsin), and by dielectric analysis of doubled-doped crystals (J. Fontanella, US Naval Academy).

As had been the case in the two previous Europhysical topical conferences, dislocations received much less attention than did point defects. One relatively new phenomenon discussed in several papers is the nonconservative dissociation of dislocations perpendicular to, rather than along, the glide plane. Another particularly interesting problem is that of dislocations in such materials as the II-VI compounds, which are partially ionic and also semiconducting. R. Whitworth (Univ. of Birmingham, UK), showed how one could differentiate between the several sets of parallel but nonequivalent slip planes, could gain information on the dynamic charges carried by the dislocations, and could greatly change the magnitude and sign of these charges by doping or by band-gap illumination.

If one examines the total program, it is clear that the European contribution greatly outweighed that of the US. This may perhaps not be surprising, since the Conference was, after all, primarily a European one. Nevertheless, one can easily come to the conclusion that, in this field which is so important to future high-technology (e.g., radiation-resistant front walls), the United States, for better or worse, is not at the focus of attention. The next Europhysical meeting on this topic is to be held in Dublin, probably during the late summer of 1982. (Lawrence Slifkin, University of North Carolina, Chapel Hill)

FATIGUE IN METALS

The seminar on fatigue held at Ranmoor House of the University of Sheffield during the last week in August 1979, was an extension of the ICM-3 (Third International Conference on Mechanical Behavior of Materials) held in Cambridge immediately before. It brought together the detailed work on fatigue and materials properties under cyclic loading. As was done in ICM-3, rapporteurs discussed a number of papers together, rather than the individual authors presenting their own results. The strength of this system is that the rapporteur can present an introduction to the work being discussed before summarizing the results of each individual contribution, and can put these into the context of overall knowledge of that subject. The weakness of the system is that individual papers don't always fit well into the groupings made by the conference organizers, and the rapporteurs are not always up to the difficulty of their task. In this meeting, the system worked at about the 70% level, which is to say that on the whole it was better than having the papers presented individually. This was assisted by having preprints of the papers available in issues of the *Fatigue of Engineering Materials and Structure* 1, Nos. 3 & 4, 2, Nos. 1 & 2.

The principal organizer, Prof. Keith Miller (Sheffield Univ.), did a good job of organizing and bringing off the Conference, and it was held in an atmosphere resulting in considerable exchange of information. Persons attending were a mix of mechanical engineers and metallurgists, giving each group an appreciation of the other's point of view and causing each group to communicate to the other some of those things that one often sees as accepted facts or concepts while the other does not.

Probably the most interesting discussions were held on the subject area

of small cracks and notches; there is disagreement among engineers on how to handle the fracture mechanics, and there is disagreement among metallurgists on the relationship of microstructure to the problem. Little was resolved, but some better understanding of the complexity of the problem may have been gained—by the metallurgists on how to handle the mechanics (or how not to)—and by the engineers on when to begin to look at the material as a noncontinuum (a metallurgical structure).

Another area highlighted by the Conference was creep produced by loading specimens under a mean stress, and its importance to the fatigue life and dimensional stability of cyclicly loaded structures. Although some progress has been made on understanding (and predicting) cyclic creep in terms of kinematic hardening, it is clear that this phenomenon cannot yet be accurately predicted.

The effects of environment and non-constant cyclic loading on fatigue crack propagation were covered by eight papers. Among these was a presentation which described a new method of measuring crack tip displacements which was used to examine overload and underload effects. Also, there was a paper on a new analytical method of calculating crack closure and delay effects caused by overloads. Environmental effects were reviewed by Raydon and coworkers (Imperial College of Science and Technology, London, UK) and again the three classes of environmental effects were shown, although it has yet to be predicted which material will fall into which class under which loading state and environment. A particularly good paper on the effect of wave form on corrosion fatigue was presented.

During the session on fatigue under multiaxial loading conditions, the statement was made that "this problem is going to be the one which we will be studying for the next 10 years;" that may be true, but the data presented indicated that if the stress intensity factor (K) could be correctly determined (and this is not easy) then K correlates crack growth rate rather well for almost all of the multiaxial states which can be reached; thus, one is led to conclude that fatigue crack propagation under multiaxial loading is mostly a problem in the mechanics of determining the appropriate stress intensity factor. This insensitivity of crack propagation to multiaxial loading may be due to the fact that regardless of the macroscopic loading state, the microscopic loading state of crack tips is more often multiaxial than not. Thus, it now appears as though further work in this area needs to concentrate mainly on the real extremes of nonaxial loading.

In summary, the 45 papers presented and 474 pages of text generated during "Fatigue 1979" were able to add some new understanding of the phenomena of fatigue and, equally important, the Seminar was an opportunity for 165 persons from 18 countries to meet one another and exchange information on a more informal basis. (D.L. Davidson, Univ. of Oxford, UK)

FINE-LINE LITHOGRAPHY

What seems to be a record in the production of fine-line width by the use of conventional (and therefore controlled) polymeric electron resist has been reported by Dr. C.D.W. Wilkinson of the Univ. of Glasgow. His group has produced lines of only 200 Å width (or less) and 25 microns length, as measured by both transmission and diffraction electron microscopy.

To produce such fine lines, a master mask, consisting of a thin carbon film on which gold lines are deposited, is made by "exposing" selected areas of a layer of thin film polymer PMMA on the carbon film with a fine electron beam, in the pattern desired. The PMMA is then "developed" by dissolving the degraded (i.e., "exposed") PMMA. After overcoating the surface with gold, the remaining PMMA is then dissolved, to leave a gold mask on the carbon film.

To fabricate a working mask, which consists of a patterned layer of gold on a thin plastic sheet, the master mask is interposed between a source of parallel soft x-rays and a layer of PMMA on the sheet of plastic. The working mask is then produced by repeating the steps of gold deposition and PMMA dissolution outlined above. This sturdy end product can then be used as an x-ray mask for photoresist in the fabrication of devices.

Application of lines of 200 Å or less in width is in the fabrication of superconducting devices and x-ray

diffraction patterns. The immediate aim of Wilkinson's group, however, is to develop techniques for Integrated Optics, where optical waveguides whose edges can be controlled to an accuracy of 0.01 of an optical wavelength (therefore around 50 Å) are to be delineated. The fabrication of lines of 200 Å total width in a controlled manner seems proof that this is now possible. The next step, according to Wilkinson, is to attempt to demonstrate that the motion of the initial "writing" beam by only 50 Å results in lines displaced by the same distance.

The effort described above is part of a considerably larger one on Integrated Optics in the Department of Electronics and Electrical Engineering at Glasgow, initiated and headed by Prof. John Lamb since 1969. (Irving Kaufman)

HOW DEEP IS THAT CRACK?

Virtually every rigid structure develops cracks during use. Some remain microscopic, others become large enough to cause the structure to fail. Except for special cases, such as the need to maintain a high vacuum, microscopic cracks are usually of no great concern to the user. But there is concern about the larger ones. Is the structure about to fail, or when can failure be expected? Can the crack be repaired, or does the structure or, at least, the part that has the fracture have to be discarded?

To make the correct decision, it is obviously necessary to know the dimensions of the crack and its orientation. How to determine these parameters without damaging the structure or part, i.e., nondestructive testing (NDT) or nondestructive evaluation (NDE), as the technique is sometimes called in the US, is a problem that has been and continues to be of great concern.

To discuss various techniques of such NDT for cracks, a colloquium was convened on 30 October 1979 by the British Institute of Non-Destructive Testing (1 Spencer Parade, Northampton NN1 5AA) at the Cavendish Conference Centre in London's West End. Here about a hundred people paid approximately $85 each to hear six persons talk about their progress in measuring crack depths. While the large majority of the participants of the colloquium were from Britain, there was also representation from Sweden, Norway, Denmark, Switzerland, and even Spain. Chairman of the meeting was Dr. Peter Emerson, head of the NDT Unit of the British Iron Research Association, Birmingham, UK.

Detecting the presence of a crack on the surface of a material is relatively easy. One simple way is to spray paint on the surface and look for the gaps in the paint. Another technique, used extensively with ferromagnetic materials, is to sprinkle iron powder on the surface and look at the interruptions in the smooth pattern. Detecting the presence of a crack near the surface of a material that is of a highly curved structure, so that the crack is not visible, is much more difficult and was not covered in this meeting. It was assumed, in fact, that the presence of a fracture and its approximate location were known; the objective was to measure its depth.

There are at least three different techniques for determining the depth of a fracture: ultrasonic, potential drop, and eddy current testing. In the ultrasonic method ultrasonic signals are sent out and the echoes are analyzed. In the potential drop method the change in voltage along the surface of a specimen through which a current is passed provides the desired information. In the eddy current technique two coils are suspended above the specimen. An ac current which passes through one coil induces a magnetic field in its surroundings, including the specimen. For a specimen without cracks the magnetic flux density will be of a different value than it would be if there were a crack. By Faraday's law of induction, the amplitude of the induced voltage in the second coil will therefore depend on whether there is a crack present or not, and on its depth. Since the second and third methods depend on passing current through the specimen, they are restricted to conducting materials. Ultrasonic techniques will function with insulators as well as conductors.

The first of the six talks, by C.A. Hunt [Royal Armament Research and Development Establishment, Woolwich Arsenal (East), London], was a success story, in that it was a report of a working technique of measuring the

depths of cracks in the bores of gun barrels. Fabricating gun barrels that are not too heavy but strong enough has been a problem for centuries. It is said that the soldiers of Napoleon's artillery were more scared of being killed by gun barrels exploding than by enemy shells.

To use a method that depends on currents flowing in the material would not be feasible in testing gun barrels actually used for firing, since during firing the cracks are firmly "loaded" with metal from the projectile. In the successful technique reported, an acoustic transducer was mounted on the outer periphery of the gun barrel, pulses were sent toward the center, and the echoes were examined (see Fig. 1).

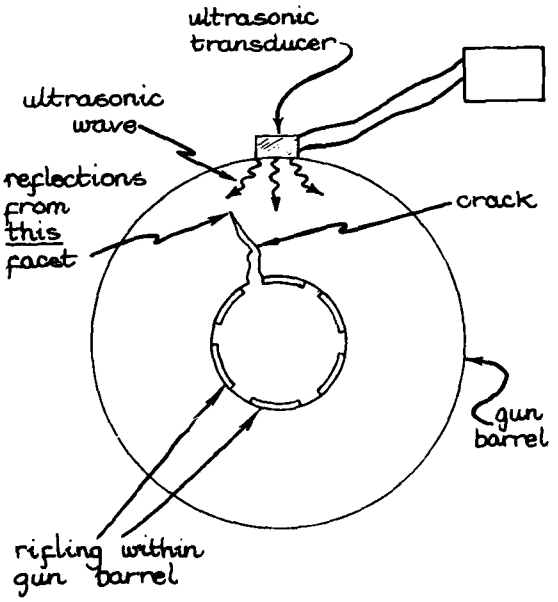


Figure 1

It was noted that the cracks are not of zero width but have facets, and that it is the time interval between the echo from the facet at the tip of the crack and that from the inside surface of the barrel that gives the depth of the crack. The minimum depth that could be measured was 3 mm; the accuracy was about ±1 mm. Hunt's ultrasonic pulses were a few msec in length and had a frequency of 4 to 5 mHz. He stated that lower frequencies would set a limit to the resolution of the depth measurement, higher frequencies had a poorer signal to noise ratio.

Instead of using gun barrels which had actually been used in firing, the tests reported on were made with hydraulically compressed gun barrels, with compression-release cycling of as many as 15,000 times. With the help of the Non-Destructive Testing Centre at Harwell (NDTCH, see *ESN* 29-8:352) automatic electronic equipment was developed to read position and depth. The advantages of the system used over others were cited as: (1) direct reading of crack depth, (2) direct reading of angular position, (3) the method was not sensitive to back surface effects, i.e., rifling and erosion, (4) a deep crack is generally surrounded by smaller ones which would be disturbing if waves came in at an angle; here the waves came in virtually parallel to the crack, (5) independence of the tapering of wall thickness, and (6) independence of angle of crack. Disadvantages were listed as: (1) good contact surface is needed, (2) a good transducer is required, (3) very clean, fine-grain material is required (gun barrels are made of such material), (4) sections required need to be at least 20-mm thick (because of front echo), and (5) not easily applicable to cracks less than 3-mm deep.

In the next talk, P.J. Mudge (The Welding Institute, Abington Hall, Abington, Cambridge, UK) described another ultrasonic method developed by NDTCH which differed from Hunt's method in that the echo received was not by straight reflection but by diffraction from a tip. (B.H. Lidington, M.G. Silk, P. Montgomery and G. Hammond, "Ultrasonic measurements of the depth of fatigue cracks." Report AERE-R 8190, AERE Harwell, Oxfordshire, UK.) The scheme is shown in Fig. 2 for a crack adjacent to a welding joint. Here a transmitting probe, the input transducer, sends out pulses into the material, as shown. The depth of the crack is found by measuring the time interval between arrival at the output transducer of a signal diffracted from the tip of the crack and that reflected from the back wall.

Mudge stated that since it was found that ultrasound propagates through cracks and gives false signals unless there is an actual gap, it was necessary during test to keep specimens under tensile load. In this manner, the accuracy for measuring crack depth

was found to be 0.8 mm. Mudge also reported that portable equipment has been developed which can be used routinely by staff who do not normally have experience with NDT.

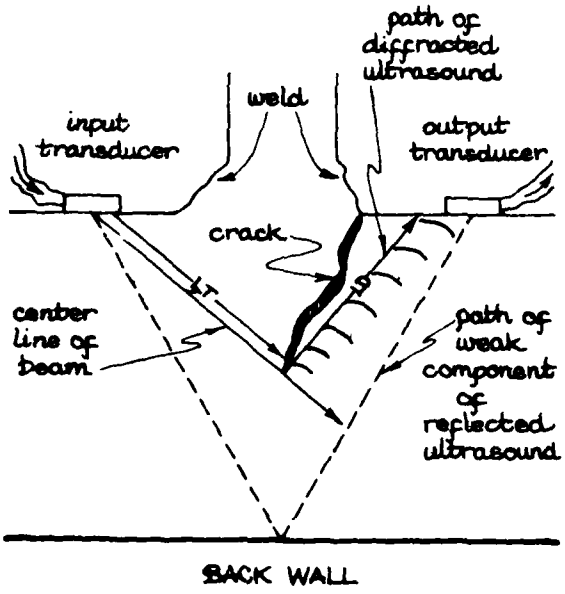


Figure 2

The next talk, entitled "Ultrasonic Methods for Cracks under Aircraft Skin Fasteners," was to be by Dr. J. Speake (Pantatron Systems Ltd., Motherwell, Strathclyde, Scotland). Since Speake was unable to be at the meeting, the paper was read by D.M. Osborne of Pantatron. The talk dealt with finding fatigue cracks in a location not visible from the surface.

Osborne pointed out a distinct difference in the fatigue behavior of nonferrous materials from that of ferrous material, as shown in Fig. 3. In a ferrous material, as long as one stays below the fatigue limit, the material can be used indefinitely. For aluminum alloy and other nonferrous materials, on the other hand, the fatigue limit decreases monotonically with the number of stress cycles. He stated that it is therefore necessary to test nonferrous material structures routinely.

Osborne described an instrument developed for measuring crack depths around wing fasteners of airplanes. Fig. 4(a) shows the basic structure of a section of airplane wing. It is seen that a spacing support member is attached by rivet fasteners to both top and bottom plates. The fatigue problem arising is that cracks develop around the fasteners, as shown in Fig. 4(b). The objective, again, is to measure the crack depths. The speaker mentioned that this has been accomplished by first locating the position of the hole through which the fastener passes, then by looking at echoes of ultrasonic waves originating from transducers placed at various angles, as shown. The instrument that has been developed is automated, so that the average test time per hole required is five minutes. Moreover, the hole and the fractures associated with it are displayed automatically. Some operators claim that they have picked up cracks as short as 0.010 inches (0.25 mm). At this time the equipment is useful for thick wing skins. Osborne stated that thin skins may require the technique of eddy current testing.

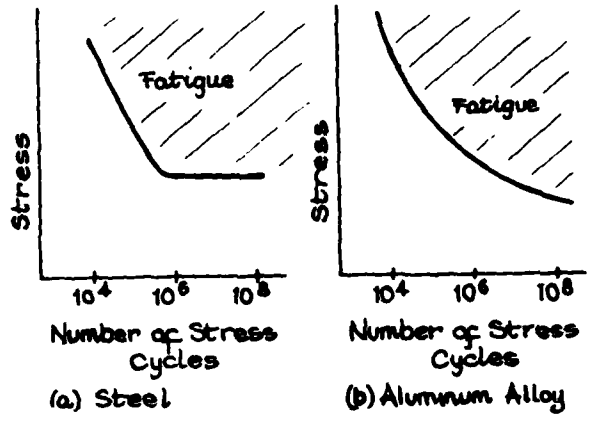


Figure 3

The basic idea of the potential drop method is shown in Fig. 5. While this method could be carried out with direct current, too much current would be required. Since alternating current flows only in a skin near the surface, ac is more suitable for large specimens. The method is then called the ACPD method. V.A. Peters (Unit Inspection Co., Ltd., Swansea, UK) discussed an apparatus called the Crack-MiCroGauge, which functions by picking up the voltages labeled as in Fig. 5. According to Peters, the optimum frequency for his instrument is 6 kHz.

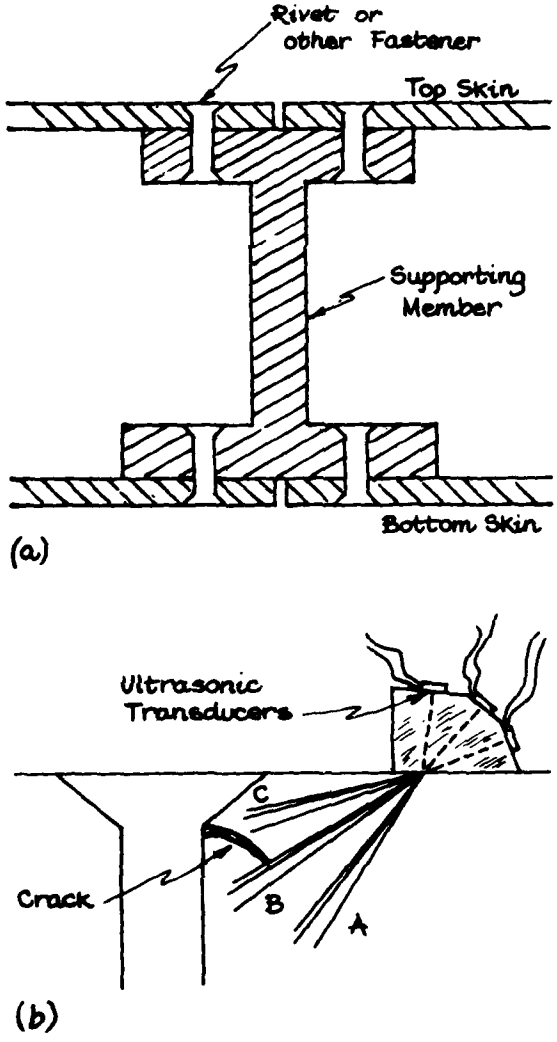


Figure 4

I saw this instrument demonstrated and made some test measurements myself. For simple shapes, such as a rectangular bar, it appeared to perform very satisfactorily. Since this system of measurement and the calculation of the crack depth assumes uniform current density except in the immediate vicinity of the crack, one would expect that difficulties would be encountered for nonuniform shapes. Peters verified this, but stated that W.D. Dover and others of University College Swansea (Wales, UK), who had performed some of the basic work, also developed correction charts for some nonuniform shapes and that additional ones could be developed. Peters stated that while ultrasonic techniques would have errors in fracture depths of 40-50%, his instrument has errors of only 10% or less. He suggested that the chief application is in the measurement of cracks in uniform shapes, where the cracks are much longer than they are deep. Since the system seemed very simple to me, I inquired about the price of the instrument. It was about $5,000. I would expect this price to drop if the instrument were produced in large quantities.

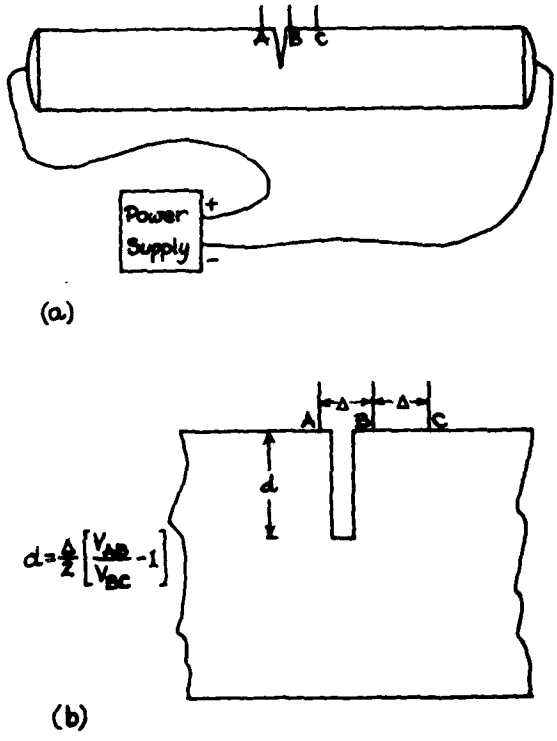


Figure 5

Another speaker who described his experience with the ACPD system was R.J. Ryman (Testwell Ltd., Daventry, Northants., UK). Ryman, whose company had developed a measuring system similar to that of Peters for the Admiralty Marine Technology Establishment, verified what Peters had said, and also pointed out some other interesting phenomena. Specifically, he stated

that there is evidence to suggest a linear relationship between change in resistivity of a material and in elastic strain, to cause a variation of potential drop volts vs load as shown in Fig. 6.

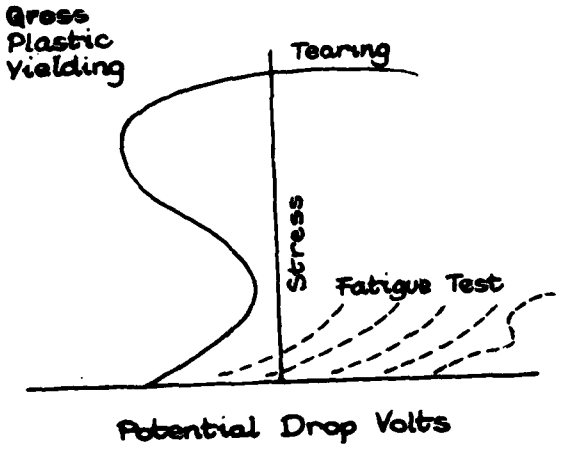


Figure 6

Here it is seen that when a material reaches gross plastic yielding, the potential drop actually can reverse. While it is expected that in practice the material would not be stressed to the limit of Fig. 6, Ryman concluded that the ACPD test provides not only crack depth information, but also interesting information on behavior under stress.

The final talk, by Dr. R. Halmshaw (Royal Armament Research and Development, Fort Halstead, Sevenoaks, Kent, UK), dealt with the eddy current method of measuring depths of cracks. Halmshaw stated: "My experience of commercial eddy current measuring equipment was that the depth of a natural crack as measured was off 100% from what it should have been." What he was saying, in fact, was that a machined slot could be measured accurately by the eddy current technique, but that a natural crack gave problems. Thus, while the ACPD method indicated the correct depth of the crack, no matter whether it was a natural crack or machine slot, this was not true for the eddy current method. He said that his talk, which was quite short, was actually a progress report, with conclusions perhaps not fully justified. For, he stated "My own conclusion is that one should stick to ultrasonic and potential drop methods."

He did mention, however, that Dr. Becker of the Institute of Nondestructive Testing (IZFP) of the Univ. of Saarbrücken, FRG, has been working on a two-frequency eddy current technique that seems to give reliable results.

In summary, it was evident from the material presented in the Colloquium that several techniques had now successfully reached the "commercial product" stage, but also that much additional work remains to be done. (Irving Kaufman)

THE IUPAC SYMPOSIUM ON MACROMOLECULES: MACRO/MAINZ

The largest conclave of polymer scientists in the world is the IUPAC (International Union of Pure and Applied Chemistry) Symposium on Macromolecules. The 26th of these meetings was held 17-21 September 1979 in Mainz, FRG at the spacious Reingoldhalle overlooking the Rhine. Each year the host organization strives to outdo the previous meetings in number of papers, number of distinguished invited speakers, topics, and, most important, the extracurricular events.

This year's host, the Gesellschaft Deutscher Chemiker, succeeded on all counts. There were no less than 6 concurrent sessions, a total of 430 presentations of which 4 were plenary lectures, and 34 invited lectures. The preprints were in 3 fat volumes and, along with assorted advertizing, the packet handed the hapless registrant weighed about 7 pounds. There were 22 tours and activities for "accompanying persons" which also attracted many of the conference participants, especially since the weather was unusually pleasant. The many concurrent sessions made comprehensive coverage of the meeting impossible. Also, some of the invited lectures on a given topic were presented at the same time as the session of short communications on the same topic. Anyone wishing to hear an overview of the subject and also new developments in the field had to miss 4 or 5 of the short talks.

The plenary lectures will be published in *Pure and Applied Chemistry*, and the invited lectures in special issues of *Die Makromolekulare Chemie*, and so this article will only summarize some of the highlights. Taken together, the plenary and invited lectures amounted to a rather comprehensive short course in polymer science.

The future of the polymer industry in this age of dwindling oil supply was forecast by Prof. K. Weissermel (Hoechst AG, Frankfurt/Main, FRG) in a plenary lecture. He started by explaining that commercial plastics now in high volume production, such as polyethylene (PE), polypropylene (PP), and the epoxys, reached high volume because crude oil and natural gas were offered at prices well below their real value. This enormous production capacity based on petrochemicals poses some serious choices that must be made now. Assuming that plastics will play a role as substitutes for energy-intensive metals in an energy-critical future, Weissermel concludes that crude oil should be allocated for petrochemicals and not for fuel. In his opinion there are no reasonable alternative sources for plastics. To utilize agricultural products or even coal to make plastics would require very costly conversion of the existing petrochemical processing equipment. A substitute for PE may be possible from coal tar, but it cannot be synthesized using the same equipment that makes PE from natural gas without drastic alterations. Alternatively, Weissermel suggests that coal liquefaction and gasification be used to make fuels. The technology is available and a limited production is coming on stream. The whole scenario can be optimized, according to Weissermel, by refining crude oil for maximum petrochemical output. Also, he suggests the use of nuclear energy to power coal liquefaction/gasification as a further saving of fossil fuel.

Looking into the future utilization of plastics, Weissermel does not see any new high-production polymers coming on the scene. Composites will be important both to extend the polymer supply and for the unique properties they offer. He also puts a premium on recycling plastics, either by reprocessing or degrading them to other chemicals.

Despite this writer's abhorrence of organic chemistry, the plenary lecture by Prof. G. Smets (Katholicke Universiteit Leuven, Heverlee, Belgium) on new developments in polymer synthesis was a delight. Smets noted that there have been few new high-production polymers in recent years and, like Weissermel, he does not see any in the future. Nonetheless, industrial production of polymers has been increasing steadily, mostly through more efficient production methods and the development of small-volume specialty polymers.

As Smets sees it, the new developments in polymer synthesis have come in understanding reaction mechanisms, in new synthesis routes, and in special applications of polymers. He cited progress in photochemical initiation, copolymerization of heterocyclic monomers, block and graft copolymerization, and chemical transformation reactions. The special applications of polymers that Smets thought important are their use as models for biopolymers and enzymes, as drug dispensing agents, and as "reagent chemicals." As an example of their use as reagents, he discussed the use of polystyrene (PS) in the synthesis of amino acids and polypeptides. The surface of the PS is modified chemically to enable reactions to take place which would not occur (or would be complicated by side reactions) in homogeneous systems.

In a plenary lecture, Nobel laureate Prof. P.J. Flory talked about the molecular structure, conformation, and properties of macromolecules. He gave a rather general and somewhat philosophical discussion of the relation between macromolecular structure, conformation, and properties. He noted that the chemical structure of polymers can be characterized on the macroscopic level in terms of molecular weight (MW), MW distribution, and degree of branching. At the micro-level, characterization is in terms of chemical composition and the sequential nature of the chain structure. Bond-angle and chain-rotation constraints, and the detailed chain architecture mean that there are usually a discrete number of configurational states, i.e., the conformational energy space is characterized by discrete minima. Flory emphasized that chain bonds need only be considered pairwise, which greatly simplifies analysis of properties from molecular structure. This bit of insight has contributed substantially to Flory's success.

Later in the week, Prof. J.E. Mark (Univ. of Cincinnati, OH), in an invited lecture, confirmed some of Flory's theoretical work, in this case in the area of elastomeric network theory. Mark, who had worked with Flory at Stanford, described his synthesis and characterization of model polysiloxane networks which have very narrow chain-length distributions and well defined cross-

link densities. With these well characterized networks Mark has shown, among other things, that at low strains they exhibit affine deformation, and at high strains they exhibit phantom network behavior; all of which had been predicted by Flory.

In contrast to Flory, Prof. K. Dusek (Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Prague) takes a chemical rather than a physical approach to polymer conformation. In his invited lecture, Dusek reviewed the statistical analysis of polymerization reactions to arrive at structural configurations. He described analyses based on cascade theory and on reaction kinetics.

Dr. R. Simha (Case Western Reserve Univ., Cleveland, OH) discussed the very difficult problem of developing equations of state for polymeric systems. The problem is not too difficult for liquid systems, since they are at equilibrium and can be dealt with in the same way as low MW liquids, except that there are constraints on chain-segment motion. Simha talked about an approximate analysis where various types of constraint are assumed to be uncoupled. In the solid state a polymer is not in equilibrium and, in fact, the heart of the problem is to find some measure of the deviation of the system from equilibrium. Simha maintains that the analysis must have a flexibility function and he defines a "freezing function" which is a measure of the deviation of the system from equilibrium as it is cooled from the melt to some temperature below the glass transition temperature.

During his lecture, Flory had noted the need for methods to investigate the microconfiguration of macromolecules—such methods as dipole measurements, optical anisotropy, nuclear magnetic resonance, and neutron scattering. As the week unfolded, the application of these techniques to polymers was the subject of a number of the invited and contributed lectures.

Prof. G. Allen (Imperial College of Science and Technology, Univ. of London) described small-angle neutron scattering (SANS) which is rather widely used in polymer studies in Europe but which is not used in the US for lack of a suitable monochromatic neutron beam. Allen restricted his talk to inelastic and quasielastic scattering. which give information on polymer chain dynamics as opposed to elastic scattering which gives information on polymer molecule dimensions. Inelastic scattering gives side-chain dynamics and quasielastic gives main-chain dynamics. The merit of neutron scattering is, of course, the short wavelength of the beam, typically 0.4-2.0 nm. Furthermore, because the neutron is uncharged, it is scattered by atomic nuclei; and because of its large size, there is a large momentum transfer. In addition, the angular momentum spin state of one-half results in spin-coherent and spin-incoherent scattering, the coherent scattering giving information about molecular structure and the incoherent scattering giving information about self diffusion. Allen explained some of the fine points of SANS, but throughout his lecture he referred to the high cost of this technique. The use of the neutron source and the assorted spectrometers is expensive; and in order to make full use of the technique, especially spin-incoherent scattering, it is necessary to synthesize the polymer in a partially (sometimes fully) deuterated form.

The more conventional light scattering is still widely used to investigate polymer configuration, although it is generally confined to studies of dilute solutions. Dr. R. Pecora (Stanford Univ., Palo Alto, CA) gave an invited lecture on quasielastic light scattering from polymers where the intensity fluctuation of the scattered light gives information about the molecular motion. If the time characteristic of the motion is less than 10 μsec, then the frequency distribution or Doppler broadening of the scattered beam is measured. If the laser beam is polarized, it is possible to measure the diffusion of polymer chains up to molecular weight of several million. Using depolarized beams, the motion observed is much more local, i.e., chain end motion.

Prof. H. Morawetz (Polytechnic Institute of New York, New York City) gave a plenary lecture on the applications of fluorescence techniques to polymer systems. He divided the technique into fluorescence depolarization, fluorescence quenching, eximer fluorescence and nonradiative energy transfer. Basically, all of these methods involve photoexcitation of a molecular

species on polymer molecule and then relating the decay of the excitation to rotational and diffusional motion of the chain or the interaction of the chain with the surrounding network. Morawetz pointed out that fluorescence depolarization had been used by biochemists long before it was used to study polymers. He went on to describe his work using excimer fluorescence to show that crankshaft rotation of a chain segment may be a reasonable motion in the solid state, but is not energetically favorable in dilute polymer solution. Nonradiative transfer from an acceptor to a donor moiety depends not only on the relationship of their respective energy levels, but on the characteristics of the surrounding polymer matrix. Morawetz described the use of this technique to study polymer compatibility.

Nuclear magnetic resonance (NMR) has come to be a very powerful tool in polymer science, not only in solution studies where highly discriminating fine-line spectra are obtained, but also for concentrated solutions and solid-state studies where special techniques can do much to resolve broad line spectra (*ESN* 33-4:154). Prof. H.J. Cantow (Institut für Makromolekulare Chemie, Univ. of Freiburg, FRG) gave a general lecture on using NMR to study polymer conformation and dynamics. He pointed out that NMR is sensitive to molecular motion in the 10^6-10^{10} Hz region and so is useful in investigating segmental motion. He talked about studies of the radius of gyration and how it is affected by temperature and explained that from this information one can determine whether the chain is expanding or contracting with temperature. He discussed the use of NMR in the kinetics of polymerization; specifically, how it can be used to learn whether chain tacticity is being determined by the catalyst or the monomer.

The *in vivo* application of polymers as body implants, tissue replacement, drug delivery agents, and even as drugs directly, raises some critical problems for both the polymer scientist and the physician. These problems were the topic of a lecture by Prof. J. Kálal (Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Prague). He stressed the responsibility of the polymer scientist to advise the physician since, understandably, the physician is generally ignorant of the chemical and physical consequences of using polymers *in vivo*. One of the points Kálal stressed is the release of unreacted monomer, reaction initiators, and additives by commercial polymers. The concentrations may be quite small, but accumulation in sensitive tissues can have disasterous consequences. There is also the problem of biological degradation, especially when it is unanticipated. The body is able to cope with certain foreign chemicals, partly by renal discharge, but Kálal pointed out that this discharge is molecular-weight dependent, which defines a renal discharge limit. In his work at the Macromolecular Institute he has found that cell adsorption and rejection is highly dependent on polymer polarity and that this fact is important in the use of polymers for drug delivery. In general, Kálal feels that there is a need to know much more about the partition coefficients of polymers between different types of tissue and different body fluids.

Prof. F.G. deGennes (Collège de France, Paris) gave a general lecture on the conformation and dynamics of entangled polymers. He defended the use of the often disparaged scaling laws to describe polymer solutions in the region between dilute solution and polymer melts. deGennes defines two scaling parameters, mesh size, ξ, and "blob" size, g. The parameter defines the distance between chains in a two-dimensional mesh of overlaying chains, i.e., the mesh opening size. The parameter g is some critical segment of chain length that deGennes defines in terms of ξ and the Flory radius. Using these scaling parameters, deGennes has been able to analyze the stability of thin films of polymer solutions and the general colloidal behavior of polymer solutions. To determine ξ, he measures the sedimentation rate of small molecules and colloidal particles through the polymer network in a centrifugal field.

The next IUPAC meeting on macromolecules is scheduled for 6-9 July 1981 in Strasbourg, France, and will be sponsored by the Centre National de la Recherche Scientifique (CNRS) and the Université Louis Pasteur. Correspondence should be addressed to MACRO 1981, Société de Chimie Industrielle, 28, rue Saint-Dominique, 75007, Paris. (Willard D. Bascom)

POLYMERS IN DENTISTRY

Legend has it that Queen Elizabeth I was fitted with a set of wooden teeth. Unhappily, they were so poorly fitted that they were too painful to wear. She was only willing to put them on at public appearances to preserve the Royal image. Dental restoration has, fortunately, improved since that dear lady's time. Wood was replaced by a number of other materials, especially vulcanized rubber, which in turn was replaced by polymethylmethacrylate (PMMA) in the 1930s. Subsequently, there has been a rapid acceleration in the use of polymers in all phases of dentistry (even for fillings) and in maxillo-facial surgery.

Dental and facial restoratives were the subject of a one-day meeting on 4 October 1979 in the Conference Center of the Zoological Society of London, near Regents Park. The meeting was sponsored by the Plastics and Rubber Institute and was attended by about 50 people of whom more than half were from the medical-supply industry or the plastics industry. The medical profession was well represented (12, mostly from dentistry) but the number of polymer scientists from academia was disappointingly small (5)—disappointing because, as the meeting progressed, it became clear that some fundamental questions about polymeric materials need answering to realize the full potential of polymers in medical applications.

Dr. D.E. Causton (Dept. of Materials, London Hospital Medical College), a polymer materials specialist, reviewed the polymers used in dentistry and some of the associated problems. He noted that the materials presently in use came about as spin-offs from nonmedical polymer R&D. There is very little research aimed at polymers for dental use because the potential market is so small. Causton divided his talk into the types of applications; denture bases, restorative materials (fillings), pit and fissure sealants, impression materials, temporary crowns and bridges, and soft denture liners.

The current material of choice for the base structure of dentures is a peroxide-cured PMMA dough molding compound. Some people (but not Causton) are concerned about the toxicity of residual free radicals generated by the peroxides. As good as PMMA has been as a denture material, it can be crazed by alcohol, and by cough medicines containing carbon tetrachloride. There is also room for improvement in impact and abrasion resistance. All of these deficiencies could be reduced by using a rubber-modified PMMA, but dental technicians complain about its molding consistency and so it has not found wide acceptance. Causton believes carbon-fiber reinforcement may prove a better solution.

There have been competitors for PMMA from time to time such as polycarbonate, nylon, and the epoxys, but all have proved unsatisfactory. However, there is a new kid on the block, the pourable acrylics developed during the late 1960s which Causton believes can seriously challenge PMMA because they cure at room temperature and have high impact resistance.

The mouth is an extremely aggressive environment. Not only is it always wet and warm, but it is frequently awash with acids, bases, strong solvents, and abrasive solids. Not only must teeth or their replacement suffer these abuses, but they must withstand enormous stresses as food is bitten and chewed. All these factors have conspired against efforts to find polymeric materials to replace the traditional mercury-amalgam, cavity-filling materials. Two of the major difficulties with polymer fillings are poor adhesion to the cavity walls and low abrasion resistance. Attempts to use the PMMA molding dough have failed on both counts. In the 1960s, a quartz-powder filled bisphenol A diglycidylmethacrylate (BisGMA) was developed. As a filling material it has good impact and abrasion resistance and adequate adhesion, and it cures rapidly; however, it cannot be polished to a smooth finish. A recently developed version which does take a better polish contains cured powdered BisGMA as a filler instead of quartz.

Sealants for shallow pits and fissures must adhere well to tooth enamel. Here again the BisGMA is widely used in these applications, but the cleaned enamel is first given a phosphoric acid etch to enhance bonding. The sealant is usually cured using uv radiation because of the rapid cure time and to avoid leachable, toxic curing agents.

Deformable elastomers are used to make oral impressions. The original

agar-based elastomers were replaced by lead oxide-cured polysulfides because of their accuracy and tear resistance. Polysiloxanes offer a cleaner alternative to the polysulfides, but suffer from poor dimensional stability. This problem seems to have beer overcome by addition-cured (platinic) polysiloxanes with terminal alkene groups. The first of these new silicones to be tried had poor tear resistance, but filled versions seem better in this respect.

A PMMA molding dough has been (and for the most part still is) used for building temporary crowns and bridges. This material is often irritating to the oral mucosa, and a more bland methacrylate polymer is now available.

Causton finished his lecture by mentioning two specific problem areas: soft denture linings and tissue adhesives for oral surgery. Currently, highly plasticized acrylates and silicone rubbers are used as liners, but become hard too quickly due to loss of plasticizer, or become swollen and bacterially contaminated. Tissue adhesives are essentially nonexistent, since the cyanoacrylates (super glues) used for this purpose in general surgery are too rapidly hydrolyzed in the oral environment.

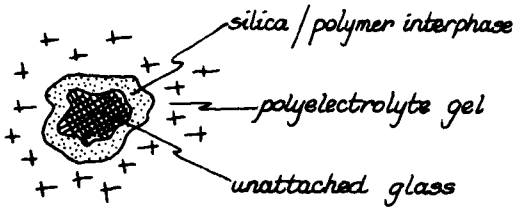
In an interesting but sometimes gruesome lecture, Mr. B.F. Conroy (Queen Mary's Hospital, Roehampton, near London) described prostheses used in maxillo-facial surgery. In these operations, large portions of jaw, facial tissue, and even an eye are removed because of birth defects, cancerous disorders, or accident damage. Plastic-coated metals are used for bone replacement, the coating usually being a silicone polymer. The metal is sometimes perforated to allow tissue to grow into and grip the component. Conroy sees an opportunity for plastics reinforced by carbon fibers to replace metal for greater stiffness and to reduce weight. Polysiloxanes are the principal tissue-replacement materials, but the physical requirements are severe. The polymer must be nontoxic and cure at room temperature, and it must have the right flow properties for casting, low weight, sufficient stiffness in thin sections, and color and dimensional stability. Some tissue replacements must transmit load, in which case the structure is built on an acrylate base. Many of these requirements come about because the prosthesis is built *in vivo*, and Conroy was merciless in illustrating these operations. He also illustrated the post-operative appearance of the patient; some of the restorations, especially the more massive ones, left something to be desired esthetically. The demarcation between prosthesis and the undamaged face, for instance, was often too obvious.

Prof. A.A. Grant (Univ. of Manchester) talked about the water absorption and thermal properties of dental polymers, which is an important issue because absorbed water may adversely affect mechanical properties such as toughness and creep reisitance. It may also lower the glass transition temperature (T_g) of the polymer, which must be kept well above mouth temperature since above T_g the polymer becomes a deformable rubber. Grant feels that the water uptake by polymers used in dentistry is much greater than generally believed, and he was critical of government water-absorption tests as being too short to determine equilibrium uptake.

Grant illustrated the need for dental polymers to have a high T_g by "the odd chap who take the kettle and pours boiling water over his choppers to clean them." At the same time, Grant is of the opinion that the T_g transition should be as broad as possible, extending from 100°C down to room temperature. He believes that over this temperature range the molecular relaxation associated with the transition will enhance toughness.

Another important property of dental polymers is their thermal diffusivity. Grant pointed out that if it should be greatly different from that of oral tissue, thermal transients would cause severe discomfort.

Dr. A.D. Wilson (Dental Material Sub-division, Laboratory of the Government Chemist, London) described a remarkable polymer/ceramic material which looks very promising as a dental filler and sealant. It is prepared by adding special aluminosilicate glass powders to aqueous solutions of polyacrylic acid. Cations in the glass are leached out by the solution and the ions crosslink the polymer. The result is a strong composite of glass particles in a crosslinked polymer network. The structure is illustrated in the figure.



Wilson has developed glass-polyelectrolyte compositions for a variety of applications, notably as a faster setting, water-resistant replacement for plaster of paris in making body casts. When formulated for dental purposes, the glass is a $SiO_2/Al_2O_3/CaF_2$ composition in which the Al^{+++} and Ca^{++} are the crosslinking cations. The Ca^{++} promotes initial gelation and the Al^{+++} produces the final set. Other inorganic salts are included to control cement consistency and curing rate. The cured cement is strong in compression, brittle, translucent and stain-resistant. Most important, the dental cement resists acid attack, and exhibits good adhesion to both dentine and enamel (other polymer fillers adhere poorly to tooth enamel). The good adhesion properties mean minimal undercutting in cavity preparation, which is usually necessary to get mechanical locking to offset poor adhesion. Less drilling means less patient discomfort, which is especially important in the dentistry of children. Two years of clinical trials have shown an 80% retention of fillings.

Overall, the meeting gave the impression that during the past decades, there has been significant progress in using polymers in dentistry and facial surgery. However, as Causton remarked, most of this progress has come as spin-off from other polymer R&D. One can only wonder what more could be accomplished by materials research devoted specifically to dentistry and medical applications in general. (Willard D. Bascom)

THIRD INTERNATIONAL CONFERENCE ON MECHANICAL BEHAVIOR OF MATERIALS, CAMBRIDGE

It is the principal purpose of the International Conference on Mechanical Behavior of Materials (ICM) to regularly bring together, from every corner of the world, the major workers in the field for the reassessment of the advances made and to provide a basis for sound and relevant scientific and engineering work for the future. ICM-3, held at the University of Cambridge, UK, 20-24 August 1979, dealt with its main objective in six themes: High temperature deformation and failure, environmental and time-dependent effects, forming and machining of materials, designing with brittle solids, fast fracture of ductile materials, and designing with new materials. The technical program included 15 plenary papers and a series of linked workshop sessions in which 127 papers were discussed. Approximately 350 participants from 25 countries attended, almost all from universities and industrial firms. The papers had been preprinted and distributed at the beginning of the meeting. The workshop discussions were conducted in a new format; a leader would "critically" present all the papers included in his meeting, exposing points of controversy and/or possible discussion depending on his interest and skill.

This procedure proved useful in setting up well structured discussions. This format, of course, did not apply to plenary lectures, which will be published early next year.

Interest in new materials, although not overwhelming, was apparent in the Conference. Two invited plenary papers were concerned with new materials. Achievements in the area of ultra-high modulus polyethylene were summarized by Prof. I. Ward (Univ. of Leeds). In his lecture Prof. A. Argon (MIT), after defining a new material as a "new microstructure," introduced the Conference to major developments in the areas of polymers and silica. Using common design parameters, he offered a skillful comparison between old and new materials.

Although an independent workshop containing an unusual 12 papers was devoted to environmentally enhanced failure, the awareness of this problem was sensed in almost all other workshops. Environmental cracking appears to be of high priority for both scientists and engineers.

Two papers, at least, drew attention to the differences between classical environmental failure which may

include chemical attack and environmental failure due to "inert" fluids. The first paper was on liquid metal embrittlement by C.F. Old and P. Trevena (Atomic Energy Research Establishment, Harwell, UK) and the second was on pressure-induced embrittlement of polymers by E. Baer (Case Western Reserve Univ., Cleveland, OH). The latter paper, in addition to a paper presented by F.P. Ford (G. E. Corporate Research, NY) pointed out the danger posed by the stress field in causing the critical growth of an existing surface flaw. In addition, Ford examined the design philosophy to account for environmental cracking. It was shown that the use of fracture mechanics concepts, although necessary to provide design oriented parameters in a flawed structure, are of a secondary importance *vis-a-vis* the mechanism of cracking. It was further illustrated during many discussions that the threshold stress value above which environmentally enhanced failure is observed in a given material/environment system should not be constant, but may be considered dependent on loading history.

A significant portion of the Conference activities was devoted to high-temperature creep. Three plenary lectures together with some 20 papers were devoted to the subject. Perhaps the most novel was presented by Prof. S. S. Manson (Case Western Reserve Univ.) in his plenary lecture. Manson discussed a new principle, "strain range conversion" in the creep fatigue range, in which a generic strain range is converted to another by subsequent loadings. This principle exploits the effect of strain reversals in the creep range of materials which may cause inherent damage repair, thereby suggesting the possibility of higher allowable loadings. The possibility of partial repair of a damaging event by deliberate subsequent loading was referred to as another consequence of this principle. He also emphasized the usefulness of the "double-linear damage rule" when dealing with the loading order effects. The rule was shown to account for the highly damaging effect associated with a high-low loading sequence.

Another important contribution in the area of high temperature creep was that of M.S. Loveday and B.F. Dyson (National Physical Lab., Teddington, UK). The paper reported results of a careful experiment to test the recent developments in finite element calculations providing information in the spatial stress distributions across the throat of circumferencial notches in uniaxially loaded bar. Measurements of cavitation distribution under such triaxial tension showed that cavity nucleation was a function of both effective and axial stresses whereas cavity growth was a function of the effective stress alone. These results serve the purpose of defining a suitable method for imposing a known and spatially uniform triaxial stress with all its three components being tensile.

Towards the end of the Conference, discussions were started on the important subject of composites by Prof. J.E. Gordon (Univ. of Reading, UK). In his plenary lecture, Gordon skillfully managed to draw the attention of both scientists and engineers to the benefits of understanding the structure-property relationships of multi-component biological composites to stimulate the creation of new and more complex composite systems. Considering the hierarchical structure of tendon, he illustrated for both design engineers and material scientists the route for safe designs and durable composite materials. Most of the research papers presented in this area, however, were limited to one system: glass-reinforced polyesters. An interesting technique, yet to be developed, was reported by N.R. Farrar (Cornell University, USA) and K.H.G. Ashbee (Univ. of Bristol, UK) to monitor changes in the state of stress at fiber/resin interfaces during water uptake by photoelastic means. If successful, the technique may enable formulating the mechanism of environmental failure in these composites.

A substantial research effort appeared to have been devoted to the development of fracture mechanics criteria for design consideration, particularly in the area of ductile materials. The session led by Prof. B.A. Bilby (Univ. of Sheffield, UK) to discuss contributed papers on this subject was extraordinarily educational. The main discussion centered around the applicability of J-integrals in elastic-plastic fracture. The data reported by Gudas and Joyce (US Naval Academy)

and H.H. Vanderveldt (Naval Sea Systems Command, USA) perceives the possibility of using the J-integral concept for treating crack growth of elastic-plastic material beyond the initiation state. This view has been further supported by C.F. Shih, W.R. Andrews and J.P.D. Wilkinson (General Electric, US) in their report on characterization of crack initiation and growth with applications to pressure vessel steel. This meeting may be summarized in one conclusion: in spite of the progress attained by recent studies in the area of elastic-plastic fracture, the proposed results still fall short of application to an actual engineering structure. (Abdelsamie Moet, Case Western Reserve Univ., Cleveland, OH)

MEDICINE

PULMONARY FUNGUS DISEASES IN EGYPT

A study of pulmonary fungus diseases in Egypt is largely another chapter in the *Aspergillus* story. Despite the dry climate, the Nile river basin evidently provides a suitable environment for *Aspergillus*, one of the world's most ubiquitous and medically important fungi.

Dr. Hassan Hosny Youssef is Professor of Pulmonary Medicine at the Ain Shams University in Cairo. In setting for himself the task of investigating pulmonary fungus diseases in Egypt, he has accepted an enormous undertaking. Poor communication, an unsatisfactory transportation system, and insufficient financial support have led to many lost samples, long delays in deliveries and letters that do not reach their destination. For these reasons as well as scientific ones, Youssef concluded several years ago that European or American antigen preparations for the various fungi found in Egypt would not be satisfactory. One of the basic decisions in his laboratory, therefore, has been the time-consuming task of manufacturing antigen preparations from native Egyptian fungi. Likewise, antibody preparations are made locally from the home grown antigen.

Youssef's research can be divided in several areas: 1) ecological and epidemiological considerations, 2) the myco-flora of the lower respiratory tract investigated by pulmonary lavage, 3) the investigation for mycotic organisms as well as serological studies of pleural fluid, 4) analysis of resected lung and post mortem specimens for fungi, and 5) extrinsic allergic alveolitis caused by *Aspergillus* or other fungi in association with various industries. The populations Youssef has investigated other than industrial ones consist predominantly of immuno suppressed patients from the cancer institute, other long term hospitalized patients, and the inhabitants of military barracks or prisons. General population surveys would not be feasible in Egypt at the present time.

Analysis of airborne fungi was carried out within the Ain Shams Hospitals. Petri-dishes containing Sabourand medium were set out in 116 rooms (patients' rooms, operating theaters, sterilization rooms, laboratories, kitchens and out-patient clinics) for 60 minutes. Spores of 31 different fungi were isolated and *Aspergillus* was most common. *Histoplama, Blastomyces,* and *Coccidiodes* have not been isolated. In addition, despite careful investigation of bird droppings as well as patients' sputa none of these fungi have been found to date. A few cases of cryptococcosis have been uncovered.

- *Aspergillus* usually thrives in damp temperate climates but the Nile Valley seems to be entirely suitable for its growth and propagation. Whether it is commonly found in the surrounding desert among the Bedouvin Arabs is as yet entirely unknown. Experience from other parts of the world suggest, however, that it is probably much less common as one moves away from the river toward the drier areas. Israel, which is not drained by a large river basin, has little aspergillosis.

Pulmonary lavage techniques in seeking the flora of the lower respiratory tract have received some attention, however, since sputum samples are generally positive in infected individuals, it is probably not worthwhile. The investigation of pleural fluid for fungal organisms as well as for its antigenic properties has not been investigated in other laboratories. Not only idiopathic effusions but those caused by malignancy and tuberculosis are being studied for the possible super

infection by fungal organisms. The same type of investigation is being carried out in all resected pulmonary specimens and post-mortem examinations. Permission for autopsy, however, is difficult to obtain in Egypt.

One of the most interesting investigations underway is concerned with extrinsic allergic alveolitis and its relationship to *Aspergillus* or one of the thermophilic *Actinomycetae*. Although bagasstosis, an extrinsic allergic alveolitis found in the sugar cane industry, is thought to be a reaction to one of the thermophilic fungi, Youssef has found 22 of 33 sugar cane workers serologically positive for *Aspergillus*. A similar study in breweries has also revealed a large number of positive serologies for *Aspergillus*.

Ninety three symptomatic grain workers from 18 mills in Cairo were investigated serologically and for the prevalence of various fungi in their sputa. 66.6% had clinical evidence of a generalized obstructive lung disease. The most common fungus found was again *Aspergillus*.

Among 401 poultry workers from various locations in Egypt, 47.4% had fungi in their sputum. Seventeen of 79 serum samples were positive for precipitating antibodies. Other industries in which symptomatic workers are being investigated includes paper production, tea packing, fertilizer, caning, and slaughter houses. Although worker populations of these industries are relatively constant in comparison with the general population, Youssef indicated that it is difficult to obtain blood samples from the workers because of their general anxiety in this regard.

In contrast to the US and Britain where *Aspergillus fumigatus* is the most common species, in Youssef's experience *A.niger* is in first place in Egypt with *A.flavis* second and *A.fumigatus* a rather poor third. However, these statistics are largely derived from positive serologies and not directly related to pathogenicity.

Other fungi under investigation include *Candida* found in the sputa of 61.4% of 993 hospital patients with various chest disorders. However, it is not known whether this percentage of *Candida* is directly related to the specific chest disorders or the general population.

In summary, the clinical and laboratory investigation of pulmonary fungi in Egypt is an enormous and frustrating task, but Youssef has taken the first step of the 1000-mile journey. His problems are many and complex but progress is being made particularly in the investigation of *Aspergillus*. The relationship between the extrinsic allergic alveolitis found in many industries and *Aspergillus* is of marked interest. Confirmation that *Aspergillus* could be associated with the asthma and chronic bronchitus found in the Nile Valley would be of considerable clinical importance. (Irwin M. Freundlich)

REPORT ON THE INTERNATIONAL CONGRESS ON RESPIRATORY DISEASES

The 1979 International Congress on Respiratory Diseases was held 10-13 October in Basel, Switzerland. The major subject of discussion was asthma but an excellent workshop on diffuse fibrosing alveolitis was also included. The meeting was very well organized in an ultramodern, recently completed facility. The lecture halls were spacious and contained all the latest electronic gadgetry. Switzerland, and Basel in particular, has a centuries-old reputation of primacy in the field of medicine. Not only the facilities used for this Congress but the entire medical school-hospital complex indicates that the Swiss are still very much in the first rank. Multiple papers were delivered in three parallel sessions and the proceedings will be published.

J. Nadel (Univ. of California, San Francisco, CA) delivered one of the main lectures on the pathophysiology of asthma. He reviewed the subject in a comprehensive manner, although the time devoted to the lecture was relatively short. Asthma is a variable disease and asthmatic patients may be quite different in their response to different allergens. Nadel listed several major points and then developed a theme to demonstrate which factors asthmatics have in common. Initially he made three observations: 1) the chemical mediators that induce an asthmatic response in patients subject to the disease have a trivial effect in normal individuals, 2) upper respiratory

allergies do not cause asthmatic symptom in the lower respiratory tract, and 3) some asthmatics have no allergies. Asthmatics have in common an extreme senstivity to physical, chemical or pharmacological stimuli. Anticholinergic drugs block the asthmatic response and it has not been clear until recently whether this was a local effect on smooth muscle or whether a vagal reflex was involved.

Nadel described tight junctions in the airway epithelium just below the surface. He showed photomicrographs of normal, orderly junctions and abnormal disordered junctions. It is well known that moist air relieves bronchospasm while excessively dry air tends to cause it. This is particularly true if the air is cold and dry, circumstances whic. enhance evaporation of water from the mucosal surface with an increase in osmolality. Under these physical conditions the normally tight junctions open and an asthmatic attack may occur. Nadel also believes that epithelial damage caused, for example, by viral infection may be the cause of chronic stimulation of the nerve endings and responsible for asthmatic attacks. He stated that the rapid shallow breathing common to asthmatics is a typical vagal response. To summarize, this investigator believes that a definitive reflex vagal action with multiple causes is the common denominator in asthmatic attacks.

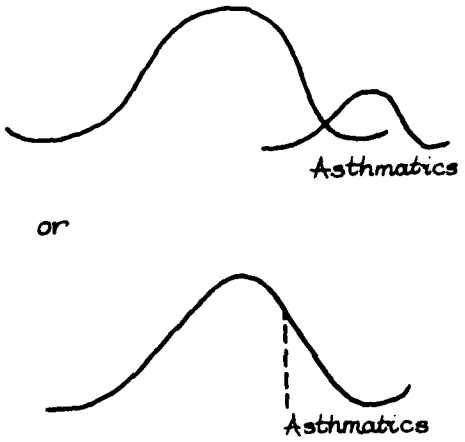
"Transient hypoxemia and breathing patterns during sleep in patients with airways obstruction," was delivered by D.C. Flenley et al., (Univ. of Edinburgh, Edinburgh, UK). These authors have studied sleep patterns in relation to airways obstruction. Pulmonary function tests made in different kinds of airways obstructive disease were correlated with the sleep pattern as measured by the electroencephalogram. Patients colloquially known as "blue bloaters" have chronic bronchitis, cyanosis, and edema with daytime hypoxemia and cor pulmonale. This type of airways obstruction results in profound falls of blood oxygen levels in sleep during the rapid eye movement (REM) phase. The typical emphysematous "pink puffers" on the other hand do not show any fall in blood oxygen during REM sleep. The authors made similar measurements in asthmatics with a nocturnal wheeze correlating the breathing patterns, thoraic movements, and blood oxygen saturation with the electroencephalogram throughout the night. Their conclusions were that asthmatics show the same kind of fall in blood oxygen levels during sleep as do the "blue bloaters" but not nearly as severe. This probably accounts for the fact that death from asthma is usually nocturnal.

In their paper on "Biofeedback control of FE_{CO_2} (forced expiration of CO_2) a prospective therapy in hyperventilation," H. Folgering et al. (Univ. Nijmegen, Nijmegen, The Netherlands) contend that the hyperventilation which accompanies asthma results in hypocapnia which in turn causes many of the symptoms. Hypocapnia induces anxiety which leads to more hyperventilation, increased hypocapnia and a vicious cycle is established. The purpose of the investigation was to determine whether a biofeedback system will allow an individual to control forced expiratory CO_2 (FE_{CO_2}) and thereby regulate alveolar $^{a}CO_2$. Ten normal subjects participated in the study. In the experimental situation the subjects observed their FE_{CO_2} on an oscilloscope as well as by an audio feedback mechanism. The investigators concluded that a biofeedback method enabled them to train subjects to breathe in a manner which resulted in an elevated FE_{CO_2}. If relief of the hypocapnia in asthmatics can be achieved in this manner then bronchoconstriction will be relieved, anxiety lessened and the cycle broken. However, two comments from the audience were worth noting. The first concerned the influence of the experimental setting, which itself could have been the cause of the subjects' ability to change the FE_{CO_2}. A controlled experiment is necessary to eliminate that variable. The other comment questioned the ability of patients suffering an asthmatic attack to accomplish what normal individuals could.

"Serum IgE determination in patients suffering from asthma, rhininits, cough and various combinations of these disorders" was the title of a paper given by W.J. Stevens and P.A. Vermeire (University of Antwerp, Wilrijk, Belgium). 745 patients were studied which the investigators divided into several groups: 1) asthma without nasal symptoms, 2) rhinitis but without asthma,

3) both conditions, 4) cough alone, 5) cough and rhinitis, and 6) normal subjects. All the patients were then subdivided into allergic and non-allergic individuals. IgE levels were determined and the investigators found that only 70% of allergic asthmatics and only 50% of patients with allergic rhinitis had an elevated serum IgE. In comparing all the allergic patients to all non-allergic patients, an elevated serum IgE was found in 64% of the allergic individuals and 26% of the non-allergic. Therefore, since 36% of allergic patients have a normal serum IgE and 26% of non-allergic patients have an elevated serum IgE, the authors concluded that serum IgE levels were of little value in the diagnosis of allergy.

The main lecture on the subject of provocation testing of asthma was by D.W. Empey (The London Hospital, Whitechapel, London, UK). This author first listed the reasons why provocation tests are carried out: 1) diagnosis, 2) epidemiology, 3) determination of etiology, 4) pathophysiology and 5) drug testing. In provoking bronchial hyperreactivity Empey emphasized that in asthmatics, in contrast to normal individuals, bronchoconstriction can be caused by very small amounts of various substances. He reminded the audience that it is actually not known whether asthmatics form a separate sub-group or are at the end of a reactivity spectrum (see figure).



Provocative testing can be carried out in three general ways: 1) exercise, 2) occupational exposure, 3) aerosols. Exercise responses are enhanced by cold and dry air, a point which was discussed at some length by the first speaker. Empey made a very strong plea in regard to provocative testing with occupational chemicals. Considerable care and monitoring are necessary as the subjects may be at considerable risk. As far as testing with aerosols are concerned, particle size is important as well as the depth of respiration. Deep breathing leads to a peripheral deposition of the particles and a larger dose is needed. At the end of his lecture Empey noted the problems of provocative testing: 1) standardization of response, 2) measurement of response, 3) the variability of base line conditions, and 4) psychological factors. Following this lecture there were a number of comments from the audience emphasizing the necessity of establishing uniform tests as at this time it is quite difficult for investigators in various parts of the world to compare their results.

A paper delivered by D.C. Stanescu and A. Frans (Univ. Cathol. Louvain, Brussels, Belgium), "Bronchial asthma without increased reactivity of airways," was severely challenged from the floor. The authors observed 9 asthmatic patients with a negative response to acetylcholine inhalation as measured by the forced expiratory volume test (FEV_1). They concluded from their work that airways hyperresponsiveness is not a constant feature of bronchial asthma and that the diagnosis of asthma cannot be excluded even in the absence of increased airways reactivity. The challenge from the floor was in regard to the FEV_1 test as it can be variable from time to time in the same patient. In addition, the deep inspiration necessary for the FE_1 can act as a bronchodilating event. This again raised the problem of lack of standardization in the tests used to measure asthmatic responses.

An entire morning was devoted to a workshop on diffuse fibrosing alveolitis, a diffuse pulmonary disease of unknown etiology and one for which no suitable therapy has been found. In searching for measureable parameters to determine the stage of the process and the best therapeutic regimen for any stage, pulmonary lavage has been tried in a number of centers (*ESN* 33-8:331). A paper by J.R. Joubert et al.

(Univ. of Stellenbosch, Tygerberg, South Africa), "Alveolar cell analysis in the management of interstitial lung disease," summarized pulmonary lavage results in that institution. In order to develop an index of comparison, the investigators established not only total cell counts and differential cell counts from the lung washes but also a lymphocyte/macrophage (L/M) ratio. In four normal non-smoking controls a mean total cell count of 50, 000 cells/ml of lavage effluent was recorded and in five smoking controls the mean value was 124, 000/ml. In both control groups a ratio of 1 lymphocyte to 9 macrophages was documented. To confirm the lavage results multiple transbronchial biopsies were carried out in 20 patients. There was good correlation not only between lavage and biopsy results but also with the radiographs made of the patients during the same time intervals. An increased L/M ratio was associated with increased histopathological evidence of disease activity regardless of the etiology of the pulmonary fibrosis.

Bronchial reactivity to inhaled histamine in patients with farmer's lung was the subject of a paper by S. Mönkäre et al. (Tiuru Hospital, Tiuruniemi, Finland). These investigators studied 80 patients with farmer's lung over a two-year period of whom 52 were challenged by histamine inhalation. The challenged subjects who showed reactivity to histamine had a more chronic and benign clinical course than those who did not respond. The authors noted the possibility that these two groups were reflecting the specific location of the inflammatory process; in the reactive group an allergic bronchiolitis with air trapping and in the non-reactive group an alveolitis.

A paper by U. Costabel and H. Matthys (Univ. of Freiburg, Freiburg, FRG) compared lung function data with different therapies for diffuse fibrosing alveolitis. These authors concluded that a combination of predisone and azathioprin seemed to be the most effective of the 2-drug regimens, which included predisone with D-penicillamine and predisone with cyclophosphamide. Three drug regimen in their experience led to excessive side effects.

Margaret Turner-Warwick (Cardiothoracic Institute London, UK) in summarizing the workshop noted that: 1) various drugs and drug combinations may indeed help only a minority of patients but are still worthwhile, 2) there is often only a subjective response which can be measured objectively in about 50% of patients, 3) pulmonary lavage showing an increase in neutrophiles and eosinophiles is a poor prognostic sign while a modest increase in lymphocytes indicates improvement, 4) if steroids decrease neutrophiles and eosinophiles improvement is suggested, and 5) patient improvement should not only be measured by objective lung functions and radiographic appearance but also by improved individual patient survival, which while only affecting a minority, is a very worthwhile parameter.

J. Meier-Sydow (Univ. of Frankfurt, Frankfurt, FRG) in his summary noted that out of 7 papers on fibrosing alveolitis, 6 were concerned with diagnosis and only one with therapy, which is indicative of the poor state of therapy. He also observed that pulmonary lavage may replace biopsy and emphasized the importance of cell counts to assess the patient as far as staging of the disease, when to begin therapy, and which drugs to use.

The subject of recent advances in the pharmacotherapy of asthma was introduced by Margaret Turner-Warwick. Turner-Warwick's first point was that asthma presents a particulary difficult problem in obtaining a good model for drug screening. Because asthma has multiple pathogenetic mechanisms, it is likely that no single experimental model will be satisfactory. She noted that new pharmacotherapy should include, 1) new preparations of known drugs to obtain a longer duration of effect, 2) new derivitives of known basic compounds having a longer action and fewer side effects and, 3) understanding new modes of action of well-known drugs. This investigator went on to illustrate these points by showing that in some patients a drug may completely block the asthmatic response, while in others the same drug may block the response temporarily giving a very unstable and erratic picture of the patients' course. The lung tissue of asthmatics will show variable pathology in the same patient at the same time. Asthmatic attacks may look identical in various individuals but will not respond to the same therapy. In summary, drug therapy must be tailored to the individual patient and each patient must actually serve as his own model. (Irwin M. Freundlich)

THE SIXTH ANNUAL MEETING OF THE INTERNATIONAL SKELETAL SOCIETY, MUNICH

The Sixth Annual Meeting of the International Skeletal Society was held in Bavaria's late summer sunshine and amidst Munich's typical Gemütlichkeit. The Society is a new and dynamic one, organized by radiologists specializing in bone diseases, but including in the membership prominent pathologists and orthopedic surgeons. The diagnosis of bone disease is somewhat unique in comparison with other subspecialities of radiology as it occupies both ends of a difficulty spectrum and not much middle ground. The great majority of bone radiographs are simple, straight forward examples of fractures and dislocations. However, at the other end of the spectrum are multiple types of of dwarfism, inborn errors of metabolism, derangements of calcium metbolism, as well as obscure benign and malignant bone tumors. It is, of course, the latter end of the spectrum that concerns the International Skeletal Society.

The six-day meeting was divided into two halves: the first, a session closed to all but members of the International Skeletal Society (this writer the only exception) and the second, a symposium and refresher course open to all. In the first half of the meeting the members of the society met to discuss common problems, interesting cases and new developments. Seventeen papers were delivered, 10 of which have been reviewed in an ONRL Conference Report (C-9-79) and 5 are reported here. During the second and open portion of the meeting, the members of the society acted as faculty, presented papers and held symposia for the audience. There were 50 such sessions, 11 of which are reviewed in the Conference Report and 6 are reported here.

The closed meeting consisted of papers alternating with groups of case presentations. This format was a good one for maintaining audience interest. In an excellent paper from South Africa, P. Beighton (Dept. of Human Genetics, Capetown) described an inherited, progressive and lethal disorder of bone he has named sclerosteosis. The author studied 45 patients, all of whom are Afrikaaners. The disease consists of progressive thickening and enlargement of many bones but particularly the skull with compression of the brain, gigantism and early facial palsy. The bones become very dense and resistant to trauma. (Beighton described one case in which a factory worker with sclerosteosis was hit in the jaw by a fly wheel with sufficient force to fragment the wheel but his jaw remained intact.) In addition 90% have syndactaly. The disease is autosomal-recessive and almost entirely confined to South Africa. It is of considerable interest that Van Buchem's disease (described in 15 patients from Holland and evidently not seen anywhere else) is quite similar, but not as severe, and all 15 of Van Buchem's patients are Dutch, while Beighton's patients are Afrikaaners all of whom are of Dutch descent. Beighton has been searching for radiographic clues in the carriers of the recessive trait but thus far has not been successful.

W. Remagen (University of Basel, Switzerland) discussed "Electron microscopic findings in fibrous dysplasia." The author demonstrated with electron photomicrographs abnormal microfibrils of collagen that give rise to the spotty calcification characteristic of fibrous dysplasia. Normal collagen fibrils, which may be immediately adjacent of the microfibrils, produce normal bone. The author believes that the microfibrils are due to an enzyme deficiency which inhibits the formation of normal collagen.

Resorption of corticle bone is seen in a number of different diseases, the most common of which is chronic renal failure. E. Meema (Department of Radiology, Toronto Western Hospital, Toronto, Canada) described work he has done on microradioscopic quantitation of endosteal and periosteal bone resorption. Using hand radiographs of 60 normal individuals and 60 patients with chronic renal failure, made with Kodak M industrail film for very fine detail and ordinary ocular magnification, Meema established an index between the number of striations in a proximal phalanx and in the metacarpal of the same digit. A large majority of patients with the chronic renal failure fall outside the normal index. In addition, by using the same measurements he showed that therapy for these patients with 1,25 $(OH)_2$ Vitamin D3 was not helpful in preventing endosteal erosion but did imporve intracortical and periosteal resorption.

I.P.C. Murray (Randwick, Australia) discussed "The Effect of Hypercalcemia on Skeletal Scintigraphy." About 60% of patients who have died with various hypercalcemic conditions will demonstrate.

histological viseral calcification predominently in the lungs and stomach, but only about 3% can be seen by x-ray examination or by ^{99m}Tc bone scans. Murray believes that the hydroxyapatite deposited in the organs affected is labeled with the isotope. However, the condition is thought to be temporary and in a case he described lasted less than 72 hours. In reviewing the literature he found 12 patients with chronic renal failure, primary hyperparathyroidism or hypervitamosis D and 15 patients with various malignancies who demonstrated visceral calcification by ^{99m}Tc scanning.

It may be quite difficult even for an expert bone pathologist to distinguish cell type and, at times, even between benign and malignant bone tumors. Frequently a panel of experts will disagree among themselves. Aggressive non-metastasing benign bone changes can be confused with malignant growths and radical surgery carried out erroneously unless great care is taken. To aid in this regard C.P. Adler (Univ. of Freiburg, FRG) described a pilot study involving the cytophotometric measurements of various bone tumors. This new method allows the pathologist to measure the DNA content of cell smears taken from the tumor. The DNA content increases considerably from the diploid to the tetraploid phase of mitosis. Adler constructed histograms and was able to distinguish between the great majority of benign and malignant bone tumors. A few benign neoplasms, which tend to be recurrent after excision, fall slightly above the remainder of the benign tumors but still can be classified as benign.

The second portion of the meeting, the refresher course, dealt largely with basic concepts and new classifications based on recently gained knowledge. The first of these papers by Hans-Georg Willert (Univ. of Göttingen, FRG) was concerned with the morphology and classification of congenital bone defects. His work was stimulated by the Thalidamide catastrophe during which so many children, whose mothers were on the drug, developed deformities. Evidently the action of Thalidamide was at a very early stage of embryogenesis and affected sensory nerve and sclerotome development, which, in turn, adversely affected the normal maturation of the limbs. Willert has developed a transverse and longitudinal classification based on the study of a number of Thalidamide babies. He demonstrated his material with radiographs, line drawings, and photomicrographs of the gross specimens. All the patients had several features in common: 1) Hypoplasia and incomplete separation of the various hypoplastic portions, 2) delay in ossification, and 3) loss of normal limb shape.

Herbert J. Kaufmann (Hospital for Sick Children, Paris, France) showed, with multiple radiographs as well as ultrasound examinations, how the diagnosis of various skeletal dysplasias can be made while the fetus is still in the uterus. He emphasized that the intrauterine diagnosis requires radiographs made in the proper projection and an extensive knowledge of the various types of congenital bone disorders that one might encounter.

A paper by H.K. Genant (Univ. of California, San Francisco, CA) was concerned with the use of scintigraphy (bone scanning) for non-neoplastic bone and joint disorders. The isotope ^{99m}Tc is absorbed or exchanged for another ion on the hydroxyapatite crystal. This absorption or exchange is influenced by 1) blood flow, 2) the state of osteogenesis, 3) the surface area, 4) capillary permeability, and 5) extracellular fluid (ecf) concentration. Patients with sacroileitis as part of their joint disease were examined and the radioactive isotope uptake measured over the sacroiliac joints was compared to that of the sacrum and graphs constructed. In normal patients, the uptake by the sacrum is approximately the same as by each sacroiliac joint. In comparing the normal controls with the patients he found that the test was not significant for all grades of sacroileitis but only for early, active disease. In other words, if grades 3 and 4 sacroileitis which represent an older, more advanced but often less active process were eliminated, the test was quite significant in separating normal patients from those with early disease.

In the second part of his paper, Genant described how scintigraphy can also be used for the detection of loosened prostheses or infection in patients with a total-hip replacement. Post-operative pain is not an uncommon complication of a joint prosthesis. The problem is to separate those with loosening of the prostheses or infection

from patients with other causes of pain. Scintigraphy has proved very useful in this regard, moreover, radioactive uptake at the distal tip of the prosthesis was particularly sensitive and specific for loosening or infection.

The second day of the refresher course opened with a discussion of various bone tumors by four eminent American pathologists. The papers given and the discussion which followed was largely visual descriptions of the histology and radiologic appearance of a number of different tumors. The point was well made, however, throughout the bone tumor papers, that the histology alone often does not provide the final answer and that a final diagnosis can only be arrived at by a correlation of the radiologic appearance, the clinical course of the disease, the biopsy site as well as the histology. Bone pathology is unique in this regard and many tumors have been classified differently after good correlation and a second biopsy. Therefore, not only is the radiologic appearance of the neoplasm itself critical but the radiologist must direct the surgeon as to the best biopsy site. The surgeon for his part must be sure that adequate tissue is provided for pathological examination. A good bone pathologist only then makes a diagnosis in conjunction with the radiologist's impression and the surgeon's findings.

An excellent paper describing the anatomic basis of a number of different radiographic observations of the proximal femur was delivered by M. Pitt (Univ. of Arizona, Tucson, AZ). The title "Lines and Lucencies of the Proximal Femur" did not do justice to the depth of the work carried out. Pitt used Indian skeletal remains found in the Arizona desert, radiographs, as well as anatomic specimens to analyze in detail normal radiographic observations of the proximal femur. An anatomic basis for these well-known radiographic observations had not been described previously and this work, meticulously carried out, will be of considerable help to the radiologist who must distinguish between early pathology and normal anatomy.

In one of the final papers K. Subbaro (Montefiore Hospital, New York) described the changes of skeletal fluorosis in certain endemic areas of the world. Fluorosis is the biochemical replacement of $CaCO_3$ with CaF_2. Industrial fluorosis also occurs but it is never as severe as the endemic variety. Excess flouride causes white patches and yellow lines on the enamel of the teeth and a generalized increase in bone density. Bone density and weight at autopsy have been measured up to 3 times normal. Although this is a pathological condition and can cause spinal osteostenosis, it has not been known to shorten the normal life span. In endemic areas diseases that increase the intake of water increase the severity of the fluorosis. The flouridation of city water supplies to decrease tooth decay is approximately one part per million and does not cause the disease. The pathological changes in the teeth and bones are no not only related to an increased amount of flouride in the water, but to the time of exposure and the amount of water ingested. (Irwin M. Freundlich)

METEOROLOGY

METEOROLOGY AT THE UNIVERSITY OF VIENNA

Although Austria is a relatively small country in both size and population, it maintains three separate and distinct weather forecasting services: One for the military; a second serving civilian aviation activities; and a third equivalent to the US National Weather Services. The headquarters of the Austrian Weather Bureau is housed in the "Zenfralanstalt für Meteorologie und Geodynamie," located in a lovely old residential area in the hilly western outskirts of Vienna, between the city and the Vienna Woods.

The Weather Bureau is very closely related to the meteorology program at the University of Vienna. Its director, Prof. Dr. H. Reuter, is also professor of theoretical meteorology at the University; and one of the two assistant directors, Prof. Dr. K. Cehak, holds the chair of general meteorology and climatology at the University. Furthermore, the Institute of Meteorology and Geophysics of the University of Vienna is physically housed in the main building of the Weather Bureau. The current director, Prof. P. Steinhauser, is himself a geophysicist.

From 4 to 6 students at the University of Vienna receive the diploma in meteorology each year and an average of one student in each graduating class goes on to obtain a doctor's degree. (The other two Departments of Meteorology in Austria are at the Universities of Innsbruck and Graz. Innsbruck has about the same number of students in meteorology as Vienna, while Graz has about half as many.)

The remainder of this article concerns the research activities of meteorologists in the University of Vienna Institute.

Reuter is currently spending most of his time improving the numerical models for weather forecasting in the Austria Weather Bureau. He has also started research in climate modeling. Most Austrian meteorologists are concerned with the orographic effects of the Alps, because of their large-scale and small-scale effects on the weather and climate of Austria. Reuter has worked on modeling local orographic effects on winds in alpine areas.

Dr. P. Kahlig does theoretical studies to predict density (temperature) dependent flow patterns into and out of reservoirs and lakes and in rivers.

Dr. H. Kolb works with all the meteorological aspects of air pollution. He has developed models for use as part of the Weather Bureau's warning system for air pollution. The usual equations for turbulent diffusivity in the atmosphere go to zero in the absence of wind. Yet one of the interesting problems Kolb is working on is the spread of air pollutants in the absence of wind that does occur under inversions in alpine valleys. An interesting aside is the fact that Welhelm Schmidt introduced the concept of a coefficient of eddy diffusivity on "Austausch" coefficient (often used in diffusion studies) across the courtyard from Kolb's office in 1917, the year of my birth.

Prof. Dr. F. Lauscher is the professor of climatology at the University, specializing in the climatology of alpine regions. He has worked out all sorts of relationships between meteorological parameters and mountain topography which are used as the basis for constructing practical charts for the distribution of wind and other meteorological parameters in the Alps.

Prof. Emeritus Dr. F. Steinhauser, father of the present director of the Institute, is the "Grand Old Man" of meteorology in Austria. For many years he was director of both the Austrian Weather Bureau and of the Institute. His main interest has been in climatology, which seems to hold more interest in Austria than any other country I have visited. Steinhauser is a member of the Austrian Academy of Sciences and the Austrian representative to the World Meteorological Organization. He also founded and is one of the editors of *Archiv für Meteorologie-Geophysik und Bioclimatologie*.

Dr. G. Skoda is expert in the distribution of solar energy at the surface as a function of cloud-cover, visibility, and elevation. He is also working on the interpretation and use of large-scale numerical forecasting systems.

The remaining senior member of the Institute, Prof. Cehak, is working with engineers and architects in an endeavor to make more efficient use of energy in buildings. He is also endeavoring to introduce new methods and techniques in mathematics and statistics into meteorology.

Most of the staff members listed also teach in the University. (Wayne V. Burt)

OPERATIONS RESEARCH

IFIP CONFERENCE ON OPTIMIZATION TECHNIQUES, POLAND

The 9th IFIP (International Federation for Information Processing) Conference on Optimization Techniques was held in Warsaw, Poland, 4-8 September 1979. There were about 275 participants, of whom less than 100 were from Poland, the rest being from almost all the countries in both eastern and western Europe, with a few from as far away as the US and Japan. To my suprise, almost all of them were still present for the closing ceremonies at noon on Saturday, 8 September, which said something for their dedication.

Before getting into the technical content I must mention the picnic on Thursday evening. Buses took the participants out into the country and we then walked about 1 km into the woods where we found several bonfires blazing

away, a band playing Polish music, and lots of Polish sausage impaled on freshly cut sticks ready for roasting over the fire, together with such other food and drink as was ample for stimulating international fellowship.

The nominal language of the Conference was English, but the actual language was mathematics. Each morning and afternoon there was a plenary session in which a single invited presentation was given. There were several simultaneous sessions, most of which were devoted to mathematics. There were, for example, five on optimal control (three on partial differential equations and two on ordinary and delay differential equations) seven on mathematical programming (two on theory, two on algorithms, two on integer programming, one on multi-objective problems), two on differential games, two on growth in networks, one on scheduling allocation problems, one on software problems, and six on applications (two on environmental and energy systems, two on industrial processes, one on biomedical systems, and one on economics and econometrics). I will confine my comments to some of the invited lectures.

The chairman of the Conference was Roman Kulikowski, the director of the Systems Research Institute of the Polish Academy of Sciences and presently visiting at the Institute for Applied Systems Analysis (IIASA, Laxenburg, Austria) (*ESN* 32-2:51). The International Program Committee, which contained members from Poland, the Soviet Union, both Germanies, France, Italy, and the UK, was chaired by Prof. A.V. Balakrishnan (UCLA). The meetings were held in the "Palace of Culture and Science," an unattractive monument erected in the Stalin era in the very middle of downtown Warsaw. The Poles say that the best view of Warsaw is obtained from the top of the Palace of Culture and Science, the reason being that this is the only place in Warsaw from which one *cannot* see the Palace of Culture and Science. The name of Joseph Stalin is on the front of the building in concrete, and while this name has not been erased it has been covered with neon lights so that it is almost impossible to see. The design of the rooms, however, was excellent, and the acoustics and visual aids were everything one could ask.

Prof. M.J.D. Powell, a distinguished mathematician from Cambridge, gave a talk entitled "Optimization Algorithms in 1979," the topic of which was the generalized nonlinear programming problem. It is clear that certain kinds of problems are always going to be very difficult, including the problem of finding a global optimum for a function that has many local optima where one is dealing with many badly behaved constraints. On the other hand, if one is willing to settle for finding a local optimum, and when the objective function and the constraints obey reasonable regularity conditions, algorithms can be developed which work quite well if the problem is not too large. Within these limits there is room for considerable difference of opinion in regard to the degree of optimism or pessimism one should express toward finding a useful generalized algorithm for nonlinear programming. I believe I am a bit more pessimistic than Powell. He confined his remarks to algorithms that are widely used for minimizing a general differentiable function of several variables. In the case of a large number of variables he recommended the "conjugate gradient method" as a device to avoid working with matrices (essential unless the matrices are sparse). For constrained problems, he was optimistic about the applicability of variable metric methods that take account of linear approximations to the constraints throughout the calculations. He discussed certain algorithmic methods which he has developed.

Andrzej P. Wierzbicki of the Institute of Automatic Control of the Technical University of Warsaw (also presently at IIASA) spoke on "A Methodological Guide to Multiobjective Optimization." It is well known that multicriteria problems lead to a set of efficient solutions where any point outside this set is dominated by some point within it (dominated meaning that the efficient solution is better by at least one of the criteria, and at least as good by all other criteria). Attempts to make a single point out of the efficient set concentrated on the utility function and weighting coefficients, but Wierzbicki pointed out that information is frequently available which is expressed in other terms, and urged the problem-oriented approach to multiobjective optimization. After reviewing various approaches to this

problem, he presented some new results on the use of reference objectives to assess efficient solutions in the interactive man-computer mode.

N.N. Krasovskii (Sverdlovsk, USSR) spoke on "Game Theoretical Optimization of Differential Systems." He spoke of the usual problem of a plant described by a phase-space variable, with a control function to be chosen in the face of a disturbance that is unknown in advance. Most work with which I am familiar treats the disturbance as a stochastic process and tries to maximize the expected value of some payoff function. Krasovskii on the other hand treats it as a two-person game, with one player choosing the control function and the other maliciously choosing the disturbance function. His mathematics was impressive, but in my experience such "games against nature" represent an excessively pessimistic view about decision problems.

Witold Gutkowski (Inst. of Fundamental Technological Research of the Polish Academy of Sciences) spoke on "Optimization of Engineering Structures—Theory and Application." He started with an interesting historical review, pointing out that such famous scientists as Bernoulli, Lagrange, and Newton were more or less involved in investigations of the internal forces involved in large-scale structures. He also briefly reviewed the classical mathematics concerning beams, plates, shells, and frames, and then went into more modern optimization formulations involving objective functions, such as weight or rigidity under constraints such as stresses, displacements, and natural frequencies. He then indicated how classical variational methods as well as mathematical programming might be applied to the solution of such problems.

Kulikowski, speaking on the "Optimization of Regional Development—Integrated Models for Socio-Economic and Environmental Planning," described an elaborate computerized mathematical model presently being tested in Poland on the development of water resources, primarily for agricultural irrigation. The model went into great detail on various networks and interactions at the macro-economic level. I was amused to note that during the question period one of the Americans asked him whether they had tried individual incentives, as distinguished from the incentives which he had described which were rewards given to entire regions. Since the economy in question was that of Poland, it was not suprising that his rather involved and lengthy answer a amounted to "no."

The Proceedings of this Conference will be published by Springer-Verlag in 9-12 months in a series "Lecture Notes in Control," under the title "Optimization Techniques—Proceedings of the 9th IFIP Conference." The 10th Conference will be held in September, 1981, in New York City under the chairmanship of Prof. R. Drenick. (Robert E. Machol)

OPTIMIZATION METHODS AND AUTOMATIC CONTROL

The Second IFAC/IFORS (International Federation for Information Processing/International Federation of Operations Research Societies) Symposium on Optimization Methods—Applied Aspects was held in the resort town of Druzhba just north of Varna on the Black Sea in Bulgaria 460 km east of the capital, Sofia. When I arrived in Sofia on 15 October, Varna was under heavy fog and therefore no planes were flying from Sofia to Varna. Finding alternative means of transportation is not always easy in Eastern Europe, but we finally arrived in Varna on 16 October barely in time to go to the hotel, check in, shave, bathe, change, and appear at the opening ceremonies at 9:00 a.m. (while the conference was scheduled 15-19 October, the 15th was confined to registration and the 19th to excursions to local industry, with all technical sessions being held 16-18 October). I mention all this because I was the IFORS representative due at the 9:00 AM ceremonies.

The representative of IFAC, Manfred Thoma (Hanover Univ., FRG), and I were given equal billing at the opening and closing ceremonies; but the actual running of the conference and of the program was dominated by IFAC members, and the admirable concept of having optimization examined jointly from the viewpoints of automatic control and operations research was hardly realized. The great bulk of the papers were on the subject of optimal control which, while it satisfies in some

technical sense the constraint of being on "optimization," is in fact the subject of the majority of papers on automatic control.

Optimal control generally involves determination of optimal trajectories and utilizes as a tool the calculus of variations, a tool rarely employed by operations researchers and unknown to many of them. I had hoped at least to see this tool applied to control of management or social systems, but most of the papers were the usual kind of thing one hears at automatic control conferences such as "Optimal Computer Control of a Three-Degree-of-Freedom Industrial Robot" or highly technical things like "Suboptimal Design of Control Systems with Variable Structure Via the Second Method of Lyapunov." Another way of looking at it is that people involved in automatic control work tend to concentrate on "process control" with a time horizon from seconds to hours, while operations researchers tend to concentrate on "production control" with time horizon from hours to days, or "planning" with time horizon from weeks to years. It would have been nice to see these people applying their tools to one another's problems.

Following the opening ceremonies the plenary session was to have been addressed by V.Z. Tsypkin, a distinguished Soviet scientist and the chairman of the program committee of this Conference, who however was unable to attend. Instead the plenary paper was given by Prof. A. Wierzbicki, a Pole who is temporarily at IIASA (The International Institute for Applied Systems Analysis, Laxenburg, Austria), on the use of reference objectives in multiobjective optimization. His talk was not unlike his talk on the same subject in Warsaw the previous month (*ESN* 34-2:91). He gave a historical review of multicriteria decision making, starting with Pareto's work 80 years ago. Pareto-optimal solutions are those that cannot be improved upon in any one criterion without making the solution worse in another criterion. Pareto's idea was to use weighting coefficients to find some average of all the Pareto-optimal points. Wierzbicki's idea is instead to use a "reference objective," which is any reasonable and desirable point in the objective space—possibly a goal which is subjectively desired by a decision maker or something chosen from past historical experience. He then derives scalarizing penalty functions with respect to the reference objective; that is, a mapping of the space of outcomes into a single-dimensional space which is order-preserving with respect to the criteria. Wierzbicki made fun of methods that require decision makers to answer innumerable questions of the type "would you prefer this alternative to that one?" and he felt that utility functions are not useful in practical decision making.

One hundred and fifty abstracts were originally submitted for this Conference and 51 papers were eventually accepted, but many of the authors were unable to come and less then 40 papers were finally presented. There were a total of 169 participants, of whom 118 were from Bulgaria, 13 from the Soviet Union, and 25 from 6 other socialist countries. There were also 13 participants from 6 western countries. Among the papers cancelled for nonattendance were the two scheduled to be given by American speakers; it turned out that I was the only delegate from an English-speaking country. Nonetheless, English was the official language. All papers were given in Russian, Bulgarian, or English with translation into the other two. Some of the translators were technically trained as well as being fluent in both languages, but others did not have the necessary technical training, making it difficult to follow the oral presentations through the translations.

Bulgarian names tend to end in "ev" or "ov," modified to "eva" and "ova" respectively in the case of women. An interesting observation is that of the 118 Bulgarian delegates 105 had both the last and middle name with these endings. Most of the remaining 13 presumably had non-Bulgarian ancestry.

The papers were divided into seven sections: 1) optimal control systems; 2) optimal time/energy control; 3) computational aspects of optimization; 4) decentralized LQG problems (I asked several people what LQG meant and got several different answers. Apparently it means linear quadratic Gaussian); 5) multilevel control; 6) technological processes parameter estimation and optimization; and 7) large scale systems optimization problems. Most of

the papers were presented in two parallel sessions so that a dedicated listener could attend half of the papers. I was particularly interested in the last-named subject and attended (among others) the sessions so classified which included 12 papers planned and 9 actually presented.

"Resource Allocation Principles in Large-Scale Systems" by V. Buorkov et al. (there were 8 authors, 4 from the Institute of Control Problems in Moscow and 4 from the Institute for Engineering Cybernetics in Sofia) discussed the allocation of scarce resources in large-scale systems (such as allocation of capital investments, water, etc., within an entire nation). One often assumes that each user announces a requirement and the usual allocation would be in proportion to the requirement. However, each user tends then to exaggerate his requirement, and the system becomes unstable. They suggest a "reverse priority principle" in which the allocation is in proportion to the requirement if the sum of the total requirements is less than the total amount of resources; and if the requirements exceed the resources, the allocation is in inverse proportion to the requirement and in direct proportion to the maximum loss incurred by the user if he is not supplied with resources. Under these circumstances the corresponding game has a Nash equilibrium solution in which each requirement is proportional to the square root of that maximum loss.

K. Leiviskä and P. Uronen (Univ. of Oulo, Finland) discussed "Dynamic Optimization of a Sulfate Pulp Mill." This is an optimization problem in which it is desired to maximize the capacity of the mill, subject to constraints on the production schedule, the capacities of the various intermediate storage facilities for storing in-process inventory, the rate of availability of raw materials such as steam, and the impossibility of storing steam directly (it can be stored indirectly in the form of pulp or black liquor which are the principal consumers of the steam). There are all sorts of constraints on production rate changes and the shutdown of processes. Variables to be controlled are the amounts of materials in the various storages and the rates of flow between them. This is essentially a problem in the calculus of variations, and much of their paper concerned the details of the computer algorithm by which the optimization was achieved in practice, using a modest amount of time on a UNIVAC 1100/20 computer.

M. Calović and three others from the Association of Power Industry (Belgrade, Yugoslavia), spoke on "The Solution of Scheduling of Thermal Units by Mathematical Programming Techniques." Thermal units in this context means electrical generators powered by turbines driven by fossil fuels. There are two separate but mutually connected problems: the "unit commitment problem" of deciding when to start up new turbines and when to stop them; and the "economic dispatch problem" dealing with the allocation of load among generating units already running. If the unit is shut down with the intention of starting it again soon, then the fires are banked, thus minimizing the cost of start-up but consuming extra energy during the waiting time. Alternatively the fire may be turned off, in which case the boiler must be heated again before the turbine can be started. In the latter case the cost is obviously an exponential (and therefore a nonlinear) function of the time since the unit was turned off. Due to fluctuations in the load (demand for power), units that are running must be run at different outputs, and the relation between fuel consumed and power produced is strongly nonlinear, although over the region of interest it may usually be adequately approximated by a quadratic function. These problems are solved by dynamic programming, although under some circumstances the second problem may be linearized and solved by linear-programming techniques. The basic idea is to minimize the total system operating costs, subject to demand and to operating constraints on generating limits, down time, load, spinning reserve, network security, and the like. Computer experience on a UNIVAC 1106 is reported, but apparently this was from a simulation, and it is not clear whether the method has actually been tried in a live control of the power system.

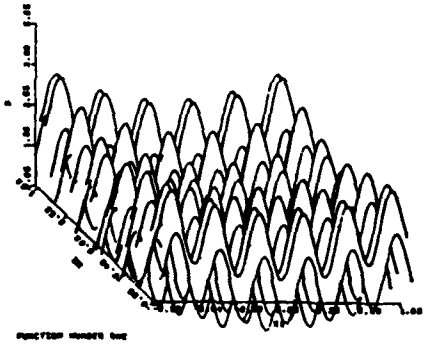
J. Ostrowski (Systems Research Institute, Warsaw, Poland, discussed a modification of the well-known assignment problem in which there are m men (rows) and n jobs (columns), the two

numbers not necessarily equal, and each is divided into k groups ($k \le m$, $k \le n$), each group being assigned as a whole. The individuals within each group may be assigned in a large number of ways, and there are of course $k!$ ways of assigning the groups, so the problem is combinatorially difficult. Ostrowski demonstrated and proved an algorithm for solving this problem.

V.G. Rumchev (Higher Institute of Mechanical and Electrical Engineering, Sofia, Bulgaria) spoke on "optimal steady-state control of manpower systems." His model had the individuals of the organization at various echelons of advancement, with people transferring between echelons as well as being recruited from a source and leaving to go to a sink. Treated as a problem in optimal control, this reduced to a classical transshipment problem which, as is well known, can be further transformed to a Hitchcock problem that is easily solved.

In the session on computational aspects of optimization, G.I. Gatev, A.S. Velkov, and G.M. Bakalov (Central Scientific Institute for Automation, Sofia, Bulgaria) gave a paper entitled "Some Algorithms for Solving Global-Constrained Minimization Problems." They were considering the large class of problems in which the analytical forms of both the objective function and the constraint functions are unknown, but the values of these functions can be found through computing procedures. They are especially interested in difficult nonlinear problems which have numerous local minima, but only one global minimum; for example, one of the test functions was $\sum_{i=1}^{n} [x_i^2 - \cos(18x_i)]$ whose global minimum value is $-n$, where $x_i = 0$ for all i. The difficulty of working with this function is indicated by the graph of the function in two dimensions indicated in the figure. They reported on considerable computer experience in applying various algorithms to this type of problem, and found the greatest success with a two stage algorithm based on geometric programming.

On the last day of the Conference, those delegates who remained were taken to view local industry. I visited the computer center of the shipbuilding institute. Apparently each of the socialist countries has a more or less autonomous shipbuilding industry. Bulgaria has shipyards in Varna on the Black Sea and in Ruse, 200 km to the north on the Danube, and also numerous factories to build steel plates and other components of ships. The center has an IBM 370/145 with 256 k bytes of central storage (MOS), four 3330 discs with 100 megabytes each of storage, additional discs and tapes, two printers, a PDP-11, and various other peripherals. They use the operating system OS/VS-1 which gives them up to 16 megabytes of virtual storage. Most of the programming is done in FORTRAN IV and PL-1.



I found it rather difficult to determine exactly what they do with the computer from the presentations we received; for example, among the software packages they mentioned having was the MPS for mathematical programming and other optimizations. I asked them for specific examples of the types of optimizations, and was told that it was used for "production processes and future planning."

It is clear that they have some extremely sophisticated design of ships. We were shown a drafting machine bought from a Norwegian company for $180,000 which was operating online at the moment and was drawing detailed prints of plates curved in 3 dimensions, to be used for a ship soon to be constructed. It was clear that they have highly sophisticated production planning and control algorithms, and keep a rather tight control over the flow of materials to the various shipyards and factories. It was also clear that they do not as yet have anything that we would call

a management information system. At the present time there are no terminals; everything is done in batch. Within the next two years they plan to expand the system and to introduce intelligent terminals, the first one to be at Ruse (the town mentioned above), at a distance of 200 km.

In the closing ceremonies, I expressed the hope that the Third IFAC/IFORS Symposium on Optimization Methods (this was the second) might have more input from operations researchers. We shall see. (Robert E. Machol).

OPTICAL PHYSICS

THE FOURTH ON THE FIRTH OF FORTH—NATIONAL QUANTUM ELECTRONICS CONFERENCE

The Fourth National Quantum Electronics Conference was held at Heriot-Watt University on 19-21 September 1979. The main campus of Heriot-Watt was established on the beautiful Riccarton Estate adjacent to the village of Currie, a 20-minute drive from the center of Edinburgh, Scotland. A few trends were noted upon comparing the Fourth Conference with V.O. Smiley's report on the Third Conference (September 1977, *ESN* 32-1:28). Whereas the total attendance was up about 10% to 189, the number of non-UK countries represented among the attendees dropped from 12 to 6. Also, as pointed out by the Conference organizer, the number of US attendees dropped from several to 3, including the author. An expected trend was the increased number of papers on laser/plasma interactions. This reflects the increased optimism regarding the possibility of laser driven fusion, and the increased effort in laser generated plasma research.

The Conference got off to a good start with two excellent keynote presentations, one by A.L. Shawlow (Stanford University, CA) and the other by D.J. Bradley (Imperial College, London). Shawlow reminded the audience that we know nothing about light except when it interacts with matter. As spectroscopy is one of the most powerful tools for studying light/matter interactions, he described spectroscopic research at Stanford that utilizes one or more of the unique properties of lasers. I particularly appreciated a bit of philosophy he expressed in the following rephrasing of a saying well known to researchers in the laser field, "The laser is a hint, not a solution, looking for a problem."

Bradley gave a lucid presentation on two fast-moving fields, phase conjugation and free electron lasers. He pointed out that groups at both Lawrence Livermore Laboratory (US) and Lebedev Physics Institute (USSR) are active in the study and use of phase conjugation as applied to CO_2 and Nd^{3+} lasers respectively. He presented a brief history of two of the approaches used in free electron laser research—the Smith-Purcell (e-beam/metal grating) and magnetic bremsstrahlung interactions. In addition to the potential for high efficiency and high average output power, the output frequency of the free electron laser does not depend on levels in atoms, and tunability is expected from 1 mm to 100 nm.

Among the session topics were: laser spectroscopy; nonlinear optics; laser-plasma interactions; lasers; photochemistry and biological applications; laser interactions with solids, and optical bistability; instrumentation and industrial applications; and detectors and modulators. The remainder of this article is a collection of reviews of the papers found most interesting by the author.

R. Wyant (Max-Planck-Institut für Biophysikalische Chemie, Göttingen, FRG) reported on the generation of tunable infrared radiation by means of the $6s\text{-}5d_{5/2}$ Raman transition in cesium vapor. The possibility of tuning from 2-20 μm is provided for by the combination of the 14597 cm^{-1} Stokes shift of the transition involved, and the relatively large detuning (>3300 cm^{-1}) of the pump frequency from the dominant intermediate levels. Cesium vapor at 1-100 Torr in a 50 cm heat-pipe was irradiated by either a KrF^* laser or frequency doubled Nd^{3+} laser pumped dye laser. The pump laser power density in the dye cell was a few GW/cm^2, and peak power out of the dye laser was 1-4 MW (5 nsec). Fortuitously, the pump band required by the cesium (510-600 nm) spans the emission bands of the very efficient courmarin and rhodamine dyes. The dye laser output was narrowed and tuned with the use of a prism/grating combination. At shorter wavelength, around 530 nm, the generation of

radiation tunable about 2.3 μm was realized with inputs as low as 1.5 mJ. At longer input wavelengths (~570 nm) an absorption by Cs_2 dimers caused a 10-fold increase in the Raman threshold. This problem was eliminated with the use of a novel heat-pipe that superheated the central vapor column, and thermally dissociated the dimers. By this means, the Raman threshold was reduced from 20 to 3 mJ.

The extremes in CO_2 lasers were described at the Conference—from the high power devices to the miniature waveguide lasers. The description and output characteristics of a CO_2 laser system capable of delivering in excess of 0.1 TW for short pulses (1 nsec) were presented by A.C. Walker (Culham Laboratory, Abingdon, UK). This 200-liter-atmosphere active volume, e-beam controlled laser module (TROJAN) has been used in both the oscillator and amplifier modes. TROJAN's main capacitor bank can store up to 64 kJ (+200 kV), and multimode output energies up to 2.5 kJ have been obtained for a specific electrical input energy of 170 J/liter-atms. Using preionization TEA CO_2 laser technology, an Oscillator/ Pre-Amplifier Laser System (OPALS) was constructed. OPALS provides a single longitudinal/transverse mode, electrooptically-selectable pulse duration output (down to 1 nsec) for amplification by TROJAN. The mode of operation, applications, and output characteristics of the TROJAN/OPALS system are summarized in Table 1. While using the same 2-3 μsec discharge, TROJAN's output pulse width was increased from 2 to 100 μsec by increasing the reflectivity of the laser mirrors and the N_2 content of the gas mixture.

OPERATING MODE (APPLICATION)	OUTPUT ENERGY	PULSE WIDTH
Oscillator (Magnetic Confinement)	1-2 kJ	2 μsec
Oscillator (Refueling)	0.3-1 kJ	100 μsec
Oscillator/Pre-Amp/Amp (Plasma Diagnostics)	0.1 kJ	100 nsec
Oscillator/Pre-Amp/Amp (Laser-Fusion Physics)	0.1 kJ	1 nsec

Table 1

Three papers were given on lasers at the other end of the size/power scale. S. Moffatt (St. Andrews Univ., St. Andrews, Scotland) described a frequency stabilized, compact, sealed CO_2 laser that exhibited a long term stability better than 3 parts in 10^8. The ends of a 24-cm laser tube were sealed with ZnSe windows oriented at Brewster's angle, and an output of 8 W (10% efficiency) on the P(20) line (10.59 μm) was obtained. Frequency stabilization was accomplished by adjusting the laser cavity length with a feedback loop incorporating a detector based on the opto-galvanic effect. Owing to the distributed nature of this detection element, the laser was found to be quite insensitive to vibrational and acoustic interference.

E.K. Gorton [Royal Signals and Radar Establishment (RSRE), Baldock, UK] pointed out that the efficiency of waveguide CO_2 lasers is limited by the detrimental effects of the discharge cathode fall. A large fraction of the total discharge energy is deposited in the cathode fall region, and the resulting heat reduces the gain. He described the operation of a TEA waveguide CO_2 laser in the pulse-sustainer mode. The increased efficiency in this mode of operation is due to the ability of the sustainer discharge to operate nearer optimum electric fields for laser pumping. Gorton reported an efficiency of 3.7%, the highest TEA waveguide efficiency reported to date. In an overview paper on waveguide lasers, D. R. Hall (RSRE, Baldock) reported achieving an output power of 1/2 W from a 1-in.-long laser.

Inertial confinement research is one of the applications of the electron beam-excited rare-gas halide laser that has stimulated research on this family of devices. C.B. Edwards (Rutherford Lab., Chilton, UK) reported on a continuing series of experiments that have the objective of producing the highest possible intrinsic laser efficiency (output energy/e-beam energy absorbed by gas) under the conditions of high current, short pulse excitation. The characteristics of the electron-beam machine (ELF) used at Rutherford are summarized in Table 2.

Beam Voltage	1 MeV
Beam Current	75 kA
Pulse Duration (FWHM)	500 nsec
Beam Area	(5X50) cm^2

Table 2

Results were presented for KrF and ArF laser media having a gain length of 50 cm and excited at a pressure of 45 PSIG. The standard technique of exciting through a titanium foil was used. The gas mixtures, active volume dimensions, and output/input energies are presented below.

KrF Laser
- Mixture; 4 torr fluorine, 100 torr krypton, 1400 torr argon
- Dimensions; 7.5 cm (wide) × 5 cm (high) × 50 cm (length)
- Output/Input Energies; 5 J/300 J

ArF Laser
- Mixture; 4 torr fluorine 400 torr argon, 2700 torr neon
- Dimensions; 3 cm (diameter) × 50 cm (length)
- Output/Input Energies; 3 J/55 J

The Rutherford group has recently (Nov.) observed an energy efficiency of 11% in KrF using Ar only as the buffer. A variety of mirror materials and reflectivities (R_1, R_2) have been evaluated, and in one experiment the cavity Q was varied to produce maximum output energy. In one case ($R_1 = R_2$) E_{max} occurred for $1 - R_1R_2 = 0.75$.

In another experiment, the output energy increased by a factor of 1.9 when injection locking was used. The injection energy was a few tens of millijoules, and the mirror reflectivities were not optimized. Optimization of the cavity Q for the injection locking case is one of the experiments to be carried out soon at Rutherford.

Acoustic waves (surface, longitudinal and shear) have been generated by the absorption at a free metal surface of Q-switched laser radiation. D.A. Hutchins reported on efficient production of acoustic pulses in a 1 in. thick aluminum sheet using 17 nsec (FWHM), 40-mJ pulses from a Nd:YAG laser. The conversion of optical to acoustic energy was observed to increase linearly with laser input energy in the non plasma regime, and to increase more sharply once plasma production commenced. The strength of the acoustic pulses, even in the non plasma regime, was sufficient to enable unamplified detection with a conventional PZT transducer. Hutchins described an experiment in which a 1/8 in. hole in a 1 in. thick aluminum sheet was detected by the presence of a delayed acoustic pulse. This delayed pulse resulted from the increased path traveled by that portion of the acoustic pulse reflected at the hole boundary.

One overview paper was given on the current state of x-ray laser research, and several papers were presented on laser generated plasmas and their characterization. Alan F. Gibson, the leader of the laser program at Rutherford Laboratory, gave an excellent invited paper on lasers for plasma research in which he discussed the DT fuel density and temperature requirements for proposed laser driven fusion research. After leading the audience through the relevant laser-plasma interactions (e.g., the role of energetic plasma electrons, absorption mechanisms, and thermal conductivity), he presented the laser requirements based on current understanding of these interactions. Some of the desired laser parameters follow; wavelength (~250 nm), peak power (>few × 10^{11} W), prepulse level (<200 μJ), radiation bandwidth (<few %), and pulse duration (0.5-1.0 nsec for 100 μm targets). The characteristics of two lasers that have promise in plasma research as given by Gibson are presented in Table 3.

Characteristics	Storage Laser (Selenium)	Nonstorage Laser (KrF)
λ	488 nm	268 nm
Flourescence Lifetime	1 sec	10 nsec
Gain Cross Section	2×10^{-19} cm^2	3×10^{-19} cm^2
$\nabla\lambda$ (1 atmos.)	3 GHz	10 GHz
Maxium Efficiency	2 %	5 %

Table 3

When one adds to the generally high quality of the papers and the breadth of topics covered, the beauty of the setting and the thoroughness of the organizers, one could hardly have expected more from a conference.
(Richard S. Hughes)

PHYSICS

FOURTH INTERNATIONAL CONFERENCE ON ION BEAM ANALYSIS

The Fourth International Conference on Ion Beam Analysis was held at the University of Aarhus in Aarhus, Denmark, 25-29 June 1979. It dealt with the use of ion beams to solve materials analysis problems and was organized by the Institute of Physics at the University; a group that is well-known for the quality of their research on the interaction of energetic ions with matter. Evidence of their strong commitment to this field of research is the fact that the Institute of Physics has the largest number of ion accelerators of any single institute in Europe; at Aarhus there are 8 accelerators which are capable of producing ion beams with energies from a few keV to tens of MeV.

The Conference was attended by approximately 200 participants from 25 countries. The sessions involved several different formats ranging from the standard one in which invited and contributed papers chosen by the program committee were presented orally, to poster sessions, and to informal workshop sessions in which contributions were extemporaneous. In all, 9 invited papers, 41 oral papers, and 80 poster papers were presented.

The papers reflected an increasing interest in applying ion beam analysis techniques to a large variety of problems. The kinds of samples analyzed included semiconductor materials, insulators, metals, and such unusual items as manganese nodules from the ocean bottom, diamonds, lichens, coal, Stradivarius and Guarneri violins, an ancient Chinese sword, and tissue from a young woolly mammoth. Contributions dealing with the analysis techniques themselves had to do mostly with refinements to previously developed methods and equipment.

In the first paper of the Conference S.M. Meyers (Sandia Laboratories, Albuquerque, NM) presented the results of an investigation of possible effects produced by the analyzing ion beam on the distribution of elements in the sample. The most serious of these effects is the inhibition of atomic diffusion of interstitial solutes by trapping at point or extended defects resulting from ion irradiation. A second effect, beam enhanced diffusion, may be significant when analysis beam damage is relatively high as, for example, when nuclear reaction measurements utilizing ions heavier than He are performed. With regard to other possible effects, rapid diffusion along extended defects has not been reported in H or He bombardment, and cascade mixing is believed to be unimportant for analysis with light particles.

Additional information on the effect of the analyzing beam was presented by W. Möller (Max-Planck-Institute, Garching, FRG). Measurements of the diffusion of deuterium in stainless steel by the use of 790 keV $^3He^+$ ions and the $D(^3He,p)^4He$ reaction demonstrated that fluences of ^3He less than about $5 \times 10^{15}/cm^2$ did not perturb the measurement, but higher fluences caused deuterium trapping and produced defects in sufficient numbers to affect the diffusion process.

N.A.G. Ahmed (Univ. of Salford, UK) reported on some experimental measurements of disorder depth distributions from implantation of 40 keV N^+ ions in Si and GaAs. They used a low angle exit combined with channeling of the incident beam to provide a depth resolution of $\sim$40 Å. This resolution was sufficient to resolve a surface peak from a peak near the range of the N^+ ions. It also demonstrated a different dependence on flux or substrate temperature for these two regions, which suggests different processes of disorder generation or annealing.

Electronic energy-loss straggling, one of the main factors limiting depth resolution in Rutherford backscattering or nuclear reaction techniques, was the subject of an invited paper by F. Besenbacher (Univ. of Aarhus). He provided some new measurements using gas targets which demonstrated that current theories based on Lindhard-Scharff are inadequate. Allowance for correlated electron collisions and charge state fluctuations produced agreement with experiment to within 10-15%. However, the situation is much worse for solid targets, where inhomogeneity and texture effects produce considerable spread in the experimental results.

J.S. Williams and M.W. Austin (Royal Melbourne Inst. of Technology,

Australia) reported that damage from ion implantation of GaAs can be removed by annealing at low temperatures if the GaAs is maintained at liquid nitrogen temperature during the implant. In contrast to this result, when the implantation is performed at room temperature, the residual damage is very difficult to remove by annealing. The implantation of 5×10^{13} 40-keV Ar ions into GaAs at liquid nitrogen temperature is sufficient to produce an amorphous region. The crystalline perfection of the sample as determined by channeling measurements after annealing at 250°C for 30 minutes was very good. This procedure would appear to solve the problem of removing implantation damage from GaAs, which tends to decompose at high temperatures.

The subject of sputter profiling received attention at one session in which various mechanisms which distort depth profiles were discussed. An invited paper by W.O. Hofer (Max-Planck-Institute, Garching), and U. Littmark (Oersted Inst., Copenhagen, Denmark) reviewed current theories of recoil implantaation and cascade mixing and their effects on the depth distribution. These effects were also considered in detail in several other papers. The important effect of surface roughening in sputtering of metals was described in a paper by Naundorf and Macht (Hahn-Meitner Institute, Berlin, FRG) which showed the important influence of dislocations and grain boundaries. In some cases it was found that, under ion bombardment, enhanced surface diffusion produced smoothing of the surface as a result of surface tension.

A rather novel application of ion beams was that of heavy ion microlithography, whose use as a tool to generate and investigate submicroscopic structures was described by B.E. Fischer and R. Spohr (GSI, Darmstadt, FRG). The process was demonstrated by placing small insects on a nuclear track sensitive material, such as mica, and bombarding the insect with a heavy ion beam so that it casts a shadow on the sensitive material. The mass distribution of the insect is registered on the material in the form of latent tracks, long tracks where the ions passed through little mass per unit area and shorter tracks through greater mass. After the latent tracks are dissolved with a suitable etchant, a relief like replica is produced which can be viewed under a scanning electron microscope. The ultimate lateral resolution obtainable is believed to be about 100 Å.

Another novel application of ion beams involves the use of 8- to 40-MeV ^{16}O and ^{32}S ions to produce desorption of organic compounds. This research, reported by P. Dück et al. (Physical Inst. of the Univ. of Erlangen-Nürnberg, FRG) shows that the mass spectra of the desorbed molecules are comparable to those obtained with heavier ions at higher energies. This technique can be used for mass spectroscopic studies of nonvolatile molecules.

One of several papers on the analysis of laser annealed materials was by D.K. Sood and co-workers (Bhabha Atomic Research Centre, India), who reported on laser annealing of Sb evaporated films on Al and Si, and implanted Sb layers in Al. Annealing was accomplished by a single Nd:glass laser pulse of 7 ns duration. For both the implanted and the evaporated Sb layers on Al, a considerable loss (as much as 67%) of Sb resulted from the annealing. However, the amount of loss showed different dependencies on laser energy density for the two cases. In the implanted case, at laser energy densities greater than 3 J/cm^2 the Sb apparently diffused to depths greater than 1.2 μm. This is a surprising result since the diffusion length calculated by the authors is only 540 Å. Such extensive diffusion of Sb was not observed in laser annealing of evaporated Sb films.

Some discussion occurred as to whether surface melting actually occurs in pulsed laser annealing. Hoonhout and Saris (FOM Inst., Amsterdam) express doubt regarding the occurrence of melting, since they did not observe an expected change in the reflectivity of the sample. Notwithstanding this result, the consensus at the Conference seemed to be that melting does actually occur.

The application of ion beams to geological studies and the analysis of minerals was discussed by several speakers. G. Clark (Minerals Research Laboratory, North Ryde, Australia) described the use of Rutherford backscattering and nuclear reactions to measure concentrations of H, C, and O in different types of coal in order to determine their suitability for

hydrogenation. He also suggested the use of ion beam analysis to select rocks for mass spectrometric analysis to obtain isotope ratios and hence ages. Continuing along this line, W.A. Lanford (Yale Univ., New Haven, CT) discussed the question of Mn nodules which are found sitting on top of the sediment on the ocean floor, in spite of the fact that the rate of deposition of sediment is believed to be 3 orders of magnitude greater than the growth rate of the nodules. By using a tandem Van de Graaff as a mass spectrometer, Lanford and co-workers have been able to measure the ^{10}Be to ^{9}Be ratio in these nodules and have confirmed that the growth rate of the nodules is indeed about 3 orders of magnitude smaller than the sediment deposit rate. How the nodules manage to remain on top of the sediment remains a mystery.

H.E. Gove described research at the University of Rochester, also utilizing a tandem Van de Graaff as a mass spectrometer, in which ratios of ^{14}C to ^{12}C were determined in order to date objects such as a piece of baby woolly mammoth muscle tissue and cloth from the Bull Mummy. Because only about 1 mg of material is required for analysis by this method, it is being considered as a candidate technique for dating the Shroud of Turin.

The Proceedings of the Conference will be published in *Nuclear Instruments and Methods*. The next Ion Beam Analysis Conference is to be held at the University of New South Wales in Australia in early 1981. (Alvin R. Knudson, Naval Research Laboratory, Washington, D.C.)

SHIP PROPELLER TECHNOLOGY

LIPS PROPELLER SYMPOSIUM, THE NETHERLANDS

The Fourth Lips Propeller Symposium was held on 4-5 October 1979 at the Lips Autotron motor-car museum, Drunen, the Netherlands, and was concerned with all aspects of the design and operation of ship propellers. Papers were presented that dealt with the theoretical hydrodynamic design of propellers, their structural and mechanical design, integration of the propeller into the total ship system, the practical design of propellers, the history of propeller development and an outlook toward future developments. The assembly of persons concerned with these different aspects of propeller design, 211 participants from 21 countries, provided a unique opportunity for personal interaction.

The Symposium was opened by Mr. Romson, Director of Lips, on the note that the energy crisis has significantly reduced the orders for new ships and has, perhaps, affected shipbuilding more than any other industry. However, Lips is optimistic about the future since more stringent requirements of ship performance will require new ship designs. These requirements include improved safety and ship handling, the capability for energy exploration in currently inaccessible areas, operation in extreme environments and increased economy of operation. This optimism set the mood for the Symposium.

The opening papers were concerned with some of the theoretical and fundamental research studies being conducted to improve propeller design methods. These included: a review of the lifting surface theories employed for hydrodynamic propeller design; the presentation of a theory for the prediction of the fluctuating pressures induced by a cavitating propeller on a ship's hull; a study of the scaling of model propeller tip vortex cavitation inception to predict the inception on the prototype propeller; and a theory for the use of nonlinear actuator disc models to predict the flow field through a propeller or a windmill. These were all excellent papers and should be of interest to research workers in the field. An observation made during the discussion of one of these papers was that perhaps the propeller designer should investigate the methods employed in fields of compressor and pump design. This is a significant point since the problems and fluid dynamics encountered in each application are similar, but the approach to their so solution is slightly different.

Several papers were presented relating to the structural or mechanical

aspects of the propeller. These included methods for the estimation of the spindle torque experienced by a controllable-pitch propeller and the design of propellers to avoid fatigue damage. The latter study was conducted with a computer simulation of the passage of a ship over a transatlantic sea route. The former paper was one of two presented by workers from the Ships Hydrodynamics Laboratory, Shanghai, China. Their second paper dealt with the development of a series of data for the design of three-bladed controllable-pitch propellers.

The integration of a propeller into the total propulsion system of a new ship design was discussed using a recent ship design example. This paper, together with one discussing the control of a controllable-pitch propeller, demonstrated that the propeller designer cannot conduct his design in a vacuum. The economics of ship building and operation require that the propeller be considered as a part of the total propulsion system.

The two remaining papers presented a major contrast in the subject of propeller design. One discussed the future development of propellers and the need, as caused by the energy crisis, to examine drastically new concepts. The other paper presented a historical review of propeller development in the 19th and early 20th centuries, showing that many of the concepts now being considered as new have, in fact, been investigated in the past. Thus, in the development of new propeller concepts the designer should carefully examine earlier efforts in order to avoid the same mistakes. This paper should be studied by every propeller designer.

To summarize the Symposium and indicate the state-of-the-art in propeller design, the Lips propeller-design team demonstrated the use of its interactive computer design method by soliciting ship performance requirements from the participants and conducting propeller designs to match these requirements. This demonstration was very impressive and clearly indicated the need for human interaction into the design process in order to conduct design trade-offs. For example, there were cases in which the specified ship performance requirements were unrealistic and had to be relaxed in order to produce a satisfactory design. The realization of this fact and the demonstration of the trade-off process was a new experience for many of the participants.

The Proceedings of the Fourth Lips Propeller Symposium are available from the Lips B.V., Drunen, the Netherlands. (R.E. Henderson, Pennsylvania State University)

NEWS & NOTES

REDUCTION IN FUNDS FOR BRITISH UNIVERSITIES

According to an article in the November 23, 1979 issue of *The Times Higher Education Supplement*, there is grave concern at British universities over the government's recently announced intention to reduce funding to universities some 12% by 1983. This figure was apparently chosen because *13% of university students in Britain* are from overseas. Universities have been told that they must recoup this income by increasing the fees of foreign students. The present annual fees for these students are £940 for undergraduates and £1,230 for graduate students. The new recommended minimum fees are £2,000 for an arts course, £3,000 for a science course, and £5,000 for medicine, dentistry, and veterinary science.

The concern of university administrators is illustrated by an interview with Prof. R.N. Haszeldine, principal (i.e., chief executive officer) of the University of Manchester Institute of Science and Technology (UMIST), which has a full-time staff of 1,614 engaged in technical education and applied research) and currently a student body composed of almost one-third foreign students. Haszeldine estimates that with the new fees only 56-60% of overseas students, and those mostly from more affluent countries would continue to attend. With such a large drop in enrollment, the University would not be able to pay its fixed costs. Haszeldine is quoted as saying, "Some uni-

versities will thereby lose a critical proportion of their income over a very short time period, and will collapse. Many others, such as UMIST, will steadily be brought to a state where they should no longer compete as teaching and research establishments of the highest quality on the required international basis."

At UMIST, as in many other universities, there is also the specific concern that a large amount of the research efforts will suffer reduction, since much of the current work is carried out by foreign students. (Irving Kaufman)

ONRL NEWS

In January, we welcomed aboard three new Liaison Scientists. Dr. Moses A. Greenfield from UCLA is covering the field of Radiological Sciences/Medical Physics. Dr. Philip Fire from GTE Sylvania, Mountain View, CA, reports on Communications/Information Theory. Dr. John Neighbours from the Naval Postgraduate School, Monterey, CA, is the second incumbent of the ONR/NPGS Chair and is covering Physics. We wish them an enjoyable and productive tour of duty with ONRL.

Memorial for George Green, Physicist

The 31 August 1975 issue of *European Scientific Notes* (*ESN* 29-8) carried an article by R.F. Potter entitled "A Memorial for George Green in Nottingham," which described the City of Nottingham's hopes for restoring the windmill of which Green was the miller. Green (1793-1841), who was a contemporary of Michael Faraday, has only begun to win recognition for his accomplishments in the theory of physics.

A number of things have happened since 1975 that might be of interest to *ESN* readers. The administrators of the George Green Memorial Fund recently bought the mill, which was privately owned, and gave it to the City. In addition, a millwright and four assistant have started the work of restoration. The City of Nottingham has committed £95,000 to the effort. Most of this will be used to build a park around the mill but some of the money will also be used directly for restoration work on the mill. According to Prof. L.J. Challis (Univ. of Nottingham), the administrators of the Memorial Fund estimate that the funds available fall about £20,000 short of what is needed to complete the restoration. They have therefore launched an international appeal to industry and to scientists throughout the world to raise the rest of the money.

PERSONAL

On January 7, 1980, Mme. Yvonne Choquet-Bruhat was admitted as a full member of the French Academy of Sciences. She is the first woman to be made a full member since the creation of the Academy in 1666. Even though the two Nobel Prize winners Mme. Marie Curie and her daughter Mme. Irene Juliot-Curie, were candidates for membership, neither was elected. (Undoubtedly the 1976 reform of the Academy, which opened its doors to younger and less tradition-bound scientists, made it possible for a woman to be elected.) Mme. Choquet-Bruhat, a mathematician specializing in relativity, is a professor at the University of Paris VI where she teaches analytical mechanics and astro-mechanics. She was awarded the silver medal of the National Centre for Scientific Research, and prior to being elected a corresponding member in 1978, she was a laureate of the Academy. She joins her husband, Gustave, who is also a mathematician and was elected to the Academy in 1977.

NEW YEAR HONORS

OBE: Miss I. Chreseson, HM Inspector, Department of Education and Science; J. Cornwell, lately principal, West Midlands College of Higher Education; A.P. Cox, principal, Dartington College of Arts, Totnes; D.B. Edwards, principal, Rotherham College of Technology; P.T. Grant, director, Institute of Marine Biochemistry; J. MacGregor, lately registrar, Leeds University; N.S. Ross, senior lecturer in employer-employee relations, Birmingham University; J.E. Sharwood Smith, senior lecturer in classics, Institute of Education, London University; E.E. Temple, assistant secretary-general, Association of Commonwealth Universities; A. Usher, professor of forensic pathology,

Sheffield University; Miss E.M.K. Welsh, director of nursing and midwifery education, Northern Ireland Council of Nurses and Midwives.

MBE: A.A. Broadbent, dental inspector, School of Dentistry, Queen's University, Belfast; J. Dickson, principal lecturer and head of English department, Guildford College of Technology; Miss S.E.M. Hamilton, warden, Foley Hall, University of Reading; Miss I. Hewitt, refectory manageress, Doncaster Institute of Higher Education; Miss D. Lincoln, lately finance officer, St. Thomas's Hospital Medical School, London.

CHAIRS

Dr. Francis Smith, director of the Royal Greenwich Observatory, has been appointed to the professorship of radio-astronomy at the University of Manchester, and to the directorship of the Nuffield Radio-Astronomy Laboratories, from April 1, 1982, in succession to Professor Sir Bernard Lovell.

Malcolm Keith Sykes, professor of clinical anaesthesia at the Royal Postgraduate Medical School, London has been appointed to the Nuffield chair of anaesthetics at the University of Oxford.

Dr. John Bridgwater, lecturer in engineering science at Oxford and Lubbock, fellow and tutor in engineering science at Balliol College, has been appointed to the chair of chemical engineering at the University of Birmingham.

The World Prize for Mathematics, which is one of the most important awards in the field of science, has been awarded for 1979 to Jean Leray and André Weil.

Jean Leray taught at the University of Nancy until 1936 and at the University of Paris until 1943. In 1947 he was appointed a professor at the Collège de France where, until 1978, he held the chair of the theory of differential and functional equations.

André Weil was one of the founders of the Bourbaki Group, and he taught at the University of Strasbourg. He is a well-known specialist in topology and algebraic geometry.

Lords Name Science Committee

Lord Todd, the president of the Royal Society, is the chairman of the newly created House of Lords Committee on Science and Technology. The first meeting of the group was scheduled for 13 February.

The rest of the committee is made up of Lords Adrian, Ashby, Avebury, Brown, Gregson, Lloyd of Kilgerran, Lucas of Chilworth, Schon, Shackelton and Sherfield, Earls Bessborough and Cranbrook, Viscount Caldecote, and Baroness Jeger.

OBITUARIES

Professor Colin Cherry, who was the Henry Mark Pease Professor of Telecommunication and a member of the Imperial College since 1947, died on 23 November 1979. His *Pulse and Transients in Communication Circuits*, published in 1949, was in its time a standard work; and his paper "A History of Information Theory", together with the London Symposia on Information Theory which he helped to organize between 1950 and 1960, did much to bring the subject to the attention of electrical engineers.

Professor Richard Tecwyn Williams, who was the first Professor of Biochemistry at St. Mary's Hospital Medical School, London, a chair he occupied from 1949 to 1976, died on 29 December 1979. He was the pioneer and father of the science of biochemical pharmacology, and his research work provided the bases for the sciences of toxicology and clinical pharmacology.

Professor Henry Francis Black, who held a personal professorship in mechanical engineering at Heriot-Watt University, Edinburgh, Scotland, died on 17 January 1980. His research lay in the dynamics of rotor and hydrodynamic bearings, and later extended to the roll stabilization of ships. Henry Black played a leading part in work preparatory to the grant of the Charter of Heriot-Watt University in 1966.

ONRL REPORTS

C-7-79

The 5th Annual Scientific Meeting of the European Undersea Biomedical Society by R.F. Goad

The 5th Annual Scientific Meeting of the European Undersea Biomedical Society was held in Bergen, Norway on the 5th and 6th of July, 1979. The program included a tour of the recently opened Norwegian Underwater Institute (NUI). Twenty-nine presentations covered a wide variety of topics, focusing to a large extent on current research in Scandinavia, but also including a number of papers from the USA, France, and Great Britain. Included are brief summaries of all the papers and a short note on the annual EUBS business meeting.

C-9-79

The Sixth Annual Meeting of the International Skeletal Society by I.M. Freundlich

Bone radiologists, pathologists and orthopedic surgeons met in Munich, Germany for a meeting and symposium concerned with diseases of bone. New procedures, methods of diagnosis and measurement were described and discussed.

C-11-79

ELECTROSTATICS 1979 by I. Kaufman

This report covers a 2 1/2 day conference on problems related to Electrostatics, held at St. Catherines College of Oxford University. Subjects discussed were industrial Electrostatics; Electrostatic Hazards; Electrostatics and Fluids; Electrostatic Behavior of Solids, including contact charging phenomena; Measuring Techniques; and Atmospheric Electricty. Five invited and 31 contributed papers were presented. Subjects discussed ranged from modeling of processes leading to electrostatic discharges to practical means of minimizing charging of jet fuel.